Establishment and Management of Showy Milkweed in Idaho's Snake River Plain

Derek Tilley, Terron Pickett, and Mary Wolf

Manager, Aberdeen Plant Materials Center, U.S. Department of Agriculture (USDA), Natural Resources Conservation Service (NRCS), Aberdeen, ID; Resource Soil Scientist, USDA-NRCS, Richfield, UT; Agronomist, Aberdeen Plant Materials Center, USDA-NRCS, Aberdeen, ID

Abstract

Milkweed (*Asclepias*) species are necessary for monarch butterflies (*Danaus plexippus* L.) to complete their lifecycle. Strategies to boost monarch populations include establishing and maintaining milkweed stands throughout their range. The Aberdeen Plant Materials Center conducted a series of studies to investigate methods to establish new milkweed populations and to manage existing milkweed populations for optimum monarch habitat. In the first study, milkweed rhizomes were sorted into various size classes and planted into greenhouse conditions to determine the viability of each class. All size classes showed at least some viability, indicating that wild-collected rhizomes may be an effective means of stand establishment. In the second study, four planting treatments, including spring and fall seeding, greenhouse transplants, and rhizomes, were evaluated in a field planting to compare establishment levels. All treatments showed good establishment ranging from 27 to 79 percent. Finally, we compared plant response to 2 years of three management strategies (mowing, burning, and a nontreated control). Management strategies did not result in significant differences in milkweed stem densities.

Introduction

Milkweeds (*Asclepias* spp.) are highly valuable species in western North American riparian and wetland ecosystems, offering a pollen and nectar source that is used by numerous native insects. Milkweeds are valuable in attracting beneficial insects in agricultural systems (Fiedler et al. 2008, James et al. 2016). As such, members of the genus are desirable for conservation and promotion of native pollinators (Borders and Lee-Mäder 2014, Landis and Dumroese 2015, Waterbury and Potter 2018). Despite their value, milkweed populations are in notable decline due to increased chemical use and agricultural and urban expansion. Perhaps of greatest importance is milkweed's critical role as the larval food source for monarch butterflies (*Danaus plexippus* L.).

The monarch butterfly is a widely recognized and iconic species in North and Central America. Western monarch populations winter in Mexico and southern California and then migrate north through California and several western States through the spring and summer. Despite once being abundant on the landscape, populations have been in steady decline for decades. For example, Thanksgiving counts conducted by volunteers of the Xerces Society on the California coast have indicated dramatic reductions in recent years (Pelton 2017, Xerces Society 2020). The species has been petitioned for listing as an endangered species under the Endangered Species Act. That listing was deemed warranted yet precluded by higher priority actions (USDI Fish and Wildlife Service 2020). Reasons cited for declining monarch numbers include habitat loss in several key areas of its migration, such as forest loss in the monarch winter range in Mexico and habitat loss along the California coast due to urbanization. Changes in the landscape have also reduced key host plant species throughout the monarch summer range (Flockhart et al. 2015, Halsch et al. 2020, Pleasants and Oberhauser 2013).

Monarch butterflies are entirely dependent on milkweed species for reproduction and completing the summer stretch of their migration. Adult females lay eggs strictly on milkweed plants, which the caterpillars then feed upon (figure 1). The chemicals within the plant tissues are taken up by the caterpillars

Figure 1. Monarch butterflies lay their eggs exclusively on milkweed. The caterpillars then feed on the plant tissue, such as the two in this photo feeding on showy milkweed in southern Idaho. (Photo by Derek Tilley, 2016)

making them unpalatable to birds and other predators. Milkweed species also provide a critical nectar and energy source for the adult monarch's late-summer migration (Alonso-Mejia et al. 1997). Many efforts are currently underway to reintroduce milkweed species for monarch recovery and to support general pollinator habitat (Tilley et al. 2018).

Idaho's Snake River Plain (figure 2) has recently been recognized as an important waypoint in the lifecycle of the western monarch (Dumroese et al. 2016). Numerous monarchs pass through this corridor in summer after leaving the Pacific coast in the spring. Showy milkweed (*Asclepias speciosa* Torr.) (figure 3), the most widespread milkweed species in the region, was once common in semiarid uplands, wetlands, flood plains, and meadows below 1,830 m (6,000 ft) elevation throughout much of the Snake River Plain and Northern Basin and Range ecoregions (Welsh et al. 2003). In the Intermountain West, however, showy milkweed populations are increasingly limited to creek sides, canals, and disturbed areas that may or may not be sprayed with chemicals or mowed regularly. Creation of new milkweed habitat and conservation of patches already on the landscape, therefore, are key to monarch preservation in the Western United States.

Showy milkweed is a native, herbaceous perennial that readily grows from widespread rhizomes, producing stems averaging 45 to 150 cm (1.5 to 5 ft) tall in summer. The gray-green leaves are opposite, 10 to 18 cm (4 to 7 in) long, oval, and covered in velvety hairs. The stems and foliage exude the namesake's milky latex sap when cut. Rose-purple flowers are situated in loose clusters at the top of

Figure 2. The Snake River Plain ecoregion in southern Idaho (Omernik and Griffith 2014) is an important corridor in the western monarch butterfly summer migration. The field experiment described in this paper is located in Aberdeen, ID, indicated by the blue star. (Source: U.S. Environmental Protection Agency, 2021)

Figure 3. Showy milkweed is widespread in the Snake River Plain and can be found growing in wet meadows and on streambanks and canals throughout the region. (Photo by Derek Tilley, 2018)

the stems. Showy milkweed flowers bloom from May to September and resemble crowns, with the corolla (petals) reflexed and hoods above the corolla. The fruit is a large pod, 8 to 13 cm (3 to 5 in) long, which splits down one side in fall to release reddish-brown, flat seeds. Each seed has a tuft of white, silky hairs (coma) that allows it to be dispersed by wind.

Establishment of showy milkweed in pollinator seed mixtures and other conservation plantings has been discouraging (Bullard et al. 2020). As a result of limited establishment success from seeding, alternative establishment methods are being explored. Greenhouse grown transplants, for example, can be a useful means of establishment. While more expensive than seed, transplants often have higher percent establishment and are more reliable than seeding. For example, Bullard et al. (2020) observed significantly higher establishment from late-spring transplants than fall-seeded showy milkweed in central California.

Showy milkweed produces large, fleshy rhizomes that may be a useful means of vegetative propagation (Tilley et al. 2018, Welsh et al. 2003). Large clonal stands are common in sandy soils. In heavier soils, the plants produce large-crowned taproots from which multiple stems arise. These rhizomes can reach over 1.2 m (4 ft) in length (figure 4) and could potentially be divided into numerous smaller sections, which could then be used for greenhouse or field establishment. Rhizomes might also offer the advantage of being planted deeper into the soil and therefore being less susceptible to drying periods that limit establishment from seed. Establishment from rhizomes could further be valuable in establishing mature plants quickly. Bullard et al. (2020) observed significantly greater establishment of fall-planted rhizomes compared with fall seeding of showy milkweed in California's Central Valley. They also found that plants grown from rhizomes were significantly taller than seeded materials after the second year of growth.

Maintaining and promoting milkweed stands may require specialized management strategies. The effects of various management treatments on stand persistence are unknown. Weed management recommendations in milkweed habitat typically include mowing late in the fall when monarchs have left the region (Borders and Lee-Mäder 2014) or early in the

Figure 4. Showy milkweed produces large, fleshy rhizomes that can offer a means of vegetative propagation. (Photo by Nathaniel Tilley, NRCS Earth Team, 2017)

spring before plants have come out of winter dormancy (Tilley et al., 2018). Early spring canal burning is a common practice throughout the Snake River Plain. This practice may be beneficial because burning often occurs before milkweeds have begun to emerge. Showy milkweed germinates and resprouts at warmer temperatures and thus later in the spring than many of its cohabitants (Borders and Lee-Mäder 2014). Heat transfer from burning and changes in species composition and density from mowing may, however, negatively affect milkweed rhizomes and seedlings.

Due to concerns regarding habitat loss in the western migration route of monarch butterflies, we conducted greenhouse and field trials to investigate establishment and management strategies for native milkweed.

Figure 5. Wildland-harvested showy milkweed rhizomes and root crowns were cut and divided into size classes to compare viability for use in propagation. (Photo by Derek Tilley, 2017)

Materials and Methods

In 2016 and 2017, the U.S. Department of Agriculture (USDA), Natural Resources Conservation Service (NRCS), Aberdeen Plant Materials Center (IDPMC; Aberdeen, ID) initiated multiple studies to examine establishment and management techniques for installing and supporting milkweed stands for monarch butterfly habitat.

Rhizome Viability

In the first study, we evaluated the viability of showy milkweed rhizomes for use in establishing new stands. On March 17, 2017, we dug rhizomes from a native stand near Rupert, ID, and cut them into segments that fell into two categories: root crowns (a thickened, but not elongated, area where the stem joins the root) and elongated spreading rhizomes. Crown segments were divided into small (< 25 mm diameter) and large (> 25 mm diameter) sizes. Elongated rhizomes were divided into six sizes (diameter by length): 3 by 100 mm, 6 by 50 mm, 13 by 50 mm, 13 by 100 mm, 20 by 25 mm, and 20 by 100 mm (1 in = 25 mm; figure 5). We then planted these into 30- by 45- by 8-cm (12- by 18- by 3-in) greenhouse flats filled with a peat and perlite growing medium (Sunshine Mix # 4, Sungro Horticulture, Inc., Agawam, MA) to a depth of approximately 25 mm (1 in). The flats were watered daily for 20 min and allowed to grow for 4 weeks. The medium was then washed away and the number of live, sprouted plants was recorded. Plants were considered sprouted if new roots or shoots longer than 2 mm were observed.

The rhizome viability evaluation was not replicated or subjected to any statistical evaluation, but the percentage of rhizomes that produced plants are presented in the results section. This information was used to make decisions on rhizome cutting size for use in the field-establishment study.

Field Establishment

In the second study, we examined showy milkweed field establishment in a drained, constructed wetland pond located at IDPMC. Our trial compared four planting treatments: fall seeding, spring seeding, rhizome transplants, and greenhouse plugs grown from seed. The establishment trial was set up as a randomized complete block with six replications. The soil at the field site is classified as a Declo silt loam, and average natural precipitation in the area is 230 mm (9 in) (USDA Natural Resources Conservation Service 2021).

The seed bed was prepared with multiple passes of mechanical tillage in the summer of 2016 followed by a pass with a packer to firm the seed bed. Each plot contained four 7.6-m (25-ft) long rows with 1-m (3.3-ft) spacing between rows. The fall and spring seeding occurred on November 9, 2016 and April 5, 2017, respectively. Seed was collected from a natural population in Rupert, ID in 2016 and cleaned following the methods described in Tilley (2016) to an approximately 95 percent purity and 85 percent viability. Both planting times were seeded using a hand-pushed belt seeder (Almaco, Nevada, IA) set to a depth of approximately 12 mm (0.5 in) with a seeding rate of 81 pure live seeds (PLS) per linear m (25 PLS/ft) at a spacing of approximately 13 mm (0.5 in). Rhizomes were harvested from the same stand in Rupert, ID, on March 17, 2017, and stored in wet burlap sacks in a dark, cold environment averaging 10 to 13 °C (50 to 55 °F) with 10 to 30 percent relative humidity. Rhizomes averaging approximately 13 mm (0.5 in) in diameter were cut into approximately 7.5- cm (3-in) long sections and planted at 0.6-m (24-in) spacing on April 20, 2017, to a depth of approximately 2.5 cm (1 in). For greenhouse transplants, we sowed five seeds into 164-ml (10-in^3) Ray Leach SC-10 Cone-tainers™ on February 24, 2017, using the same growing medium and greenhouse conditions described for the viability assessment. The transplants were thinned as needed to one plant per pot and installed in the field after 88 days of growth on May 23 at 0.5-m (20-in) spacing. At the time of planting, the greenhouse transplants were 5 to 10 cm (2 to 4 in) tall. Effective plants/m (ft) of row for each treatment were: seeds = 81 (25), rhizomes = 1.6 (0.5), and transplants = 2 (0.6).

The study site was sprinkler irrigated once weekly for approximately 12 h or 7.5 cm (3 in) of applied water to encourage growth and to approximate conditions typically associated with local milkweed habitat in wet meadows and canal banks. Nontarget species observed in the planting area included Kentucky bluegrass (*Poa pratensis* L.), crown vetch (*Coronilla varia* L.), Canada goldenrod (*Solidago canadensis* L.), yellow salsify (*Tragopogon dubius* Scop.), and various ruderal weeds. We did not apply any weed-control treatments during the study period as we wanted the site to revegetate naturally and develop typical competition levels.

The plots were evaluated for percent establishment and average plant height in the first and second growing seasons (July 13, 2017 and May 30, 2018, respectively). Because of mortality and recruitment from seed and rhizomatous spread, we did not do any further evaluation after 2018. Percent establishment was determined by counting the number of plants in a randomly located 1-m (3.3-ft) section of the middle two rows encompassing an area of 2 m^2 (21.5 ft^2). Because different numbers of propagules were used for each treatment, counts were converted to percent establishment for comparison using the following equation: [(plants/m)/(propagules/m)] x 100. For average height, we randomly measured four plants within the randomly selected evaluation area.

Stand Management

In 2020, we established new plots within the test area to measure the effect of management treatments on milkweed stands. We established 60-m^2 (646-ft^2) (4 by 15 m [13.1 by 49.2 ft]) plots in a randomized complete block design with four replications. Each management plot incorporated equal areas of the four establishment methods and thus were expected to possess similar plant densities and age groups. The management trial consisted of two active treatments (mowing and burning) and a passive, nontreated control. Mowing treatments were done using a push mower with the blade set at 10 cm (4 in) off the ground. The burning treatments were conducted by spreading a 5 cm (2 in) deep layer of dry straw evenly throughout the plot and igniting it with a propane torch (figure 6). We measured fire temperatures at the soil surface with a high temperature, K-type thermocouple (Minnesota Measurement Instruments, St. Paul, MN) and with a handheld infrared thermometer (Etekcity, Anaheim, CA). Average temperatures generally ranged from 400 to 500 °C (752 to 932 °F) with some flareups exceeding 1,000 °C (1,832 °F). Mowing and burning treatments were done each spring in mid-March, consistent with common management practices on Idaho canals. We conducted management treatments for 2 years (2020 and 2021). The plots were evaluated in July 2021 using five, 1-m^2 (10.8-ft^2) frames placed randomly in the plot. Because plants are rhizomatous and a single plant could produce multiple stems, we counted stem density rather than whole plants (Cracroft et al. 2020). Sums were averaged for mean stems/m^2.

Experimental Analysis

All analyses were conducted using Statistix 10 Analytical Software (Tallahassee, FL). Data for all experiments were tested for normality and homogeneity of variances to determine the appropriate test analyses. Percent establishment data for 2017 and 2018 and the plant height data for 2018 were normally distributed and met the assumptions needed for an analysis of variance (ANOVA). We therefore used the one-way ANOVA procedure followed by the least significant difference means separation at $P<0.05$ level of significance. Establishment density measurements for 2017

Figure 6. The field experiment evaluated 3 management treatments, including burning as shown in this photo, applied for 2 years on established showy milkweed stands. (Photo by Derek Tilley, 2021)

and 2018 and plant height data for 2017 did not meet the assumptions of normality. For those data, we used a Kruskal-Wallis nonparametric analysis followed by Dunn's Test to separate mean ranks with a significance level of $P<0.05$. Stem density data from the 2021 management study were not normally distributed and were log transformed prior to analysis using the one-way ANOVA as described above. Means were back transformed for presentation.

Results and Discussion

Rhizome Viability

We saw excellent sprouting from the larger rhizome sections, including both sizes of crown sections and the large 20- by 100-mm segments (figure 7). Longer sections produced more viable sprouts than shorter sections of the same diameter, but segments as short as 25 mm still had sprouting from 80 percent of segments (table 1). Small-diameter rhizomes (3 and 6 mm) had the lowest sprouting percentages but were above 50 percent viability. Several uncounted rhizomes exhibited early signs of sprouting at the time of measurement, indicating that we might have recorded higher sprouting percentages if we had postponed the evaluation. These results indicate that practically all portions of harvested rhizomes have potential for use in field plantings.

Table 1. Rhizome crowns and larger segments tended to have the highest viability after 4 weeks.

Initial size (diameter by length in mm)	Total segments planted	Viability (% sprouting)
3 by 100	24	50
6 by 50	30	70
13 by 50	20	67
13 by 100	20	85
20 by 25	14	80
20 by 100	10	100
Crowns < 25	15	100
Crowns >25	4	100

1 in = 25 mm

Figure 7. Showy milkweed rhizome sections of all sizes showed excellent viability. This photo shows sprouts emerging from a 13- by 100-mm-rhizome section after 4 weeks in the greenhouse. (Photo by Derek Tilley, 2017)

Field Establishment

Seeding treatments had more propagules/m and resulted in significantly greater plant establishment densities in the first 2 years of establishment than transplanting greenhouse-grown materials or planting rhizome sections (figure 8). Because of this higher density, spring-seeded plots had 25 times more plants than the rhizome plots and 45 times more than the greenhouse transplants during the establishment year. These differences persisted during the second year. Spring seeding tended to result in more plants than fall seeding for both seasons, though this difference was nonsignificant (figure 8). Plant density of greenhouse transplants increased from 0.9 to 1.7 plants/m of row (0.3 to 0.5 plants/ft) over the two seasons, suggesting these more mature plants had begun to spread vegetatively in the second year of growth.

Final plant density was largely determined by initial planted propagule spacing and density. If more plants per area are desired, a higher planting rate can be successfully adopted. Even with fewer plants resulting from rhizomes, the number of established plants may be sufficient to develop healthy stands, especially considering the clonal nature of the species. The observed trend in rhizome mortality from the first to second growing season, however, is surprising and cause for concern.

Because of differences in initial propagule density, plant density may not fully explain the differences between planting methods. For example, young plants from the seeding treatments are likely to experience higher competition and be more susceptible to environmental stressors such as drought. More mature transplants and plants developed from healthy rhizomes may be more resilient and thus be an economical alternative for establishing milkweed populations. Percent establishment may be a valuable measure for determining the optimum planting method.

Despite having the lowest plant density in 2017, nearly 80 percent of rhizomes produced plants in 2017. By 2018, however, rhizome mortality reduced percent establishment significantly (figure 9). Establishment from seeding treatments were 27 to 54 percent from the fall- and spring-seeded treatments, respectively, in the first growing season (figure 10) which is higher than

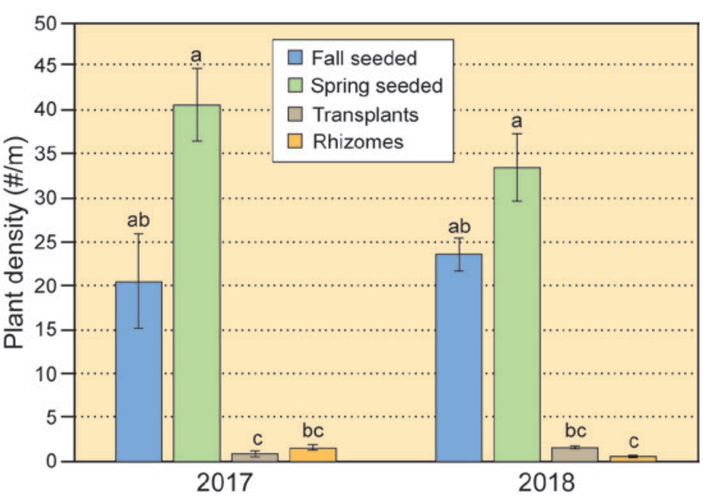

Figure 8. Fall and spring seeding treatments had significantly higher showy milkweed plant density after 1 and 2 growing seasons compared with greenhouse transplants or rhizomes, although initial planting density was also much higher for seeded plots. Error bars are ±1 standard error. Within each year, bars with different letters were significantly different at P<0.05.

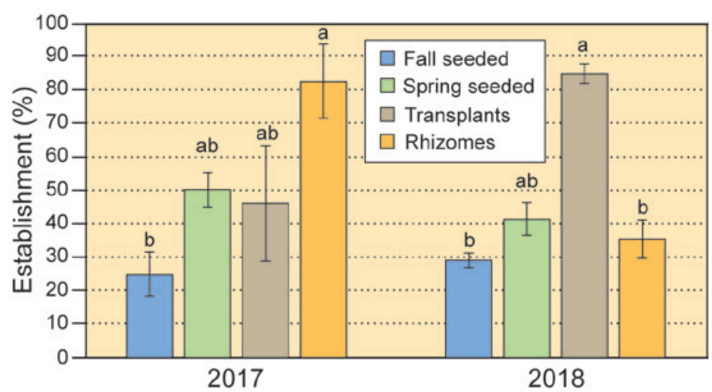

Figure 9. In the first growing season after planting, showy milkweed rhizomes produced the highest percent establishment compared with the other planting methods. By the second season, transplanted plants had the highest percent establishment. Error bars are ±1 standard error. Within each year, bars with different letters were significantly different at P<0.05.

Figure 10. Seeded rows averaged 21 and 41 showy milkweed plants/m^2 (6.5 and 12.6 plants/ft^2) from fall or spring seedings, respectively, in the first growing season. (Photo by Derek Tilley, 2018)

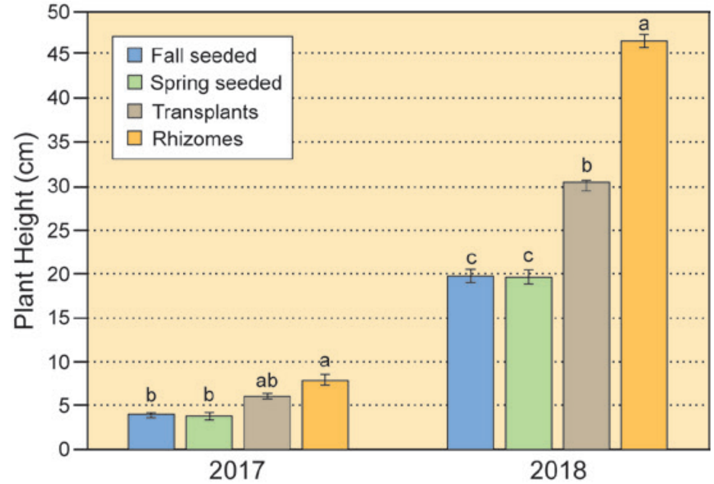

Figure 11. Showy milkweed plants that emerged from rhizomes were significantly taller than plants established with seeding or greenhouse transplants. Error bars are ±1 standard error. Within each year, bars with different letters were significantly different at $P<0.05$.

reported previously (Bullard et al. 2020). In the second season, transplanted greenhouse plants had significantly more establishment than all other treatments.

Milkweed establishment for all treatments was likely aided by site treatment (i.e., reduction of competition prior to establishment) and irrigation. Although showy milkweed is often found in semiarid sites, it may be worthwhile to target areas with higher soil moisture, such as depressions or areas with a shallow water table for milkweed establishment rather than spreading seed across an entire project, especially if seed or stock materials are limited.

Average height of plants from rhizomes was significantly taller in both seasons that it was for those germinated from seeds (figure 11). Our results differ from those observed in the San Joaquin Valley of California (Bullard et al. 2020), where fall seeded and fall transplants of showy milkweed were similar in height to rhizome-grown plants at the end of two growing seasons. This difference could be due to variations in growing degree days between the two locations.

Some of the rhizome-grown plants produced flowers in 2018 (figure 12), while none of the plants from the other planting methods produced flowers during the study. Establishing more mature plants via rhizomes may be a means of more quickly providing a nectar source for monarchs and other pollinators than direct seeding or using young greenhouse-grown plants. Flower and seed production from rhizome-established plants could also be beneficial in promoting stand spread via seed dispersal.

Response to Management

An outbreak of cobalt blue milkweed beetles (*Chrysochus cobaltinus* LeConte) decimated showy milkweed plants in 2020 at the study site (figure 13). These insects are commonly observed on Idaho milkweeds,

Figure 12. Some of the showy milkweed plants produced from rhizomes had flower buds after 2 growing seasons, whereas those planted from seed or greenhouse transplants did not produce any flowers during the 2-year field experiment. (Photo by Derek Tilley, 2018)

preferring showy milkweed, but rarely cause issues. The larvae feed on milkweed roots and the adults feed on the foliage. These beetles tend to balloon in dense stands of milkweed, peaking over a 2- to 4-year period, and can wipe out entire stands. Occasionally, outbreaks are so bad that hand removal may be necessary (Vaughan 2020). In 2021, cobalt blue milkweed beetle numbers had returned to acceptable levels and did not require treatment.

The burn and control treatments had about twice the plant density as the mowing treatment, though this difference was not statistically significant (figure 14). Flash burning of aboveground grass and thatch is common in southern Idaho canal systems. Apparently, this practice does not transfer heat far enough into the soil to harm the deep-sitting rhizomes and rootstocks of showy milkweed despite reaching surface temperatures in excess of 1,000 °C (1,832 °F). Burning

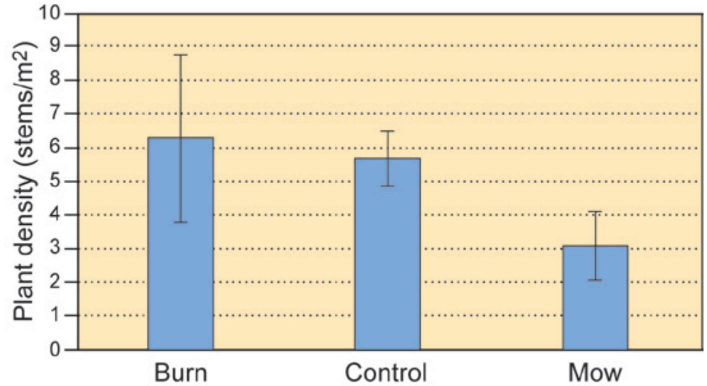

Figure 14. Showy milkweed plant density did not differ statistically among burning, mowing, and nontreated control management treatments applied for 2 years, though there tended to be fewer plants in the mowing treatment. Error bars are ±1 standard error.

treatments completely clear the area of aboveground cover and increase sunlight capture by milkweed after emergence. Conversely, mowing treatments could promote vegetative spread and cover of sod-forming grasses, such as Kentucky bluegrass, thus reducing light interception by milkweed.

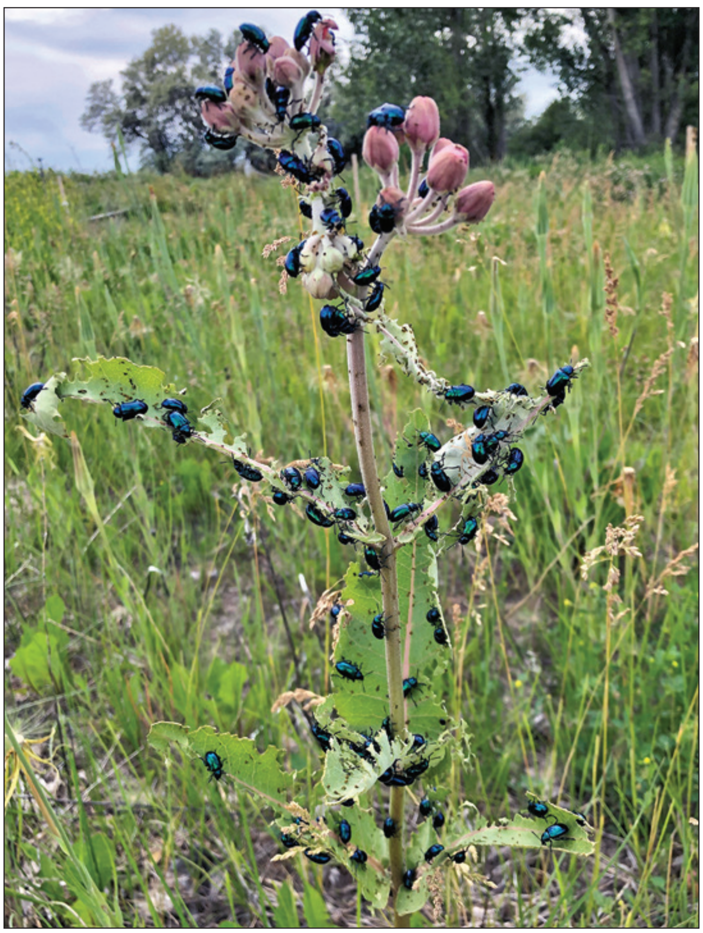

Figure 13. An infestation of cobalt blue milkweed beetles significantly damaged mature showy milkweed plants at the field experiment site in 2020. (Photo by Derek Tilley, 2020)

Conclusion

Showy milkweed can be established in the field through a variety of methods that can be tailored for a given project. Wildland-collected rhizomes are highly viable and can be cut into small sections to establish new plants on field sites. A small number of rhizomes could easily yield several dozen plants at minimal cost or effort. For larger plantings, direct seeding in the spring or fall can generate milkweed stands under the right conditions. Irrigation or targeting areas of increased moisture may increase establishment success. Greenhouse-grown transplants and plants from rhizomes establish more quickly, produce larger plants, and have earlier flowering compared with plants from seed in the first two growing seasons. Effects of mowing and burning treatments on stem density are inconclusive. Current recommendations (Borders and Lee-Mäder 2014, Tilley et al. 2018) may be adequate.

Address correspondence to—

Derek Tilley, Aberdeen PMC, PO Box 296, Aberdeen, ID 83210; email: derek.tilley@usda.gov; phone: 208–397–4133.

REFERENCES

Alonso-Mejia, A.; Rendon-Salinas, W.; Montesinos-Patin, W.; Brower, L.P. 1997. Use of lipid reserves by monarch butterflies overwintering in Mexico: implications for conservation. Ecological Applications. 7: 934–947.

Borders, B.; Lee Mäder, E. 2014. Milkweeds: a conservation practitioner's guide. Portland, OR: The Xerces Society for Invertebrate Conservation. 143 p.

Bullard, V.; Kay Cruz, J.; Smither-Kopperl, M. 2020. Milkweed establishment in California's Central Valley: I. showy milkweed, *Asclepias speciosa* by seed, rhizome and transplants. Lockeford, CA: U.S. Department of Agriculture, Natural Resources Conservation Service, Lockeford Plant Materials Center. 16 p.

Cracroft, T.; Vaughan, M.; Tilley, D.; Brazee, B. 2020. Pacific Northwest (PNW) monarch wildlife habitat evaluation guide (WHEG). Idaho Biology Technical Note no. 36. Boise, ID: U.S. Department of Agriculture, Natural Resources Conservation Service. 32 p.

Dumroese, R.K.; Luna, T.; Pinto, J.R.; Landis, T.D. 2016. Forbs: foundation for restoration of monarch butterflies, other pollinators, and greater sage-grouse in the Western United States. Natural Areas Journal. 36(4): 499–511.

Fiedler, A.K.; Landis, D.A.; Wratten, S.D. 2008. Maximizing ecosystem services from conservation biological control: the role of habitat management. Biological Control. 45: 254–271.

Flockhart, D.T.; Pichancourt, J.B.; Norris, D.R.; Martin, T.G. 2015. Unraveling the annual cycle in a migratory animal: breeding season habitat loss drives population declines of monarch butterflies. Journal of Animal Ecology. 84: 155–165.

Halsch, C.A.; A. Code, A.; Hoyle, M.; Fordyce, J.A.; Baert, N.; Florister, M.L. 2020. Pesticide contamination of milkweeds across the agricultural, urban and open spaces of low-elevation Northern California. Frontiers in Ecology and Evolution. 8: 1–11.

James, D.G.; Seymour, L.; Lauby, G.; Buckley, K. 2016. Beneficial insect attraction to milkweeds (*Asclepias speciosa*, *A. fascicularis*) in Washington State, USA. Insects. 7: 30.

Landis T.D.; Dumroese, R.K. 2015. Propagating native milkweeds for restoring monarch butterfly habitat. International Plant Propagators' Society, Combined Proceedings (2014). 64: 299–307.

Omernik, J.M.; Griffith, G.E. 2014. Ecoregions of the conterminous United States: evolution of a hierarchical spatial framework. Environmental Management. 54:1249–1266. https://doi.org/10.1007/s00267-014-0364-1.

Pelton, E. 2017. Monarch numbers are down, lengthening a worrying trend. Portland, OR: The Xerces Society for Invertebrate Conservation. https://xerces.org/blog/monarch-numbers-are-down. (March 2022)

Pleasants, J.M.; Oberhauser, K.S. 2013. Milkweed loss in agricultural fields because of herbicide use: effect on the monarch butterfly population. Insect Conservation and Diversity. 6:135–144.

Tilley, D. 2016. Propagation protocol for production of container (plug) *Asclepias speciosa* Torr. In: Native Plant Network. U.S. Department of Agriculture, Forest Service, National Center for Reforestation, Nurseries, and Genetic Resources. https://NativePlantNetwork.org. (March 2022)

Tilley, D.; Cracroft, T.; Brazee, B.; Vaughan, M. 2018. Monarch butterfly habitat: development and maintenance. Idaho Plant Materials Technical Note no. 71. Boise, ID: U.S. Department of Agriculture, Natural Resources Conservation Service. 10 p.

USDA Natural Resources Conservation Service. 2021. Custom soil resource report for Bingham County area. Web Soil Survey. U.S. Department of Agriculture, Natural Resources Conservation Service. https://websoilsurvey.sc.egov.usda.gov. (March 2022)

USDI Fish and Wildlife Service. 2020. Endangered and threatened wildlife and plants, 12-month finding for the monarch butterfly. U.S. Department of the Interior, Fish and Wildlife Service. Federal Register 81813-81822. https://www.federalregister.gov/documents/2020/12/17/2020-27523/endangered-and-threatened-wildlife-and-plants-12-month-finding-for-the-monarch-butterfly (April 2022).

U.S. Environmental Protection Agency. 2021. Level III and IV ecoregions of the Continental United States. United States Environmental Protection Agency. https://www.epa.gov/eco-research/level-iii-and-iv-ecoregions-continental-united-states/. (January 2022)

Vaughan, M. 2020. Personal communication. Pollinator Program Co-Director, The Xerces Society for Invertebrate Conservation. Portland, OR.

Waterbury, B.; Potter, A. 2018. Integrating strategic conservation approaches for the monarch butterfly in the state wildlife action plans of Idaho and Washington. Final Report. Boise, ID: Idaho Department of Fish and Game. 79 p.

Welsh, S.L.; Atwood, N.D.; Goodrich, S.; Higgins, L.C. 2003. A Utah flora. 3rd ed. revised. Provo, UT: Brigham Young University Press. 912 p.

Xerces Society for Invertebrate Conservation. 2020. The western monarch Thanksgiving and New Year's Day counts. Portland, OR. https://www.westernmonarchcount.org/data/. (March 2022)