Draba weberi Price & Rollins (Weber's draba): A Technical Conservation Assessment

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Author's Biography

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Cover Photo Credit

Draba weberi (Weber's draba). Photograph by William Jennings, used with permission.

SUMMARY OF KEY COMPONENTS FOR CONSERVATION OF *DRABA WEBERI*

Status

Draba weberi is an extremely narrow endemic known only from the type locality, a single occurrence in the Monte Cristo Creek drainage in Summit County, Colorado, containing between 20 and 100 individuals. It is not currently considered a sensitive species in Region 2 of the USDA Forest Service because there is insufficient information available to determine if the species merits sensitive status, and because the only known population is not on National Forest System land. The NatureServe and Colorado Natural Heritage Program ranks for *D. weberi* are G1 and S1, respectively. No management plans or conservation strategies have been developed for *D. weberi*, and the single known location does not have any protective designation.

Primary Threats

There are several threats to the persistence of *Draba weberi* in Region 2. In order of decreasing priority, these are environmental stochasticity, disturbance by anthropogenic activities such as road and dam construction and maintenance, recreation, mining, spread of exotic species, and global climate change. Anthropogenic threats to the known population of *D. weberi* are primarily due to its proximity to a water storage project and the possibility of disturbance by dam and road construction and maintenance, but they also include potential impacts from recreation and mining. *Draba weberi* may be vulnerable to habitat change due to global warming or competition from invasive species. If the known population is the only occurrence, it is also vulnerable to destruction by catastrophic natural events.

Primary Conservation Elements, Management Implications and Considerations

Because *Draba weberi* was only discovered after the construction of the dam that now dominates its habitat, it is impossible to know if current conditions represent either its original or optimum habitat. Because the species is currently known only from one small population that has no protective designation, it may be vulnerable to the effects of management activities in its general vicinity. *Draba weberi* is obviously vulnerable to environmental stochasticity because of its small population size, but not enough is known about its life history or reproductive capacity to conclude that it is inherently vulnerable due to biological factors. The little we know about *D. weberi* suggests that current site conditions should be maintained, but that we should not assume that cautious non-interference will be sufficient to preserve the species. At a minimum, desired conditions may include maintaining approximately average stream flow in Monte Cristo Creek and preventing anthropogenic disturbance to the area where *D. weberi* is growing. The most pressing information needs for this species are clarifying its taxonomic status, surveying to locate additional populations, if any exist, and monitoring of the existing population.

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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). *Draba weberi* (Weber's draba) is the focus of an assessment because it is a local endemic species whose population viability is identified as a concern based on its extremely limited global distribution. Although it is a globally rare species, *D. weberi* is not currently listed as a sensitive species in Region 2 because there is insufficient information available to determine if the species merits sensitive status, and because the only known occurrence is not on National Forest System land (USDA Forest Service 2003a). 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 in habitat capability that would reduce its distribution (FSM 2670.5(19)). A sensitive species or species of concern may require special management, so knowledge of its biology and ecology is critical. This assessment addresses the biology of *D. weberi* throughout its range in Region 2. This introduction defines the goal of the assessment, outlines its scope, and describes the process used in its production.

Goal of Assessment

Species conservation assessments produced as part of the Species Conservation Project are designed to provide forest managers, research biologists, and the public with a thorough discussion of the biology, ecology, conservation status, and management of certain species based on available scientific knowledge. The assessment goals limit the scope of the work to critical summaries of scientific knowledge, discussion of broad implications of that knowledge, and outlines of information needs. The assessment does not seek to develop specific management recommendations. Instead, it provides 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 examines the success of those recommendations that have been implemented.

Scope of Assessment

This assessment examines the biology, ecology, conservation status, and management of *Draba weberi* with specific reference to the geographic and ecological characteristics of Region 2. Although some, or even a majority, of the literature on *Draba* species may originate from field investigations outside the region, this document places that literature in the ecological and social contexts of the central Rocky Mountains. Similarly, this assessment is concerned with reproductive behavior, population dynamics, and other characteristics of *D. weberi* in the context of the current environment rather than under historical conditions. The evolutionary environment of the species is considered in conducting the synthesis, but it is placed in a current context.

In producing the assessment, refereed literature, non-refereed publications, research reports, and data accumulated by resource management agencies and other investigators were reviewed. Other than the original published description (Price and Rollins 1991), there are no refereed publications devoted to *Draba weberi* although it is mentioned in a few sources. Because basic research has not been conducted on many aspects of the biology of *D. weberi*, literature on its congeners was used to make inferences. The refereed and non-refereed literature for the genus *Draba* and its included species is more extensive and includes other endemic or rare species. All known publications on *D. weberi* are referenced in this assessment, and many of the experts on this species were consulted during its synthesis. Specimens were viewed at University of Colorado Herbarium (COLO) and Kalmbach Herbarium, Denver Botanic Gardens (KHD). The assessment emphasizes peer-reviewed literature because this is the accepted standard in science. Non-refereed publications or reports were regarded with greater skepticism, but they were used in the assessment since there is very little refereed literature that specifically addresses *D. weberi*. Much of the information about past and current conditions affecting *D. weberi* was compiled through conversations with land managers and other agency employees. For an unstudied species such as *D. weberi*, these personal communications constitute an important body of knowledge that provides a baseline for more formal investigations. An added benefit is that the conversations probably resulted in a greater awareness of conservation issues for *D. weberi* among the pertinent land owners and managers. Unpublished data (e.g., Natural Heritage Program records, reports to state and federal agencies, specimen labels) were important in providing historical observations and data from individuals who could not be contacted during the preparation of this assessment.

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 includes 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, in the ecological sciences it is difficult to conduct experiments that produce clean results. Often, observations, inference, critical thinking, and models must be relied on to guide our understanding of ecological relations. Confronting uncertainty, then, is not prescriptive. In this assessment, the strength of evidence for particular ideas is noted, and alternative explanations are described when appropriate.

Treatment of This Document as a Web Publication

To facilitate the use of species assessments in the Species Conservation Project, they are published on the Region 2 World Wide Web site. Placing documents on the Web makes them available to agency biologists and the public more rapidly than publishing them as reports. More important, it facilitates revision of the assessments.

Peer Review of This Document

Assessments developed for the Species Conservation Project have been peer reviewed prior to release on the Web. This assessment was reviewed through a process administered by the Society for Conservation Biology and the Center for Plant Conservation, 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

Draba weberi is not currently considered a sensitive species in Region 2, and because it occurs only in Colorado, it is not included on any other USFS special status lists in the United States. The single known occurrence is on land owned and managed by Colorado Springs Utilities for the City of Colorado Springs. The occurrence is surrounded by National Forest System land administered by the Dillon Ranger District of the White River National Forest, where *D. weberi* is not a species of local concern (Edelmon personal communication 2004). *Draba weberi* is not on the Bureau of Land Management (BLM) Sensitive Species List for Colorado, and there are no BLM lands adjacent to the known occurrence. The vicinity contains a patchwork of mining claims, both patented and unpatented (**Figure 1**; Semmer personal communication 2004). *Draba weberi* has never been listed as, or been a candidate for, Threatened or Endangered status under the federal Endangered Species Act.

The NatureServe and Colorado Natural Heritage Program ranks for *Draba weberi* are G1 and S1, respectively. The global (G) rank is based on the status of a taxon throughout its range. The G1 rank indicates that the species is considered critically imperiled globally because of extreme rarity or because of some factor(s) making it especially vulnerable to extinction. A G1 species typically has five or fewer occurrences or very few remaining individuals (<1,000). The state (S) rank is based on the status of a taxon in an individual state; in this case the global and state distributions and ranking reasons are equivalent.

Existing Regulatory Mechanisms, Management Plans, and Conservation Strategies

No management plans or conservation strategies have been developed for *Draba weberi*, and the single known occurrence does not have any protective designation. The USFS evaluation of *D. weberi* for sensitive species status concluded that there was insufficient information available to determine whether the species merits sensitive status (USDA Forest Service 2003b). No occurrences are known from National Forest System lands, no surveys have been completed, and no information is available on population trends for this species. Unless occurrences are discovered on National Forest System land, USFS options for conservation are limited.

The Blue Lakes area was evaluated by both the Colorado Natural Heritage Program and the Colorado Natural Areas Program (Spackman et al. 1997, Carsey and Decker 1999). General management recommendations by these two programs emphasize the need for conservation organizations to work with Colorado Springs Utilities, the USFS, Summit County government, and other land managers in the area to

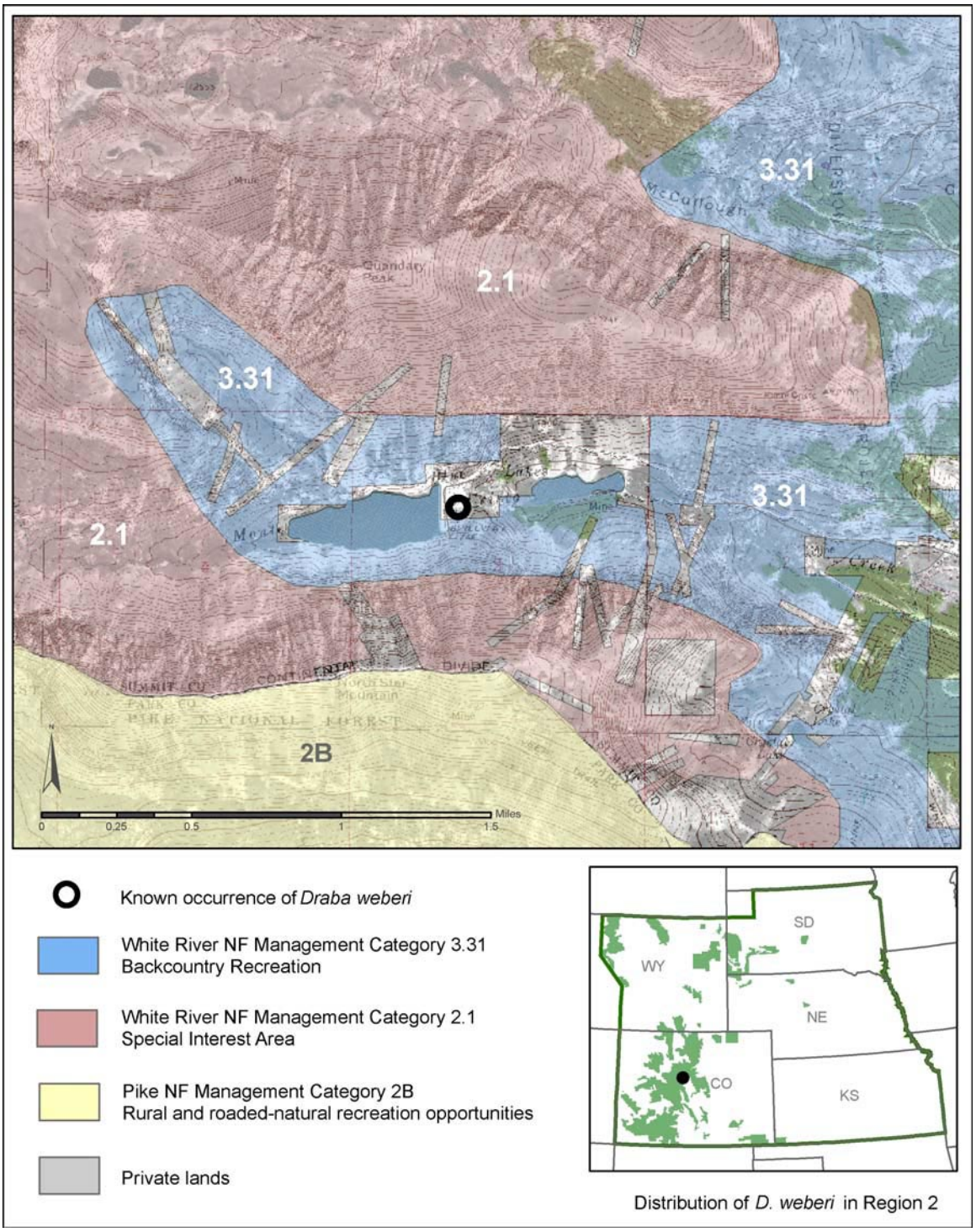


Figure 1. Local and regional distributions of *Draba weberi*.

monitor and protect the species, but no group has taken the lead in this task. As a consequence, current laws and regulations are probably inadequate to insure the conservation of *Draba weberi* in the long term because the species has no federal status that could compel non-federal landowners to take responsibility for its preservation. The occurrence has survived for at least 35 years, due in part to the attention and expert knowledge of Colorado's professional and amateur botany community, but there is no organized effort to protect it. Special status may be warranted for this species.

Biology and Ecology

Classification and description

Draba weberi is a member of the Mustard family (Brassicaceae, also called Cruciferae). The North American Cruciferae were treated by Rollins (1993), who recognized 99 genera, 778 species, and 248 subspecies and varieties. The mustards are considered a very natural family, largely characterized by a radial flower with four petals in the form of a cross and six stamens in a pattern of two short and four long, together with a two-loculed fruit. The fruits of the Cruciferae are quite diverse and are generally considered to provide the easiest and most reliable basis for classification. *Draba* is the largest genus within the Cruciferae, both worldwide and in North America. There are currently about 104 recognized species in North America, with the greatest concentration of species in the western United States (Rollins 1993). Most *Draba* are found at high elevations, and it is common for species to be endemic to local mountain ranges (Rollins 1993).

Draba weberi was apparently first collected by Dr. William A. Weber in July 1969, but this specimen was originally identified as *D. grayana* (University of Colorado Museum Herbarium 2004). *Draba weberi* was finally described by Price and Rollins in 1991 from specimens collected by Price in the early 1980s. Price and Rollins (1991) described *D. weberi* as an extremely restricted endemic, known only from a population of perhaps 100 individuals at the type locality. They considered *D. weberi* to be most closely related to what Price (1979) called the *D. crassa* complex, a group of yellow-flowered alpine perennials, with short stems and one to five cauline leaves, that are endemic to the Rocky Mountains. Other members of the group found nearby include *D. streptobrachia* Price, a central Colorado alpine endemic that occurs on the rocky slopes of North Star Peak, *D. grayana* (Rydberg) C.L. Hitchcock, endemic to alpine fell fields in northern and central Colorado and occurring a few kilometers away on Hoosier Ridge, and *D. crassa* Rydberg, an alpine species of the Rocky Mountains from southern Montana to Colorado and Utah's Uinta Mountains that also grows on the slopes of North Star Peak. Other, presumably less closely related *Draba* species that occur nearby include *D. borealis* and *D. fladnizensis* (University of Colorado Museum Herbarium 2004).

As described by Price and Rollins (1991), Rollins (1993), and Weber and Wittmann (2001), *Draba weberi* is a caespitose perennial with erect stems about 2 to 6 (10) cm long (**Figure 2**), moderately pubescent with simple and forked trichomes, or glabrous. Basal leaves are narrowly oblanceolate, ciliate (with a marginal fringe of hairs), and sparsely pubescent with simple and short-stalked forked trichomes (sometimes appressed and cruciform), and the one to three stem leaves are narrowly oblong. Plants have five to 15 yellow claw-petaled flowers per stem, each about 3 to 5 mm long. *Draba weberi* flowers from June to July. The fruits (siliques) are ascending, ovate, glabrous, and strongly compressed parallel to the plane of the septum. Siliques are sessile, and about 4 to 8 mm long and 2 to 3 mm wide. The unwinged seeds are oblong and about 1.2 mm long. Complete technical descriptions are available in Price and Rollins (1991) and Rollins (1993); a less detailed description is available in Weber and Wittmann (2001). A drawing (**Figure 3**) and photograph of the plant and its habitat appear in the *Colorado Rare Plant Field Guide* (Spackman et al. 1997) in both online and print versions.

Draba weberi is distinguished from sympatric species of the *D. crassa* complex by differences in pubescence, trichome structure, and style length (**Table 1**). *Draba crassa* is generally a more robust plant, with basal leaves that appear succulent, often having four or more stem leaves, and with style length similar to *D. streptobrachia* (Rollins 1993). Price and Rollins (1991) describe *D. streptobrachia* has having tangled, irregularly branched stellate pubescence on the stems, predominantly short-stalked 4- to 5-armed hairs on the leaf surfaces, fruits generally curved in three dimensions, and styles generally longer than those of *D. weberi* (0.5 to 1.2 mm vs. 0.3 to 0.5 mm). *Draba grayana* differs by having denser and usually more tangled stem pubescence, leaves more coarsely and evenly pubescent with longer simple and forked hairs, and a range of style length similar to that of *D. streptobrachia* (Price and Rollins 1991). *Draba weberi* may also differ from these species in its wetter habitat of stream edges, but the possibility that it can survive in less mesic areas cannot be ruled out.

Distribution and abundance

Draba weberi is an extremely narrow endemic (**Figure 1**, **Table 2**). As of this writing, it is known only from the type locality, a single occurrence in the Monte Cristo Creek drainage in Summit County, Colorado. The plants are found in crevices among rocks beside a cascading stream below the outlet of the upper Blue Lake Reservoir. The occurrence has been in existence since at least 1969, when it was originally collected by Weber. This occurrence has been reported to be as large as 100 plants (Price and Rollins 1991), but only 31

Photograph by Steve Olson, used with permission.

Photograph by William Jennings, used with permission.

Figure 2. *Draba weberi* in flower and fruit.

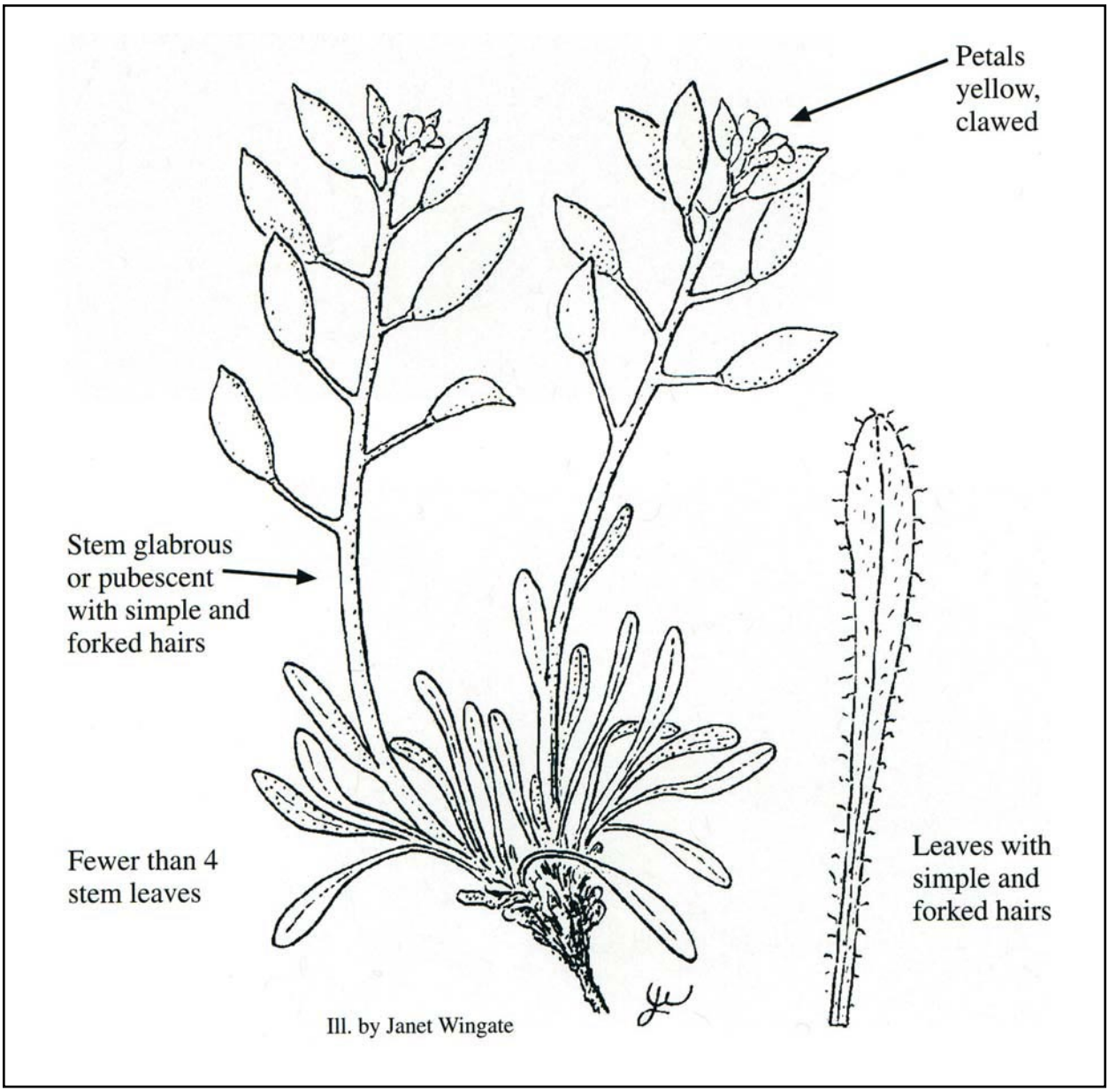


Figure 3. Drawing of *Draba weberi* from Spackman et al. 1997. Drawing by Janet Wingate, used with permission.

individuals were seen during the most recent recorded visit (Doyle personal communication 2006).

The dam at the upper Blue Lake Reservoir was constructed in 1965, and it has not been substantially modified since (Haynes personal communication 2004). A comparison of the current extent of the dam and reservoir with topographic maps from the years prior to 1965 indicates that the construction and subsequent filling of the reservoir primarily affected parts of Monte Cristo Creek above the *Draba weberi* occurrence. It is possible that additional individuals were destroyed during the construction process, or that the occurrence was displaced from its original habitat. If there are additional occurrences in existence, it is possible they may be found in somewhat different habitats.

Population trend

Price and Rollins (1991) described the *Draba weberi* occurrence as consisting of "perhaps 100 individuals." This estimate is presumably based on observations by Price from the early 1980s, but his survey technique, if any, was not reported. Other observers report substantially lower numbers. In June 1994, between two and 10 individuals were observed in the rocks a short distance below the dam (Jennings personal communication 2004), but an extensive search

Table 1. Distinguishing features of *Draba* species sympatric with *D. weberi* in USDA Forest Service Region 2. Compiled from Rollins 1993.

Species	Style length (mm)	Pubescence / trichomes	Habitat
Draba weberi	0.25 - 0.5	stems: moderately pubescent with simple or once-forked trichomes or glabrous leaves: ciliate, sparsely pubescent on upper and lower surfaces with simple and short-stalked once-forked, sometimes cruciform trichomes silique: glabrous	crevices along rocky streamside
D. crassa	ca. 0.75	stems: moderately pubescent with soft, simple, crooked trichomes leaves: glabrous, fruiting pedicels soft-pubescent silique: glabrous	rocky alpine tundra, talus, rock crevices, steep slopes, clay summits and rocky cliffs
D. exunguiculata	0.5 - 1	stems: glabrous to sparsely hairy with simple or forked trichomes leaves: (basal) ciliate and very sparsely covered with simple trichomes only silique: glabrous	tundra, alpine fell-fields, rocky slopes and talus
D. grayana	0.5 - 1	stems: densely pubescent with tangled simple and forked trichomes leaves: (basal) conspicuous marginal fringe of hairs, upper surfaces glabrous or with few simple trichomes silique: glabrous	open knolls, steep hillsides, alpine fell-fields and gravely slopes
D. streptobrachia	0.5 - 1.2	stems: stellate-pubescent leaves: stellate-pubescent on both surfaces silique: with simple or forked trichomes or sometimes glabrous	finely weathered rock and loose soil, ridges and slopes, scree margins and fell-fields, alpine tundra
D. borealis	0.5 - 1	stems: with simple and branched trichomes leaves: uniformly pubescent with mostly stalked cruciform trichomes silique: usually pubescent with forked or stellate trichomes, sometimes glabrous	creek banks, cliffs, gravelly terraces, steep slopes, meadows, and roadsides
D. fladnizensis	< 0.5	stems: glabrous or pubescent near the base with mostly simple, rarely forked trichomes leaves: ciliate and glabrous to sparsely pubescent with simple trichomes on leaf surfaces silique: usually glabrous	exposed slopes and ridges, rocky alpine tundra, rocky granitic slopes

of the area was not performed. In July 2000, Colorado Natural Heritage Program botanists were able to identify one individual of *D. weberi*, together with another 20 plants that were probably *D. weberi* during an hour-long search of the area below the outflow pipe and on the cliffs above the adjacent roads (Colorado Natural Heritage Program 2006). In July 2003, 22 individuals were observed by USFS botanist Steve Olson and U.S. Fish and Wildlife Service botanist Ellen Mayo. No plants were in seen in a visit during August of the next year, presumably because the plants had already senesced (Mayo personal communication 2004). Colorado Natural Heritage Program botanists found 31 plants at the site in July 2006. A 2003 general botanical survey of the surrounding area by USFS workers did not locate any additional occurrences of *D. weberi* or other rare *Draba* species (Edelmon personal communication 2004). If the initial population size estimate by Price and Rollins was accurate, there may have been a decline in numbers of plants during the past few decades. However, the goal of most observers has been simply to relocate the single known occurrence, and there are no records of intensive searches for this species in other areas of the drainage, or in nearby drainages. Population

Table 2. Documented occurrence of *Draba weberi* in USDA Forest Service Region 2.

Location	Colorado, Summit County Valley of Monte Cristo Creek, below the Upper Blue Lake Reservoir Dam Elevation: 11,500 -11,600 ft.		
Land Ownership	Private. Reservoir and surrounding area is owned and operated by Colorado Springs Utilities. Nearby federal lands are managed by the White River National Forest, Dillon Ranger District.		
Date Last Observed	17 July 2003		
Habitat	In crevices of rocks beside cascades, amid rocks at edge of stream.		
Population size	about 31 individuals at last observation.		
Source ID	Colorado Natural Heritage Program Element Occurrence Record-01		
	Herbarium specimens:		
	12 Jul 1969	Weber, W.A. #sn	COLO
	12 Jun 1980	Price, R.A. #443	GH, UC
	28 Jun 1981	Price, R.A. #464	UC-holotype, GH-isotype
	30 Jul 1985	Price, R.A. #825	UC
	18 Jun 1994	Jennings, W.F. #9419, with C.L. Crawford & R.E. Jennings	KDH

COLO = University of Colorado, UC = University of California, GH = Harvard, University, KDH = Kalmbach Herbarium, Denver Botanic Gardens

monitoring is required to quantify accurately the trend of this species.

Habitat

The single known occurrence of *Draba weberi* is found in the drainage of Monte Cristo Creek below the upper Blue Lake Reservoir dam. This reservoir is situated in the glaciated upper basin of the Monte Cristo Creek drainage northwest of Hoosier Pass in southern Summit County, Colorado (**Figure 4**). This valley at the southern end of the Tenmile Range is bounded by Quandary Peak on the north, Fletcher and Wheeler Mountains on the west, and North Star Mountain to the south. The Continental Divide forms the boundary between the Tenmile Range and the Mosquito Range extending to the southwest. Higher elevation valley slopes valley support talus, alpine tundra, willow scrub, and spruce-fir forest (Carsey and Decker 1999). Subalpine willow carrs occupy much of the riparian zone below the upper and lower reservoirs. The occurrence is located just above treeline, between 11,500 and 11,600 ft. elevation. This range is at the low end of elevations reported for related species of *Draba* occurring nearby (Ladyman 2004a, 2004b, University of Colorado Museum Herbarium 2004).

The streamside habitat of *Draba weberi* is wetter than that reported for nearby related *Draba* species. Plants occupy crevices among streamside rocks below the dam (**Figure 4**). This species was not collected before the construction of the dam, so it is impossible to know whether its current habitat is equivalent to its pre-dam environment, or indeed representative of its optimal habitat. Reported population numbers are small, and there is additional unoccupied suitable habitat along the drainage for about 1/2 mile below the dam, as well as potentially similar habitat available in nearby drainages of the Tenmile Range (Olson personal communication 2004).

Although the Blue Lakes area supports at least nine other state rare species (Colorado Natural Heritage Program 2006), *Draba weberi* is not known to be associated with any of these. It is found with other alpine and subalpine species that favor mesic rock crevice habitats. No associated species have been reported for *D. weberi*, but *Oxyria digyna, Rhodiola integrifolia*, several types of graminoids, mosses and lichens are visible in photographs of *D. weberi*. In other instances, *D. weberi* appears to be the sole occupant of the rock crevices (Jennings personal communication 2004). The extent of *D. weberi*'s dependence on streamside habitat is not known, but as with *O. digyna* and sympatric *Draba* species (**Table 1**), it may be able to survive in suitably moist crevices not immediately adjacent to streams. If this is the case, there is likely to be potential habitat both in the immediate drainage and in the larger surrounding area of the Tenmile Range.

View of Monte Cristo Creek drainage below Upper Blue Lake Reservoir. Dam is visible in upper right. Draba weberi habitat, shown in inset, is below the dam. Photographs by Susan Spackman Panjabi, used with permission.

View from road below Upper Blue Lake Reservoir showing *Draba weberi* habitat. Photograph by Susan Spackman Panjabi, used with permission.

Figure 4. Habitat of *Draba weberi*.

Reproductive biology and autecology

Life history

Draba weberi is an herbaceous, rosette-forming perennial of high elevations, flowering in June and July. Plants are difficult to see when not flowering, and they may die back soon after setting fruit (Mayo personal communication 2004). Price and Rollins (1991) reported that individuals produce ample seed without pollination, and they were able to grow plants from collected seed without difficulty. The few specimens deposited in Colorado herbaria have one to three dozen fruits per plant. Dispersal mechanisms and seed bank dynamics are unknown, but some authors have speculated that pikas (*Ochotona princeps*) may disperse seed of other alpine *Draba* species in the course of collecting vegetation for their haypiles (Ladyman 2004a).

Although little is known about the life history of *Draba weberi*, its small growth form and restricted alpine habitat suggest that it is a stress-tolerator in the Competitive/Stress-Tolerant/Ruderal (CSR) model of Grime (2001). Although environmental conditions above treeline can be harsh, the habitat has probably been relatively stable over the known existence of the species, at least until the construction of the upper Blue Lake dam. Stable habitat, low growth form, and moderate reproductive potential typify *D. weberi* as a K-selected species as defined by MacArthur and Wilson (1967).

Reproduction

As a genus, *Draba* exhibits a variety of reproductive systems, including apomixis, autogamy (selfing), and outcrossing. Most North American *Draba* species are thought to be primarily self-pollinating (Mulligan 1976), but various reproductive systems are probably represented by *Draba* species that occur in the vicinity of the *D. weberi* occurrence. In addition to *D. weberi*, there are twenty-five species of *Draba* that have been reported from Colorado (Price 1985, Weber and Wittmann 2001), including five other endemics. Eight Colorado species, including *D. weberi*, are reported to reproduce apomictically through agamospermy, but a few may have some sexual populations (Mulligan and Findlay 1970, Mulligan 1976, Price 1979, 1985). Another eight species are known to be primarily self-pollinating (autogamous), with occasional outcrossing in some species (Mulligan and Findlay 1970). At least three of the remaining 10 species are known to be outcrossing to some degree, and at least one species has been reported to be self-incompatible (Mulligan and Findlay 1970).

Draba weberi shares the trait of other Colorado endemic species (*D. streptobrachia*, *D. exunguiculata*, and *D. grayana*) of having sterile pollen and anthers that do not dehisce. These species appear to reproduce asexually through agamospermy, which is a form of apomixis in which seeds are formed without fertilization and carry only maternal genes. This form of reproduction has also been reported for several other yellow-flowered, arctic-alpine *Draba* species in North America (Mulligan and Findlay 1970, Mulligan 1976). Rollins (1993) speculated that the failure to produce viable pollen may have evolved in connection with the breakdown of the sexual system of reproduction in harsh arctic or alpine environments. Asexual reproduction may allow *D. weberi* to achieve a higher reproductive potential than high-elevation species that must rely on pollinators.

Draba weberi apparently belongs to what Price (1979) characterized as the *D. crassa* complex, a group of yellow-flowered perennials with styles generally greater than 0.5 mm and primarily occurring above treeline in the Rocky Mountains of the western United States. This group includes *D. crassa*, *D. exunguiculata*, *D. graminea*, *D. grayana*, *D. streptobrachia*, and *D. weberi*. All are endemic to Colorado except *D. crassa*, and all are apparently apomictic except *D. graminea* and possibly some populations of *D. grayana* (Price 1979). **Figure 5** depicts the distribution of this group.

The prevalence of uniparental reproduction in *Draba* presents difficulties in taxonomic classification. Organisms that reproduce either asexually through clonal growth or apomixis, or sexually through self-fertilization, do not fit the biological species concept, where the units of classification are interbreeding population systems (Grant 1981). Apomictic lineages such as those found in the *D. crassa* complex may fulfill the classic reproductive isolation criteria of the biological species concept in that they are morphologically distinguishable, have distinct ecological requirements, and do not hybridize. However, since individuals do not interbreed, the biological species concept breaks down, and every apomictic individual becomes a "species" (Asker and Jerling 1992). As a result of this difficulty, apomictic species are often treated as taxonomic (phenetic) species, where units of classification are groups of morphologically similar individuals (Grant 1981). This system requires that morphological differences be

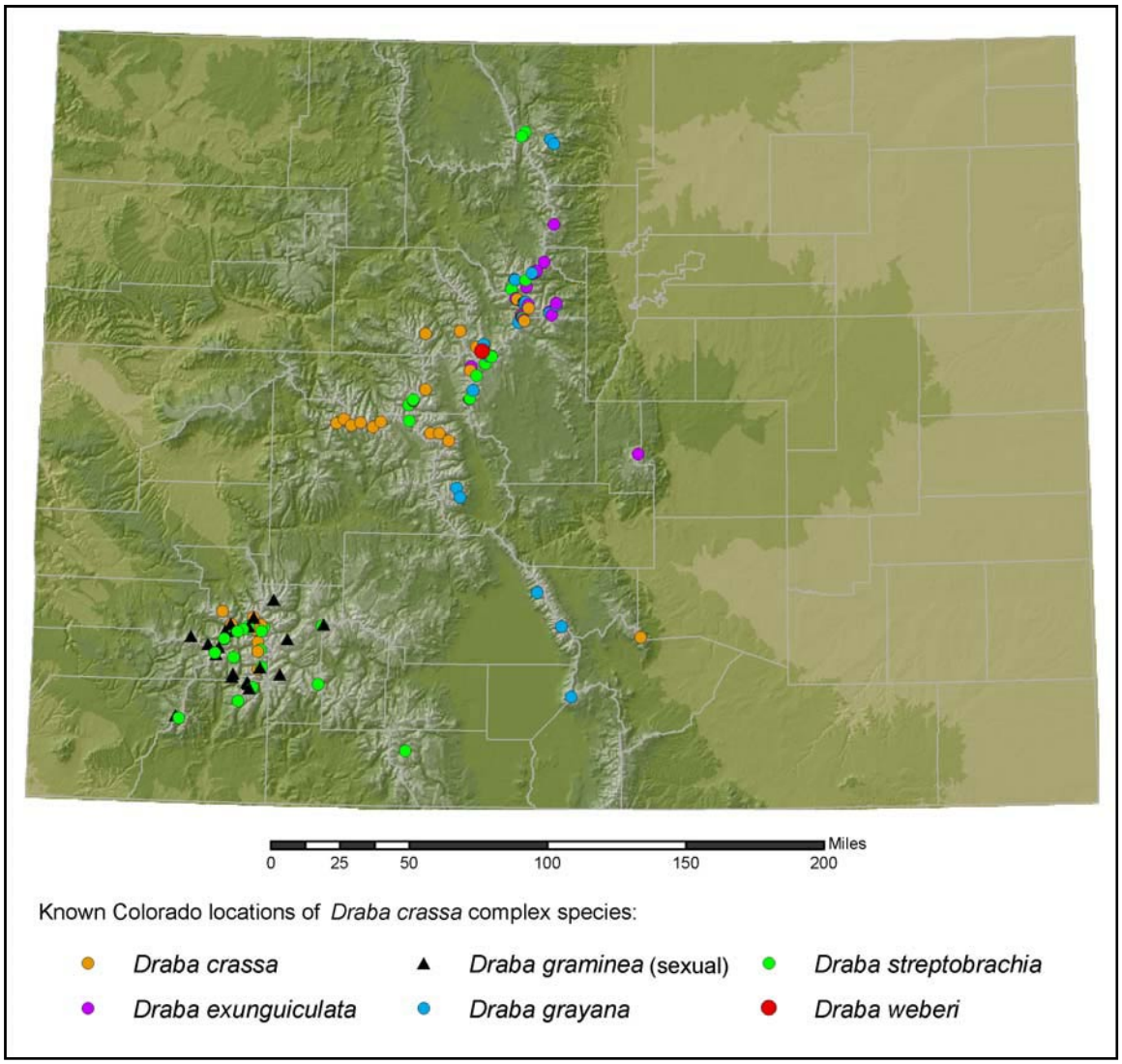


Figure 5. Generalized distributions of *Draba weberi* and closely related *Draba* species (Colorado Natural Heritage Program 2004).

useful in classification (i.e., not genetic or microscopic). In *Draba*, trichome characters are heavily relied on for taxonomic distinctions (Rollins 1993) and are assumed to reflect underlying taxonomic relationships.

Grant (1981) proposed that populations in uniparental organisms be defined as "microspecies" as an alternative to either the biological or taxonomic species concept. He characterized microspecies as uniform populations in predominantly uniparental plant groups that are slightly differentiated morphologically from one another. Microspecies are often (but not necessarily) restricted in distribution to a relatively small geographical area, and they are often of hybrid origin (Grant 1981). In most organisms, the hybrid offspring of two species are unlikely to form a new species since they are often sterile, or, if they are fertile, the hybrid characters are likely to be lost by backcrossing with the parental species. In the case of an apomictic hybrid, these potential difficulties for the origin of a species through hybridization are overcome, and a hybrid microspecies is able to build up a uniform population by asexual reproduction. This description of microspecies may be applicable to *Draba weberi* and perhaps to some other Colorado *Draba* species as well, but there is obviously a continuum between microspecies and full species. Current taxonomic practice accords full species status to the apomictic *Draba* (Windham personal communication 2004), including *D. weberi*, regardless of possible hybrid origin.

Asker and Jerling (1992) reported that more than 99 percent of all apomicts are polyploid. Polyploidy is often associated with hybridization, and it is common in the Cruciferae, both within species and between species of the same genus (Rollins 1993). However,

polyploidy is not always due to hybridization events. Polyploid organisms that receive all their chromosomal sets from the same species are autopolyploids, and those whose chromosome sets come from different species are allopolyploids. Polyploids may occur naturally when a cell undergoes abnormal mitosis or meiosis and chromosomes fail to separate correctly to opposite poles of the cell. The apomictic *Draba* species are believed to be primarily triploids with irregular meiosis (Windham personal communication 2004). Triploid organisms are usually autopolyploids that result from fertilization involving a haploid and a diploid gamete, but they may also originate as the result of backcrosses between tetraploid hybrids and the diploid parental species (Grant 1981).

Although polyploid hybridization appears to have played a role in the origin of some *Draba* species (Widmer and Baltisberger 1999), cytological and molecular studies (Windham 2000, Beilstein and Windham 2003, Windham 2003) of the *Draba* species of western North America highlight the importance of aneuploidy within the genus. Beilstein and Windham (2003) reported two well-supported clades within the western North American *Draba*, one composed of euploid taxa with chromosome numbers based on x = 8, and the other representing an aneuploid group with base chromosome numbers higher than x = 8. The little we know of *D. weberi* suggests that it likely fits into the aneuploid group (Windham personal communication 2004). Chromosome studies are ongoing (Beilstein and Windham 2003, Windham personal communication 2004), and they will help to clarify relationships within the genus. No chromosome numbers for *D. weberi* have been published, so its position in the North American clades is unknown. Given the complexity of reproductive systems and possible mechanisms of speciation in North American *Draba* species, it is premature to label *D. weberi* as a simple hybrid or to assign putative parental status to any particular nearby species purely on the basis of proximity. Future treatments of the genus are likely to maintain the treatment of *D. weberi* as a full species (Windham personal communication 2004).

Among apomictic *Draba* species, pollination is not necessarily a reproductive requirement, but it can be a means of gene flow for facultatively sexually reproducing species as well as a source of hybridization. *Draba weberi* is believed to reproduce primarily by apomixis, does not require pollen for seed formation, and is unlikely to be a source of fertile pollen for transport to other plants (Price and Rollins 1991). A 25-minute observation by Colorado Natural Heritage Program botanists in May 2000 failed to detect any potential pollen-transporting invertebrates associating with *D. weberi* (Colorado Natural Heritage Program 2006).

Phenotypic plasticity

Draba weberi is not known to exhibit phenotypic plasticity, other than some variation in the degree of glabrousness of the stems (Rollins 1993). Price and Rollins (1991) reported that differences in type and distribution of pubescence that distinguish *D. weberi* from related *Draba* species were maintained in plants grown from seeds under controlled conditions, and are not merely induced by a wet environment.

Demography

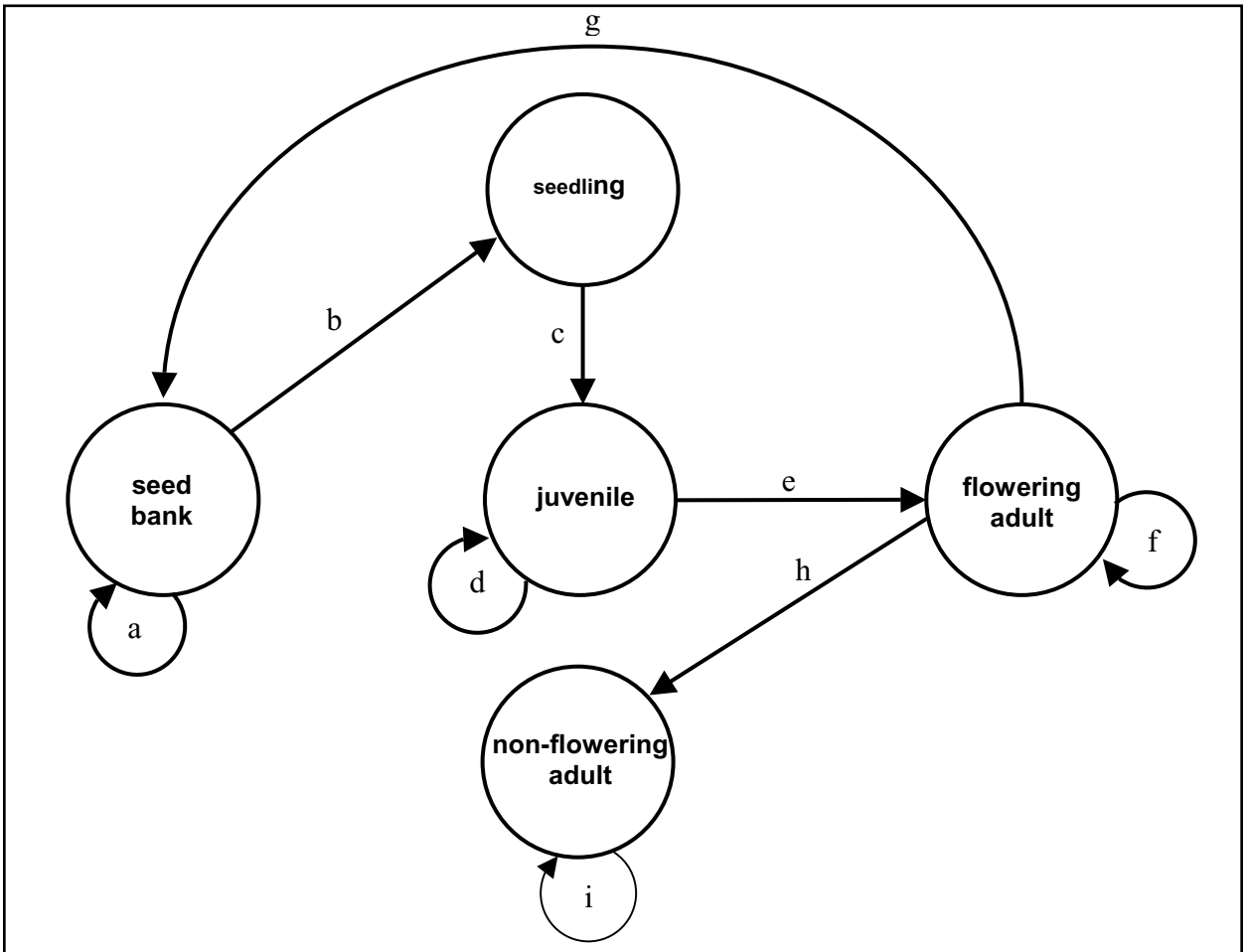
Species that reproduce asexually are often thought of as having reduced evolutionary potential due to lack of genetic variation. However, Asker and Jerling (1992) pointed out that naturally occurring apomictic populations often contain genetically distinct clones. Moreover, most apomictic species are not strictly obligate apomicts. Sexual and apomictic individuals may coexist in a population, and even obligate apomicts may participate in gene flow and hybridization if they produce some functional pollen. For apomicts that do not produce fertile pollen, gene flow is reduced, but not necessarily eliminated.

Results reported by Price (1979) and Price and Rollins (1991) indicated that for *Draba weberi* and other apomictic *Draba* species, pollen sterility is high, but variable in at least one species (*D. grayana*). However, sample sizes were usually limited to one or two individuals, and could have missed functional pollen produced by unsampled individuals. Additional research is needed to determine the possibility and extent of sexual reproduction and hybridization in the *D. crassa* complex.

The life history characteristics of *Draba weberi* are almost completely unknown. Most individuals observed have been in flower or fruit. During a recent observation of the population in 2003, more than 85 percent of the individuals observed were in a reproductive state (Mayo personal communication 2004). A few non-flowering rosettes have been identified, but no seedlings have ever been reported. It is not known if the majority of individuals are usually reproductive, or if non-reproductive individuals are simply overlooked. In asexually reproducing organisms, demographic classes do not represent discrete generations in the sense of recombinatorial offspring, but for an apomictic rosette-

forming plant with limited vegetative reproduction, such as *D. weberi*, the asexual lifecycle is sufficiently similar to the regular sexually reproducing life cycle to allow similar demographic investigation. **Figure 6** shows a hypothetical life cycle diagram for *D. weberi*, but because there are no demographic studies of this species, transition probabilities are left unquantified.

The theory of minimum viable population was developed under the animal model of the sexually reproducing, obligate outcrossing individual, and incorporated the effects of genetic stochasticity from elevated inbreeding coefficients in small populations (Soulé 1980). In the case of an apomictic species, the genetic and demographic issues are less clear, and population viability analysis must instead concentrate on probabilities of extinction through natural environmental variation. There are no Population Viability Analysis (PVA) models available for *Draba weberi*. Morris et al. (1999) discuss general classes of data sets and methods suitable for PVA including:



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

Figure 6. Life cycle diagram for *Draba weberi* (after Caswell 2001).

1) count-based extinction analysis, which requires censusing individuals in a single population for a minimum of 10 years (preferably more)

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

3) projection matrix modeling, which requires detailed demographic information on individuals collected over three or more years (typically at only one or two sites).

In the case of *D. weberi*, the lack of multiple sites means method 2 is not an option, and a multi-year study of the lone population would be required. There is clearly a trade-off in the years required versus intensity of data collection between methods 1 and 3. Currently there are no data sets available that could be used for PVA of *D. weberi*. Better information on dispersal mechanisms, germination site requirements, and life cycle stages of *D. weberi* would greatly facilitate a viability analysis.

Community ecology

The single known occurrence of *Draba weberi* is in an ecotonal area just above treeline. This alpine-subalpine boundary is characterized by a sharp gradient between the areas protected by forest canopy and the exposed alpine environment of bare rocky crests, relatively low atmospheric pressure, low temperatures, wind, blowing snow, long-lasting snow drifts, and intense solar radiation (Billings 2000). The elevation of treeline is determined primarily by the physical aspects of the mountain habitat, including weather, temperature, wind, snowdrifts, rocks, and soils. As these factors change over time, treeline retreats or advances (Billings 2000). The Monte Cristo Creek valley is a mosaic of alpine and subalpine plant associations whose distribution is largely determined by the same factors. Although *D. weberi* individuals have only been found in close proximity to the cascading creek, it is not certain that the species could not also survive in other mesic-protected habitats nearby, if it could disperse to those sites.

Almost nothing is known about the community interactions of *Draba weberi*. Its rocky streamside habitat has limited space for vegetation to grow; within this restricted habitat, *D. weberi* is likely to experience both intra- and interspecific competition for germination sites, light, nutrients, water, and other resources. It is also possible that *D. weberi* occurs in nearby habitats, where competitive relationships may be different from those of the known occurrence.

There are no reports of herbivory on *Draba weberi* invertebrates or larger animals. The site is not grazed by domestic livestock, but mountain goats (*Oreamnos americanus*) have been observed in the vicinity (Mayo personal communication 2004). The potential for herbivory by small mammals exists. There are no reports of parasites or diseases affecting *D. weberi*, and no information on symbiotic relationships such as mycorrhizae.

CONSERVATION

Threats

Based on the available information, there are several threats to the persistence of *Draba weberi* in Region 2. In order of decreasing priority, these are environmental stochasticity, disturbance by road and dam construction and maintenance, recreation, mining, spread of exotic species, and global climate change. Some of these threats are also pertinent to occurrences that may yet be found.

Environmental stochasticity

Environmental stochasticity generally refers to variation over time in the physical and biological environment. For a single population, this includes randomly occurring events that cause the deaths of a large proportion of individuals in the population. Such events may occur very rarely, yet still have a large effect on persistence of the population (Menges 1991). Multiple populations can have a mitigating effect against the operation of environmental stochasticity. For a species with only one population, such as *Draba weberi*, severe local events have the potential to eliminate the entire species.

Potential events that could severely affect *Draba weberi* include extreme, isolated precipitation events or unusually high precipitation years that result in excessive discharge from the reservoir, structural failure of the dam, and unusually severe avalanche runout that covers the occurrence with debris. Unusual weather events, including severe drought or unseasonable temperatures, could also drastically affect the occurrence. The random nature and infrequent occurrence of catastrophes mean that even long-term observations may not detect them. Any event that results in the mortality of a large proportion of the occurrence could be the greatest

threat to the persistence of *D. weberi* even if it occurs extremely rarely.

Disturbance by anthropogenic activities

The threat to the known occurrence of *Draba weberi* from human activity is due principally to its proximity to a water storage project. The Upper Blue Lake Reservoir dam is owned and operated by Colorado Springs Utilities as part of the Continental-Hoosier Diversion System (a.k.a. the Blue River Project). The project diverts water from the Blue River and its tributaries west of the Continental Divide to the Middle Fork of the South Platte River, just on the other side of the Divide from the Blue Lakes area (Winchester 2001). Water is diverted through a series of tunnels that cut across the lower reaches of Spruce Creek, McCullough Gulch, and Monte Cristo Creek. The dam spans Monte Cristo Creek at an elevation of 11,748 ft., creating a reservoir with a storage capacity of 2,120 acre-feet. A spillway is located on the south end of the dam, but water is normally released through an outlet pipe in the bottom center of the structure. Water from this outlet flows down the more-or-less natural creek bed into the lower pond. The single known occurrence of *D. weberi* is below the dam.

Colorado Springs Utilities does not have senior water rights in Monte Cristo Creek and must therefore continue to pass water through the reservoir in response to calls from other water rights owners, especially the Colorado River Project (Herrin personal communication 2004). When senior calls have been satisfied, Colorado Springs Utilities is permitted to store water in the reservoir. This arrangement means that under most circumstances, there is water flowing from the outlet pipes into the creek channel. When Colorado Springs Utilities has permission to store water, the dam is filled to spillway level if possible. Excess flow would normally go over the spillway, as happened in 1999 when a snow slide from the south face of Quandary Peak ran into the reservoir and forced water over the spillway (Newell personal communication 2004).

Maintenance of the structure has consisted primarily of repairs to the lining of the upstream side of the dam. The liner was last repaired in 1992 (Haynes personal communication 2004), and another refacing may occur within the next five years. It is possible that some work to extend and stabilize the ends of the dam will be required (Newell personal communication 2004). Although this work will require a draw-down of the reservoir, it is not expected to result in excessive stream flows because draw-down would be accomplished during the fall and winter when run-off is low. Colorado Springs Utilities employs a watershed operator who checks reservoir levels, dam movement, monitors seeps from the dam, and controls the flows. The upper portion of the road to the dam is open to public access and is graded and cleared of debris annually (Herrin personal communication 2004). *Draba weberi* appears to have escaped impacts from these activities, but any loss of habitat through road expansion or fill dumping into the creek could have severe consequences for the species.

There is some potential for disturbance by recreational activities. National Forest System land around the reservoir is managed for "backcountry recreation, year-round motorized" (USDA Forest Service 2002). Although there are no established trailheads in the area, the upper valley is becoming increasingly popular as a point of access for climbers, hikers, and backcountry skiers bound for Quandary Peak or Fletcher Mountain (Semmer personal communication 2004). Areas adjacent to the road and parking area, including the area where *Draba weberi* occurs, receive incidental use by people exploring the general area (Jennings personal communication 2004). There is also some snowmobile use in the area during winter months (Semmer personal communication 2004), but the avalanche tracks crossing the road below the dam may discourage heavier use. The rock crevice habitat of *D. weberi* may protect it from the effects of compaction by snowmobile use, but the pollutants associated with vehicles are still an issue. Very little of the Tenmile Range has escaped the impact of mining (Benedict 1991), and the Monte Cristo Creek valley is no exception. Nearby mountainsides are crisscrossed by mining claims, both patented and unpatented. A proposal to reopen an old mine in McCullough Gulch on the other side of Quandary Peak is currently under consideration. There are currently no such proposals for the Monte Cristo Creek drainage, but at least one claim in the upper valley has seen prospecting activity in the past few decades (Semmer personal communication 2004). There is no evidence of direct impact from mining activities on the occurrence of *D. weberi*. However, any activity that brings increased use to the valley has the potential to affect environmental quality of the occurrence.

Most of the remaining threats typically associated with human activities (i.e., livestock grazing, timber harvest, off-road vehicle use, nitrogen deposition and development) are not significant for the known *Draba weberi* occurrence. The area is not part of an active grazing allotment, and it does not support timber suitable for harvest. The steep, rocky habitat

where *D. weberi* grows virtually precludes any use by motorized vehicles other than snowmobiles. Snowpack measurements at Fremont Pass, about 5 miles southwest of the occurrence, show mid-to lower-range levels of nitrogen deposition in comparison with other high elevation sites in the western United States (Nanus et al. 2003). Nothing is known about the potential effects of nitrogen deposition on *D. weberi*. There are a few cabins in the trees near the lower Blue Lake, at least one of which may have been built illegally on National Forest System land, but in general the area is not subject to residential development (Semmer personal communication 2004).

Invasive species

Few non-native species occur at higher elevations. While high altitude conditions have been thought to act as a barrier to exotic plant infestation, this belief is changing as documentation of the distribution and abundance of invasive species includes more high elevation locations. For instance, even the alpine tundra portions of Rocky Mountain National Park are now considered to be at moderate risk of infestation (USDI National Park Service 2003). **Table 3** lists troublesome noxious weeds in Summit County (Summit County 2004). Of these, scentless chamomile (*Matricaria perforata*) has been reported nearby on the North Star Mountain road (Spackman et al. 2001). No noxious weed species have been reported from the Monte Cristo Creek drainage. However, the road and recreational traffic present the potential for exotic plants to enter the area. None of the species listed in **Table 3** are known to be aggressive invaders in wet, rocky habitats.

Global warming

The long-term survival of *Draba weberi* could be affected by habitat shifts induced by global climate change. *Draba weberi* is found in open habitat just above treeline. Under two widely used climate change models, as levels of atmospheric CO_2 increase, the prediction is that alpine tundra habitat will essentially disappear (National Assessment Synthesis Team 2000). Upward movement of treeline due to warming trends could eventually result in smaller, less-continuous islands of habitat on mountain peaks and high ridges. This would decrease the opportunities for migration by alpine species and potentially increase competition from lower elevation species (Billings 2000). The effects of forest invasion on the persistence of *D. weberi* are unknown.

Conservation Status of Draba weberi in Region 2

Draba weberi has been known as a species for less than 40 years, and our knowledge of it remains limited. Although *D. weberi* is an extremely restricted endemic known only from a single small occurrence,

Table 3. Noxious weed species in Summit County, Colorado.

State listed noxious weed species in Summit County, Colorado.
* Known to occur on White River National Forest.

	Scientific name	Common name
*	*Acroptilon repens*	Russian knapweed
*	*Cardaria draba*	hoary cress
*	*Carduus acanthoides*	plumeless thistle
*	*Carduus nutans*	musk thistle
*	*Centaurea maculosa*	spotted knapweed
	Chrysanthemum leucanthemum	oxeye daisy
*	*Cirsium arvense*	Canada thistle
*	*Cynoglossum officinale*	houndstongue
*	*Euphorbia esula*	leafy spurge
	Hesperus matronalis	dames rocket
	Lepidium latifolium	perennial pepperweed
*	*Linaria dalmatica*	Dalmatian toadflax
*	*Linaria vulgaris*	yellow toadflax
	Matricaria perforata	scentless chamomile
	Tanacetum vulgare	common tansy

it is not clear that the species should be considered non-viable because of its small population size. The occurrence may have declined from its originally reported size, but it appears to have remained fairly constant for the past decade or so. The possibility remains that additional occurrences exist, and that they may be found in habitats slightly different from that of the known occurrence. Similar habitats and adjacent areas have not been searched for *D. weberi*, so it is not known if other similar or different habitats can support the species.

As far as we know, the global and regional status of *Draba weberi* is precarious simply because of its rarity. *Draba weberi* is obviously vulnerable to environmental stochasticity because of its small population, but not enough is known about its life history or the implications of its apomictic habit to conclude that it is inherently vulnerable due to biological factors. It is possible that some individuals may be capable of occasional sexual reproduction. Because we lack good information on population trends over time and because we have not adequately surveyed for additional populations, it is difficult to say that the species is at risk for any reason other than its apparent rarity.

Because *Draba weberi* is currently known only from one small occurrence that has no protection, it may be vulnerable to the effects of management activities in its general vicinity. However, there is no strong evidence that current or past management actions have harmed *D. weberi*. The Land and Resource Management Plan for the White River National Forest lists 12 other *Draba* species that need baseline inventory and evaluation (USDA Forest Service 2002). It is reasonable to consider *D. weberi* similarly, and to be prepared for the possibility that inventory for other species may result in discovery of *D. weberi* populations on National Forest System land.

Management of Draba weberi in Region 2

Implications and potential conservation elements

There is no documentation of the consequences of historic, ongoing, or proposed management activities on the abundance or distribution of *Draba weberi*. The construction of the Upper Blue Lake Dam is obviously an event of importance for the persistence of the species, but since there are no records of the existence of *D. weberi* prior to this event, we can only speculate about the effects of the construction and subsequent changes to the environment. For instance, the dam may have the effect of reducing variation in streamflow patterns, but we do not know if this is beneficial or detrimental to *D. weberi*. Moreover, legal considerations (i.e., water rights) and the potential for stochastic events that are beyond human control mean that management options for stream flows in *D. weberi* habitat are, in any case, limited.

The little we know about *Draba weberi* suggests that current site conditions should be maintained; however, we should not assume that cautious non-interference will be sufficient to preserve the species. Desired conditions might, at a minimum, include the maintenance of approximately normal stream flow in Monte Cristo Creek, and prevention of any anthropogenic disturbance to the area where *D. weberi* is growing. Because the population is not known to occur on National Forest System land, USFS options for conservation of *D. weberi* are limited to:

- regulating uses of adjacent National Forest System land that have the potential to impact the occurrence
- coordinating awareness of potential impacts to the species with Colorado Springs Utilities and other land owners
- continuing to search for additional populations that can receive protective designation from the USFS
- identifying opportunities for the potential establishment of additional populations for conservation.

Tools and practices

Management prescriptions intended to protect *Draba weberi* will be mostly speculative until basic research on its biology and response to disturbance can be performed. Moreover, efforts to quantify appropriate management would be greatly enhanced if other populations could be located. Consequently, species inventory and population monitoring are the most effective conservation tools for *D. weberi*.

Species inventory

Immediate needs for *Draba weberi* are to locate additional populations that are large enough for monitoring and taxonomic research, are not immediately threatened, and are in land tenure that is available for

research. Priority areas for inventory are all public lands near the known population that contain similar habitat. Since National Forest System land constitutes the greatest part of alpine/subalpine habitat in the area surrounding the known occurrence (**Figure 1**), it should have priority for species inventory. The USFS could make a substantial contribution to conservation of *D. weberi* if new populations are located on public land. If additional populations cannot be located, it may be that this species is declining and in need of federal protection under the Endangered Species Act.

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

Surveys usually attempt to target all species of concern in an area. In the case of inventory for *Draba weberi*, this practice is particularly applicable since there are many other rare species in the area, including other *Draba* species. Inventory techniques should attempt to maximize the potential discovery of the targeted species in the survey area by:

1. Identifying areas that are most likely to contain populations. Because detailed micro-site requirements are not known for *D. weberi*, it may be difficult to refine search areas as other than "alpine to subalpine streamside" or "wet rocky areas at high elevation." Searchers can begin with areas similar to the known population (i.e., rocky streamside crevices).

2. Searching at the time when plants are most visible. For *D. weberi*, this is during peak flowering period, probably in late June to early July. Before beginning surveys in a given year, at least one member of the survey crew should visit the known population of *D. weberi* to confirm the phenology of the target species. Due to the cryptic nature of non-flowering *D. weberi* plants and the difficulties of high-elevation inventory work, searching for populations at other times of the year is not recommended. In addition, surveys should take into account the effects of drought conditions on the potential visibility of the plants; surveys are likely to be more successful in years with normal precipitation patterns.

3. Employing searchers who are familiar with the plant. Field survey crews should include at least one member who has seen *D. weberi* growing in its natural habitat. Photographs and/or herbarium specimens may be used to familiarize other team members with the plant if necessary, but the diminutive growth form of the species and its similarity to other *Draba* species in the area make it advisable for all search team members to form a search image directly from a living plant in situ whenever possible.

4. Covering the area to be searched systematically. Because *D. weberi* is difficult to find and identify when not in flower, survey efforts should only take place during the period of maximum flowering. Intensive, systematic survey will be required. Searchers should concentrate first on the entire Monte Cristo Creek drainage, searching all reasonably mesic rocky habitat. They should then expand searches to nearby drainages with similar habitat. Potential search areas should not be eliminated merely because they do not possess the exact combination of rocky, sparsely vegetated, streamside habitat that characterizes the known occurrence.

Surveys for *Draba weberi* should be carefully documented. Survey reports should document the location visited; the date of the visit; number and condition of individuals found; habitat and associated species; evidence of disturbance, disease, or predation; and any other pertinent observations. If a new population of *D. weberi* is located, a completed element occurrence report form, accompanied by a copy of the appropriate portion of a 7.5- minute topographic map with the occurrence mapped, should be submitted to the Colorado Natural Heritage Program. Occurrence boundaries should be mapped as accurately as possible. Voucher specimens should be collected if the population is larger than about 50 plants, and these should be submitted to regional herbaria. Regardless of population size, voucher photographs should be taken, and the location should be determined as exactly as possible. Occurrences located on National Forest System land should be permanently marked to facilitate population monitoring. The use of multiple markers (e.g., corner stakes) and Global Positioning System coordinates can help to relocate populations. Records should also document areas that were searched unsuccessfully. Negative results, however, are not a guarantee that the plant is absent from an area.

Habitat inventory

Until we have a better understanding of the habitat requirements of *Draba weberi* and whether the known habitat represents optimal conditions, habitat inventory is of secondary importance for this species. Although there has probably been loss of habitat in the Blue Lakes area, it is possible that suitable but unoccupied habitat remains, both in the Monte Cristo Creek drainage and in nearby drainages of the upper Blue River watershed. Until the existence of additional populations is confirmed, it is not critical to perform habitat surveys beyond identifying likely search areas.

Population monitoring

Monitoring that tracks population trend is the most important tool for the conservation of *Draba weberi*. This monitoring should be combined with other research on the biology and autecology of the species. The small size of the known population means that it may be possible to monitor all individuals, and even to collect demographic data with a slight additional effort. The first year of monitoring should concentrate on establishing the timing of critical seasonal elements such as flowering and fruit set, and determining the most useful and practical data collection protocols. Subsequent years could concentrate on collecting data at consistent times.

Habitat monitoring

Until a more exact habitat characterization can be obtained, it is better to monitor the immediate habitat of the known occurrence, rather than larger tracts of potential habitat. More information is needed to determine the effects of management practices and natural disturbances on *Draba weberi*. Observations should be correlated with population trends determined through monitoring. Until *D. weberi*'s specific habitat requirements are understood, it is not appropriate to suggest detailed management actions that may or may not benefit the species. However, it is likely that management actions that minimize disturbance and maintain approximately natural flow levels in Monte Cristo Creek will generally be beneficial for *D. weberi*. The acquisition of instream flow rights for Monte Cristo Creek by the Colorado Water Conservation Board would be a valuable conservation tool for *D. weberi*.

Ex-situ conservation

No seeds or genetic material of *Draba weberi* are in storage at the National Center for Genetic Resource Preservation (Miller personal communication 2004). It is not among the National Collection of Endangered Plants maintained by the Center for Plant Conservation (Center for Plant Conservation 2002). Because of the small population size of *D. weberi*, any seed collection should be conservative, but collections could make a substantial contribution to our knowledge of the species and to restoration techniques.

Information Needs

The most pressing need is to locate additional populations of *Draba weberi*, if any exist. Surveys should be combined with efforts to locate additional populations of other rare species in the same area, including *D. grayana*, *D. exunguiculata*, *Ptilagrostis porteri, Parnassia kotzebuei, Eutrema penlandi, Sauserea weberi, Braya humilis, Ipomopsis globularis,* and others. If additional populations of *D. weberi* are located, especially on National Forest System land, our knowledge of conditions appropriate for conserving the species will be enhanced. Until additional occurrences are located, monitoring of the single known population is also very important.

Given the small number of known individuals, there is insufficient material to allow manipulative investigations of *Draba weberi*'s life cycle, habitat relations, population trends, and response to disturbance. Likewise, metapopulation dynamics are irrelevant if this is the only population. However, these topics are essentially completely unexplored, and observations that would add to our knowledge on any of these subjects would be helpful in determining the effects of land management practices on the survival and persistence of the species and in formulating management and conservation plans.

Conservationists are understandably reluctant to expend effort on a species that could turn out to be a form of a more common taxon. More information on the position of *Draba weberi* in the genus and its relationship to nearby taxa could strengthen the case for direct action to protect the species. Dr. Michael Windham, of the Utah Museum of Natural History, made important collections of *Draba* species in the southwestern Colorado mountains (Windham personal communication 2004); if he and his coworkers are able to expand their collection efforts into the Tenmile Range, the cooperation of local and regional USFS personnel would be valuable. Windham's forthcoming treatment of the genus *Draba* in volume seven of the *Flora of North America*, scheduled for publication in 2006, should clarify the taxonomic status of the genus,

and contribute to our understanding of the position of *D. weberi* within that genus.

No restoration methods have been developed for this species, but the apparent success of Price and Rollins (1991) in growing individuals from collected seeds indicates that *ex-situ* propagation may be an important tool in the conservation of *D. weberi*.

Definitions

Agamospermy – formation of seed without fertilization. In gametophytic agamospermy, embryo sacs are produced from unreduced gameophyte cells, and the eggs develop parthenogenetically (Asker and Jerling 1992).

Aneuploidy – variation in chromosome number not in exact multiples of the basic set, but in single or a few chromosomes only (Stace 1989).

Apomixis – reproduction by non-sexual means, typically intended to exclude vegetative reproduction.

Ascending – growing obliquely upward, usually curved (Harris and Harris 1994).

Autogamy – self-fertilization, pollination of a flower by its own pollen.

Base chromosome number (x) – the gametophytic chromosome number of the diploid species. In a diploid species, x = n (haploid number), but in a polyploid species n is a multiple of x (Stace 1989).

Caespitose – growing in dense tufts (Harris and Harris 1994).

Ciliate – having a marginal fringe of hairs

Clade – a phylogenetic lineage.

Clawed – with a narrow stalk, as in the petals of many mustards (Weber and Wittmann 2001).

Diploid – an organism with two copies (2n) of each homologous chromosome.

Diploid number (2n) – the number of chromosomes in the sporophytic material.

Euploid – variation in chromosome numbers in multiples of the basic set (Stace 1989).

Fellfield – rocky habitat on exposed alpine summits and ridges, characterized by low mat and cushion plants and an abundance of surface rocks.

Gametophyte – the haploid, gamete-producing phase in plants, which have a life cycle characterized by the alternation of generations between gametophyte and sporophyte phases (Raven et al.1986).

Glabrous – smooth, without hairs.

Haploid number (n) – the number of chromosomes in the gametophytic material.

Oblanceolate – reversely lanceolate, long and narrow, but broadest at the tip instead of the base (Weber and Wittmann 2001).

Patented claim – a mining claim whose title is held by the claim owner, and not by the federal government.

Polyploid – an organism with three or more copies of each homologous chromosome.

Pubescent – covered with short soft hairs

Rank – 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 (NatureServe 2006). *These ranks should not be interpreted as legal designations.*

Silique – fruit of the Brassicaceae or mustard family. Typically more than twice as long as wide. When shorter, often called a silicle.

Sporophyte – the spore-producing, diploid phase in plants, which have a life cycle characterized by the alternation of generations between gametophyte and sporophyte phases. (Raven et al. 1986).

Stellate – star-shaped, as when trichomes have several to many branches radiating from the base.

Style – the usually narrow portion of the female reproductive portion of a flower, between the stigma above and the ovary below.

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

Talus – a sloping mass of loose rocks at the base of a cliff.

Trichome – the term applied to any type of plant hair (Weber and Wittmann 2001). The diversity in form of these structures may be an important characteristic distinguishing between species.

Triploid – having three complete sets of chromosomes.

Unpatented claim – a mining claim upon which the claimant has only the right to explore for and to mine certain minerals.

References

Allaby, M. 1998. A Dictionary of Plant Sciences. Oxford University Press, New York, NY.

Asker, S.E. and L. Jerling. 1992. Apomixis in Plants. CRC Press, Boca Raton, FL.

Beilstein, M.A. and M.D. Windham. 2003. A Phylogenetic Analysis of Western North American *Draba* (Brassicaceae) Based on Nuclear Ribosomal DNA Sequences from the ITS Region. Systematic Botany 28:584-592.

Benedict, A.D. 1991. A Sierra Club Naturalist's Guide: The Southern Rockies. Sierra Club Books, San Francisco, CA.

Billings, W.D. 2000. Alpine Vegetation of North America. *In*: M.G. Barbour and W.D. Billings, editors. North American Terrestrial Vegetation, Second edition. Cambridge University Press, Cambridge, United Kingdom.

California Native Plant Society. 2001. Botanical survey guidelines of the California Native Plant Society. Fremontia 29:64-65.

Carsey, K. and K. Decker. 1999. Identification and evaluation of wetlands of statewide significance in Colorado, 1998-1999. Final report to the EPA. Colorado Natural Areas Program, Denver, CO.

Caswell, H. 2001. Matrix Population Models. Second edition. Sinauer Associates, Inc. Sunderland, MA.

Center for Plant Conservation. 2002. National Collection of Endangered Plants. Database available online at: http://www.mobot.org/CPC/NC_choice.html.

Colorado Natural Heritage Program. 2006. Biodiversity Tracking and Conservation System. Colorado Natural Heritage Program, Colorado State University, Fort Collins, CO.

Colorado Natural Heritage Program Site Committee. 2002. Recommendations for Development and Standardization of Potential Conservation Areas and Network of Conservation Areas. Colorado Natural Heritage Program, Colorado State University, Fort Collins, CO.

Cypher, E.A. 2002. General rare plant survey guidelines. California State University, Stanislaus. Endangered Species Recovery Program. Available online at: http://sacramento.fws.gov/es/documents/rare_plant_protocol.pdf.

Doyle, G. 2006. Personal communication with Colorado Natural Heritage Program Botanist regarding *Draba weberi*.

Edelmon, T. 2004. Personal communication with White River National Forest Biologist regarding *Draba weberi*.

Grant, V. 1981. Plant Speciation. Second edition. Columbia University Press, New York, NY.

Grime, J.P. 2001. Plant Strategies, Vegetation Processes, and Ecosystem Properties. John Wiley & Sons, Chichester, West Sussex, England.

Haynes, M. 2004. Personal communication with Colorado Division of Water Resources, Dam Safety Branch staff regarding Upper Blue Lake Reservoir.

Harris, J.G. and M.W. Harris. 1994. Plant Identification Terminology. An Illustrated Glossary. Spring Lake Publishing, Spring Lake, UT.

Herrin, M. 2004. Personal communication with Colorado Springs Utilities Operations Manager regarding Upper Blue Lake Reservoir.

Jennings, W.F. 2004. Personal communication with Botanist regarding *Draba weberi*.

Ladyman, J.A.R. 2004a. *Draba exunguiculata* (O.E. Schulz) C.L. Hitchcock (Grays Peak draba): a technical conservation assessment. USDA Forest Service, Rocky Mountain Region. Available online at: http://www.fs.fed.us/r2/projects/scp/assessments/drabaexunguiculata.pdf.

Ladyman, J.A.R. 2004b. *Draba grayana* (Rydb.) C.L. Hitchcock (Gray's draba): a technical conservation assessment. USDA Forest Service, Rocky Mountain Region. Available online at: http://www.fs.fed.us/r2/projects/scp/assessments/drabagrayana.pdf.

MacArthur, R.H. and E.O. Wilson. 1967. The Theory of Island Biogeography. Princeton University Press, Princeton, NJ.

Mayo, E. 2004. Personal communication with U.S. Fish and Wildlife Service Botanist regarding *Draba weberi*.

Menges, E.S. 1991. The application of minimum viable population theory to plants. Chapter 3 *in* D.A. Falk and K.E. Holsinger, editors. Genetics and Conservation of Rare Plants. Oxford University Press, New York, NY.

Miller, A. 2004. Personal communication with National Center for Genetic Resource Preservation Seed Analyst regarding *Draba weberi*.

Morris, W., D. Doak, M. Groom, P. Kareiva, J. Fieberg, L. Gerber, P. Murphy, and D. Thomson. 1999. A Practical Handbook for Population Viability Analysis. The Nature Conservancy. Arlington, VA.

Mulligan, G.A. 1971. Cytotaxonomic studies of *Draba* species of Canada and Alaska: *D. ventosa, D. ruaxes*, and *D. paysonii*. Canadian Journal of Botany 49:1455-1460.

Mulligan, G.A. 1976. The *Draba* in Canada and Alaska: key and summary. Canadian Journal of Botany 54:1386-1393.

Mulligan, G.A. and J.N. Findlay. 1970. Sexual reproduction and agamospermy in the genus *Draba*. Canadian Journal of Botany 48:269-270.

National Assessment Synthesis Team, Climate Change Impacts on the United States. 2000. The Potential Consequences of Climate Variability and Change, US Global Change Research Program, Washington, D.C.

NatureServe. 2004. NatureServe Explorer: An online encyclopedia of life, version 4.7. NatureServe, Arlington, VA. Available online at: http://www.natureserve.org/explorer.

Nanus, L., D.H. Campbell, D.P. Ingersoll, D.W. Clow, and M.A. Mast. 2003. Atmospheric deposition maps for the Rocky Mountains. Atmospheric Environment 37:4881-4892.

Newell, B. 2004. Personal communication with Colorado Springs Utilities Customer Operations Supervisor regarding Upper Blue Lake Reservoir.

Olson, S. 2004. Personal communication with USDA Forest Service Botanist, Pike-San Isabel National Forest regarding *Draba weberi*.

Platt, J.R. 1964. Strong inference. Science 146:347-353.

Price, R.A. 1979. The *Draba crassa* complex (Brassicaceae): systematics and geography. MS Thesis, University of Wisconsin – Madison, Madison, WI.

Price, R.A. 1985. Locality information for *Draba* (Brassicaceae) in Colorado. Unpublished report on file with Colorado Natural Heritage Program, Fort Collins, CO.

Price, R.A. and R.C. Rollins. 1991. New taxa of *Draba* (Cruciferae) from California, Nevada, and Colorado. Harvard Papers in Botany 3:75-77.

Raven, P.H., R.F. Evert, and S.E. Eichhorn. 1986. Biology of Plants. Fourth edition. Worth Publishers, Inc., New York, NY.

Rollins, R.C. 1993. The Cruciferae of Continental North America. Stanford University Press, Stanford, CA.

Semmer, P. 2004. Personal communication with Lands staff, White River National Forest, regarding status of Monte Cristo Creek area.

Soulé, M.E. 1980. Thresholds for survival: maintaining fitness and evolutionary potential. *In*: M.E. Soulé and B.A. Wilcox, editors. Conservation Biology, An Evolutionary-Ecological Perspective. Sinauer Associates, Inc., Sunderland, MA.

Spackman, S., K. Fayette, D. Culver, K. Murrell, and M. Sherman. 1997. Summit County Conservation Inventory Volume I: A Natural Heritage Assessment, 1997 Final Report. Colorado Natural Heritage Program, Colorado State University, Fort Collins, CO.

Spackman, S., B. Jennings, J. Coles, C. Dawson, M. Minton, A. Kratz, and C. Spurrier. 1997. Colorado Rare Plant Field Guide. Prepared for the Bureau of Land Management, the U.S. Forest Service and the U.S. Fish and Wildlife Service by the Colorado Natural Heritage Program. Available online at: http://www.cnhp.colostate.edu/rareplants/intro.html.

Summit County. 2004. Noxious weed presentation. Produced by Summit County Noxious Weed Department and the Town of Silverthorne. Available online at: http://www.co.summit.co.us/ and http://www.silverthorne.org/key_documents/NoxiousWeeds.pdf.

Stace, C.A. 1989. Plant Taxonomy and Biosystematics. Second edition. Cambridge University Press, Cambridge, United Kingdom.

University of Colorado Museum Herbarium. 2004. Specimen database of Colorado vascular plants. Available online at: http://cumuseum.colorado.edu/Research/Botany/botany_databases.html.

USDA Forest Service. 2002. Land and Resource Management Plan - 2002 revision for the White River National Forest, Glenwood Springs, CO.

USDA Forest Service. 2003a. Region 2 Regional Forester's Sensitive Species List. Available online at: http://www.fs.fed.us/r2/projects/scp/sensitivespecies/index.shtml.

USDA Forest Service. 2003b. Region 2 Individual Species Recommendations, *Draba weberi*. Available online at: http://www.fs.fed.us/r2/projects/scp/evalrationale/rationales/dicots/drabaweberi.pdf.

USDI National Park Service. 2003. Invasive exotic plant management plan and environmental assessment, Rocky Mountain National Park. Prepared by USDI National Park Service, Rocky Mountain National Park, CO.

U.S. Fish and Wildlife Service. 2000. Guidelines for conducting and reporting botanical inventories for federally listed, proposed, and candidate plants. Available online at: http://ventura.fws.gov/es/protocols/botanicalsurvey_protocol.pdf.

Weber, W.A. and R.C. Wittmann. 2001. Colorado Flora: Western Slope. University Press of Colorado, Niwot, CO.

Widmer, A. and M. Baltisberger. 1999. Molecular evidence for allopolyploid speciation and a single origin of the narrow endemic *Draba ladina* (Brassicaceae). American Journal of Botany 86:1282-1289.

Winchester, J.N. 2001. A historical view: transmountain diversion development in Colorado. A Technical Paper Presented at: Trans Basin Water Transfers, Proceedings of the 2001 Water Management Conference, US Committee on Irrigation and Drainage, June 27-30, 2001. Available online at: http://www.hydrosphere.com/HRC/Projects/Jnw_Trans_Mtn_Div/Transmountain_paper.htm.

Windham, M.D. 2000. Chromosome counts and taxonomic notes on *Draba* (Brassicaceae) of the Intermountain West. 1: Utah and vicinity. Madroño 47:21-28.

Windham, M.D. 2003. Chromosome counts and taxonomic notes on *Draba* (Brassicaceae) of the Intermountain West. 2: Idaho, Nevada, and vicinity. Madroño 50:221-231.

Windham, M.D. 2004. Personal communication with curator, Garret Herbarium, Utah Museum Of Natural History, regarding *Draba weberi*.

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