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Monarch waystations

PROPAGATING NATIVE PLANTS TO CREATE TRAVEL CORRIDORS FOR MIGRATING MONARCH BUTTERFLIES

Thomas D Landis

ABSTRACT

Monarch waystations have tremendous potential for native plant nurseries, agencies managing public lands, and even the general public. Popularized by Monarch Watch, these specialized pollinator gardens provide habitat (food, shelter, and water) for monarch butterflies (*Danaus plexippus* L. [Lepidoptera: Nymphalidae]) on their long migrations. Using source-identified and locally adapted seeds and nursery stock of milkweed (*Asclepias* L. spp. [Asclepiadaceae]) and flowering nectar plants, conservation groups and backyard gardeners can create critical habitat for this beleaguered butterfly. The unprecedented popular support for the plight of the monarch has made it a charismatic microfauna and has focused much-needed attention on the proven success of using native plants for restoration purposes.

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KEY WORDS

Danaus plexippus, Nymphalidae, nectar, habitat, nursery, seeds, propagation, milkweed, *Asclepias* L., Asclepiadaceae, restoration

NOMENCLATURE

Plants: (USDA NRCS 2014)

Monarch: (ITIS 2014)

With its large size and striking orange-and-black coloration, the monarch butterfly (*Danaus plexippus* L. [Lepidoptera: Nymphalidae]) may be the most well-known butterfly in the world (Commission for Environmental Cooperation 2008). The monarch is a tropical butterfly that has been able to colonize much of temperate North America through extensive migrations. Monarch butterflies in the US and Canada can be divided into 2 general populations (Figure 1). The eastern population is by far the largest and it overwinters in the mountains of Mexico, whereas the much smaller western population overwinters along the southern California coast (Commission for Environmental Cooperation 2008). The monarch's long-distance migrations

of 1610 to 3220 km (1000–2000 mi) to their overwintering sites in Mexico and California are among the unique and most spectacular biological phenomena in the world (Luna and Dumroese 2013).

Like me, many school children learned one of their first biology lessons from capturing monarch caterpillars and watching their magical transformation into beautiful butterflies. In southern Kansas where I grew up, monarchs were so common I remember wishing that I could find some other butterflies to collect for my Boy Scout merit badge. Unfortunately, things have changed. Surveys taken at overwintering sites confirm my observations that monarch populations have experienced a major collapse.

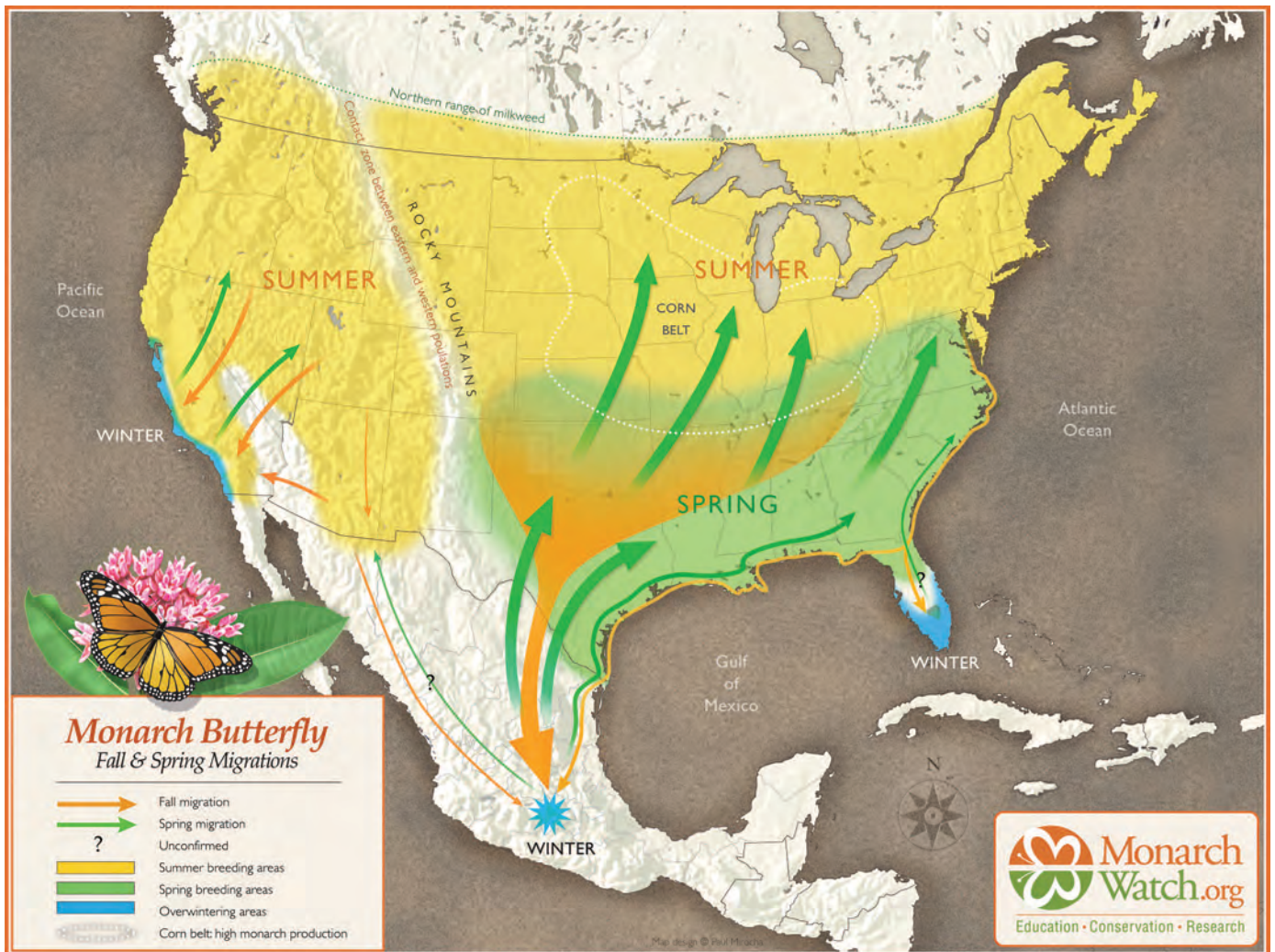


Figure 1. Monarchs are one of the most common butterflies in North America and can be divided into an eastern population, which overwinters in the mountains of Mexico, and a western population, which overwinters on the southern California coast. Reprinted with the generous permission of Monarch Watch

THE PROBLEM: THE MONARCH POPULATION CRASH

Most people have heard of the severe decline of monarch butterfly populations in North America, but most do not appreciate how quickly it happened. Both eastern and western population levels have plummeted during the past 2 decades (Figure 2). At overwintering sites in Mexico, monarch populations declined 59% in the past year and were at the lowest level ever measured (Conniff 2013). Similarly, annual counts of overwintering butterflies on the California coast have suffered a nearly 90% decline during the past decade (Jepsen and others 2010).

Because the monarch migrates across North America, a recent trilateral commission between the US, Canada, and Mexico conducted an intensive investigation and identified 5 causes for this decline (Commission for Environmental Cooperation 2008).

1. **Breeding Habitat Loss and Degradation.** A 2000 study found that up to 70% of Midwestern monarchs fed on milkweed (*Asclepias* L. spp. [Asclepiadaceae]) in agro-ecosystems (Oberhauser and others 2006). Urbanization also reduces milkweed habitat, and mowing and herbicide spraying of roadsides and vacant lots reduce or eliminate native plants (Boyer 2011), especially milkweed stands and the monarch eggs and caterpillars on them.
2. **Wintering Habitat Loss and Degradation.** Illegal harvesting of oyamel fir (*Abies religiosa* (Kunth) Schldl. & Cham. [Pinaceae]) in Mexico was originally considered very serious, but efforts by the Mexican government have reduced this threat. Water diversion and adverse effects from tourists are becoming more of a negative factor. On the California coast, urban development and the aging of trees in monarch groves are most worrisome.
3. **Disease and Parasites.** Although the alkaloids from milkweed help protect the caterpillars and adult butterflies from bird predation, monarchs are subject to a number of diseases, predators, and parasitoids. A protozoan parasite (*Ophryocystis elektroscirrha*) has been shown to reduce the growth and survival of caterpillars and adults; as many as 30% of western monarchs are heavily infected (Altizer and Oberhauser 1999).
4. **Climate Change.** One of the most serious effects of climate change is the increased frequency of extreme weather events, which can seriously threaten overwintering monarchs. The combination of unusually high rainfall and cold weather killed up to 80% of the 2 largest overwintering populations in Mexico during the winter of 2002 (Brower and others 2002, 2004).
5. **Pesticide Use.** In addition to the herbicide use already mentioned, insecticides may be significant sources of mortality

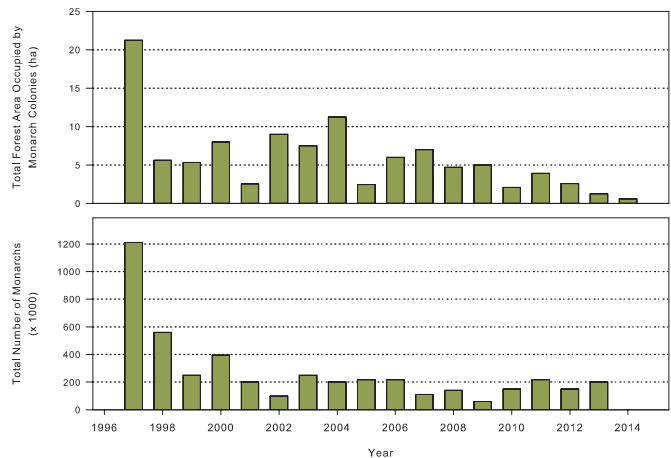


Figure 2. Both populations of North American monarch butterflies have declined drastically in the last 2 decades. Modified from Rendon (2013) and Monroe and others (2014)

in agricultural and urban areas. Indiscriminate and improper use of pesticides, such as spray programs to control mosquitoes, threaten all pollinators (Oberhauser and others 2006). Even “biologically friendly” insecticides containing *Bacillus thuringiensis* can kill monarch caterpillars.

MONARCH WAYSTATIONS: PROVIDING HABITAT FOR BREEDING AND DURING MIGRATION

Habitat conservation and restoration are absolutely necessary for the survival of monarch butterflies (Commission for Environmental Cooperation 2008). Like all animals, monarch butterflies need a specific habitat (food, shelter, and water) for overwintering and breeding. Although we cannot directly control overwintering habitat in Mexico, we can create favorable habitat for monarchs as they migrate across North America. With proper habitat, monarch populations can improve (see sidebar on p 9). Both the eastern and western monarch populations breed in the US so we can restore and create good habitat (Figure 3). The monarch waystation concept originated with the University of Kansas Monarch Watch program, which provides online registration of waystations (Monarch Watch 2013). At the end of 2013, Monarch Watch had registered 7322 waystations across North America (Figure 3).

Monarch waystations can be divided into 2 types.

1. **Backyard Pollinator Gardens.** Monarch waystations are specialized pollinator gardens that contain a wide variety of native and ornamental species for host and nectar plants. Milkweeds and nectar plants can be kept healthy and vigorous

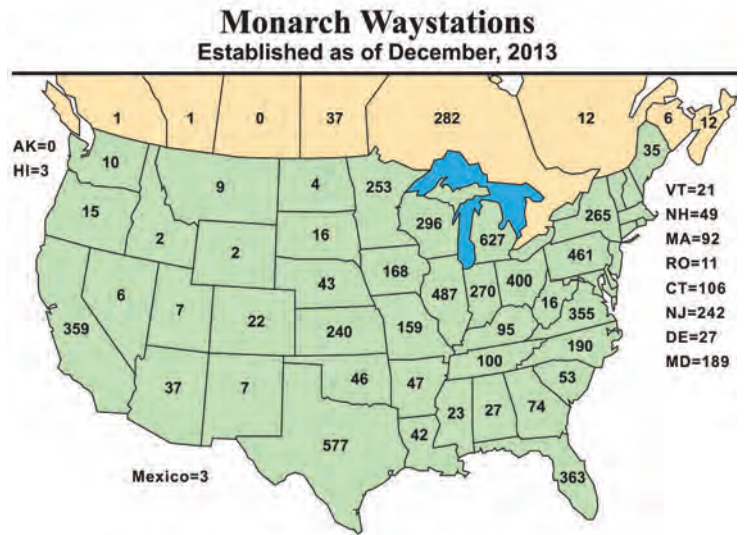


Figure 3. Monarch waystations create habitat (food, water, and shelter) for caterpillars and adult butterflies on their extensive migrations (left). Waystations have been established in every state in the US with the exception of Alaska (right). Right image modified from Monarch Watch (2013)

because the plant composition can be closely controlled and plants can receive regular irrigation and fertilization. Stevens and Frey (2010) found a strong correlation between moisture availability and monarch abundance in California and surrounding states. With a severe drought affecting most of the western states, backyard pollinator gardens could provide habitats with much-needed water and healthy plants for caterpillars and abundant nectar for adult monarchs.

2. **Waystations in Natural Areas.** Parks, bike trails, schools, and other public lands are excellent sites for monarch waystations because they not only provide habitat but also create invaluable opportunities for environmental education. Natural waystations should contain only native plant species because ornamental plants could possibly become invasive.

Host Plants

Monarch caterpillars are obligate feeders on milkweed plants. Botanical information on 75 milkweed species that are native to North America can be found on the PLANTS database website (USDA NRCS 2014). All milkweeds are potential food plants for caterpillars although some species are less desirable (Oberhauser and Solensky 2006). For the eastern population of monarchs, the most important northern host plant is common milkweed (*Asclepias syriaca* L.) whereas in the southern US, zizotes milkweed (*A. oenotheroides* Cham. & Schldl.), antelopehorn milkweed (*A. viridis* Walter), and spider milkweed (*A. asperula* (Decne.) Woodson) are important. For the

western monarch populations, 15 different milkweed species can be found in California alone and most are host plants for monarch caterpillars (Borders 2012). Early growing milkweed species in the coastal range and interior valleys of California are particularly desirable, because they provide vital breeding habitat for monarchs as they come off their overwintering sites in early spring. Across the rest of the western range, monarch caterpillars utilize 2 widely distributed species as host plants: showy milkweed (*A. speciosa* Torr.) and narrowleaf milkweed (*A. fascicularis* Decne.).

Nectar Plants

Adult butterflies obtain energy from the nectar of a wide variety of flowering plants. Nectar is high in sugars but also contains other necessary food components such as amino acids. “Nectaring” is particularly important during the late summer and fall when the super generation of monarchs begins their long migration south to their overwintering sites. Butterflies convert the sugar to body fat that has to sustain them not only during migration but also at the overwintering sites when most flowering plants are dormant (Alonso-Mejia and others 1997). Lists of garden nectar plants can be found online (Monarch Watch 2013), and books (Mader and others 2011) and websites (Holm 2013) provide lists of nectar species for specific regions. To find out which native plants are good nectar sources, contact your local Native Plant Society and botanists for the USDA Forest Service, the USDI Bureau of Land Management, and the USDI National Park Service.

MILKWEED RESTORATION AND MONARCHS: ONE SUCCESS STORY

Susan J Tweit

I'M A PLANT BIOLOGIST, not a monarch butterfly specialist. Still, what I've observed while restoring the degraded urban creek that runs by my house in the mountains of south-central Colorado may offer a hopeful example of the power of native milkweeds to bring back monarch butterflies and the other species in their community.

My experience suggests it's possible to save this "charismatic" insect and its improbable multi-generation migration by reestablishing colonies of milkweed, the only food the caterpillars eat. Almost sixteen years ago, when my late husband Richard and I bought our "decaying industrial empire," a weedy and junk-filled property bounded along

2007: the first colony of showy milkweed had grown to six plants, and another small colony had self-sprouted. My highest daily count that summer was five adult monarchs. Four years later, Richard spotted two fat monarch caterpillars munching adjacent plants in a new clump of milkweed. We had seen ten adult monarchs on our best daily count that summer, but these were the first-ever mature caterpillars produced by "our" milkweed. Last summer, while monarch-watchers in other parts of the country were reporting dismal counts, I tallied an astonishing twenty-one monarch adults on the best day of censusing the milkweed plants along my portion of creek.

Eleven years and three historic droughts after the first showy milkweed plants returned, this restored urban creek boasts more monarchs than I have seen anywhere in the area. And more milkweed plants, all of which established on their own, given time and space. That's the power of restoring habitat, even in a place that's at the dodgy margins of monarch butterflies' range. Imagine what we could do in the places where monarchs once truly flourished!



Before

one edge by a degraded urban creek locals still call "The Ditch," there were no milkweeds in evidence. And no monarchs either—or any butterflies at all in the expanse of weeds. As we gradually removed the carpet of invasive weeds, reestablished the high-desert prairie, and began planting native high-desert shrubs to shade and nurture the creek, birds, butterflies and other insects began returning. But no monarchs. Until the shrub canopy along the creek filled in enough to trap the silken parachutes of showy milkweed seeds that blew in and self-seeded from the closest colony about three-quarters of a mile up creek (and upwind).

The summer of 2001, four milkweed plants bloomed. We saw our first adult monarch butterfly next year, 2002, during a historic drought that dried the creek up for weeks. Still, those four milkweed plants bloomed. Fast-forward five years (through two additional, less-severe droughts) to



After

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Shelter

Monarchs fly only by day so woody plants are critical to migrating monarchs as a place to rest overnight or during inclement weather. Because they are tropical by nature, monarch butterflies do not tolerate cold temperatures. Caterpillars become active only when the temperature is at least 5 °C (41 °F), and adults require temperatures above 13 °C (55 °F) before they fly (Journey North 2014). Very hot weather also stresses monarch caterpillars and adult butterflies, and studies have shown that temperatures above 35 °C (95 °F) can be lethal (York and Oberhauser 2002). So, monarch waystations benefit from a shelterbelt of woody vegetation. East or southeast aspects are best in warmer climates to avoid the scorching after-

aphids and the foliage is then rinsed with fresh water (The Monarch Program 2014).

OBTAINING MILKWEED PLANTS FOR MONARCH WAYSTATIONS

Purchasing

With the increased interest in monarchs, more native plant nurseries are growing milkweed for sale. Monarch Watch has a state-by-state list of milkweed plant and seed suppliers on their website (Monarch Watch 2013) and, working with the plant distribution maps on the PLANTS website (USDA NRCS 2014), buyers can determine which species would be appropri-

“You don’t have to have acres of milkweed,” Taylor said. In fact, he said “it’s better to have small, scattered sites than large plots, because big stands of milkweed attract predators and parasites.”

– Chip Taylor of Monarch Watch as quoted in Breckenridge (2014)

noon sun, but in more northerly locations, southern exposures help maintain life-supporting temperatures.

Water

All butterflies obtain water and mineral nutrients by “puddling” (National Wildlife Federation 2014). Monarch waystations should contain a shallow basin such as the top section of a birdbath containing coarse sand and small pebbles. If you have a drip irrigation system to water your plants, insert a slow-rate drip nozzle in the basin to maintain an adequate water level.

Pesticides

All monarch waystations should be managed organically, because any insecticide is a potential hazard to monarch eggs, caterpillars, and adults. Even “organic” pesticides can kill monarch caterpillars. The most visible pests of milkweed plants are oleander aphids, which are easy to see because they are yellow-orange in color. The aphids themselves are not damaging to monarch caterpillars although heavy infestations do weaken the milkweed plants. Prevention is the best control by washing or brushing them off before they become too plentiful. Insecticidal soaps can be used if they are sprayed directly on the

ate for their location. Most milkweed plants are sold as container stock, although it would be possible to produce bareroot stock as well.

Propagation

Milkweed can be propagated by either seeds or vegetative means, although seedling production is much more common. All of the 10 propagation protocols for milkweed from the Propagation Protocol Database (Native Plant Network 2014) are for seed propagation in containers. Although producing milkweed in containers offers many advantages, growers should be aware that this species does not form a firm root plug. Because they are rhizomatous, milkweed plants do not produce an abundance of fine roots to hold the growing medium together (Borland 1987). Therefore, consider using a container system that maintains plug integrity. Jiffy plugs (Jiffy Products, International BV; <http://www.jiffygroup.com/>), which consist of compressed peat surrounded by a plastic mesh, or EllePots (The Blackmore Company; <http://www.blackmoreco.com/ellegaard.html>), which are paper-lined plugs in plastic trays, keep the root plug intact even with young seedlings (Figure 4). These systems also make transplanting to larger containers much easier.



Figure 4. Milkweed seedlings are most easily propagated as container plants (above). Because they are rhizomatous, milkweeds do not develop many fibrous roots so it is best to use container systems that ensure a firm root plug regardless of root development, such as EllePots (right). Photos courtesy of Greenheart Farms

Seed Propagation

Finding suppliers for source-identified, locally adapted milkweed seeds has been a serious obstacle in the past. One of the primary objectives of the Xerces Society’s Project Milkweed, however, is to develop local milkweed seed sources (Xerces Society 2013). Local native plant societies or nature centers are good sources for local milkweed seeds. Monarch Watch sells seed packets of several species of milkweed seeds, but the only choice is “Eastern” or “Western” (Figure 5). For a widely distributed species such as showy milkweed, such a broad geographical designation is practically useless (Figure 5). Use of source-identified, locally adapted milkweed seeds is even more important in mountainous areas. For example, in southwestern Oregon, showy milkweed occurs from around 305 m (1000 ft) of elevation to well over 1525 m (5000 ft). Low-elevation plants would not be adapted to the much earlier frosts at the higher site.

Cleaning milkweed seeds of their feathery pappi is relatively



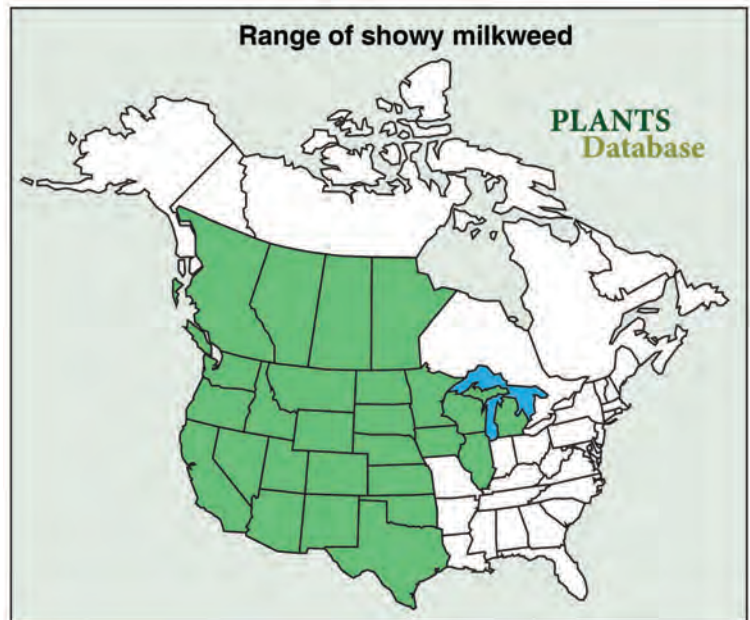


Figure 5. The source of milkweed seeds is important to ensure that plants will be adapted to the local environment. Monarch Watch sells seed packets of “Western” origin (left), but for species with wide ranges, such as showy milkweed (right), this designation offers little information about seed source. Right image modified from USDA NRCS (2014)

easy: gently rub the seeds and their pappi on a 0.6 cm (0.25 in) screen and the cleaned seeds will fall through. Be sure to clean seeds outdoors if at all possible because the pappi blows all over. Wearing rubber gloves is recommended because some people are sensitive to milkweed. Another less messy technique is to place the uncleaned seeds in a resealable plastic bag containing a small rubber ball; gently shaking the bag dislodges the pappi and allows the cleaned seeds to fall to the bottom where they can be harvested by clipping the corner off the bag.

Many sources of milkweed seeds require stratification (cold, moist treatment) before sowing. In a review of stratification requirements for common milkweed, recommendations varied from as short as 7 d to as long as 11 mo at 5 °C (41 °F) (Luna and Dumroese 2013). Butterfly milkweed (*A. tuberosa* L.) germination increased from 29 to 48 to 62% as stratification duration increased from 0 to 30 to 60 d (Bir 1986). Swamp milkweed (*A. incarnate* L.) requires at least 4 to 12 wk of stratification at 1.5 to 3.3 °C (35–38 °F) (Luna and Dumroese 2013) but 50% germination can be achieved by 2 sequential 12-h soaks in hot water (88 °C [190 °F]) (Kirk and Belt 2011).

Any of the standard seed propagation methods (Landis and others 1999) are effective with milkweed. Direct sowing of non-stratified seeds in the fall of the year can be effective but the seeds must be mulched and protected during the winter. Cover sown seeds with a thin mulch; research has found that common milkweed seeds germinated better when planted 1 to 2 cm (0.4–0.8 in) deep than when at the soil surface (Jeffery and Ro-

bison 1971). Non-stratified showy milkweed seeds that were direct sown into Ray Leach Cone-tainer Super cells (164 ml [10 in³]; Stuewe & Sons, Tangent, Oregon) filled with Sunshine #1 mix showed 85% germination within 2 wk under typical greenhouse culture. After 5 mo, plants were averaging 13 cm (5 in) tall but the root system had not formed a firm plug, especially at the top of the container (Bartow 2006). Common milkweed in a fully controlled greenhouse grew taller and developed more roots under warm temperatures (27 °C [81 °F]) and a 16-h photoperiod (Bhowmik 1978).

Sowing germinants directly out of stratification has the highest seed efficiency because only live seeds are sown into containers. Growing milkweed in shallow germination trays, and then transplanting (“pricking out”) the emergents to larger growth chambers is also effective. Fill trays with a well-drained growing medium, press the milkweed seeds gently into the substrate, and cover with a very thin layer of peat moss or perlite. The trays should remain “moist, but not wet” by misting as needed, and temperatures should be maintained between 18 to 24 °C (65–75 °F). Transplant young seedlings into larger growth containers when they have at least one set of true leaves (Kirk and Belt 2011).

Vegetative Propagation from Rhizomes

Propagating milkweeds from tuberous rhizomes is less common but has a much higher success rate than seed propagation. The type of rhizome varies with species. Some, like showy



Figure 6. The tuberous rhizomes of milkweeds vary among species. For example, showy milkweed (*A. speciosa*) has horizontal rhizomes (A) whereas rhizomes of narrowleaf milkweed (*A. fascicularis*) are vertical (B). Rhizomes with dormant buds can be used as propagules (C) and will sprout into large shoots (D) under cultivation. Photos A, B, and C by Thomas D Landis, photo D by R Kasten Dumroese

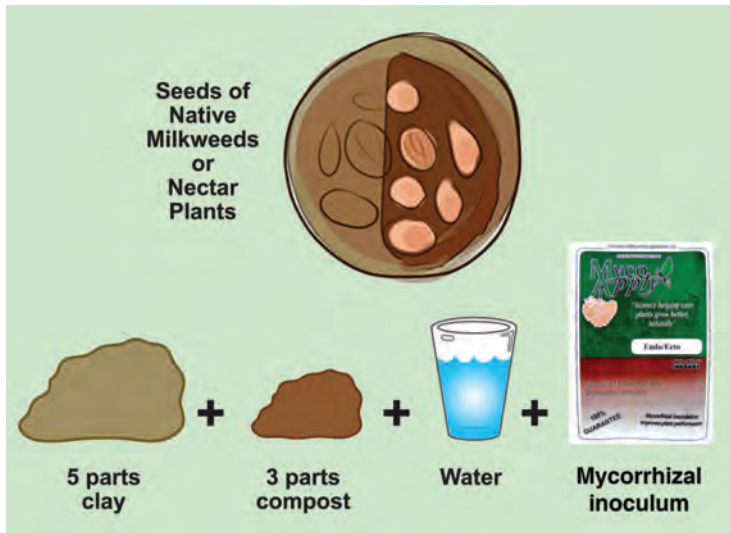
milkweed, form large clones from rhizomes that grow just beneath the ground (Figure 6A) whereas others, such as narrowleaf milkweed, form individual rhizomes that are more vertical than horizontal (Figure 6B). The best time to collect rhizomes is during the late fall to early spring when the buds are dormant and the rhizomes contain high levels of stored energy. You can locate milkweed plants during the winter by looking for the dried flowering stalks. Rhizomes can be stored by trimming off dead shoots and replanting them outdoors in raised beds or in a large container filled with a well-drained growing medium. Sprouts will form once the weather warms

(Figure 6C,D), at which point encourage shoot growth with light watering and a little fertilizer. Even rhizome sections as short as 5 cm (2 in) contain buds and can be used as propagules (Easyliving Wildflowers 2014). The size of the resultant plant is correlated to the size of the rhizome; when cultured properly, plants propagated from large rhizomes will flower and produce seeds the first year.

Direct Seeding with Seed Balls

Direct seeding is another option for establishing native plants but, when broadcasting milkweed and nectar plant seeds, controlling specific locations or plant densities is impossible. Seed balls are a better choice because it is possible to place seeds in specific locations and at the desired spacing. Seed balls made of soil are a traditional farming practice used around the world that was improved after World War II (Adler 2009).

A seed ball is a mixture of clay and compost that contains seeds of the desired plant (Figure 7). One popular recipe is 5 parts clay to 3 parts compost to 1 part seeds (Saito 2014). The number of seeds to add depends on seed size and germination percentage but, for milkweeds, the objective is 4 to 5 seeds per seed ball to ensure that at least one seed will germinate. Other seed balls can be made with mixtures of flowering forbs that will develop into the nectar plants. Adding a tablespoon (15 ml = 0.5 oz) of powdered mycorrhizal inoculant to the dry mixture



protects the germinating seeds from pathogens and then aids in moisture and nutrient uptake once the seedling is established. A highly plastic clay is needed to hold the balls together and so pottery clay works well: 2.3 kg (5 lb) of clay will make more than 300 seed balls about 2 cm (0.75 in) in diameter. Mix the dry ingredients well, and then slowly add just enough water to create a consistency of fresh cookie dough. The balls can then be rolled by hand, dried, and stored until needed. Seed balls protect fragile seeds from weather and animal predation. The seed-humus mixture also maintains seed dormancy until enough precipitation occurs to allow prompt germination and survival. By placing seed balls out in the late fall or winter, seeds are stratified naturally and dormancy is broken. Several websites provide good information on seed balls and also sell ingredients (for example, <http://seedsinaball.com/> and <http://seed-balls.com/>).

Seed balls are an excellent project for volunteers or school children who enjoy “playing in the mud” (Figure 7). Making seed balls and outplanting them into waystations is a wonderful way to connect children and nature (see Cramer 2008). An operational advantage of seed balls is that they are light and portable so that monarch waystations can be established in locations where using nursery stock would be difficult or impractical. Compared with the cost of buying or growing plants and the labor to outplant them, seed balls are a low-cost way to establish monarch waystations.

MILKWEED AND MONARCH MANIA: A MARKETING OPPORTUNITY

The plight of this charismatic butterfly is in the news almost daily, garnering worldwide publicity in many formats, including this journal (Luna and Dumroese 2013). The monarch butterfly has become a charismatic microfauna in that it is attract-



Figure 7. Seed balls are a mixture of clay, compost, water, and mycorrhizal inoculum (above left) and are an excellent low-cost way to establish milkweeds and flowering nectar plants in monarch waystations. They also are an excellent way to involve volunteers, especially children, in the process (above). Modified from WikiHow (2014) by Jim Marin Graphics, photo by Molly Kreuzman

ing unprecedented popular support. Monarch waystations illustrate the need to establish or restore pollinator habitat by supplying host plants for butterflies (Gehring and others 2013) and flowering nectar plants. These specialized pollinator gardens are an excellent example of how native plants are the building blocks to create diverse habitats for all types of wildlife. Monarch waystations are also a marketing opportunity. Progressive nursery managers, or associations of nurseries (for example, Meyer 2005), could use the current monarch craze to draw attention to the larger benefits of using all types of native plants. Monarch waystations provide a ready market for source-identified, locally adapted seeds or native plants. In addition, all nurseries have some marginally productive land that could be used to establish monarch waystations, which would educate customers and create new markets. Once they are established, the milkweed and native nectar plants could also be used as seed production areas.

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