RESTORATION STATUS OF THE FEDERAL THREATENED MEAD'S MILKWEED (*ASCLEPIAS MEADII*) IN ILLINOIS AND INDIANA *

Bowles, Marlin, Jenny McBride, The Morton Arboretum, Lisle, Ill.,
and Timothy Bell, Chicago State University

ABSTRACT: Mead's milkweed is a federal threatened perennial prairie forb of undisturbed Midwestern prairies. This species is self-incompatible, and the few remaining eastern populations have been fragmented into small clones that no longer reproduce. Recovery will require restoration of genetically diverse populations capable of reproduction. Following state and federal recovery planning guidelines, Mead's milkweed has been experimentally restored to one Indiana and eight Illinois sites. Most restorations have been in small high quality prairie remnants and have compared the efficiency of planting either seeds or one-year old juvenile nursery stock propagated at the Morton Arboretum. After six years, these restored populations average about 60 plants each, with about 20 different genetic lines represented in each restoration. This species flowers after 3-4 years in cultivation, but requires a longer period of growth to a threshold flowering size in the field. Juvenile plantings have had about 26% survivorship with five or fewer plants flowering annually since 1995; but seed production did not occur until 2000. Seed plantings have had 33% germination and 34% seedling survivorship, but with almost no growth and complete lack of flowering. Seedling survivorship is enhanced by fire and greater than normal rainfall, while juvenile survivorship has a greater positive response to fire than rainfall. Continued restoration efforts, coupled with fire management, are needed to create viable restored populations of this species.

*Reprinted from: Proceedings of the Northern Illinois Prairie Workshop, College of DuPage, DuPage Co., Ill., C. Peterson (ed.). 2001.

INTRODUCTION

Mead's milkweed (*Asclepias meadii*) is a federal threatened (Harrison 1988) and Illinois endangered (Herkert 1991) milkweed restricted to the tallgrass prairie region of the central United States. This species was discovered in Hancock Co., Illinois in 1843 by Samuel Barnum Mead, a medical doctor and plant collector (Betz 1989). It was rare and declining even during the time of Dr. Mead. In 1879 he indicated that he had been unable to cultivate the plant and suggested that it ought to be protected and preserved for cultivation (Kibbe 1953). As predicted by Mead, this species is endangered due to the nearly wholesale destruction of its primary habitat, the virgin prairie, and restoration is now a necessary component of its recovery.

BACKGROUND

Distribution and abundance of populations

The range of Mead's milkweed follows the tallgrass prairie, extending from eastern Kansas through Missouri, Iowa, and Illinois to southwestern Wisconsin and northwestern Indiana, with outlier populations in southeastern Missouri and southern Illinois. Because of conversion of tallgrass prairie to agriculture, Mead's milkweed has been reduced to about 150 populations, primarily in Kansas and western Missouri native haymeadows where summer haying removes seed pods (follicles) and prevents sexual reproduction (Bowles *et al*. 1998). One former haymeadow, the Rockefeller Prairie, Jefferson Co., Kansas, has been fire-managed since the 1950s and may contain 200 or more plants (Alexander *et al*. 1997, Kettle *et al*. 2000). Less than 20 former haymeadow populations have been preserved as public prairies in Missouri since the mid-1980s, and only one site contains a large Mead's milkweed population (Smith 1997). This species occurs in igneous glades in southeast Iron and Reynolds counties, Missouri. The largest of these populations has more than 100 plants and occurs at the fire-managed Weimer Hill site in Iron Co (Bowles et al. 1998). Eastward, small colonies occur at two sites in northern Missouri, six Iowa sites, and five sites in Illinois; populations are extirpated from Wisconsin and Indiana (Betz 1989, Bowles *et al.* 1998, Hayworth *et al.* in press).

Native Illinois and Indiana populations

Mead's milkweed probably occurred across much of Illinois; but many populations may have disappeared before they could be discovered. As a result, this milkweed is known from only nine Illinois counties, which represent the Northeastern Morainal, Grand Prairie, Western Forest-Prairie, and Shawnee Hills Natural Divisions of Illinois (Schwegman *et al.* 1973). Half of the thirteen Illinois collections or records for Mead's milkweed were made during the 1800's (Lapham 1857, Huett 1897, McDonald 1899), and it was thought extirpated from the state until discovered in Saline Co. in 1959. New stations were found in single railroad prairies in Cook Co. in 1966 and in Ford Co. in the early 1970's. Three additional stations have been found within one km of the first Saline Co. station since 1984. The Cook Co. station was destroyed soon after it was found, and native Illinois populations of Mead's milkweed are now known only from the Ford Co. station and the four Saline Co. stations (Table 1). Fewer than five ramets have been censused in Ford County, and 1 to < 20 ramets have been censused at the Saline Co. stations. The Saline Co. populations appear to be remnants of a larger population that has been fragmented by fire protection. The single historic Indiana collection was from Lake Co., on dry-mesic habitat of the Valparaiso Moraine; but searches of potential habitats have not relocated plants (R.F. Betz, pers. comm.).

Biological characteristics

Mead's milkweed is a long-lived perennial herb of virgin tallgrass prairie. Mature plants usually produce a single terminal umbel with about 12 flowers, and a single seed pod with < 100 seeds (Betz 1989). This correlates with low levels of pod production reported for most milkweeds (Wyatt 1976). Milkweed species are usually self-incompatible, requiring crosses between genetically different individuals to produce viable seeds (Kephart 1981; Shannon & Wyatt 1986; Kahn & Morse 1991; Broyles & Wyatt 1991; Wyatt & Broyles 1994). Mead's milkweed is genetically diverse, with 74% of its genetic diversity maintained within populations and no geographic genetic pattern apparent among populations (Tecic *et al*., 1998). The Illinois populations appear to comprise single clones (Table 1), although two genotypes may occur at one Saline Co. site (Tecic *et al*. 1998, Hayworth *in press*). Because this species is self-incompatible, these small fragmented Illinois populations no longer produce seeds and are vulnerable to stochastic extinction processes. Data on reproduction and survivorship in native Mead's milkweed populations is very limited, but plants appear to have great longevity and low reproductive rates. For example, no mortality occurred among Mead's milkweed genets in a 7-year study of plants in Missouri railroad prairies, during which seed pods formed on 6% of the flowering stems (Betz 1989). Demographic studies of a Kansas population have also found a low percentage (15%) pod formation and no seedlings, with greater flowering during years of prescribed burns (Alexander *et al.* 1997).

Ecological habitat requirements

Mead's milkweed is a late-successional species characterized by poor colonizing but good competitive abilities. It is essentially restricted to virgin prairies and haymeadows, and rarely, if ever, persists or recolonizes in habitat disturbed by grazing or plowing. It appears adapted to the bunch-grass structure of prairie by establishing in interstitial patches between grasses, and using its longevity to persist in this competitive but apparently stable environment. Seedling establishment may be infrequent, occurring with opportunistic colonization of micro-disturbance patches.

Mead's milkweed occurs across a wide range of soil conditions, ranging from calcareous Wisconsinan-aged loess or glacial till in the northern part of its range to nutrient poor acidic residual soils over sandstone in the south (Bowles *et al*. 1998). However, this species is less tolerant of wide variation in moisture conditions. Although early habitat descriptions (*e.g.* Brendel 1887) refer to"dry" prairies, White (1978) applied this term to "somewhat excessively well drained" sites, which do not support Mead's milkweed. Thus, the most appropriate habitat description is the range between "dry-mesic to mesic," or well-drained to moderately well drained conditions. The Ford Co. plants occur in mesic railroad prairie on a rise of the Ellis ground moraine. The southern Illinois populations occur in glades or openings in barrens along the blufftops and sandstone ledges of the northern escarpment of the Shawnee Hills in Saline Co. This habitat is elevated 400 feet above the Saline River lowlands to the northwest.

RECOVERY CRITERIA

Setting recovery objectives

Illinois recovery, or de-listing, targets for Mead's milkweed are to restore, protect, and manage a minimum number of viable populations in habitats representing, to the extent possible, the different Illinois Natural Divisions or Sections in which this species formerly occurred (Bowles & Bell 1998). Viability is indexed by seven biological and habitat variables that most likely affect population persistence: 1) population size, 2) population growth trend, 3) effective population size (Ne), based on number of genotypes, 4) habitat size, 5) habitat protection status, 6) vegetation successional stage, and 7) habitat management condition. These variables are combined into a Population Viability Index (PVI) that can be used to target recovery actions that will reduce the chances of population extinction to acceptable levels (Bowles & Bell 1998).

Restoration methods

Restoration of new Mead's milkweed populations will require large numbers of different genotypes to increase population genetic diversity and allow successful outcrossing. To facilitate recovery, The Morton Arboretum has assembled a genetically diverse nursery population and propagule source for population restoration and research (Bowles *et al.* 1993, 1998). To maximize genetic diversity, we have used seed sources from multiple sites, which have > 98% probability of representing genetically different individuals, based on analysis of Random Amplified Polymorphic DNA (Hayworth et al. *in press*). Propagated plants are hand-pollinated to produce seeds for propagation and restoration, and these crosses have been supplemented by pollen crosses from fragmented eastern populations in southern (Saline Co.) and central (Ford Co.) Illinois, northern Missouri (Harrison Co.), and southern Iowa (Adair Co.). By 1999, the nursery population contained about 60 adult plants representing 30 different seed sources or crosses.

Experimental plantings of Mead's milkweed seeds and seedlings began in 1994, and included nine study sites between 1994 and 2000. Our strategy was to maximize numbers of genetically different individuals within sites so as to increase potential for compatible outcrossing and seed production. This has allowed planting of over 2000 seeds and juvenile plants representing over 50 different seed sources or crosses. Milkweeds were planted in early May, using either stratified seeds or dormant tubers of one-year-old nursery grown plants (Bowles *et al*. 1998). Seedlings and juvenile plants are monitored for survivorship, growth, and flowering.

Characteristics of restored populations

Over a seven-year period, over 500 Mead's milkweed plants were established at nine sites in four Illinois Natural Divisions and one Indiana Natural Division (Table 2). Sites average about 60 plants each, about 60% of which are derived from planted one-year-old juveniles and 40% from planted seeds. Typically, survivorship of these plants is high during the initial year of planting, drops after the first over-winter period, and then begins to stabilize (Figure 1). Long-term survivorship has averaged about 26% for planted juveniles and 34% for seedlings (Table 2). Although this suggests an advantage to planting of seeds, establishing juveniles is more effective for several reasons. Because greenhouse germination averages 74% in comparison to only 33% germination in the field, planting juveniles provides a higher rate of return than planting seed. Planted juveniles have also been the only plants to flower, after reaching a threshold size as measured by a leaf area index (Figure 2). In contrast, plants derived from planted seeds have shown almost no growth, and may take 15 years or more to reach reproductive size (Figure 3). However, only five or fewer plants have flowered across all sites since 1984, and seed pods were not formed until 2000, when three pods were initiated at the Schulenberg Prairie. One of these pods was aborted, a second was harvested and all but three seeds consumed by an animal, and the third produced 7 viable and 17 non-viable seeds.

Based on data from the Beisecker, Pellville, and Munson restorations, rainfall and fire have had significant and slightly different effects on milkweed seedling and juvenile growth and survivorship (Figure 4). Seedling survivorship in 1996, a year with 200% of normal May-July rainfall, was more than three times as high than during 1994-95, which were years of normal rainfall. Seedling survivorship was also higher in burned than unburned plots during 1996, but not earlier because of the overriding effect of low rainfall. In contrast, juvenile survivorship was not higher in 1996 but was higher in burned plots during years of normal rainfall. Because planted juveniles have developed tubers, their responses to fire may be less dependent upon high soil moisture levels.

CONCLUSIONS

Six years of experimental restoration of Mead’s milkweed indicate that successful flowering and seed production can be achieved by planting one-year old juvenile plants. However, few plants have flowered and seed production did not occur until 2000. Growth rates of seedling cohorts are much slower, apparently due to grass competition and variation in rainfall, they may not reach a flowering threshold for 15 or more years. Fire management appears to be critical for enhancing survivorship, growth, and flowering of plants, and will probably play a key role in achieving and maintaining viable populations. Viable populations will also require large numbers of different genotypes to increase population genetic diversity and allow successful outcrossing. Because genotypes are collected from different populations across the species range, later generation crosses could produce outbreeding depression if co-adapted gene complexes exist and are disrupted (Fenster & Dudash 1994). This will require experimentation to assess such effects on Mead's milkweed. In preliminary experiments, no differences were found in percent seed germination among natural and geographically distant crosses of Mead's milkweed, and F1 seedlings from long-distance crosses were competitively superior to seedlings derived from natural crosses (Bowles *et al*. 1998). Clearly, these experiments must be extended to include later generation crosses and field testing to ascertain long-term fitness components relevant to restoration efforts.

ACKNOWLEDGMENTS

We thank the Shawnee National Forest, U. S. Fish & Wildlife Service, Illinois Department of Natural Resources, Illinois Nature Preserves Commission, Indiana Division of Nature Preserves, and the Illinois Endangered Species Protection Board for providing either funding or permission for this project. We also thank numerous landowners, volunteers, and agency staff for assistance, and Bob Betz for guidance.

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Table 1. Location and characteristics of native Illinois populations of *Asclepias meadii*. Genotype numbers of natural populations are based on *Tecic* et al. (1998) and Hayworth et al. (*in press*).

Co./Site name	**Natural Division**	**Area of habitat**	**Population size No. of ramets**	**No. of genotypes**
Ford/Railroad prairie	Grand Prairie	< 0.1 ha	1-5 ramets	1
Saline/No. 1	Shawnee HIlls	< 0.1 ha	1-5 ramets	2
Saline/No. 2	Shawnee Hills	< 0.1 ha	1-5 ramets	1
Saline/No. 3	Shawnee Hills	< 0.1 ha	1-5 ramets	1
Saline /No. 4	Shawnee Hills	< 0.1 ha	< 20 ramets	1

Table 2. Location, Natural Division, and population characteristics of restored or supplemental (*) Illinois and Indiana populations of *Asclepias meadii*. Indiana Natural Divisions: NWM = Northwestern Morainal. Illinois Natural Divisions, NEM = Northeastern Morainal, GP = Grand Prairie, WFP = Western Forest Prairie, SH = Shawnee Hills. Percent germination for seedlings is based on the number of seedlings surviving at the end of the first growing season, actual germination rates may be higher. Genotype numbers are estimates based on seed sources and crosses. Shawnee Hills data comprise five sites. Data from Hancock Savanna are preliminary.

	Natural Division	**No. juveniles (& genotypes)**	**Juvenile survivorship**	**No. seedlings (& genotypes)**	**Percent germination**	**Percent survivorship**
Biesecker Prairie (Lake Co., Ind.)	NWM	58 (10)	32.0.2%	50 (15)	35.4%	57.5%
Hickory Creek (Will Co., Ill.)	NEM	11 (8)	18%	24 (6)	44.5%	34.8%
Schulenberg (DuPage Co., Ill.)	NEM	59 (19)	43.7%	66 (20)	28.3%	54.5%
West Chicago (DuPage Co., Ill.)	NEM	29 (3)	13.8%	5 (3)	34.4%	15.15%
Munson Cemetery (Henry Co., Ill.)	GP	**7**1 (22)	39.7%	21 (7)	48.6%	15.6%
Pellville (Vermilion co., Ill.)	GP	27 (20)	22.0%	15 (7)	25%	42.9%
Vermont (Will Co., Ill.)	GP	27 **(**12)	16.1%	21 (9)	27.9%	20%
Hancock Savanna (Hancock Co., Ill.)	WFP	8 (8)	2%	18 (3)		
***Shawnee** (Saline Co., Ill.)	SH	45 (30)	22.5%	4 (3)	18.5%	14.8%
TOTAL		335 (132)		224 (73)		
MEAN		37.2 (14.7)	26.0%	25.0 (8.1)	32.8%	33.7%
± std. err.		±.7.4 (± 2.9)	± 3.7	± 6.8 (± 1.95)	± 3.35	± 5.8

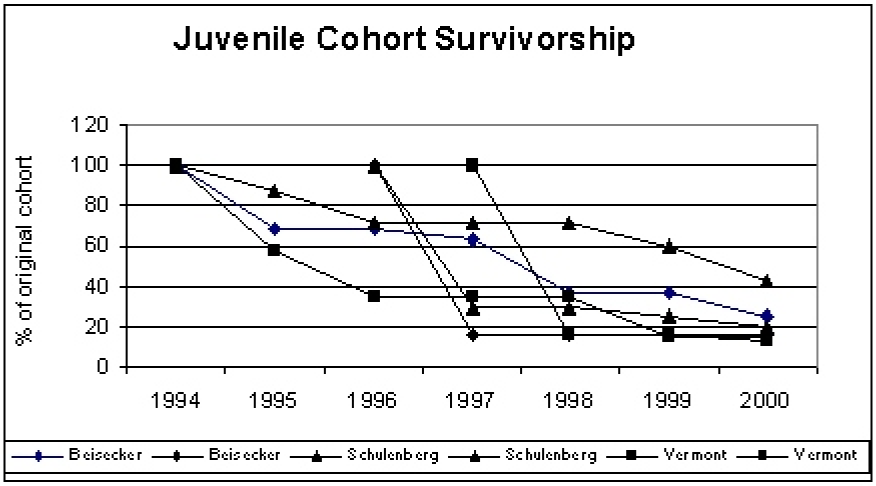

Figure 1. Survivorship of juvenile Mead's milkweed cohorts usually stabilizes after initial over-winter mortality.

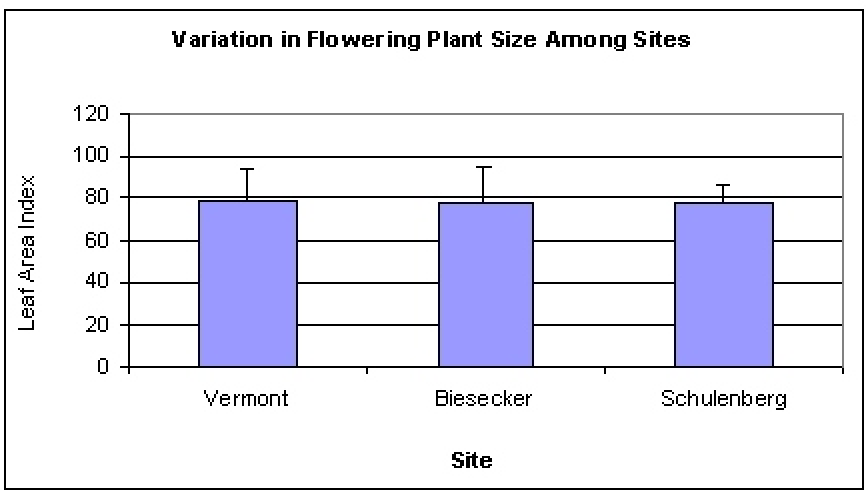

Figure 2. Mean size of flowering Mead's milkweeds established by planting juvenile plants is similar among sites. Leaf Area Index = (length x width of one leaf from largest leaf pair) x (number of leaves).

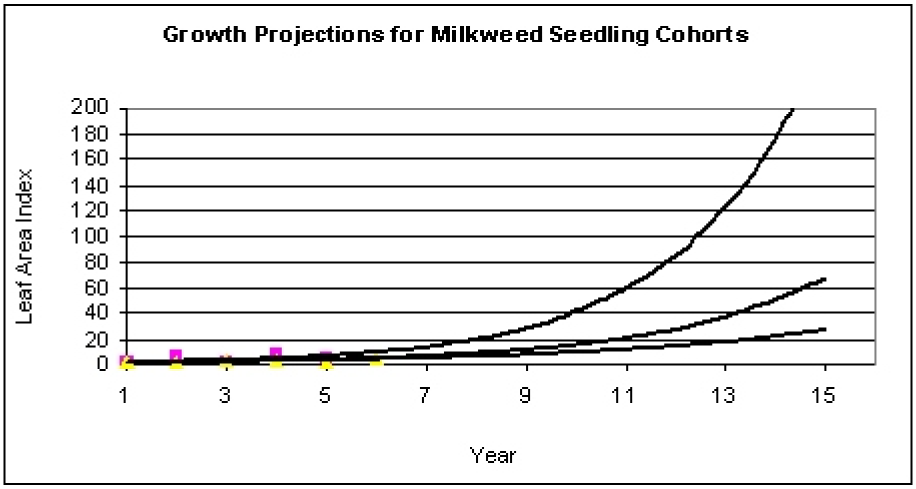

Figure 3. Exponential growth projections of Mead's milkweed seedling cohorts predict 12 years or more to attain flowering size threshold s at Schulenberg (n= 2) and Beisecker (n = 1) Prairies.

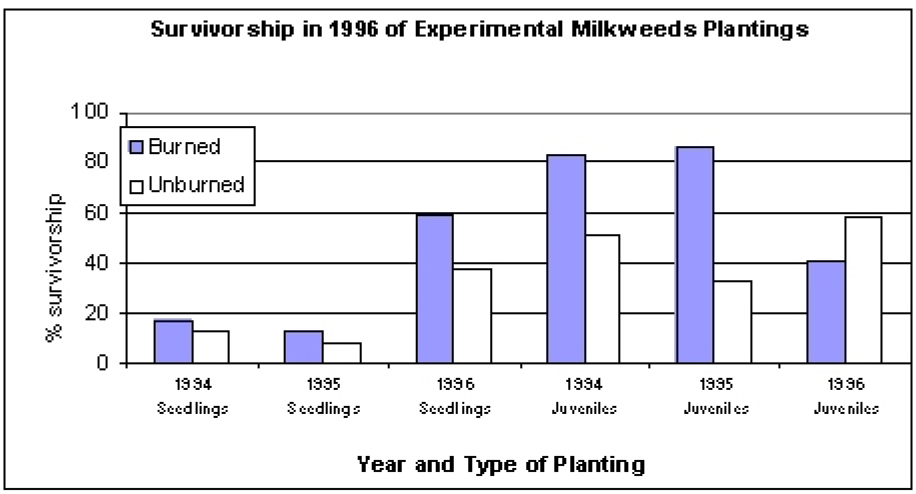

Figure 5. Burning and rainfall effect seedling and juvenile Mead's milkweeds differently. Higher rainfall and higher seedling survivorship (P = .001) occured in 1996, and seedling survivorship was higher (P = .057) in burned habitat in 1996. Juvenile survivorship was higher in burned habitat in 1994 (P <.001) and in 1995 (P = 0.013). Data from Bowles et al. (1998), with permission of the Annals of the Missouri Botanical Garden.