Cirsium perplexans (Rydb.) Petrak (Rocky Mountain thistle): A Technical Conservation Assessment

Prepared for the USDA Forest Service, Rocky Mountain Region, Species Conservation Project

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Authors' Biographies

Susan Spackman Panjabi is a botanist with the Colorado Natural Heritage Program at Colorado State University in Fort Collins. Ms. Panjabi's work there includes building the international Biodiversity Tracking and Conservation System with information on the location and condition of 500 rare, threatened, and endangered plant species known to occur in Colorado. She has conducted biological inventories and rare plant surveys for various public agencies and private organizations such as the Bureau of Land Management, the USDA Forest Service, The Nature Conservancy, the American Mountain Foundation, and the Summit, Pueblo, and Pitkin county planning departments. She has worked with the Colorado Natural Heritage Program for eleven years. Ms. Panjabi received her B.A. in Environmental Conservation from the University of Colorado, Boulder (1982) and her M.S. in Botany from the University of Vermont, Burlington (1993).

David G. Anderson is the Botany Team Leader with the Colorado Natural Heritage Program. Mr. Anderson's work there includes inventory and mapping of rare plants throughout Colorado, mapping weeds, maintaining and updating the heritage program's database, and writing reports on the rare plants of Colorado. He has worked with Colorado Natural Heritage Program for five years. Much of Mr. Anderson's prior experience comes from five years of fieldwork studying the flora and ecosystem processes of the Alaskan and Canadian Arctic. Mr. Anderson also served in the Peace Corps as a science teacher in the Solomon Islands from 1996 to 1998. Mr. Anderson received his B.A. in Environmental, Populational, and Organismic Biology from the University of Colorado, Boulder (1991) and his M.S. in Botany from the University of Washington, Seattle (1996).

Cover Photo Credit

Cirsium perplexans (Rocky Mountain thistle). Photograph by Mike Klish. Used with permission.

Summary of Key Components for Conservation of *Cirsium perplexans*

Status

Cirsium perplexans (Rocky Mountain thistle) is a local endemic whose global distribution is restricted to western Colorado. It is designated a sensitive species in Region 2 of the USDA Forest Service. NatureServe considers it to be globally imperiled (G2), and because it is only found in Colorado, *C. perplexans* is also considered imperiled (S2) by the Colorado Natural Heritage Program. The most current data available suggest that *C. perplexans* is imperiled due to the small number of occurrences and small population sizes. Thus, the loss of any population is significant and could result in the loss of important components of the genetic diversity of the species. The primary threats to *C. perplexans* include the use of biological control and herbicides in the management of non-native *Cirsium* species, invasions of non-native plant species, and impacts from recreational, agricultural, industrial, and residential land uses.

Although there is insufficient evidence for recommending federal listing of this species under the Endangered Species Act of 1973 (U.S.C 1531-1536, 1538 -1540), *Cirsium perplexans* remains vulnerable in many portions of its range. It is clear that the biology and ecology of this species is poorly known. Management strategies will need to be coupled with long-term biological monitoring programs to ascertain which management actions are effective. Without intervention through active management and without a better understanding of the natural history of this species and its habitat, it is very possible that *C. perplexans* could significantly decline over the next several decades.

Present research priorities include gathering baseline data on the distribution and population sizes for *Cirsium perplexans*. Identifying high quality occurrences of *C. perplexans* in which the size, condition, and landscape context are excellent will also help to prioritize conservation efforts for *C. perplexans*.

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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). *Cirsium perplexans* (Rocky Mountain thistle) is the focus of an assessment because it is designated a sensitive species in Region 2. 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 and/or habitat capability that would reduce its distribution (FSM 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 *Cirsium perplexans* throughout its range, all of which is within Region 2. This introduction defines the goal of the assessment, outlines scope, and describes the process used in its production.

Goal of Assessment

Species 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. It does provide the ecological background 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, it cites management recommendations proposed elsewhere, and when management recommendations have been implemented, the assessment examines the success of the implementation.

Scope of Assessment

This assessment examines the biology, ecology, conservation status, and management of *Cirsium perplexans* with specific reference to the geographic and ecological characteristics of the USFS Rocky Mountain Region. This assessment is concerned with reproductive behavior, population dynamics, and other characteristics of *C. perplexans* 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 in a current context.

In producing the assessment, refereed literature, non-refereed publications, research reports, and data accumulated by resource management agencies were reviewed. All known publications, reports, and element occurrence records on *Cirsium perplexans* are referenced in this assessment, and all of the experts on this species were consulted during its synthesis. The assessment emphasizes refereed literature because this is the accepted standard in science. Non-refereed publications and reports were used in the assessment when information was unavailable elsewhere, but these sources were regarded with greater skepticism. Unpublished data (e.g., state natural heritage program records) were important in estimating the geographic distribution. These data required special attention because of the diversity of persons and methods used in collection.

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. However, because our descriptions of the world are always incomplete and our observations are 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). However, 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 their use in the Species Conservation Project, species assessments are being published on the Region 2 World Wide Web site. Placing the documents on the Web makes them available to agency biologists and the public more rapidly than publishing them as reports. More important, it facilitates their revision, 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 their release on the Web. This assessment was reviewed through a process administered by the Society for Conservation Biology employing at least 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

Cirsium perplexans is designated a sensitive species in USFS Region 2. NatureServe considers it to be globally imperiled (G2), and because it is only found in Colorado, *C. perplexans* is also considered imperiled (S2) by the Colorado Natural Heritage Program (NHP). It is considered imperiled because it is known from only 25 occurrences, over a limited range, and many of the known occurrences are very small. For explanations of NatureServe's ranking system, see the Definitions section of this document. *Cirsium perplexans* is not listed as threatened or endangered on the Federal Endangered Species List (U.S.C. 1536-1536, 1538-1540). It is included on the Bureau of Land Management (BLM) Colorado State Director's Sensitive Species List (U. S. Department of the Interior 2000, available at www.co.blm.gov). There is no state designation for this species.

Of the 25 known occurrences of *Cirsium perplexans*, only one is located on lands administered by the USFS, the Land's End Mountain location on the Gunnison National Forest in southeast Delta County, Colorado. Fifteen of the occurrences are located wholly or in part on lands administered by the BLM, eleven are wholly or in part on private lands, four are wholly or in part on State of Colorado lands, and one is on lands administered by the National Park Service (some of the locations have multiple land managers/owners). Two of the occurrences administered by the BLM are on lands that have special designations. The Pyramid Rock location is found within a BLM Area of Critical Environmental Concern (ACEC) and an adjacent State Designated Natural Area. The State Tunnel Dam location is found within the Gunnison Gorge National Conservation Area (NCA).

Existing Regulatory Mechanisms, Management Plans, and Conservation Strategies

To date, there are no regulatory mechanisms, management plans, or conservation strategies developed for *Cirsium perplexans*. The Pyramid Rock ACEC management plan does not mention *C. perplexans* because the plan was written in 1992, before the species was known from that location (Lambeth personal communication 2004). The Resource Management Plan for the Gunnison Gorge NCA is currently being drafted. The plan will mention *C. perplexans*, and the BLM has the broad goal of maintaining healthy populations of *C. perplexans* on the NCA (Ferguson personal communication 2004). However, specific management objectives for *C. perplexans* at the Gunnison Gorge NCA will not be addressed until subsequent, more specific plans are formulated (Ferguson personal communication 2004). The area that supports *C. perplexans* that is managed by the National Park Service is a campground, and there is no specific management for *C. perplexans* at this location. Similarly, the occurrences of *C. perplexans* that are found on lands managed by the State of Colorado do not have any special management plans or conservation strategies.

Adequacy of current laws and regulations

Laws are not adequate to protect *Cirsium perplexans* from issues that are resulting from efforts to control noxious weeds, including biological control and use of herbicides. Regarding biological control, at least two insects have been introduced widely in Colorado to control non-native thistles. These insects are now reducing seed production and population density of several native thistles. One of these insects, *Rhinocyllus conicus*, has been found feeding on *C. perplexans* (Dodge personal communication 2003). Current laws do not prevent further introductions of these biocontrol agents. Regarding the use of herbicides, while agencies and individuals may not intentionally spray native taxa such as *C. perplexans*, this species can be mistaken for *Cirsium* species that are noxious weeds (e.g., *C. arvense* [Canada thistle]), and education is needed to assure accurate identification of target species.

Alternatively, *Cirsium perplexans* could benefit from efforts to control noxious weeds that could threaten the occurrences (e.g., *C. arvense* at Cimarron State Wildlife Area). Federal, state, and local agencies and

local governing bodies are required to manage a specific set of noxious weeds (Colorado Noxious Weed Act, Title 35 Article 5.5, available at www.ag.state.co.us/DPI/publications). However, some of the non-native plants invading the occurrences of *C. perplexans* (e.g., *Bromus tectorum* [cheatgrass], Colorado Natural Heritage Program 2004) are not on the state list of noxious weeds that are required to be controlled.

Adequacy of current enforcement of laws and regulations

There have been no known cases in which an occurrence of *Cirsium perplexans* was extirpated due to human activities or the failure to enforce any existing regulations. However, this does not necessarily indicate that current regulations or their enforcement are adequate for its protection.

Biology and Ecology

Classification and description

Cirsium perplexans is a member of the sunflower family (Asteraceae, or Compositae). The Asteraceae is one of the largest families of flowering plants, second only to the Orchidaceae in size (Smith 1977). It includes approximately 1,100 genera and approximately 25,000 species (Heywood 1993). The taxonomy of the family is still in a state of transition as a result of recent analyses of morphological and molecular data (Heywood 1993, Zomlefer 1994). In fact, as recently as 1977 the family was reported to have only 920 genera and 19,000 species (Smith 1977). Some species have agricultural and economic significance, such as lettuce, artichokes, and sunflowers (Heywood 1993), though overall the family is of little economic importance given its size (Smith 1977). It is a family of world-wide distribution, but is infrequent in the tropical rain forests (Smith 1977, Cronquist et al. 1994), and it is absent from the Antarctic mainland (Heywood 1993). Species in the Asteraceae are abundant in arctic, alpine, temperate, and montane areas throughout the world. It is a diverse family that includes mostly herbaceous species as well as trees, shrubs, and lianas. Aquatic, marsh, and epiphytic species are uncommon. The Asteraceae is characterized by flowers arranged in head-like inflorescences made up of numerous individual flowers, all surrounded by an involucre of bracts. Other common family characteristics include milky or watery sap, leaves usually alternate or sometimes opposite and frequently in basal rosettes. The fruit is an achene with a persistent pappus.

The Asteraceae family is in the Dicotyledon group, subclass Asteridae, and order Asterales (Heywood 1993, USDA Natural Resources Conservation Service 2002). The Asteraceae have been divided into two subfamilies, and a new third subfamily has been proposed (Zomlefer 1994). *Cirsium* is in the subfamily Carduoideae (National Center for Biotechnology Information Taxonomy Browser 2002, available at www.ncbi.nlm.nih.gov). This subfamily has also been called Cichorioideae (Zomlefer 1994) and Lactucoideae (Heywood 1993, Zomlefer 1994). The Asteraceae family has been further divided into 13 or 14 tribes (Zomlefer 1994), and *Cirsium* is placed in the tribe Cardueae (Heywood 1993, Cronquist et al. 1994, Zomlefer 1994). This tribe has also been listed as Cynareae (Smith 1977, Dabydeen 1987), and it is synonymous with Cardueae (Zomlefer 1994).

The genus *Cirsium* includes 250 (Smith 1977) to 300 (Zomlefer 1994) species, and it is one of the largest genera in the Asteraceae family in North America (Zomlefer 1994), with 200 species native to the Northern Hemisphere and more than 70 species native to the United States (Cronquist et al. 1994). Weber and Wittmann (2000, 2001a, and 2001b) recognize 20 native species of *Cirsium* in Colorado, as well as the non-native species, *C. vulgare* and *Breea arvensis* (=*C. arvense*). The Colorado Natural Heritage Program tracks three rare species of *Cirsium* (*C. perplexans*, *C. ownbeyi*, and *C. barnebeyi*) in Colorado (Colorado Natural Heritage Program 2004).

The genus *Cirsium* and associated dichotomous keys are in need of taxonomic review (e.g., according to Harrington 1954, Cronquist et al.1994, Weber and Wittmann 2001a and 2001b). The genus is regarded as difficult and complex because of the intergradation of diagnostic characteristics (Dabydeen 1987, Cronquist et al. 1994). Further, many species in the genus have shown natural interspecific hybridization (Ownbey 1951, Davidson 1963, Ownbey 1964, Bloom 1977, Dabydeen 1987, Cronquist et al. 1994).

The most recent monograph of *Cirsium* of North America was done in 1917 by Petrak (Petrak 1917). He classified 62 species in five sections and further divided some of these into subsections and series (Moore and Frankton 1963). Since then there have been many new species described and much systematic revision of the genus, and a revision of the genus is wanting (Harrington 1954, Cronquist et al. 1994, Weber and Wittmann 2001a and 2001b).

Dr. David Keil with the California Polytechnic State University in San Luis Obispo is currently working on updating the treatment of *Cirsium* for the Flora of North America project (Keil personal communication 2003). Most of the collections of *C. perplexans* housed at the Rocky Mountain Herbarium (Hartman personal communication 2003) and University of Colorado Herbarium (Lederer personal communication 2003) are currently on loan to Dr. Keil.

Although *Cirsium perplexans* was first classified in the genus *Carduus* (Rydberg 1905), taxonomists appear to have been in agreement with the 1917 classification as *C. perplexans* (Petrak 1917, Harrington 1954, Hartman and Nelson 1999, Kartesz 1999, Weber and Wittmann 2001b, USDA Natural Resources Conservation Service 2002, Keil personal communication 2003, NatureServe 2003). Nonetheless, there has been some confusion with identifying this species through the years. In 1920, Osterhout's specimen 5970 collected in DeBeque was identified as *C. vulgare* (Osterh.) Cockerell, and it was not annotated to *C. perplexans* until 1956 by C.L. Porter. In 1979, there was some thought that *C. perplexans* was actually synonymous with *C. vulgare* (Colorado Natural Heritage Program 2004). Today, *C. vulgare* is considered to be found only in Colorado (USDA Natural Resources Conservation Service 2002) and is likely synonymous with *C. perplexans* (Weber and Wittmann 2000). An observation by Peggy Lyon in 1998 (Colorado Natural Heritage Program 2004) suggested that *C. perplexans* could be a hybrid between the native *C. tracyi* and the non-native noxious weed, *C. arvense* (based on the juxtaposition of the three species at the same location). Dr. David Keil confirmed that this was not the case (Keil personal communication 1998).

Cirsium perplexans was first collected in 1901 by C.F. Baker in Cimarron, Montrose County, Colorado. The collection was first identified by Dr. E.L. Greene as *Carduus americanus* Greene, and then annotated in 1905 as it was used to describe a new species by Rydberg: *C. perplexans* sp. nov. Coulter and Nelson (1909) listed the species as *C. americanus perplexans* (Rydb.) in their New Manual of Botany of the Central Rocky Mountains. In 1917 the species was reclassified for the last time as *Cirsium perplexans* (Rydb.) Petrak (Petrak 1917).

Rydberg (1905) described the species using the single specimen collected in 1901 by Baker. This type specimen is deposited at the New York Botanical Garden Herbarium (New York Botanical Garden 2003). When Petrak reclassified the species in *Cirsium*, he cited Baker's collection as well as one other specimen collected by Osterhout in 1911 in Paonia, Delta County, Colorado. Osterhout's specimen is housed at the Rocky Mountain Herbarium in Laramie, Wyoming.

In 1915 Payson collected *Cirsium perplexans* on adobe hills in Montrose. This specific record has not been updated, and the occurrence may in fact be extirpated given the expansion of Montrose into what may have been suitable habitat for *C. perplexans* (Lyon personal communication 2003). The specimen is deposited at the Rocky Mountain Herbarium in Laramie, Wyoming. *Cirsium perplexans* was then collected near Cerro Summit in Montrose County in 1926 by Osterhout. Although this record has not been updated in the Colorado NHP databases, Dr. William Weber made a note in 1982 on a copy of the type specimen stating that "the species grows between Cimarron and Montrose, across Cerro Summit from Cimarron on the "adobe" hills of the valley around Montrose."

In 1951, Penland and Hartwell documented a new location about seven miles east of Montrose, near the AB Canal. This specimen, deposited at the University of Colorado Herbarium, was identified as *Cirsium carolinianum* until it was annotated by Dr. William Weber in 1998 (Lederer personal communication 2003). This location has not been updated since 1951. In 1953, Weber and Jones documented another new location about four miles east of Montrose (Colorado Natural Heritage Program 2004). This record has also not been updated since that time.

Cirsium perplexans was not collected at any new locations between 1953 and 1979. On June 7, 1979, Ratzloff collected *C. perplexans* southeast of Montrose, near Kinikin Road. On June 24, 1981 Harner-White Environmental Consultants collected *C. perplexans* in Stevens Gulch in Delta County, and then, on June 20, 1987 Joan Young documented a new population at the Plateau Creek State Wildlife Refuge in Mesa County. Another gap in collection occurred from 1987 until the second half of the 1990's, when eight new locations were documented by Peggy Lyon: Winter Flats in Mesa County; Land's End Mountain, Dry Creek, and Crawford in Delta County; a new Cimarron location in Montrose County; two county records in Ouray County in the Billy Creek area; and Crawford in Montrose County. In 2000 and 2001, Lyon located five new occurrences: Pyramid Rock, West of Red Rocks, near Flat Top, and west of Landfill in Montrose County; and Logan Wash in Garfield County. Denslow located one new location at State Tunnel Dam, also in Montrose County (Colorado Natural Heritage Program 2004). In 2004, just as this report was being finalized, two

additional locations were reported. Mike Klish with WestWater Engineering located *C. perplexans* in the Horsethief Creek area of Mesa County (Klish personal communication 2004), and Ginger Bradshaw located *C. perplexans* in the West Elk Creek area of Gunnison County (Bradshaw personal communication 2004). Bradshaw's discovery represented a new county record for this species.

Extensive field work in the late 1990's and early 2000's by Peggy Lyon contributed greatly to our understanding of the range, population size, and habitat of *Cirsium perplexans*. Current research by Gary Dodge holds promise for understanding the demography and breeding systems of *C. perplexans* as well as the threats from biological control (Dodge personal communication 2003).

Members of the tribe Cardueae are distinguished from other members of the Asteraceae family using primarily the following characteristics: they are robust herbs that are spiny or woolly, have leaves that are pinnately divided and spiny, involucral bracts in several series, and flowers that are discoid (Zomlefer 1994). Species in the genus *Cirsium* are recognized from other species in the Asteraceae as being "thistle-like" with spiny margined leaves, discoid flower heads (without ray flowers), herbaceous plants that are sometimes woody at the base, and achenes with a pappus of plumose bristles (Cronquist et al. 1994).

Cirsium perplexans is an erect perennial or biennial, 2 to 6 dm tall. Stems are often purplish and slightly tomentose. Leaves are toothed with short weak spines, glabrate above, and tomentose below. Upper leaves are clasping at the base. Flowers are purple to red. Flower heads are solitary on the stem or branches, and they are about 2.5 to 3.5 cm high and about as wide (Rydberg 1905, Harrington 1954). Lyon notes from her field observations that this species is not rhizomatous (Colorado Natural Heritage Program 2004).

The involucral bracts (phyllaries) are used in most keys to distinguish *Cirsium perplexans* from other species. Bracts are glabrate with a dorsal glandular ridge and dilated fringed tips (Rydberg 1906, Harrington 1954). The dorsal glandular ridge is sometimes obscure (Harrington 1954). There may be a few spines on the outer phyllaries. Weber and Wittmann (2001b) note that when present, the spines on the phyllaries are about 2 mm long, and the phyllaries with spines often have an erose fringe at the sides. The purple to red flower color and the leaves being tomentose below are also characters used in these keys.

Cirsium species are known for their infraspecific variation (Cronquist et al. 1994), and evidently *C. perplexans* is no exception. Lyon notes that plants observed at the Chaffee Gulch site in Ouray County had upper leaf surfaces ranging from glabrous to tomentose, leaf margins ranging from nearly entire to spiny, and phyllary margins erose to entire (Colorado Natural Heritage Program 2004). Taxonomic research of this genus is warranted to clarify the differences between natural intraspecific variation, interspecific hybridization, and what should be recognized as new species, subspecies, or varieties.

Cirsium perplexans occurs within the range, and often within the same sites as *C. tracyi*, and these taxa could be confused. *Cirsium tracyi* inflorescences are relatively larger (2.5 to 4 cm), phyllary spines are longer (3 to 5 mm), and phyllary margins are not erose. *Cirsium tracyi* may also be found at slightly lower elevations (Colorado Natural Heritage Program 2004).

Cirsium perplexans could also be confused with *C. centaureae* because both of these species have fringed phyllaries, but *C. perplexans* bracts are broader with glandular backs, and its flowers are purple. *Cirsium centaureae* flowers are typically white to cream. Furthermore, *C. centaureae* occurs in forests in the mountains near the Continental Divide (Weber and Wittmann 2001b). Location and flower color are probably the most reliable characteristics for distinguishing *C. perplexans* from *C. centaureae*.

Cirsium perplexans also loosely resembles the noxious weed, *C. arvense*. Although they have been documented at the same locations, the two species can easily be distinguished by both physical characteristics and habitat. *Cirsium arvense* is found in relatively moist areas such as along irrigation ditches, tends to be much more leafy, and has no spines on the bracts of the flower head. *Cirsium perplexans* has more slender and less leafy stems with a reddish cast and very short spines (2 mm), some of which are fringed (Lyon and Denslow 2001).

A few published sources are available for technical descriptions of *Cirsium perplexans*. Those cited above (Rydberg 1905, Harrington 1954, Weber and Wittmann 2001b) are particularly useful and are relatively accessible. The only source with an illustration, range map, and photographs of *C. perplexans* is found in an update to the Colorado Rare Plant Field Guide (Spackman et al. 1997). This source is available through the Colorado Natural Heritage Program and can be accessed via the Internet at www.cnhp.colostate.edu. Baker's type specimen of *C. perplexans* is housed at

the New York Botanical Garden Herbarium and can be viewed on line under *Carduus perplexans* at http://www.nybg.org/bsci/hcol/vasc. See **Figure 1** and **Figure 2** for photographs of *C. perplexans* and its habitat. See **Figure 3** for an illustration of *C. perplexans*. Note that the drawing depicts a plant that appears to have a shorter flowering stem than is typical of the species.

Distribution and abundance

The global distribution of *Cirsium perplexans* is limited to western Colorado (**Figure 4**), in the Colorado and Gunnison river valleys (Weber and Wittmann 2001b). There is only one occurrence known from lands administered by the USFS, the Land's End Mountain location on Gunnison National Forest in the southeast corner of Delta County. The Horsethief Creek occurrence, located on BLM and private lands in northern Mesa County, appears to be about a quarter-mile from National Forest System lands. The West Elk Creek occurrence, the only location in Gunnison County, is located on lands managed by the BLM and is only about a half-mile from the Gunnison National Forest. **Figure 5** shows the distribution of *C. perplexans* in relation to National Forest System lands in Region 2.

Cirsium perplexans has been reported from Delta, Garfield, Gunnison, Mesa, Montrose, and Ouray counties in Colorado (Colorado Natural Heritage Program 2004). The majority of the known occurrences are in Montrose County (twelve occurrences documented in the Colorado Natural Heritage Program Biodiversity Tracking and Conservation System in 2004), and the largest occurrences, with thousands of individuals, are at Cedar Mesa in Delta County and at Logan Wash in Garfield County (Colorado Natural Heritage Program 2004). All occurrences are found within an approximately 35 x 85 mile area that runs north to south from Garfield County in the north to Ouray County in the south.

The Colorado Natural Heritage Program (2004) documents a total of twenty-five occurrences of *Cirsium perplexans* in its Biodiversity Tracking and Conservation System. However, these do not equate directly to populations or patches; several of these records include two or more discrete patches that are included within a single record. For lack of better information, records of patches within one mile of each other are considered a single occurrence assuming that they are genetically connected and approximate a panmictic population. Twelve occurrences are documented from Montrose County, five from Mesa County, four from Delta County, two in Ouray County, one in Garfield County, and one in Gunnison County. Four of the occurrences in Montrose County and one occurrence in Delta County have not been seen in over twenty years. Lyon visited fourteen occurrences of *C. perplexans* from 1996 through 2002, all of which were extant (Lyon personal communication 2003).

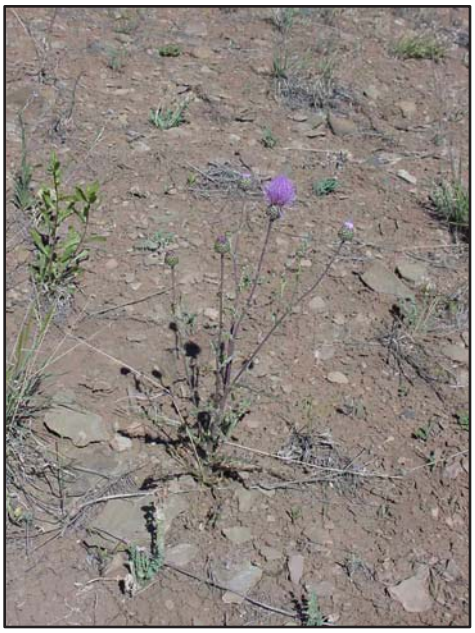
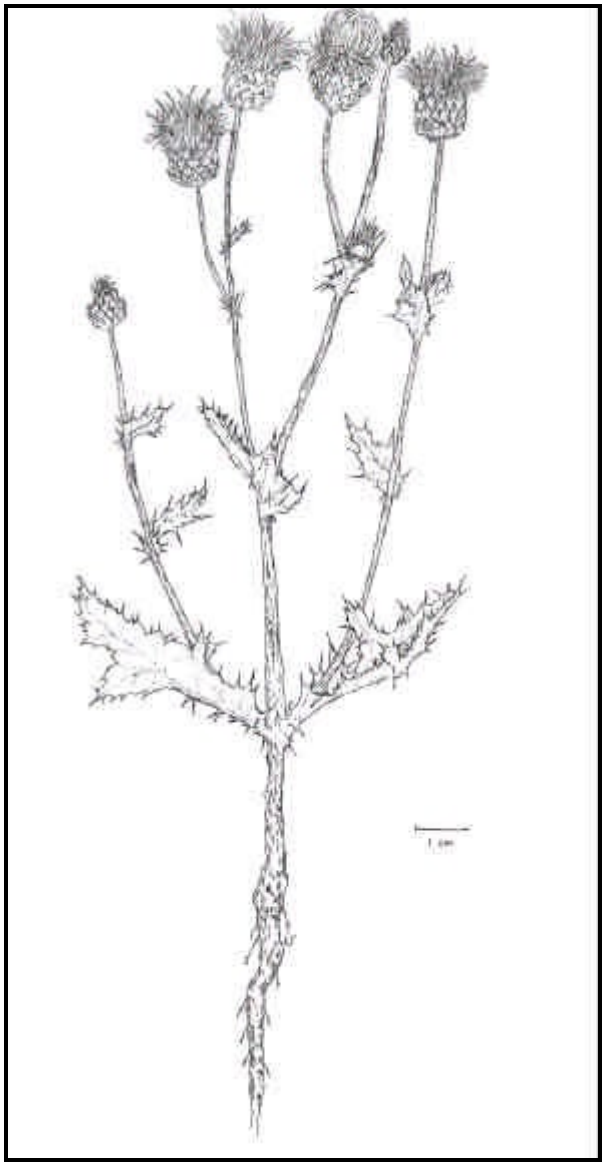


Figure 1. Close up of photographs *Cirsium perplexans* by Peggy Lyon.

Figure 2. Habitat photos of *Cirsium perplexans* by Mike Klish, WestWater Engineering (top, taken in Garfield County) and by Ginger Bradshaw, National Park Service (bottom, taken in Gunnison County).



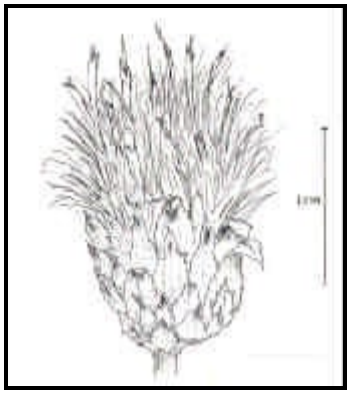


Figure 3. Illustration of *Cirsium perplexans* by Ann Fenwick. Please note that the drawing depicts a plant that appears to have a shorter flowering stem than is typical of the species.

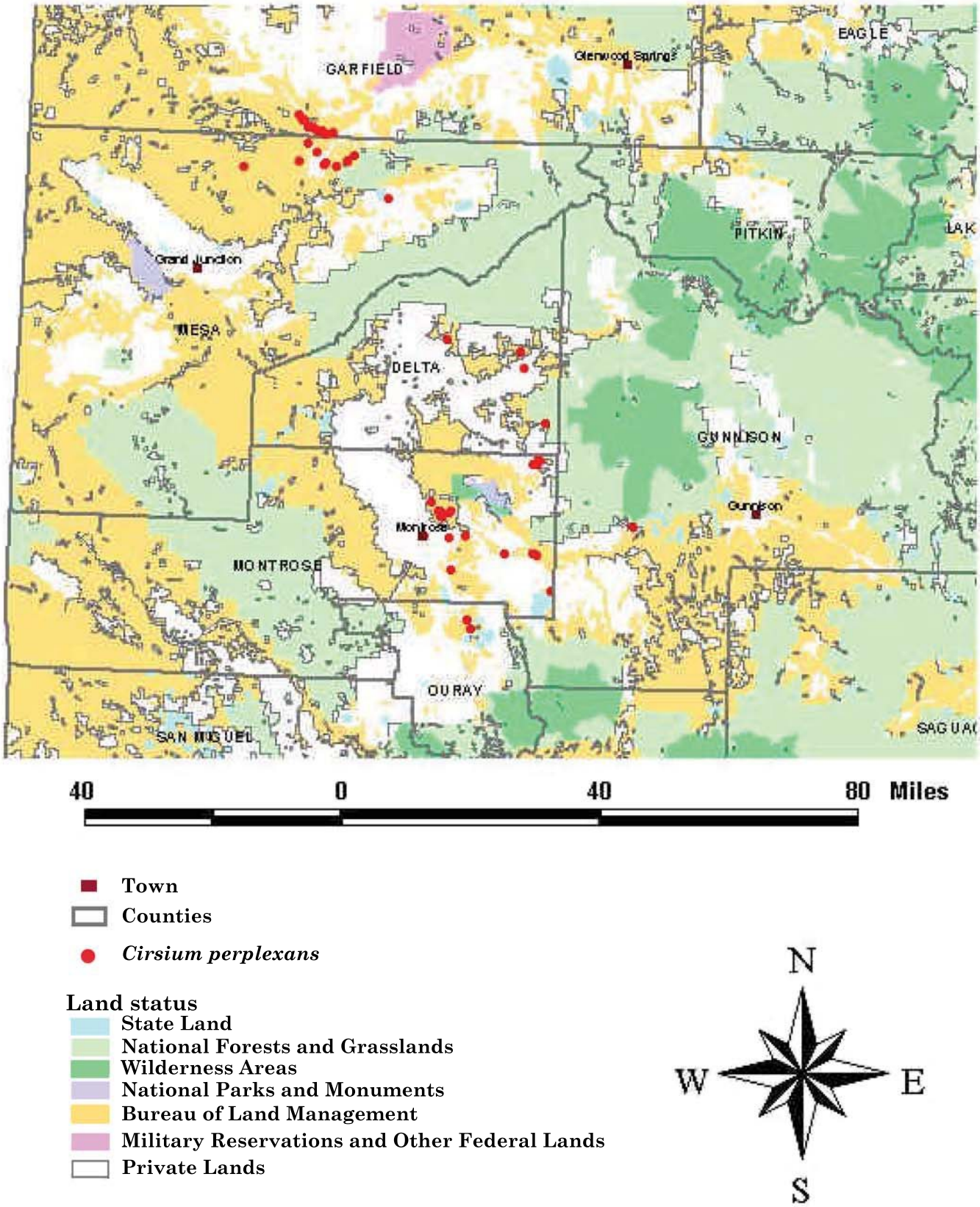


Figure 4. Global distribution of *Cirsium perplexans*. The only location that falls on National Forest lands is the Land's End Mountain occurrence in the southeast corner of Delta County.

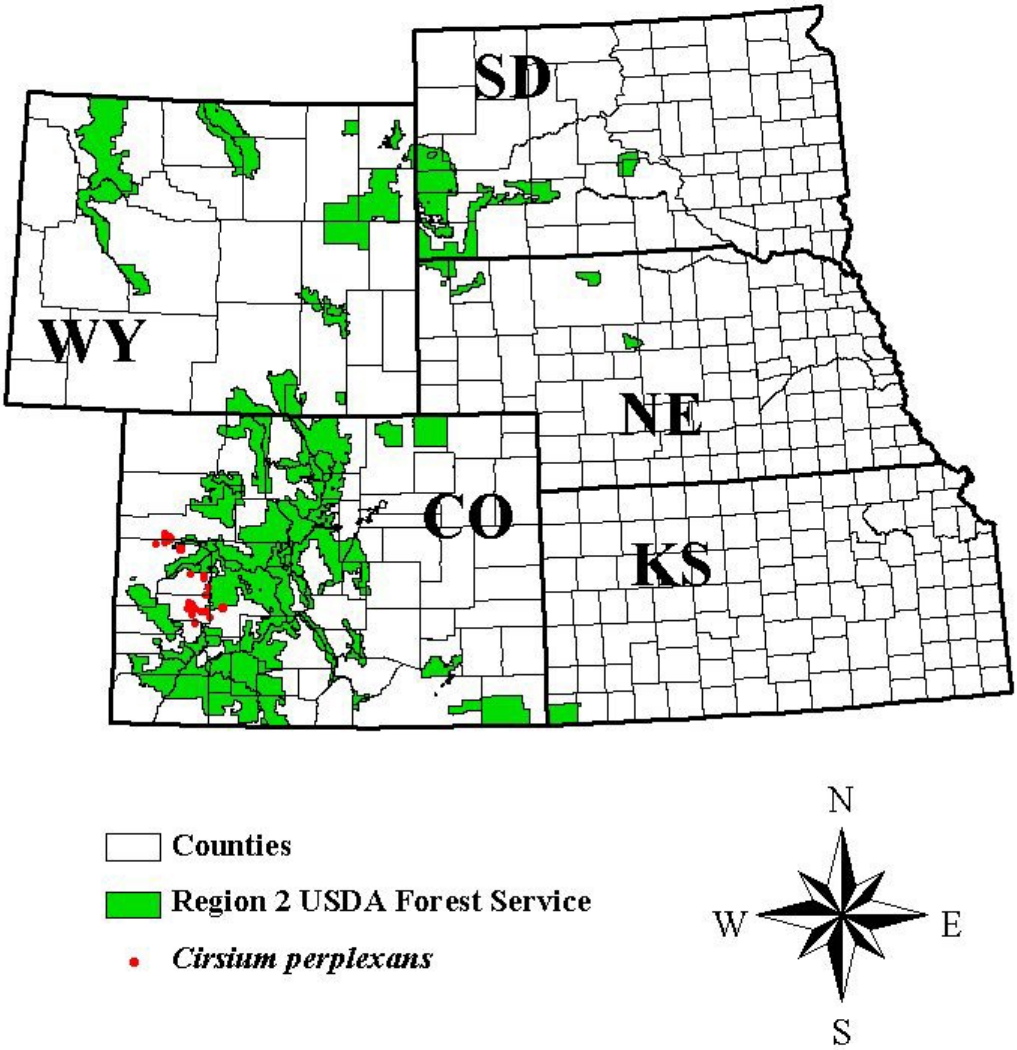


Figure 5. Distribution of *Cirsium perplexans* in relation to USDA Forest Service Region 2. Despite close proximity and apparent overlap, the Land's End Mountain location (see **Figure 4**) is the only location that is found on National Forest System lands.

Further dedicated survey work is needed to search for *Cirsium perplexans*. All of the known counties contain additional apparently suitable habitat for *C. perplexans*. In 1996 Lyon noted that many barren shale areas are similar to those occupied by *C. perplexans*, but no other occurrences were seen (Colorado Natural Heritage Program 2004).

The population size of *Cirsium perplexans* has not been rigorously quantified, and better population size data are greatly needed at all of the documented occurrences. Lyon (Colorado Natural Heritage Program 2004) estimates a total population size of at least 5,739 individuals, and possibly up to 10,000 or more individuals. This range is supported by estimates in Element Occurrence Records (Colorado Natural Heritage Program 2004). Single occurrences at Cedar Mesa and Logan Wash contain thousands of plants (Colorado Natural Heritage Program 2004), while most other occurrences have population size counts or estimates ranging from a few individuals to about 300 plants (Colorado Natural Heritage Program 2004). In the spring of 2004, several researchers noticed a dramatic increase in *C. perplexans* numbers (Klish personal communication 2004, Lyon personal communication 2004). The researchers noted that 2004 seemed to be a "boom year" for *C. perplexans*, and that population sizes probably varied considerably in other years. See **Table 1** for population size estimates for each occurrence.

Table 1. Summary information for the 25 known occurrences of *Cirsium perplexans* in USDA Forest Service Region 2. Information on county, location, land management context, dates observed, abundance, phenology, habitat description, and associated species are provided. Non-native species are listed in bold, rare natives are underlined. Location names are provided as a useful reference, rather than to identify a specific place on the ground. Source: Colorado Natural Heritage Program 2004.

Arbitrary occurrence number	County	Location	Land ownership	Date of Last observation	Observer: occurrence size and phenology	Habitat description	Associated species
1	Delta	Cedar Hill at Paonia	Private	7/10/1997	Lyon: about 60 plants observed, in late flower.	Fairly dense shrub cover. Plants in disturbed areas along trail and in other bare spots on north facing hillside. Also a few above canal on east facing slope. Elevation: 5,720 to 5,760 ft.	*Artemisia tridentata*, *Amelanchier utahensis*, and *Peraphyllum ramosissimum*
2	Delta	Stevens Gulch	Private, Bureau of Land Management (BLM)	1981	Harner-White Environmental Consultants: population size and phenology not reported.	Stony loam, east facing slope. Elevation: 6,500 feet	None listed
3	Delta	Cedar Mesa	Private	7/31/1997	Lyon: plant recently established here, according to landowner. Thousands of plants, appearing weedy.	Dry, uncultivated field with sagebrush. Elevation: 6,520 to 6,640 ft.	None listed
4	Delta	Land's End Mountain	Gunnison National Forest	8/22/1997	Lyon: about 20 plants.	Elevation: 7,540 to 7,560 ft.	Gambel's oak, Utah serviceberry, squawapple, snowberry, elk sedge, *Bromus inermis* and *Melilotus officinalis*
5	Garfield	Logan Wash	BLM, Private, and County road right of way	5/1/2004	Lyon: 500+ plants in a small disturbed area. Klish: 2,464 or more plants estimated along proposed pipeline route. Plants in flower.	Grey or reddish colored, vertisolic (clay) soils. Pasture and roadside, disturbed area with *Bromus tectorum*. Clay soils. Occurrence observed between road and ditch. Elevation: 5,200 to 5,400 ft.	*Descurainia pinnata* and widely spaced *Atriplex confertifolia; Bromus tectorum*
6	Gunnison	West Elk Creek	BLM	6/25/2003	Bradshaw: about 35 plants within about 200 meters squared. A few plants also noted outside of this plot. Plants in flower.	Growing in clayey soil. Elevation: 7,838 ft.	Wyoming big sagebrush and western wheatgrass
7	Mesa	DeBeque Cemetery	BLM, Private	8/5/1997	Keil: about 200 plants scattered in small local colonies and open areas. All individuals completely dry.	Aspect:South. Soil:clay and rock. Slope: steep. Crumbly dry adobe hills in open juniper woodland.	Associated with scattered *Sarcobatus*, *Atriplex confertifolia*, *Chrysothamnus* spp., *Grindelia* spp., *Achnatherum hymenoides*, and lots of *Aegilops cylindrica* and *Bromus tectorum*
8	Mesa	Horsethief Creek	BLM and Private	5/15/2004	Klish: five small populations.	Reddish clay soils, 90 percent bare ground. Elevation: 5,000 to 5,800 feet.	*Descurainia pinnata* and scattered *Atriplex confertifolia; Phacelia submutica* was in close proximity in a couple of small areas

Arbitrary occurrence number	County	Location	Land ownership	Date of Last observation	Observer: occurrence size and phenology	Habitat description	Associated species
9	Mesa	Plateau Creek State Wildlife Area	State of Colorado	6/20/1987	Young: population size and phenology not reported.	Pinyon-juniper zone. Elevation: 5,800 ft (original source reports 5,000 feet, however, the directions given do not support this).	None listed
10	Mesa	Winter Flats	BLM	5/29/1996	Lyon: about 100 plants in an area of about 100 x 100 meters. only about five flowering (<10 percent), the rest basal rosettes only.	On barren gray shale slope above intermittent stream bed. Soil: shale. Few other plants. Surrounding area with pinyon-juniper. Elevation: 6,160 ft.	None listed
11	Mesa	Pyramid Rock	BLM Area of Critical Environmental Concern and State Designated Natural Area	7/9/2000	Lyon: counted about 300 plants. Plants mostly dried up, with a few flowers remaining.	Dark brown, soft soil, loosened by shrink-swell and rodents. Total plant cover about 25 percent. Elevation: 5,400 to 5,480 ft.	*Grindelia squarrosa*, *Hilaria jamesii*, *Platyschkuhria integrifolia*, *Atriplex brandegeei*
12	Montrose	Montrose	Private	6/15/1915	Payson: population size and phenology not reported.	Adobe hills. Elevation: 5,800 ft.	None listed
13	Montrose	Cerro Summit	Private	1982	Weber: population size and phenology not reported.	No habitat information provided.	None listed
14	Montrose	Cimarron Campground	National Park Service, Morrow Point Ranger Station	6/2/1998	Lyon: over 300 vegetative basal rosettes, over 50 in early bud.	South facing hillside. Elevation: 7,020 to 7,200 ft.	Scattered pinyon-juniper, *Artemisia tridentata*, *Heterotheca villosa*, *Hymenoxys acaulis*
15	Montrose	Cimarron State Wildlife Area	State of Colorado	6/30/1998	Lyon: 42 plants in bloom, and about 50 basal rosettes.	Within *Artemisia tridentata* ssp. *wyomingensis/Pascopyrum smithii* community. *Cirsium perplexans* is seldom found away from disturbed areas. Elevation: 8,060 ft.	*Artemisia tridentata* ssp. *wyomingensis*, *Pascopyrum smithii*. *Cirsium tracyii* also common in area
16	Montrose	Doug Creek	Private	7/2/1998	Lyon: 152 in flower, approximately 50 basal rosettes. Widely scattered in pasture.	Roadside in *Artemisia tridentata* community. Elevation: 6,760 to 7,080 ft.	*Artemisia tridentata*. *Melilotus officinale*, *Cirsium tracyi*, *C. arvense* and *Carduus nutans* also present
17	Montrose	West of Red Rocks	BLM	5/27/2001	Lyon: at least 140 plants, at least six of these flowering.	Ridge top, south and northwest slopes of adobe hills. Elevation: 5,804 to 6,217ft.	*Halogeton glomerata*, *Abronia elliptica*, *Eriogonum gordonii*, *Ephedra torreyana*, *Lygodesmia* spp., *Astragalus asclepiadoides*, *Acrolasia* spp., *Lomatium concinnum*, *Penstemon retrorsus*, *Atriplex corrugata*, *Xylorhiza venusta*, *Hordeum* spp., *Calochortus nuttallii*, *Cymopterus bulbosus*, *Oryzopsis hymenoides*

Arbitrary occurrence number	County	Location	Land ownership	Date of Last observation	Observer: occurrence size and phenology	Habitat description	Associated species
18	Montrose	Near Flat Top	BLM	5/28/2001	Lyon: at least 172 plants, about 15 percent in flower. Population continues down drainage.	Drainage and steep southwest slope of adobe hills. Sparsely vegetated. Elevation: 5,961 to 6,300 ft.	*Atriplex corrugata*, *Astragalus flavus*, *Abronia elliptica*, *Oryzopsis hymenoides*, *Ephedra torreyana*, *Atriplex gardneri*, *Chorispora tenella*, *Hordeum* sp., *Atriplex confertifolia*, *Erigeron pulcherrimus*, *Eriogonum gordonii*, *Leymus salina*
19	Montrose	State Tunnel Dam	BLM, Gunnison Gorge National Conservation Area	5/31/2001	Denslow: estimated population size: 55; vegetative: 97 percent, flower: 3 percent, fruit: 0 percent.	Aspect: south. Slope: 10 to 20 percent. Moisture: xeric. Light exposure: full sun. Parent material: Mancos Shale. Soil: adobe clay. Landform: adobe badlands. Dominant plant community: saltbush. Elevation: 6,174 to 6,194 ft.	*Eriogonum gordonii*, *Cleomella palmerana*, *Xylorhiza venusta*, *Tetradymia spinosa*, *Oenothera caespitosa*, *Camissonia* spp., *Atriplex confertifolia*, *Helianthus annuus*, *Phacelia crenulata*, *Acrolasia humilis*
20	Montrose	West of Landfill	BLM	5/31/2001	Lyon: 81 plants.	West facing drainage of large adobe hill. Elevation: 5,961-6,200 ft.	*Atriplex corrugata*, *Hordeum* spp., *Eriogonum gordonii*, *Xylorhiza venusta*
21	Montrose	East of Montrose	BLM and/or Private	7/17/1953	Weber and Jones: one colony seen. Vegetative.	On barren gypsum hills.	None listed
22	Montrose	AB Canal	BLM and/or Private	6/7/1951	Penland and Hartwell: population size and phenology not reported.	Dry *Atriplex* slopes. Elevation: 6,300 ft.	*Juniperus* spp. and *Amelanchier* spp.
23	Montrose	Kinikin Road	BLM	6/20/1998	Lyon: population size and phenology not reported.	Disturbed roadside in Mancos Shale. Elevation: 6,300 ft.	*Artemisia nova*, *Atriplex confertifolia*, *Xylorzhiza venusta*, *Bromus tectorum*
24	Ouray	Chaffee Gulch	State of Colorado	6/9/1998	Lyon: only a few plants observed in flower, although there were many more basal rosettes; plants were mostly vegetative, with only a few in flower.	On roadside and small earth dams in pinyon-juniper community. Elevation: 7,000 ft.	*Pinus* spp. and *Juniperus* spp.
25	Ouray	Billy Creek	BLM	6/9/1998	Lyon: about 100+ plants seen, most vegetative.	At edge of pinyon-juniper area, along gullied dry wash. Elevation: 6,820 to 6,920 ft.	*Pinus* spp. and *Juniperus* spp.

Population trend

Internet and literature searches revealed virtually no information or citations concerning research or monitoring of this species. These searches cannot be considered definitive, but they do highlight the paucity of information on this taxon.

Eight of the 25 known occurrences (at Land's End Mountain on Gunnison National Forest, DeBeque Cemetery, Cimarron State Wildlife Area, Doug Creek, West of Red Rocks, Near Flat Top, Pyramid Rock, and State Tunnel Dam) are imperiled by invasive weeds, and occurrences could be declining as a result (Colorado Natural Heritage Program 2004). Three occurrences in Montrose have not been seen for several decades, and it is possible that they have been extirpated. The occurrences at the West of Red Rocks, Near Flat Top, State Tunnel Dam, and West of Landfill locations were found by Lyon and Denslow (2001) not to have lost individuals to off-road vehicle use. However, Lyon indicates that the plants are threatened by off-road vehicle use (Lyon personal communication 2003). Given present data, there is no reason to believe that other occurrences are declining.

Habitat

All of the documented information regarding habitat and associated species of *Cirsium perplexans* is listed in **Table 1**. Much of this information comes from the work of Lyon between 1996 and 2002. *Cirsium perplexans* is found almost exclusively on clay soils or "adobe hills" (Weber and Wittmann 2001b) that are derived from shales of the Mancos or Wasatch formations (Lyon personal communication 2003). "Adobe hills" are a local term for barren outcrops of clay soils (Foutz 1994), which are common in western Colorado. Our understanding of the distribution of *C. perplexans* would probably benefit most from research investigating distribution patterns of this species in relation to edaphic characteristics.

Associated plant communities have been described as pinyon-juniper woodlands, and sagebrush, saltbrush, and mixed shrublands. More specifically, *Cirsium perplexans* has been documented within plant communities dominated by *Pinus edulis* (pinyon pine) *Juniperus osteosperma* (Utah juniper), *Artemisia tridentata* (big sagebrush), *Artemisia tridentata* ssp. *wyomingensis* (Wyoming sagebrush), *Atriplex confertifolia* (saltbush), *Amelanchier utahensis* (Utah serviceberry), and *Quercus gambelii* (Gambel's oak). However, *C. perplexans* most often grows in open sites accompanied by few other species of vascular plants.

Although habitat descriptions are rather sparse for *Cirsium perplexans*, some inferences can also be drawn from available vegetation maps and literature. *Cirsium perplexans* is found on barren adobe soils, and it has been documented within four primary vegetation types (after West and Young 2000) or ecological systems (as defined by Anderson et al. 1999). These are sagebrush shrubland (Johnston et al. 2001, Rondeau 2000a), pinyon-juniper woodland (Rondeau 2000b), and oak/serviceberry shrubland (Rondeau 2001) (equivalent to mountain mahogany-oak scrub of West and Young 2000), and saltbush shrubland (West and Young 2000). For detailed descriptions of these vegetation types, their geographic extent, and perturbations caused by human impacts, please see the Community Ecology section of this document.

Overall, *Cirsium perplexans* tends to grow in dry, sparsely vegetated or disturbed areas. It has been described as occurring adjacent to a drainage and a dry wash and along roads, usually infrequently used roads. Populations found along roads were thought to be moving into the habitat created by the roads (Lyon personal communication 2003).

Cirsium perplexans is found across an approximately 3,000 foot elevational range, within sites in montane shrublands or woodlands. The range of elevation documented in Element Occurrence Records of the Colorado Natural Heritage Program (2004) is 5,800 feet (at the Plateau Creek State Wildlife Area) to 8,060 feet (at Cimarron State Wildlife Area). Although Harrington (1954) reported an elevation range of 4,500 to 7,000 feet, there are no specimens known to have been collected below 5,800 feet.

Cirsium perplexans has been described as occurring in sites with south, west, and east exposure (Colorado Natural Heritage Program 2004). Lyon (personal communication 2003) has found *C. perplexans* on all aspects and on flat sites.

There is a general consensus among experts that there is much potential habitat for *Cirsium perplexans* (Lyon personal communication 2003, Colorado Natural Heritage Program 2004). However, *Cirsium perplexans* is inexplicably absent from many locations of apparently suitable habitat (Lyon personal communication 2003). There may be unidentified environmental variables involved, such as soil chemistry or microclimate, that

C. perplexans responds to. Its absence may also be due to limitations in its ability to colonize new sites caused by dispersal limitations, germination requirements, absence of disturbance, or other factors.

Reproductive biology and autecology

Little is known about the reproductive biology and autecology of *Cirsium perplexans*. Members of the genus *Cirsium* typically have a biennial or perennial life cycle (Cronquist et al. 1994), and *C. perplexans* has been described as both a biennial (Harrington 1954) and perennial (Harrington 1954, USDA Natural Resources Conservation Service 2002).

According to Harper (1977), there may be no plants that have an obligate biennial lifecycle, and biennials might better be referred to as short-lived semelparous perennials (Barbour et al. 1987). The biennial life history is an adaptation to a short growing season because it makes it possible for plants to produce a much larger seed crop than they could in only one year (Barbour et al. 1987). However, there is a cost to this strategy, since there is a significant chance that the second year will not be favorable for growth or that a disturbance will occur. Biennials are often found in sites that are disturbed periodically but not every year. Lyon (personal communication 2003) notes that on some of the *Cirsium perplexans* specimens she collected, the roots started off as a taproot and had root sprouts approximately 18 inches below ground.

Research on the life history and population demography of *Cirsium palustre* found that this species is a facultative biennial (Falinska 1997). Plants were observed during different successional stages. In all stages, a proportion of individuals in a population flowered during year two. Further along in successional stages (including an increase in plant cover, shading by macroforbs, and the formation of forest communities), the proportions of ''triennial'' and ''quadriennial'' forms (monocarpic perennial forms) increased (Falinska 1997). It is possible that *C. perplexans* is similarly a facultative biennial.

The mating system of *Cirsium perplexans* has not been investigated. While many species of *Cirsium* are outcrossers, others are apomictic (Barlow personal communication 2003). Apomixis is a form of reproduction that involves structures commonly concerned in sexual reproduction but in which there is no actual fusion of male and female gametes (Gould and Shaw 1983). Apomixis is a common phenomenon among members of the genus *Cirsium* (Barlow personal communication 2003).

There has been no research regarding the pollinators and pollination ecology of *Cirsium perplexans*. In general, *Cirsium* species are usually capable of self-pollination, but they may rely on insects for some outcrossing (Barlow personal communication 2003). The relatively large flower heads and flowers of a conspicuous color found on *C. perplexans* may be an adaptation for insect pollination. *Cirsium pitcheri*, a listed threatened species known from the sand dunes of the Great Lakes, is pollinated by bees and can also self-pollinate (Center for Plant Conservation 2003). In their investigations of *C. purpuratum* and nectar foraging bumblebees, Ohashi and Yahara (1998) found that the number of flowering heads visited on a plant increased with floral display size. However, the visitation rate per head was independent of floral display and nearly constant within each day.

Cirsium perplexans flowers from May to early July (Colorado Natural Heritage Program 2004), and seeds are dispersed in the summer and fall. Additional information about the seeds of *C. perplexans* is lacking. Based on studies of other *Cirsium* species, *C. perplexans* may produce one hundred or more achenes (each containing one seed) per flowerhead. However, in their investigations of *C. purpuratum*, Ohashi and Yahara (2000) found that increased flower production may not always improve plant reproductive success because of pre-dispersal seed predation. In general, *Cirsium* species have large seeds, and they generally rely on current seed production for their establishment and persistence (Harper 1977). Seeds from plants growing on exposed sites are probably dispersed effectively by wind. The pappus (thistle down) of the seed coat may permit windborne dispersal over long distances to suitable habitats. Craddock and Huenneke (1997) found the seeds of *C. vinaceum*, a threatened endemic thistle of New Mexico, to move in substantial numbers for considerable distances along streams.

It is not known how long the seeds of *Cirsium perplexans* remain viable. The "population boom" noticed by several researchers in 2004 (Klish personal communication 2004, Lyon personal communication 2004) suggests that the seeds of *C. perplexans* may remain dormant for many years until conditions are favorable for germination. Although *C. perplexans* was not included in the study, seeds from herbarium sheets up to eight years of age of 17 *Cirsium* species studied by Moore and Frankton (1963) were found to be viable.

In some cases it appeared that scarification of the seed coat was necessary to promote germination (Moore and Frankton 1963). Rowland and Maun (2001) found that *C. pitcheri* has the ability to form a persistent seed bank under field conditions but only at soil depths of greater than or equal to 15 cm. Since we do not know if it is capable of vegetative modes of reproduction, an understanding of seed and seedling ecology is critical for preservation and restoration of *C. perplexans*.

Seed germination requirements of *Cirsium perplexans* are also unknown. Studies of *C. pitcheri*, a threatened species endemic to the shoreline sand dunes of the Great Lakes, found that seed germination requirements for this species are very specific (Chen and Maun 1998). High germination was obtained only when seeds were pretreated either by surgically removing the seed coat or by nicking the seed on the radicle or cotyledonary end. Under natural conditions, germination of *C. pitcheri* seeds occurs in the spring, after they have experienced stratification and scarification through freezing and thawing of the substrate over winter. Although it has not been studied, *C. perplexans* may have similar scarification needs.

In their investigations of *Cirsium scopulorum*, Wied and Galen (1998) found that seedlings were disproportionately abundant under decaying adult rosettes and infructescences relative to other microsites equidistant from the parent plant. Beneath decaying adult plants, the soil was significantly moister, and evaporation rates were significantly lower than in exposed microsites. These data suggest that, for *C. scopulorum*, drought stress can be reduced for seedlings associated with adult debris.

Although little is known about the reproductive ecology of *Cirsium perplexans*, using the information detailed above, we present a hypothetical life cycle diagram for this species (**Figure 6**). It should be emphasized that additional research is necessary to clarify the reproductive strategies and autecology of this species.

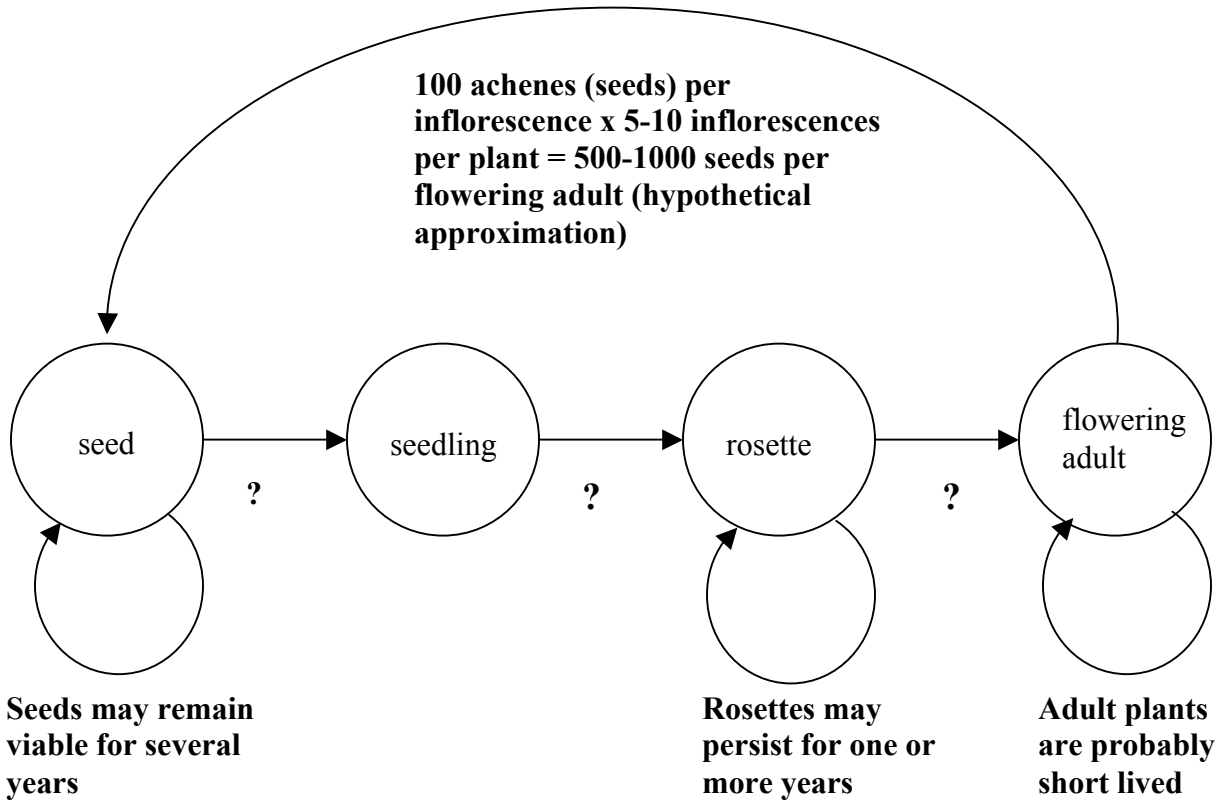


Figure 6. Hypothetical life cycle graph (after Caswell 2001) for *Cirsium perplexans*, including the known life history stages gleaned from limited observations and from information on other species of *Cirsium*. No transition probabilities are known for *Cirsium perplexans*, and there has been no demographic monitoring of other species of *Cirsium* from which valuable inferences can be drawn.

Without further information about the autecology of *Cirsium perplexans*, we can also only speculate about how this species would fit in the CSR (Competitive/Stress-Tolerant/Ruderal) model of Grime (2001). The characteristics of *C. perplexans* appear to most closely approximate those of ruderal species. Attributes of ruderal species include an herbaceous life form with limited lateral spread, relatively short lifespan, rapid growth rate, flowers produced early in life, high frequency of flowering, and a relatively large number of seeds produced each year. Although its characteristics appear to most closely match those of a ruderal species, *C. perplexans* can evidently persist at sites where it becomes established. For example, *C. perplexans* was documented at the DeBeque Cemetery location in 1909, 1912, 1920, 1970, and 1997.

Ruderal species are also characterized by how they respond to stress (Grime 2001). Ruderal species typically respond to disturbances by curtailing vegetative growth and diverting resources into seed production (Grime 2001). The specific response of *C. perplexans* to disturbance is not known. Most occurrences are on barren outcrops of clay soils or on sites where erosion or other potential disturbance is high. It is found growing along roads at Land's End Mountain in Gunnison National Forest, Logan Wash, Doug Creek, and Billy Creek, and it appears to favor these areas (Colorado Natural Heritage Program 2004). The tolerance of *C. perplexans* to various types of disturbance is a key question to answer for its management and stewardship.

Because it probably allocates a relatively large percentage of its biomass to reproduction and dispersal of seeds, the life history pattern of *Cirsium perplexans* may be best classified as r-selected (using the classification scheme of MacArthur and Wilson 1967). The long-distance dispersal capabilities of *Cirsium* and many other taxa within the Asteraceae are exemplary among r-selected organisms. The instability of its habitat also typifies *C. perplexans* as r-selected.

The chromosome number of *Cirsium perplexans* is unknown. North American *Cirsium* species' somatic numbers that have been documented are 34, 32, 30, 28, 26, 24, 22, 20, and 18, whereas the numbers of the Eurasian species are exclusively multiples of the base number 17 (Moore and Frankton 1963). The number 34 is primitive, and species with this number are more likely to exhibit more primitive characters (Moore and Frankton 1963). Species with low numbers (26, 24, 22, 20, and 18) may be more successful, indicated by having broad ranges and/or being abundant (e.g., *C. flodmannii*, *C. undulatum*) (Moore and Frankton 1963). Greater understanding of the morphology and cytology of *Cirsium* will help to answer questions regarding relatedness and distinctiveness of species in this complex genus.

Understanding the range of phenotypic plasticity expressed in *Cirsium perplexans* is a key step in understanding the range of morphological attributes possible within the taxon. Members of the genus *Cirsium* are known to have a relatively high level of infraspecific variation (Cronquist et al. 1994). At the Billy Creek location in 1998, Lyon observed that the upper surface of the leaves of *C. perplexans* range from glabrous to tomentose, the leaf margins range from nearly entire to spiny, and the phyllary margins range from erose to entire (Colorado Natural Heritage Program 2004).

There are many known and putative hybrids in the genus *Cirsium* (Ownbey 1951, Davidson 1963, Ownbey 1964, Bloom 1977, Dabydeen 1987, Cronquist et al. 1994). Although hybrids are often not highly fertile, apomixis allows them to persist for indefinite periods, during which they may backcross or hybridize again (Eriksen 1996). Thus the patterns of morphological variation among many related species of *Cirsium* are very complex (Cronquist et al. 1994). Currently there is not enough data to determine the role of hybridization in *C. perplexans*. *Cirsium tracyi* and *C. arvense* are found in close proximity to occurrences of *C. perplexans*, so hybridization with these species is possible.

There has been no investigation of the mycorrhizal symbionts of *Cirsium perplexans*.

Demography

There have been no demographic studies of *Cirsium perplexans*. Preliminary observations by Dodge (personal communication 2003) indicate that seed production of *C. perplexans* is limited by insect herbivory. This could be from the non-native weevil (*Rhinocyllus conicus*) or some native herbivorous insect (i.e., flies and moths). Dodge plans to address the question of whether of not *C. perplexans* populations may be seed limited in the coming years.

The lifespan of *Cirsium perplexans* has not been determined and a Population Viability Analysis (PVA) has not been performed. Apparently there has never been a PVA of any member of the genus *Cirsium*, even though four taxa are currently listed as endangered (*C. fontinale* var. *fontinale*, *C. fontinale* var. *obispoense*, *C.*

hydrophilum var. *hydrophylim*, *C. loncholepis*) and two are listed as threatened (*C. pitcheri* and *C. vinaceum*) (U.S. Fish and Wildlife Service, Endangered Species Program 2003 available at www.endangered.fws.gov). Identifying critical life history stages that contribute most to population or metapopulation dynamics is crucial to developing recovery strategies for rare plants (Schemske et al. 1994). However, these have not been identified for *C. perplexans*.

Many life history parameters and metapopulation dynamics remain unknown in *Cirsium perplexans*. Of particular value would be information on seeds and recruitment. Seed production, seed longevity, seed dormancy, and variables controlling these parameters would help to reveal potential bottlenecks in the survival of *C. perplexans*. Recruitment and longevity are also unknown, yet they are critical for understanding the demography of this species.

As a habitat specialist, population sizes of *Cirsium perplexans* are probably naturally limited by the availability of habitat. The adobe soils that support *C. perplexans* are limited in extent and often insular. Within an area of suitable habitat, the availability of microsites suitable for *C. perplexans* is also limited, in most places precluding the development of a large population. Thus, the distribution and physiognomy of habitat for *C. perplexans* impose constraints on population growth at a variety of scales.

Community ecology

Detailed lists of species associated with *Cirsium perplexans* have not been written. In some sites there are few, if any, associated plant species, suggesting that *C. perplexans* possesses adaptations to its habitat that other species do not have. The known associated species listed in **Table 1** are those included on herbarium specimen labels and brief descriptive notes (Colorado Natural Heritage Program 2004). The known associated species are mostly woody dominant or subdominant species.

Although found primarily on barren slopes with few other species of vascular plants, *Cirsium perplexans* has been documented in areas within four broadly defined vegetation types. These are described below using the typology developed by Rondeau (2000a, 2000b, 2001) and Neely et al. (2001). Included within the description of each type is a brief overview of human impacts on these systems. More detailed treatments of these impacts are offered in the excellent references cited below.

Cirsium perplexans has been reported in association with sagebrush at six of the 25 known locations, and this vegetation type is common in the area inhabited by *C. perplexans*. Sagebrush shrublands are widely distributed in the broad valleys and lower foothills of the Intermountain Region (Cronquist et al. 1986). Basin big sagebrush (*Artemisia tridentata* ssp. *tridentata*) and mountain sagebrush (*A. tridentata* ssp. *wyominensis*) are the most common dominant species in these shrublands in the Gunnison Basin and in the area to the west of the West Elk Mountains (Colorado Division of Wildlife 1998). Agriculture has greatly diminished the extent of sagebrush shrublands (Cronquist et al. 1986). Invasion of sagebrush shrublands by *Bromus tectorum* (cheatgrass) increases the likelihood of fire, after which sagebrush must resprout from seed. This can lead to dominance by *B. tectorum* and other non-natives rather than sagebrush (Bunting et al. 1987 as cited in Johnston et al. 2001). Grazing reduces the availability of water in these systems (Johnston et al. 2001, Rondeau 2000a).

Cirsium perplexans is documented at six of the 25 locations in association with pinyon-juniper woodlands. Pinyon-juniper woodlands are widely distributed throughout the Intermountain West (West and Young 2000). In the pinyon-juniper woodlands of western Colorado and the Colorado Plateau, *Pinus edulis* and *Juniperus osteosperma* are the dominant overstory species. These woodlands are found at elevations slightly higher than many shrubland and grassland types, including saltbush-greasewood shrublands (West and Young 2000). In Colorado, pinyon-juniper woodlands are found roughly between 4,000 to 9,000 feet in elevation (Rondeau 2000b). At approximately 6,500 feet the relative abundance of pinyon and juniper is roughly equal, but as elevation increases the relative cover of juniper decreases and pinyon increases (Tueller et al. 1979). Grazing and fire suppression have greatly altered this vegetation type throughout its range (West and Young 2000).

Shrublands dominated by *Quercus gambelii* with *Amelanchier utahensis* and/or *Cercocarpus montanus* (mountain mahogany) are also widespread on the lower slopes of mountains in western Colorado. At least one of the *Cirsium perplexans* occurrences is found on barren slopes within this community type. In western Colorado these shrublands typically occur at slightly higher elevations than pinyon-juniper woodlands, from roughly 5,000 to 9,500 feet (Rondeau 2001). However, because these vegetation types have broad elevation ranges, this vegetation type may be found below stands of pinyon-

juniper woodlands. This vegetation type usually occurs as large or small patches rather than as zones or a matrix community (Johnston et al. 2001, Rondeau 2001). Fire is frequent in this chaparral-like vegetation, and *Q. gambelii* is capable of resprouting after fire. Like pinyon-juniper woodlands, grazing and other human influences have caused changes in the structure and fire periodicity in this vegetation type (West and Young 2000). Increased fire frequency causes relative density of *Q. gambelii* to increase, which can lead to stand closure (Komárková et al. 1988). *Quercus gambelii* also increases with grazing and browsing by elk (*Cervus canadensis*) and deer, while *A. utahensis*, which is a favorite browse for elk, decreases (Johnston et al. 2001).

Cirsium perplexans is documented in five of 25 locations in association with saltbush-greasewood communities. This community type is common in intermountain lowlands in the western United States (West and Young 2000). It is characterized by very dry and salty conditions and low total plant cover (West and Young 2000). Most of the vascular plants found in saltbush-greasewood shrublands are in the Chenopodiaceae (goosefoot family). The species in this community type that are most commonly associated with *Cirsium perplexans* are *Atriplex confertifolia* and *Hilaria jamesii* (Lyon personal communication 2003). Three other rare plant species are found to occur with *C. perplexans* when it is found in association with this community: *Penstemon retrorsus*, *Lomatium concinnum*, and *Cryptantha longiflora* (Colorado Natural Heritage Program 2004). Management concerns for saltbush-greasewood shrublands include impacts from sheep and cattle grazing, invasion of non-native plants, especially *Halogeton glomeratus*, and population explosions of insects and mammals (West and Young 2000).

Herbivory probably plays a role in the ecology of *Cirsium perplexans*, but there has been little documentation of this. In 2004, up to 10 percent of the plants at Logan Wash appeared to have been grazed by rabbits or rodents (Klish personal communication 2004). The lower portions of the leaves and the top of the root had been dug up to a depth of 2 or 3 inches and nipped off. Large herbivores, including deer and elk, as well as small mammals, birds, and insects also potentially play a role in the ecology of this species.

In general, *Cirsium* species are an important source of food for birds, such as goldfinches and hummingbirds (Barlow personal communication 2003). Rodents and birds feed on the seeds of *C. pitcheri* (Center for Plant Conservation 2003). In their studies of *C. pitcheri*, Rowland and Maun (2001) found that when white-tailed deer (*Odocoileus virginianus*) removed more than 50 percent of the transplant's leaf tissue, the plant died.

There is no information on competitors for biotic and abiotic resources with *Cirsium perplexans*. If competitive interactions are important in the autecology of *C. perplexans*, some of the associated species cited in **Table 1** are the most probable competitors.

Lyon notes that some of the *Cirsium perplexans* plants at the Doug Creek location have some insect damage, cobwebby material, and ants (Colorado Natural Heritage Program 2004). There have been no reports in the literature or other observations of parasite or disease attack on *C. perplexans*.

CONSERVATION

Threats

Given the lack of substantive information, it is difficult to assess threats to *Cirsium perplexans* confidently. In order of decreasing priority, possible threats to *C. perplexans* are the use of biological control and herbicides to manage populations of non-native thistles, off-road vehicle use, non-native species invasion, road and pipeline construction, residential and agricultural development, and global climate change. These threats and the hierarchy ascribed to them are speculative due to a lack of information specific to *C. perplexans*. Assessment of threats to this species should be an important component of future inventory and monitoring work.

The most significant threat to the long-term survival of *Cirsium perplexans* probably results from the use of biological control to manage populations of non-native thistles. The Eurasian weevil *Rhinocyllus conicus* was released widely in the United States and Canada by private organizations and state and federal agencies in an effort to control introduced thistles, primarily *Carduus nutans* (musk thistle). Introductions were initiated in 1968 following limited research to determine impacts to native species (Strong 1997). Since that time the weevil has been found attacking at least 22 native North American taxa (Louda and O'Brian 2002), including at least four native *Cirsium* species (Strong 1997, Louda et al. 1997), and also *C. perplexans* (Dodge personal communication 2003). The weevils lay their eggs on developing flower heads, and the larvae develop while feeding on the heads, flowers, and developing seeds (Louda 1998). Louda and her colleagues found up to 86 percent reduction

of seeds on *C. canescens* (Platte thistle) in Nebraska, and an average of 72 percent reduction of viable seeds on *C. undulatum* (wavyleaf thistle) compared with non-infested flower heads. Significantly, the first of the weevils were documented on *C. canescens* in the Nebraska Sandhills in 1992, two decades following their first release in the region (Strong 1997). Louda and her colleagues had been studying *C. canescens* since 1984. The weevils were found to increase exponentially from 1992 through 1997 (Louda 1998).

Another Eurasian weevil, *Larinus planus*, is currently being distributed in North America for the control of the noxious weed *Cirsium arvense*. During screening processes to determine if the weevil was suitable for biological control, no North American species of *Cirsium* were tested (Louda and O'Brian 2002). Although *L. planus* has not yet been found on *C. perplexans*, it was released in the Gunnison National Forest in 1992 and 1993 and at the Paonia Reservoir in 1997, and like *Rhinocyllus conicus*, this species may not be evident in other areas for many more years. The release areas are in close proximity to populations of *C. perplexans*. It is not known if the Land's End Mountain occurrence on Gunnison National Forest is infested with weevils. In 1999 Louda and O'Brian (2002) found *L. planus* feeding in the flower heads of *C. undulatum* var. *tracyi* (Tracy's thistle), a native thistle that is known to co-occur with *C. perplexans* (Colorado Natural Heritage Program 2004). Louda and O'Brian (2002) found that the *L. planus* infestation had decreased the average number of viable seeds produced per plant by 51 percent. Unfortunately, they also found that *L. planus* had less effect on its targeted host, *C. arvense*.

In addition, Dodge has observed another non-native weevil, *Trichosirocalus horridus*, on *Carduus nutans* in the vicinity of *Cirsium perplexans*, and plans to investigate whether or not this species is infecting *C. perplexans* in the coming years (Dodge personal communication 2003). Eric Lane, the Colorado Department of Agriculture Weed Coordinator, confirmed that *T. horridus* has been released in Colorado (Lane personal communication 2003).

Cirsium perplexans may also be threatened by the use of herbicides meant for control of non-native thistles. It is vulnerable to being mistaken for a non-native thistle by weed managers who may not have keen plant identification skills and who are not informed of the presence of this native species.

At least eight of the 25 known occurrences of *Cirsium perplexans* are found in areas with anthropogenic disturbances (Colorado Natural Heritage Program 2004). Some level of natural disturbance might be beneficial to *C. perplexans* (Lyon and Denslow 2001). However, anthropogenic disturbances that occur in habitat for *C. perplexans* may also result in habitat degradation and destruction. Off-road vehicle use is widespread and difficult to regulate in the area inhabited by *C. perplexans*, and it has resulted in degradation of rare plant habitat on large areas of the Gunnison Gorge NCA (Lyon and Denslow 2001). However, in this same research effort, Lyon and Denslow estimated that no individuals of *C. perplexans* had yet been lost to roads and trails. Nonetheless, Lyon indicates that there is no way to be sure that plants have not been lost given the paucity of available data , and without multiple years of observation (Lyon personal communication 2003).

The small occurrence of *Cirsium perplexans* on the Gunnison National Forest, Land's End Mountain, is found along a gravel road, with a few plants in an adjacent area that is grazed by cattle. It is not known how much these land uses have helped or hurt *C. perplexans* here, or at the other locations listed below. At the Cedar Hill at Paonia location *C. perplexans* is found in disturbed areas along a trail, and the area is used for a crèche and lighted cross during the Christmas season. The occurrence at Chaffee Gulch is found along a roadside and on small earth dams. At the Cimarron State Wildlife Area plants are growing in disturbed areas around an entrance sign and along an old road. The Doug Creek population is a roadside occurrence. Portions of the Logan Wash location are described as being in a pasture and roadside. At the West of Red Rocks site Lyon notes that although there is little off trail use in the area, an off-road vehicle trail runs along a ridge through a portion of the occurrence. Also a few small off-road vehicle trails were observed at the Near Flat Top site. In 2001 Denslow noted that the primary land uses at the State Tunnel Dam location were sheep grazing and off-road vehicle use. Off-road vehicle trails also run above a portion of the occurrence at the West of Landfill site. Off-road vehicle use in this area is primarily motorcycles (Lyon personal communication 2003). Cattle grazing at Cedar Mesa may have created habitat for *C. perplexans* (Lyon personal communication 2003).

Exotic species may also threaten *Cirsium perplexans*. Lyon reports that the Land's End Mountain site on Gunnison National Forest is heavily invaded by exotics including *Bromus inermis* (smooth brome) and *Melilotus officinalis* (yellow sweet clover). Dr. David Keil (personal communication 2003) reported high cover of *Aegilops cylindrica* (jointed goatgrass) and *B. tectorum* at the Debeque Cemetery site. Lyon noted a

population of *C. arvense* adjacent to *C. perplexans* at the Cimarron State Wildlife Area. She also noted *M. officinale*, *C. arvense*, and *Carduus nutans* at the Doug Creek site. At Pyramid Rock Lyon notes significant cover of *B. tectorum*, *Plantago patagonica* (woolly plantain), *Ranunculus testiculatus* (curveseed butterwort), and *Lepidium perfoliatum* (clasping pepperweed) growing in the vicinity of *Cirsium perplexans*, as well as a small amount of *B. tectorum* within the occurrence of *C. perplexans*. Lyon documented *Halogeton glomeratus* (halogeton) at the West of Rocks site. Lyon also reports a large patch of *Acroptilon repens* (Russian knapweed) at the Flat Top site. Denslow reports *B. tectorum* and *C. arvense* at the State Tunnel Dam location. Impacts from the introduced invasive species, *Dipsacus sylvestris* (teasel), may be endangering *C. vinaceum*, which is narrowly endemic in New Mexico (Huenneke and Thomson 1995).

Roads run through or adjacent to several occurrences of *Cirsium perplexans*. Roads threaten occurrences of *C. perplexans* largely through indirect effects as dispersal corridors for weeds and as sources of erosion. In highly outcrossing species, roads and trails might act as barriers to pollinators and prevent effective gene flow. New road construction threatens occurrences if it involves occupied habitat.

In 2004, Mike Klish with WestWater Engineering located approximately 2,464 *Cirsium perplexans* plants in the Logan Wash area (Klish personal communication 2004). Of these, 462 were located within a proposed pipeline route. It is not known if the pipeline will be realigned to accommodate *C. perplexans* at this location.

Although it currently is not known to be threatening any specific occurrence, with 11 of the 25 known occurrences located at least partially on private land, residential development is potentially a significant threat to *Cirsium perplexans*. Residential development is proceeding rapidly along the Colorado Western Slope. The municipalities of Montrose, Delta, and Paonia are likely to expand greatly in coming decades. The population of Montrose County grew by 36.9 percent between 1990 and 2000 (Montrose County 2001). Subdivision of property into ranchettes and construction of second homes are perhaps greater threats to *C. perplexans* than suburban development at the periphery of metropolitan areas. This type of low-density development fragments large areas of natural habitat (Knight et al. 2002). The proliferation of roads and disturbance from construction could encourage the spread of weeds into habitat for *C. perplexans*. Horse grazing on ranchettes often results in serious degradation and erosion due to overgrazing. A natural fire regime is incompatible with dispersed development, resulting in fire suppression at the expense of the functional needs of the ecosystem. Please see the Community Ecology section of this assessment for more information regarding fire suppression.

Livestock grazing may threaten occurrences that are accessible to cattle, horses, and sheep. Grazing is occurring at nine or more locations for this species (Land's End Mountain, Cedar Mesa, Winter Flats, Logan Wash, Cimarron State Wildlife Area, State Tunnel Dam, West of Red Rocks, Near Flat Top, and West of Landfill). Lyon (personal communication 2003) notes that cattle often tend to stay off of the barren shale areas that typically support *Cirsium perplexans*. However, sheep, which are grazed at the State Tunnel Dam, West of Red Rocks, Near Flat Top, and West of Landfill locations, are found to spend time and create trails on the barren slopes that support *C. perplexans* (Lyon personal communication 2003). Grazing may threaten *C. perplexans* by trampling and herbivory and thereby reduce plant biomass. Grazing may also threaten *C. perplexans* because of the broad impacts it has on habitat quality and ecosystem processes in the plant communities it occupies. These are summarized in the Community Ecology section of this assessment. Indirect impacts via habitat degradation are well documented in West and Young (2000). However, it should also be noted that in some cases cattle may help to create a disturbance that is beneficial to *C. perplexans*. For example, at Cedar Mesa, one of the largest known populations of *C. perplexans*, the plants are growing in a pasture grazed by cattle (Lyon personal communication 2003).

Global climate change is likely to have wide-ranging effects in the near future. Projections based on current atmospheric CO_2 trends suggest that average temperatures will increase while precipitation will decrease in Colorado (Manabe and Wetherald 1986). This will have significant effects on nutrient cycling, vapor pressure gradients, and a suite of other environmental variables. Temperature increase could cause vegetation zones to climb 350 feet in elevation for every degree F of warming (U.S. Environmental Protection Agency 1997). Effects on *Cirsium perplexans* and its habitats are difficult to project given this scenario.

Atmospheric nitrogen deposition (of both organic and inorganic forms) is increasing worldwide. Relatively low levels of nitrogen enrichment are advantageous to some species but deleterious to others, making it difficult to predict species- and community-level

responses. The proximity of occurrences of *Cirsium perplexans* to developing areas leaves them vulnerable to effects of atmospheric pollution. The tolerance of *C. perplexans* to heavy metals and other pollutants has not been investigated.

Influence of management activities or natural disturbances on habitat quality

The effects of fire suppression on *Cirsium perplexans* habitat quality are unknown. Given the sparse vegetation in sites occupied by *C. perplexans*, the role of fire in these habitats is probably minor. However, ecosystem processes in the surrounding habitats probably directly or indirectly affect *C. perplexans* and its habitat quality, and fire might be important in the maintenance of these processes.

The construction of roads has apparently created small amounts of suitable habitat in five locations (Land's End Mountain, Doug Creek, Logan Wash, Cimarron State Wildlife Area, and Chaffee Gulch), but it may have also destroyed habitat and individuals. Off-road vehicle use may influence the availability and quality of *Cirsium perplexans* habitat. In 2001, Lyon and Denslow did not find the populations of *C. perplexans* at the Gunnison Gorge NCA (State Tunnel Dam, Near Flat Top, West of Red Rocks, Near Flat Top locations) to be impacted by off-road vehicle use. However, future research is warranted to determine fully the impacts of off-road vehicles to this species (Lyon personal communication 2003).

Indirect effects on habitat quality for *Cirsium perplexans* caused by fragmentation and hydrologic alteration are not clear. The impact of these actions on habitat quality depends largely on the importance of ecological connectivity between occurrences, which is not known.

Influence of management activities or natural disturbances on individuals

Impacts to individuals and occurrences of *Cirsium perplexans* resulting from various management activities have not been investigated. However, observations suggest that *C. perplexans* is vulnerable to certain kinds of ongoing impacts. As is mentioned earlier under threats, efforts to control non-native plants through the use of biological control and herbicides may have serious implications for *C. perplexans*. It is likely that *C. perplexans* will end up being an unintended target for one or more agents of biological control, and land managers could spray *C. perplexans* if they are not aware of how it differs from their non-native targets. Land managers at the Gunnison National Forest would improve their ability to manage the Land's End Mountain occurrence of *C. perplexans* by checking the plants for the presence of non-native weevils and by assuring that weed control staff can accurately identify thistle species.

Cattle are breaking through a fence and eating *Cirsium perplexans* at the Cimarron State Wildlife Area (Dodge personal communication 2003). In the future, Dodge hopes to put up a temporary exclosure to investigate this dynamic further. Grazing pressure may also present problems at Land's End Mountain on Gunnison National Forest, Winter Flats, Logan Wash, Cedar Mesa, West of Landfill, West of Red Rocks, Near Flat Top, and State Tunnel Dam (Colorado Natural Heritage Program 2004).

Because occurrences of *Cirsium perplexans* probably remain to be documented, surveys should take place within potential habitat before management actions are implemented. Although many occurrences are in remote locations, some of these areas are accessible by off-road vehicles and receive fairly heavy recreational use. There has been no documentation of recreational impacts to the species.

Interaction of the species with exotic species

Cirsium perplexans may interact with several non-native agents of biocontrol and several non-native weeds that are known or suspected of occurring within its habitat. For more detailed information on these subjects please see the Threats section of this assessment. Vigilance in monitoring for the impacts of these non-natives is crucial to the survival of *C. perplexans*.

Bromus tectorum probably presents the greatest threat to *Cirsium perplexans* from exotic plant species for several reasons. It aggressively invades native plant habitat, and its spread throughout the sagebrush shrublands and pinyon-juniper woodlands in the Intermountain West has been well documented (Young and Blank 1995). *Bromus tectorum* has been documented with *C. perplexans* and is common throughout its range. As a winter annual, *B. tectorum* is likely to compete with *C. perplexans* for water and nutrients, and as it outcompetes perennial understory species, erosion increases (West and Young 2000). Efforts to manage *B. tectorum* often employ early season burning, but this is likely to injure *C. perplexans* as well. The dramatic changes wrought by *B. tectorum* on the fire ecology of

woodland ecosystems are also likely to affect the habitat of *C. perplexans*.

Centaurea solstitialis (yellow starthistle) has been found in Montrose and Delta counties (Dillon 1999), and it poses a threat to *Cirsium perplexans* and many other native plant species if current efforts to contain it fail. It has a wide ecological range and the potential to spread widely in Colorado. It currently infests 10 million acres in California (Colorado Weed Management Association 2002).

Other exotic species of particular concern for *Cirsium perplexans* include *C. arvense*, *Carduus nutans*, *Halogeton glomeratus*, and *Acroptilon repens*.

Threats from over-utilization

There are no known commercial uses for *Cirsium perplexans*. However, other species of *Cirsium* are edible and used for medicinal purposes. Freitus (1975) indicates that the roots and young shoots of *C. arvense* are edible. Harrington (1967) reports that thistle-leaf tea is sold by some companies and that the seeds and young leaves of *Cirsium* species are also edible. Due to its small population size, *C. perplexans* is vulnerable to potential impacts from harvesting wild populations if for some reason it became sought after as a medicinal herb, or if it is misidentified as another desirable species of *Cirsium*. Over-collection for scientific purposes, particularly in small populations, is also a potential threat.

Conservation Status of the Species in Region 2

Is distribution or abundance declining in all or part of its range in Region 2?

Changes in the distribution and abundance of *Cirsium perplexans* over time are unknown. Most occurrences of *C. perplexans* appear healthy and show no signs of decline. However, only six of the 25 known occurrences had been documented prior to 1996, and rigorous long-term data are not available for any of the occurrences. Although the occurrence at DeBeque Cemetery could be in decline as a result of non-native species invasions, *C. perplexans* has persisted at that location since 1909. Other occurrences of *C. perplexans* that are reported to have non-native species present have not been known as long. For example, the Land's End Mountain location on Gunnison National Forest, which is known to have *Melilotus officinale* and *Bromus inermis*, was first documented in 1997, and it has not been visited since. Although occurrences at Land's End Mountain (Gunnison National Forest), Cedar Mesa, Logan Wash, Cimarron State Wildlife Area, and Winter Flats could be impacted by cattle grazing, the barren shale slopes may provide some natural protection because cattle tend to avoid these areas, and the disturbance caused by cattle may even help *C. perplexans* maintain its population size (Lyon personal communication 2003). Although data on distribution have been amassed, these are largely qualitative or include rough population estimates, if any at all. Populations that have not been visited recently should be visited to assess or re-assess their status.

Do habitats vary in their capacity to support this species?

The variation in population size and density documented thus far in occurrences suggests that habitats vary greatly in their capacity to support *Cirsium perplexans*. However, the underlying ecological reasons for this variation are unknown and difficult to speculate on until research is conducted to clarify the relationships between *C. perplexans* and its habitat. Areas that support the largest occurrences, such as Cedar Mesa and Logan Wash, probably benefit from the combination of clay soils, lack of competing vegetation, and disturbance (Lyon personal communication 2003).

Vulnerability due to life history and ecology

Cirsium perplexans is vulnerable due to its specificity for certain types of habitats. The elevation range of *C. perplexans* may buffer it somewhat from climate change impacts that are most likely to affect low elevation occurrences first.

The minimum viable population size is not known for *Cirsium perplexans*, but even small populations may still be viable and of conservation importance. For conservation planning purposes, the Colorado Natural Heritage Program considers populations of *C. perplexans* containing 10 or more plants as viable, but this threshold will be revised when a minimum viable population size is determined.

Like all rare plants, *Cirsium perplexans* is vulnerable to unforeseen impacts from noxious weeds. New exotic species are arriving constantly, and it may be only a matter of chance that the habitat for *C. perplexans* has not already been substantially invaded by exotics.

Evidence of populations in Region 2 at risk

Some occurrences of *Cirsium perplexans* are at risk as a consequence of human activities that have persisted for many years. Occurrences on private lands are arguably the most imperiled since they are more vulnerable to increasing population density, proliferation of low-density residential development, and associated roads and other infrastructures, which are significant threats and may place many populations at risk in the future. Occurrences near Montrose or other urban centers are especially at risk, as are those in areas planned for low-density residential development. Increased human visitation to occurrences of *C. perplexans* is inevitable given the current population growth projections for the area, and the effects this will have on *C. perplexans* are difficult to ascertain. Development might also negatively impact some of the pollinator species on which *C. perplexans* depends by reducing nectar resources in the area.

Although quantitative data are not available, recent observations of some occurrences of *Cirsium perplexans* suggest that weeds present a tangible threat to this species. Aggressive weed management programs may be necessary to assure the survival of some occurrences. In particular, potentially problematic, non-native weeds have been documented at Land's End Mountain on the Gunnison National Forest, Logan Wash, DeBeque Cemetery, Doug Creek, Kinikin Road, and West of Red Rocks locations. Weed management programs may be challenging to develop since they will need to use methods that will not harm *C. perplexans*.

Cattle are breaking through a fence and eating *Cirsium perplexans* at the Cimarron State Wildlife Area (Dodge personal communication 2003). In the future, Dodge hopes to put up a temporary exclosure to further investigate this dynamic. Grazing pressure from may also present problems at Land's End Mountain on Gunnison National Forest, Cedar Mesa, Logan Wash, and Winter Flats. Dodge also observed the biocontrol weevil, *Rhinocyllus conicus*, feeding on *C. perplexans* at the Cimarron State Wildlife Area location (Dodge personal communication 2003).

Management of the Species in Region 2

Implications and potential conservation elements

The most current data available suggest that *Cirsium perplexans* is imperiled due to the small number of occurrences and small population sizes. Given the distribution and distance between the known occurrences, it is likely that some populations have alleles that are not present in other populations, so the loss of any one population could result in a significant loss of genetic diversity. Maintaining the genetic integrity of populations of *C. perplexans* is an important management consideration.

To identify appropriate restoration habitat, comparisons can be made to the nearest occupied *C. perplexans* habitat. More research is needed to identify appropriate microhabitat. Controlling threats and periodic reintroductions may be necessary to maintain populations.

Desired environmental conditions for *Cirsium perplexans* include sufficiently large areas where the natural ecosystem processes on which *C. perplexans* depends can occur, permitting it to persist unimpeded by human activities and their secondary effects, such as weeds and biological control. This includes a satisfactory degree of ecological connectivity between occurrences to provide corridors and other nectar resources for pollinators if necessary. Given the current paucity of detailed information on this species, it is unknown how far this ideal is from being achieved. It is possible that most or all of the ecosystem processes on which *C. perplexans* depends are functioning properly at many or most of the occurrences of this species. Further research on the ecology and distribution of *C. perplexans* will help to develop effective approaches to management and conservation. Until a more complete picture of the distribution and ecology of this species is obtained, priorities lie with conserving the known occurrences, particularly those that support large numbers of individuals, are in excellent condition, and in which the surrounding landscape remains largely intact. Lyon notes that the Pyramid Rock location is the best known occurrence in a natural setting, away from roads and grazing (Colorado Natural Heritage Program 2004).

It is likely that a thoughtful assessment of current management practices on lands occupied by *Cirsium perplexans* would identify some opportunities for change that would be inexpensive and have minimal impacts on the livelihood and routines of local ranchers, managers, stewards, and recreationists while conferring substantial benefits to *C. perplexans*.

Within the last 15,000 years, the climate in the southern Rocky Mountains region has been both warmer and colder than it is at present. There is much evidence to suggest that the elevational and latitudinal distributions of many plant species were much different

in these periods than they are today. Given the changes predicted in the global climate for the next 100 years, incorporation of higher elevation areas for *Cirsium perplexans* into preserve designs and conservation plans may allow *C. perplexans* to move into these areas over time, and help to ensure its long-term viability.

Tools and practices

Monitoring occurrences of *Cirsium perplexans* could answer many important questions. A research and monitoring program that addresses recruitment, seed production, plant longevity, and pollinators would generate data useful to managers and the scientific community. Collecting baseline information and developing a detailed baseline map of the known occurrences will provide a starting point from which population trend can be assessed. It will be important to define *a priori* the changes the sampling regime is designed to detect and the management actions that will follow from the results (Schemske et al. 1994, Elzinga et al. 1998).

Because of its high rate of population turnover (as a possible biennial or short-lived perennial species), resampling of monitoring plots will be necessary every year to gain insight into the population dynamics of *Cirsium perplexans*. Johnston (personal communication 2002) has recommended a broadly applicable method employing the use of randomly arrayed systematic sampling units. Each sampling unit should consist of a transect with randomly placed $1m^2$ quadrats. The quadrats are evenly spaced, but the placement of the first quadrat on the transect is done randomly. After they are established, the quadrats would become permanent. Within each quadrat, plants would be marked and tracked using aluminum tags or other field markers. Recruitment within each plot will be quantified by counting seedlings. To reduce the chance of missing seedlings, a quadrat frame subdivided with tight string would help observers search each quadrat systematically. Elzinga et al. (1998) offers additional suggestions regarding this method.

A stratified random design might also be employed to establish the sampling units, particularly at locations where it is difficult to lay a transect due to the ruggedness of the site. Permanent plots could be selected within a habitat unit by randomly choosing X and Y UTM coordinates. Then, the plots could be located using a highly accurate Global Positioning System (GPS) unit. Once established and marked, the plots could be relocated with a recreation grade GPS. If subsequent power analysis indicates that the sample size is inadequate, it is easy to add more quadrats in this sample design.

Estimating cover and/or abundance of associated species within the plots described above could permit the investigation of interspecific relationships through ordination or other statistical techniques. In very sparsely vegetated plots this can be difficult, but it can be done accurately using appropriate cover classes or subdivided quadrat frames. Understanding environmental constraints on *Cirsium perplexans* would facilitate the management of this species. Gathering data on edaphic characteristics (moisture, texture, and soil chemistry) from the permanent plots described above would permit analysis of species-environment relationships. These data would facilitate hypothesis generation for further studies of the ecology of this species.

Most of the occurrences *Cirsium perplexans* have only been visited once, so relocating and updating basic occurrence and habitat information will help to develop a more detailed monitoring program. A thorough inventory for *C. perplexans* has never been conducted. When occurrences were documented by Lyon in the late 1990's and early 2000's, she was working on larger projects including numerous other plant species. Therefore, she was unable to focus inventory efforts on *C. perplexans* (Lyon personal communication 2003). Inventory work is among the highest priorities for research on *C. perplexans*. Recent searches by botanists in suitable habitat areas have found many previously unknown occurrences in the last ten years, contributing the vast majority of our basic knowledge of the distribution and habitat for species. Contracting botanists to search for more occurrences and to update information for known records would contribute greatly to our knowledge of *C. perplexans*.

The Colorado Natural Heritage Program routinely uses aerial photography, topographic maps, soil maps, and geology maps to refine search areas when conducting inventories of large areas. This approach has been highly effective in Colorado and elsewhere. It is most effective for species such as *Cirsium perplexans* about which we have basic knowledge of its substrate and habitat specificity from which distribution patterns and potential search areas can be deduced.

Searches for *Cirsium perplexans* could be aided by modeling habitat based on the physiognomy of known occurrences. The intersection of topography, geologic substrate, and vegetation could be used to generate a map of a probabilistic surface showing the likelihood of

the presence of *C. perplexans* in given locations. This would be a valuable tool for guiding and focusing future searches. Techniques for predicting species occurrences are reviewed extensively by Scott et al. (2002). Habitat modeling has been done for other sensitive plant species in Wyoming (Fertig and Thurston 2003), and these methods apply to *C. perplexans* as well.

Because *Cirsium perplexans* is only known from 25 locations, all the known occurrences should be monitored. Visiting occurrences in May through early July while the plants are flowering and most easily visible would also allow researchers to observe insect visitors that may play a crucial role in the breeding biology of *C. perplexans*, or non-native insects that may pose a threat. It may also be possible to count seedlings at this time. Measuring seed production will require another visit later in the summer.

Adding a photo point component following the recommendations offered in Elzinga et al. (1998) could facilitate the tracking of individuals and add valuable qualitative information. A new handbook on photo point monitoring (Hall 2002) is available, and it offers excellent instructions on establishing photo point monitoring plots. Monitoring sites should be selected carefully, and a sufficient number of sites selected if the data are intended to detect population trends.

At present the priorities lie in gathering baseline data on the distribution and population sizes for *Cirsium perplexans*. At a minimum, presence/absence monitoring should be conducted. However, since it is time consuming and difficult to reach many of the occurrences, the additional time investment of gathering population size and other data is worthwhile to maximize the information gleaned during each visit. Gathering population size data can be done rapidly and requires only a small amount of additional time and effort (Elzinga et al. 1998).

Cirsium perplexans habitat monitoring should be conducted concurrently with population monitoring. Descriptions of habitat during population monitoring efforts will greatly augment our present knowledge of its requirements and attributes. Habitat monitoring of known populations would also help to alert managers of new impacts such as weed infestations and trampling. Huenneke and Thomson (1995) offer useful criteria for determining whether non-native plants pose problems for rare native plants.

Changes in habitat variables might not cause observable demographic repercussions for several years, so resampling the chosen variables may help to identify underlying causes of population trends. Evidence of current land use practices and management are important to document while monitoring occurrences. Monitoring all the known occurrences of *Cirsium perplexans* with a visit every third year is feasible given the small number of occurrences.

Observer bias is a significant problem with habitat monitoring (Elzinga et al. 1998). Thus, habitat monitoring is usually better at identifying new impacts than at tracking change in existing impacts. For estimating weed infestation sizes, using broad size classes helps to reduce the effects of observer bias. To assess trampling impacts, using photographs of impacts to train field crews will help them to consistently rate the severity of the impact.

Management actions that reduce impacts to *Cirsium perplexans* and its habitat are likely to procure significant benefits for the species. Johnston et al. (2001) offer a detailed treatment of range management strategies for sagebrush-dominated systems and for tall non-riparian shrublands such as the oak/serviceberry shrublands. Please see West and Young (2000) for recommendations on the management of pinyon-juniper woodlands. There have been no active population or habitat management efforts on behalf of *C. perplexans*.

Given the potential threats to *Cirsium perplexans* and its habitat from exotic species, particularly *C. arvense*, *Bromus tectorum*, and *Acroptilon repens*, aggressive management of weeds in and near *C. perplexans* occurrences is a high priority for its conservation. Unfortunately it will probably be difficult to remove *B. tectorum* from *C. perplexans* occurrences without harming *C. perplexans* as well. Any management strategies that work to prevent the infestation of uninfested occurrences of *C. perplexans* are likely to confer the greatest benefits. Lyons notes that at Pyramid Rock weed control at the base of the mountain might forestall the weeds from invading the rare plant locations above.

Management practices that reduce the impacts from grazing to occurrences of *Cirsium perplexans* are likely to contribute greatly to the achievement of conservation goals for this species. Since habitat for *C. perplexans* is of very low forage value, it is unlikely that actions on behalf of *C. perplexans* will affect the grazing regime or have economic impacts. Some approaches that might be considered on a site-by-site basis include the use of exclosures and the reduction of stocking rates.

Well-intentioned use of herbicides may do more harm than good if their use kills *Cirsium perplexans* too. Thus, the use of herbicides within occurrences should be limited to direct application to weeds. To this end, training on the proper identification of native vs. non-native thistles is critical. Weed managers could also have information on known occurrences of *C. perplexans* and other rare plants so that they can incorporate this knowledge into their management plans.

Occurrences of *Cirsium perplexans* need to be further evaluated for negative impacts resulting from recreational use of its habitat, particularly off-road vehicle activity. Where off-road vehicle use is causing mortality or habitat degradation, efforts to route activity around occurrences would procure substantial benefits to *C. perplexans*.

Identifying high quality occurrences of *Cirsium perplexans* in which the population size, condition, and the landscape context are excellent will help managers to prioritize conservation efforts for *C. perplexans*. Delineating special management areas for these locations will help to ensure the long-term viability of this species. Lyon indicates that the Pyramid Rock location is the best known occurrence in a natural setting, away from roads and grazing. This occurrence is located within a BLM ACEC, as well as a state designated natural area. Because many occurrences reside on land managed by the BLM, designation of other selected areas as ACECs is one option for garnering protection for occurrences of high conservation value.

No seeds or genetic material are currently in storage for *Cirsium perplexans* at the National Center for Genetic Resource Preservation (Miller personal communication 2003). It is not among the National Collection of Endangered Plants maintained by the Center for Plant Conservation (Center for Plant Conservation 2002). Collection of seeds for long-term storage will be useful if future restoration work is necessary.

Pursuit of conservation easements to protect occurrences on private land would add significant protection to some of the other occurrences. This would help to broaden the range and habitat types protected for this species, which in turn should help to maintain the genetic diversity of *Cirsium perplexans*.

Information Needs

Distribution

Further inventory work is among the top priorities for research on *Cirsium perplexans*, and it is likely to result in the identification of additional occurrences. Until we have a better picture of the distribution and population size of *C. perplexans*, it will not be possible to accurately assess the conservation needs and priorities for this species.

Although the entire global range of *Cirsium perplexans* is within six counties in western Colorado, much suitable habitat between known occurrences remains to be searched. The "population boom" noted by several researchers in 2004 (Klish personal communication 2004, Lyon personal communication 2004) suggests that *C. perplexans* could be missed if surveys are conducted in years that are not favorable to the plants. Complex land ownership patterns, particularly in subdivided areas, can also thwart search efforts due to the need for permission to access these sites. However, recent search efforts, particularly those of Lyon from 1998 to 2001, have been successful, but time and funding constraints limited the intensity of these inventory efforts. Further focused searching for *C. perplexans* is warranted. Revisiting and assessing the occurrences that have not been visited in more than 10 years is also a research priority. More detailed habitat specificity information will help to refine future search efforts.

Life cycle, habitat, and population trend

Very little is known about the population ecology of *Cirsium perplexans*. Baseline population size data are available for many occurrences, but there are no monitoring data with which to determine the population trend. Further work is needed to more rigorously quantify population size and to attempt to determine population trend. Basic life history parameters, such as life span and seed viability, also need to be determined from which the viability of populations can be inferred.

Autecological research is needed for *Cirsium perplexans*. Such research will help to refine our definition of appropriate habitat and to understand why

many sites that appear to be suitable are not occupied. Information on soil chemistry and nutrient relations could yield valuable insights into the ecological requirements of *C. perplexans*, which would facilitate effective stewardship of this species. Physiological ecology studies will also help to determine what substrate characteristics are required by *C. perplexans*, which will be valuable information in the event that a population needs to be restored and will help to model the potential distribution of the species.

Collections are needed of this and other species of *Cirsium* to better understand relationships within this genus. Collections including the roots would help to determine if the life cycle is perennial or biennial. However, Lyon indicates that this can be quite difficult because the roots of *C. perplexans* tend to break as they are taken from the clay soils (Lyon personal communication 2003).

Response to change

Reproduction, dispersal, and establishment, and the effects of environmental variation on these parameters have not been investigated in *Cirsium perplexans*. Thus, the effects of various management options cannot be assessed during project planning. Understanding the breeding systems employed by *C. perplexans* will assist managers by determining the importance of pollinators for reproduction and population genetics. At this time, it is not known how management changes that affect insect visitors will affect *C. perplexans*.

The introduction of non-native weevils for the control of non-native thistle species will likely cause a decline in populations of *Cirsium perplexans*. However, the rate and severity of the decline is not known. The relationship of seed availability to plant population dynamics and interspecific relationships are also unknown. Louda et al. (1997) found that native flies feeding on *C. canescens* and *C. undulatum* declined precipitously in response to infestation with *Rhinocyllus conicus*. Research is needed on *C. perplexans* to determine if there is a similar interspecific competition that could be impacting other native species related to *C. perplexans*, especially insects and birds.

The importance of herbivory in the ecology of *Cirsium perplexans* is not understood. Observations made thus far suggest that cattle grazing may have an impact on biomass reduction and disturbance of the species (Dodge personal communication 2003), but this has not been assessed.

It can be assumed that any management change that promotes the spread and abundance of *Bromus tectorum* in the vicinity of *Cirsium perplexans* occurrences will be detrimental. A more rigorous study of the impact on *C. perplexans* of exotic species, particularly *B. tectorum*, *C. arvense*, and *Acroptilon repens* is needed.

Metapopulation dynamics

Research on the population ecology of *Cirsium perplexans* has not been done to determine the importance of metapopulation structure and dynamics to the long-term persistence of *C. perplexans* at local or regional scales. Migration, extinction, and colonization rates are unknown for *C. perplexans*. Thus, analyses of local or regional population viability must rely on observable trends in individual populations. This approach can provide reliable assessments of species status in the absence of metapopulation structure information (Harrison and Ray 2002). Given our current understanding of the distribution of *C. perplexans*, despite the fact that all 25 occurrences are found within an approximately 35 x 85 mile area, most occurrences are fairly disjunct from one another.

Demography

Population size has been estimated but not rigorously quantified for occurrences of *Cirsium perplexans*. Growth, survival, and reproduction rates are also unknown. Our knowledge of the distribution of the species is probably incomplete. Therefore, much work is needed in the field before local and range-wide persistence can be assessed with demographic modeling techniques. Short-term demographic studies often provide misleading guidance for conservation purposes, so complementary information, such as historical data and experimental manipulations, should be included whenever possible (Lindborg and Ehrlén 2002). However, the value of demographic data for conservation planning and species management cannot be overstated.

Population trend monitoring methods

There has been no monitoring of occurrences of *Cirsium perplexans*, but methods are available to begin a monitoring program. Lesica (1987) described a technique for monitoring populations of non-rhizomatous perennial plant species that would apply to *C. perplexans*.

Restoration methods

Because no attempts have been made to restore populations of *Cirsium perplexans*, there is no applied research to draw from in developing a potential restoration program. Rowland and Maun (2001) found that populations of *C. pitcheri*, a threatened species endemic to the shoreline sand dunes of the Great Lakes, could be restored by planting seeds at shallow depths, transplanting greenhouse-grown plants, applying water soluble fertilizers, and protecting plants from herbivores.

Research priorities for Region 2

Understanding the distribution and demographics of *Cirsium perplexans* are among the top research priorities for this species. Demographic research will have great value for management and conservation purposes. If populations are robust and contain healthy levels of genetic diversity, demographic studies will help to determine how to keep them that way through management. If they are not, then we can become aware of the problem though demographic research and develop management guidelines to address genetic concerns. Some key questions to address are: 1) Are populations stable? and 2) What is the minimum viable population size for *C. perplexans*?

Understanding the breeding systems employed by *Cirsium perplexans* is another research priority for this species due to the practical and scientific value of such studies. Answers to questions about whether *C. perplexans* is apomictic or a frequent outcrosser will provide needed guidance for developing appropriate management practices. If *C. perplexans* reproduces predominantly through apomixis, the genetic population structure is more stable than if the species is an outcrosser, since a pollinator is not required. Thus, a trail or road through an apomictic population will not be as detrimental as one through a population of outcrossers.

The response of *Cirsium perplexans* to human impacts and disturbance has not been studied. Gaining practical knowledge of how to best manage populations of this species is of considerable importance given the rapid change in land use patterns, increasing recreational use, and increasing human population density of Colorado's western slope communities.

Although many new occurrences of *Cirsium perplexans* have been discovered in recent years, more inventory work is needed throughout the range of the species. Further attempts to locate occurrences in Delta, Garfield, Gunnison, Mesa, Montrose, and Ouray counties are warranted, mainly because extant occurrences are known from these areas, and they contain additional apparently suitable habitat. Other neighboring counties where *C. perplexans* has not yet been found (e.g., Rio Blanco County) are also worthy of species inventory work.

Definitions

Achene — a small, dry, indehiscent fruit with a single locule and a single seed (Harris and Harris 1999).

Apomixis — seed production without fertilization (Harris and Harris 1999).

Autecology — study of the ecology of single species.

Biocontrol — biological agents (e.g., insects) that are used to control pests.

Cotyledon — a primary leaf of an embryo; a seed leaf (Harris and Harris 1999).

Entire — not toothed, notched, or divided, as the continuous margins of some leaves.

Erose — with the margin irregularly toothed, as if gnawed (Harris and Harris 1999) or fringed.

Gametes — a mature cell.

Glabrate — almost hairless.

Inflorescence — a flower cluster, or group of flowers; a flowerhead.

Infructescence — a fruit cluster, a group of fruits.

Involucre — a whorl of bracts subtending a flower or flower cluster (Harris and Harris 1999).

Panmictic — referring to unstructured (random-mating) populations.

Pappus — the modified calyx of the Asteraceae, consisting of awns, scales, or bristles at the apex of the achene (Harris and Harris 1999).

Phyllaries — the bracts around the base of the inflorescence of plants in the Asteraceae (Harris and Harris 1999).

Pinnate — a compound leaf with leaflets arranged on opposite sides of an elongated axis (Harris and Harris 1999).

Radicle — the first part of a seedling to emerge from the seed during germination. The embryonic root of the plant that grows downward in the soil.

Tomentose — with a covering of wooly hairs.

Imperilment Ranks used by Natural Heritage Programs, Natural Heritage Inventories, Natural Diversity Databases, and NatureServe.

Global imperilment (G) ranks are based on the range-wide status of a species. State-province imperilment (S) ranks are based on the status of a species in an individual state or province. State-province and Global ranks are denoted, respectively, with an "S" or a "G" followed by a character. **These ranks should not be interpreted as legal designations.**	
G/S1	Critically imperiled globally/state-province because of rarity (5 or fewer occurrences in the world/state; or very few remaining individuals), or because of some factor of its biology making it especially vulnerable to extinction.
G/S2	Imperiled globally/state-province because of rarity (6 to 20 occurrences), or because of other factors demonstrably making it very vulnerable to extinction throughout its range.
G/S3	Vulnerable through its range or found locally in a restricted range (21 to 100 occurrences).
G/S4	Apparently secure globally/state-province, though it might be quite rare in parts of its range, especially at the periphery.
G/S5	Demonstrably secure globally, though it may be quite rare in parts of its range, especially at the periphery.

GX	Presumed extinct.
G#?	Indicates uncertainty about an assigned global rank.
G/SU	Unable to assign rank due to lack of available information.
GQ	Indicates uncertainty about taxonomic status.
G/SH	Historically known, but not verified for an extended period, usually.
G#T#	Trinomial rank (T) is used for subspecies or varieties. These taxa are ranked on the same criteria as G1-G5.
S#B	Refers to the breeding season imperilment of elements that are not permanent residents.
S#N	Refers to the non-breeding season imperilment of elements that are not permanent residents. Where no consistent location can be discerned for migrants or non-breeding populations, a rank of SZN is used.
SZ	Migrant whose occurrences are too irregular, transitory, and/or dispersed to be reliable identified, mapped, and protected.
SA	Accidental in the state or province.
SR	Reported to occur in the state or province, but unverified.
S?	Unranked. Some evidence that the species may be imperiled, but awaiting formal rarity ranking.

Notes: Where two numbers appear in a G or S rank (e.g., S2S3), the actual rank of the element falls between the two numbers.

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