Asclepias uncialis Greene (wheel milkweed): A Technical Conservation Assessment

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COVER PHOTO CREDIT

Asclepias uncialis (wheel milkweed). Photograph by Steve Olson. Used with permission.

Summary of Key Components for Conservation of *Asclepias uncialis*

Status

Asclepias uncialis (wheel milkweed) is the subject of taxonomic controversy. The *A. uncialis* "cluster" of closely related populations includes *A. eastwoodiana*, *A. ruthiae*, and *A. sanjuanensis* (the latter classified by some as *A. uncialis* ssp. *ruthiae*), as well as *A. uncialis* ssp. *uncialis*. This assessment addresses only material classified as *A. uncialis* (in the strict sense) or *A. uncialis* ssp. *uncialis*.

Asclepias uncialis is a diminutive milkweed occurring in small colonies scattered along the eastern edge of the southern Rocky Mountains. Occurrences are distributed in a westward trending arc from northeastern Colorado to southeastern Arizona. Twenty extant occurrences within USDA Forest Service (USFS) Region 2 include one from the Pawnee National Grassland and two from the Comanche National Grassland. Additional occurrences within Region 2 are known from Bureau of Land Management, Department of Defense, State of Colorado, and private lands. Ten extant occurrences outside Region 2 are known from New Mexico, the Oklahoma panhandle, and Arizona. *Asclepias uncialis* is a sensitive species in USFS Region 2. Because of taxonomic uncertainty, *A. uncialis* is ranked G3 or T2 by NatureServe at the global level. State Heritage Program ranks are S1 in Oklahoma, S1? in Arizona, S1S2 in Colorado, S2S3 in New Mexico, and SH in Wyoming. This species is not listed as threatened or endangered under the Federal Endangered Species Act.

Primary Threats

Based on available information, there are several threats to the persistence of *Asclepias uncialis* in Region 2. In order of decreasing priority, these threats are population limitation by unknown biological requirements, altered disturbance regime, habitat loss, spread of exotic species, and global climate change. A lack of understanding of population trends and habitat conditions for *A. uncialis*, and the lack of knowledge about its life cycle, population extent, and demographics also contribute to the possibility that one or more of these factors will threaten the long-term persistence of the species.

Primary Conservation Elements, Management Implications and Considerations

Occurrences of *Asclepias uncialis* are small and generally isolated from each other. The species also has extremely low rates of sexual reproduction. These factors, and the fact that *A. uncialis* is apparently absent from many locations where it was collected historically, make it difficult to confirm that populations in Region 2 are stable. There is some indication that *A. uncialis* requires intact native habitat; however, before appropriate conservation elements can be identified, surveys and research to define the distribution, abundance, and population ecology of the species are needed. A more accurate picture of population numbers, occurrence extent, and variability will allow the identification of conservation targets. Additional investigation of the biology and ecology of *A. uncialis* will eventually allow land managers to formulate management strategies for the conservation of the species.

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INTRODUCTION

This assessment is one of many being produced to support the Species Conservation Project for the Rocky Mountain Region (Region 2) of the USDA Forest Service (USFS). *Asclepias uncialis* is the focus of an assessment because it is a sensitive species in Region 2 (USDA Forest Service 2005). Within the National Forest System, a sensitive species is a plant or animal whose population viability is identified as a concern by a Regional Forester because of significant current or predicted downward trends in abundance or significant current or predicted downward trends in habitat capability that would reduce its distribution (Forest Service Manual 2670.5(19)). A sensitive species may require special management, so knowledge of its biology and ecology is critical. This assessment addresses the biology of *A. uncialis* throughout its range in Region 2. This introduction defines the goal of the assessment, outlines its scope, and describes the process used in its production.

Goal of Assessment

Species conservation assessments produced as part of the Species Conservation Project are designed to provide forest managers, research biologists, and the public with a thorough discussion of the biology, ecology, conservation status, and management of certain species based on available scientific knowledge. The assessment goals limit the scope of the work to critical summaries of scientific knowledge, discussion of broad implications of that knowledge, and outlines of information needs. The assessment does not seek to develop specific management recommendations. Rather, it provides the ecological backgrounds upon which management must be based and focuses on the consequences of changes in the environment that result from management (i.e., management implications). Furthermore, this assessment cites management recommendations proposed elsewhere and examines the success of those recommendations that have been implemented.

Scope of Assessment

This assessment examines the biology, ecology, conservation status, and management of *Asclepias uncialis* with specific reference to the geographic and ecological characteristics of Region 2. This assessment treats all known occurrences of *A. uncialis* that fall within the administrative boundaries of Region 2 (**Figure 1**), regardless of ownership or management status. Although some of the literature on the species originates from field investigations outside the region, this document places that literature in the ecological and social contexts of the western Great Plains. Similarly, this assessment is concerned with reproductive behavior, population dynamics, and other characteristics of *A. uncialis* in the context of the current environment rather than under historical conditions. The evolutionary environment of the species is considered in conducting the synthesis, but it is placed in a current context.

In producing the assessment, refereed literature, non-refereed publications, research reports, and data accumulated by resource management agencies and other investigators were reviewed. Because basic research has not been conducted on many facets of the biology of *Asclepias uncialis*, literature on its congeners was used to make inferences. The refereed and non-refereed literature on the genus *Asclepias* and its included species is more extensive and includes other endemic or rare species (*A. meadii* and *A. welshii* are federally listed as threatened). All known publications on *A. uncialis* are referenced in this assessment, and many of the experts on this species were consulted during its synthesis. Specimens were viewed at University of Colorado Herbarium (COLO), Colorado College Carter Herbarium (COCO), Colorado State University (CS), Rocky Mountain Herbarium (RM), and Kalmbach Herbarium, Denver Botanic Gardens (KHD). James Locklear, director of the Nebraska State Arboretum, compiled additional information on specimens beyond the scope of this search, providing a comprehensive review of all known specimens. The assessment emphasizes refereed literature because this is the accepted standard in science, and refereed literature is used to address general ecological and management concepts. Non-refereed publications or reports were regarded with greater skepticism, but they were used in the assessment since they are the primary source of information about *A. uncialis* in Region 2. Unpublished data (e.g., Natural Heritage Program records, reports to state and federal agencies, specimen labels) were important in determining the geographic distribution of this species. Unless otherwise indicated, this assessment follows the nomenclature of Kartesz (1994, 1999) since this is the accepted standard in Region 2.

Treatment of Uncertainty in Assessment

Science represents a rigorous, systematic approach to obtaining knowledge. Competing ideas regarding how the world works are measured against observations. Because our descriptions of the world are always incomplete and our observations are

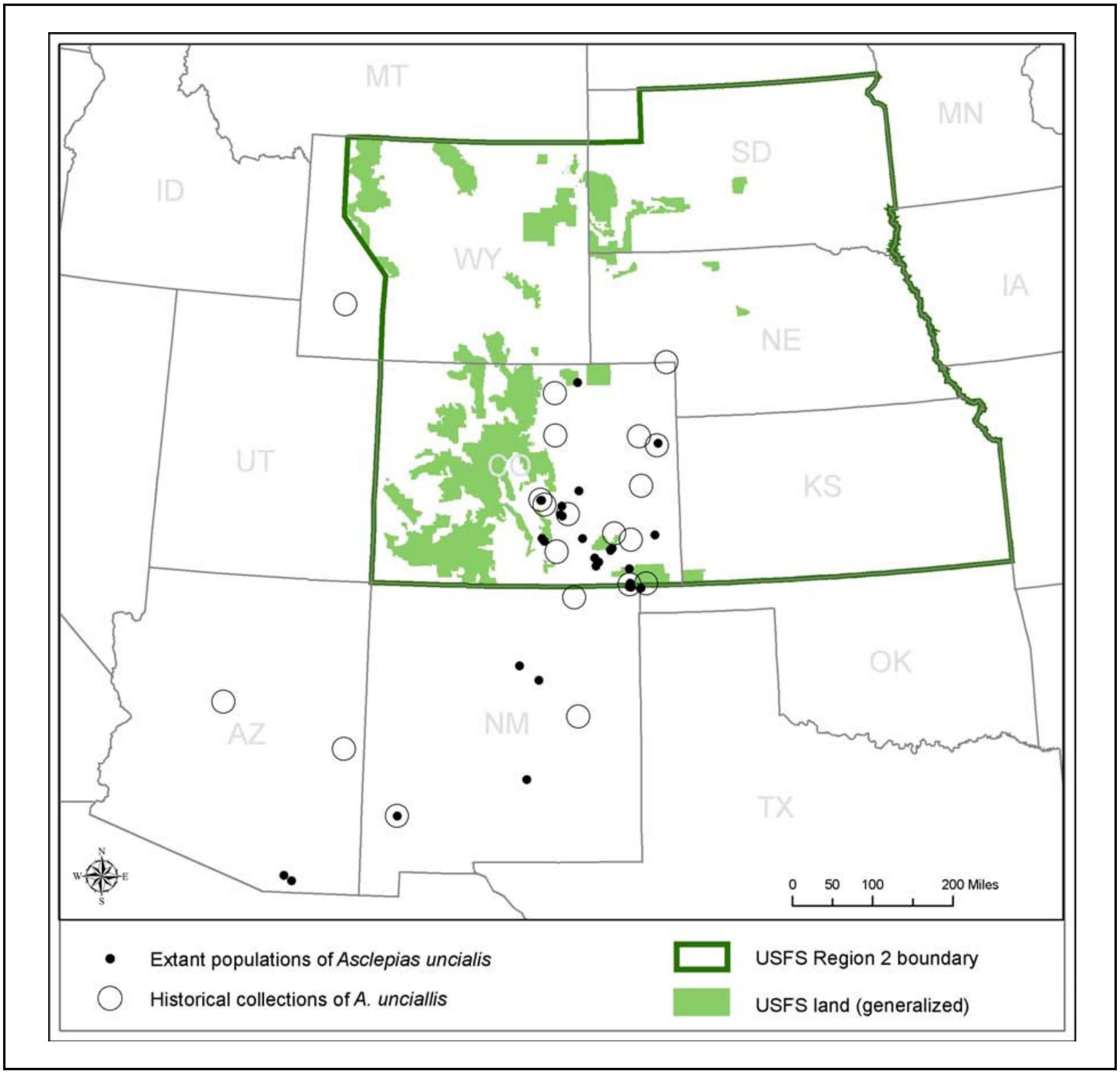


Figure 1. Historic and extant occurrences of *Asclepias uncialis* within and surrounding USDA Forest Service Region 2.

limited, science focuses on approaches for dealing with uncertainty. A commonly accepted approach to science is based on a progression of critical experiments to develop strong inference (Platt 1964). It is difficult to conduct experiments that produce clean results in the ecological sciences. Often, observations, inference, good thinking, and models must be relied on to guide our understanding of ecological relations. Confronting uncertainty, then, is not prescriptive. In this assessment, the strength of evidence for particular ideas is noted, and alternative explanations are described when appropriate.

Treatment of This Document as a Web Publication

To facilitate the use of species assessments in the Species Conservation Project, they will be published on the Region 2 World Wide Web site. Placing documents on the Web makes them available to agency biologists and the public more rapidly than publishing them as reports. What is more important it facilitates revision of the assessments, which will be accomplished based on guidelines established by Region 2.

Peer Review of This Document

Assessments developed for the Species Conservation Project have been peer reviewed prior to release on the Web. This assessment was reviewed through a process administered by the Center for Plant Conservation, employing two recognized experts on this or related taxa. Peer review was designed to improve the quality of communication and to increase the rigor of the assessment.

MANAGEMENT STATUS AND NATURAL HISTORY

Management Status

Asclepias uncialis is the subject of taxonomic uncertainty (see Classification and description section below). Pending resolution of the taxonomy of the *A. uncialis* "cluster" of closely related populations (*A. eastwoodiana*, *A. ruthiae*, *A. sanjuanensis*, and *A. uncialis* ssp. *ruthiae*), this assessment is restricted to a discussion of populations known as *A. uncialis*, in the strict sense, or *A. uncialis* ssp. *uncialis*.

Asclepias uncialis was included in the 1993 Review of Plant Taxa for Listing as Endangered or Threatened (Federal Register 58 (51144)) as a Category 2 species (i.e., taxa for whom proposing to list as endangered or threatened was possibly appropriate, but having insufficient data on biological vulnerability and threat), but it was removed from the 1994 revised list. *Asclepias uncialis* is currently included on the sensitive species list for USFS Region 2, where there are 20 extant occurrences, including three on National Forest System land (**Figure 1**, **Table 1**; USDA Forest Service 2005). Other occurrences within Region 2 are on Bureau of Land Management (BLM), Department of Defense, State of Colorado, and private lands. The BLM includes *A. uncialis* on its Colorado State Sensitive Species List for the Royal Gorge Field Office. Ten additional extant occurrences are known from New Mexico, the Oklahoma panhandle, and Arizona, and six historic collections are known from southwestern Wyoming, New Mexico, and Arizona (**Table 2**). There are no federal designations for *A. uncialis* outside Region 2.

Because NatureServe follows the taxonomy of Kartesz (1994, 1999), ranks are assigned to both *Asclepias uncialis* (in the broad sense) and *A. uncialis* ssp. *uncialis*. The global (G) rank is based on the status of a taxon throughout its range. The current global NatureServe rank for *A. uncialis* is G3 (vulnerable: at moderate risk of extinction due to a restricted range, relatively few populations [often 80 or fewer], recent and widespread declines, or other factors). *Asclepias uncialis* ssp. *uncialis* is ranked T2 (imperiled: at high risk of extinction due to very restricted range, very few populations [often 20 or fewer], or other factors); a "T" indicates that the ranked entity is a subspecies. The ranking for *A. uncialis* ssp. *uncialis* most accurately reflects the conservation status of the subject taxon of this assessment. NatureServe's concept of *Asclepias uncialis* in the broad sense includes *A. uncialis* ssp. *ruthiae*, which contains *A. eastwoodiana* and *A. sanjuanensis*, thus the less-imperiled global rank.

The state (S) rank is based on the status of a taxon in an individual state. State ranks for *Asclepias uncialis* are S1 in Oklahoma, S1? in Arizona, S1S2 in Colorado, S2S3 in New Mexico, and SH in Wyoming. New Mexico is the only state to rank *A. uncialis* ssp. *uncialis* at S2. A rank of S1 indicates that the species is considered critically imperiled in the state because of extreme rarity (often five or fewer occurrences) or because of some factor(s) making it especially vulnerable to extirpation from the state/province. Criteria for S2 and S3 ranks correspond to global ranks T2 and G3 as explained above. A numeric range rank (e.g., S1S2) is used to indicate the range of uncertainty in the status of a species. The state rank "SH" indicates a historical record that is possibly extirpated. This rank is used when a species occurred historically in the state, and there is some possibility that it may be rediscovered. The SH rank is reserved for species for which some effort has been made to relocate occurrences, rather than simply using this status for all elements not known from verified extant occurrences (NatureServe 2005). NatureServe global and Heritage Program state rankings have no regulatory status.

Asclepias uncialis is represented in six Potential Conservation Areas (PCAs) that the Colorado Natural Heritage Program identifies as having natural heritage significance. PCA status does not confer any protection to a site, nor does it automatically exclude any specific activity from the area. PCA boundaries are based primarily on factors relating to ecological systems, and they represent the best professional estimate of the primary area supporting the long-term survival of the targeted species or plant associations. These boundaries delineate ecologically sensitive areas where land use practices should be carefully planned and managed to ensure that they are compatible with the protection of natural heritage resources and sensitive species (Colorado Natural Heritage Program Site Committee 2002).

Table 1. Documented occurrences of *Asclepias uncialis* within USDA Forest Service Region 2. Occurrences are arranged by location (state and county) and arbitrarily numbered. Historic or questionable occurrences are shaded.

	State County	Land Ownership	Date Last Observed	Location	Elevation (ft.)	Habitat[1]	Population Size[2]	Source ID[3]
1	CO Baca	USDA Forest Service (USFS) Comanche National Grassland	1947	Sand Creek Canyon - south of Pritchett	4,000	Low bench land	Unknown	CNHP EO-01 Harrington, H.D. #2540; Weber, W.A. #3294
2	CO Bent	Unknown	1946	Toonerville, south of Las Animas	4,000	Sandstone rocks	Unknown	CNHP EO-11 Penland and Hartwell #3271
3	CO Cheyenne	Unknown	1960	West of Kit Carson	4,200	—	Unknown	CNHP EO-04 Harris, V.T. #s.n.
4	CO Denver	Unknown	1867	Cutoff near Denver	—	—	Unknown	CNHP EO-16 Parry, C.C.
5	CO Denver	Unknown	1895	Fairmont-Denver	—	—	Unknown	CNHP EO-03 B. Bradley #s.n. with G.L. Cannon.
6	CO El Paso	State of Colorado State Land Board	1998	Bohart Ranch	5,700	In sandy soil of plains	Unknown	CNHP EO-34 Kelso, T., D. Clark, N. Lederer, and G. Maentz #9857
7	CO Fremont	Unknown	1967	East of Canon City	5,460	Clay soil	Historical	CNHP EO-12 Turner, B.L. #5446
8	CO Fremont	Bureau of Land Management (BLM)	1995	Garden Park - Fourmile Creek	5,970 to 6,120	Flat meadows and rocky slopes. Surrounding landscape dominated by pinyon-juniper woodlands. Soils: fine sand-silt.	24 plants	CNHP EO-22
9	CO Fremont	BLM/Private	1990 1877	Garden Park - Marsh quarry / Cope quarry	6,000	On side slope of clay with sandstone rocks	5 plants	CNHP EO-08 Anderson, J.L. #90-103 CNHP EO-09 Brandegee, T.S. #s.n.
10	CO Huerfano	BLM/Private	1998	Gardner Butte	7,050 to 7,270	Grassland with areas of pinyon pine	Unknown	CNHP EO-32 Hartman, R. #60945

Table 1 (cont.).

	State County	Land Ownership	Date Last Observed	Location	Elevation (ft.)	Habitat[1]	Population Size[2]	Source ID[3]
11	CO Huerfano	State of Colorado Department of Parks and Outdoor Recreation	1977	Lathrop State Park - west of Merriam lake	6,460	Piñon-juniper woodland with scattered open areas of shortgrass prairie. Slope: 5-20% with adjacent foothill-type topography. Soils gravelly.	Unknown	CNHP EO-13 Gould, J. & Hartman, L. #s.n.
12	CO Huerfano	BLM/Private	1998	Sand Arroyo, north-northwest of Gardner Butte	7,500 to 7,640	Grassland and pinyon pine-juniper woodland.	Unknown	CNHP EO-33 Hartman, R. #61135
13	CO Kit Carson	Private	1995 1909	Tuttle, northwest of Bethune	4,010	Shortgrass prairie vegetation. Sloping (20%) ground below an escarpment of the Ogallala formation. Soil fine-textured with scattered rock chips.	17 plants	CNHP EO-29 Locklear, J.H. #165 CNHP EO-18 Cary, M. #279
14	CO Las Animas	USFS Comanche National Grassland	1997	O U Creek	5,380	Grassland on rise above drainage. Soil: sandy. Slope: level. Aspect: north. Dakota sandstone/ Graneros contact/ Greenhorn limestone.	1 plant	CNHP EO-30
15	CO Las Animas	Department of Defense (DOD) Pinyon Canyon Maneuver Site	1997	PCMS - Burson Camp	5,380	Shortgrass prairie vegetation with a juniper savannah component. Relatively level (0- 3% slope) terrain, with no notable topographic features. Soil is a loose sandy clay with very few rocks; derived from limestone.	101 plants or more?	CNHP EO-26 Anderson, D. #s.n.
16	CO Las Animas	DOD Pinyon Canyon Maneuver Site	1997	PCMS - North Boundary	4,720	—	Unknown	Rifici 2004

Table 1 (cont.).

	State County	Land Ownership	Date Last Observed	Location	Elevation (ft.)	Habitat[1]	Population Size[2]	Source ID[3]
17	CO Las Animas	DOD Pinyon Canyon Maneuver Site	2004	PCMS - Taylor Arroyo	4,980	Shortgrass prairie vegetation with a juniper savannah component. Slightly sloping (0- 4%) crest above arroyo. Sandstone outcrops present. Soil fine-textured, with some gravel.	29 to 50 plants	CNHP EO-28
18	CO Las Animas	DOD Pinyon Canyon Maneuver Site	1997	PCMS - Van Bremer Arroyo	5,100	Shortgrass prairie vegetation. Flat crest above arroyo. Slope: 0-3%. Soil: sandy, loam derived from Dakota formation sandstone.	79 plants	CNHP EO-24
19	CO Las Animas	Unknown	1948	Plains at base of Mesa de Maya southeast of Troy	—	—	Unknown	CNHP EO-10 Rogers, C.M. #5912
20	CO Las Animas	State of Colorado State Land Board	1990	Sheep Pen Canyon Road North	4,800	In open patches in short grass prairie vegetation. Slightly sloping (5-10%) terrain at foot of sandstone mesa. Sandy loam soil.	6 plants	CNHP EO-06 Locklear, J.H. #158
21	CO Las Animas	Private	1990	Sheep Pen Canyon Road South	4,700	In small open patches of soil in shortgrass prairie vegetation. Geol: red sandstone. Aspect: ENE. Soil: Rezozo sandy loam. Slope: 10%.	8 plants	CNHP EO-05 Locklear, J.H. #155, possibly the same as EO-10
22	CO Las Animas	USFS Comanche National Grassland	1997	Withers Canyon	4,610	—	Unknown	Rifici 2004
23	CO Otero	Unknown	1948	South of La Junta	—	—	Unknown	CNHP EO-21 Kelly, G.W. #782
24	CO Prowers	Private	1991	Clay Creek	3,920	Shortgrass prairie vegetation. Gently sloping ground below an escarpment of Dakota sandstone.	Few plants	CNHP EO-20 Wittmann, R.C. & W.A. Weber #18143

Table 1 (concluded).

	State County	Land Ownership	Date Last Observed	Location	Elevation (ft.)	Habitat[1]	Population Size[2]	Source ID[3]
25	CO Pueblo	DOD Fort Carson	1997	Fire Break Road site	5,510	—	16 plants	Rifici 2004
26	CO Pueblo	BLM/Private	1997	Haystack Butte	—	Gravelly edge of road.	25 to 30 plants	CNHP EO-31 Cooper, A. #3364
27	CO Pueblo	Unknown	1895	Pueblo	—	—	Unknown	CNHP EO-02 Farwell, O.A. #1056; Marvin, L.B. #13
28	CO Pueblo	State of Colorado Department of Parks and Outdoor Recreation	1995	Pueblo Reservoir Marina	4,920	Shortgrass prairie vegetation. SSW facing, slope 0-2% with no notable topographic features. Soil: fine sand and silt with outwash cobbles and gravel.	47 plants	CNHP EO-23
29	CO Pueblo	State of Colorado Department of Parks and Outdoor Recreation	1995	Pueblo Reservoir South	4,900	Shortgrass prairie vegetation dominated by Bouteloua gracilis and Juniperus monosperma. Rather steeply sloped terrain (15-45%) below steep bluffs. Soil fine-textured with rock chips, derived from limestone bluffs above. Slope: ~5%. Soils: silty.	47 plants	CNHP EO-23
30	CO Washington	Unknown	1971	West of Cope	—	Shortgrass rangeland	Unknown	Denham, D.L. #4003
31	CO Weld	USFS Pawnee National Grassland	2004	Murphy Pasture	4,960	Shortgrass prairie. Aspect nearly flat, N/NNE, Slope 2°, Rocky cobble.	3 plants	CNHP EO-35 Humphrey E. #s.n.
32	CO Weld	Unknown	1896	Windsor	—	—	Unknown	CNHP EO-17 Osterhout, G.E. #1021
33	CO or NE	Unknown	1862	Great Plains, Lat. 41	—	—	Unknown	Hall, E. and J.P. Harbour #478

[1]Habitat type names are given as in the original source, using either scientific or common names.

[2]Population sizes are numbers of individual plants.

[3]Sources include Colorado Natural Heritage Program data (CNHP) and herbarium labels. CNHP ID's are Element Occurrence Records (of the format EO-00). Herbarium label ID's are collector name and collection number.

Table 2. Documented occurrences of *Asclepias uncialis* outside of USDA Forest Service Region 2. Occurrences are arranged by location (state and county) and arbitrarily numbered. Historic or questionable occurrences are shaded.

	State County	Land Ownership	Date Last Observed	Location	Elevation (ft.)	Habitat[1]	Population Size[2]	Source ID[3]
1	AZ Apache	Unknown	1915	White Mountains near Springerville	—	—	—	Ellis, C. #9
2	AZ Santa Cruz	NFS Coronado NF	1990	South of Sonoita	5,000	*Bouteloua* dominated grassland opening in oak woodland	—	Porter, J.M. #7021
3	AZ Santa Cruz	Unknown managed by Audubon Society	2001	Appleton-Whittell Research Ranch	4,789	—	—	McLaughlin, S.P. and J.E. Bowers #9173
4	AZ Yavapai?	Unknown	1903	Jerome Junction	—	—	—	Jones, M.E. #s.n.
5	NM Colfax	Unknown	1848	Canadian River	—	—	—	Gordon, A. #s.n.
6	NM Grant	Private	1992	Silver City	6,000	Remnant yucca grassland	2 plants	Zimmerman, D.A.
7	NM Grant	Private	1992	North of Silver City	6,000	Ungrazed *Bouteloua gracilis* grassland with scattered junipers	1 plant	Zimmerman, D.A.
8	NM Grant	Unknown	1880 and 1919	Silver City	—	—	—	Green, E.L. various #s.n., Eastwood, A. #8259
9	NM Lincoln	Unknown	1905	Fort Stanton	—	—	—	Sivinski, R. Photograph online
10	NM San Miguel	USDA Forest Service (USFS) Santa Fe National Forest Mesita de los Ladrones Research Natural Area	1983	Mesita de los Ladrones	5,800	Calcareous sandstone in *Juniperus monosperma*	Rare	Fletcher, R. #6989
11	NM Santa Fe	National Park Service	1995	Pecos National Historical Park	—	—	—	Sivinski, R. 1995 Botanical Inventory
12	NM Union	Unknown	1958	—	—	—	—	Rogers, C.M. #5633
13	NM Union	Unknown	1990	Shiprock East	4,700	Base of sandstone mesa	5 plants	Locklear, J.H. #156
14	NM Union	Unknown	1990	Shiprock West	4,700	Base of sandstone mesa	6 plants	Locklear, J.H. #157
15	OK Cimarron	Unknown	1993	Black Mesa	—	—	—	McPhearson, J.K. #816
16	WY Sweetwater	Unknown	1873	Green River	—	—	—	Parry. C.C. #246

[1]Habitat type names are given as in the original source, using either scientific or common names.

[2]Population sizes are numbers of individual plants.

[3]Sources include Locklear (1991, 1996) and herbarium labels. Herbarium label ID's are collector name and collection number.

Existing Regulatory Mechanisms, Management Plans, and Conservation Strategies

Asclepias uncialis is no longer a candidate for listing under the Endangered Species Act, and there are no state laws or federal regulations concerned specifically with its conservation. Because it is a sensitive species in Region 2, USFS personnel are required to "develop and implement management practices to ensure that species do not become threatened or endangered because of Forest Service activities" (USDA Forest Service Manual, Region 2 supplement, 2670.22). Although such practices may include developing an individual species conservation strategy, as of this writing, a conservation strategy has not been designed for this species at a national or regional level by USFS or any other federal agency.

Adequacy of current laws and regulations

No occurrences of *Asclepias uncialis* in Region 2 are on lands with a protective designation, and there are no laws, regulations, or detailed conservation strategies for this species. The low number of documented occurrences and the small size of most known occurrences are matters of concern. Assessing the adequacy of current management practices is difficult due to the lack of quantitative information on population trends for *A. uncialis*. Our limited knowledge of this species' life history parameters indicates that unidentified biological factors (e.g., habitat requirements, pollination dynamics, low reproductive rates) may have important implications for its persistence. The dispersed nature of *A. uncialis* occurrences makes it unlikely that the species could be suddenly decimated by anthropogenic activities, but without range-wide monitoring of the species, individual occurrences could decline and disappear without notice.

If additional occurrences are located on National Forest System land, they would be protected under current sensitive species directives. The same is true for occurrences on public land managed by the BLM in Colorado, where its sensitive species status requires that *Asclepias uncialis* be considered in management actions to ensure that those actions do not cause the species to need to be listed as threatened in the future. Occurrences on lands under other ownership have few options for protection. This includes the largest occurrences on the Piñon Canyon Maneuver Site, where the Department of Defense's Directorate of Environmental Compliance and Management (DECAM) is tasked to "manage, conserve, and demonstrate sound stewardship of the public trust for the environmental resources under our responsibility while providing for the sustained and enhanced opportunity to accomplish the military training mission," but not specifically directed to consider species that are not federally listed in management decisions. Occurrences of *A. uncialis* on private lands may require protection through conservation easements or other initiatives.

Adequacy of current enforcement of laws and regulations

Although *Asclepias uncialis* has not been relocated in many of the sites from which it was historically documented, none of these disappearances can be confirmed as being due to human activities. The recent discovery of a small occurrence on the Pawnee National Grassland signifies the possibility that there are other undocumented occurrences under USFS jurisdiction. Both historic and undiscovered occurrences may have been impacted by land use decisions without agency personnel being aware of their effect on *A. uncialis*. Compliance with the directives of sensitive species management requires more detailed knowledge of the species' presence on USFS and BLM lands. Occurrences on lands under other ownership are not protected; enforcement of laws and regulations for conservation of the species is not an issue with these occurrences.

Biology and Ecology

Classification and description

Asclepias uncialis is a member of the Milkweed family (Asclepiadaceae). Cronquist (1981) classified this family under Division Magnoliophyta (flowering plants), Class Magnoliopsidae (Dicotyledons), Subclass Asteridae, Order Gentianales, Family Asclepiadaceae. The North American members of this family currently include 15 genera and about 178 accepted taxa, 90 of which belong to the genus *Asclepias* (USDA Natural Resources Conservation Service 2005). The North American species of *Asclepias* were monographed by Woodson (1954), who recognized 108 taxa. There have been no comprehensive treatments of the North American species since his publication.

Nearly all species of *Asclepias* possess latex canals that when broken exude a milky fluid, giving rise to the common name "milkweed" for the genus. The milkweeds are also characterized by a specialized floral structure and pollination mechanism (see Pollination ecology below). The genus *Asclepias* is familiar to many as the food of monarch butterfly (*Danaus plexippus*) larvae. The adult butterflies acquire their unpalatability to predators through the sequestration of cardenolides from milkweed tissue (Cronquist et al. 1984).

Within the genus *Asclepias*, Woodson (1954) recognized nine subgenera. *Asclepias uncialis* belongs to the subgenus *Asclepiodella*, which is characterized by sessile hoods that are open above, and the presence of reduced horns. At the time of Woodson's monograph, *Asclepiodella* included seven species: *A. cinerea*, *A. cordifolia*, *A. feayi*, *A. brachystephana*, *A. uncialis*, *A. ruthiae* (including *A. eastwoodiana*), and *A. cutleri*.

Woodson (1954, pg. 167) characterized these last three as "an odd little constellation of satellites about *Asclepias brachystephana*; all greatly reduced in size and scattered in their arid distributions." The more recently described *A. sanjuanensis* was also placed in *Asclepiodella* by Heil et al. (1989). Cronquist et al. (1984) and Welsh et al. (1987) separated *A. eastwoodiana* from *A. ruthiae*, increasing the number of *A. brachystephana* "satellites" that have distributions in western North America to five.

Asclepias brachystephana has the largest distribution in the group, ranging from central Mexico into western Texas and the southern parts of New Mexico and Arizona (**Figure 2**). The geographic range of *A. uncialis* is the second largest, with the known distribution of occurrences forming an arc from northeastern Colorado to southwestern New Mexico and southeastern Arizona. The other four species are found to the west of the range of *A. uncialis*. *Asclepias cutleri* is known from northeastern Arizona and southeastern Utah; *A. eastwoodiana* is endemic to central Nevada; *A. ruthiae* occurs in northern Arizona and southeastern Utah; and *A. sanjuanensis* is known only from San Juan County in northwestern New Mexico. All of these species except *A. brachystephana* appear to be rare within their areas of distribution (Locklear 1991). The remaining members of the subgenus *Asclepiodella* are not sympatric with the *A. brachystephana* group (Woodson 1954): *A. feayi* (Florida), *A. cinerea* (South Carolina, southern Georgia, and northern Florida), and *A. cordifolia* (northern California and adjacent Oregon and Nevada).

History of knowledge

The history of our knowledge of *Asclepias uncialis* has been one of constant confusion and mistaken identities (see **Appendix**). This species was first described by E.L. Greene in 1880 from material collected near Silver City, New Mexico. Greene did not designate a type specimen, but Woodson, in his 1954 monograph of *Asclepias*, typified the name, designating a Greene specimen at Missouri Botanical Garden as the lectotype (Locklear 1991). Isotypes of this collection are at the Field Museum of Natural History (F), New York Botanical Garden (NY), and Philadelphia Academy of Natural Sciences (PH). Earlier collections by a number of botanists were identified only to genus or mistakenly identified as *A. brachystephana*, and only later recognized as *A. uncialis*. Even as the confusion of *A. uncialis* with *A. brachystephana* was beginning to be resolved, the description of other entities in the *A. uncialis* complex added a new perplexity to the mixture.

The systematic treatment of *Asclepias uncialis* used by Region 2 (USDA Natural Resources Conservation Service 2005) includes two subspecies: *A. uncialis* ssp. *uncialis*, and *A. uncialis* ssp. *ruthiae* (Sundell 1990, Kartesz and Gandhi 1991). Subspecies *ruthiae* subsumes three taxa that are considered separate species by other authors (Cronquist et al. 1984, Heil et al. 1989): *A. ruthiae*, *A. eastwoodiana*, and *A. sanjuanensis*. This treatment is controversial among botanists familiar with these taxa in the field (Locklear 1996a, Fishbein personal communication 2004). There is evidence from isozyme analysis that justifies the taxonomic separation (Therrien 1998). Generalized ranges of the four taxa are shown in **Figure 2**. This assessment focuses on what is currently designated *A. uncialis* ssp. *uncialis* since it is the only taxon occurring within Region 2. In the interest of simplicity, *A. uncialis* is used herein as synonymous with *A. uncialis* ssp. *uncialis*, but it excludes populations named as *A. eastwoodiana*, *A. ruthiae*, and *A. sanjuanensis*.

The common name "dwarf milkweed" has been widely used for this species (Weber 1953, Weber 1976, Great Plains Flora Association 1986, Colorado Native Plant Society 1997, and others), except by the PLANTS Database (USDA Natural Resources Conservation Service 2005), which gives *Asclepias uncialis* the common name "wheel milkweed", and assigns "dwarf milkweed" to *A. involucrata*. Region 2 uses the common name of "wheel milkweed".

Our knowledge of *Asclepias uncialis* relies heavily on the work of James Locklear, who conducted field surveys and herbarium searches, and compiled information from a variety of sources to produce a picture of the status of the species between 1989 and 1996. The newsletter articles and unpublished status

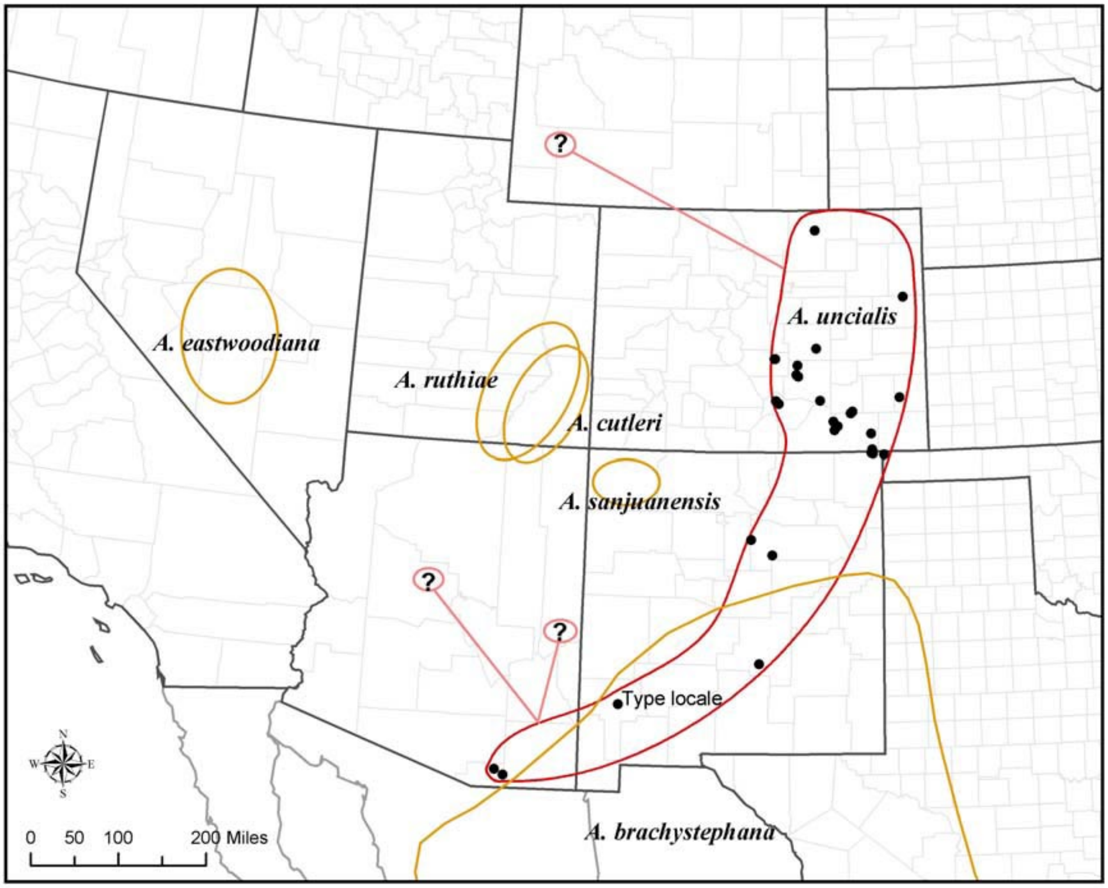


Figure 2. Generalized distributions of *Asclepias uncialis* (in the strict sense) and closely related milkweed species. The generalized range of *A. brachystephana* in Arizona has been revised as suggested by Fishbein (personal communication 2004).

reports he produced (Locklear 1991, 1993a, 1993b, 1994, 1996a, 1996b, 1996c) constitute the entire body of literature concerned exclusively with *A. uncialis*.

Description

As described by Hartman (in Great Plains Flora Association 1986) and Locklear (1991), *Asclepias uncialis* is a diminutive, herbaceous perennial with several to many spreading or erect stems 1 to 2.5 inches high. The stems contain a milky sap, and they appear to elongate when the plant is in fruit. The leaves are primarily opposite, and the species is distinguished by the presence of two different forms of leaves: lower leaves are oval to lance-shaped, 0.5 to 0.75 inches long and 0.23 inches wide while upper leaves are much narrower (about 0.125 inches) and 0.75 to 1.5 inches long (**Figure 3**). Plants are without hairs except occasionally along the leaf margins. The rose-purple flowers are 0.25 inches wide and generally occur in clusters of seven to 12 at the tips of the stems (**Figure 4**). Fruits (follicles) are spindle-shaped (thick but tapering toward the ends) and about 2 inches long (**Figure 5**). *Asclepias uncialis* flowers from late April to mid-May, and fruits are produced in late May and early June. Seeds are about 0.25 inches long with a tuft of silky hairs about 1 inch long.

Its small stature, early blooming period, and heterophyllous leaves are diagnostic field characteristics of *Asclepias uncialis*. These features distinguish it from the sympatric and similarly small-sized *A. pumila*, which has white flowers, blooms from July to September, and has only filiform leaves (Locklear 1991). The low-growing *A. involucrata* may also be found in the southern portion of the range of *A. uncialis*. It has greenish-white flowers, blooms later than *A. uncialis*, and has longer leaves that are uniformly lanceolate (Locklear 1996a).

Published descriptions and other sources

Complete technical descriptions of *Asclepias uncialis* are available in Great Plains Flora Association

Figure 3. Herbarium specimen of *Asclepias uncialis* (Locklear #158), showing heterophylly.

(1986) and Locklear (1991); less detailed descriptions are available in Dorn (1992), Fertig (2000), and Weber and Wittmann (2001). A drawing (**Figure 6**) and photograph of the plant and its habitat are available in the *Colorado Rare Plant Field Guide* (Spackman et al. 1997) and in the *Wyoming Rare Plant Field Guide* (Fertig et al. 1994), in both online and print versions. Photographs are also available in *Rare Plants of Colorado* (Colorado Native Plant Society 1997). Woodson's 1954 monograph includes a drawing of the flower. An image of an isotype specimen is available on the website of the New York Botanic Garden (http://www.nybg.org/bsci/hcol/vasc/Asclepiadaceae.html).

Distribution and abundance

Locations of documented occurrences of *Asclepias uncialis* are shown in **Figure 1**, and described in **Table 1** and **Table 2**. Most of the distribution information was compiled from herbarium specimen labels by James Locklear. He was able to search more than 70 herbaria (Locklear 1996b) and located the great majority of *A. uncialis* specimens. Because many older specimens have little to no location information, our knowledge of the distribution and range of the species is imperfect. Historically, this species appears to have been known from two or three disjunct geographical areas: 1) the western Great Plains of eastern Colorado, northeastern New Mexico, and the adjacent Oklahoma panhandle; 2) central to southwestern New Mexico and scattered locations in Arizona; and 3) Sweetwater County in southwestern Wyoming. Some botanists consider the location of the Wyoming collection (*C.C. Parry #246*) to be an error in labeling and speculate that it may have come from northeastern Colorado (Fertig 2000, Fishbein personal communication 2004). Recent observations (i.e., those less than 20 years old) are confined to the first two areas mentioned plus a few observations in central New Mexico, and are primarily within Region 2. Based on collection location and frequency, the range of the species appears to have contracted in northeastern Colorado since the mid to late 1800's (**Figure 1**).

Currently, *Asclepias uncialis* is found in small occurrences throughout most of its range. Known occurrences are largest on the Piñon Canyon Maneuver Site in Las Animas County, Colorado and in the area around Pueblo Reservoir in Pueblo County, Colorado. Although there is almost no information on the size

(A)

(B)

Figure 4. *Asclepias uncialis* in flower. **(A)** Photograph by Susan Spackman Panjabi, used with permission; **(B)** Photograph by Steve Olson, used with permission.

Figure 5. *Asclepias uncialis* in fruit. Photograph by Susan Spackman Panjabi, used with permission.

of historic occurrences, it is generally assumed that the plant was more common 100 to 150 years ago (Locklear 1996b). This assumption is based on the fact that the plant was often collected in quantity by early botanical surveyors, and such an inconspicuous plant would likely have been overlooked by these collectors unless it was fairly common. However, it is possible that *A. uncialis* was more conspicuous to surveyors than its stature warrants simply because of its early blooming period and showy (albeit small) flowers. As additional evidence of this species' decline in abundance, Locklear was unable to relocate *A. uncialis* at many of the historic localities. It should be noted, however, that botanical surveyors of the late 19th and early 20th century were often able to collect for extended periods of time in the same location and were able to travel freely over lands where private owners today restrict access. Also, plants may have been less conspicuous during the years Locklear was surveying due to a period of relatively low precipitation.

In Region 2, the species has been documented from 33 occurrences in eastern Colorado, 13 of which are considered historical and probably extirpated. Of the 20 occurrences believed to be extant, three are located on National Forest System land (one on the Pawnee National Grassland and two on the Comanche National Grassland), five are at least partly on BLM land, five are on Department of Defense land, four are on land owned or managed by the State of Colorado, and three are on privately owned land. Ownership for most of the ten occurrences outside Region 2 is unknown, but at least two are on National Forest System land (one each on the Santa Fe National Forest in New Mexico and the Coronado National Forest in Arizona). Extant occurrences are known from eight counties in Colorado, one in Oklahoma, five in New Mexico, and one in Arizona.

Population trend

Although the range of *Asclepias uncialis* currently encompasses some 75,000 square miles and historically may have been much larger, it is now known from only about thirty different localities encompassing a tiny fraction of that area. Two possible explanations for

Figure 6. Drawing of *Asclepias uncialis* from Spackman et al. 1997.

the current scarcity of the species have been proposed. The diminutive and inconspicuous *A. uncialis* may not be as rare as thought, but simply overlooked by collectors. Locklear (1991) speculates that its early blooming period and occurrence in areas little explored by professional botanists may account for the small number of known occurrences. It is also possible that *A. uncialis* was more common in the past than it is today.

Locklear (1991) reported that distinguishing individual plants in the field was difficult, due to their tendency to occur in clusters. These clusters may actually represent a single genetic individual, if the members of a cluster are connected by underground rhizomes. Evidence from one plant that was excavated at Piñon Canyon Maneuver Site suggests that plants that appear to be separate at the ground surface may in fact be connected to the same root crown (**Figure 7**). Although Woodson (1954) indicated that he knew of no truly rhizomatous species of *Asclepias*, the growth habitat of *A. uncialis* may be characterized as at least semi-rhizomatous for the purposes of population inventory. Locklear (1991, 1996a) identified individual plants as separate clumps of one or more stems, and this method has been followed by subsequent observers (Rifici personal communication 2004).

No population numbers are available for *Asclepias uncialis* prior to Locklear's survey work. In 1990, he observed six small occurrences with a total of 39 individuals; no occurrence had more than nine individuals. In 1995, additional surveys increased the

Clump of six stems, before digging.

Root crown exposed, about 10” below soil surface.

Part of excavated plant.

Figure 7. Excavation of a clump of *Asclepias uncialis* stems. Photographs by Carolyn Crawford, used with permission.

number of known individuals to 372. The documentation in 1997 of several large occurrences at the Piñon Canyon Maneuver Site in southeastern Colorado increased the number of individuals known from extant occurrences to about 630 (**Table 1** and **Table 2**). This number is only an estimate, and the actual number of individuals may be much smaller if plants counted as individuals are in fact shoots of the same genetic individual. It is also possible that some reported occurrences consist of a single genetic individual and do not constitute a viable population. About two-thirds of all known plants are on the Piñon Canyon Maneuver Site. Occurrence sizes range from two to 189 individuals; nearly half of the occurrences have fewer than 10 individuals, and only three occurrences have more than 50 individuals.

Reliable repeat counts have been made of only a few occurrences; there has been no formal monitoring of any occurrence. Population numbers are likely to vary between years in response to a variety of factors in addition to observer error. Anecdotal evidence suggests that plants are less visible in some years (Rifici personal communication 2004), but it is not clear if this is a true fluctuation in numbers of individuals, or the effect of plants remaining dormant in poor conditions.

No strong conclusions about population trends can be made from the available data. On the one hand, it appears that populations may have declined substantially in comparison with those sampled 100 to 150 years ago. On the other hand, the recent discovery of large, robust occurrences at Piñon Canyon Maneuver Site indicates that there may be additional such occurrences yet to be discovered. Some botanists have expressed the opinion that concern for *Asclepias uncialis* is overstated, and that there are probably many occurrences that have never been reported. Although the expert knowledge of botanists is invaluable in determining the status of rare species, the unsubstantiated belief that a plant is common and merely undocumented should not be accepted as evidence of stable populations. Current total documented numbers are low, even if there is no hard evidence of dramatic decline in recent years. Additional research is needed to clarify true population trends.

Habitat

The distribution of known occurrences of *Asclepias uncialis* forms an arc along the flank of the Southern Rocky Mountains from northeastern Colorado to southwestern New Mexico and adjacent southeastern Arizona (**Figure 1**). With the exception of the occurrences at Silver City, New Mexico, and in Santa Cruz County, Arizona, the extant occurrences are found east of the Continental Divide in drainages tributary to the South Platte, Arkansas, or Rio Grande rivers. Historical collections were also made in the drainages of the Republican and Canadian rivers. This area is the southwestern edge of the Western Great Plains Ecological Division (NatureServe 2003) and is characterized by rolling plains and low tablelands that slope gradually eastward from the foot of the Rocky Mountains (Bailey 1995). Although the Great Plains are generally flat, they are interrupted by local topographic features such as valleys, mesas, buttes, canyons, and escarpments. *Asclepias uncialis* is sometimes associated with such features, and it often occurs on lower side slopes at the base of mesas or escarpments (Locklear 1996a).

The range of *Asclepias uncialis* from northeastern Colorado to southeastern Arizona has a continental climate, characterized by abundant sunshine, low total precipitation, low relative humidity, and a relatively large annual and daily temperature range. In the summer months, daily maximum temperatures are often at least 95 °F in northeastern Colorado, and often higher in New Mexico locations below 5,000 feet. Winters are cold, with average low temperatures below freezing throughout the range; temperatures may dip below 0 °F in northeastern Colorado. Temperatures largely depend on elevation throughout the area, except near the Colorado mountain front, where mountain and valley winds have a moderating effect on the climate. In the eastern plains of Colorado, the rain shadow effect of the Rocky Mountains causes decreasing precipitation totals westward to a minimum near the mountain front. Annual precipitation ranges from 12 to 17 inches, with most precipitation falling during the period from May to August. The period of greatest precipitation varies from north to south, with northeastern Colorado receiving the greatest portion of its annual total in May to June, southwestern Colorado and northeastern New Mexico from June to July, and central and southwestern New Mexico during July and August (Western Regional Climate Center 2004).

The current range of *Asclepias uncialis* is located primarily in the Central and Southern Shortgrass Prairie ecoregions as defined by The Nature Conservancy (2001). Occurrences are also known from grassland and savanna habitats in the Southern Rocky Mountains, Arizona-New Mexico Mountains, and Apache Highlands ecoregions. Within these ecoregions, *A. uncialis* is primarily associated with the Western Great Plains Shortgrass Prairie ecological system and also occasionally with a variety of other grassland or open coniferous woodland ecological systems (NatureServe

2003). With the possible exception of Parry's collection at the Green River in southwestern Wyoming, current habitats are broadly comparable to historically reported habitats. The amount of intact habitat within these areas has declined over time with the conversion to crop production and grazing land of large parts of the western Great Plains (The Nature Conservancy 1998).

The Western Great Plains Shortgrass Prairie ecological system is found primarily in the western half of the Western Great Plains Division east of the Rocky Mountains and generally ranges from the Nebraska Panhandle south into Texas and New Mexico. This system occurs on flat to rolling uplands with loamy, ustic soils ranging in texture from sandy to clayey. In Region 2, this is a matrix-forming system dominated by *Bouteloua* species. Other associated graminoids may include *Buchloë dactyloides*, *Hesperostipa comata*, *Koeleria macrantha*, *Pascopyrum smithii*, *Aristida purpurea* and *Sporobolus cryptandrus*. Although tallgrass and mixed-grass species may be present on more mesic soils, they are secondary in importance to the sod-forming, short grasses. Shrub species such as *Artemisia filifolia*, *A. tridentata*, and *Chrysothamnus* spp. that dominate the Western Great Plains shrubland systems may also be present. Relative dominance of species may vary across the range of this system (NatureServe 2003). In the southern part of its range (including southeastern Colorado in Region 2), *Asclepias uncialis* is also associated with the Southern Rocky Mountain Pinyon-Juniper Woodland or Rocky Mountain Juniper Woodland and Savanna ecological systems. It is always found in the prairie or grassland components of these systems (**Figure 8**).

Locklear (1996a) described the typical habitat for *Asclepias uncialis* as level to gently sloping terrain without notable micro-topographic features. Although plants are often found at the base of escarpments or mesas (**Figure 8**), the species does not occur on rock ledges or outcroppings, and it is absent from highly disturbed habitats such as sand dunes, erosion channels, wash slopes, and badlands (Locklear 1996a). The occurrence on the Pawnee National Grassland is on nearly flat ground. Elevations of extant occurrences in Region 2 range from 3,920 to 7,640 ft. (1,190 to 2,330 m). The elevations of historical occurrences and occurrences outside Region 2 are generally unknown but are likely to be similar. The type locality at Silver City, New Mexico is around 5,900 ft. (1,800 m). Soils in the range of *A. uncialis* belong to orders characterized by dry, warm conditions (Mollisols, Entisols, Aridisols, and Alfisols), and there is no evidence that *A. uncialis* is restricted to a particular soil type. Occurrences are known from soils derived from a variety of substrates, including sandstone, limestone, and shale, but they are most often found in sandy loam soils. This species does not occur in pure sand (Locklear 1996a).

Asclepias uncialis is most commonly associated with species typical of shortgrass prairie. Associated vegetation consists primarily of grasses; forbs, shrubs, and trees typically comprise less than 15 percent of the total vegetation cover (Locklear 1996a). *Asclepias uncialis* plants are usually found growing in open spaces between grass clumps. Associated forbs are variable throughout the range of *A. uncialis* since many species found with *A. uncialis* in southeastern Colorado (e.g., *Melampodium leucanthum*) are near the northern edge of their distribution in that area (Locklear 1996a). Data from specimen labels and element occurrence records show *A. uncialis* occurring with the species in **Table 3**.

Reproductive biology and autecology

As a long-lived perennial species that probably devotes several years to vegetative growth before reproducing, has very low reproductive rates, and lives in a relatively stable environment, *Asclepias uncialis* can be regarded as a *K*-selected species in the classification scheme of MacArthur and Wilson (1967). The reduced stature, apparent unpalatability, and long lifespan of *A. uncialis* tend to indicate that it is a stress-tolerator in the Competitive/Stress-Tolerant/Ruderal (CSR) model of Grime (2001).

Woodson (1954) characterized the North American Asclepiadaceae as entirely self-incompatible. Experimental crosses have confirmed self-incompatibility in some species (Broyles and Wyatt 1993, Wyatt et al. 1998). Other researchers have found low to moderate levels (1 to 29 percent) of self-compatibility in hand-pollination of some species (Wyatt 1976, Kephart 1981, Wyatt et al. 1996), and a few species appear to be fully self-compatible (Wyatt and Broyles 1997). Self-compatibility has not been investigated for *Asclepias uncialis* or for any of the other species in subgenus *Asclepiodella*. Because most milkweeds appear to exhibit at least some degree of self-incompatibility, *A. uncialis* is likely to share this trait.

Asclepias uncialis, like all milkweeds, possesses perfect flowers (i.e., having both female and male structures), and it is usually considered to be primarily sexually reproducing. Although *A. uncialis* is not fully rhizomatous, the root crown is typically found up to a

(A)

(B)

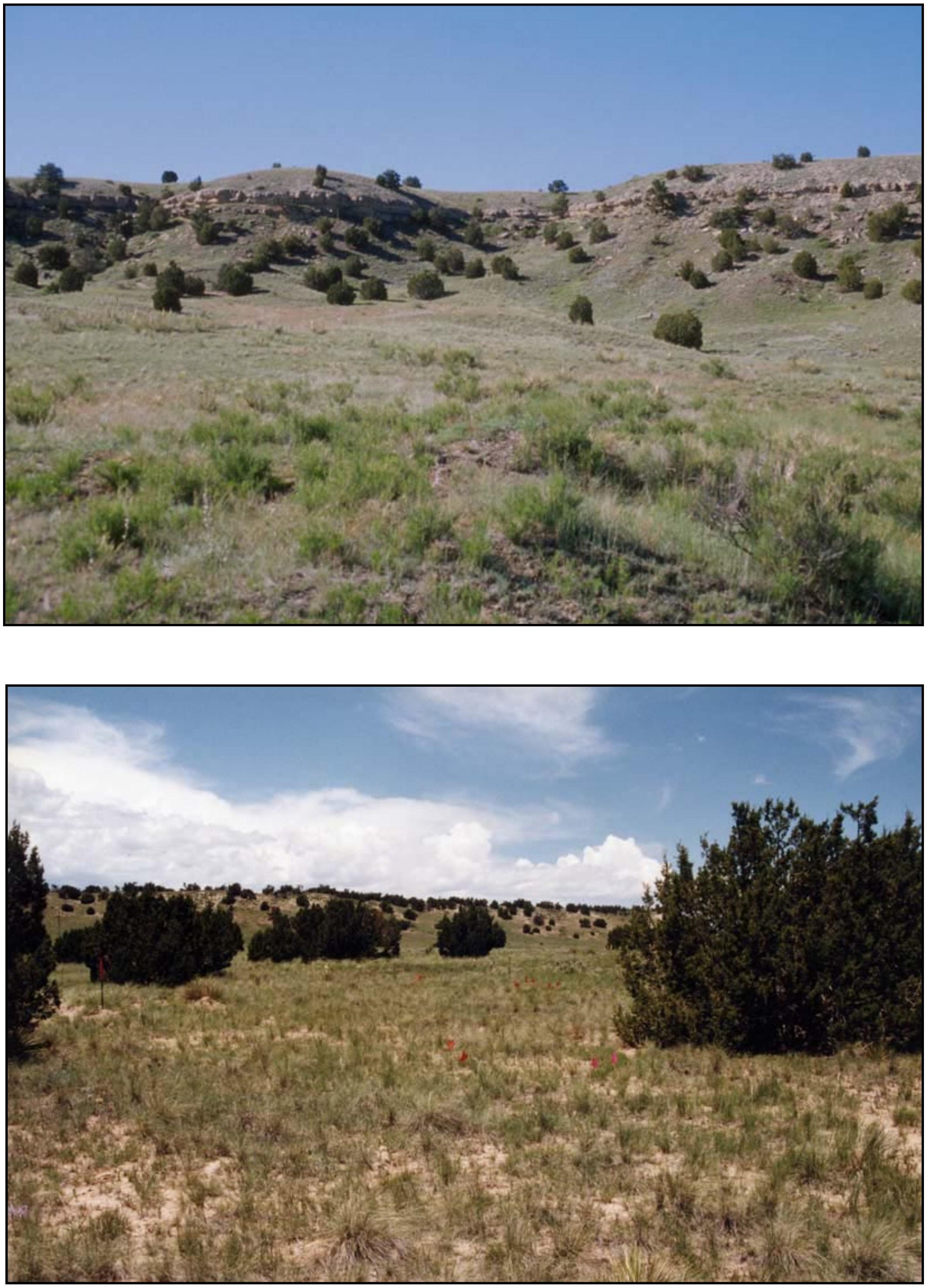


Figure 8. Habitat of *Asclepias uncialis*. **(A)** Photograph by Susan Spackman Panjabi, used with permission; **(B)** Photograph by Caron Rifici, Directorate of Environmental Compliance and Management, used with permission.

Table 3. Species associated with *Asclepias uncialis* in USDA Forest Service Region 2. The most commonly reported species are shown in bold type.

TREES	SHRUBS / SUBSHRUBS
Juniperus monosperma	*Artemisia bigelovii*
Juniperus sp.	*Artemisia* sp.
Pinus edulis	*Echinocereus viridiflorus*
	Gutierrezia sarothrae
	Mammillaria sp.
	Opuntia imbricata
	***Opuntia* spp.**
	Yucca glauca
GRAMINOIDS	**FORBS**
Achnatherum hymenoides	*Chaetopappa ericoides*
Aristida purpurea	*Cryptantha jamesii*
Bouteloua curtipendula	*Cryptantha* spp.
Bouteloua gracilis	*Heterotheca villosa*
Bouteloua hirsuta	*Lesquerella* sp.
Bromus tectorum	*Lithospermum* sp.
Buchloe dactyloides	*Melampodium cinereum*
Elymus elymoides	*Melampodium leucanthum*
Hesperostipa neomexicana	*Polygala alba*
Pascopyrum smithii	*Psoralidium tenuiflorum*
Pleuraphis jamesii	*Tetraneuris acaulis*
Sporobolus airoides	

foot below the surface, and multiple stems arising from this root may emerge at some distance from each other (**Figure 7**; Crawford personal communication 2004). It is possible that *A. uncialis* can spread by fragmentation and subsequent resprouting of these underground stems. Vegetative reproduction may enable occurrences to persist when rates of sexual reproduction are low.

The Asclepiadaceae share with the Orchidaceae the character of transmitting pollen grains in discrete packets (Wyatt and Broyles 1994). Unlike orchids, however, milkweeds have not evolved species-specific pollinator relationships. The highly specialized floral structure of the genus *Asclepias* has an abundance of specialized terminology in the literature (reviewed by Bookman 1981) and is difficult to visualize from diagrams. The arrangement of floral parts is much easier to grasp with a fresh specimen in hand.

Milkweed flowers consist of five showy petals that are typically bent severely downward (reflexed). Below the petals are five (usually greenish) sepals. The corolla of *Asclepias uncialis* is described as "reflexed-rotate", that is, more wheel-shaped than reflexed. Above the petals is an additional whorl of floral structures called "hoods" that arise from bases of the stamens. Each hood usually contains an inward arching "horn" that serves as a nectar reservoir. The hoods and horns together form the corona, an additional floral layer above the corolla. The stamens unite with the head of the stigma to form a columnar "gynostegium" in the center of the flower. In *A. uncialis*, the hoods and gynostegium are typically pink or cream-colored, contrasting with the rose-purple petals. Flowers possess two separate, superior ovaries. Between each pair of stamens, the two adjacent anther sacs are joined by "translator arms" and a "corpusculum" to form the "pollinarium" (**Figure 9**). The pollinarium is typically removed from the flower when the leg of an insect visitor slips into the opening between the anthers. As the insect pulls its leg upward and out, the corpusculum is attached to the appendage and pulled out of the flower. A bend forms in each translator arm as it dries, and the attached pollinium rotates 90 degrees. This change in configuration of the pollinarium is essential for correct pollination. Pollination is completed when the reconfigured pollinarium is inserted in the correct

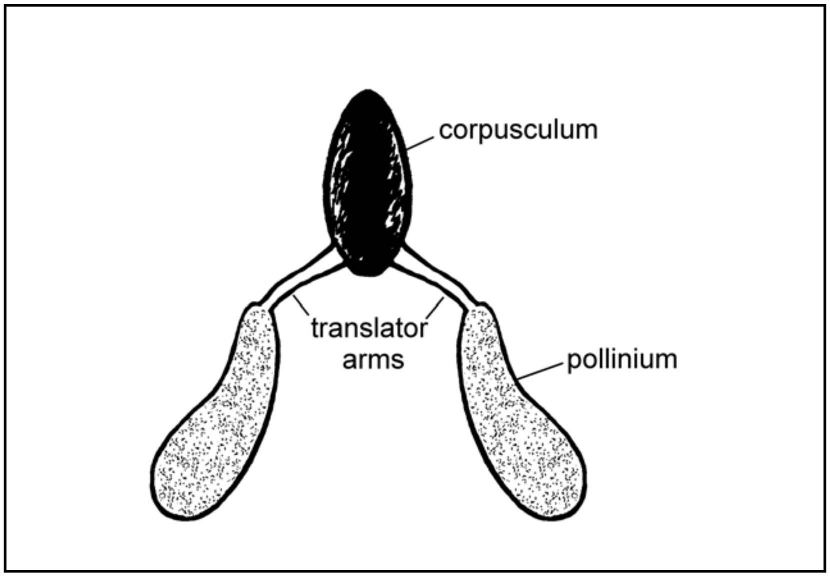


Figure 9. Pollinarium diagram.

orientation in the stigmatic chamber of another flower. As the insect visitor withdraws its leg from the chamber, the translator arm breaks, leaving the pollinarium to germinate in the stigmatic chamber.

Milkweeds are typically visited by a variety of potential pollinators who are not specialists either on milkweeds in general or on a particular species (Willson et al. 1979, Kephart 1983, Fishbein and Venable 1996, Ivey et al. 2003). Insect pollinators reported for seven species of *Asclepias* belong to the families Hymenoptera, Diptera, Lepidoptera, Coleoptera, and Hemiptera (Woodson 1954). Robust insects, typically wasps and bees, are easily able to dislodge their legs from between the anther wings, and thus transport the pollinarium. Weaker species are likely to remain trapped or lose a leg in the process of escape, and they will not be good pollinators.

Asclepias uncialis is likely to be pollinated by generalist species since the sparse occurrences and their scattered distribution do not constitute a predictable floral resource (Locklear 1996a). Ants, crab spiders, and hesperiid butterflies are the only insects that have been observed in association with *A. uncialis*, and only the last are likely pollinators. Observers have reported that *A. uncialis* has a strong fragrance (Zimmerman, 1993, Locklear 1996a), described as "an aroma suggesting rose fragrance or that of citrus blossoms (Zimmerman 1993). The scent may serve as an attractant for pollinators.

Asclepias uncialis is the earliest blooming milkweed in the Great Plains (Great Plains Flora Association 1986) although its flowering period can potentially overlap those of a few other species in its range (e.g., *A. asperula*, *A. speciosa*, and *A. involucrata*). In Region 2, flowering begins in late April and extends to the end of May. Phenology may be earlier in the southwestern portion of the range; flowering specimens have been collected in late March and mid April from southeastern Arizona and southwestern New Mexico (Zimmerman 1993). Herbarium specimens and field observations indicate that peak blooming period in Region 2 is normally the first half of May (Locklear 1996a). Flowers of *Asclepias* species are long-lasting, with reproductive spans of four to eight days (Kephart 1987). Floral longevity in some species declines later in the season (Kephart 1987). Kephart (1987) reported substantial variation in flowering times between individuals for three species of *Asclepias*. For one species (*A. incarnata*), flowering time variation between individuals was greater than variation between years for the same individual, suggesting a genetic component for variability of anthesis. Although flowering time probably at least partly depends on local environmental conditions and year-to-year variation, Locklear (1991) found *A. uncialis* blooming in early May in southeastern Colorado even when heavy snow had fallen the previous week. He also reported apparent frost damage to plants observed on the first of May, 1995 in eastern Colorado.

Fruits develop by late May or early June (Locklear 1991). Although the two carpels of a milkweed flower are both mature at flowering time, it is extremely rare for both to develop into fruits (Woodson 1954). Furthermore, even when most flowers in an umbel are fully pollinated, it is rare for more than one to develop into a mature fruit (Bookman 1984). Milkweeds as a family typically have very low fruit production, averaging 1 to 5 percent (Wyatt 1976, Wyatt and Broyles 1994), and *Asclepias uncialis* appears to share this trait. There are two primary hypotheses about causes of low fruit production: 1) resource limitation restricts fruit maturation, and 2) low pollen availability limits fruit initiation. The difficulty of separating these two factors in experimental designs (Zimmerman and Pyke 1988) has prevented a resolution of the question. It is likely that either resource or pollen limitation can limit fruit set in milkweeds, depending on circumstances (Wyatt and Broyles 1994).

Almost nothing is known about the fertility and seed viability of *Asclepias uncialis*, other than that very few fruits are produced in relation to the number of flowers. Locklear (1991) reported that almost all herbarium specimens that were in fruit had only a single pod. Similarly, the nine plants observed at Lake Pueblo State Park (number 29 in **Table 1**) in 1990 had only one or two fruits per plant, with some having none (Locklear 1991). During the same year, plants in this occurrence produced an average of 72 flowers (range 15 to 146), indicating that the fruiting rate is only 1 to 2 percent of flowering.

Germination requirements of *Asclepias uncialis* seeds are unknown. Seeds of other *Asclepias* species have been reported to be innately dormant at maturity, with cold stratification required to break dormancy (Baskin and Baskin 1998). Todd Morrissey at the Nebraska Statewide Arboretum successfully germinated 10 of 12 *A. uncialis* seeds collected in 1995 after soaking them in water for 48 hours (Locklear 1996a), but germination under natural conditions has not been investigated.

Most milkweed seeds, including those of *Asclepias uncialis*, are tipped with a tuft of hairs called a coma, making them adapted to dispersal by wind (**Figure 5**). Depending on weather and other conditions, seeds may ripen as early as the end of May, but later dispersal is probably more typical. Seeds have been observed dispersing in late June and early July in Union County, New Mexico (Locklear 1996a). Some observers have reported that fruit-bearing stems of *A. uncialis* appear to be elongated in comparison with other stems, perhaps to facilitate wind dispersal. Some herbarium specimens have flowers in addition to fruits of the previous year. Locklear (1996a) concluded that *A. uncialis* seeds can mature in as few as 40 to 60 days, and he speculated that the rapid rate of seed maturation may be a mechanism to avoid summer drought. There are no known seed predators or instances of loss by fungal infection.

Seed bank dynamics and seed longevity have not been investigated for *Asclepias uncialis*. Numbers of *A. uncialis* seeds in the seed bank are unknown, but they can be expected to be low due to infrequent fruit production. Another possible cryptic phase is a dormant stage in which an individual plant does not produce aboveground vegetation for one or more years and then “reappears” at a later time. The deeply buried root crown with multiple stems makes this phase likely for *A. uncialis*. Some observers report that plants may become dormant several weeks after flowers have senesced (Locklear 1996a).

Asclepias uncialis appears to exhibit some phenotypic variation from north to south within its range. The gradual and widespread variations in leaf morphology have contributed to the confusion regarding the taxonomy of the *A. uncialis* complex.

Mycorrhizal relationships have not been investigated for *Asclepias uncialis*. Endomycorrhizal fungi belonging to the taxonomic order Glomales are a key component of one of the most common underground symbioses. These endomycorrhizae are characterized by inter-and intracellular fungal growth in the root cortex where they form fungal structures known as vesicles and arbuscles (Quilambo 2003). Vesicular-arbuscular mycorrhizae (VAM) occur in about 80 percent of all vascular plants (Raven et al. 1986), and the association is geographically widespread. VAM associations have been identified from a broad range of habitats occupied by *A. uncialis*, including semi-arid grasslands (Wicklow-Howard 1994) and pinyon-juniper woodlands (Klopatek and Klopatek 1987).

The specialized mechanics of pollinarium insertion in milkweeds were once thought to prevent interspecific pollination, acting as a barrier to hybridization (Woodson 1954). Nevertheless, Kephart and Heiser (1980) found that sympatric species may experience high levels of interspecific pollination without apparent hybridization, indicating the presence of a post-pollination isolating mechanism. Low levels of hybridization have been observed between a few *Asclepias* species (Kephart et al. 1988, Wyatt and Hunt 1991, Wyatt and Broyles 1992, Broyles et al. 1996); however, it appears to be a rare occurrence. None of the hybridizing species is closely related to *A. uncialis*. The early flowering period of *A. uncialis* may also act as a reproductive isolating mechanism.

Demography

The small size of most *Asclepias uncialis* occurrences makes inbreeding depression, loss of genetic diversity, genetic drift that overrides natural selection, and population fragmentation important issues for the conservation of the species. Effective population sizes of 50 to 500 individuals are believed to be required to avoid inbreeding depression, and much larger populations (N_e = 500 to 5,000 individuals) are required to maintain evolutionary potential. Inbreeding, loss of genetic diversity, and loss of adaptive evolution are inevitable in all small, closed populations and could contribute to the risk of extinction for *A. uncialis*.

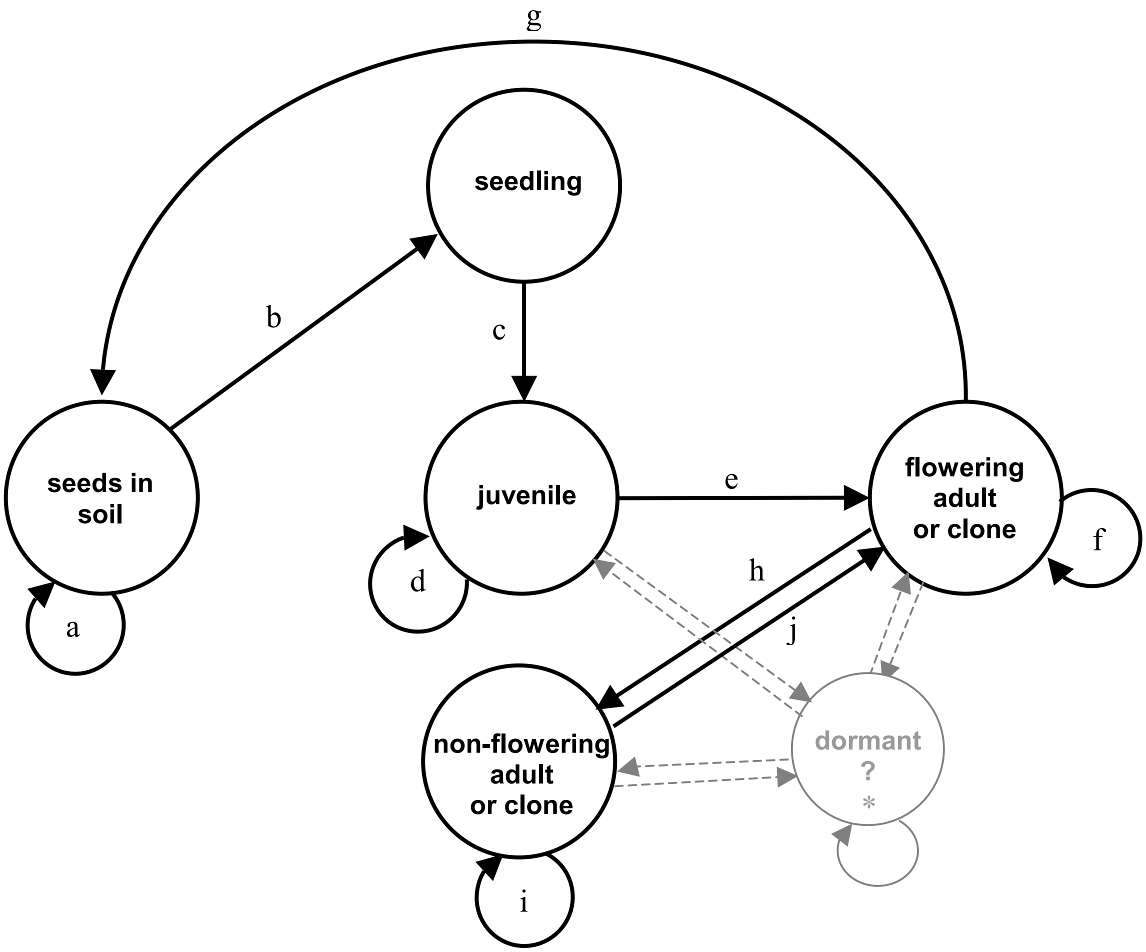
Little is known about the population genetics of *Asclepias uncialis*. The degree of connectedness among occurrences is not known although current knowledge of the distribution indicates that many occurrences may be genetically isolated from each other. Unless *A. uncialis* is in fact continuously distributed within the bounds of its range, it is likely that gene flow between most populations is not occurring. Studies of allele frequencies in the different population centers could clarify the degree of population connectivity and facilitate prioritization of protection efforts.

Many prairie forb species are long-lived perennials with life spans of 10 to 30 years or longer (Hartnett and Keeler 1995). Although long-term observations of individual plants are not available for *Asclepias uncialis*, another rare prairie milkweed (*A. meadii* [Mead's milkweed]) is known to live at least 25 years and may be capable of living as long as a century (Kettle et al. 2000). *Asclepias uncialis* is likely to have a similar life span. Long individual life spans mean that a population may persist at a site for many years even if it has a negative growth rate due to low reproduction (Kettle et al. 2000). Small population sizes can reduce the ability of plants to attract pollinators and lead to lower recruitment rates. The rare *A. meadii* is believed to be threatened with extinction due to low total numbers of plants. Populations of *A. meadii* appear to be both significantly larger and more numerous than those of *A. uncialis* even though mowing in most *A. meadii* populations eliminates reproduction (Kettle et al. 2000). This example suggests that management practices that prevent or reduce fruit set and dispersal could have drastic consequences for the persistence of rare milkweeds such as *A. uncialis*.

Figure 10 shows a hypothetical lifecycle diagram for *Asclepias uncialis*. Because there are no multi-year studies of this species, transition probabilities are left unquantified. The few demographic studies of *Asclepias* species (Klemow and Raynal 1986, Kettle et al. 2000, Slade et al. 2003) have found that year-to-year survivorship of adult plants is high (>95 percent) while recruitment events are infrequent and plants require several years' growth before flowering. Under the basic scenario shown for *A. uncialis*, flowering plants produce seeds in early summer. These seeds overwinter and germinate in the spring or remain dormant. Seedlings require one or more years before flowering. Reproductive adults flower every year as conditions permit. The model assumes a transition interval of t = one year, and plants do not move between stages in intervals less than t. Until better demographic data are available for *A. uncialis*, it is impossible to conduct any kind of elasticity analysis to determine which demographic transitions have the greatest effect on population trend.

Asclepias uncialis plants are often clustered, but clusters and single plants are often widely scattered within an occurrence. Clustering, along with this species' early blooming period, may increase its attractiveness to pollinators. Clusters at Piñon Canyon Maneuver Site averaged three to four plants in an area about 0.4 m in diameter, but some clusters were larger and denser, with 20 to 40 plants in an area 0.8 to 1.5 m diameter (Rifici, unpublished data). Plants can produce numerous flowers; large plants may have more than 100 flowers. However, plants may not flower every year. Flowering also appears to be staggered, so that during most of the flowering season, there are seven or eight times as many buds as open flowers (Rifici, unpublished data). Occurrences contain areas of unoccupied habitat, or an occurrence may be interrupted by small habitat breaks (e.g., arroyos, juniper stands). Sub-occurrences are generally within 0.5 miles of each other while occurrences are separated by several to hundreds of miles (Colorado Natural Heritage Program 2004, Rifici personal communication 2004).

Observations of three large *Asclepias uncialis* occurrences at the Piñon Canyon Maneuver Site (Rifici, unpublished data) suggest that sub-occurrences vary widely in the numbers and sizes of individuals. The majority of sub-occurrences contained one to several dozen plants of intermediate size (inferred from stem number). One sub-occurrence was made up of a few very large plants, and another had many small plants (**Figure 11**). These observations are similar to temporal population dynamics observed by Locklear (1996a) at the Pueblo Reservoir site between 1990 and 1995. In 1990 he found nine individual plants scattered along a 1 km stretch below the escarpment. The plants were



a. survival of dormant seeds in the seed bank
b. probability of seed becoming a seedling
c. survival of seedling to juvenile, pre-reproductive stage
d. probability of juvenile remaining non-reproductive
e. probability of juvenile plant becoming reproductive
f. probability of flowering adult flowering again next year
g. seed production of flowering plants
h. probability of flowering adult not flowering next year
i. probability of non-flowering adult remaining non-flowering
j. probability of non-flowering adult flowering

* * is there a dormant phase, and if so, probabilities of transition between this and other rosette stages

Figure 10. Lifecycle diagram for *Asclepias uncialis* (after Caswell 2001).

robust, with six to 15 stems and an average of 72 flowers per plant. In 1995, a Colorado Native Plant Society field trip counted 48 plants at the site. Locklear speculated that the dramatic increase could be due to the greater number of searchers in 1995 and may not necessarily be the result of a recruitment event. The plants found in 1995 were generally much smaller than the 1990 plants; most had only two or three stems and fewer flowers per plant. Locklear (1996a) also noticed similar variation in robustness and flower number between Greene's Silver City 1880 specimens and Alice Eastwood's collection from the same area in 1919. Eastwood's specimens are more robust, with longer stems, more stems per plant, and many more flowers per inflorescence.

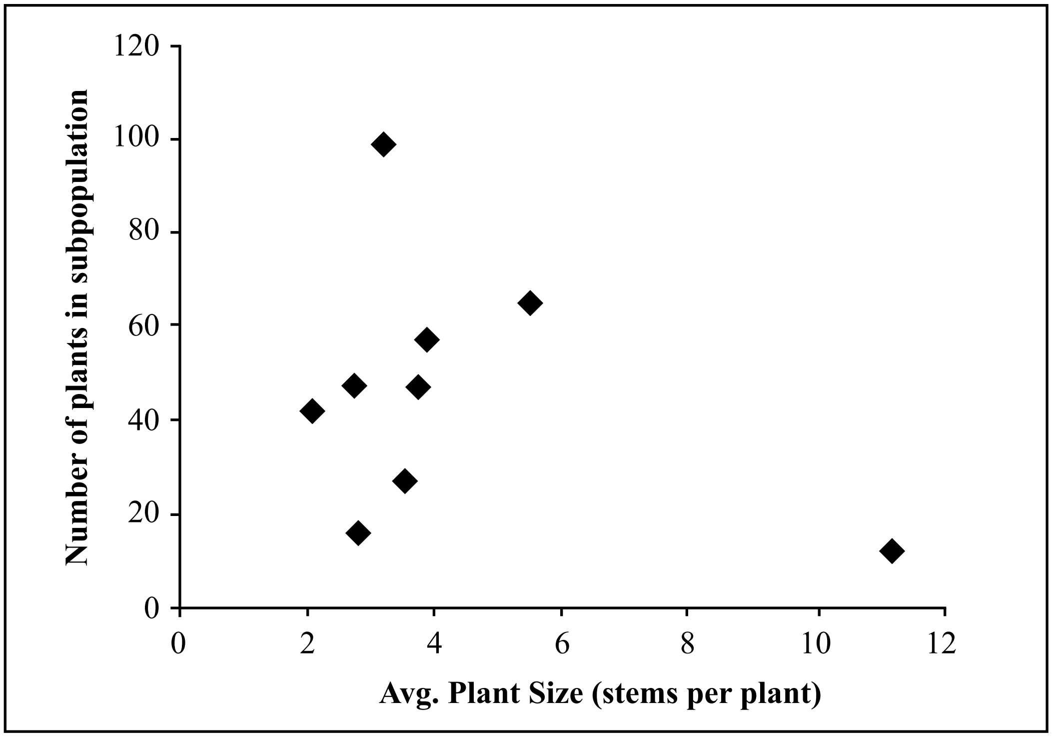


Figure 11. Population sizes of *Asclepias uncialis*.

Most *Asclepias uncialis* occurrences in Region 2 are small enough for the consequences of demographic, genetic, or environmental stochasticity to be important considerations. Variations in numbers and sizes of individuals both between populations and within a population over time are likely to be an important demographic character of *A. uncialis*. Because seedlings and non-flowering adults are difficult to see, populations may not be as variable as suggested by previous observations.

The recovery plan for the threatened *Asclepias* meadii (U.S. Fish and Wildlife Service 2003) includes criteria specifying the number and distribution of populations, population size, reproductive status, and genetic variability for viable populations of that species. Developing similar viability criteria for *A. uncialis* would require new research to define recruitment and mortality rates, and to quantify genetic diversity within and among occurrences.

Minimum viable population (MVP) theory was developed under the animal model of the sexually reproducing, obligate outcrossing individual, and it incorporated the effects of genetic stochasticity from elevated inbreeding coefficients in small population (Soulé 1980, Shaffer 1981). The MVP is the smallest population that has a very high chance of survival for the forseeable future (Primak 1995). Shaffer (1981) emphasized the probabilistic nature of the definition of a MVP, noting that survival probabilities and timeframes may be set at various levels (e.g., 95, 99, or 100 percent; 100, 1000, or 10,000 years). Different "rule-of-thumb" estimates for MVP have been suggested in response to the various types of uncertainty affecting populations (e.g., demographic, environmental or genetic stochasticity or large scale natural catastrophe; see Shaffer 1981) Suggested MVP numbers range from 50 to buffer demographic stochasticity, 500 to buffer genetic stochasticity (Franklin 1980), and up to 1,000,000 to buffer environmental stochasticity and natural catastrophes (Menges 1991).

This range of MVP estimates highlights the necessity of developing robust Population Viability Analysis (PVA) models for *Asclepias uncialis*. Such analyses, including estimates of MVP, require substantial data sets and an understanding of the links among environmental variability, demography, and genetics (Menges 1991). There are no Population Viability Analysis (PVA) models available for *A. uncialis*. Morris et al. (1999) discuss general classes of data sets and methods suitable for PVA including:

1) Count-based extinction analysis: Requires censuses of individuals in a single population for a minimum of 10 years (preferably more)

2) Multi-site extinction analysis: Requires counts from multiple populations, including a multi-year census from at least one of those populations

3) Projection matrix modeling: Requires detailed demographic information on individuals collected over three or more years (typically at only one or two sites).

There is clearly a tradeoff in the years required versus intensity of data collection. Currently there are no data sets available that could be used in a PVA of *A. uncialis*. Most occurrences appear to be at or below the generally accepted estimate of minimum viable size. Identification of a MVP could assist in the formation of quantitative management objectives.

Community ecology

Asclepias uncialis is always a minor component of the communities in which it occurs. Its small size and sparse distribution make it unlikely to be important as forage for grazers, and its short, early blooming period makes it unlikely to be an important source of pollen or nectar for insects. Observations of herbivory on *A. uncialis* are rare. In two instances in 1995, the disappearance of plants was attributed to herbivory (Locklear 1996a), and in both cases the entire aboveground portions of the plants were removed. Several plants were presumed to have been eaten by rabbits at Garden Park Fossil Site in 1995 (Colorado Natural Heritage Program 2004), and many plants disappeared over a two-week period in May at the Pueblo Reservoir South site although no herbivore was identified (Locklear 1996a). There have been no reports of domestic livestock grazing on *A. uncialis*. Plants with heavy insect damage were reported at the Piñon Canyon Maneuver Site (Rifici personal communication 2004), but no herbivore was identified. Insects that have been reported on *A. uncialis* include small ants, crab spiders, and Hesperiid butterflies (skippers) (Locklear 1991, Rifici personal communication 2004). Ants may be acting as nectar robbers, as they are known to do in some other milkweed species (Wyatt 1980). Nectar-robbing can lower the effectiveness of pollinator visits by reducing the amount of time that pollinators spend on the flower (Wyatt 1980), and it may have implications for the reproductive capacity of *A. uncialis*.

Asclepias uncialis is typically found in open spaces between other plants, which may indicate that it is not competitive in dense vegetation. Its diminutive stature may make it susceptible to shading by taller species. Its early flowering and fruiting period may be an adaptation to avoid competition. Because it is difficult to define a genetic individual in the field, it is hard to evaluate the extent of intraspecific competition in *A. uncialis*. Some occurrences appear to occur in clumps of up to several dozen plants. Individuals close to each other may be competing for resources, or they may be ramets growing from the same root crown. Clumps are scattered, and competition among individuals in different clumps is not likely to be as important as competition with neighboring individuals.

There have been no reports of parasites or disease in *Asclepias uncialis*. There is also no evidence of symbiotic or mutualistic interactions involving *A. uncialis*. However, these topics have never been investigated.

The potential role of natural disturbance in the biology of *Asclepias uncialis* is of great interest, but poorly understood. Several other milkweeds in subgenus *Asclepiodella* appear to be adapted to continual disturbance (Heil et al. 1989). *Asclepias uncialis*, however, does not appear to persist in heavily disturbed sites, but it is also not found in dense patches of prairie sod, implying that it may be best adapted to intermediate levels of disturbance (Locklear 1996a). *Asclepias uncialis* is probably adapted to historic disturbance regimes driven by the herds of large grazers and burrowing mammals characteristic of pre-settlement Great Plains ecosystems, as well as by frequent, light intensity fire (Collins and Glenn 1995, Hartnet and Keeler 1995).

CONSERVATION

Threats

Based on the available information, there are several threats to the persistence of *Asclepias uncialis* in Region 2. In order of decreasing priority, these are effects of population limitation by unknown biological requirements, altered disturbance regime, habitat loss, spread of exotic species, and global climate change. Most of these threats are also pertinent to occurrences that are yet be found. A lack of systematic tracking of population trends and conditions, and the lack of knowledge about the species' life cycle, abundance, and demographics means that we are ignorant of the degree to which these factors may threaten the long-term persistence of the species.

Population limitation by unknown biological requirements

Locklear (1996a) identified patterns of distribution and behavior exhibited by *Asclepias uncialis* that are of concern:

1) *Asclepias uncialis* is often missing from historical sites that retain other native vegetation. In these cases, the absence of *A. uncialis* may be due to causes peculiar to its biology, and not habitat degradation

2) Most of the known occurrences of *A. uncialis* are small and isolated from each other. Large areas of apparently suitable but unoccupied habitat separate occurrences. Gene flow among occurrences is unlikely and may lead to a decline in species viability over time

3) *Asclepias uncialis* exhibits extremely low rates of sexual reproduction, perhaps even lower than is characteristic of the genus.

There are several potential factors that could be operating to restrict population size in *Asclepias uncialis*, including inbreeding depression, pollinator loss, changes in the soil environment, lack of suitable germination sites, herbivory by introduced or previously uncommon taxa, and so on. It is likely that all occurrences of *A. uncialis* are vulnerable to such limitations, especially the smaller, more isolated occurrences. Without additional information on the biology of the species, we can only speculate on the possibilities.

Altered disturbance regime

Asclepias uncialis appears to tolerate, and may actually require, low levels of disturbance. Changes in grazing, fire frequency, and soil disturbance may result in individuals and populations experiencing disturbance conditions very different than those under which the species evolved. In consequence, substantial disturbance that significantly changes the native community is likely to eliminate occurrences of *A. uncialis*.

During its evolutionary history, the Great Plains experienced episodic heavy grazing pressure, first from the herbivores of the Pleistocene, and then from pre-settlement herds of bison and pronghorn, as well as prairie dogs and rabbits (Collins and Glenn 1995). There is little detailed information about what the plains were like before the advent of cattle ranching and settlement. Hart and Hart (1997) and Hart (2001) summarized observations of explorers and travelers on the plains from the late 16th to the mid 19th century. Historic reports indicated that density of bison herds (and of other large grazers such as pronghorn, elk, and deer) and intensity of grazing use did not typically follow seasonal patterns, but varied dramatically both within and between years. In addition to the landscape variation produced by large grazers, the occupation of perhaps 100 million acres by the black-tailed prairie dog (*Cynomys ludovicianus*) was a significant source of landscape heterogeneity (Kotliar et al. 1999). A shifting mosaic of vegetation patches differing in structure, composition, and quality may have been an important component of *Asclepias uncialis* habitat several hundred years ago. The known range of *A. uncialis* corresponds fairly closely to the southwestern quadrant of the historic range of the black-tailed prairie dog, and the dramatic reduction in populations of this animal might have contributed to the loss of habitat patches that are important for some stage of the *A. uncialis* life-cycle.

Grazing pressure from domestic cattle is typically more homogeneous in timing and intensity than that of wild grazers (The Nature Conservancy 1998). Most large herbivores probably do not directly affect individuals of *Asclepias uncialis*. Changes in patterns of grazing disturbance have the potential to alter environmental factors such as species composition, soil compaction, nutrient levels, and vegetation structure. Although we do not know the details of how domestic livestock grazing affects *A. uncialis*, the fact that the species is missing from areas that were subjected to long-term intensive grazing suggests a tolerance threshold beyond which it cannot persist. Almost all occurrences in Region 2 are on lands that are used for cattle grazing at least occasionally, and have been grazed for many years. Exceptions are the Withers Canyon occurrence on the Comanche National Grassland, and occurrences on military reservations at Fort Carson and Piñon Canyon. The occurrence on the Pawnee National Grassland is on an old cow trail, and the area has been grazed from May to October for many years (Humphrey personal communication 2006). The persistence of *A. uncialis* at this site indicates that it tolerates some level of domestic livestock grazing.

Fire suppression, especially in combination with heavy grazing that removes fine fuels, may allow the invasion of trees and shrubs into the prairie and eliminate open areas needed by *Asclepias uncialis*. Although juniper woodlands and savannas occur naturally on the landscape, changes in fire intensity and frequency, grazing, and climate have resulted in juniper trees occurring on sites that were once grasslands or open shrublands (Commons et al. 1999, West 1999). Many of the known occurrences are in ecotonal areas between grassland and juniper savanna that may be especially vulnerable to successional changes. Although some occurrences appear to persist in very open woodlands, the degree of canopy closure that *A. uncialis* can tolerate is unknown.

Historically, soil disturbance was largely the result of occasional concentrations of large native herbivores, or the digging action of fossorial mammals. *Asclepias uncialis* is likely to tolerate this type of disturbance, and any new type of disturbance that mimics it (Locklear personal communication 2004). Plants appear to tolerate infrequent vehicle use, such as two-tracks, or occasional passes by tanks; however, younger or smaller individuals may be killed by such disturbance. Although native communities are able to recover from occasional heavy disturbance during tank maneuvers (Milchunas et al. 1999) and at least one possibly disturbance-dependent species was able to expand into disturbed areas (Schulz and Shaw 1992), the long-term effects of such use are unknown. At least some of the occurrences at Fort Carson and Piñon Canyon Maneuver Site are likely to be exposed to disturbance by tanks during training maneuvers, especially if frequency of use increases. Conversely, deep soil disturbance (e.g., plowing, grading, excavating) probably kills most plants or weakens them by destroying rootstocks and underground connections and leaving them unable to resprout. Occurrences around Pueblo Reservoir may also be subject to deep soil disturbance during the construction of recreational facilities and access roads.

Habitat loss

Habitat loss may have contributed to the apparent decline in the abundance of *Asclepias uncialis* since the mid-1800s. When compared with the mid- and tallgrass prairie, the conversion of shortgrass prairie to agriculture is limited. Nevertheless, Knopf and Samson (1997) estimated that 29 percent of the native shortgrass prairie in the United States has been converted to cropland or pasture. An analysis of satellite imagery for the Central Shortgrass Prairie (The Nature Conservancy 1998) indicated that only about 40 percent of the ecoregion remains in relatively large and intact parcels, unfragmented by tilling. Because *A. uncialis* apparently does not persist in lands converted to agriculture, this threat has probably affected *A. uncialis* occurrences in the past. The current rate of conversion of native grassland to agriculture is low, but this is driven in part by market prices and remains a possibility in some areas (The Nature Conservancy 1998).

Another widespread source of habitat loss in eastern Colorado is the development of oil and gas resources. The Denver-Julesberg basin is the most active area in the state in terms of natural gas well permits and production (Colorado Oil and Gas Conservation Commission 2004). Currently most activity in eastern Colorado is concentrated in the Wattenberg field in southwestern Weld County and in Yuma County (**Figure 12**). The number of inactive wells in the basin shows that past drilling activities have probably altered habitat for a substantial portion of *Asclepias uncialis* habitat in northeastern Colorado.

Spread of exotic species

In the range of *Asclepias uncialis*, invasive species are most prevalent in areas disturbed by cultivation, especially in northeastern Colorado. The Nature Conservancy (1998) identified the major problem weeds in grasslands of the Central Shortgrass Prairie Ecoregion as leafy spurge (*Euphorbia esula*), cheatgrass (*Bromus tectorum*), Russian thistle (*Salsola kali*), musk thistle (*Carduus nutans*), Canada thistle (*Cirsium canadensis*), knapweed (*Centaurea* spp.), and toadflax (*Linaria dalmatica*). Of these, only cheatgrass has been reported occurring with *A. uncialis*, although invasives may be present but undocumented at other occurrences. The potential for exotic species to spread into *A. uncialis* occurrences has been mentioned in connection with occurrences at Pueblo Reservoir, Garden Park, and the Piñon Canyon Maneuver Site. The potential interaction of *A. uncialis* with exotic species has not been investigated. This species is typically not found in weedy areas, indicating that it may be sensitive to this form of habitat degradation.

Broadleaf weeds are commonly treated by spraying with herbicides such as picloram (Tordon), clopyralid, and 2,4-D (Colorado Natural Areas Program 2000). Broadcast treatments are likely to kill any *Asclepias uncialis* plants growing in the treated area.

Global climate change

Habitat contraction induced by global climate change could affect the long-term survival of *Asclepias uncialis*. Most of the range of *A. uncialis* is in a grassland ecosystem, with small inclusions of shrubland, woodland and arid lands, especially in the southwestern part of the range. Under two widely-used

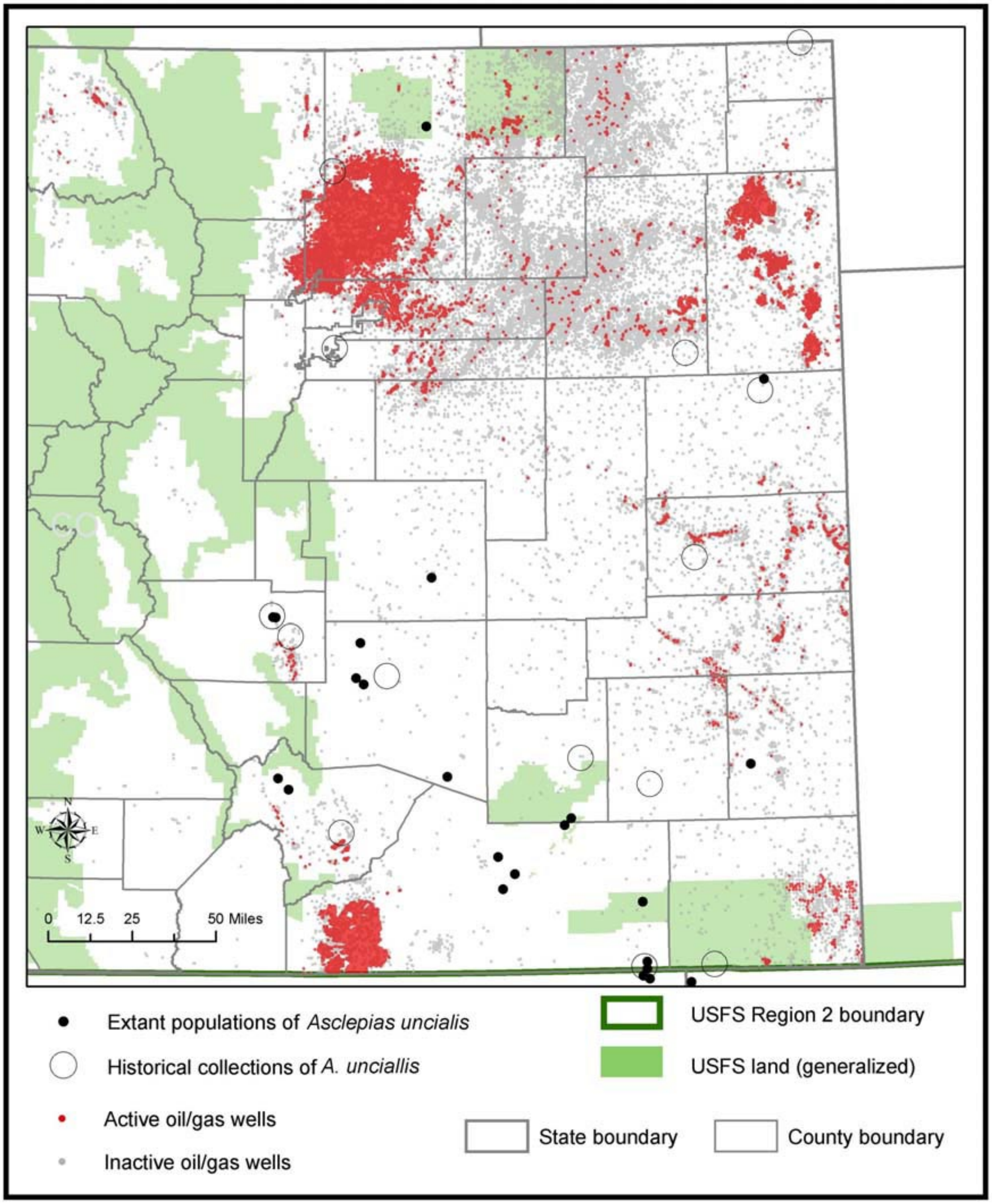


Figure 12. Oil and gas development in eastern Colorado relative to historic and extant occurrences of *Asclepias uncialis*.

climate change models (National Assessment Synthesis Team 2000), as levels of atmospheric CO_2 increase, the predicted scenario for much of this species' range is a shift away from grassland to either shrubland/woodland (under increased precipitation conditions) or arid land (under decreased precipitation). Change in either direction may harm *A. uncialis* if it is unable to persist in more densely vegetated areas or under conditions of reduced soil moisture.

Conservation Status of Asclepias uncialis in Region 2

Although documented population numbers are very low, the lack of repeat observations of *Asclepias uncialis* occurrences, and the fact that the existence of additional occurrences is likely but unconfirmed, makes it impossible to substantiate a population decline within Region 2. There is likewise no evidence that populations are expanding or remaining stable. The absence of *A. uncialis* from large areas of apparently suitable habitat points to the operation of unidentified factors controlling the distribution of the species. The current perception of the insecure status of the species in Region 2 arises from the low number of widely scattered occurrences, the small size of these occurrences, and the disappearance of the species from many historic locations.

Occurrences of *Asclepias uncialis* in Region 2 are generally small (fewer than 50 individuals), and it is unclear how many genetic individuals are represented by reported counts. Small populations are often vulnerable to genetic, demographic, and environmental stochasticity (Menges 1991). For most occurrences with population size estimates, numbers appear to be insufficient to buffer genetic and demographic stochasticity. The relatively long life span of *A. uncialis* plants may give the species some tolerance of environmental stochasticity. The degree to which plants can survive bad years may depend largely on how long their rhizomes persist in unfavorable conditions or how long their seeds remain dormant. These factors have not been investigated. The low reproductive capacity of *A. uncialis* will limit its ability to recover from catastrophic events or prolonged poor conditions. The total population size in Region 2 is also very small (perhaps fewer than 700 individuals), and occurrences are isolated from each other, making the recolonization of extirpated sites unlikely without human intervention. Stochastic processes and normal environmental variation could cause the extirpation of any of the Region 2 occurrences, regardless of protective status.

Management of Asclepias uncialis in Region 2

Implications and potential conservation elements

Asclepias uncialis is of interest to conservationists as one of the few endemic or near-endemic plants of the Great Plains. Its pattern of distribution is sufficiently unusual to be noteworthy from a biogeographical standpoint. Although very little is known about the response of *A. uncialis* to changes in the environment, anecdotal evidence suggests that it requires intact native habitat, and that it has not persisted in areas that have been converted to cropland, even if those lands are no longer used for such activities. *Asclepias uncialis* has not been found in crop field margins, roadsides, or Conservation Reserve Program (CRP) land (Crawford personal communication 2004). Disturbance that does not substantially degrade the native habitat may be tolerated or even required by *A. uncialis*. More information is needed to determine the appropriate management practices on this issue. At the very least, management activities should strive to maintain intact native habitat for known occurrences and surrounding areas.

Additional surveys could confirm or disprove the perception of some botanists that the plant is probably much more abundant and widespread than it currently appears to be. Before appropriate conservation elements can be formulated, survey and research work is needed to address a series of questions about the distribution, abundance, dynamics, and population ecology of the species. The answers to the first questions will determine the need to address the subsequent questions:

1. How rare is the species? Are there really only a few dozen occurrences, most with very few plants, or are many occurrences undocumented and overlooked? If *Asclepias uncialis* is as rare as current documentation suggests (<700 known individuals in 30 occurrences), it may require additional legal protection and vigilant management to ensure its persistence.

2. What is a typical occurrence size? Are occurrences really as small as they appear to be, or have non-flowering individuals been missed during surveys? If most occurrences include fewer than 50 individuals, genetic and demographic stochasticity may threaten the persistence of the species.

3. How do population numbers vary over time? How long does the species normally persist at a site? Is the species stable or declining? Repeated observations of *Asclepias uncialis* occurrences and detailed data on population demography will help land managers to identify the best conservation targets (i.e., stable populations), and to determine how critical protection is for those occurrences. Research and experimentation are needed to clarify the relationship of the species to historic types of disturbance, such as prairie dog colonization.

4. If *Asclepias uncialis* populations are declining, can the decline be tied to habitat conditions and/or management practices, or to natural processes that are no longer able to operate? If population monitoring can quantify long-term trends for the species, repeated measurements of environmental conditions and the effects of management practices for monitored occurrences may allow land managers to detect factors that are negatively impacting the species.

5. If management practices are having a negative effect on *Asclepias uncialis*, how should they be altered to prevent harm to the species? Observations of occurrences under a variety of conditions and management scenarios could help to identify specific management practices that are favorable for the persistence of *A. uncialis*.

6. If management practices are not affecting species stability, what is? Detailed investigation of the population genetics, pollination ecology, response to natural disturbance, and other factors may be able to identify appropriate conservation tactics.

For occurrences of *Asclepias uncialis* on National Forest System land, the USFS has several options for conservation:

- ❖ continued listing as a sensitive species
- ❖ regulation of occupancy and use of National Forest System lands where it is found
- ❖ implementing or improving Land and Resource Management Plan standards and guidelines that apply to lands where *A. uncialis* occurs
- ❖ increasing the protective nature of management designations for lands that support occurrences
- ❖ identifying and cooperating in potential land exchanges or purchases that would bring occurrences under USFS management
- ❖ providing opportunities for off-site conservation of *A. uncialis* through seed collection or vegetative propagation
- ❖ potentially providing opportunities for establishment of additional populations for conservation purposes.

Tools and practices

Before research on the biology of *Asclepias uncialis* can begin, occurrences suitable for such activities must be located. Consequently, species inventory is a priority. Occurrences of *A. uncialis* at known sites need to be monitored for changes in abundance and to gain an understanding of the phenology and pollination ecology of this species.

Species inventory

National Forest System lands should have priority for *Asclepias uncialis* inventory since they contain abundant suitable habitat and small occurrences have already been found on both the Pawnee and Comanche national grasslands. The USFS could make a substantial contribution to the conservation of this species if additional occurrences can be located on National Forest System land. Both national grasslands should be formally surveyed since they are likely to contain additional occurrences, and because occurrences would be available for research. Immediate needs for *A. uncialis* are to locate occurrences that 1) are large enough for monitoring and ecological and demographic research, 2) are not immediately threatened, and 3) are in land tenure that is amenable to this research. Other priority areas are public lands near known occurrences that contain similar habitat. More complete knowledge of the distribution and abundance of *A. uncialis* will insure that the most viable occurrences are protected across the range of the species and that any population restoration goals are appropriate. If substantial new occurrences cannot be located, it may be that this species is declining and in need of federal protection.

Existing protocols for species inventory are primarily based on surveys for rare, threatened, or endangered species. Although not rigorously standardized, these methods all include the same basic principles. The following methods are adapted from U.S. Fish and Wildlife Service (2000), California Native Plant Society (2001), and Cypher (2002).

Plant surveys usually attempt to target all species of concern in an area. In the case of inventory for *Asclepias uncialis*, this practice may not be feasible since it blooms earlier than many other species, and its diminutive stature requires the full concentration of searchers for successful inventory. Inventory techniques should attempt to maximize the potential discovery of the targeted species in the survey area by:

1. <u>Identifying areas that are most likely to contain occurrences</u>. Because detailed microsite requirements (if any) are not known for *Asclepias uncialis*, it may be difficult to refine search areas as other than "intact shortgrass prairie" or "grassland inclusions in pinyon-juniper woodland." Searchers can begin with areas similar to known occurrences; however, potential habitat should not be omitted just because it is not exactly like known habitat. Although Locklear has already resurveyed all historical sites, it is possible that *A. uncialis* may yet be found in some of these areas. It is also important for future searches to expand to previously unsurveyed sites.

2. <u>Searching at the time when plants are most visible</u>. For *Asclepias uncialis*, this is during peak flowering period, in the first half of May. Before beginning surveys in a given year, at least one member of the survey crew should visit known occurrences of *A. uncialis* that occur in areas similar in elevation, latitude, vegetation, and topography to the survey area to determine whether precipitation has been adequate for germination and growth, as well as to confirm the current phenology of the target species. Due to the cryptic nature of non-flowering *A. uncialis* plants, searching for occurrences at other times of the year would be extremely inefficient.

3. <u>Employing searchers who are familiar with the plant</u>. Field survey crews should include at least one member who has seen *Asclepias uncialis* growing in its natural habitat. Photographs and/or herbarium specimens may be used to familiarize other team members with the plant if necessary, but the cryptic nature of the species makes it advisable for all search team members to form a search-image directly from a living specimen *in situ* whenever possible.

4. <u>Systematically covering the area to be searched</u>. Because *Asclepias uncialis* is difficult to find and identify when it is not in flower, surveys should only take place during the period of maximum flowering. Intensive, systematic surveys will probably be required. Common techniques involve searchers walking parallel transects spaced 5 to 10 m (16 to 33 ft.) apart throughout an entire site, regardless of subjective habitat evaluations. Depending on local vegetation conditions, this distance may need to be revised downward.

The return from the effort invested in species inventory should be maximized by careful documentation of results. Survey reports need to document the locations that were visited, the date of the visit, number and condition of individuals in the occurrence, habitat and associated species information, evidence of disease or predation, and any other pertinent observations. When a new occurrence of *Asclepias uncialis* is located, a completed element occurrence report form for the appropriate state, accompanied by a copy of the appropriate portion of a 7.5-minute topographic map with the occurrence boundaries marked as accurately as possible, should submitted to the Heritage Program of the state in which the population was found. When appropriate, voucher specimens should be collected and submitted to regional herbaria. In some cases, a piece of the aboveground portion of the plant may be sufficient for identification by experts. Regardless of occurrence size, voucher photographs should be taken, and the location should be determined as exactly as possible. Occurrences located on National Forest System lands can be permanently marked in some way, to facilitate population monitoring. The use of multiple markers (e.g., corner stakes) and Global Positioning System coordinates can help in relocating occurrences. It is also important to document unsuccessful searches (i.e., date, general vegetation condition, search methods, and other observations). Negative results are not a guarantee that the plant is absent from an area.

Habitat inventory

Until we have a better understanding of this species' microhabitat requirements, habitat inventory is of secondary importance for *Asclepias uncialis*. Although there has probably been loss of habitat, much apparently suitable but unoccupied habitat remains, especially in southeastern Colorado. Until the question of why this habitat is unoccupied is resolved, it is not critical to perform habitat surveys beyond identifying likely search areas. Current georeferenced spatial datasets for vegetation types are adequate for locating shortgrass prairie habitat, at least in Colorado. More information about habitat types in New Mexico and Arizona is needed before inventory is practical in those states.

Survey of known occurrences could collect habitat characterization data such as vegetation cover type and percent, disturbance, soil types, and other environmental conditions. Data may need to be collected over several different years in order to capture natural variation, or to detect important patterns. This type of investigation would be ideal for graduate students or volunteer researchers.

Population monitoring

Monitoring population trends and the effects of management would provide immediately useful information to land managers. Monitoring sites with a variety of land uses will help managers to identify appropriate management practices for *Asclepias uncialis* and to understand its population dynamics and structure. To be effective, the implementation of a monitoring program must be accompanied by a commitment by the managing agency to adjust management practices based on the results.

Population monitoring that generates demographic data is also an important tool for the conservation of *Asclepias uncialis*. It may be most effective to choose a few populations for intensive demographic monitoring while visiting other occurrences annually to determine presence/absence. Population monitoring could be combined with other research on the biology and community ecology of the species. Techniques that track marked individuals or patches are critical to determining the conservation needs of this species. Some methods developed for the study of the threatened *A. meadii* can be adapted for use with *A. uncialis*. Researchers found it difficult to assess the status of *A. meadii* populations because individuals were difficult to identify, and difficult to locate in their characteristic habitat (Kettle et al. 2000). The same difficulties are likely to be encountered by workers investigating *A. uncialis*. The growth form of *A. uncialis*, where apparently separate plants may be connected to the same rootstock, makes it difficult to distinguish genetic individuals. In addition, stems that are not flowering are hard to see. The cryptic nature of non-flowering stems is likely to result in poor estimates of population size, as well as an estimated age distribution that is largely devoid of seedlings and juvenile plants.

Regardless of the difficulties, monitoring is the only means of obtaining reliable estimates of population trends and demographic parameters. It took researchers monitoring *Asclepias meadii* populations several years to settle on appropriate techniques for marking and reading permanent plots. Similar experiences may be expected in any new monitoring study, but results can be improved by careful attention to detail in establishing and revisiting study locations. The following techniques are based on the methods developed by the *A. meadii* researchers, and methods used in other long-term monitoring studies (Naumann personal communication 2004). First year tasks may be accomplished over a period of two years, if necessary.

<u>Year 1</u>:

1. Identify suitable study locations. Criteria include ease of access, sufficient population size to generate reasonable data sets over time, but not so large as to prevent complete reading under normal circumstances.

2. Set up a grid network of permanent stakes that divides the occurrence into manageable areas. Record the exact coordinates of all permanent markers using GPS.

3. During the flowering period, systematically search for plants and mark them with permanent tags, using exactly the same technique (e.g., tag 10 cm south of plant) for each individual. Record the exact distance of each plant to the two nearest grid stakes.

4. If individual plants cannot be distinguished in a "patch", choose a protocol to identify patches (e.g., any two stems within 0.5 m of each other are part of the same patch), and mark them appropriately. Record stem number and position in patch. Diagrams can be used for clarity. Adjust this protocol as necessary for realistic data collection, but try to settle

on a method and stick to it. Consistency over time in data collection methods is one of the most critical factors in any long-term study.

5. Collect information about flowering status, vigor, and other parameters of interest.

6. Plan the study so that occurrences will be revisited a month after flowering so that fruit set can be determined.

7. Record general observations about the area (e.g., vegetation cover by species along a permanent transect, evidence of disturbance).

Year 2 and following years:

1. Revisit each marked occurrence during the flowering period. Relocate all marked plants or tags, noting flowering status and vigor.

2. Search for new plants or patches, and process them exactly the same as for plants discovered in year 1.

3. Record general observations about the area (e.g., vegetation cover by species along a permanent transect, evidence of disturbance).

4. Plan the study so that occurrences will be revisited a month after flowering so that fruit set can be determined.

Recent studies of cryptic, long-lived perennials have adapted mark-recapture techniques originally developed for the study of free-ranging animals (Alexander et al. 1997, Shefferson et al. 2001, Slade et al. 2003). This technique holds promise for the future study of *Asclepias uncialis* occurrences, but parameters required by the statistical models used must be collected in field studies of five to ten years duration.

Habitat monitoring

Until more exact habitat characterization can be obtained, it is appropriate to monitor the immediate habitat of known occurrences, rather than larger tracts of potential habitat. More research is needed to determine the effects of various management practices and natural disturbances on occurrences of *Asclepias uncialis*. Because it is not known if *A. uncialis* has specific habitat requirements beyond intact native vegetation, it is not appropriate to suggest detailed management actions that may or may not benefit the species. It is likely that management actions that maintain native grassland dynamics will generally benefit *A. uncialis*. Sites should have a mosaic of vegetation that is in different stages of recovery from disturbance, and be dominated by native species. Alteration from pre-settlement conditions (e.g., tilled areas, roads, oil and gas wells, windmills, stock ponds, fences) should be minimal. A variety of habitat monitoring techniques are described in Elzinga et al. (1998).

Off-site conservation

No seeds or genetic material of *Asclepias uncialis* are stored at the National Center for Genetic Resource Preservation (Miller personal communication 2004). It is not among the National Collection of Endangered Plants maintained by the Center for Plant Conservation (Center for Plant Conservation 2002). Because of the low fruiting rate of *A. uncialis*, any seed collection should be conservative and used only to make a substantial contribution to our knowledge of the species or its restoration.

Information Needs

Distribution

At this time our knowledge regarding the extent of *Asclepias uncialis* distribution is accurate only on a broad scale. Within the known distribution, accurate information on the real abundance and extent of the species is needed. It will be difficult to formulate conservation strategies for Region 2 without clarifying this issue. It is important to identify large occurrences on public lands that can be earmarked as priorities for protection. It would be useful to determine the relationship of *A. uncialis* occurrences to areas that have been or are currently disturbed by prairie dogs. More complete information on the environmental characters influencing distribution patterns would be helpful in formulating management strategies.

Life cycle, habitat, and population trend

The dynamics of the grassland and savanna habitat types where *Asclepias uncialis* is found are reasonably well studied. The specific position of *A. uncialis* within these ecological systems is not well understood. Furthermore, although the species has been casually observed in the field for many years by a variety of workers, there are no multi-year observations that would contribute to an understanding of the species' life cycle or population trends. Some inferences can be made from other *Asclepias* species, but members of this genus often exhibit restricted ranges, which may indicate local adaptation and differentiation.

Repeated observations of marked individuals in multiple occurrences could greatly clarify the population dynamics of *Asclepias uncialis*. In particular, it would be useful to identify the extent of vegetative reproduction, rates of sexual reproduction, germination requirements, life expectancy, seed bank dynamics, and transition probabilities for different life-cycle stages. The development of an elasticity analysis could identify the critical stages of the life cycle and aid in the identification of threats to the persistence of *A. uncialis*. Similarly, multi-year census or tracking efforts for a subset of occurrences would greatly facilitate the quantification of population trends for the species as a whole.

Response to change

The effects of environmental variation on the reproductive rates, dispersal mechanisms, and establishment success of *Asclepias uncialis* have not been investigated. The same is true for its relationship with pollinators, herbivores, and exotic species. As a consequence, the effects of both fine- and broad-scale habitat change in response to management or disturbance will be difficult to evaluate. Detailed information on the habitat requirements of *A. uncialis* will enable better understanding of the potential effects of disturbance and management actions in these habitats. In particular, the response of the species to soil disturbances of varying intensity and duration should be investigated, especially in relation to historic disturbances by prairie dogs or bison. Because disturbances can easily be followed by an increase in invasive species, additional information on the effects of these invaders on the habitat and life cycle of *A. uncialis* is also needed. The effects of grazing by both domestic livestock and bison and of fire suppression on the dynamics and pollination ecology of *A. uncialis* are also of interest.

Metapopulation dynamics

The apparent tendency of *Asclepias uncialis* to occur in scattered, small occurrences and for occurrences to apparently vanish from known localities where habitat remains suitable may mean that metapopulation dynamics are especially important to the survival of this species. Virtually nothing is known about the metapopulation structure and processes of *A. uncialis*. It is not even clear if the known occurrences can act as a metapopulation. Baseline studies should collect data on migration, colonization, and extinction rates, as well as environmental factors contributing to the maintenance of inter-population connectivity. Until this information is available, we cannot realistically predict the likelihood of *A. uncialis* persisting at either the local or regional scale.

Demography

As with metapopulation dynamics, current demographic information is also not sufficient to predict the persistence of *Asclepias uncialis* at either the local or regional scale. The most useful demographic information would include 1) the determination of whether individual and population numbers are increasing, declining, or stable, 2) the identification of which life cycle stages have the greatest influence on population trends, and 3) what are the biological and ecological factors that influence the important stages (Schemske et al. 1994). It is especially important to identify and track seedlings, juvenile plants, and non-flowering adults. Research on the rare *A. meadii* (Tecic et al. 1998, Kettle et al. 2000, Slade et al. 2003) provides a good model for similar long-term study of *A. uncialis*. Collection of useful demographic data will require the investment of at least five to ten years, ideally more. While providing useful data, short-term studies can miss important demographic events that reoccur at intervals longer than the study period (Coles and Naumann 2000).

Population trend monitoring methods

A variety of population monitoring methods could be easily adapted to the tracking of *Asclepias uncialis*. Pilot studies may be required to adapt some methods to the particular growth and distribution patterns of *A. uncialis*.

Restoration methods

Restoration methods have not been developed specifically for *Asclepias uncialis*. Researchers investigating restoration methods for the rare *A. meadii* found that seedling success was significantly affected by weather, competition from annual oats (*Avena sativa*), and the genetic composition of the seedling (Bowles et al. 1998). Seedling survivorship in the field varied from 11 percent or less in poor rainfall years, to 40 percent in an exceptionally wet year. Individuals planted as juveniles were more successful than those planted as seedlings, as were artificially outcrossed seedlings. Bowles et al. (1998) concluded that restoration of *A. meadii* populations might require management as a metapopulation, since the restoration of genetic diversity for this species would require mixing seeds from different geographic locations, potentially disrupting locally adapted genotypes. Similar considerations are likely to be important in developing restoration methods for *A. uncialis*.

Research priorities for Region 2

Research priorities for *Asclepias uncialis* in Region 2 are, in order of priority, population inventory, population monitoring at a level sufficient to determine trends, identification of critical habitat factors (if any), demographic studies sufficient to perform elasticity analyses, and quantification of the effects of land management practices on the survival and persistence of the species.

Additional research and data resources

Data on the Fort Carson occurrences that could be compared to occurrences at the Piñon Canyon Maneuver Site were unavailable for this assessment. The forthcoming treatment of the Asclepiadaceae in volume 14 of the Flora of North America is expected to clarify the taxonomic status of the *Asclepias uncialis* group.

DEFINITIONS

Corolla – The collective name for all of the petals of a flower; the inner whorl of perianth segments (Harris and Harris 1994).

Corona – Petal-like or crown-like structures between the petals and stamens in some flowers (Harris and Harris 1994).

Follicle – A dry, dehiscent fruit composed of a single carpel and opening along a single side, as a milkweed pod (Harris and Harris 1994).

Heterophylly – The condition of having different kinds of leaves on the same plant (Harris and Harris 1994).

Heterozygous – having two different alleles of the same gene.

Hood – The hollow, arched, petal-like segment of a corona.

Horn – An inwardly curved, pointed appendage within the hood (Bookman 1981).

Inbreeding depression – A decrease in vigor among offspring after inbreeding, due to an increase in the expression of deleterious genes resulting from homozygosity.

Outcrossing – Mating between different individuals, implying that the individuals are sufficiently genetically different that progeny are highly heterozygous.

Perfect – Flowers that include both male and female structures; bisexual (Weber and Wittmann 2001).

Pollinium – One of the two pollen bearing sacs that together with the corpusculum and translator arms form the pollinarium of milkweeds (Bookman 1981).

Potential Conservation Area (PCA) – A best estimate of the primary area supporting the long-term survival of targeted species or natural communities. PCAs are circumscribed for planning purposes only (Colorado Natural Heritage Program Site Committee 2002).

Sympatric – Applied to species whose habitats (ranges) overlap (Allaby 1998).

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APPENDIX: CHRONOLOGY OF KNOWLEDGE OF *ASCLEPIAS UNCIALIS*

(Adapted from Locklear 1996a).

1820-46 Botanical explorers James, Fremont, Abert, Fendler, and Emory cross the plains of eastern Colorado, their expeditions reaching Colorado in July, August, or September, well after the flowering period of *Asclepias uncialis*.

1848 Alexander Gordon collects *Asclepias uncialis* at "Canadian River" in April near Raton, NM; labeled "*Asclepias*" (MO).

1858 Gold discovered in Colorado; Denver City founded; stage coach lines to Denver begin operating, allowing travel across the plains in the spring.

1859 *Asclepias brachystephana* described.

1860 Travel over "Fort Morgan Cut-off" between Fort Morgan and Denver begins.

1861 Charles Parry's first trip to Colorado Territory. Undated Parry collection of *Asclepias uncialis* at MO states, "Cut off near Denver"; labeled "*Asclepias brachystephana*?"

1862 Hall & Harbour, accompanying Parry to Colorado, collect *Asclepias uncialis* at "Great Plains, Lat. 41"; labeled "*Asclepias brachystephana*."

1873 Parry collects *Asclepias uncialis* on the Green River in southwest Wyoming; labeled "*Asclepias brachystephana*"; collected "June" (GH, ISC).

1874 Porter and Coulter's Synopsis of the Flora of Colorado lists *Asclepias brachystephana*, citing Hall & Harbour's collection and stating, "On the plains." *Asclepias brachystephana* remains in Colorado botanical literature until Weber's Rocky Mountain Flora (1976).

1877 Townsend Brandegee collects *Asclepias uncialis* at two locations near Canon City, Colorado; labeled "*A. brachystephana*" and "*Asclepias*?" (MO, UC).

1880 Edward Greene describes *Asclepias uncialis* from Silver City, NM, collections.

1885 Coulter's Botany of the Rocky Mountain Region lists *Asclepias brachystephana* ("from Wyoming and Colorado to Arizona and Texas") and *A. uncialis* ("Wyoming, Colorado, and New Mexico", citing Greene's paper).

1896 Aven Nelson's First Report on the Flora of Wyoming lists *Asclepias uncialis* and *A. brachystephana* (citing Parry's 1877 collection) as "Plants Reported by Other Collectors."

1906 Rydberg's Flora of Colorado lists *Asclepias brachystephana* ("Wyo. to Tex. and Ariz.") and *A. uncialis* ("Wyoming to Arizona and New Mexico," citing Hall & Harbour's collection).

1915 Wooton and Standley's Flora of New Mexico includes *Asclepias uncialis* ("Wyoming to Arizona and New Mexico").

1941 Maguire and Woodson describe *Asclepias ruthiae* from Emery Co. Utah.

1945 Barneby describes *Asclepias eastwoodiana* from Lander Co. Nevada.

1951 Kearny and Peebles Arizona Flora includes *Asclepias uncialis* ("Wyoming to New Mexico and eastern Arizona"), but not *A. ruthiae*.

1954 R.E. Woodson, Jr. publishes "The North American Species of *Asclepias*." Clarifies distribution of *A. brachystephana* ("Western Texas and southern New Mexico and Arizona; Coahuila to Sonora and southward to Guanajuato") and *A. uncialis* ("Eastern Colorado and southwestern New Mexico"). Includes *A. eastwoodiana* as a synonym of *A. ruthiae*, with a range of "Utah and central Nevada".

1981 Martin and Hutchins, A flora of New Mexico, vol. 2. includes *Asclepias uncialis* ("Wyoming to New Mexico, Utah, and Arizona"). They describe a larger, later-blooming plant.

1984 Cronquist et al., Intermountain Flora, Volume 4 includes *Asclepias ruthiae* ("se. Utah to n. Ariz."), and *A. eastwoodiana* ("endemic to c. Nev.").

1986 Ron Hartman's treatment in Great Plains Flora includes *Asclepias uncialis* with a distribution of "CO: Baca, Cheyenne, Denver, Pueblo, Weld" counties, and, incorrectly, Texas County, OK.

1987 Welsh Utah Flora, first edition includes *Asclepias ruthiae* ("a Navajo Basin endemic").

1989 Locklear surveys historical localities of *Asclepias uncialis* in Kit Carson and Baca Counties, Colorado.

1989 Heil et al. describe *Asclepias sanjuanensis* ("pinyon-juniper woodlands of the San Juan River Valley, San Juan County, New Mexico").

1990 Locklear surveys historical localities of *Asclepias uncialis* in southeast Colorado and northeast New Mexico.

1990 Eric Sundell, in preparing a treatment of the Asclepiadaceae for the Arizona flora project, revises the *Asclepias uncialis* complex into *A. uncialis* var. *ruthiae* (including *A. ruthiae*, *A. eastwoodiana*, and *A. sanjuanensis*), and *A. uncialis* var. *uncialis*.

1991 Locklear's first status report treats *Asclepias uncialis* in the strict sense, excluding the other members of the complex, disagrees with Sundell on morphological characters. This report collates the information regarding *A. uncialis* from 45 major and minor herbaria, as far as is known reviewing the great bulk of field collections for this species.

1991 Kartesz and Gandhi revised variety to subspecies for *Asclepias uncialis* ssp. *ruthiae* and ssp. *uncialis*.

1992 Locklear surveys historic localities of *Asclepias uncialis* in northeast Colorado.

1993 Welsh Utah Flora (second edition) continues to treat *Asclepias ruthiae* as a full species.

1994 Sundell's treatment of Asclepiadaceae published in Journal of the Arizona-Nevada Academy of Science gives var. *uncialis* and var. *ruthiae*.

1995 Locklear surveys historic localities of *Asclepias uncialis* additional historically known sites and revisits known extant populations.

1996 Locklear's second status report summarizes results of field surveys and additional herbarium searches.

1998 James Therrien investigates genetic diversity and taxonomic status of the four taxa in the *Asclepias uncialis* complex. This unpublished study concludes that *A. uncialis* forms a monophyletic group.

2009? Flora of North America (volume 14) treatment of Asclepiadaceae by Mark Fishbein and Steve Lynch, expected to treat the complex as at least three distinct species: *Asclepias uncialis*, *A. ruthiae*, and *A. eastwoodiana* (disposition of *A. sanjuanensis* uncertain).