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Monarch Conservation on Department of Defense Lands in the West:

Best Management Practices

Adult monarch butterfly on swamp milkweed (*Asclepias incarnata*) near Mountain Home Air Force Base, Idaho. Photo by Stephanie McKnight, the Xerces Society.

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Acronyms

AFB = Air Force Base
AUM = Animal Unit Month
BMP = Best Management Practice
DoD = Department of Defense
ESA = Endangered Species Act
HDSD = High density, short duration
INRMPs = Integrated Natural Resources Management Plans
IPM = Integrated Pest Management
IVM = integrated vegetation management
JBLM = Joint Base Lewis McChord
NAS = Naval Air Station
NWSTF = Naval Weapons Systems Training Facility
OE = *Ophryocystis elektroscirrha*
OHV = Off highway vehicle
WAFWA = Western Association of Fish and Wildlife Agencies

Table of Contents

Table of Figures

Introduction

The monarch butterfly (*Danaus plexippus plexippus*) has experienced dramatic declines across North America. Western monarchs, which overwinter in coastal California, have declined by 95% since the 1980s and current trends indicate a quasi-extinction risk (i.e., risk of the population dropping below 30,000 butterflies) of 72% in 20 years and 86% in 50 years (Espeset et al. 2016; Pelton et al. 2016; Schultz et al. 2017). This is similar to the decline observed in the eastern monarch population, which overwinters in central Mexico and has declined by more than 80% since the 1990s; this population has a quasi-extinction risk of 11-57% in 20 years (Semmens et al. 2016).

As monarch populations have rapidly declined in a single human generation, many are wondering what they can do to save the monarch and its milkweed host plant. While guidance to answer this question for monarchs is in development for the eastern and central areas of the U.S. (see Monarch Joint Venture's *Mowing for Monarchs* and the *Monarch Butterfly Conference Report* developed by Natural Resources Conservation Service and the U.S. Fish and Wildlife Service), guidance for how land managers can conserve and revive monarch populations in the western U.S. has not been available. This lack of guidance has been due in part to lack of knowledge about when and where monarchs occur in the landscape across the West.

To address this gap, the Xerces Society for Invertebrate Conservation and Washington State University-Vancouver started a project to investigate the seasonal timing of monarchs across the West, using a combination of systematic field surveys and demographic models. Field surveys began in spring 2017 and took place across five military installations in the West (Vandenberg Air Force Base (AFB) in California, Naval Weapons Systems Training Facility (NWSTF) Boardman in Oregon, Joint Base Lewis McChord (JBLM) Yakima Training Center in Washington, Naval Air Station (NAS) Fallon in Nevada, and Mountain Home AFB in Idaho). While this project is only at its midpoint, preliminary data from the first year of efforts can be used to develop broad management windows for managing existing monarch habitat and, where appropriate, restoring additional habitat on military installations in the West.

This document provides Best Management Practices (BMPs) for monarch breeding and migratory habitat in the West. Monarch overwintering habitat management is covered in the Xerces Society's publication *Protecting California's Butterfly Groves: management guidelines for monarch butterfly overwintering habitat*.

Management actions for monarch breeding and migratory habitat covered in this document include general management timing, grazing, mowing, roadsides and rights-of-ways, prescribed fire, restoration, invasive plant management, pesticides, and military training and testing. The following BMPs are directly informed by the results of a review of the peer-reviewed and technical literature, an online survey and multiple interviews with monarch butterfly experts and public land managers in the western U.S., and by field experience gained through surveys of monarchs and their habitat in California, Oregon, Nevada, and Idaho. Very little peer-reviewed or technical guidance exists that is specific to managing for monarchs and their breeding and

migratory habitat in the West. Thus, the authors relied on the best-available science on monarchs in the eastern U.S., Canada, Australia, and other parts of the world where 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 given the current state of knowledge.

It is our intention that these BMPs help the Department of Defense (DoD) develop management plans that minimize conflict between military and training activities and monarch needs, create efficient and effective conservation strategies, and incorporate monarch breeding phenology into the planning process. Specifically, these BMPs can be incorporated into key aspects of Integrated Natural Resources Management Plans (INRMPs) at installations across the West (specific guidance for installations in Appendix 4). We expect these BMPs to become more refined for DoD lands after the conclusion of our third year of field studies. In addition, a more comprehensive set of BMPs for monarchs on public lands in the West are currently available from The Xerces Society for Invertebrate Conservation.

Meet the Butterfly

Monarch on showy milkweed. Photo: Stephanie McKnight/Xerces Society.

Monarch life cycle

Female monarch butterflies lay eggs on milkweed (*Asclepias* spp.), which the caterpillars (larvae) rely on for food as they develop through five instars. Milkweed also provides the caterpillars with cardenolides--toxic compounds that make them unpalatable to many vertebrate predators. Their bright, aposematic coloration warns predators of their toxicity. However, parasitism and predation of caterpillars by invertebrates can be high--with less than 10% of eggs typically surviving to adulthood (Nail et al. 2015). Fifth instar caterpillars form a cryptic green chrysalis (pupa) with gold trim and attach to milkweed, surrounding vegetation, or other structures. A few days later, the adult butterfly emerges and quickly becomes mobile to find a mate and nectar on flowers, with females searching for milkweed upon which to lay their eggs. 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.

Left: Monarch larva on showy milkweed (*A. speciosa*); right: monarch pupa. Photos: Stephanie McKnight/Xerces Society

Migration and distribution

Monarch butterflies (*Danaus plexippus plexippus*) are found throughout North America, as well as Hawaii, other Pacific Islands, Australia, New Zealand, Spain, and Portugal. In North America, where monarchs are most numerous, they migrate travel hundreds or thousands of miles from their breeding grounds found across the U.S. and into southern Canada (about 50 degrees North) to overwintering grounds in both Mexico and California. The eastern monarch population—defined as monarchs that 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 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 (under 100 butterflies at any one site) of butterflies 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 (Gail Morris, personal communication). There are also smaller, non-migratory 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 the United States as far north as Southern Canada (**Figure 1**). In the West, monarchs are thought to breed continuously from spring through fall in California, Nevada, and Arizona and subsequent generations continue to travel north and east into the interior of the continent throughout the summer. Preliminary data show that adult detections in all regions except Southern California peak between mid-July and mid-August, with high numbers of immature stages detected in most regions in June (Schultz et al., unpublished data). High numbers of immature stages were also detected in early August in Northern California, Nevada, and Oregon, and increased again in September and October in Southern California (Schultz et al., unpublished data).

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 a strong association of monarch collection record location and close proximity to rivers, and proposed that western monarchs use rivers as major migratory corridors since they provide more reliable sources of water, nectar, and overnight roosting trees. Anecdotes of monarchs forming temporary aggregations in trees along rivers and in suburbia to spend the night or take shelter from storms have been reported from Arizona in the fall (Gail Morris, personal communication). 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 (Yang et al. 2016). Overwintering monarchs are typically in reproductive diapause—conserving their fat for survival and spring dispersal--until 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 non-native, tropical milkweed (*A. curassavica*) and a mild winter climate has led to year-round breeding and possibly the modification of overwintering behavior. Monarchs are also known to breed year-round on native, evergreen milkweeds in parts of Arizona (Gail Morris, personal communication).

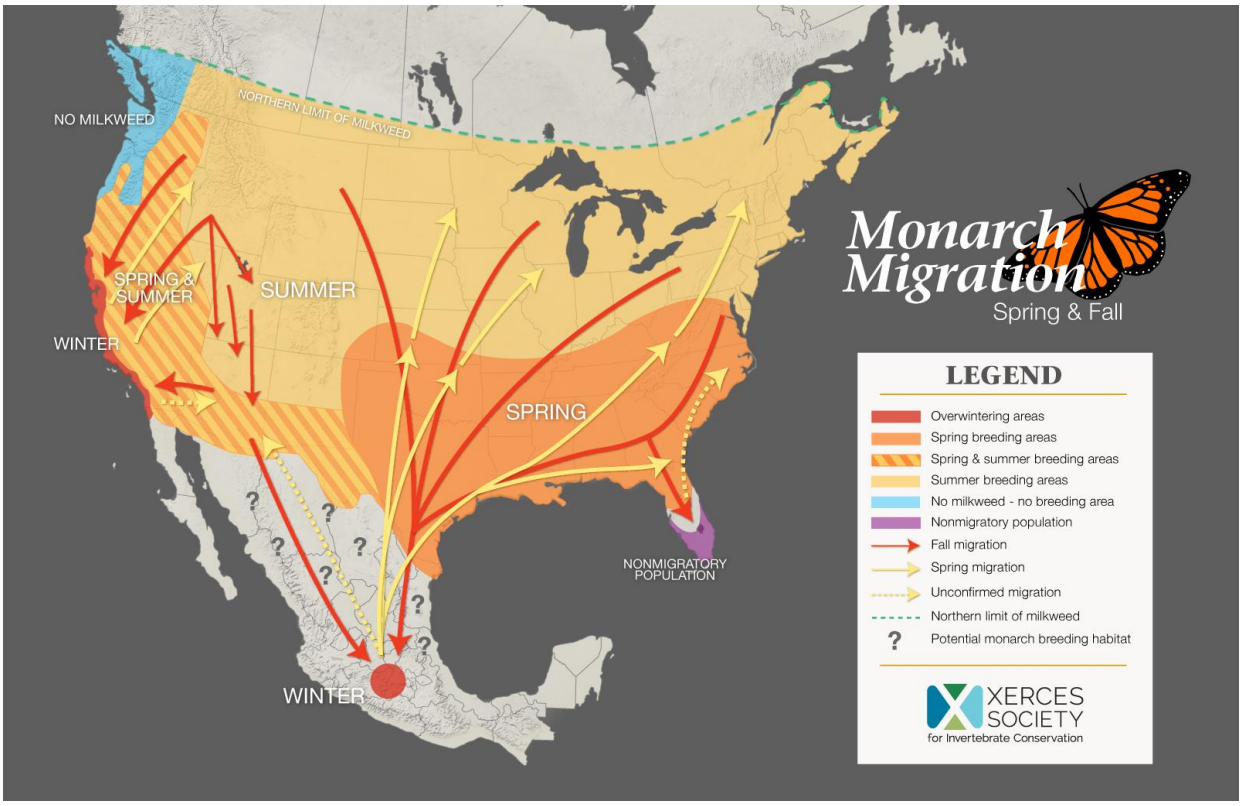


Figure 1. *Monarch migration and distribution in North America.*

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 that 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 monitoring over the past 40 years 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. 2015; Stenoien et al. 2016; Saunders et al. 2017; Thogmartin et al. 2017; 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. 2017) in the eastern population. The relative importance of milkweed, 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 Columbia Basin) in southeastern Washington and northeastern Oregon—glyphosate use has also increased dramatically since the 1990s. 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. Moreover, glyphosate is not the only herbicide that kills milkweed or harms monarch habitat--it is simply the most widely used. Other herbicides can also be used over large swaths of land. Dicamba 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 imidacloprid and clothianidin) are the most commonly used class of insecticides, and have been shown to have sublethal and lethal effects on developing 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. 2017).

Neonicotinoids have been used extensively in both agricultural and urban/suburban areas since the early 2000s. Data from California's Pesticide Use Reporting system demonstrates the large-scale use of neonicotinoids: imidacloprid, the oldest neonicotinoid, is 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, as is the planting of neonicotinoid treated seed.

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 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, 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. 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 (note: this does not include grasslands). 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). 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 (Emma Pelton, personal observation). 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, an increase in the duration of milkweed dormancy, and reduced palatability of milkweeds to monarch larvae. 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 can decrease 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.

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 (e.g., 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. For example, Espeset et al. (2016) show negative population trends based on analyses of 40 years of summer flight records in northern California, yet these declines were not fully explained by climate variables. Furthermore, 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.

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, Steller'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*) is 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 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 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, evergreen 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 Non-native Milkweed** on page 36 for more detail.

What is High-Quality Monarch Habitat?

The principal features of high-quality monarch habitat are:

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 43 for more information.)
4) Places that are safe from high levels of pathogens. (See **Recommendation against Planting Non-native Milkweed**, on page 36, 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.

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).

Migration 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 quite similar and are grouped together in this document.

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 (Western Monarch Milkweed Mapper; 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 and Oregon, where only four 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.

Milkweed grows throughout the West (see **Figure 2**). 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.

On the Pacific Coast, milkweed is largely confined to southern California. Historically, milkweeds occurred very rarely north of Santa Barbara, but they are more common 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 Range 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.

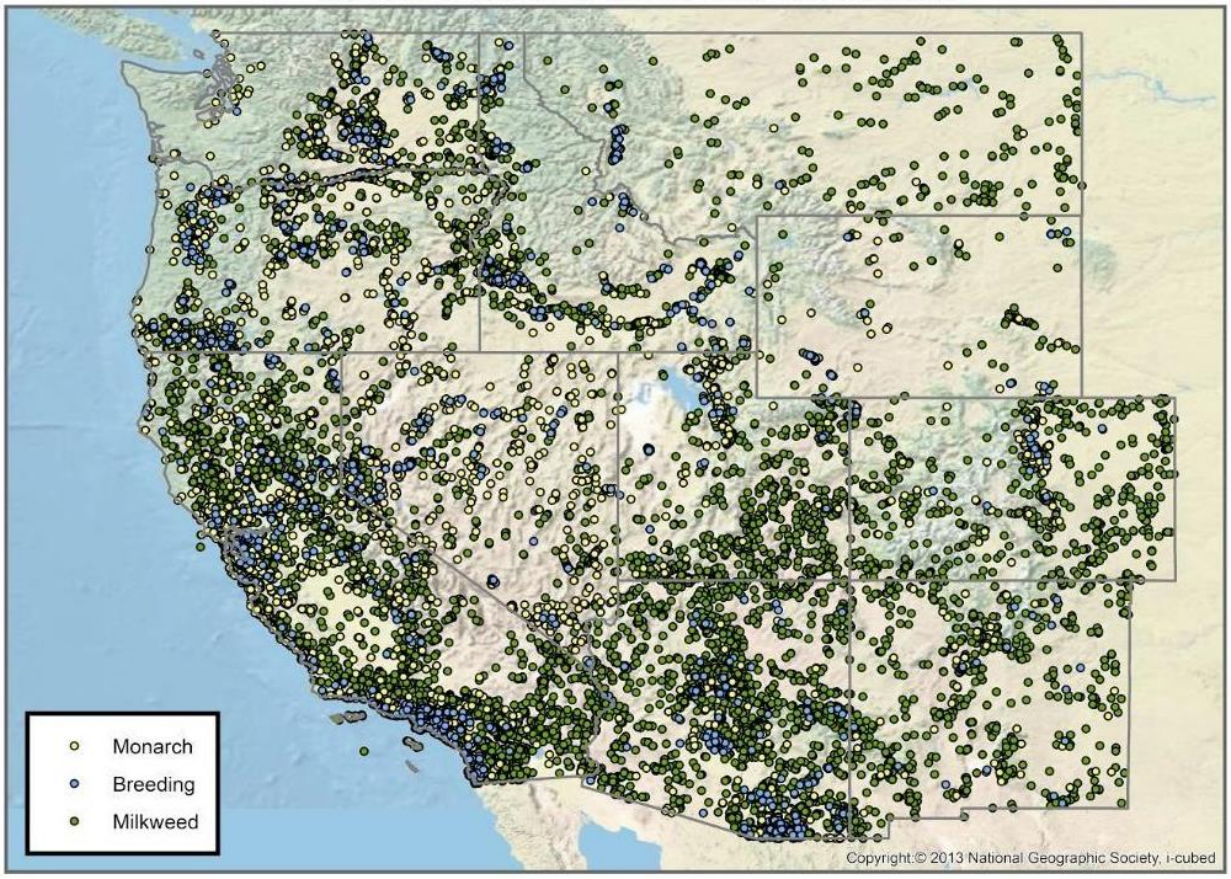


Figure 2. *Milkweed, monarch adult, and monarch breeding records in the western U.S. from the Western Monarch Milkweed Mapper, accessed March 19, 2018.*

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, several milkweed species 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. 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 are laid on young plants and those that are flowering versus those that are fruiting or beginning to senesce (e.g., Zalucki and Kitching 1982).

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.
- 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 website (www.xerces.org).

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.

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 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 (Emma Pelton, personal observation) 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 since 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 **Invasive Plant Management** on page 42 for more details.

Approach to Monarch 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 natural 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 that are most likely to be resilient and important to monarchs under climate change. Northern latitudes 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. 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 the current land use.

For example, planting milkweed may be recommended in agricultural landscapes in key monarch breeding areas 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, Xerces Society, and the University of Nevada-Reno. The data used in the modeling were 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, Xerces Society, Idaho Department of Fish and Game, Washington Department of Fish and Wildlife, and others. In addition, results from monitoring monarch breeding on DoD installations suggest that early spring and winter are critical times for western monarchs, and therefore priority actions in overwintering areas and coastal breeding areas greater than 10 miles from the coast are critical conservation actions.

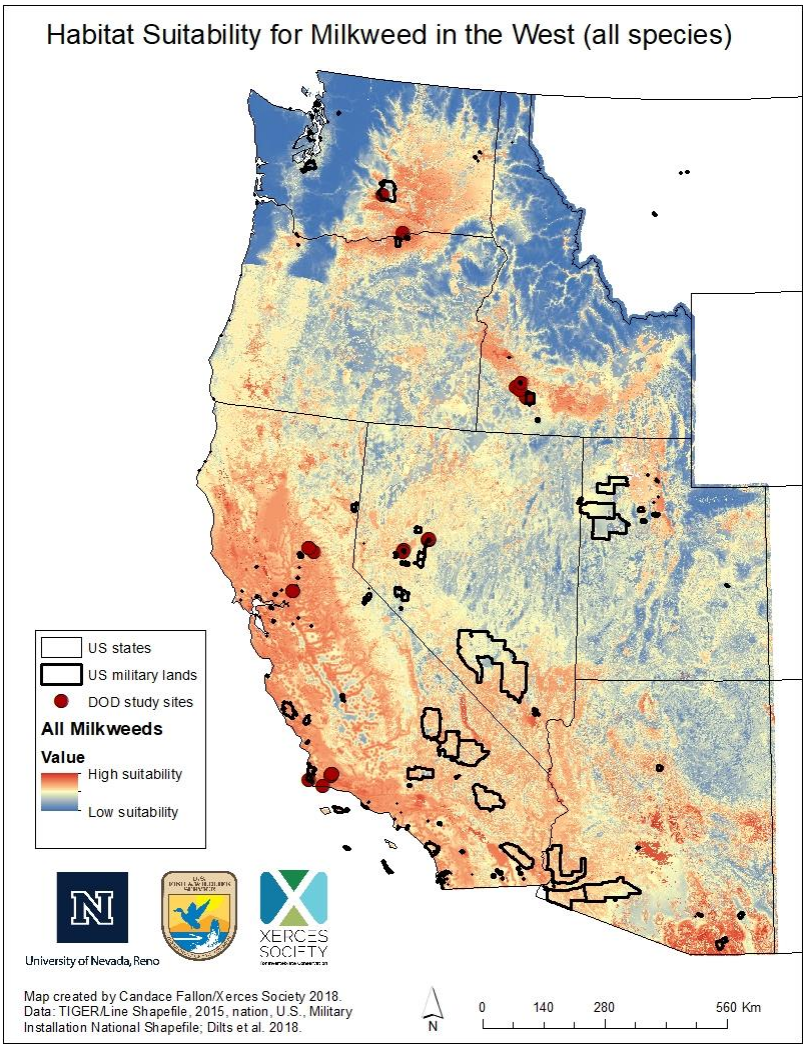
Consistent with the wide-ranging nature of the monarch butterfly, suitable breeding and migratory habitat is widespread across the West. The modeling results show there are notable concentrations of potentially highly suitable habitat in the Central Valley of California as well as in southern Idaho and 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 3**). 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. On a finer scale, habitat heterogeneity within suitable areas for the western monarch is important. This includes shade from trees and shrubs that provide refugia from heat in the summer in arid regions of the West, and access to water and open areas with nectar.

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 3**—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 (see the Western Monarch Milkweed Mapper). Not every area that 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 22.

Because habitat suitability modeling is influenced in part by survey effort and requires a minimum number of records that 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 to read more information about this modeling project, see the results from two phases of modeling, and contribute data.

Figure 3. *Maximum milkweed suitability map.*



Issues with planting milkweed outside of 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 (Western Monarch and Milkweed Mapper 2018). Nevertheless, 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 Non-native Milkweed** on page 36). However, 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 that provide nectar resources for monarchs and other pollinators.

Best Management Practices for Monarch Habitat on Western DoD Lands

The Best Management Practices (BMPs) below provide recommendations on how to incorporate monarchs in management decisions on DoD lands in the West. These BMPs are based off an extensive literature review and interviews and surveys of land managers and conservation practitioners. This guidance is provided to help DoD land managers minimize harm to monarchs when considering broader goals for land management that align with the DoD's mission.

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 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, burning, grazing, or using pesticides 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 timing (**Figure 4**). 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 the Department of Defense Legacy program funded monarch research project, Journey North 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. This map was revised in 2019 to reflect data gathered on Department of Defense lands in 2017 and 2018. Based on the availability of data, some ecoregions were combined into the same window and one ecoregion in southern California (the Sonoran Desert Ecoregion 10.2.2) was split into two management windows.

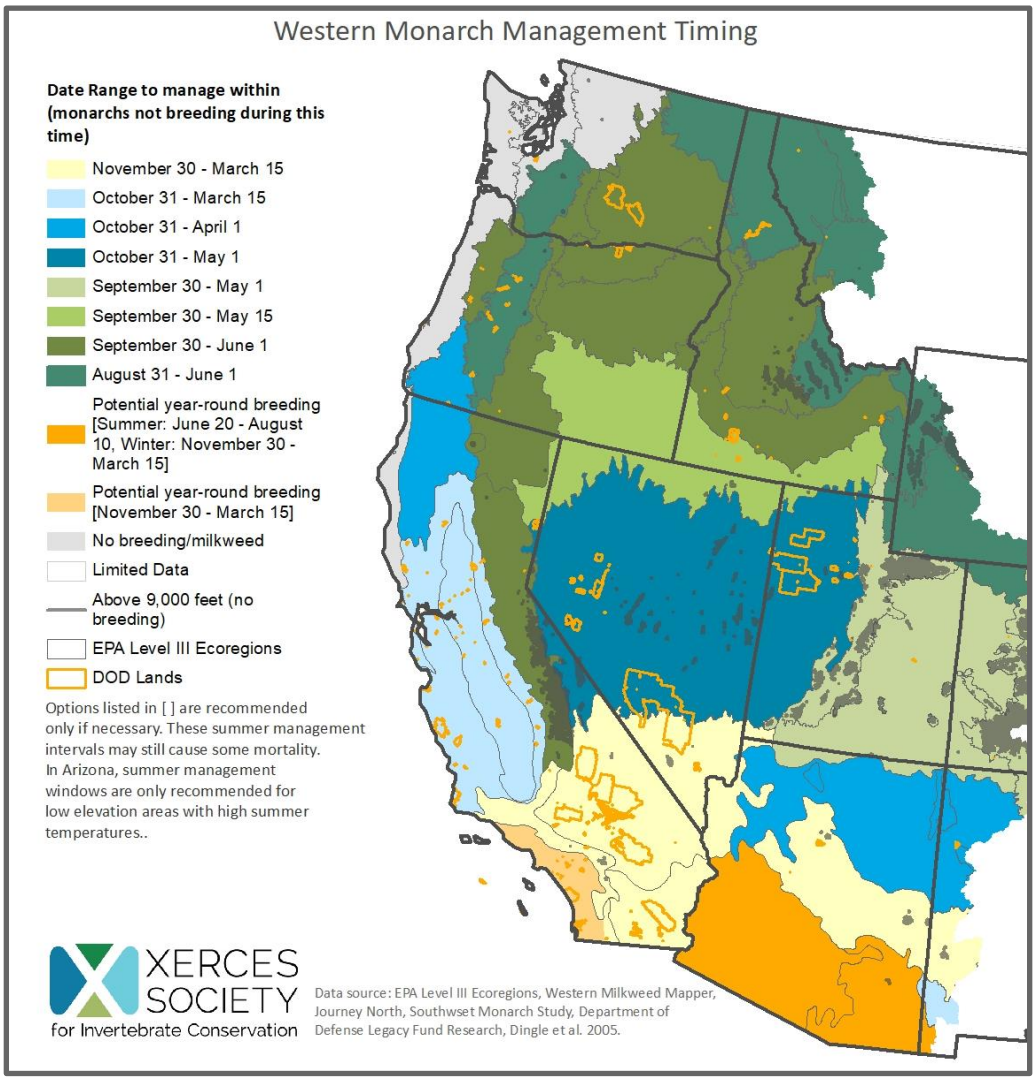


Figure 4. *Monarch butterfly breeding habitat: recommended management timing.*

We are still learning about the phenology of 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 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 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.

A few notes:

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

Using pesticides outside these management windows may still negatively impact monarchs and other pollinators if the chemicals are long-lived. See Guidance to Protect Pollinator Habitat from Pesticide Contamination to learn more.

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 that 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 specific grazing stocking rates or timing that would be needed to develop broad, general recommendations. 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). 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.

Grazing best management practices

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

- Low intensity (low AUMs for site or allotment) for season-long grazing; high intensity, short duration and/or rest-rotation are recommended for maintaining habitat for pollinators including the monarch. Generally, grazing that is of short intensity and duration in the fall (when there is less competition for floral resources with pollinators) is best. 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.

Utilization recommendations. 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, 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.
- In times of drought, follow AUMs or stocking rates recommended for your region in drought conditions.
- 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 as well as milkweed for monarchs during the breeding season.
- In sagebrush-steppe habitats, aim for short-term 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.

Timing. The following adjustments will maintain flowering resources and benefit monarchs.

- 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 to a site.
- Avoid grazing the same location at the same time every year.
- If feasible, and soils can withstand it, adjust grazing time to fall or winter grazing when milkweed is dormant and monarchs are not breeding - generally between frost and spring (see **Figure 4**).
- Ideally, sheep grazing should occur in the fall and winter after flowering plants have senesced. If grazing must occur during peak pollinator activity (April-September), then sheep should be introduced at low stocking rates and the animals should be continuously moved to avoid depleting floral resources in any single location.
- In desert regions or high elevation habitats, after a flood or high precipitation event, there may be a large flush of annual or perennial plants that have been dormant - including some milkweed species. Adjusting the timing of grazing can allow ephemeral flowering

resources to set seed (e.g. high elevation meadows reliant on snowpack, annual plants in the desert southwest dependent on seasonal precipitation).

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, what, and why you took certain actions---a photo, paper, or electronic trail to learn from and draw on in years to come.

- **Flexible grazing management plans:** 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 1-2 blooming nectar plant species in an allotment or pasture throughout the season. This is especially important when a grazing allotment contains milkweed plants**.**
    - Management plans should be flexible to allow for adjustments of stocking rates and timing to prevent depleting nectar resources and milkweed plants. This will vary annually and by region, elevation, habitat type, and season.

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).

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).

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.

- Maintain existing conditions of 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 the U.S. Forest Service Great Basin Fact Sheet #1.

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 over utilization. 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 (HDSD) 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.
        - Move livestock using supplements.
        - Consider releasing livestock in areas that will limit or postpone their access to sensitive habitats.
    - The following riparian grazing standards 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).
        - Limits on livestock hoof damage to soil and streambanks (e.g. <10% soil shearing by hooves).

- **Native ungulates.** In areas with large native ungulate populations, it may be necessary to adjust the timing, intensity, and duration of 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 such as elk and deer (DeBano et al. 2016). Avoiding overlap between cattle and native ungulates may help to maintain important floral resources for monarchs.

- **Grazing post-fire.** Allow 2-3 years of rest after a fire before grazing again 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. 2015).

- **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) —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. Grazing during times of drought has the potential to extirpate local 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 regionally-specific mowing guidance to benefit monarchs and their habitat. 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--a tactic recommended 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 later in the season is beneficial to monarchs.

- Avoid mowing milkweed during the breeding season. (See **Figure 4** for region-specific guidance on mowing windows for monarchs.)

- Delay mowing milkweed until 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.
    - Generally, fall mowing after the first frost is ideal to avoid mowing floral resources and host plants for breeding and migrating 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.
- If mowing must occur during monarch breeding season,
    - 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 2015), 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 reduce the spread of weeds at the site by limiting the number of weed seeds that attach to mowing equipment and potentially move to a different site.
    - If mowing to control weeds occurs during the breeding season for your region, consider surveying for milkweed. If milkweed is present, consider flagging and avoiding it, if possible.
    - Control of invasive weeds generally takes precedence over protecting milkweed.
    - See **Invasive Plant Management** on page 42 for more information.

General considerations.

Use spot mowing. Avoid mowing large patches of milkweed in order to reduce immature monarch mortality. Instead, focus on areas with weeds and other target plants.

- 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 monarchs.
    - Where possible, vary mowing times every few years to increase plant diversity.

Roadside 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 that 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-way, 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.
- 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.
- Consult the Federal Highway Administration's Pollinators and Roadsides handbook and 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.
- 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.

Left: showy milkweed (*A. speciosa*) with monarch larva on roadside; right: sunflower/nectar on roadside. Photos: Stephanie McKnight/Xerces Society

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).

Prescribed fire best management practices

Timing. 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 only when monarchs are not actively breeding in your region - see **Figure 4**.
- If burning milkweed habitat during the breeding season is necessary for invasive plant control or other management objectives, then all milkweed plants should be surveyed for immature stages. If milkweed plants do not have immature monarchs, then burning can proceed; if milkweed plants have immature stages, consider flagging and avoiding those plants or delaying burning until after the breeding season.

- 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; November) to stimulate flower production of spring-blooming nectar sources.

Fire interval. 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.

Scale. Manage fire to increase habitat heterogeneity at multiple-scales: within site 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 your milkweeds, but is also important for other pollinators.
- Include unburned refugia in the burn plan - especially areas that contain milkweed.

Prescribed fire post-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 20.

Monitor. Monitor the effects of prescribed fire on monarchs and milkweed plants. Pre- and post-project monitoring is necessary to determine the effects of fire on monarchs, and data are limited for the West.

Restoration

There are two core components to monarch habitat restoration; one is restoring habitat for adult butterflies, and the second is restoring habitat for the immature stages (eggs, larvae, pupae). Adult monarchs require an abundance and diversity of nectar during spring and fall migration, and during the breeding season. They also rely on roosting sites - such as trees and shrubs - near breeding sites and along migration routes to rest. Adults 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. Recent research suggests that monarchs continuously breed in many areas of the West, and it is important to provide milkweed plants as larval hosts during the time when monarchs are in each region (see **Figure 4**). The overall breeding period in western states is generally from early spring (March-May), through the fall months (September-October). These two primary components of habitat restoration—native milkweed and nectar plants—can be incorporated into any management or restoration plan and are likely to be compatible with management for other species of conservation concern.

General 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 3**). Including 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 pesticide use. Consider past land use such as residual pesticide use. Local, state, and extension soil laboratories can test soil for pesticides, soil fertility, and microorganisms. See **Pesticides** on page 43**.**
- Consider replacing non-native landscaping at DoD installations with native plants including milkweed and monarch nectar plants. Ensure any landscaping of native plants will be protected from pesticides.
- 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 late blooming asters in the seed mix or planting plan.
- Prioritize sites without invasive non-native/noxious weeds that may impede restoration efforts. Consider whether the seed bank may contain problematic plants.
- Soil type is an important factor to consider when selecting 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. Some species may have a higher chance of establishing 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.

Plant composition

Include at minimum one milkweed species, and select nectar species that will provide floral resources throughout the breeding season with a minimum of 3 blooming species 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 overtime 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, 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 drought tolerant. In contrast, desert milkweed (*A. erosa*) grows in dry washes, sagebrush, or creosote communities and would be incompatible with a stream restoration site. Habitat type is also summarized in **Appendix 1.**

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 milkweed (*A. cordifolia*) 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 as narrowleaf (*A. fascicularis*) and showy milkweed (*A. speciosa*) tend to have much longer growing seasons extending into the fall. If historically and regionally appropriate, planting a variety of milkweed species can extend the temporal availability of larval hosts for monarchs. 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). Until more research is available, planting multiple species may increase the likelihood that monarchs will use a given area. In addition, planting a diversity of milkweed species may also provide monarchs with increased disease resistance. Research suggests that trade-offs exist between rapid growth (low cardenolide content) of milkweeds and protection from predation and parasites such as OE (high cardenolide content; De Roode et al. 2008; Tao et al. 2016).

Recommendation against planting non-native milkweed

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 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.

Milkweed establishment guidance

Milkweed establishment can be a challenge, but there is guidance to 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 be 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 39.

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.
- Planting in the fall, before plants go dormant (October, November) may 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 solarizing, herbicide, or similar site preparation technique a season or two in advance.
- 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 into ~4” chunks for replanting elsewhere in the fall.
- Irrigate if possible.

For all milkweed planting and seeding, getting plants 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 and cited literature provide detailed information regarding milkweed propagation, including seed collection, seed cleaning, 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 milkweed herbivores 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."
- The Western Monarch Milkweed Mapper's western milkweed species profiles including information about habitat type, growth form, and distribution.

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 species; Griswold and Messinger 2009).

- **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, and fall).
    - Refer to the Xerces Society's Monarch Nectar Guides to determine regionally appropriate nectar plants for each season.
    - Some common late season species in the West: rabbitbrush (*Ericameria* spp. and *Chrysothamnus* spp.), goldenrod (*Solidago* spp.), sunflowers (*Helianthus* spp.), blanketflower (*Gaillardia* spp.), asters (*Symphyotrichum* spp.), or any late-blooming regionally appropriate Asteraceae.

- **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".

- **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 U.S. 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 be generated. This is part of a collaboration between the Federal Highway Administration, U.S. 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 through the Federal Highway Administration's website.

- **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. 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. For milkweed, consider using provisional milkweed seed zones outlined in Landis (2014), which are based on ecoregions. Ask questions of providers of native milkweed plant materials to ensure they are from local ecotypes.

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). 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, 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 Milkweed Market Vendors provides a map of native milkweed vendors across the country.
- The Xerces Society's Pollinator Resource Center provides regional-specific information about native plant nurseries.

Alternatively, collect your own seed, referring to the following 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 **Pesticides** on page 43 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.

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. 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. 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 (Pollinator Health Task Force 2015), 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 and monarch butterflies 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 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.

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 survivorship of plants. This is particularly important in arid regions of the Southwest and California.

- 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 irrigation systems that are low maintenance and increase planting survival - especially in arid environments (Bainbridge 2002, 2012).
- Consider mulching transplants to retain moisture—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.

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 non-native 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. Restore habitat connectivity in the post-fire landscape. Focus seeding or planting efforts to 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).
- 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). Seeding in high elevation and/or high precipitation sites in arid habitats is likely to be the most successful and cost-effective use of resources. In low elevation sites, using a seed drill or planting bare-root perennial plants may be the most cost-effective way to establish native plants.
- Reduce or eliminate the use of non-native grasses in post-fire rehabilitation seed mixes, and instead use native grasses and forbs.

Invasive plant management

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. However, while research indicates that invasive plant removal can improve habitat for pollinators, removal of flowering invasive plants in some cases has been suggested as a cause of decline for some pollinator populations, by removing available floral resources (Severns and Moldenke 2010). Controlling or removing invasive plants may be a concern for land managers working in degraded landscapes where nectar for pollinators may be scarce. In some degraded landscapes, invasive plants such as thistles may be the only species available as forage for monarchs. Similarly, invasive trees and shrubs may provide important places of shelter. Removal of invasive plants under these circumstances may reduce nectar availability and other habitat resources for monarchs and other pollinators. To avoid this, plans should be in place to plant commensurate native resources immediately after large-scale removal of invasive plants that are known to provide important resources for pollinators.

Invasive plant best management practices

- **Management of invasive plants should be guided by 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 non-target organisms and the environment.
- **Use Early Detection Rapid Response for new invasive plant occurrences.**

    - Invasive plants reduce cover of native plants, and can result in simplification of pollinator networks, and select for generalist pollinators over specialists.
- **Ensure revegetation plans are in place.** When invasive plants are removed on a large scale, they should immediately be replaced with commensurate native floral resources.
    - Native perennial plants can deter recolonization of invasive plants.
    - Replace invasive plants with native perennial monarch nectar or host plants with similar phenology as the invasive targeted for removal.
- **Determine the level of overlap between native plants and target invasive plant phenology and morphology to predict potential effects to the native pollinator community.**
    - If the invasive plant is providing nectar during a time of scarce floral resources, then removal during flowering could reduce floral resource availability for native pollinators. If there are native plants in flower at the same time as the target invasive, then removal may have less impact.
- **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.

Pesticides

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 how to best approach 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 in agricultural settings is available in our materials:

- *Guidance to Protect Pollinator Habitat from Pesticide Contamination*
- NRCS/Xerces guide *Preventing or Mitigating Potential Negative Impacts of Pesticides on Pollinators Using Integrated Pest Management and Other Conservation Practices*
- *Ecologically Sound Mosquito Management in Wetlands* outlines mosquito management methods that effectively respond to public health risks while reducing non-target effects.

General pesticide best management practices

- Any pesticide should be used within an integrated pest management (IPM) 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 non-target 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 juvenile) are present.
        - 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 removing floral blooms in the treatment area prior to pesticide applications (e.g., mow).
    - 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, nectar sources or 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 onto field margins or boundaries 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 or 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 best management practices

- 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 best management practices

- 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 applying to herbicide-resistant crops or when drying-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.

Military training and testing

Military training activities on installations and bases in the West can include munitions explosions, heavy vehicle tracking, and chemical contamination, among others. Where feasible and when it does not compete with the military mission, land managers are advised to avoid military training and testing activities in one third of monarch habitat during the breeding season. Disturbance is a critical ecological process for most butterflies, including monarchs. Military training-based disturbance can be compatible with monarch breeding habitat if there is sufficient habitat that can be maintained in a variety of disturbance states, and monarch productivity can be sustained broadly across the installation. In many areas important to the western monarch, habitat heterogeneity is important. This includes a mix of shrubs and open areas as well as access to water. Additional installation-specific guidance can be found in Appendix 4.

Military activities best management practices

- When possible, avoid or limit training and testing activities that occur in monarch breeding habitat during the breeding season (see management timing on page 23).
- Establish protective buffers or other boundaries habitat areas identified as important for monarch breeding and nectar sources.

- Maintain a variety of disturbance states in monarch breeding habitat such that habitat structure (trees and shrubs for shade, and water), host plants (milkweed), nectar plants are maintained across the installation.

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 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 that are likely to be resilient under climate change. For example, northern areas may become more important as the climate warms.
- Select milkweed and nectar plant species that are drought tolerant, especially in more southern and arid areas that are expected to become more drought-impacted.
- Create stepping stones or corridors of habitat across the landscape, which are always 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 good projections of west-wide milkweed habitat suitability under climate change scenarios are currently unavailable).

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Appendices

Appendix 1. 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:
https://drive.google.com/open?id=1Rwpwm-1d3P4eNPbCY3sc4N-_q_RY1UfgLmnBNt9S2Xw

Appendix 2. Native Monarch Nectar Plants in the West

https://docs.google.com/spreadsheets/d/1usZFfxaJ8rL0rVBA6B2sNIIBcHUO-F9yA6xHt5Gn7Ps/edit?usp=sharing

Appendix 3. Western Monarch Call to Action

https://xerces.org/wp-content/uploads/2019/01/19-001_Western-monarch-call-to-action_XercesSociety.pdf

Appendix 4. Recommendations to Incorporate Monarch Butterfly Conservation Strategies into Integrated Natural Resources Management Plans (INRMPs).

Introduction

Monarch butterflies have declined dramatically across North America and are under review for Endangered Species Act (ESA) protection. Monarchs west of the Rockies occur broadly and are distinct from the larger eastern population. Monarchs in the west have declined >99 percent since the 1980s. They overwinter in California and Mexico, and breed and migrate across the west, including a considerable portion of Department of Defense (DoD) land (Figure 1). If listed, federal land managers, including those responsible for wide swaths of DoD land, would be required to minimize take of monarch butterflies. To better inform management of DoD land in the West, the research project titled "Conservation and management of Western Monarchs on DoD lands: Implications of breeding phenology" was initiated in 2017, and is entering the third year of surveys in 2019. Data from this project have been used to develop this document: Monarch Conservation on Department of Defense Lands in the West: Best Management Practices, in a monarch population viability analysis, and the data will be used to develop a full

demographic model of the western monarchs after completion of surveys in 2019.

The following document provides general recommendations to improve Integrated Natural Resources Management Plans at the five DoD installations included in this research project: Vandenberg AFB in California, NWSTF Boardman in Oregon, JBLM Yakima Training Center in Washington, NAS Fallon in Nevada, and Mountain Home AFB in Idaho.

Project Overview

The research project includes surveys at five DoD sites throughout the western monarch breeding season and range: Vandenberg AFB in California, NWSTF Boardman in Oregon, JBLM Yakima Training Center in Washington, NAS Fallon in Nevada, and Mountain Home AFB in Idaho. The survey data provide direct information about the abundance of butterflies at different points in the life cycle; which allows researchers to identify key points in space and time at which habitat is (and is not) limiting the western monarch population. These data are also a key building block for constructing a full demographic model of western monarchs to conduct population viability analyses. The data is being used to develop specific guidance for INRMPs (Integrated Natural Resources Management Plans) at each installation included in the project. This guidance will be further refined in 2020 with data from the 2019 field season.

Military Mission Benefits

When a species occurring on military lands is listed under the Endangered Species Act (ESA), military training and operations can be negatively impacted. Should the monarch be listed, the impact to military training operations could be especially extensive, given the broad distribution of monarchs in the US. If monarchs are listed under the ESA, habitat management could impact nearly all DoD installations (Figure 1). Furthermore, if DoD actively engages in monarch conservation on DoD lands, those efforts – in concert with other monarch habitat conservation efforts on public and private land – may eliminate the need to list the species under the ESA because adequate actions to recover the species would already be in place. Efficient and effective species conservation planning requires knowledge of essential aspects of species biology.

Incorporating these general recommendations into Integrated Natural Resources Management Plan (INRMPs) will benefit the military mission by allowing managers to balance habitat protection for monarchs with training activities by avoiding the phenological windows with greatest importance to breeding monarchs. Developing and implementing proactive conservation strategies before the species becomes federally listed increases the probability that USFWS may find that listing this species is not warranted. Further, if a species which has had proactive management as a candidate does get listed, regulatory constraints placed on activities at the base are substantially reduced if the base has been proactive. The general guidelines outlined in this document can inform INRMPs revisions and enhance DoD ability to maintain mission readiness.

Preliminary Data Analysis

To date, the project has found that western monarchs differ from eastern monarchs in at least two ways: (1) western monarchs breed throughout the summer in central parts of their breeding range (California and Nevada in Figure 2), in contrast to eastern monarchs which migrate north through successive summer generations; and (2) densities of immature monarchs (eggs and larvae per milkweed stem) in the west are much lower than reported numbers for the east (<0.1 eggs/stem in the West vs. 0.2 – 0.4 eggs/stem in the East); this implies that stem densities of milkweed per se are not the critical limiting factor in the same way that they are for eastern monarch (Nail et al. 2015, Thogmartin et al. 2017). Data from this project fills a critical gap in western monarch knowledge; past research focused on broad trends in overwintering populations in the west, and mechanisms responsible for declines in the west are poorly understood (USFWS 2018). A third year of surveys began in 2019, and a revision to this document will be completed with additional data.

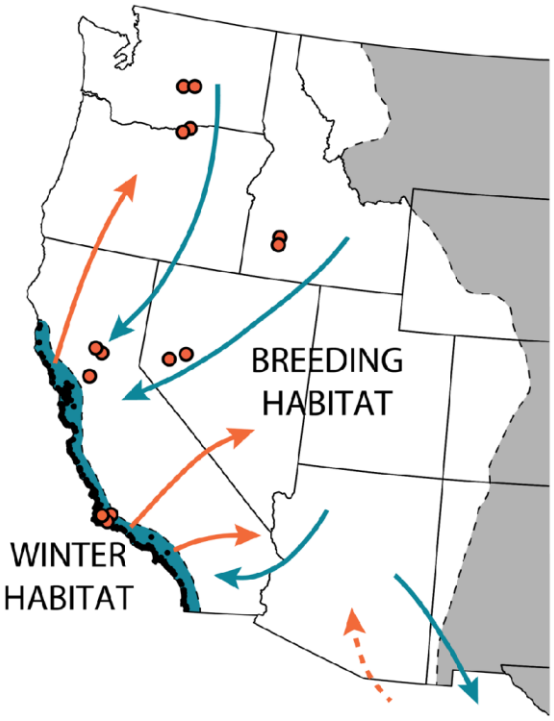

Figure 1. Western monarchs breed west of the Rocky mountains and primarily overwinter at over 200 sites (black points) along the Pacific coast in California. During the spring, monarchs leave the overwintering habitat (colored blue) to disperse (orange arrows) across the West. The butterflies breed continuously across the West during the summer (colored white); in the fall, they return (blue arrows) to the overwintering grounds. [Tag recoveries in Mexico show that at least some western monarchs migrate to central Mexico, mixing with the eastern monarch overwintering population; whether or not monarchs from Mexico return to the West in the spring has not been documented, but is suspected (dashed orange arrow).] In 2017 and 2018 DoD Legacy-funded work, we monitored monarch breeding phenology and milkweed throughout the West (orange points).

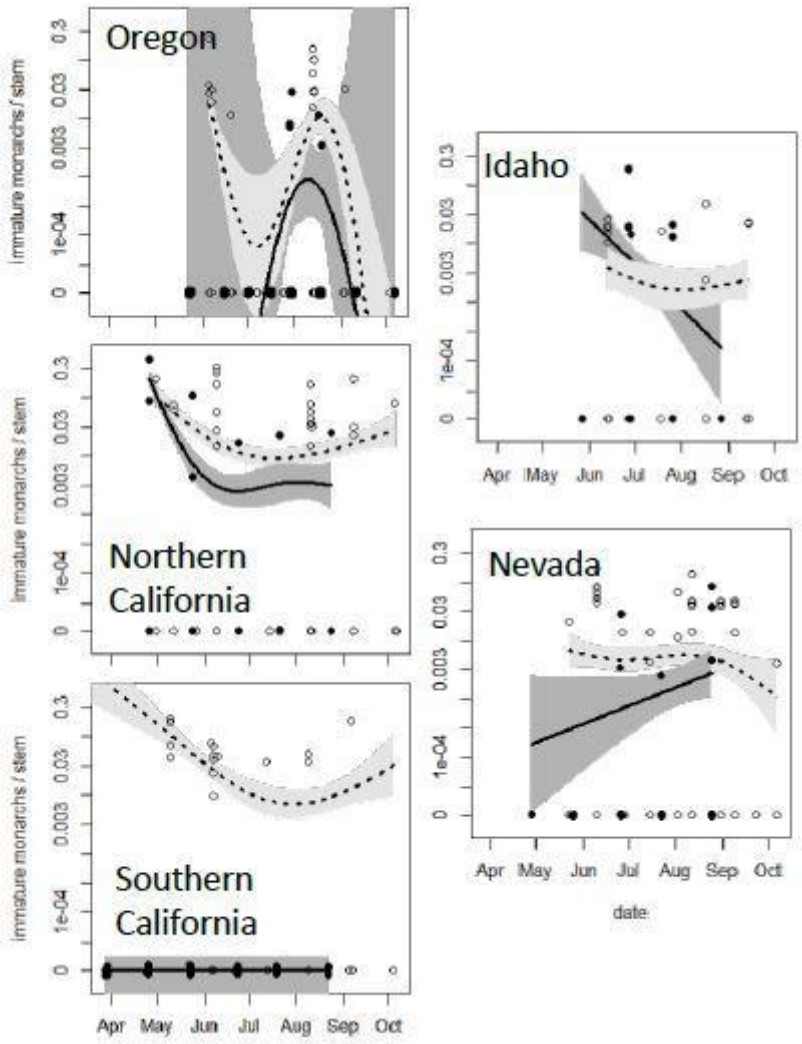

Figure 2. 2017-2018 monarch breeding in each region with sufficient breeding to document phenology. Monarch breeding was continuous throughout the summer in California and Nevada, and with distinct generations in Oregon. Breeding within the survey area was too limited in Idaho to document breeding phenology. Monarchs did not breed in Washington in 2018 and was limited in 2017, so it is not represented in the figure below. (light gray = 2017, dark gray = 2018).

In addition, preliminary data suggest that some habitat associations such as shade may be important for monarch breeding (Figure 3) – particularly in areas of the arid intermountain west. Data from Oregon and Washington suggest that monarchs may be selecting milkweed plants in the shade or near water for breeding more frequently than plants without shade or that are not near water. This research project is now investigating this habitat association in more detail in 2019 to better understand the importance of shade and proximity to water for monarch breeding. This will help land managers prioritize areas to conserve monarch habitat.

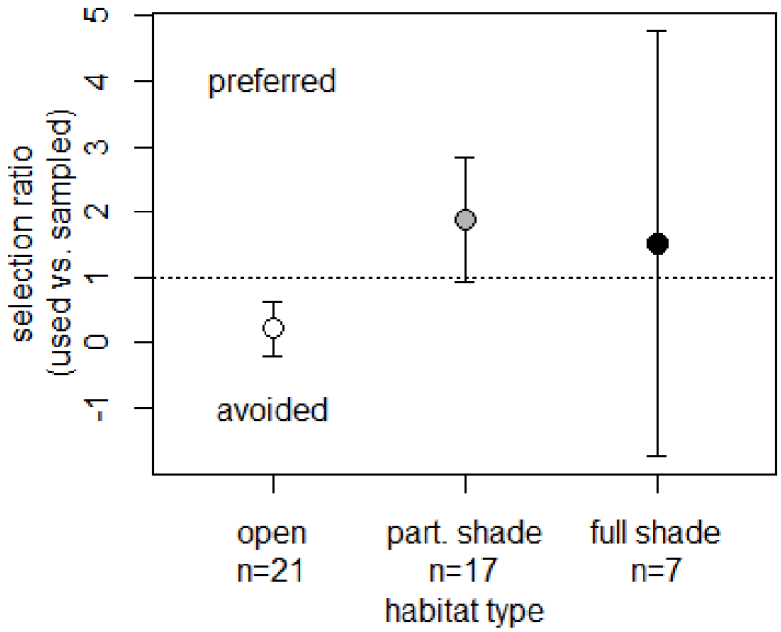

Figure 3. Preliminary estimates of habitat selection ratios for monarch butterfly reproduction, calculated from the locations of immature monarchs (eggs and larvae) relative to the number of plots surveyed in each habitat type. Points show selection ratios ± 95% CI based on pilot surveys conducted near NWSTF Boardman in 2017. Overall test for habitat selectivity, based on these pilot data: c2 = 5.5, p = 0.063.

General Recommendations for Managing Monarch Habitat on DoD Lands

The following general recommendations are intended to supplement the Best Management Practices for western monarch breeding and migratory habitat outlined in this document. For monarch overwintering habitat management consult Xerces Society's publication *Protecting California's Butterfly Groves: management guidelines for monarch butterfly overwintering habitat*.

Collaborative Resource Planning Partnerships with County, State, Federal and Non-governmental Agencies and Groups

State Wildlife Action Plans

Integrated Natural Resource Management Plans identify key state, federal and non-governmental organizations to collaborate with in regards to natural resource management to protect or improve habitat for wildlife species. This includes the State Wildlife Action Plans. All five study locations for this research project occur within states that have included the monarch butterfly in the State Wildlife Action Plan except for Nevada (Fallon Naval Air Station). In addition to the State Wildlife Action Plans, The Western Association of Fish and Wildlife Agencies (WAFWA) developed a Western Monarch Conservation Plan that was released in January 2019 with specific recommendations from the year 2019 to 2069. DoD land managers can collaborate with state and federal agencies to help implement the Western Monarch

Conservation Plan by incorporating the plan into INRMPs.

Right of Ways

Surveys for this project have identified roadsides and managed waterways (irrigation canals/ditches) as important habitat for milkweed and monarch breeding at study sites. DoD INRMPs could work with local water management agencies and roadside managers at the local level to identify milkweed along roadsides and managed waterways to protect it from mowing, ditching, grading or herbicide treatments, or other management during the active monarch breeding season. Refer to the **Roadside and other Rights-of-Way** section of this BMP document on page 31 for detailed guidance.

Western Monarch Call to Action for DoD Study Sites

The Western Monarch Call to Action, led by the Xerces Society for Invertebrate Conservation, aims to provide a set of rapid-response conservation actions that, if applied immediately, can help the western monarch population bounce back from its extremely low 2018-19 overwintering size. The plan recognizes and supports longer-term recovery efforts for western monarchs such as the WAFWA Western Monarch Conservation Plan mentioned above. The call to action outlines the following five key steps to help recover the western monarch population, and listed below each step includes those DoD project sites that can contribute to each. We note that other DoD installations in the West also contribute to monarch breeding, migratory and overwintering habitat. The recommendations for specific installations below are limited to installations surveyed in the 2017 and 2018 monarch breeding seasons.

1. Protect and manage California overwintering sites
    a. Vandenberg AFB
2. Restore breeding and migratory habitat in California
    a. Vandenberg AFB
3. Protect monarchs and their habitat from pesticides
    a. Vandenberg AFB, NWSTF Boardman, JBLM Yakima Training Center, Mountain Home AFB, Naval Air Station Fallon
4. Protect, manage, and restore summer breeding and fall migration monarch habitat outside of California
    a. NWSTF Boardman, JBLM Yakima Training Center, Mountain Home AFB, Naval Air Station Fallon
5. Answer key research questions about how to best aid western monarch recovery
    a. Vandenberg AFB, NWSTF Boardman, JBLM Yakima Training Center, Mountain Home AFB, Naval Air Station Fallon

The full Western Monarch Call to Action can be accessed at: https://xerces.org/wp-content/uploads/2019/01/19-001_Western-monarch-call-to-action_XercesSociety.pdf

Recommendations for DoD Study Sites

There are three key ways that INRMPs can be updated to improve management for the monarch butterfly. The primary way that INRMPs can be updated to benefit monarch butterflies,

is to identify and protect existing milkweed populations from disturbance (mowing, fire, road maintenance, pesticide application, etc.) during the active monarch breeding season. The following sections include management timing derived from surveys of monarch breeding on DoD lands, the most common and abundant milkweed species, and maps of known milkweed records for each of the five DoD lands included in this research project. This information can be used to survey for existing milkweed populations so that protective measures can be put in place. The second way that INRMPs can improve habitat for monarch butterflies, is to increase the availability of nectar during the spring and fall migration of the butterfly. Regional monarch nectar plant lists are included below. A third way that INRMPs may be able to enhance habitat for breeding monarchs in semi-arid areas is to focus on milkweed in areas near water and/or nearby access to shade or roosting structures. Our preliminary analyses from our DoD Legacy supported research suggests these may be important components of habitat structure, and important for boosting monarch numbers. Future studies to quantify the importance of these structures for boosting monarch numbers would be valuable.

These key recommendations are based on survey data from this project that show that overall milkweed availability does not appear to be a limiting factor for the monarch population in the West like it is in the East. However, nectar availability for adult migrating monarchs may be limiting, especially during the key migration periods – spring and fall. At this point, we do not know the value of adding milkweed in areas that are near water or close to roosting/shade structure and this information would help guide future management recommendations. Therefore, we recommend that restoration projects incorporate native monarch nectar plants into restoration projects first, and then if funding allows, add milkweed species that are native to and historically occurred in a region. Monarch nectar plants and native milkweed species for each of the five DoD study sites are detailed below.

Oregon - NWSTF Boardman

Recommended Management Timing

Recommended Management Dates	Active Monarch Breeding Dates
September 30-June 1	June 1-September 30

Monarch and Milkweed Records in the Region

The following map contains documented milkweed and monarch records. A complete survey of this area has not been completed, and additional milkweed and monarch breeding areas may be present. A full survey of the area is recommended to locate all milkweed and potential monarch breeding habitat.

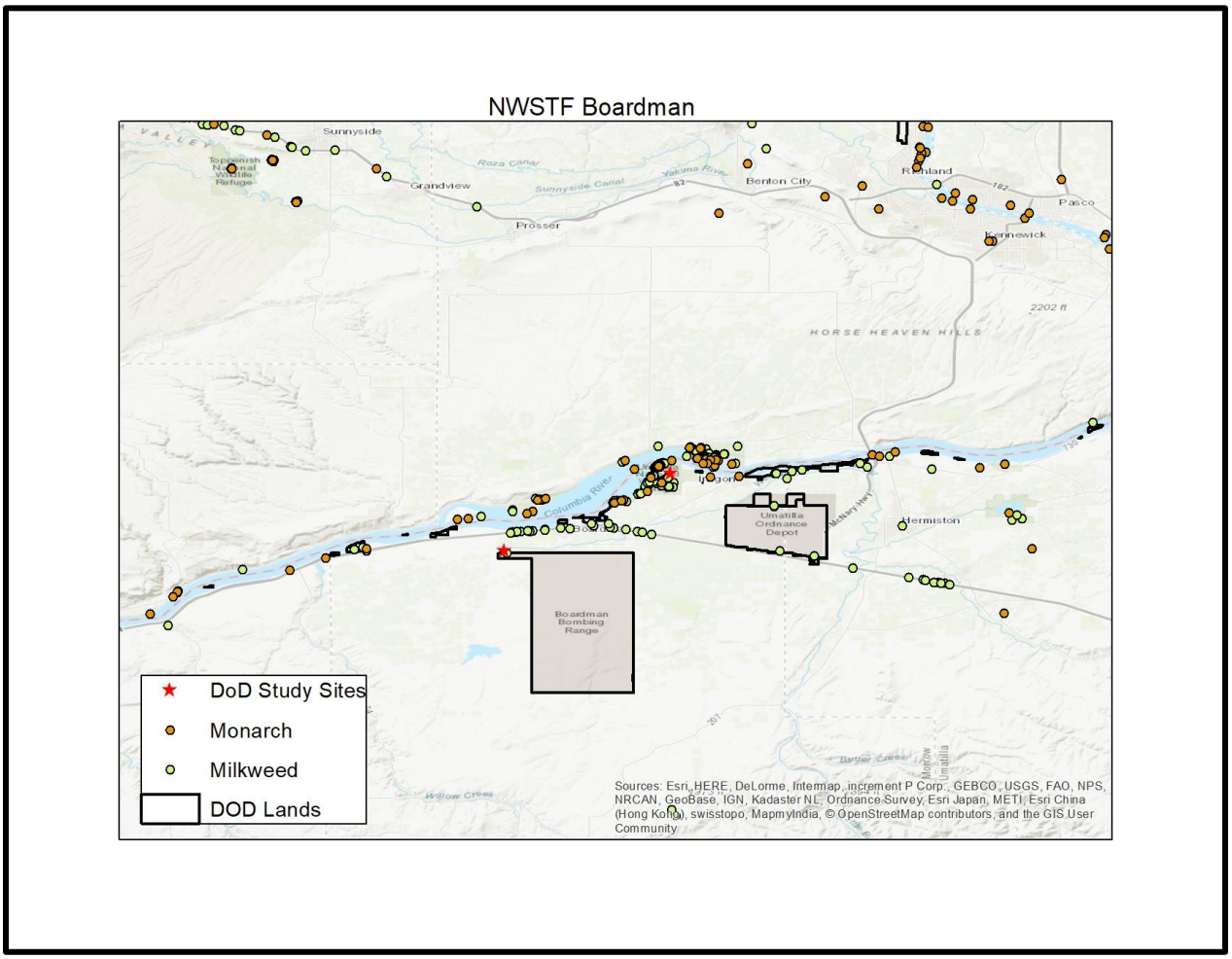

Figure 4. Monarch and milkweed records at NWSTF Boardman

Milkweed Species

Species	Common Name	J	F	M	A	M	J	J	A	S	O	N	D	Habitat Type
Asclepias speciosa	showy milkweed					x	x	x	x	x				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.

Priority Recommendations for the Region

Preliminary data analysis from NWSTF Boardman suggests that monarch butterflies may prefer to breed on milkweed plants in the shade of trees. At this site, the trees are primarily the invasive Russian Olive tree (*Elaeagnus angustifolia*). Until we better understand the importance of shade for monarch butterfly breeding in this location, it is recommended that Russian olive tree removal be conducted in phases where milkweed occurs. By doing a phased removal it could help maintain some shaded monarch breeding habitat in some areas while still removing the invasive tree. In addition, tree removal projects could include planting native trees to replace the invasive Russian olive to replace shade in monarch habitat.

Monarch Nectar Plant List

Manage for and include monarch nectar plants in vegetation management and restoration plans. The monarch nectar plant guide for NWSTF Boardman: https://xerces.org/wp-content/uploads/2016/10/Inland_NW_Monarch_Plant_List_spread.pdf

Washington - JBLM Yakima Training Center

Recommended Management Timing

Recommended Management Dates	Active Monarch Breeding Dates
September 30-June 1	June 1-September 30

Monarch and Milkweed Records in the Region

The following map contains documented milkweed and monarch records. A complete survey of this area has not been completed, and additional milkweed and monarch breeding areas may be present. A full survey of the area is recommended to locate all milkweed and potential monarch breeding habitat.

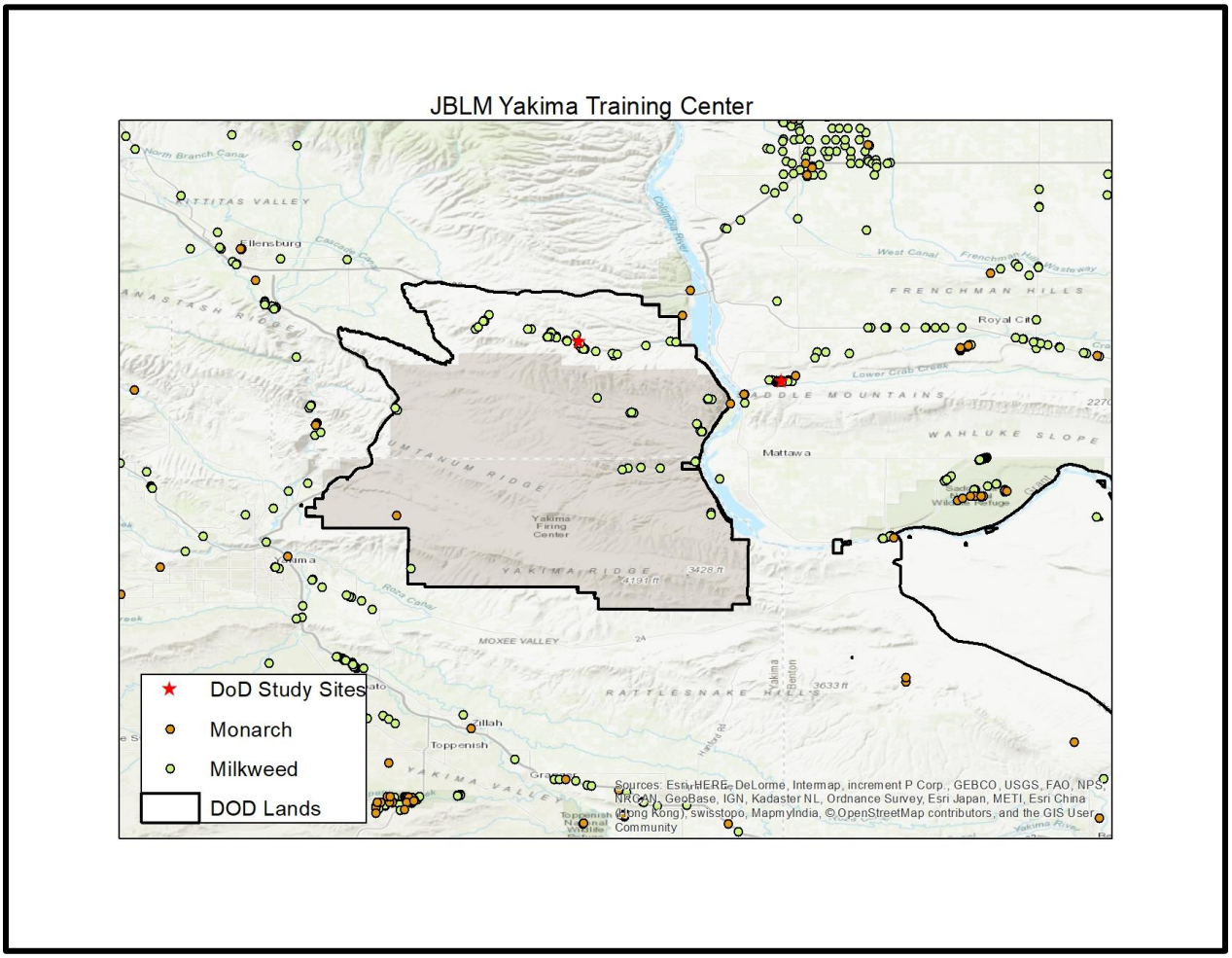

Figure 5. Monarch and milkweed records in and around JBLM Yakima Training Center

Milkweed Species

Species	Common Name	J	F	M	A	M	J	J	A	S	O	N	D	Habitat Type
Asclepias speciosa	showy milkweed					x	x	x	x	x				Dry to moist soil in open, sunny areas and occurs in many plant communities including wetlands, meadows, savannah, and forest clearings, as well

Species	Common Name	J	F	M	A	M	J	J	A	S	O	N	D	Habitat Type
														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.

Priority Recommendations for the Region

See priority recommendations for NWSTF Boardman above.

Monarch Nectar Plant List

Manage for and include monarch nectar plants in vegetation management and restoration plans. The monarch nectar plant guide for JBLM Yakima Training Center: https://xerces.org/wp-content/uploads/2016/10/Inland_NW_Monarch_Plant_List_spread.pdf

Nevada - Naval Air Station Fallon

Recommended Management Timing

Recommended Management Dates	Active Monarch Breeding Dates
October 31-May 1	May 1-October 31

Monarch and Milkweed Records in the Region

The following map contains documented milkweed and monarch records. A complete survey of this area has not been completed, and additional milkweed and monarch breeding areas may be present. A full survey of the area is recommended to locate all milkweed and potential monarch breeding habitat.

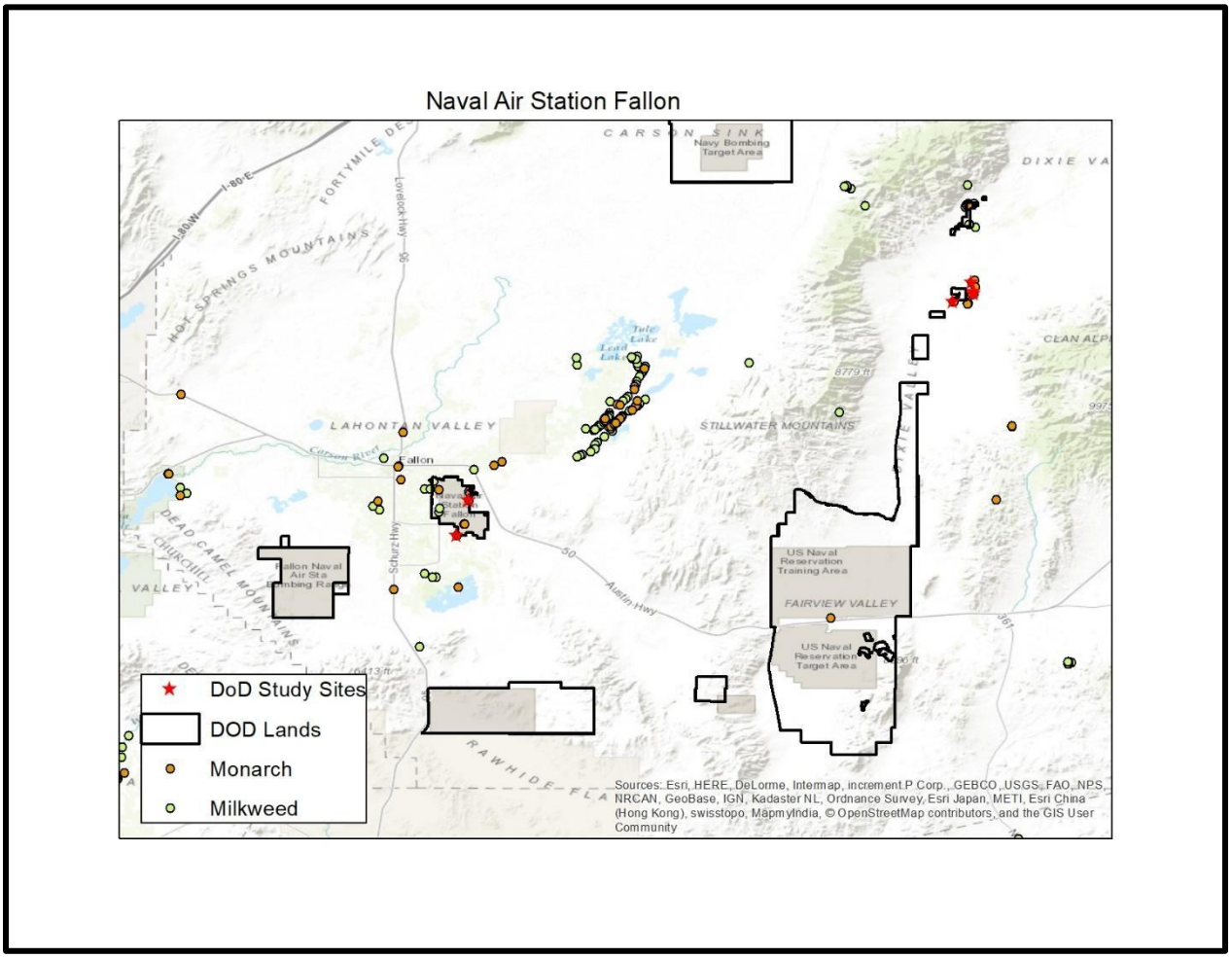

Figure 6. Monarch and milkweed records in and around Naval Air Station Fallon

Milkweed Species

Species	Common Name	J	F	M	A	M	J	J	A	S	O	N	D	Habitat Type
Asclepias cryptoceras	pallid milkweed				x	x	x							Dry, open, barren places such as washes, slopes, and hillsides, in pinyon-juniper woodland, sagebrush communities, salt desert

Species	Common Name	J	F	M	A	M	J	J	A	S	O	N	D	Habitat Type
														shrublands, and aspen zones. May grow in clay, sand, gypsum, or serpentine soils.
Asclepias fascicularis	narrowleaf milkweed					x	x	x	x	x	x			Grasslands, wetland-riparian areas, woodlands, and chaparral. In the Great Basin it grows in pinyon-juniper, sagebrush, and mountain brush communities, and moist to dry places including stream banks, roadsides, the banks of irrigation ditches, and fallowed fields.
Asclepias speciosa	showy milkweed					x	x	x	x	x				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.

Priority Recommendations for the Region

Two species of milkweed are abundant at Naval Air Station Fallon, narrowleaf milkweed (*Asclepias fascicularis*) and showy mlkweed (*A. speciosa*). Both species occur in a wide variety of habitat types. At Fallon NAS, there is one primary management action that could be adjusted to improve habitat for monarchs. One is to incorporate grazing best management practices (page 26 of this document) into the INRMPs. At study sites for this project livestock grazing has resulted in trampled and grazed milkweed plants in the Dixie Valley. Monarch breeding and milkweed occurs at the highest density in the spring fed wetlands of the Dixie Valley. To prevent mortality to monarchs during the breeding season, it is recommended that timing of grazing in these wetlands be adjusted occur outside of the active monarch breeding season.

Monarch Nectar Plant List

Manage for and include monarch nectar plants in vegetation management and restoration plans. The monarch nectar plant guide for Naval Air Station Fallon: https://xerces.org/wp-content/uploads/2016/10/Great_Basin_Monarch_Plant_List_spread.pdf

Idaho - Mountain Home AFB

Recommended Management Timing

Recommended Management Dates	Active Monarch Breeding Dates
September 30-June 1	June 1-September 30

Monarch and Milkweed Records in the Region

The following map contains documented milkweed and monarch records. A complete survey of this area has not been completed, and additional milkweed and monarch breeding areas may be present. A full survey of the area is recommended to locate all milkweed and potential monarch breeding habitat.

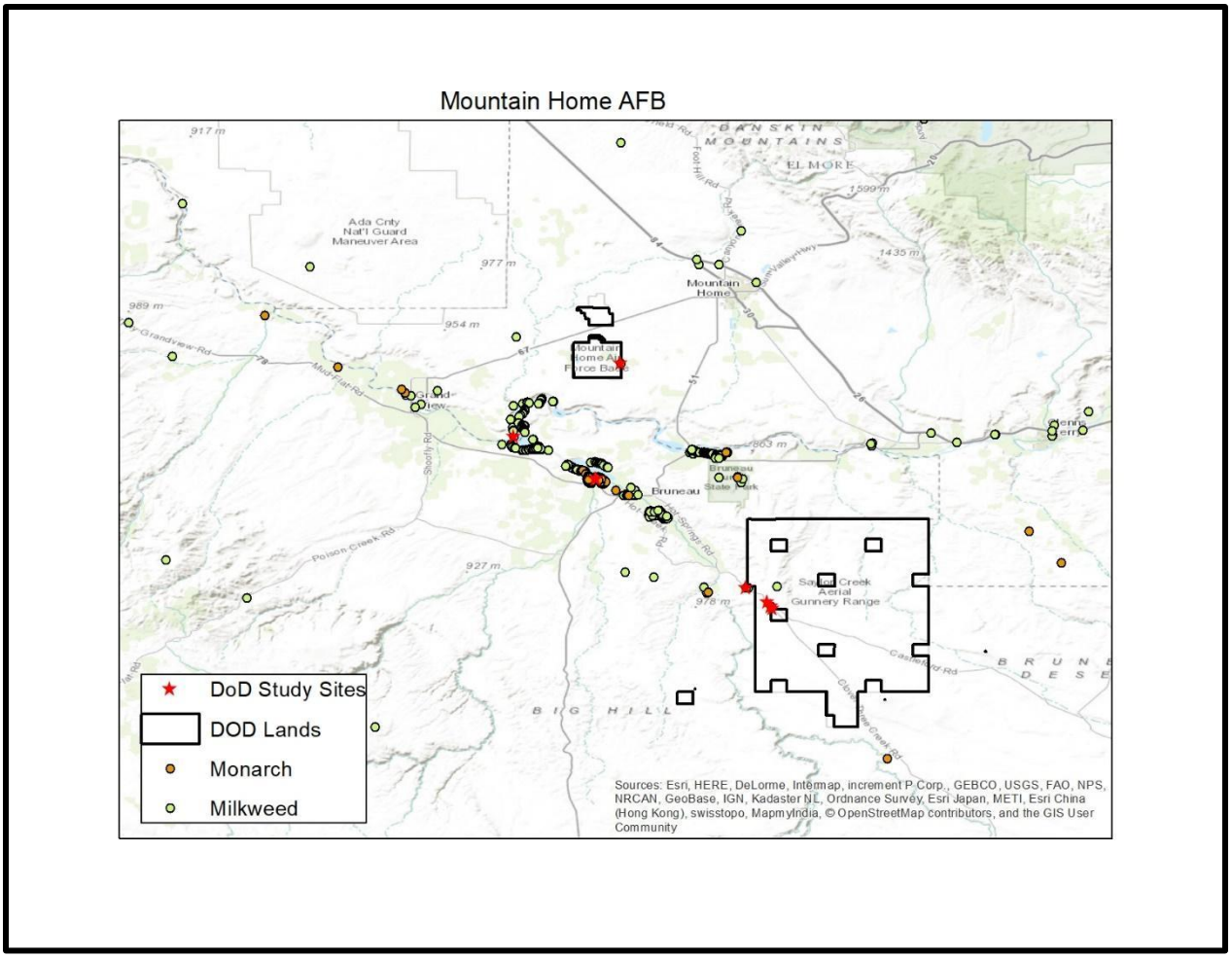

Figure 7. Monarch and milkweed records in and around Mountain Home AFB

Milkweed Species

Species	Common Name	J	F	M	A	M	J	J	A	S	O	N	D	Habitat Type
Asclepias cryptoceras	pallid milkweed				x	x	x							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.
Asclepias incarnata	swamp milkweed						x	x	x					Wet, flat, grassy meadows as well as streams and ditch-banks, marshes, and moist or wet ground. Occasionally found growing in water.
Asclepias	showy					x	x	x	x	x				Dry to moist soil in open, sunny areas and

Species	Common Name	J	F	M	A	M	J	J	A	S	O	N	D	Habitat Type
speciosa	milkweed													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.

Priority Recommendations for the Region

The most abundant milkweed species at Mountain Home AFB is showy milkweed (*A. speciosa*). This species grows in a variety of habitat types and is abundant along roadsides on and around the base. At this site, the primary management action that could be adjusted to reduce disturbance to monarch breeding habitat, is to adjust the timing of roadside management to occur outside the monarch breeding season outlined above. Some of the roads are not managed by Mountain Home AFB, rather they are managed by the county or state. Milkweed is not a limiting factor for the monarch population in this region, however nectar plants do appear to be limiting. Incorporating monarch nectar plants into restoration or seeding projects could improve habitat for monarchs. To do this DoD managers could expand the existing collaboration between Mountain Home AFB and the BLM Seeds of Success program to increase commercial availability of monarch nectar plant species plant materials for the region.

Monarch Nectar Plant List

Manage for and include monarch nectar plants in vegetation management and restoration plans. The monarch nectar plant guide for Mountain Home AFB: https://xerces.org/wp-content/uploads/2016/10/Great_Basin_Monarch_Plant_List_spread.pdf

California - Vandenberg Air Force Base

Recommended Management Timing

Monarch breeding has been observed at Vandenberg AFB on narrowleaf milkweed (*Asclepias fascicularis*) from May through October, however records from adjoining land show that breeding can occur in coastal California from the middle of March to late November depending on climate and milkweed phenology in a given year. Surveying for milkweed and immature stages of monarchs where milkweed is known to occur is recommended before implementing management since the timing of breeding can change from year to year.

Recommended Management Dates	Active Monarch Breeding Dates
November 1-March 15	March 15-November 1

Monarch and Milkweed Records in the Region

The following map contains documented milkweed and monarch records. A complete survey of this area has not been completed, and additional milkweed and monarch breeding areas may be present. A full survey of the area is recommended to locate all milkweed and potential monarch breeding habitat.

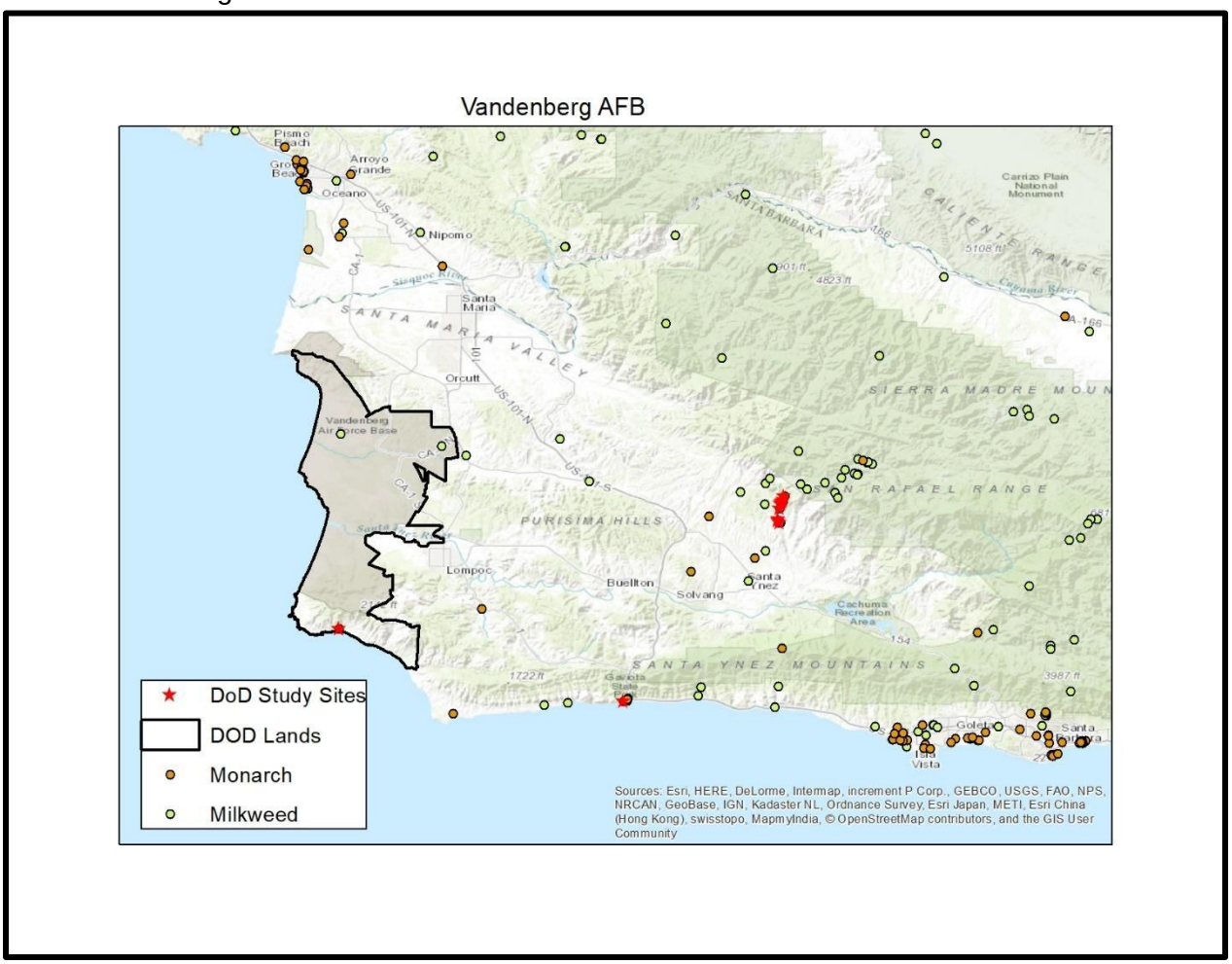

Figure 8. Monarch breeding season records and milkweed records in and around Vandenberg AFB.

Milkweed Species

The only species of milkweed confirmed on Vandenberg AFB is narrowleaf milkweed *(A. fascicularis*). However, it is possible that California, woollypod, and wooly milkweed could occur on slopes on the East side of the base.

Species	Common Name	J	F	M	A	M	J	J	A	S	O	N	D	Habitat Type
Asclepias	California				x	x	x	x						Flats and grassy or brushy slopes in many

Species	Common Name	J	F	M	A	M	J	J	A	S	O	N	D	Habitat Type
californica	milkweed													plant communities, including grassland, woodland, and chaparral.
Asclepias eriocarpa	woollypod milkweed					x	x	x	x	x	x			Dry, rocky areas in many plant communities, including valley grassland, chaparral, and foothill woodland. It also grows along stream banks and roadsides.
Asclepias fascicularis	narrowleaf milkweed					x	x	x	x	x	x			Grasslands, wetland-riparian areas, woodlands, chaparral.
Asclepias vestita	wooly milkweed				x	x	x	x						Grassland, chaparral, and foothill woodland on dry plains and hillsides and in canyons in the South Coast Ranges.

Priority Recommendations for the Region

The only milkweed population at Vandenberg AFB occurs in coastal scrub habitat that is regularly grazed by livestock. Consider incorporating best management practices for grazing (see grazing best management practices on page 26 of this document) into the Vandenberg AFB INRMPs. Historically and presently milkweed was and is very uncommon in the coastal area around Vandenberg AFB. However, where milkweed does occur, monarchs will find and breed on milkweed plants primarily from March through November, but in rare cases milkweed can grow during all months of the year and therefore it is possible (but rare) that monarch breeding can occur in the area year-round if milkweed is actively growing.

Monarch Nectar Plant List

Manage for and include monarch nectar plants in vegetation management and restoration plans. The monarch nectar plant guide for Vandenberg AFB:
https://xerces.org/wp-content/uploads/2016/10/CA_Coast_Monarch_Plant_List_spread.pdf