ABSTRACTS

Introduction to Mead's milkweed (*Asclepias meadii* Torr.) and its habitat

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Mead's milkweed (*Asclepias meadii* Torr.) is a long-lived, perennial herb endemic to the central United States. Plants are self-incompatible, pollinated by small bees, and can spread by rhizomes. Seed dispersal is by wind. Populations occur on dry-mesic to mesic, glaciated or unglaciated tallgrass prairies or glades. Substrates are sedimentary (limestone or sandstone) or, rarely, igneous. Described 150 years ago, few extant populations were known until the 1980s. When listed as threatened in 1988, Mead's milkweed was known from 81 extant populations. Today, 225 extant populations are known in 34 counties in Illinois, Iowa, Kansas, and Missouri. Distribution of these populations is highly skewed toward the southwest edge of the historic range. Nearly 91% of extant populations are in 23 counties in eastern Kansas and west-central Missouri, largely in the southern Central Irregular Plains ecoregion. Another 4% of extant populations are in eight counties in southwest Iowa and north-central Missouri, in the northern half of the Central Irregular Plains. Remaining extant populations are in the Ozark Highlands of southeast Missouri and Interior River Lowlands of extreme southern Illinois. Populations from the Central Corn Belt Plains (northern Illinois, northwest Indiana), Driftless Area (southwest Wisconsin), and Western Corn Belt Plains (east-central Iowa) are historic. Surveys for new populations continue to be fruitful; systematic inventories in Kansas in 2004 and 2005 yielded 39 new populations. Notwithstanding these discoveries, the species faces serious threats. Roughly 60% of populations for which counts are available never have been observed with more than 25 ramets. Habitat destruction and alteration from residential and urban development, and from agricultural changes, continue to impact populations. Annual haying, a common land use on prairies in Kansas and Missouri, prevents full development of fruits and is implicated in reduced genetic diversity within populations on hay meadows. Sericea lespedeza [*Lespedeza cuneata* (Dum. Cours.) G. Don] may pose a new threat to some populations.

Mead's Milkweed Recovery Plan

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The Mead's Milkweed (*Aesclepias meadii*) Recovery Plan was completed in 2003. Like most federal recovery plans it consists of three chapters, introduction; recovery; and implementation. This presentation will briefly cover chapter one, introduction, of the plan which provides a description of the species, its status, habitat, and biology. This presentation will focus mainly on the recovery plan's chapters that mesh with the theme of the symposium, recovery and implementation. Chapter two of the plan identifies the recovery objective to delist the species with populations representative of the range of the species' habitats and geographic distribution. A brief description will be discussed of the plan's framework to meet the recovery criteria with a minimum number of viable populations across Mead's milkweed's range. Chapter two continues

with a description of the actions that will be accomplished in order to reach the recovery criteria. Chapter three of the plan summarizes the actions that need to be implemented to recover the species in a schedule that provides an approximation of the cost and timeframe that actions may be accomplished. Hardcopies of the plan will be available for attendees and can be downloaded at: http://www.fws.gov/midwest/Endangered/plants/meads-fnl-rp.pdf.

Research on Mead's milkweed at the Rockefeller Prairie in eastern Kansas: A 19-year perspective

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Nineteen years of observation, using a standard monitoring protocol, has provided new insights into the population biology of Mead's milkweed in a 4 ½ hectare prairie remnant in northeastern Kansas. Our initial question (is the population increasing, decreasing, or staying constant in numbers over time?) has proved to be challenging since milkweed patches (i.e. spatially aggregated groups of stems, which approximate genetic individuals) are difficult to detect in the dense prairie, and individual plants can survive, but have no above ground parts in some years. We have thus combined our analyses of observed patches with estimation of population size and patch survival using mark-recapture methodologies more typically used in animal studies. Our study has revealed that population size at the site is likely to exceed 125 patches despite the fact that many years have many fewer patches. Yearly patch survival is high (geometric mean = 0.96), and can only be accurately assessed with long term data sets. Recruitment, as measured by the appearance of new patches, occurs frequently enough to balance the 4% mortality, suggesting that population numbers are being maintained over time. Fruit production at the site is variable, but never exceeds 45 pods across the site in a single year, and often is much smaller. The best predictor of fruit number is the number of flowering stems, which in turn is often higher in years with dormant season burning. The variability observed in both fruit number and number of new patches suggest that recruitment may be often episodic in nature.

Factors limiting Mead's milkweed fruit production in eastern Kansas

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Most remaining populations of Mead's milkweed produce very few fruit, threatening their long-term viability. In Rockefeller Prairie in 2002, we conducted an observational study to test hypotheses of factors limiting fruit production. We found that lower rates of pollinator visitation were not associated with lower fruit production, suggesting that pollen limitation was not

important in this population. Larger plants tended to produce more fruit, indicating that resource limitation may have lowered fruit production. However, impacts of both pollen and resource limitation were outweighed by vertebrate herbivory, which caused a 63% reduction in the number of plants capable of producing fruit. Understanding the factors limiting fruit production in a natural population can help us increase fruit production and population growth in natural and managed populations of Mead's milkweed.

Mead's milkweed monitoring at Taum Sauk Mountain State Park, Missouri

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In 1991, after a winter prescribed burn, Mead's Milkweed was found in the St. Francois Mountains of southeast Missouri on igneous substrates on a lobe of Proffitt Mountain know as Weimer Hill. In 1995, the population was described as "providing the largest viable seed source for restoration on acidic, nutrient poor soils [1]." The Missouri Department of Natural Resources manages the igneous glades and associated woodlands with prescribed fire. The area has had 4 prescribed burns over the past 16 years. Stewardship includes monitoring populations of threatened or endangered species to assess management effects.

Mead's milkweed monitoring was initiated in 2001 on Weimer Hill (27 plants) and above Mina Sauk Falls (6 plants). Characteristics recorded included stem height or length, leaf number, width of the widest leaf, and total number of flowers produced.

From 2001 until 2006 no prescribed burns were conducted at either site. General trends observed over the monitoring period at the Weimer Hill site were an increase in the number of plants with multiple stems, an increase in the number of stems inventoried, a decrease in the number of flowering stems, a decrease in the average height of the stems, and a decrease in the average width of the widest leaf. The Mina Sauk Falls population exhibited an increase in the number of stems inventoried, and an increase in the number of flowering stems over the same time period.

1- "Genetic Variability in the Federal Threatened Mead's Milkweed, *Asclepias meadii* Torrey (Asclepiadaceae), as Determined by Allozyme Electrophoresis." Diane L. Tecic, Jenny L. McBride, Marlin L. Bowles, Daniel L. Nickrent*Annals of the Missouri Botanical Garden*, Vol. 85, No. 1 (1998), pp. 97-109.

Population status, propagation, and management for *Asclepias meadii* (Mead's milkweed) in Missouri

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There are 59 known sites in Missouri with extant Mead's milkweed populations documented within the Missouri Natural Heritage Database. Over the past few decades periodic monitoring of these sites has occurred, with longer term surveys at Paintbrush Prairie and Taum Sauk State Park. Overall, the majority of Missouri populations contain < 15 plants, from initial surveys in the 1970's and 1980's and in recent surveys. Individual prairie populations that once contained significant stem numbers have declined in total population size, including Paintbrush Prairie, with >700 stems in 1983 to < 90 stems in each of the last 10 years. An effort began in 2005 through 2006, to survey all known Missouri populations, with 36 locations surveyed to date. Limited additional surveys

of undocumented sites occurred. In 2005, 10 of 34 prairie and glade locations surveyed contained a total of 256 stems, with 15% flowering and 13% fruit production (2% of all plants). In 2006, 9 of 21 prairie and glade locations contained 561 stems, with 27% flowering and 2% fruit production (<0.01%). Proffitt Mountain, containing igneous glade populations, resulted in 43% of the total stems and 62% of the flowers found in 2006. Fall and winter burning resulted in the greatest stem numbers. However, the lack of rain in 2005 and 2006 may have limited growth, flower and seed production and accounted for the large number of sites with no plants. No new populations were discovered; while a loss of three populations occurred due to fescue conversion and development. Augmentation of genotypic diversity and population size began in 2006 with translocations of 38 propagated plants from Miami Co., KS to Wah' Kon-Tah Prairie, St. Clair Co., MO. Further translocation efforts will continue with seed collected from two Missouri prairies (Dade and Cass Co.) to evaluate individual population response to introduced genotypes.

Low fecundity and slow seedling growth in Mead's milkweed: limits to population growth and ability to produce demographic models

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Mead's milkweed (*Asclepias meadii*) is a long-lived self-incompatible iteroparous herb of late-successional midwestern tallgrass prairie and glades. This species has infrequent natural reproduction, and many eastern populations fail to produce seeds because they comprise single clones. In an effort to restore viable populations in the eastern part of its range, a genetically diverse *ex situ* garden population was established from multiple seed sources, and served as a propagule source for restoration. Since 1991, nine restorations have been initiated in Illinois and adjacent Indiana, in which plantings of seeds and 1-year old juveniles have been repeated over time to simulate recruitment. Plants may be grown to flowering within three years in cultivation, but seedling growth is suppressed by competition under natural conditions, and 12 or more years may be required for seedlings to reach reproductive size in the field. Therefore establishing cohorts by transplanting greenhouse propagated juveniles is more efficient than planting of seeds. However, after initial transplant mortality, survivorship is similar in plants established from seed or planted juveniles. Natural seed production has occurred repeatedly at one restoration site, indicating that genetic diversity may be sufficient to overcome self-incompatibility in restorations. Because Mead's milkweed requires many years to reach maturity and rarely reproduces, seedling and juvenile transition stages are missing from matrix models required to estimate population growth. For this reason it is impossible to project whether the restorations have reached short-term or long-term persistence. However, we used composite matrices of 6 years of transplant and seedling survivorship data to analyze elasticity and variance to mean ratios (V/M). High V/M indicated that environmental stochasticity, driven by annual variation in precipitation, may be strong in these restorations. Matrices had G/L/F elasticity ratios similar to those expected for late-successional plants. Interpretation of *A. meadii* elasticities supported a logical

management need to increase growth despite limitations due to slow growth, low fecundity and lack of data from natural populations.

Propagation and establishment of Mead's milkweed

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The Kansas Biological Survey, Lawrence, Kansas, and USDA-Natural Resources Conservation Service's Plant Materials Center (PMC) Manhattan, Kansas, teamed up to assist with development of a recovery plan to reestablish Mead's milkweed (*Asclepias meadii* Torr. *ex* Gray), a Federally listed threatened species, to eastern Kansas prairies. The PMC focused on areas where information about the species was lacking: germination requirements, propagation and establishment techniques, and maintenance of plant populations. The best germination occurred at the 20/24 ˚C 16h/8h (night/day) alternating temperature regime following periods of cold-moist stratification. The mean germination rate was 95.7%. The seedlings were transplanted to 10.2-cm^3 cone-tainers with a success rate of 95%. Established container stock was transplanted into restored tall grass prairie and monoculture settings at Manhattan to compare cultural techniques in establishment and maintenance of plants. Seedlings were established on monoculture sites at a success rate of 74% compared to 69% on prairie sites over a two-year period. Established plants in the two settings were monitored to observe morphological differences in flowering and non-flowering plant populations. Monoculture plants were more robust than their prairie counterparts in terms of ramet height, leaf width, and stem diameter. The mean number of ramets per clone for the monoculture and prairie settings was 2.4 and 1.3, respectively. No prairie ramets flowered until year 7, while monoculture plants first flowered in year 2. The peak flowering period was in May. During year 6, 73.7% of the more robust ramets in the monoculture produced 199 flowers yielding 14 pods, 14.2 buds per umbel, 1.4 pods per plant, and 80.8 seeds per pod. Mature monoculture plants exhibited greater leaf area and stem diameter to support seed production while prairie plants tended to exhibit juvenile morphological characteristics.

Introduction to the Natural Heritage Program database on Mead's milkweed

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The Kansas Natural Heritage Inventory maintains an integrated database management system containing comprehensive biological data on the plants, animals, and natural communities of Kansas. These databases have been developed over a period of 18 years and continue to be updated as new information becomes available. The system currently contains 155 records of extant populations of Mead's milkweed (*Asclepias meadii*). Thirty-nine of these populations were discovered during a prairie inventory conducted in five northeast Kansas counties in 2004-2005.

Viability ranks are assigned to populations where survey data are available. These ranks help determine conservation priorities and may be useful in determining when recovery plan goals have been met. Five populations in Kansas have an estimated viability of "excellent" and six have an estimated viability of "good". Nearly 40% of all populations have not been assigned viability

ranks due to lack of complete survey data. Surveys to determine the size of known populations, as well as to locate new populations, are needed to create a more complete picture of the status of Mead's milkweed in Kansas.

Mead's milkweed on private land: Role of conservation easements

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In Kansas 93 % of all 155 Mead's milkweed sites are on private property. Only 5 sites are owned by the state or federal government, and 4 additional sites have conservation easements held by the Kansas Land Trust. Tracts of land that harbor Mead's milkweed can be protected by purchasing them or by using conservation easements (which are legal agreements with landowners that protect conservation values of the land). We calculate that about $2.7 million would be needed to protect half of the Mead's milkweed sites in Kansas with conservation easements (purchased easements at $1000 per acre). Typically, conservation easements can be purchased at 1/3 or less of the value of the land. Creative means of protecting land that contains Mead's milkweed will need to be used to get landowner involvement. In addition, restoring prairies to connect Mead's milkweed populations will be necessary to create viable populations. An example of how this could be done, will be highlighted with an example from Miami County, Kansas. Conservation of Mead's milkweed through the use of conservation easements and prairie restoration could help de-list this federally-protected species.

An adaptive framework for managing Mead's milkweed in the face of uncertainty

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Collaborating scientists and managers from federal, state, and university institutions are developing an adaptive decision framework for the recovery of Mead's milkweed (Asclepias meadii). Most (>75%) known populations of the plant occur on private lands managed for hay or otherwise receive no formal conservation protection or management. Even on conservation lands, three sources of uncertainty make management for recovery of Mead's milkweed profoundly difficult: (1) structural uncertainty about the key biological mechanisms most limiting to population growth, (2) environmental stochasticity in the plant's response to management actions and chance disturbances, and (3) a partially observable system that could mislead managers toward poor decisions. Our framework focuses on the management of lands where mowing is not practiced, where alternative forms of management (e.g.,

burning, augmentation, hand-pollination, etc.) are generally feasible, and where population monitoring is likely to be continued through time. The general decision problem is how to allocate management actions among a fixed number of sites through time – within the constraint of a total budget cap – so that the expected probability of population persistence among sites is maximized. Persistence probability is a quantity averaged over all possible decision outcomes induced by uncertainties represented in a stage-structured population model. We express structural uncertainty in the system through competing models that use parameter values corresponding to alternative hypotheses about biological mechanisms. By assignment of a weight that reflects the relative credibility of each model, optimal management decisions can be obtained for the current degree of uncertainty among models. Data obtained following the decision are used to adjust the model weights, leading to adaptation in the decision policy. Whereas this framework could not be feasibly applied to all populations in the plant's range, the development, testing, and reassessment of models in this focused application should yield knowledge usable in a broader-scale effort.

Opportunities for conservation and research on Mead's milkweed at the University of Kansas Field Station and Ecological Reserves: Rockefeller Prairie and Anderson County Prairie Preserve

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The University of Kansas Field Station and Ecological Reserves (KSR) consists of more than 3300 acres (1337 ha) of diverse habitats, facilities for supporting research, an experienced staff, and a cadre of scientists and educators focused on environmental research and outreach. Two native prairie areas within KSR holdings, Rockefeller Native Prairie and the Anderson County Prairie Preserve (ACPP), support Mead's milkweed populations and these areas are available to researchers. The 10-acre (4-ha) Rockefeller Prairie acquired by KSR in 1956 and located near KSR headquarters (Jefferson Co., KS), has a robust Mead's milkweed population that has been monitored intensively for more about 15 years. Several scientific papers have resulted from work with Mead's milkweed at Rockefeller Prairie (dealing with population estimation and biology of the species) and seeds from the genetically diverse population have been provided to further conservation efforts elsewhere. Management at Rockefeller Prairie has since 1957 consisted of springtime burns every 1–3 years, with burns once every two years from 1986–present. Woody species have invaded under this management and a new prescription is proposed for the next three years that will include a summer disturbance (haying). The ACPP, about 60 miles (97 km) south of KSR headquarters, is owned by The Nature Conservancy who transferred management responsibility for the area to KSR in 2006. The established goals for the site are preservation and enhancement of native biodiversity, research, and education. Although the bulk of the 1370-acre (554-ha) preserve is grazing land, there is an area of about 100 acres (40 ha) of former hay meadow where hundreds of Mead's milkweed ramets have been seen. KSR is now working with TNC and others to develop a management prescription for the former hay meadows. The ACPP and the Rockefeller Prairie, as well as the entire KSR, are available to interested scientists and educators for research and teaching, and to support conservation efforts.