# *Draba ventosa* A. Gray (Wind River draba)
# A Technical Conservation Assessment

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

**April 16, 2004**

**Juanita A. R. Ladyman, Ph.D.**
*JnJ Associates*
6760 S. Kit Carson Circle East
Centennial, CO 80122

Peer Review Administered by
Society for Conservation Biology

Ladyman, J.A.R. (2004, April 16). *Draba ventosa* A. Gray (Wind River draba): a technical conservation assessment. [Online]. USDA Forest Service, Rocky Mountain Region. Available: http://www.fs.fed.us/r2/projects/scp/assessments/drabaventosa.pdf [date of access].

## ACKNOWLEDGEMENTS

The time spent and the help given by all the people and institutions mentioned in the Reference section are gratefully acknowledged. I would also like to thank the Colorado Natural Heritage Program, in particular Susan Spackman and David Anderson, and the Colorado Natural Areas Program, in particular Ron West, for their generosity in making their files and records available. I also appreciate access to the files and assistance given to me by Andrew Kratz, USDA Forest Service Region 2, and Chuck Davis, U.S. Fish and Wildlife Service, both in Denver, Colorado. The data and information provided by Marta Donovan of the British Columbia Data Centre, John Rintoul of the Alberta Natural Heritage Information Center, Bruce Bennett of NatureServe Yukon, Ray Coupé of the Williams Lake Herbarium Caribou Forest Region, Carolyn Parker of the University of Alaska Fairbanks Museum, Alison Kelly of the Utah State University Intermountain Herbarium, and Ron Hartman and Joy Handley of the Rocky Mountain Herbarium at Laramie, were all invaluable The conversations with and information sent from Bonnie Heidel Wyoming Natural Diversity Database, Teresa Prendusi USDA Forest Service Region 4, Jim Ozenberger USDA Forest Service - Bridger-Teton National Forest, Barry Johnston USDA Forest Service - Gunnison National Forest, Steven Shelley USDA Forest Service Region 1, Joe Hicks USDA Forest Service - Shoshone National Forest, and Michael Windham and Ann Kelsey of the Garrett Herbarium, Museum of Natural History at the University of Utah are also very much appreciated. I appreciate the thoughtful reviews of this manuscript by Dr. David Inouye, Beth Burkhart, and an unknown reviewer, and thank them for their time in considering the assessment.

## AUTHOR'S BIOGRAPHY

Juanita A. R. Ladyman received her B.Sc. degree (with First-class honors) in Biochemistry from London University, England. Her first professional position was as plant pathology laboratory technician and, later, as greenhouse research supervisor with the Arid Lands Research Center on Sadiyat Island in the United Arab Emirates. She obtained her Ph.D. degree in Botany and Plant Pathology from Michigan State University where she was also a research assistant with the D.O.E. Plant Research Laboratory. She worked as a plant physiological ecologist and plant scientist for Shell Development Company conducting research on the physiology, ecology, and reproductive biology of economically important plant species and their wild relatives. She then worked for a plant biotechnology company in their Genetic Transformation and Plant Tissue Culture Division. For the last 11 years she has worked in the area of conservation, particularly on rare, endemic, and sensitive plant species in the southwest United States. For three years of that time, she was the botanist with the New Mexico Natural Heritage Program. She has conducted research and monitoring programs on both non-vascular and vascular species. She currently is a partner in *JnJ Associates*, an environmental consulting company in Colorado.

# SUMMARY OF KEY COMPONENTS FOR CONSERVATION OF *DRABA VENTOSA*

## *Status*

*Draba ventosa* (Wind River draba) is a rare member of the mustard family. The NatureServe Global rank for this species is vulnerable (G3). It is designated critically imperiled (S1) by the Colorado Natural Heritage Program, the Montana Natural Heritage Program, and the Utah Natural Heritage Program and vulnerable (S3) by the Wyoming Natural Diversity Database. In Canada, it is designated between vulnerable to critically imperiled (S1S3) in British Columbia and imperiled (S2) in Alberta (NatureServe 2003). *Draba ventosa* has been reported from Nevada.

## *Primary Threats*

Recreational use of habitat, such as foot traffic and skiing-related activities, may pose a threat to some populations throughout its range. As the human population grows in areas within easy access to *Draba ventosa* habitat and as recreational use increases, the impacts may become substantially more significant. Mining activities are not currently perceived to be a threat to any of the known populations although individual populations may have been impacted in the past. Introduced mountain goats likely have a negative impact on habitat in some parts of its range. Invasive weeds may pose an additional risk to long-term sustainability. Wet nitrogen deposition (acid rain) and air pollution pose a substantial risk to forb communities in alpine tundra, especially in some regions where *D. ventosa* occurs in Colorado and Wyoming. Global warming is a potential threat to all species currently restricted to sub-alpine and alpine-tundra zones.

## *Primary Conservation Elements, Management Implications and Considerations*

*Draba ventosa* is a rare but widespread species. It is reported from Alaska, Montana, Nevada, Wyoming, Utah, and Colorado in the United States, as well as Yukon, British Columbia, and Alberta in Canada. However, recent nuclear ribosomal DNA (nrDNA) analysis placed Canadian and Utah samples in different lineages, suggesting that more than one taxon may be represented. Therefore, *D. ventosa* may be considerably more restricted in range than is currently appreciated, and it may even be a regional endemic to the central Rocky Mountains. It grows at elevations above 2,865 m (9,400 feet) in Region 2. There are no management plans directly concerning *D. ventosa*. Since relatively little information concerning its abundance, distribution, and biology is available, more biological information is needed before management strategies can be confidently implemented. The current information available suggests that several populations are relatively secure because they occur in areas that are afforded protection either by their remote, relatively inaccessible location or by land use designation, for example USDA Forest Service Wilderness Area. *Draba ventosa* appears to be a naturally uncommon species well-adapted to its fragile alpine habitat.

# TABLE OF CONTENTS



EDITOR: Beth Burkhart, USDA Forest Service, Rocky Mountain Region

# LIST OF TABLES AND FIGURES

**Tables:**



**Figures:**

# INTRODUCTION

This assessment is one of many being produced to support the Species Conservation Project for the Rocky Mountain Region (Region 2), USDA Forest Service (USFS). *Draba ventosa*, Wind River or tundra draba, is the focus of an assessment because it is a rare species that occurs within the Rocky Mountains. Rare species or those species whose populations are in decline need to be recognized because they may require special management and therefore knowledge of their biology and ecology is critical. *Draba ventosa* is not designated a sensitive species in Region 2 of the USDA Forest Service (2003). Within the National Forest System, a sensitive species is a plant or animal whose population viability is identified as a concern by a Regional Forester because of significant current or predicted downward trends in abundance or in habitat capability that would reduce its distribution (FSM 2670.5 (19)).

This assessment addresses the biology of *Draba ventosa* 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*

Species conservation assessments produced as part of the Species Conservation Project are designed to provide forest managers, research biologists, and the public 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 but provides the ecological background upon which management must be based. While the assessment does not provide management recommendations, it does focus 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*

This assessment examines the biology, ecology, conservation status, and management of *Draba ventosa* with specific reference to the geographic and ecological characteristics of the USFS Rocky Mountain Region. Although some of the literature relevant to the species originates from field investigations outside the region, this document places that literature in the ecological and social context of the central Rockies. Similarly, this assessment is concerned with reproductive behavior, population dynamics, and other characteristics of *D. ventosa* in the context of the current environment rather than under historical conditions. The evolutionary environment of the species is considered in conducting this synthesis but placed in a current context.

In producing this assessment, refereed literature, non-refereed publications, research reports, and data accumulated by resource management agencies have been reviewed. Not all publications on *Draba ventosa* may have been referenced in the assessment, although an effort was made to consider all relevant documents. Refereed literature is preferred because it is the accepted standard in science. Non-refereed publications and reports were used in the assessment when information was unavailable elsewhere and is regarded with greater skepticism. Many reports or non-refereed publications on rare plants are often 'works-in-progress' or isolated observations on phenology or reproductive biology and are reliable sources of information. For example, demographic data may have been obtained during only one year when monitoring plots were first established. Insufficient funding or manpower may have prevented work in subsequent years. One year of data is generally considered inadequate for publication in a refereed journal but still provides a valuable contribution to the knowledge base of a rare plant species. Unpublished data (for example, Natural Heritage Program and herbarium records) were important in estimating the geographic distribution and population sizes. These data required special attention because of the diversity of persons and methods used in collection. Records that were associated with locations at which herbarium specimens had been collected at some point in time were weighted higher than observations only.

## *Treatment of Uncertainty*

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 critical experiments in the ecological relations. Therefore, while well-executed experiments represent the strongest approach to developing knowledge, alternative methods, such as observations, inference, good thinking, and models must be relied on to guide the understanding of features of biology. In this assessment, the strength of evidence for particular ideas is noted, and alternative explanations are described when appropriate. Nuclear ribosomal DNA (nrDNA) studies placed Canadian and Utah samples in different lineages, suggesting that more than one taxon are represented (Windham personal communication 2002). Therefore, for this particular species of *Draba*, uncertainty has been generated by allopatry, which is the occurrence of species in different geographical regions. The questions as to whether similar but widely disjunct populations should be named as species or varieties are judgments based on the observations of users and the tools of taxonomy.

### *Publication of Assessment on the World Wide Web*

To facilitate use of species assessments in the Species Conservation Project, they 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 books or reports. More importantly, it facilitates revision of the assessments, which will be accomplished based on guidelines established by Region 2.

### *Peer Review*

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, 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 ventosa* is a rare mustard. The NatureServe Global rank (2003) for this species is vulnerable (G3). It is designated critically imperiled (S1) by the Colorado Natural Heritage Program, Montana Natural Heritage Program, and the Utah Natural Heritage Program, and vulnerable (S3) by the Wyoming Natural Diversity Database. *Draba ventosa* has been reported in Nevada, but it remains essentially unranked (SR) by the Nevada Natural Heritage Program, which has no basis for either accepting or rejecting the report (NatureServe 2003). In Canada, it is designated between vulnerable to critically imperiled (S1S3) in British Columbia and imperiled (S2) in Alberta (NatureServe 2003). USFS Intermountain Region (Region 4) proposed that *D. ventosa* be designated a sensitive species (USDA Forest Service 1999a). As of April 2004, *D. ventosa* has not been designated sensitive in Region 4. *Draba ventosa* is not designated a sensitive species in USFS Region 2 (USDA Forest Service 2003). A sensitive species "is a plant species identified by the Regional Forester for which population viability is a concern as evidenced by a significant current or predicted downward trend in population number or density and/or a significant current of predicted downward trend in habitat capability that would reduce a species' existing distribution" (USDA Forest Service 1993).

### *Existing Regulatory Mechanisms, Management Plans, and Conservation Strategies*

*Draba ventosa* occurs on private land and land managed by the USFS within the boundaries of Region 2. In Wyoming, it occurs on the Shoshone National Forest and in Colorado on the Gunnison, Pike-San Isabel, and White River national forests. In Colorado, several populations are in designated wilderness areas, specifically the Mount Massive Wilderness and the Maroon Bells Snowmass Wilderness, where they are afforded some protection from anthropogenic activities. Wilderness is defined in the law as "an area of undeveloped Federal land retaining its primeval character and influence, without permanent improvements or human habitation, which is protected and managed so as to preserve its natural conditions" (Environmental Media Services 2001). Although Congress has granted exemptions, commercial activities, motorized access, roads, bicycles, structures and facilities are typically prohibited in wilderness areas. In addition, the size of visitor groups may be limited in some circumstances.

Few formal surveys have been conducted for this species. The Wyoming Natural Diversity Database does not track this species. Most reports are incidental to surveys for other sensitive species. Some location information is sufficiently vague as to preclude precise locations and occurrences may be on patented mining claims. Because it is not formally recognized as a sensitive species in Region 2, *Draba ventosa* does not receive the attention required to clarify its rarity. For example, two specimens were collected and deposited at an herbarium during a 1994 survey of the Gros Ventre Range for the Bridger-Teton National Forest, but understandably they were not included in the formal report on sensitive species encountered during the survey (Hartman 1995). Another example is that it was excluded from the Shoshone National Forest Field Guide that is designed to help field crews identify rare and sensitive species (Mills and Fertig 1996). There are no specific management or conservation plans for this species within Region 2. However, it is included by name in a document outlining general management strategy for selected plant species in the Grand Mesa, Uncompahgre, Gunnison, San Juan, Rio Grande, Pike, and San Isabel national forests published by USFS Region 2 (USDA Forest Service 1999b).

Outside of Region 2 in the United States, occurrences have been documented on lands managed by the USDA Forest Service and the National Park Service, and on privately owned land. Some occurrences are afforded some level of protection through general land-use designation, for example on land managed by the National Park Service. Several occurrences have been reported from Yellowstone National Park. No livestock grazing or mechanized travel off designated roads is allowed in national parks. In addition, the less-accessible alpine areas of Yellowstone National Park are not heavily frequented and are thus unlikely to be impacted by recreational activities (Whipple personal communication 2002).

## *Biology and Ecology*

### Classification and description

#### *Systematics and synonymy*

*Draba* is the largest genus of the Brassicaceae or Cruciferae family, also commonly known as the mustard family. *Draba* species are found almost worldwide in relatively cooler, either high elevation or high latitude, habitats. There are approximately 350 species worldwide and 104 throughout Central and North America (Rollins 1993). High elevation sites can be likened to virtual islands and are recognized for rapid speciation in sedentary species, such as plants.

*Draba ventosa* was once considered to have two varieties, var. *ventosa* and var. *ruaxes* (Hitchcock 1941). *Draba ventosa* and *D. ruaxes* are now recognized as unique species (Mulligan 1971, Rollins 1993). *Draba ventosa* is a triploid species whereas *D. ruaxes* is a hexaploid. Because of the original designation of subspecies of *D. ventosa*, its distribution has been somewhat confused, and *D. ventosa* has been reported from Washington State (Beckett 1993) where it does not occur (Caplow personal communication 2002). *Draba ruaxes* is restricted to Washington, and British Columbia to Alaska (Hitchcock et al. 1964), whereas *D. ventosa* grows in Alaska and the Rocky Mountains of the United States, British Columbia, and the Yukon. Recently, nrDNA studies placed Canadian and Utah samples of *D. ventosa* in different lineages, suggesting that more than one taxon may be represented (Windham personal communication May 2002).

#### *History of species*

*Draba ventosa* was first collected by C. C. Parry on Snake Pass during the North Western Wyoming expedition led by Capt. W. A. Jones commanding the U.S. Engineers in 1873. This collection formed the type specimen of C. Leo Hitchcock in 1939. The holotype is in the Harvard University Herbarium, and the isotype ( 185358) is in the herbarium at the New York Botanical Garden. This early collection in the Wind River Range of Wyoming no doubt accounts for the common name, Wind River draba, and the botanical epithet "*ventosa*", which is derived from the Latin word for "windy". This plant's other common name, tundra draba, also reflects the area in which it is found.

#### *Non-technical description.*

*Draba ventosa* is a diminutive, mat-forming perennial with leaf rosettes at the ends of numerous root crown branches that are covered by old leaf bases and dead leaves below the current leaves. The midribs of old basal leaves are persistent for many years. The short leafless stems arise from the rosettes and terminate in a cluster of flowers. The stems are 2 to 4 cm tall. The small, fleshy, oval-shaped leaves have entire margins and are 2 to 4 mm wide and 5 to 12 mm long, with some leaves as much as 18 mm long. All leaves are densely covered with branched hairs and appear to have a silvery green color because of the dense pubescence, or "hairiness". There are 3 to 20 flowers per flower cluster (inflorescence). The petals are yellow, and there are four per flower. The style is 1.0 to 1.5 mm long. The hairy fruits or "pods" (silicles) are flattened, oval to oblong in shape, and 5 to 8 mm long. Each is on a slightly ascending, spreading stalk approximately as long as the silicle. The seeds are approximately 1.0 to 1.5 mm in length. This description is taken principally from Rollins (1993) and the Montana Rare Plant Field Guide (2002). An illustration of *D. ventosa* is in **Figure 1**.


**Figure 1.** Illustration of *Draba ventosa*. Illustration by Jeanne R. Janish from Hitchcock and Cronquist (2001), used with permission from University of Washington Press.

It is important that both leaves and fruit are available when making identifications (Mills and Fertig 1996). Hair morphology is a particularly important characteristic amongst *Draba* species (Rollins 1993, Stone 1995). Many alpine *Draba* species are covered by hairs, but those of *D. ventosa* are dense and most commonly much-branched (stellate).

*References to technical descriptions, photographs, line drawings and herbarium specimens.*

A detailed technical description and a line drawing that shows the leaf and fruit characters of *Draba ventosa* are in Hitchcock (1941). Another comprehensive technical description is published in Rollins (1993). Technical descriptions are also in Schulz (1927), Welsh et al. (1993), Scott (1995), Cody (1996), Dorn (2001), Hitchcock and Cronquist (2001), Weber and Wittmann (2001). A photograph and a general description are published in the Montana Rare Plant Guide (Montana Natural Heritage Program 2002). In addition, the excellent line drawing by Janish can be accessed in Hitchcock et al. (1964) and in the Montana Rare Plant Guide (Montana Natural Heritage Program 2002). A photograph of the isotype herbarium specimen (C. C. Parry 15, 1873) is on the New York Botanical Garden web page (http://scisun.nybg.org:8890/).

### Distribution and abundance

*Draba ventosa* is reported from Montana (Dorn 1984), Wyoming (Fertig 1992, Dorn 2001), Utah (Welsh et al. 1993), Colorado (Weber and Wittman 2001), and Nevada (Charlet 1994) in the U.S., as well as Yukon (Cody 1996), British Columbia (Ogilvie 1998, Douglas et al. 2002), and Alberta (Cody 1996) in Canada. *Draba ventosa* is also reported from Alaska (Biota of North America Program 1998), but at the present time there are no verified collections from that state (Lipkin personal communication 2002). The Nevada occurrence is located in the Ruby Mountains. This mountain range is very unusual for Nevada, as it is very similar to the Rocky Mountains in geology, climate, and flora. There are many other Rocky Mountain disjuncts in this range and, therefore, the occurrence of *D. ventosa* there is not unlikely (Morefield personal communication 2002). As mentioned in the Biology and Ecology Section of this assessment, nrDNA studies placed Canadian and Utah samples in different lineages, and this suggests that more than one taxon is represented (Windham personal communication 2002). Therefore, it is not clear if one taxon is endemic to the central Rocky Mountains and another taxon is unique to the northern Rocky Mountains and up into Yukon and Alaska, or if the two proposed taxa have a sympatric and wide distribution. The former hypothesis is more likely, but whichever the case, *D. ventosa* may be rarer than is currently believed.

Within the middle Rocky Mountains of Colorado, Utah, Wyoming, and Montana, occurrences of *Draba ventosa* tend to be disjunct. Plants have been found in the Uinta Mountains of Utah, the Wind River, Salt and Absaroka ranges of Wyoming, and the Sawatch Range and Elk Mountains of Colorado (**Figure 2**). This disjunct occupation of mountain "islands" is not uncommon among *Draba* species. For example, although not quite as disparate, *D. standleyi* is found in the Organ Mountains of New Mexico, the Chiricahua Mountains of Arizona, the Davis Mountains of Texas, and has been reported in the Canyon el Morena in northeast Coahuila, Mexico.

Approximately 40 documented occurrences of *Draba ventosa* have been reported in the states that include the middle Rocky Mountain region. Approximately eight or possibly nine occurrences have been reported in Colorado, approximately 23 occurrences in Wyoming, five occurrences in Utah (three of which likely belong to the same population), and three occurrences in Montana. Of those occurrences, at least 16 occurrences have been documented within the last 25 years in Wyoming, five in Colorado, two in Utah, and two in Montana. Within Region 2, all occurrences in Colorado are on land managed by the USFS, specifically the San Isabel National Forest, the Gunnison National Forest, and the White River National Forest. In Wyoming approximately half the occurrences are located within the Shoshone National Forest. One occurrence in Wyoming is located in a national park. Occurrence data is summarized in **Table 1**.

Only two occurrences are known from Yukon, both within the Kluane National Park (Bennett personal communication 2002). Approximately four are reported in British Columbia, at least one of which is in the Caribou Forest Region (Coupé personal communication 2002, Douglas et al. 2002). Eighteen occurrences are recorded in Alberta, four of which were annotated "*D. ventosa*" by Mulligan who wrote the treatment distinguishing *Draba ruaxes* from *D. ventosa* (Mulligan 1971, Alberta Natural Heritage Information Centre 2002).

Occurrence data have been compiled from the Colorado Natural Heritage Program, the Montana Natural Heritage Program, the Alberta Natural Heritage Information Centre, the British Columbia Conservation Data Centre, NatureServe Yukon, and specimens at the University of Colorado Herbarium (COLO), Colorado State University Herbarium (CS), the Rocky Mountain Herbarium (RM), the Kathryn Kalmbach Herbarium at Denver Botanic Gardens (KHD), the Intermountain Herbarium at Utah State University (UTC), the Garrett Herbarium at the University of Utah herbarium (UT), the Gray Herbarium at Harvard University (GH), the New York Botanical Garden Herbarium (NY), the University of Alaska Museum, Fairbanks (ALA), the Williams Lake Herbarium at the Caribou Forest (WLK), and from the literature (Hitchcock 1941, Mulligan 1971, Rollins 1993, Schulz 1927). It must be noted that many, particularly older, records do not have precise location information and errors may have been made in determining the exact number of occurrences; in some cases a site may have been revisited and designated a new occurrence, or discrete populations in the same general vicinity may have been estimated to be the same site.

There is little information on the abundance of *Draba ventosa*. Although *D. ventosa* has a relatively wide geographical range, it is not inevitably found in suitable alpine habitats within that range. It may occur in small isolated patches of only a few individuals, or plants can be sparsely, but essentially contiguously, distributed up a slope that encompasses 100 m or more

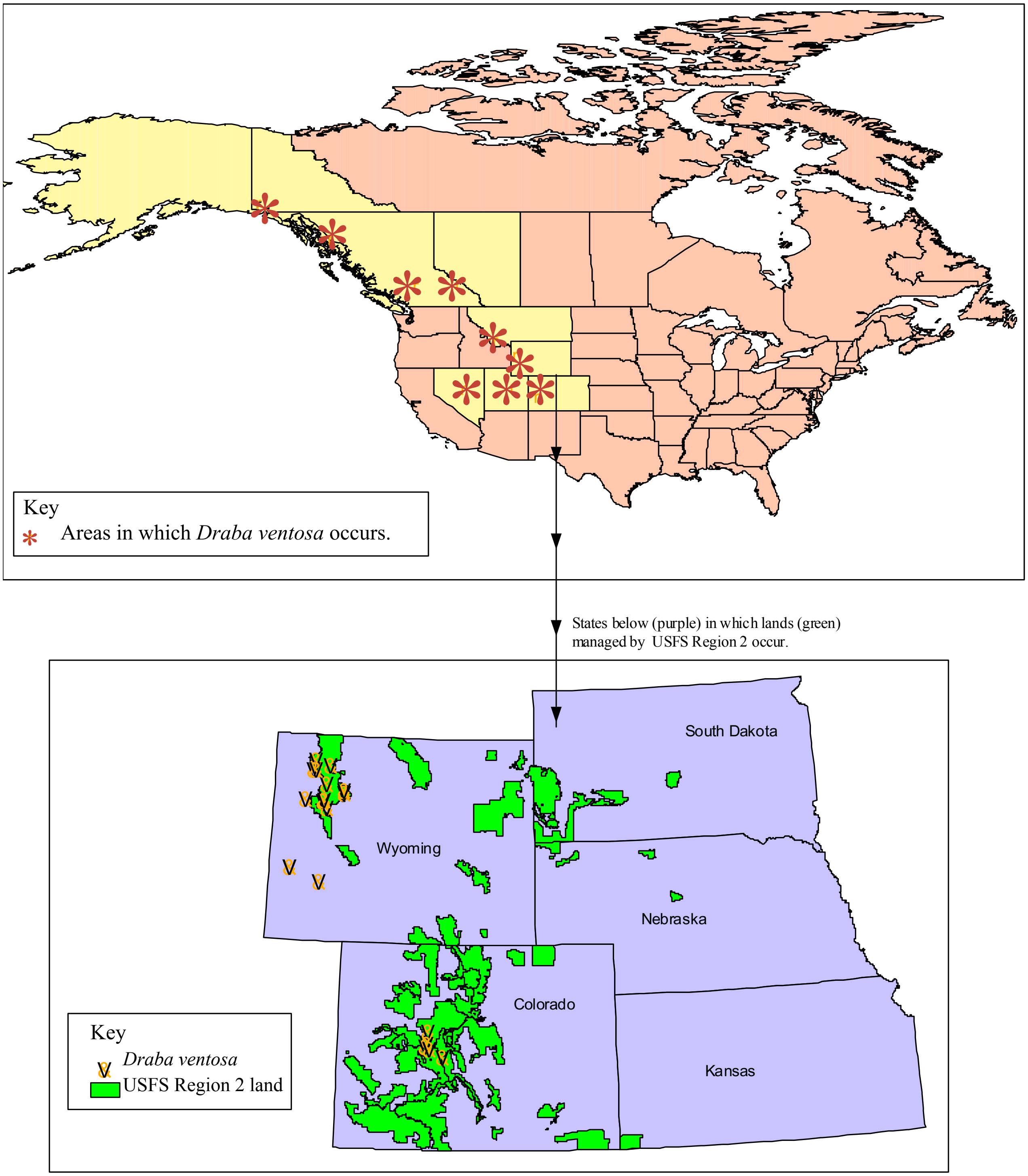


**Figure 2.** Maps showing the approximate locations of *Draba ventosa* within Canada and the United States of America. One point on the map may represent multiple occurrences. Areas (provinces and states) in which *D. ventosa* has been reported are marked in yellow.

**Table 1.** Summary of the reported occurrences of *Draba ventosa*. Two occurrences not presented in the table are known from unspecified locations in the Yukon, Canada. The names and addresses corresponding to herbaria abbreviations are listed in the **Definitions section**.

| Arbitrary occurrence no. | State or Province | County (only for occurrences in United States) | Date | Management | Location | Source of information |
|---|---|---|---|---|---|---|
| CO-1 | Colorado | Gunnison | 13-Aug-1951 | Gunnison National Forest - Region 2 | North Italian Mountain, northeast of Gothic. | J. Langenheim 1476. CS and COLO |
| CO-2 | Colorado | Gunnison | 26-Aug-1954 | Gunnison National Forest - Region 2 | North Italian Mountain. | J. Langenheim3964 1954 COLO |
| CO-3 | Colorado | Gunnison | 1967 | Gunnison National Forest - Region 2 | Italian Mountain. | Spongberg, S. 67-167A. 1967. National Museum of Natural History, Smithsonian Institute. Colorado Natural Heritage Program element occurrence database. |
| CO-4 | Colorado | Gunnison | 17-Jul-1980 | Gunnison National Forest - Region 2 | South Italian Mountain Ridge between Italian Mountain and its southern saddle (population may be extension of CO-3). | Johnston, B.C., P. Dixon, and R. Wiley 2360, and 2355. 1980. COLO. Colorado Natural Heritage Program element occurrence database. |
| CO-5 | Colorado | Pitkin | Undated | White River National Forest - Region 2 | Maroon Bells Snowmass Wilderness-Conundrum Pass area. | Price, R. 5 Undated. COLO Colorado Natural Heritage Program element occurrence database. |
| CO-6 | Colorado | Pitkin | 18-Jul-1971 | White River National Forest - Region 2 | Maroon Bells Snowmass Wilderness-Summit of Electric Pass. | Hartman, D. 6978 1971 COLO. Colorado Natural Heritage Program element occurrence database. |
| CO-7 | Colorado | Lake | 16-Aug-1995 | San Isabel National Forest - Region 2 | On saddle between Mount Massive and another peak. | Colorado Natural Heritage Program element occurrence database. |
| CO-8 | Colorado | Chaffee | 18-Aug-1989 | San Isabel National Forest - Region 2 | Lost Lake, Cottonwood Pass region. | Colorado Natural Heritage Program element occurrence database. |
| CO-9 | Colorado | Chaffe | 20-Jul-1987 | San Isabel National Forest - Region 2 | Northwest ridge of La Plata Peak in the Sawatch Range (possibly in or at the boundary the Collegiate Peaks Wilderness). | Erwin F. Evert 13327 RM |
| WY-1 | Wyoming | Not known | 15-Feb-1905 | Not known | Snake Pass. | C.C. Parry - Holotype Gray Herbarium |
| WY-2 | Wyoming | Teton | 26-Aug-1970 | Grand Teton National Park | South summit of Mt. Moran, directly above dike. | Richard J. Shaw, Richard W. Shaw, Russel Miller 1763 UTC |
| WY-3 | Wyoming | Teton | 10-Aug-1983 | Private land and likely Shoshone National Forest - Region 2 | North of Togwotee Pass and Two Ocean Peak in Absaroka Mountains. Plants observed in 3 contiguous sections. | Erwin F. Evert 5976 RM |
| WY-4 | Wyoming | Teton | 1-Aug-1933 | Shoshone National Forest-Region 2 and/or private land | Two Ocean Mountain, continental divide. | Louis Williams 1362 UTC |
| WY-5 | Wyoming | Teton | 9-Sep-1948 | Shoshone National Forest-Region 2 | Two Ocean Mountain, in the Wind River Range. | Reed C. Rollins 2498 with Alan A. Beetle RM |

**Table 1 (cont.).**

| Arbitrary occurrence no. | State or Province | County (only for occurrences in United States) | Date | Management | Location | Source of information |
|---|---|---|---|---|---|---|
| WY-6 | Wyoming | Sublette | 16-Aug-1994 | Bridger-Teton National Forest - Region 4 | West face of Big Sheep Mountain, approximately 2.25 miles west of Lower Green River Lake, on the west slope Wind River Range. | Walter Fertig 15407 1994 RM |
| WY-7 | Wyoming | Sublette | 1-Aug-1925 | Bridger-Teton National Forest - Region 4 | Sheep Mountain in the vicinity of Green River Lakes. | Edwin B. Payson 4501 with Lois B. Payson RM; Walter Fertig 15407 1994 RM |
| WY-8 | Wyoming | Sublette | 2-Aug-1994 | Bridger-Teton National Forest - Region 4 | Hodges Peak in Gros Ventre area. Plants observed in 4 contiguous sections. | Ronald L. Hartman with Tom Cramer 49208 RM |
| WY-9 | Wyoming | Sublette | 4-Aug-1998 | Bridger-Teton National Forest - Region 4 | North side of Triangle Peak in Gros Ventre area. | Walter Fertig 18499 RM |
| WY-10 & WY-11 | Wyoming | Sublette | 5-Aug-1994 | Bridger-Teton National Forest - Region 4 | Palmer Peak in Gros Ventre area. | Ronald L. Hartman 49370 RM |
| WY-12 | Wyoming | Sublette and Teton | 1990 and 1991 | Bridger-Teton National Forest - Region 4 (uncertain) | Two occurrences reported in 1990-1991: Green River Lakes region and Moccasin Basin Region on the west slope of the Wind River Range. | Fertig (1992) |
| WY-13 | Wyoming | Lincoln | 29-Jun-1985 | Bridger-Teton National Forest - Region 4 | Summit of Wyoming Peak. | Richard W. Scott 4429 RM |
| WY-14 | Wyoming | Lincoln | 9-Aug-1978 | Bridger-Teton National Forest - Region 4 | South of Wyoming Peak in the Wyoming Range. | Frank Smith with John S. Shultz 1123 RM |
| WY-15 | Wyoming | Fremont | 26-Aug- 1965 (uncertain) | Shoshone National Forest - Region 2 (and possibly private land) | Lava Mountain, Togwotee Pass area. | Richard W. Scott 694 RM |
| WY-16 | Wyoming | Fremont | 11-Aug-1983 | Shoshone National Forest - Region 2 (and possibly private land) | North of Bonneville Pass on the Continental Divide in the Absaroka Mountains. | Erwin F. Evert 5989 RM |
| WY-17 | Wyoming | Park | 21-Jul-1984 | Shoshone National Forest - Region 2 | In the vicinity of East Fork Pass and Cascade Creek Pass, south of Kirwin (apparently on boundary of Washakie Wilderness). | Richard W. Scott 3855 RM |
| WY-18 | Wyoming | Park | 13-Aug-1986 | Shoshone National Forest - Region 2 | Southwest side of Brown Basin. | R. Dorn 4459 RM |
| WY-19 | Wyoming | Park | 21-Jul-1981 | Shoshone National Forest - Region 2 | Washakie Wilderness – top of Ptarmigan Mountain in the Absaroka Mountains. | Erwin F. Evert 3224 UTC, Erwin F. Evert 3224 RM |

**Table 1 (cont.).**

| Arbitrary occurrence no. | State or Province | County (only for occurrences in United States) | Date | Management | Location | Source of information |
|---|---|---|---|---|---|---|
| WY-20 | Wyoming | Park | 26-Aug-1983 | Shoshone National Forest - Region 2 | Ridge above and northwest of the head of East Fork Big Creek south of Trout Peak in the Absaroka Mountains. | Erwin F. Evert 6263 RM |
| WY-21 | Wyoming | Park | 9-Jul-1979 | Shoshone National Forest - Region 2 | North Absaroka Wilderness - West side of Monument Mountain, North Fork Shoshone River Drainage in the Absaroka Mountains. | Erwin F. Evert 1471 RM |
| WY-22 | Wyoming | Park | 28-Aug-1983 | Shoshone National Forest - Region 2 | North Absaroka Wilderness - Top of Buttress Mountain, North Fork Shoshone River Drainage in the Absaroka Mountains. | Erwin F. Evert 6325 RM |
| WY-23 | Wyoming | Park | 13-Aug-1965 | Shoshone National Forest- Region 2 | Stinking Water Mountain and Sunlight Peak near the head of Sunlight Creek. Plants observed in 3 contiguous sections. | Richard W. Scott 646 RM |
| MT-1 | Montana | Madison | 2-Aug-1946 | Gallatin National Forest - Region 1. | Lee Metcalf Wilderness - On a mountain approximately 0.5 miles north of Koch Peak. On border between Gallatin and Beaverhead national forests. | Hitchcock and Muhlick 15213 1946. WTU. Montana Natural Heritage Program element occurrence records (comment: “Not field-checked”) |
| MT-2 | Montana | Madison | 1-Aug-1981 | Gallatin National Forest - Region 1 | Lee Metcalf Wilderness - East side of Koch Basin. | Lesica, P. 92776, 92779. MONTU. 1981. Montana Natural Heritage Program |
| MT-3 | Montana | Beaverhead | 9-Jun-1993, 25-Jul-1991 | Beaverhead and Deerlodge national forests - Region 1 and private land | Lion Mountain. | Lesica, P. and L. Bacon 119293. 1993. MONTU. Lesica, P. and S. Cooper.115123. 1991. MONTU. Montana Natural Heritage Program element occurrence records |
| UT-1 | Utah | Duchesne | 25-Aug-1995 | Ashley National Forest - Region 4 | Northwest slope of Blind Stream Peak in the Uinta Mtns. West-northwest of Horsehair Spring. | M.D. Windham, E. Rickart 95-220 UTC |
| UT-2 | Utah | Duchesne | 1-Aug-1979 | Ashley National Forest - Region 4 | Rock Creek drainage in the Uinta Mountains. | S. Goodrich 13565 UTC |
| UT-3 | Utah | Summit | 7-Aug-1936 | Wasatch-Cache National Forest - Region 4 | Mount Gilbert-western exposure. | Bassett Maguire, Dean A. Hobson, 14480 UTC |
| UT-4 | Utah | Summit | 7-Aug-1936 | Wasatch-Cache National Forest - Region 4 | Mount Gilbert - southern exposure. | Bassett Maguire, Dean A. Hobson, 14461 UTC |
| UT-5 | Utah | Summit | 16-Aug-1936 | Wasatch-Cache National Forest - Region 4 | Little Basin, west Gilbert Peak. | Bassett Maguire, Dean A. Hobson, 14462 UTC |

**Table 1 (cont.).**

| Arbitrary occurrence no. | State or Province | County (only for occurrences in United States) | Date | Management | Location | Source of information |
|---|---|---|---|---|---|---|
| BC-1 | British Columbia | --- | 10-Jun-1980 | Unavailable | Klastline River, southeast of Mount Meehaus. | A. Ceska s.n. In British Columbia Conservation Data Centre element occurrence records |
| BC-2 | British Columbia | --- | 17-Jul-1978 | Unavailable | Mount Bowman. | L.E. Pavlick 683 in British Columbia Conservation Data Centre element occurrence records |
| BC-3 | British Columbia | --- | 6-Jul-1980 | Unavailable | Northeast ridge of Perkins Peak. | L.E. Pavlick 80-41 in British Columbia Conservation Data Centre element occurrence records |
| BC-4 | British Columbia | --- | 22-Jul-1981 | Caribou Forest | Headwaters of Valleau Creek in the Niut Range. | A. Roberts 81-389 in British Columbia Conservation Data Centre element occurrence records. Also specimen from area in Cariboo Forest Region Williams Lake Herbarium. |
| AL-1 | Alberta | --- | 13-Jul-1971 | Unavailable | West-southwest of fire lookout on Ram Mountain. | CD Birdin Alberta Conservation Data Centre element occurrence records |
| AL-2 | Alberta | --- | 8-Aug-1969 | Unavailable | Highwood Pass. | Packer, J.G Accession 27400 UA (Univ. of Alberta?) in Alberta Conservation Data Centre element occurrence records |
| AL-3 | Alberta | --- | 11-Aug-1969; 18-Aug-1903 | Banff National Park | Mt. Bourgeau. | G.W. Scotter; in Alberta Conservation Data Centre element occurrence records |
| AL-4 | Alberta (extending to British Columbia?) | --- | 7-Jul-1969 | Banff National Park | Near Sunshine Ski Lodge on Quartz Ridge. NOTE: Mulligan 3446 UTC specimen describes: ‘Quartz Ridge (BC side), near Sunshine Ski Lodge. | G.A. Mulligan 3446 28-Jul-1969 UTC; G.W. Scotter; in Alberta Conservation Data Centre element occurrence records |
| AL-5 | Alberta | --- | 5-Jul-1969; 25-Jul-1951 | Banff National Park (?) | Shale slope on hill behind ski lodge. | G.W. Scotter in Alberta Conservation Data Centre element occurrence records |
| AL-6 | Alberta | --- | 7-Sep-1966 | Unavailable | Snow Creek Valley; south of Harrison Lake up to cairn. | K. Beder in Alberta Conservation Data Centre element occurrence records |
| AL-7 | Alberta | --- | July 1959; August 1969 | Unavailable | Approximately 30 miles north of Banff at Snow Creek Pass. | Alberta Conservation Data Centre element occurrence records |
| AL-8 | Alberta | --- | 12-Aug-1979 | Jasper National Park. | Opal Hills. | Alberta Conservation Data Centre element occurrence records |
| AL-9 | Alberta | --- | 26-Aug-1955 | Unavailable | Cairn Pass. | Flook, D. CF 1001. Alberta Conservation Data Centre element occurrence records |
| AL- 10 | Alberta | --- | 13-Jul-1969 | Banff National Park | Lookout Mountain. | Scotter, G.W. Accession no. 121896 AC & Scotter, G.W. Accession no. 2967. CF. Alberta Conservation Data Centre element occurrence records |
| AL- 11 | Alberta | --- | 1-Aug-1945 | Banff National Park | Bourbeau Lake near Mt. Bourgeau and Mt. Brett. | Porsild & Breitung NM 289306. Alberta Conservation Data Centre element occurrence records |

**Table 1 (concluded).**

| Arbitrary occurrence no. | State or Province | County (only for occurrences in United States) | Date | Management | Location | Source of information |
|---|---|---|---|---|---|---|
| AL- 12 | Alberta | --- | 4-Jul-1945 | Banff National Park | Northeast slope of Protection Mountain near Mt. Temple Ski Lodge. | Porsild & Breitung NM 289307. Alberta Conservation Data Centre element occurrence records |
| AL- 13 | Alberta | --- | 21-Aug-1946 | Unavailable | Southwest slope of Bare Mountain near the Panther River. | Porsild & Breitung NM 289304. Alberta Conservation Data Centre element occurrence records |
| AL- 14 | Alberta | --- | 26-Jul-1959 | Unavailable | Snow Creek Pass. | Mosquin, T. UC 12758, Porsild, A.E. NM 258277. Alberta Conservation Data Centre element occurrence records |
| AL- 15 | Alberta | --- | 9-Aug-1945 | Unavailable | Citadel Pass near Sunshine Ski Lodge. | Porsild & Breitung NM 289309. Alberta Conservation Data Centre element occurrence records |
| AL- 16 | Alberta | --- | 23-Jul-1946 | Unavailable | South of Healy Creek near Sunshine Ski Lodge. | Porsild & Breitung NM 289308. Alberta Conservation Data Centre element occurrence records |
| AL- 17 | Alberta | --- | 26-Jul-1945 | Unavailable | Goat's Eye Mountain, south of Healy Creek near Sunshine Ski Lodge. | Porsild & Breitung NM 289305. Alberta Conservation Data Centre element occurrence records |
| AL- 18 | Alberta | --- | 14-Jul-1945 | Unavailable | Near Mt. Temple Ski Lodge, Mt. Redoubt. | Porsild & Breitung NM 289301. Alberta Conservation Data Centre element occurrence records |

difference in elevation. In the latter situation, it may be relatively abundant. Several hundred individuals were estimated sparsely distributed up a slope that spanned several hundred meters in Colorado (CO-7 in **Table 1**; Colorado Natural Heritage Program 2002).

### Population trend

There are insufficient data in the literature, associated with herbarium specimens, or at the Natural Heritage Programs to determine long-term trends for *Draba ventosa* over its entire range or even within USFS Region 2. It was discovered in the Wind River Range in 1873 and has been periodically observed within this range, and the adjacent Absaroka Range, ever since. Since it was first collected at the end of the nineteenth century, *D. ventosa* has been documented in approximately 26 to 30 locations within Region 2, but the number of extant populations and their persistence is not well defined. Occurrences were documented in the Italian Mountain region of Colorado in 1951, 1954, and 1980, but all appeared to be in discretely different locations and may not have been part of the same population (COLO specimens and Colorado Natural Heritage Program element occurrence records). Similarly, observations made in the Ocean Mountain area in Wyoming in 1933, 1948, and 1983 were apparently of different sites within the same general area (WY-3, WY-4, WY-5). The Massive Mountain population in Colorado was visited in 1995 and again 2000, but observations on abundance in 2000 were not recorded. In Montana, the same population was visited in 1991 and again in 1993 and was described as "locally common", but no indication of specific abundance at each visit was given. In addition, little information exists on revisited sites in Canada. It appears natural for this species to occur infrequently, and there is little evidence to suggest it is either more or less common at the present time than in the past.

### Habitat

*Draba ventosa* is one of several *Draba* species found in the subalpine and alpine tundra zone of the Rocky Mountains. Within the United Stated, it grows at elevations between 2,865 m and 4,243 m, with the majority of occurrences located between 3,250 m and 3,749 m (**Figure 3**). Where a range was given for an occurrence, the lowest and highest elevations reported were included in the analysis. The lowest elevation was reported from Wyoming at 2,865 m, and the highest from Colorado at 4,243 m. In Canada, *D. ventosa* is found at substantially lower elevations, but the elevation range where it is found cannot be strictly related to latitude. In British Columbia it has been found as low as 990 m, and in the Canadian Rockies in Alberta it has been reported to occur as high as 2,955 m.

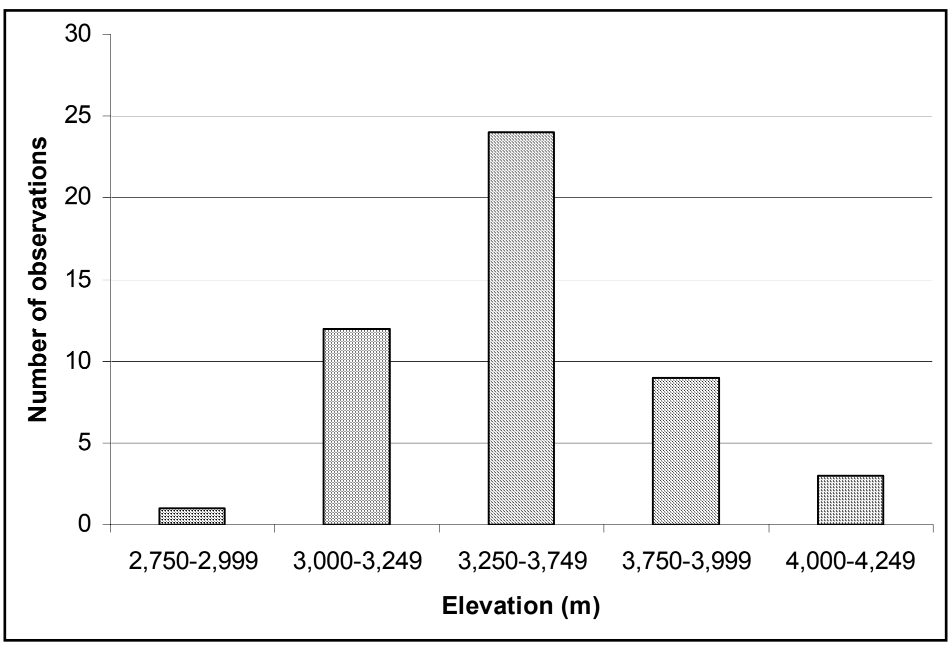


**Figure 3.** Range in elevation reported for the occurrences of *Draba ventosa* in Colorado, Wyoming, Utah, and Montana.

In all states, when habitat is described, plants are always associated with a high rock or talus cover (**Table 2**). Within USFS Region 2 and adjacent regions, limestone, dolomite, and calcareous substrates are most common where geology is reported, although occurrences have also been reported on sandstone and sedimentary rocks (Colorado Natural Heritage Program 2002, Rocky Mountain Herbarium 2002, Utah State University Intermountain Herbarium 2002). Langenheim (1962) noted that in two areas in which it occurs in Colorado, the rocks are derived from highly metamorphosed sediments, in one case siltstones and the other limestone. Although likely to be on metamorphosed limestone, individuals on North Italian Mountain may have been found on intrusive igneous rock (Colorado Natural Areas Program undated, Langenheim 1962).

There are essentially two general habitat types. Plants are found on rocky slopes, low ridges, and dry, rocky, alpine meadows, or on semi-stable and unstable slopes of scree and talus usually at the base of cliffs. Slope gradient has seldom been reported, but where it is mentioned, incline ranges from 11 percent to as much as 60 percent (Colorado Natural Heritage Program 2002, Montana Natural Heritage Program 2002, Rocky Mountain Herbarium 2002, Utah State University Intermountain Herbarium 2002). Plants have been reported to grow on aspects facing north, northwest, south, west and, less commonly, east. Habitat is usually described as dry and, more rarely, as periodically moist. Habitat information associated with each occurrence is summarized in **Table 2**.

*Draba ventosa* is a member of cushion plant communities. These low-growing species generally have their highest woody, perennial parts flat on the soil surface and are described as hemicryptophytes according to Raunkiaer's life form system (Raunkiaer 1934). *Draba ventosa* has been described as growing intimately in a mat with species such as the sensitive species *D. incerta* (*Spongeberg* 67-167A 1967 at the National Museum of Natural History Smithsonian Institute). Unspecified moss is also a frequent associate. Some of the other associated species and the state where they were observed are listed in **Table 3**.

### Reproductive biology and autecology

*Draba ventosa* is a perennial species. Similar to many other hemicryptophytes, the perennating buds of *D. ventosa* are usually protected by the old dead leaves and leaf bases of the plant. Flowering occurs from late June through August, and fruits are present in mid-July to early September (specimens from the middle Rocky Mountains at the University of Colorado Herbarium and the Rocky Mountain Herbarium, Wyoming).

*Draba* is a reproductively interesting genus, as examples of self-fertilization, self-incompatibility, and apomixis have all been reported (Mulligan and Findlay 1970, Mulligan 1971, Brochmann et al. 1992). Mulligan (1971) reported irrefutable evidence that *D. ventosa* collected in Canada, apparently Alberta and British Columbia, reproduces by apomixis, specifically agamospermy and that pollen stimulation is not required for apomictic seed production. Apomixis, or "reproduction without fertilization," is relatively common among vascular plants (Grant 1981). One of the main forms of apomixis is agamospermy, which is seed formation without fertilization. Interestingly, gametophytic agamospermy, where a morphological gametophyte is present but unreduced, is most common in plants of northern and colder regions. In the alternative form of apomixis, adventitious embryony, there is no gametophyte stage, and the embryo is derived from a somatic cell of the ovule. Mulligan (1976) reported that apomixis in *Draba* is associated with polyploidy, and Grant (1981) reported that apomictic species in general are often triploid. The pollen in triploid species often fails to mature normally because the three sets of chromosomes are unable to align effectively during meiosis (Grant 1981). In keeping with these general rules, the base chromosome number of *D. ventosa* ($2n = 36$, a triploid) is probably $x = 12$ (Mulligan 1971, Windham 2000). The closely related hexaploid species, *D. ruaxes*, is an outcrossing species (Mulligan 1971). A single population of an apomictic taxon may show little genetic variation, and locally adapted populations are likely. However, it is only prudent to emphasize that the work on reproductive biology was made on northern specimens and that nrDNA studies placed Canadian and Utah samples in different lineages, indicating that information gathered on specimens in Canada may not be relevant to specimens in Region 2 (Windham personal communication 2002). In addition, many species are not exclusively apomictic. They exhibit facultative agamospermy, and may reproduce sexually depending upon conditions (Grant 1981). There are also instances where some populations of predominantly apomictic taxa reproduce sexually. For example, some Montana populations of the primarily apomictic *D. oligosperma* are probably sexual (Mulligan and Findlay 1970). Alternatively, there are examples of apomictic populations among predominately sexually reproductive species. Some populations of *D. densifolia* in Alaska and Canada were apomictic (Mulligan 1976).

**Table 2.** Summary of the habitat at each occurrence of *Draba ventosa*. See **Table 1** for source information.

| Arbitrary occurrence no. | State or Province | Date | Habitat and comments summarized from records |
|---|---|---|---|
| CO-1 | Colorado | 13-Aug-1951 | Talus. "Metamorphic parent material. West exposure." |
| CO-2 | Colorado | 26-Aug-1954 | "Large mats on northwest-facing slopes of marbleized limestone." |
| CO-3 | Colorado | 1967 | "Forming large mats with *Draba incerta*." On "moist to dryish, gravelly soil on the northwest-facing slope." |
| CO-4 | Colorado | 17-Jul-1980 | "On ridge. In little white-limestone saddle." |
| CO-5 | Colorado | Undated | Gray-rock talus. |
| CO-6 | Colorado | 18-Jul-1971 | Rocky alpine summit of pass. |
| CO-7 | Colorado | 16-Aug-1995 | Sparse but constant on wind blown, eroding slope. Recent snow melt area. |
| CO-8 | Colorado | 18-Aug-1989 | Scree. Aspect: east. Slope: medium 11% to 20 percent. Highly disturbed by down slope movement. Substrate: carbonate. Moisture: dry all season. Associated species: *Draba exunguiculata*, *D. albertina*, *Oxytropis splendens*, *O. lonchocarpa*, *Potentilla uniflora*, *Poa glauca*, *Erigeron simplex*. |
| CO-9 | Colorado | 20-Jul-1987 | Rocky tundra and talus slopes. |
| WY-1 | Wyoming | 15-Feb-1905 | No information. |
| WY-2 | Wyoming | 26-Aug-1970 | Frequent in sedimentary rock. With *Carex nigricans*, *Selaginella densa* |
| WY-3 | Wyoming | 10-Aug-1983 | On tundra. |
| WY-4 | Wyoming | 1-Aug-1933 | Rock slides. |
| WY-5 | Wyoming | 9-Sep-1948 | On rock slide. |
| WY-6 | Wyoming | 16-Aug-1994 | Limestone and sandstone talus slopes from timberline to near crest; alpine community dominated by *Parrya nudicaulis*, *Senecio canus*, *Trisetum spicatum*, and *Polemonium* spp.. |
| WY-7 | Wyoming | 1-Aug-1925 | Limestone slide. |
| WY-8 | Wyoming | 2-Aug-1994 | Rocky alpine areas. |
| WY-9 | Wyoming | 4-Aug-1998 | Calcareous talus slopes on semi-stable ridgeline leading to summit cone; cushion plant community with scattered *Silene acaulis*, *Dryas* spp., and *Polemonium* spp. |
| WY-10 & WY-11 | Wyoming | 5-Aug-1994 | Rocky alpine slopes and summits, calcareous. |
| WY-12 | Wyoming | 1990/1991 | Sub alpine and alpine zones in dry meadows |
| WY-13 | Wyoming | 29-Jun-1985 | Rocky scree. |
| WY-14 | Wyoming | 9-Aug-1978 | Southwest exposure, rocky hillside, associates include *Phlox* spp., *Poa* spp., *Polemonium* spp., and *Erigeron* spp. |
| WY-15 | Wyoming | 26-Aug-1965 | Scattered alpine areas on the tops of the mountains. |
| WY-16 | Wyoming | 11-Aug-1983 | On tundra. |
| WY-17 | Wyoming | 21-Jul-1984 | Scree slopes and ridges. |
| WY-18 | Wyoming | 13-Aug-1986 | Rocky slopes with *Senecio fuscatus* and *Papaver* spp. Flowers yellow. |
| WY-19 | Wyoming | 21-Jul-1981 | "Tundra, scree and talus. With *Townsendia condensata*, *Arenaria rossii* (also with *Claytonia megarhiza*)." |
| WY-20 | Wyoming | 26-Aug-1983 | Talus and scree. |
| WY-21 | Wyoming | 9-Jul-1979 | Growing in scree at base of cliffs. |
| WY-22 | Wyoming | 28-Aug-1983 | On talus. |
| WY-23 | Wyoming | 13-Aug-1965 (uncertain) | Steep scree slides. |

**Table 2 (concluded).**

| Arbitrary occurrence no. | State or Province | Date | Habitat and comments summarized from records |
|---|---|---|---|
| MT-1 | Montana | 2-Aug-1946 | On talus; "rockledges and talus slopes above timberline, often on limestone." |
| MT-2 | Montana | 1-Aug-1981 | "On shifting talus on steep west-facing slope, with *Stellaria americana* and *Senecio fremontii*." |
| MT-3 | Montana | 9-Jun-1993, 25-Jul-1991 | "Dolomite talus, limestone scree with *Saxifraga oppositifolia*, *Dryas octopetala*, *Draba oligosperma*, *Antennaria aromatica*." Slope = negative; aspect = south. "Locally common". |
| UT-1 | Utah | 25-Aug-1995 | In shaley soil among rocks on steep, northwest-facing slope. Exposed locality in alpine talus community. |
| UT-2 | Utah | 1-Aug-1979 | *Polemonum viscosum* and *Erigeron compositus*. |
| UT-3 | Utah | 7-Aug-1936 | Under cliffs in talus slope on west exposure. |
| UT-4 | Utah | 7-Aug-1936 | In rocks and rocky soil; southern exposure. |
| UT-5 | Utah | 16-Aug-1936 | Sand, gravelly talus slopes. |
| BC-1 | British Columbia | 10-Jun-1980 | Meadow. |
| BC-2 | British Columbia | 17-Jul-1978 | Alpine; fellfield. |
| BC-3 | British Columbia | 6-Jul-1980 | Alpine. |
| BC-4 | British Columbia | 22-Jul-1981 | "Alpine rocky ridge, scree slopes, *Salix nivalis*, *Carex pyrenaica*, *Cassiope mertensiana*; sub-xeric". |
| AL-1 | Alberta | 13-Jul-1971 | On soil. |
| AL-2 | Alberta | 8-Aug-1969 | Fairly stable scree slope. West aspect. |
| AL-3 | Alberta | 11-Aug-1969; 18-Aug1903 | No information. |
| AL-4 | Alberta | 7-Jul-1969 | Dry gravelly slope near top of ridge; alpine community. Calcareous shale slide-rock on alpine slopes and summits. |
| AL-5 | Alberta | 5-Jul-1969; 25-Jul-1951 | Montane slope, alpine community. |
| AL-6 | Alberta | 7-Sep-1966 | Rocky ridge. |
| AL-7 | Alberta | July 1959; August 1969 | Montane, shale, bare scree slopes. |
| AL-8 | Alberta | 12-Aug- 1979 | Non-calcareous colluvial rubble on a ridge top. |
| AL-9 | Alberta | 26-Aug-1955 | No information. |
| AL-10 | Alberta | 13-Jul-1969 | Alpine community. |
| AL-11 | Alberta | 1-Aug-1945 | Dry, alpine slopes and screes from timberline to summit; dominant on calcareous shale scree below summit. |
| AL-12 | Alberta | 4-Jul-1945 | Loose shale slide on alpine slopes. |
| AL-13 | Alberta | 21-Aug-1946 | Shale screes near summit. |
| AL-14 | Alberta | 26-Jul-1959 | Rock slide, alpine slopes west of pass. |
| AL-15 | Alberta | 9-Aug-1945 | Shale rock-slide on alpine slopes and screes. |
| AL-16 | Alberta | 23-Jul-1946 | No information. |
| AL-17 | Alberta | 26-Jul-1945 | Calcareous rock slide on alpine summits. |
| AL-18 | Alberta | 14-Jul-1945 | Rock slide on alpine slopes. |

**Table 3.** Plant species reported to be associated with *Draba ventosa* in the mid-Rocky Mountain region. This is not an exhaustive list and represents only observations made on herbarium sheets and in occurrence records.

| Associated species | State where the observation was made | Associated species | State where the observation was made |
|---|---|---|---|
| *Antennaria aromatica* | Montana | *Parrya nudicaulis* | Wyoming |
| *Arenaria rossii* | Wyoming | *Phlox* spp. | Wyoming |
| *Carex nigricans* | Wyoming | *Poa* spp. | Wyoming |
| *Claytonia megarhiza* | Wyoming | *Poa glauca* | Colorado |
| *Draba albertina* | Colorado | *Polemonium* spp. | Wyoming |
| *Draba exunguiculata* | Colorado | *Polemonium viscosum* | Utah |
| *Draba incerta* | Colorado | *Potentilla uniflora* | Colorado |
| *Draba oligosperma* | Montana | *Saxifraga oppositifolia* | Montana |
| *Dryas* spp. | Wyoming | *Selaginella densa* | Wyoming |
| *Dryas octopetala* | Montana | *Senecio canus* | Wyoming |
| *Erigeron* spp. | Wyoming | *Senecio fremontii* | Montana |
| *Erigeron compositus* | Utah | *Senecio fuscatus* | Wyoming |
| *Erigeron simplex* | Colorado | *Silene acaulis* | Wyoming |
| *Geum rossii* (syn: *Acomastylis rossii* (Weber & Wittmann 2001)) | Wyoming | *Stellaria americana* | Montana |
| *Oxytropis lonchocarpa* | Colorado | *Townsendia condensata* | Wyoming |
| *Oxytropis splendens* | Colorado | *Trisetum spicatum* | Wyoming |
| *Papaver* spp. | Wyoming | | |

One accepted consequence of polyploid speciation has been that the polyploid will be reproductively inaccessible from its progenitor species because of a chromosome number barrier (Grant 1981). However, unlike many genera, ploidy differences may not preclude successful hybridization between *Draba ventosa* and other species of alpine *Draba*. Mulligan (1976) concluded that interspecific hybridization in *Draba* was rare in nature and appeared to result in sterile first generation hybrids. However, he reported that although pollen fertility was low (25 percent or less), it was not zero. Some hybrids produced some poorly formed seed, although most silicles were aborted, indicating that sexual reproduction was not impossible but probably unlikely. More recently, Brochman et al. (1992) demonstrated that interspecific hybridization across ploidy levels in *Draba* can result in re-establishment of fertility and probably euploid chromosome numbers. They suggest that it is more likely that hybridization will occur between polyploids rather than between a diploid and a polyploid.

If sexual reproduction can occur, flies are likely pollinators. Price (1979) reported that insect pollinators were comparatively few to all species of *Draba* when he studied the *D. crassa* complex that, like *D. ventosa*, occurs in the alpine zone in Colorado. Members of the Diptera order of arthropods, commonly known as flies, frequently visit and probably pollinate flowers of high elevations (Shaw and Taylor 1986, Kearns and Inouye 1994). Price (1979) noted that only members of the Syrphidae (flies) are likely effective pollinators of the *Draba* he studied. Although they do not sting or bite, syrphid flies resemble wasps and bees and can be quite hairy (Borror and White 1970).

The rate of seed recruitment to the seed bank, the longevity of seed in the soil, and the extent of seed predation are all unknown. Relative to other species, *Draba* seeds generally are less abundant in the tundra seed bank (McGraw and Vavrek 1989). Untreated seeds of arctic-alpine *Draba* are reported to germinate very poorly whereas pretreatments such as scarification and/or gibberellic acid increase germination considerably (Brochmann et al. 1992). Seed dispersal mechanisms are also not known. Being in alpine tundra regions, wind may be effective in dispersing seed although wind-dispersed seeds frequently move only short distances (Silvertown 1987).

## Demography

*Draba ventosa* is a perennial that reproduces by seed. No demographic studies have been undertaken, and transition probabilities between the different stages, from seed production to the flowering adult are unknown. A three-year demographic study was made on another perennial, rock dwelling *Draba* in Idaho, *D. trichocarpa* (Moseley and Mancuso 1991, 1992, 1993). This species grows at somewhat lower elevations (approximately 1922 m), and apparently it is not a close relative to *D. ventosa*. However, the results of this demographic study may be useful to bear in mind when considering the few data that have been gathered for *Draba ventosa*.

*Draba ventosa* populations appear to be largely comprised of adults. Information associated with herbarium specimens and element occurrence records provided by the Natural Heritage Programs report individuals were either in fruit or flower indicating that seedlings were few or particularly inconspicuous. In the *D. trichocarpa* study, non-reproductive and reproductive individuals were stable, but the seedling mortality rate was very high (Moseley and Mancuso 1993). In long-lived perennials, seed production may be low and the most important life cycle components are growth and survival of the adult plants (Silvertown et al. 1993). In this case, assets are allocated to favor the survival of the adult. Moseley and Mancuso (1993) concluded that mature *D. trichocarpa* plants are relatively long-lived but poor seedling recruitment, caused by a 73 percent mortality rate, poses significant limitations to population growth and longevity. Seed germination and seedling establishment are very sensitive to environmental conditions, and the high elevation environment of *D. ventosa* has high variability. In fact, most alpine species have a long-lived stage in their life cycle (Johnston and Huckaby 2001).

Unfortunately, there are more questions than facts available pertaining to the life cycle of this species, and speculation is accepted as a poor substitute for facts. A simple life cycle model of *Draba ventosa* is diagrammed in **Figure 4**. Heavy arrows indicate phases in the life cycle that appear most prominent, and lighter weight arrows indicate the phases that are either apparently less significant or unknown. The steps that particularly need to be clarified are noted by "?" at the appropriate arrow. More information is needed to define which of the life history stages has the greatest effect on population growth and survival. It is not known if plants flowering one year revert to vegetative plants in following years or if size reflects the age of the plant. It is likely that environmental conditions, for example moisture, have a primary effect on plant size. Limits to population growth are not well-defined. At the present time it would appear that growth is restricted to some extent by substrate and other edaphic conditions such as moisture. The current evidence suggests that *D. ventosa* is a perennial species that is maintained in established, small populations and corresponds to the profile of a k-selected species, apparently having a stress-tolerant life strategy (MacArthur and Wilson 1967, Grime et al. 1988).

Population viability analyses for this species have not been undertaken. Apomictic taxa may be thought to be at an evolutionary disadvantage, but many purely asexual taxa, for example *Taraxacum officinale* (dandelions), have proved to be very successful for fairly long periods of time (Grant 1981, Menges 1991). The ecological consequences of the complicated reproductive systems and the complexity of polyploidy in *Draba* are not well-defined. Brochmann (1993) hypothesizes that allopolyploidy prevents genetic depauperation in the arctic *Draba*. In the case of *D. ventosa*, short-term analyses of population viability that emphasize demography rather than genetics may be most rewarding (Landes 1988, Menges 1991). Studying the genetics of just a few populations may not represent the species in total and may lead to misconceptions.

Metapopulation analyses based on the proportion of occupied suitable microsites may be an effective method of understanding population viability of this species at the management level (Menges 1991). It appears that *Draba ventosa* often exists in patches, or rather as a subdivided population. It is unknown whether there is a balance of frequent local extirpations and colonizations within a colonized area or whether, once established, microsites are occupied for long periods of time. The instability of talus and scree slopes of its habitat suggests that the species can deal with a certain amount of disturbance. Certainly it must be well-adapted to the freeze-thaw perturbations that occur (Johnston and Huckaby 2001). In addition, there is a constant slide associated with talus slopes. In one study in Colorado, the mean displacement of talus (downslope slide) over a 25-year period was 14.7 m, which is 0.59 m per year. However, this "average rate" is very variable as it was five times the rate measured at the same site in 1967. This is likely due to the fact that the 25-year period was marked by several high-intensity storms, including a 100-year precipitation event (52 mm in 8 hr). In addition, the dispersion patterns and travel distances were found to be highly variable within and between sections of the same talus deposits (Davinroy 1993). The shape of talus affected movement. As one would expect, displacement distance increases as particle shape approximates a sphere. Therefore, the shape of the rocks and gravels and their propensity for movement may contribute to the patchy nature of *D. ventosa* distribution. It may well grow in

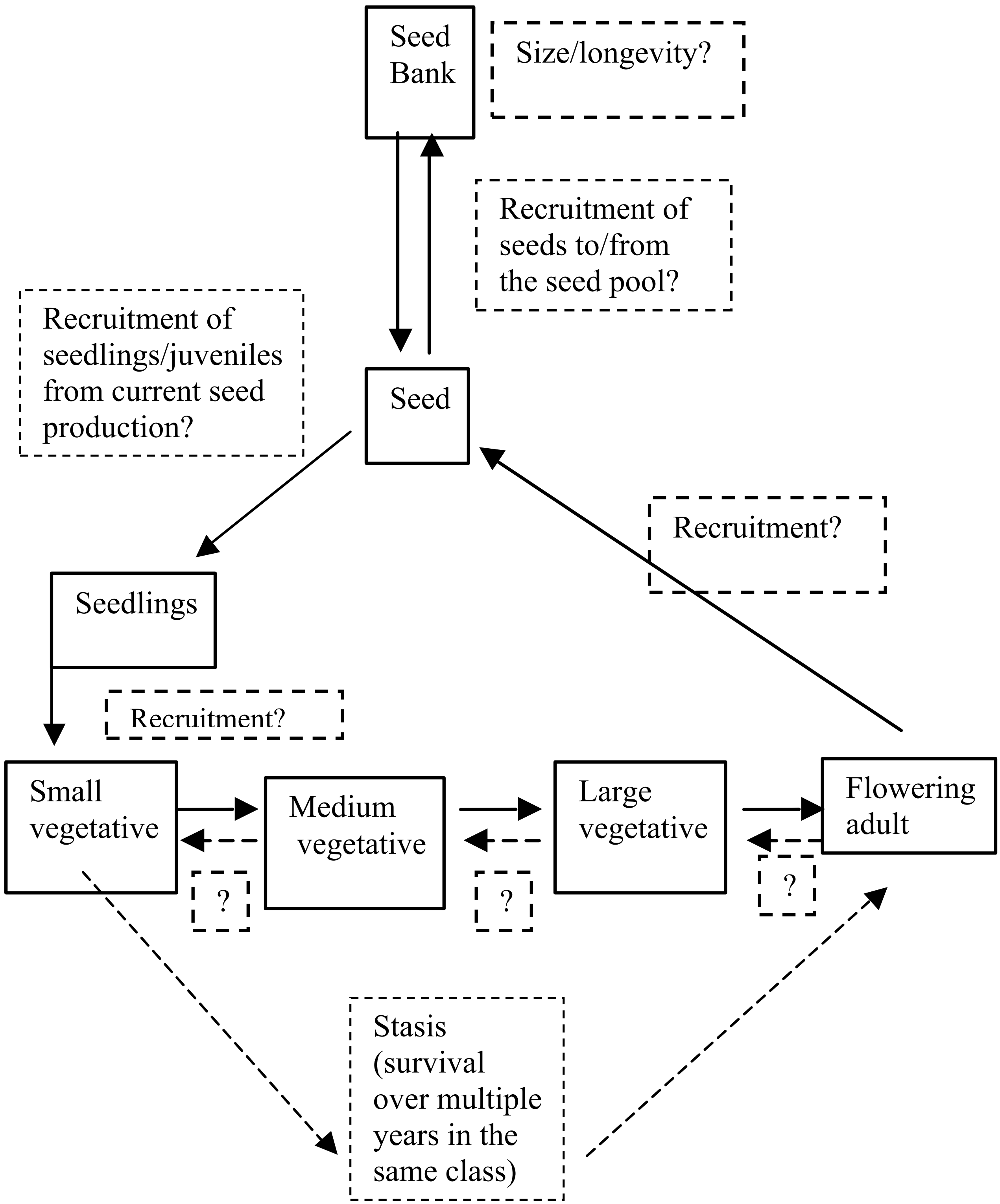


**Figure 4.** Life cycle diagram for *Draba ventosa*.

microsites that are relatively stable in an otherwise unstable environment.

A consequence of an agamospermous lineage with intermittent sexual episodes is that new adaptive hybrids can reproduce themselves by successive cycles of agamospermy, and thus genotypes specifically adapted to local conditions can become established (Grant 1981). Because populations of *Draba ventosa* are often separated by considerable distances of inappropriate habitat, local selection pressures may have led to increased fitness to local conditions.

### Community ecology

The population size of this species is quite variable. Fewer than 10 individuals to several hundred may comprise a population. The causes of the differences in population size are unknown. It appears that *Draba ventosa* does not flourish in highly competitive communities and favors more environmentally harsh and sparsely vegetated sites, such as rocky meadows or, more commonly, talus and scree slopes. Invasive weed species have not been specifically reported at any of the recorded occurrences although several species of noxious weed have been reported above the treeline in Colorado (Ray 2001). Interactions with the fauna of its associated community, for example the role of arthropods in potential seed dispersal or seed predation, have not been documented.

An envirogram is a graphic representation of the components that influence the condition of a species and reflects its chance of reproduction and survival. Envirograms have been used especially to describe the conditions of animals (Andrewartha and Birch 1984) but may also be applied to describe the conditions of plant species. Those components that directly impact *Draba ventosa* make up the centrum, and the indirectly acting components constitute the web (**Figure 5** and **Figure 6**). Unfortunately, as mentioned previously, much of the information needed to make a comprehensive envirogram for *Draba ventosa* is unavailable. The envirograms in **Figure 5** and **Figure 6** are constructed to outline some of the major components known to impact the species directly and also include some more speculative factors that can be tested in the field by observation or by management manipulation. Dotted boxes indicate resources or malentities that are either likely but not proven or that are of a regional nature. The lack of direct studies on this species leads to stretching the significance of observations and forming opinions from inference rather than from fact. Inferences must be tested and are dangerous to use in predicting responses to management decisions.

Resources have been listed as calcareous or sedimentary (sandstone) soils providing a suitable edaphic environment, and soil moisture for adequate growth. Size and shapes of the talus particles is also speculated to be important to microsite colonization (see Demography section). *Draba ventosa* may not have very stringent growth requirements, as it has been described as easy to cultivate (Williams et al. 1996). Snow pack may be important in providing sufficient soil moisture. Snow pack itself may be a resource if it gives protection against wind erosion and wind chill to some occurrences. It also contributes to scree and talus disturbance, but its importance is speculative. Alternatively, snow pack over consecutive growing seasons may be conjectured as a significant malentity. However, as reduced snow pack may be a more likely consequence of global climate change, it does not appear to be a significant avoidable threat. Disturbance in the form of slides from snow pack and precipitation may aid seed dispersal, but there is no evidence to support this speculation. Pollinators for sexual reproduction have not been included because current evidence indicates that the species is primarily apomictic.

At the current time, malentities tend to be of regional, rather than universal, importance and are indicated as such in **Figure 6** by dotted lines. Direct disturbances such as the trampling or dislodging of individual plants by hikers, casual summer sightseers at ski areas, and introduced mountain goats are harmful. These forces also contribute to soil erosion and rock slides that lead to habitat destruction, which is deleterious over the long term. Air pollution has been included in the envirogram (**Figure 6**) as it is a significant threat within parts of *Draba ventosa*'s range including that within Region 2. For example, the populations within the Maroon Bells-Snowmass Wilderness area in Region 2 may be vulnerable to pollutant sources from the west, southwest, and south (Hudnell et al. 1988-93). The impacts of air pollution and other threats are discussed further in the Threats section. The extent and duration of malentities are important factors and need further study.

## CONSERVATION

### *Threats*

Natural catastrophes and environmental stochasticity are likely the primary threats to *Draba*

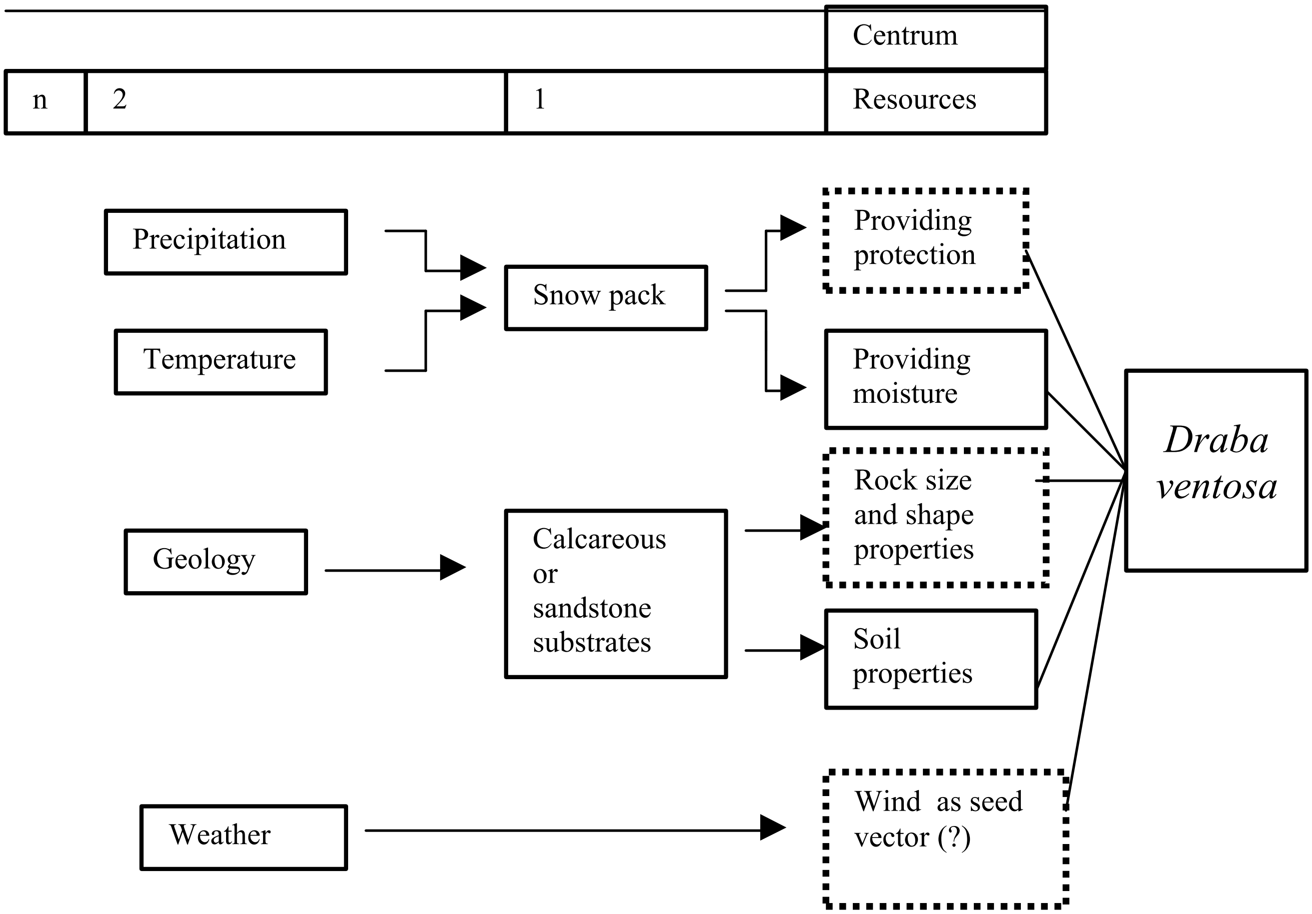


**Figure 5.** Envirogram of the resources of *Draba ventosa*.

*ventosa* at the rangewide scale. Few comments can be made on the influence of demographic stochasticity on individual populations because there is no information on the survival probability of individuals at any given life-stage or age (see Demography section). Where occurrences are small, perhaps less than 50 individuals, demographic uncertainties may well be of significance (Pollard 1966, Keiding 1975). That is, chance events independent of the environment may affect the reproductive success and survival of individuals that, in very small populations, have an important influence on the survival of the whole population.

It is generally assumed that there are few threats because of *Draba ventosa*'s largely inaccessible habitat. However, at the level of individual populations, several specific threats have been identified. Activities associated with recreation, mining, grazing, and over-collection are all potential threats. Each is addressed in the following paragraphs.

Although areas where *Draba ventosa* occurs tend to be remote, many are affected by anthropogenic activities. Foot traffic is a significant threat in many areas. One known site in the San Isabel National Forest (CO-7 in **Table 1**) is within a popular hiking area and is particularly vulnerable to hikers tramping across occupied, as well as potential, habitat. Utility lines and roads, particularly in and near ski areas, may also impact certain populations in the Bridger-Teton National Forest in Region 4 (Ozenberger personal communication 2002). Ski areas are established throughout the range and habitat of *D. ventosa*, but the impacts of skiing and related maintenance and construction activities have not been documented. In the Canadian Rockies, occurrences are often associated with ski area construction, for example lodges, and it is unknown what impact this has had on those populations (AL-5, AL-6, AL-13, AL-16, AL-17, AL-18 in **Table 1**).

Mining activities may have affected some populations in areas that have been exploited for their rich mineral deposits, for example around Italian Mountain in the Gunnison National Forest (CO-1, CO-2, CO-3, CO-4 in **Table 1**). Plants have also been found in three contiguous sections in the area designated the

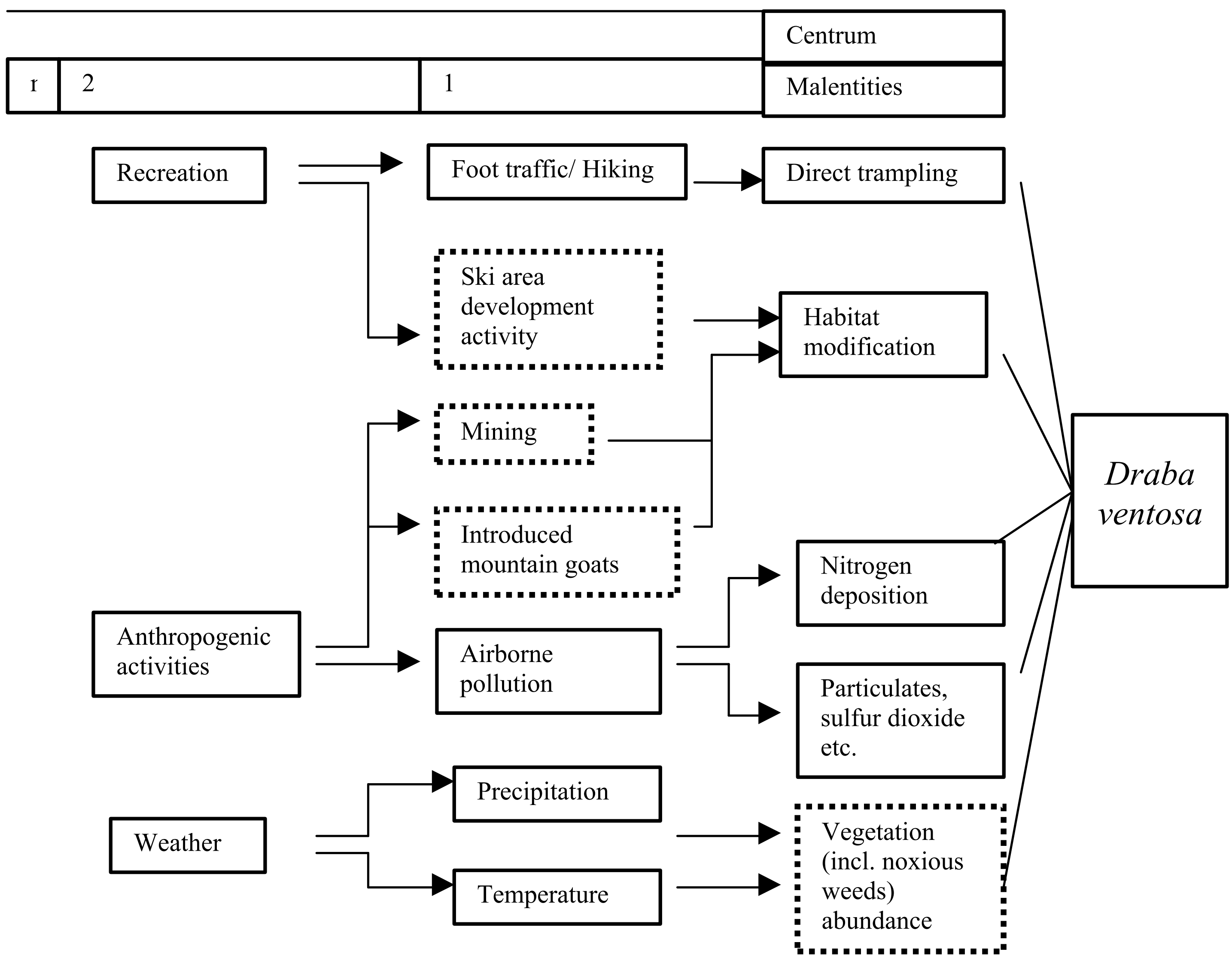


**Figure 6.** Envirogram outlining the malentities to *Draba ventosa*.

Sunlight Mining Region in the Shoshone National Forest (WY-23 in **Table 1**; USDA Forest Service 1989). There are no confirmed instances where mining has directly impacted populations, and it is unknown what the consequence of mining activities has been to the overall abundance of the species.

The effects of historic sheep grazing cannot be estimated, but present-day grazing by domesticated animals is unlikely to be a significant threat on lands managed by the USDA Forest Service because livestock grazing is presently discouraged above the timberline (Goodrich personal communication 2002, Hatcher personal communication 2004). In the Shoshone National Forest, approximately half of the occurrences are in active grazing allotments, but the areas in which *Draba ventosa* occurs are not accessible to livestock (Hicks personal communication 2004). Specifically this applies to occurrences WY-3, WY-5, WY-15, WY-16, WY-20 (**Table 1**), which are within cattle and horse allotments but unlikely to be accessible to the animals. Occurrences WY-17, WY-18, WY-19, WY-21, WY-22 and WY-23 (**Table 1**) are not within active grazing allotments at the present time (Hicks personal communication 2004).

In Utah, introduced mountain goats (*Oreamnos americanus*), have been cited as a possible threat to *Draba globosa* and its habitat (USDA Forest Service 2001). Trampling by the mountain goats, rather than browsing or grazing, is likely to be the main problem. These animals may be of a concern for *D. ventosa* in Region 2. Mountain goats were introduced into Colorado in the 1940s and are still relatively few in number, being estimated to total 1,600 individuals in 2001 (Colorado Division of Wildlife 2001). However, in recent years the number of mountain goats killed by hunters has increased significantly in certain areas (Colorado Division of Wildlife 2001). This fact suggests that mountain goat populations are increasing in size in those particular locations. One of the locations that appears to have high mountain goat populations is the Mount Massive area that also supports a *D. ventosa* population in Region 2 (CO-07 in **Table 1**). Plants in regions with high mountain goat density may be vulnerable to the disturbance mountain goats cause.

Another potential threat, especially in areas within easy reach of urban centers, is the over-collection of desirable rock garden species, such as *Draba*, by amateur and professional gardeners (Williams et al. 1986, USDA Forest Service 2001). *Draba ventosa* is on many web sites that offer seeds and plants for sale worldwide, for example The Alpine Garden Society (2002), NARGS Seed Exchange (2002), Seed Trials (2002), and Lemmens (2002). No details are available on the vulnerability of specific populations.

A significant threat to alpine tundra plants is global climate change. Warming could affect alpine areas, causing tree lines to rise by roughly 350 feet for every degree Fahrenheit of warming. Mountain ecosystems such as those found in the Rocky Mountains could shift upslope, reducing habitat for many subalpine and alpine tundra species (U.S. Environmental Protection Agency 1997). In the last one hundred years, the average temperature in Fort Collins, Colorado, has increased 4.1 °F, and precipitation has decreased by up to 20 percent in many parts of the state (U.S. Environmental Protection Agency 1997). Based on projections made by the Intergovernmental Panel on Climate Change and results from the United Kingdom Hadley Centre's climate model (HadCM2), a model that accounts for both greenhouse gases and aerosols, by 2100 temperatures in Colorado could increase by 3 to 4 °F in spring and fall, with a range of 1 to 8 °F and 5 to 6 °F in summer and winter, with a range of 2 to 12 °F (U.S. Environmental Protection Agency 1997). Similar predictions have been made for regions in Wyoming (U.S. Environmental Protection Agency 1998).

Atmospheric deposition of nitrogen oxides and ammonium is increasing throughout the world. The western United States has been less affected than the eastern, but there are hotspots of elevated wet nitrogen (acid rain) deposition in Southern California and along the Colorado Front Range when compared with the rest of the West (Baron 2001). Wet nitrogen deposition occurring in the high mountain areas of the Colorado Front Range is high enough to cause chemical and ecological change (Baron et al. 2000, Baron 2001, Rueth and Baron 2002). Populations in the Maroon Bells/Snowmass Wilderness, Region 2, may be especially vulnerable to pollutant sources, which include seven coal-fired power generation plants, from the west, southwest, and south (Hudnell et al. 1988-98). In addition, the area has the potential to capture deposition from emissions originating in southern California and Mexico (Hudnell et al. 1988-93). Experiments have indicated that nitrogen additions in alpine tundra influence the species composition of the community (Bowman et al. 1993, Theodose and Bowman 1997). Grasses particularly increase in abundance, at the expense of other species, in dry meadows in response to additional nitrogen. Therefore, an increase in nitrogen deposition could have a detrimental impact on *Draba ventosa*, especially in its dry meadow habitats. Air quality is also a concern in the Wind River Range in Wyoming, where field developments associated with resource extraction are contributing to a high level of air pollution (Ozenberger personal communication 2002). Given the remote locations of most occurrences, other forms of pollution seem an unlikely threat. However, a study sponsored the Colorado School of Mines, the National Park Service, and Public Counsel of the Rockies, analyzed the chemical content of snow near a snowmobile route (Skid Marks Newsletter 2000, Ray 2001). It reported that "an unnatural level of pollution" and at least 20 hydrocarbon compounds, some toxic and carcinogenic, were located 50 feet above the snowmobile route. The significance of this finding to the sustainability of plant populations that are located near such routes cannot be evaluated without further information.

The competitive ability of *Draba ventosa* is likely low considering the habitat to which it is adapted. Although at the present time significant impact from known invasive species appears slight, invasive weeds such as *Linaria vulgaris* (yellow toadflax), *Centaurea biebersteinii* (spotted knapweed), and *Matricaria perforata* (scentless chamomile) have all been reported at or above the treeline in Region 2 and are potential threats to endemic alpine species (Ray 2001). Unfortunately, one important difference between true islands, those surrounded by large expanses of water, and high elevation habitats is that the latter are separated by lands that are inhabited by a multitude of potential competitors that may have many opportunities for colonization (MacArthur and Wilson 1967). In addition to noxious weeds, some persistent species that have been used for revegetation projects may also pose a threat. Global warming is expected to benefit the spread of invasive species from lower to higher elevations. Invasive plant species can be direct competitors for resources, such water, nutrients, and light, and may also secrete alleopathic chemicals into the substrate making it uncolonizable by other species (Sheley and Petroff 1999).

Small populations of plants are often considered genetically depauperate as a result of changes in gene frequencies due to inbreeding or founder effects (Menges 1991) and, although by no means universal, locally endemic species frequently exhibit reduced levels of polymorphism (Karron 1991, Gitzendanner and Soltis 2000). However, these concerns associated with small populations may not be applicable because *Draba ventosa* is likely polyploid and apomictic. In this case, genetic variation may be essentially stored and deleterious recessive genes masked (Grant 1981).

If *Draba ventosa* reproduces solely by agamospermy, hybridization with sympatric species is not an issue. However, considering the lack of specific information on the taxon occurring in Region 2, hybridization with native sympatric species cannot be dismissed (see Reproductive Biology and Autecology section, Brochmann et al. 1992). Similarly, because the extent of the genetic variability between locations is unknown and there is the potential for cross-pollination, transplanting *D. ventosa* from one area into another where there is a pre-existing population may be inadvisable. Introduction of another genotype from a distant location may eventually lead to a reduction in long-term fitness of the existing population.

In summary, the threats to *Draba ventosa*, including those concerned with global climate change, are likely largely dependent upon the extent and intensity of the activity and the rarity of the species. At the present time, all threats appear to be at manageable levels. Threats from mining, recreation activities, and large mammal disturbance at the current levels appear to present no rangewide problems as there are large tracts of land that should be unaffected by current activities. However, the emphasis is on "current levels." Even if the intensity of a threat remains the same, an increase in its area of impact will have negative consequences on the species because alpine tundra systems are relatively fragile and are not able to recover rapidly from destructive forces. After 40 years of disuse, one two-track trail has remained clearly defined and without vegetation in the alpine tundra of the Rocky Mountain National Park (Willard 1979). Impacts from recreational pressures are becoming increasingly apparent. For example, thousands of people are estimated to walk in the alpine tundra regions in Colorado each weekend during the spring, summer, and autumn (Morrow 2002). On one hiking trail alone, 250 people were counted on one weekend day and hiking trails have become 12 to 15 feet wide in some areas caused by people walking at the sides of established trails that become slippery (Morrow 2002). In addition, Morrow (2002) reported some people were averse to following designated trails to the extent that markers were destroyed. The potential colonization by invasive and competitive plant species that will be exacerbated by anthropogenic disturbances and warming temperatures also should not be underestimated.

## *Conservation Status of the Species in Region 2*

Existing management plans have not specifically addressed *Draba ventosa*. There is no evidence to support or to deny that the distribution or abundance of this species is changing within Region 2 or within its total range. It appears rare in all parts of its range. Approximately one third (21 of 61) of occurrences reported over the last century in both Canada and the United States are on land managed by the USDA Forest Service Region 2 (**Table 1**).

Sustainability of *Draba ventosa* may rely on relatively long-lived mature individuals. Thus, management practices that increase either the frequency or intensity of natural perturbations, or provide additional stresses, may significantly negatively impact population viability. At the present time, there appear to be several populations in Region 2 that are secure because of their remote locations or specific designation of land management unit, for example wilderness status. In general, the Wilderness Act that governs management of wilderness areas prohibits commercial activities, motorized access, roads, bicycles, and the development of structures and facilities, although Congress has granted exemptions (Environmental Media Services 2001).

## *Management of the Species in Region 2*

### Implications and potential conservation elements

The alpine tundra ecosystem is fragile, in that it is slow to recover from disturbance such as hiking trails and roads. The growing season is very short, and environmental conditions can be severe. It is likely some practices, such as mining and certain recreational activities, have impacted some individuals of *Draba ventosa* but their effect on population size and structure is unknown. One problem is that there is little information on which to base predictions about *D. ventosa*'s response to specific disturbance types or levels. Consequences of disturbance depend upon the source, frequency, and intensity.

The scree and talus habitat of *Draba ventosa* suggests that it should be able to tolerate, or may even require, a certain level of substrate disturbance. However, the spatial dynamics of a population have not been clarified (see Demography section). In addition, it should be remembered that plants occur in rocky meadows as well as in potentially unstable scree. Also, there is variation in the stability within a particular scree slope that may contribute to the patchy distribution of *D. ventosa* (see Demography section). The scree habitat may be relatively stable and colonized by *D. ventosa* because there is low competition from other species rather than because it has unstable (shifting) edaphic conditions. If the patchy nature of *D. ventosa*'s distribution is influenced by natural disturbance and it only successfully colonizes relatively stable areas, the consequences of hikers who also seek out the more stable parts of a slope may be relatively more significant.

Growth in recreational activities in the backcountry, and thus potentially in *Draba ventosa* habitat, is an important consideration in national forests in Region 2. The number of visitors to national forests and the type and extent of their uses have increased considerably over the last two decades (USDA Forest Service 2004). Within Region 2, mountain biking, snowshoeing, rafting, kayaking, rock climbing, caving, and the use of all-terrain vehicles are among the more recent recreational pursuits. Traditional activities such as hunting, fishing, and four-wheel-drive travel also have increased (USDA Forest Service 2004). In addition, there has been a parallel increase in the use of the backcountry (USDA Forest Service 2002). Some national forests receive significantly more visitors than others. Within Region 2, national forests in Wyoming generally receive fewer visitors than those in Colorado (USDA Forest Service 2004). Based on recreation use reported by all national forests, the White River National Forest in Region 2 ranked fifth in the nation in 1995 (USDA Forest Service 2002). Since 1984, overall recreation use on the White River National Forest has more than doubled. Although the White River National Forest encompasses only about 16 percent of National Forest System lands in Colorado, it hosts about 30 percent of the recreation on these lands (USDA Forest Service 2002). On the San Isabel National Forest, a popular hiking route goes through a population of *Draba ventosa* in the Mount Massive Wilderness Area. Currently, a designated trail is being established on Mount Massive in order to minimize hiker impacts on the plants (Madsen personal communication 2002).

The potential for the commercial collection of some taxa, including *Draba ventosa* (see Threats section), suggests that permitting may be valuable to track the impact on accessible populations. Such collection regulations and potential monitoring devices are important considerations when planning management guidelines for specific taxa.

*Draba ventosa* is likely apomictic, but its genetic vulnerability is unclear (see sections on Demography and Reproductive biology and autecology sections). It is likely that the most geographically separated populations will have the greatest genetic divergence, and a significant loss of genetic diversity will likely result if populations at the edge of the range, or in obviously disjunct localities, are lost. The apparent commercial availability of *D. ventosa* raises an important issue for restoration. Introduction of *D. ventosa* into an area with existing populations is probably inadvisable. Although genetic dilution is unlikely because it is understood to be primarily apomictic, until it is determined that sexual strains do not exist genetic dilution must remain a concern (see Classification and description - systematics and synonymy section).

### Tools and practices

Documented inventory and monitoring activities are needed for this species. Most occurrence information is derived from herbarium specimens or relatively casual observations by botanists and does not provide quantitative information on abundance or spatial extent of populations. In addition, there is little information on population structure and persistence of either individuals or populations.

#### *Species inventory*

Relatively little information has been collected on *Draba ventosa*. An important consideration in inventorying this particular species is that it may be easily confused with other species. It is also important to remember during field identification that *D. ventosa* grows in close association with other species of *Draba*. For example, it has been described growing in a mat with *D. incerta* and was found near *D. exinguiculata* and *D. oligosperma*. The current "Field survey form for endangered, threatened or sensitive plant species" used by the Gunnison National Forest and the Colorado Natural Heritage Program requests the collection of data that are appropriate for inventory purposes. The number of individuals, the area they occupy, and the apparent potential habitat are important facts for occurrence comparison. The easiest way to describe populations over a large area may be to count patches, making note of their extent, and to estimate or count the numbers of individuals within patches. Information collected on dates of flowering and reproductive stage is also valuable in assessing the fecundity and potential sustainability of a population. Observations on habitat should also be recorded.

#### *Habitat inventory*

The available information on habitat supplied with descriptions of occurrences is generally too diverse and in insufficient detail to make accurate analyses. These habitat descriptions suggest that, within the restrictions of geology and the eco-climate zones in which it exists, *Draba ventosa* grows in a variety of rocky habitats. It would likely be prudent to consider essentially any rocky, particularly scree and talus, areas of calcareous- or sandstone-derived soils in alpine tundra and subalpine regions above 2,800 m as potential habitat. However, there is an insufficient understanding of all the features that constitute "potential" habitat to be able to make a rigorous inventory of areas that will actually be colonized. There are no studies that relate the abundance or vigor of populations to habitat conditions or even elevation. The patchy and sparse distribution pattern of *D. ventosa* suggests that certain microclimate conditions need to be met to support plants. However, these conditions are currently unknown.

#### *Population monitoring*

No monitoring or demographic studies have been reported. Lesica (1987) has discussed a technique for monitoring non-rhizomatous, perennial plant species using permanent belt transects. He also described life stage or size classes and reproductive classes that would be appropriate to consider for *Draba ventosa* (Lesica 1987). Moseley and Mancuso (1991, 1992, 1993) successfully employed such methods when studying the population structure over time of *D. trichocarpa*. Mapping individuals within an occurrence and monitoring tagged individuals over time is a good way to understand the demographics and life history of a taxon. The diameter and number of leaves in the basal rosette are useful measurements in such detailed studies.

Problems associated with spatial auto-correlation can occur when using permanent plots to monitor a dynamic population. If the size of the plot is too small or the establishment of new plots is not part of the original scheme, when plants die and no replacement occurs it is impossible to know the significance of the change without studying a very large number of similar plots. Permanent transects may be the most accurate way to study long-term trends. Elzinga et al. (1998) and Goldsmith (1991) have discussed using a rectangular quadrant frame along transect lines to monitor effectively the "clumped-gradient nature" of populations, and this might be applicable to the most abundant populations, such as the population on Mount Massive.

Photopoints and photoplots are very useful in visualizing changes over time, especially in places such as steep talus slopes that are relatively inaccessible and/or can easily be disturbed by monitoring activities. It is very important not to contribute to disturbance when monitoring occurrences. Even though digital copies are convenient and easy to store, many museums and researchers suggest storing additional slides or even hardcopies, as in 50 years time the technology to read memory sticks and CDs may no longer be available.

Yearly monitoring is very useful if population size and/or vigor exhibits a high degree of year-to-year variation. This is particularly the case for many annual species or herbaceous perennial species that possess underground organs that undergo prolonged dormancy. For species that exhibit more stable aboveground populations, monitoring may occur at longer intervals. The appropriate interval will be most successfully determined after a period of yearly monitoring. It is very important to clearly define the goals of any monitoring plan and to identify the methods of data analyses before the beginning of the project. The time commitment per year will depend on the protocols adopted, the skill of the surveyor, and the distance between monitoring plots.

*Habitat monitoring*

The relative lack of information on habitat requirements makes it premature to consider that habitat monitoring in the absence of plants can effectively occur. Habitat monitoring in the presence of plant occurrences should be associated with population monitoring protocols. Descriptions of habitat should always be recorded during population monitoring activities in order to link environmental conditions with abundance over the long term. Recording observations on the size and shape of the gravels comprising the scree and talus may be particularly important as this aspect may help to explain the patchy distribution of this species. Conditions several years prior to the onset of a decrease or increase in population size may be more important than conditions existing during the year that the change is observed. Current land use designation and evidence of land use activities are important to include with monitoring data. For example, where possible, it should be noted if populations are in an active grazing allotment and if so whether the habitat and/or the plants appear to be disturbed by livestock. Observations on herbivory and its likely cause, for example insect, rodent or mammal, should also be made.

Population or habitat management approaches

There have been no systematic monitoring programs for the populations in protected areas, and therefore, the benefits of protection cannot be evaluated. Beneficial management practices that have been generally implemented within national forests include restricting recreational vehicle traffic and routing hikers to designated trails. In many cases such policies have been only recently initiated and their consequences have not been documented. Creating designated trails is particularly important to some known populations that are on heavily used routes. For example, a popular hiking route goes through a population in the Mount Massive Wilderness in the San Isabel National Forest. Currently, a designated trail is being established on Mount Massive that may reduce impacts on the plants (Madsen personal communication 2002). It would be very useful to obtain baseline information on the distribution and abundance of that population and then to monitor it in yearly, or at least 3-year intervals (see Population monitoring section). Establishing a map of the individuals within a defined area is important in order to assess long-term trends. As well as providing information on how trail management impacts the species, such monitoring would aid in understanding the spatial dynamics of individuals and populations.

## *Information Needs*

Molecular studies are required in order to determine definitively the relationship between the *Draba ventosa* of Canada and that of the middle Rocky Mountains. It would be very useful if this study included material from the Ruby Mountains in Nevada. At the present time, *D. ventosa* seems to be a naturally uncommon species although one cannot say with certainty that it has not experienced a decline in the last century. Other than clarification as to whether two unique taxa are presently identified as *D. ventosa*, the most pressing need rangewide is for more information on the numbers and distribution of this species. The present knowledge of its distribution indicates some widely disjunct occurrences; for example, occurrences in central Colorado are several hundred miles away from the next nearest mountain range locale. Its perceived rarity may be due to a lack of surveys. It may be that this species has often been overlooked or misidentified in the field and is more common than believed. However, if *D. ventosa* is restricted to the middle Rockies and the Ruby Mountains in Nevada, both it and the presumptive Canadian taxa are more rare than currently perceived. Monitoring pre-existing sites is essential in order to understand the implications of existing and new management practices. Where management practices are likely to change, inventory should be taken to collect baseline data and periodic monitoring should be conducted after the new policy is initiated. Therefore, inventory and periodic monitoring of existing sites appear to be the most important needs.

Habitat requirements need to be more rigorously defined. *Draba ventosa*'s ability to tolerate competition is speculated to be very low, and it appears to be good management practice to eliminate non-native invasive species swiftly. However, it is unclear what constitutes optimal, adequate, and marginal (implying unsustainable) habitat. The spatial dynamics of populations are unknown. It is known that *D. ventosa* colonizes unstable habitats, namely scree and talus, but the rate at which it does so is not known. The rate of colonization and the quality of habitat would influence how populations recover after significant disturbance, for example, due to hiking or activities related to mining. In addition, different parts of scree and talus slopes have varying degrees of instability (see Demography section).

The current understanding of *Draba ventosa*'s reproductive biology is based upon Canadian specimens that may be genetically different from plants in Region 2. Current evidence indicates that *D. ventosa* is apomictic. However, if it reproduces by facultative agamospermy, pollinators assume importance. Management practices may need to be modified if specific pollinators are found to be essential for cross-pollination. The relative importance of different stages of the life cycle is largely inferred by comparison to other *Draba* species rather than through direct studies on *D. ventosa*. The factors that limit population size and abundance and that contribute to the variable occurrence sizes are not known and should be determined.

Primary information needs can be summarized as follows:

- ❖ Clarification is needed regarding whether there are two, or more, unique taxa that are presently identified as *Draba ventosa*.
- ❖ Inventory and periodic monitoring of existing sites would lead to a better understanding of the rarity and sustainability of the taxon.
- ❖ A critical examination of *Draba ventosa*'s habitat requirements might explain the rarity of the taxon and lead to biologically and ecologically rational management plans.
- ❖ Information on reproductive biology would increase awareness of potential genetic and reproductive vulnerabilities.

# DEFINITIONS

**Agamospermy.** Occurs when a diploid embryo sac (sporophyte) develops by somatic division of a nucellus or integument cell, no meiosis takes place so the diploid sporophyte gives rise directly to a diploid gametophyte (Allaby 1992)

**Allopolyploid.** "A polyploid formed from the union of genetically distinct chromosome sets, usually from different species" (Allaby 1992).

**Apomixis.** This term refers to a type of asexual reproduction in plants, that is reproduction without fertilization or meiosis (Allaby 1992).

**Edaphic.** "Of the soil or influenced by the soil" (Allaby 1992).

**Endemic.** The situation when a species is restricted to one particular geographical area or restricted to a specific environmental condition, for example a particular geological formation.

**Facultative.** "Applied to organisms that are able to adopt an alternative mode of living" (Allaby 1992).

**Hemicryptophyte.** A life from category that described a plant whose perennating buds are at ground level, the aerial parts dying down at the onset of unfavorable conditions (Raunkiaer 1934)

**Herbarium abbreviations:**

COLO = Herbarium, University of Colorado, Boulder, Colorado
CS = Herbarium, Biology Department, Colorado State University, Fort Collins, Colorado
MONTU = Herbarium, University of Montana, Missoula, Montana
NM = Herbarium, Biology Department, Northern Michigan University, Marquette, Michigan
RM= Rocky Mountain Herbarium, University of Wyoming, Laramie, Wyoming
UT = Garrett Herbarium, University of Utah, Salt Lake City, Utah
UTC = Intermountain Herbarium, Utah State University, Logan
WTU = Herbarium, University of Washington, Seattle, Washington

**Polyploidy.** "The condition in which an individual possesses 1 or more sets of homologous chromosomes in excess of the normal 2 sets found in a diploid organism" (Allaby 1992).

**Ranks.** NatureServe and the Heritage Programs Ranking system. G3 indicates *Draba ventosa* is "vulnerable globally either because it is very rare and local throughout its range, found only in a restricted range (even if abundant at some locations), or because of other factors making it vulnerable to extinction or elimination". S1 designation indicates that the species is "critically imperiled because of extreme rarity or because of some factor(s) making it especially vulnerable to extirpation from the subnation [state]". For an S1 designation there are typically 5 or fewer extant occurrences or less than 1,000 remaining individuals. S2 designation indicates it is "imperiled in the subnation [state] because of rarity or because of some factor(s) making it very vulnerable to extirpation from the subnation". S3 denotes it is "Vulnerable—Vulnerable in the subnation, either because it is rare and uncommon, or found only in a restricted range (even if abundant at some locations), or because of other factors making it vulnerable to extirpation. Typically 21 to 100 occurrences or between 3,000 and 10,000 individuals". (Internet site: http://www.natureserve.org/explorer/granks.htm).

**Scree.** Scree is comprised of rocks the size of a fist or smaller, down to gravel size, and also offers little in the way of secure footing, especially when the gravels are ankle deep (Zwinger and Willard 1996). "A term commonly used in Great Britain as a loose equivalent of talus; it may also include any loose fragmental material lying on or mantling a slope." (Bates and Jackson 1984)

**Silicle.** The short fruits, usually not more than twice as long as wide, of the Cruciferae (mustard) family.

**Stochastic.** Uncertainty. "Of, pertaining to, or arising from chance" (Guralnik 1982)

**Sympatric.** "The occurrence of species together in the same area" (Allaby 1992).

**Talus.** "Talus slopes are composed of rocks the size of a fist or larger, usually sharp and loose" (Zwinger and Willard 1972). "Rock fragments, usually coarse and angular, lying at the base of a cliff or steep slope from which they have been derived; also, the heap or mass of such broken rock, considered as a unit. Synonym: scree" (Bates and Jackson 1984).

# References


Allaby, M. 1992 . The concise Oxford dictionary of Botany, Oxford University Press, New York, NY.

Alberta Natural Heritage Information Centre. 2002. Element occurrence records received from John Rintoul, Alberta Natural Heritage Information Center, Canada.

The Alpine Garden Society. 2002. *Draba ventosa* seed source. Internet web site: http://www.alpinegardensociety.org/seeds/list.htm [Accessed October 2002]

Andrewartha, H.G. and L.C. Birch. 1984. The ecological web: more on the distribution and abundance of animals. University of Chicago Press, Chicago, IL.

Baron, J.S. 2001. Acid Rain in the Western United States. Statement of Jill S. Baron, ecologist U.S. Geological Survey. Before the House Committee on Science. United States House of Representatives. May 3, 2001. http://www.greennature.com/article.php?sid=869 [Accessed April 2002].

Baron, J.S., H.M Rueth, A.M. Wolfe, K.R. Nydick, E.J. Allstott, J.T. Minear, and B. Moraska. 2000. Ecosystem responses to nitrogen deposition in the Colorado Front Range. Ecosystems 3:352-368.

Bates, R.L. and J.A. Jackson. 1984. Dictionary of geological terms. Third Edition. Doubleday, New York, NY.

Beckett, K. 1993. Encyclopedia of alpines. Volume 1 (A-K). Alpine Garden Society Publications Ltd., Worcestershire, England, UK.

Bennett, Bruce. 2002. Personal communication. NatureServe, Yukon Environment V5A, Whitehorse, Yukon, Canada.

Biota of North America Program. 1998. Internet site: http://www.csdl.tamu.edu/FLORA/b98/check98.htm [Accessed December, 2002].

Borror, D.J. and R.E. White. 1970. A field guide to insects-America north of Mexico. Houghton Mifflin Company, New York, NY.

Bowman, W.D., T.A. Theodose, J.C. Schardt, and R.T. Conant. 1993. Constraints of nutrient availability on primary production in alpine communities. Ecology 74:2085-2098.

Brochmann, C.1993. Reproductive strategies of diploid and polyploid populations of arctic *Draba* (Brassicaceae). Plant Systematics and Evolution 185(1-2):55-83

Brochmann, C., B. Stedje, and L. Borgen. 1992. Gene flow across ploidal levels in *Draba* (Brassicaceae). Evolutionary Trends in Plants 6(2):125-134.

Caplow, Florence. 2002. Personal communication. Washington Natural Heritage Program, Olympia, WA.

Charlet, D. 1994. Plant Species in the Ruby Mountains, Nevada. Last modified: 1 November 2001. Internet site: http://www.brrc.unr.edu/data/plant/ruby.htm [Accessed January 2003]

Cody, W.J. 1996. Flora of the Yukon Territory. NRC CNRC. NRC Research Press, Ottawa, Canada.

Colorado Division of Wildlife. 2001. Successful goat, sheep, and moose management. Wildlife Report. Release Date: 04/17/2001. Colorado Division of Wildlife, Denver, CO.

Colorado Natural Areas Program. Undated. Elk Range carbonate tundra sites. Unpublished report. Colorado Natural Areas Program, Denver, CO.

Colorado Natural Heritage Program. 2002. Element occurrence records received from Colorado Natural Heritage Program, Fort Collins, CO.

Colorado Natural Heritage Program On-line Rare Plant Guide, Fort Collins, Colorado. Internet site: http://www.cnhp.colostate.edu/rareplants/intro.html [Accessed January, 2002].

Coupé , Ray. 2002. Personal Communication. Williams Lake Herbarium. Ministry of Forests, Cariboo Forest, Williams Lake, British Columbia, Canada.

Davinroy, T.C. 1993. A Twenty-Five Year Study of Talus Movement, Colorado Front Range. Proceedings - Niwot Ridge (Colorado) Long-Term Ecological Research Workshop, 21 August 1993. Niwot Ridge Long-Term Ecological Research Station, CO.

Dorn, R.D. 1984. Vascular plants of Montana. Mountain West Publishing, Cheyenne, WY.

Dorn, R.D. 2001. Vascular plants of Wyoming. Third Edition. Mountain West Publishing, Cheyenne, WY.

Douglas, G.W., D. Meidinger, and J. Penny. 2002. Rare native vascular plants of British Columbia. 358p. Second Edition. Province of British Columbia, Victoria, British Columbia, Canada.

Elzinga, C.L., D.W. Salzer, and J.W. Willoughby. 1998. Measuring and monitoring plant populations. Bureau of Land Management Technical Reference 1730-1. U.S. Department of Interior, Bureau of Land Management, Denver, CO.

Environmental Media Services. 2001. Definitions for Public Land Designations, Last update: April 27, 2001. Internet site: www.ems.org [Accessed December 2003]

Fertig, W. 1992. A floristic survey of the west slope of the Wind River Range, Wyoming. M.S. Thesis. University of Wyoming, Laramie, WY.

Gitzendanner, M.A. and P.S. Soltis. 2000. Patterns of genetic variation in rare and widespread plant congeners. American Journal of Botany 87(6):783-792

Goldsmith, F.B. 1991. Monitoring for conservation and ecology. Chapman and Hall, New York, NY.

Goodrich, Sherel. 2002. Telephone communication. USDA Forest Service, Ashley National Forest, Utah.

Grant, V. 1981. Plant speciation. Second Edition. Columbia University Press, NY.

Grime, J.P., J.G. Hodgson, and R. Hunt. 1988. Comparative plant ecology – a functional approach to common British species. Allen and Unwin, Inc., Winchester, MA.

Guralnik, D.B., editor. 1982. Webster's New World Dictionary of the American Language. Simon and Schuster, New York, NY.

Hartman. R. 1995. General floristic/sensitive plant species survey of the Gros Ventre Range, Wyoming. Unpublished document. USDA Forest Service, Bridger-Teton National Forest, Jackson Hole, WY.

Hatcher, Mark. 2004. Personal communication. Rangeland Management Specialist, Region 2, Grand Mesa, Uncompahgre & Gunnison National Forests, Delta, CO.

Hicks, Joe. Rangeland Management Specialist, Shoshone National Forest, USDA Forest Service Region 2, Cody, Wyoming. Personal communication February, 2004

Hitchcock, C.L. 1941. A revision of the Drabas of Western North America. University of Washington Publications in Biology 11:1-132.

Hitchcock, C.L. and A. Cronquist. 2001. Flora of the Pacific Northwest. 1st printing 1973. University of Washington Press, Seattle, WA.

Hitchcock, C.L., A. Cronquist, M. Ownbey, and J.W. Thompson. 1964. Vascular Plants of the Pacific Northwest. Part 2: Salicaceae to Saxifragaceae. University of Washington Press, Seattle, WA.

Hudnell, L., M. Lindsey, T. Franklin Blett, and J. McCarthy .1988-93. Air Resource Management Plan White River National Forest. Updated and Revised By: A. Holland-Sears.1998. USDA Forest Service, Rocky Mountain Region unpublished technical report. White River National Forest, Glenwood Springs, CO.

Johnston, Barry. 2002. Personal communication. USDA Forest Service, Gunnison National Forest, CO.

Johnston, B. and L. Huckaby. 2001. Ecological types of the Upper Gunnison Basin. Technical Report R2-RR-2001-01. USDA Forest Service, Rocky Mountain Region, Denver, CO.

Karron J.D. 1991. Patterns of genetic variation and breeding systems in rare plant species. *In*: Genetics and conservation of rare plants. D.A. Falk and K.E. Holsinger (eds). p. 87-98. Oxford University Press, New York, NY.

Kearns, C.A. and D.W. Inouye. 1994. Fly pollination of *Linum lewisii* (Linaceae) American Journal of Botany 81: 1091-1095

Keiding, N. 1975. Extinction and exponential growth in random environments. Theoretical Population Biology 8: 49-63.

Landes, R.1988. Genetics and demography in biological conservation. Science 241:1455-1460.

Langenheim, J.H. 1962. Vegetation and environmental patterns in the Crested Butte area. Ecological Monographs. 32(3):249-285

Lemmens, J. 2002. *Draba ventosa* seed source. Internet web site: http://users.skynet.be/jozef.lemmens/plant.htm [Accessed October 2002].

Lesica, P. 1987. A technique for monitoring non-rhizomatous, perennial plant species in permanent belt transects. Natural Areas Journal 7(2):65-68

Lipkin, Rob. 2002. Personal communication. Alaska Natural Heritage Program, Fairbanks, AK.

Madsen, Benjamin. 2002. Personal communication. USDA Forest Service, Pike-San Isabel National Forest, Salida, CO.

MacArthur, R.H. and E.D. Wilson. 1967. The theory of island biogeography. Princeton University Press, Princeton, NJ.

Markow, S. 1996. A sensitive species and general floristics survey of the Bridger Ridge ski area development area. Unpublished document. US Forest Service, Bridger-Teton National Forest, Jackson, WY.

McGraw, J.B. and M.C. Vavrek. Buried viable seeds in Arctic and alpine communities. 1989. *In*: Ecology of soil seed banks. M.A. Leck V.T. Parker and R.L. Simpson (eds). P 96. Academic Press Inc, San Diego, CA.

Menges, E.S. 1991. The application of minimum viable population theory to plants. Pages 45-61 *in*: D.A. Falk and K.E. Holsinger, editors. Genetics and conservation of rare plants. Oxford University Press, New York, NY.

Mills S. and W. Fertig. 1996. Field guide to rare and sensitive plants of the Shoshone National Forest. Limited publication. Prepared for the USDA Forest Service, Shoshone National Forest. Wyoming Natural Diversity Database, The Nature Conservancy, Laramie, WY.

Moseley, R.K. and M. Mancuso. 1991. Long-term demographic monitoring of two Stanley Basin endemics, *Draba trichocarpa* and *Eriogonum meledonum*. I. First-year results. Natural Heritage Section, Nongame/Endangered Wildlife Program, Idaho Department of Fish and Game, Boise, ID.

Moseley, R.K. and M. Mancuso. 1992. Long-term demographic monitoring of two Stanley Basin endemics, *Draba trichocarpa* and *Eriogonum meledonum*. II. Second-year results. Conservation Data Center, Nongame/Endangered wildlife program. Idaho Department for Fish and Game, Boise, ID.

Moseley, R.K. and M. Mancuso. 1993. Demographic monitoring of two Stanley Basin endemics, *Draba trichocarpa* and *Eriogonum meledonum*. III. Third-year results. Conservation Data Center, Nongame/Endangered wildlife program. Idaho Department for Fish and Game, Boise, ID.

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.

Montana Natural Heritage Program. 2001. Element occurrence records received from Whitney L. Weber, GIS/Database Coordinator, Montana Natural Heritage Program, MT.

Montana Natural Heritage Program. 2002. Montana Rare Plant Guide. 1997-2003. Montana Natural Heritage Program, Helena, Montana. Internet site: http://nhp.nris.state.mt.us/ [Accessed December 2002].

Morefield, James. D. 2002. Personal communication. Nevada Natural Heritage Program, State of Nevada, Dept. of Conservation and Natural Resources, Carson City, NV.

Morrow, Bruce. Education and Outreach Manager, "Colorado Fourteeners Initiative". Radio broadcast, "Colorado Matters", Colorado Public Radio. April 17, 2002

NARGS Seed Exchange. 2002. *Draba ventosa* seed source. Internet web site: http://www.nargs.org/seed/pageg10.html [Accessed October 2002]

NatureServe. 2003. NatureServe Explorer: An online encyclopedia of life [web application]. Version 1.8. NatureServe, Arlington, Virginia. Available http://www.natureserve.org/explorer. [Accessed: January 20, 2004].

New York Botanical Garden. Herbarium records. Internet site: http://scisun.nybg.org:8890/ [Accessed May 2002].

Ogilvie, R.T. 1998. Vascular Plants. *In* I.M. Smith and G.G.E. Scudder, editors. Assessment of species diversity in the Montane Cordillera Ecozone. Burlington: Ecological Monitoring and Assessment Network, Canada. Internet site: http://www.naturewatch.ca/eman/reports/publications/99_montane/mites/intro.html [Accessed November 2002].

Ozenberger, J. 2002. Personal communication. USDA Forest Service, Bridger-Teton National Forest, Jackson, WY.

Parker, Carolyn. 2002. Personal communication. Museum Herbarium, University of Alaska, Fairbanks, AK

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

Pollard, J.H. 1966. On the use of the direct matrix product in analyzing certain stochastic population models. Biometrika 53:397-415.

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

Raunkiaer, C. 1934. The life forms of plants and statistical plant geography. 632 p. Clarendon Press, Oxford, England, UK.

Ray, J. 2001. Leadville Milkvetch (*Astragalus molybdenus* Barneby). Unpublished report from the Center for Native Ecosystems for the Colorado Natural Heritage Program, Fort Collins, CO.

Rocky Mountain Herbarium. 2002. Herbarium records from the Rocky Mountain Herbarium. Laramie, WY.

Rollins, R.C. 1993. The Cruciferae of continental North America, systematics of the mustard family from Arctic to Panama. Stanford University Press, Stanford, CA.

Rueth, H.M. and J.S. Baron. 2002. Differences in Englemann spruce forest biogeochemistry east and west of the Continental Divide in Colorado, USA. Ecosystems 5:45-57.

Schulz, O.E. 1927. Cruciferae-Draba et Erophila. Das Pflanzenreich. 105:123

Scott, R.W. 1995. The alpine flora of the Rocky Mountains. Vol. 1. The Middle Rockies. University of Utah Press, Salt Lake City, UT.

Seed Trials. 2002. *Draba ventosa* seed source. Internet web site: http://users.anet.com/~manytimes/ zeno_def.htm [Accessed October 2002]

Shaw, D.C. and R.J. Taylor. 1986. Pollination ecology of an alpine fell-field community in the North Cascades. Northwest Science 60:21-31

Sheley, R.L. and J.K. Petroff. 1999. Biology and management of noxious rangeland weeds. Oregon State University Press, Corvallis, OR.

Silvertown, J.W. 1987. Introduction to plant population ecology. Second Edition. Longman Scientific and Technical, Harlow, England, UK.

Silvertown, J., M. Franco, I. Piasanty, and A. Mendoza. 1993. Comparative plant demography – relative importance of life cycle components to the finite rate of increase in woody and herbaceous perennials. Journal of Ecology 81:465-476.

Skid Marks Newsletter. 2000. Study finds snowmobile pollution in snow. Issue 26 October 27.

Stone, R.D. 1995. Status Review of *Draba globosa* Payson (Brassicaceae) [= *D. densifolia* var. *apiculata* (C.L. Hitchcock) Welsh] and related species [*D. densifolia* Nutt. Ex Torrey & Gray, *D. davisiae* (C.L. Hitchcock) Rollins]. Final report. Unpublished report. Utah Department of Natural Resources and USDA Forest Service, Intermountain Region, Salt Lake City, UT.

Theodose, T.A. and W.D. Bowman. 1997. Nutrient availability, plant abundance, and species diversity in two alpine tundra communities. Ecology 78(6):1861-1872.

USDA Forest Service 1989. Shoshone National Forest – North half. Map – Reviewed by USDA Forest Service, Denver, Colorado. Available for purchase at appropriate Federal Agency Offices.

USDA Forest Service. 1993. Region 2 Regional Forester Sensitive Species List. Internet site: http://roadless.fs.fed.us/documents/feis/data/sheets/summspd/tes_supp/r2_ssspecies.pdf [Accessed March 2002].

USDA Forest Service, 1999a. Intermountain Region 4 Regional Forester Sensitive Species List Review. Draft copy, USDA Forest Service, Ogden, UT.

USDA Forest Service. 1999b. TES Plant Management Strategy, Grand Mesa, Uncompahgre and Gunnison, San Juan, Rio Grande, Pike-San Isabel National Forests and Comanche-Cimarron National Grasslands. Five year action plan 1999 to 2003. USDA Forest Service, Denver, CO.

USDA Forest Service. 2001. Wasatch-Cache National Forest - Draft Environmental Impact Statement May 2001. Unpublished document. Wasatch-Cache National Forest, UT.

USDA Forest Service. 2002. Final Environmental Impact statement Volume 1 for the White River Forest. Land and Resource Management Plan 2002 Revision. USDA Forest Service, White River National Forest, Glenwood Springs, CO.

USDA Forest Service. 2003. Forest Service Manual Chapter 2670 – Threatened, endangered and sensitive plants and animals. Supplement No.: 2600-2003-1. USDA Forest Service Rocky Mountain region (Region 2), Denver, CO.

USDA Forest Service. 2004. Recreational Activities, Recreation, Heritage & Wilderness Programs, National Visitor Use Monitoring Program. Internet site: http://www.fs.fed.us/recreation/programs/nvum Last Modified: Tuesday, Jan 20, 2004 [Accessed February 4, 2003]

U.S. Environmental Protection Agency. 1997. Climate Change and Colorado. EPA 230-F-97-008f. Office of Policy, Planning and Evaluation, Climate and Policy Assessment Division, Washington D.C.

U.S. Environmental Protection Agency. 1998. Climate Change and Wyoming. EPA 236-F-98-007n. Office of Policy, Planning and Evaluation, Climate and Policy Assessment Division, Washington D.C.

Utah Natural Heritage Program. 2002. Element occurrence records received from Utah Natural Heritage Program, Salt Lake City, UT.

Utah State University Intermountain Herbarium. 2002. Records received from Alison Kelly

Collections Manager, Intermountain Herbarium, Utah State University, Logan, UT.

Weber, W.A. and R.C. Wittmann, 2001. Colorado Flora, western slope. Third Edition. University Press of Colorado, Boulder, CO.

Welsh, S. L., N.D. Atwood, S. Goodrich, L.C. Higgins. 1993. A Utah Flora. Second Edition-revised. Brigham Young University, Provo, UT.

Whipple, Jennifer. 2002. Personal communication. National Park Service, Yellowstone National Park, Wyoming.

Willard, B.E. 1979. Plant sociology of alpine tundra, Trail Ridge, Rocky Mountain National Park, Colorado. Colorado School of Mines quarterly: Vol. 4, no. 4.

Williams, J., R. Radebaugh, D. Hall, G. Keladis, P. Keladis, P. A. Pachuta. 1986. Rocky Mountain Alpines. Timber Press, Portland, OR.

Windham, Michael. 2002. Personal communication. Intermountain Herbarium, Utah State University, Logan, UT.

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

Wyoming Natural Diversity Database. 2002. Element occurrence records received from Bonnie Heidel, Wyoming Natural Diversity Database, Laramie, WY.

Wyoming Natural Diversity Database, Laramie, Wyoming. Internet site: http://uwadmnweb.uwyo.edu/wyndd/ [Accessed January 2004].

Zwinger, A.H. and B.E. Willard. 1972. Land above the trees, a guide to American alpine tundra. Reprinted 1996. Harper and Row Publishers Inc., New York, NY.