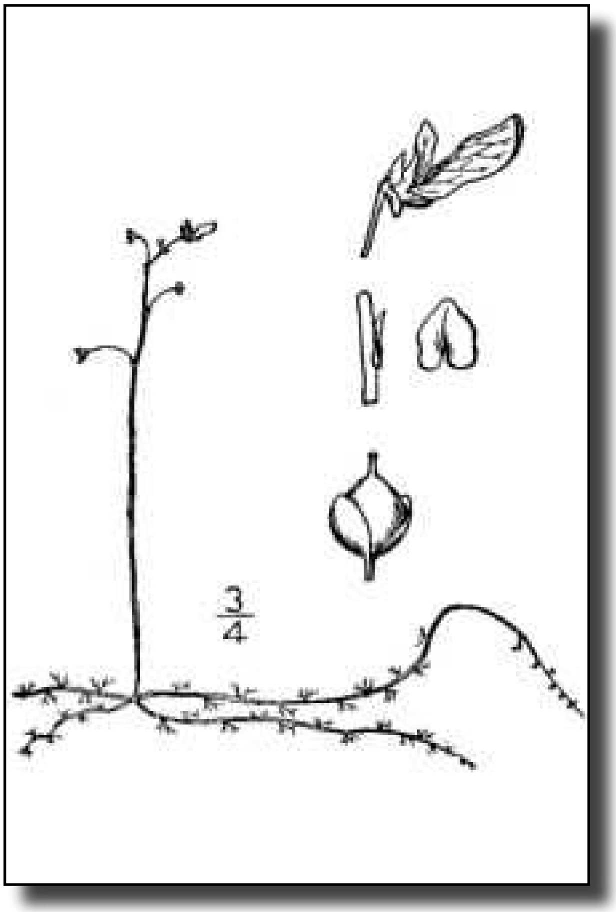
Utricularia minor L. (lesser bladderwort)
A Technical Conservation Assessment



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COVER PHOTO CREDIT

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SUMMARY OF KEY COMPONENTS FOR CONSERVATION OF *UTRICULARIA MINOR*

Status

Utricularia minor is a geographically widespread, aquatic plant species that is rare throughout much of its range. Known populations in the Rocky Mountain Region (Region 2) of the USDA Forest Service (USFS) occur primarily in fens, which are highly specialized peatland habitats that are very restricted in distribution and abundance. This species also occurs in freshwater marsh habitat. Of 28 known occurrences in Region 2, 11 are on National Forest System lands. Of these 11 occurrences, six are in Colorado (one on the Grand Mesa National Forest, one on the Roosevelt National Forest, two on the Routt National Forest, two on the San Juan National Forest), one is in Nebraska (Samuel R. McKelvie National Forest), and four are in Wyoming (two on the Medicine Bow National Forest, one on the Bighorn National Forest, one on the Shoshone National Forest where it is within the Swamp Lake Special Botanical Interest Area). The global conservation status rank of *U. minor* is G5 (secure – common, widespread, and abundant), but it is considered state imperiled (S2) in Colorado, Nebraska, and Wyoming. It is unranked in South Dakota and not known to currently or historically occur in Kansas. *Utricularia minor* is not listed as a threatened or endangered species on the federal endangered species list.

Primary Threats

Direct threats to *Utricularia minor* are hydrologic impacts, especially degradation of water quality and hydrologic alteration, habitat loss, and invasive species. Indirect threats include land use practices that impact water quality and habitat integrity. *Utricularia minor* is sensitive to habitat perturbations, both on local and landscape scales. Further, its primary habitat, peatlands, is sensitive to environmental change, restricted in distribution and abundance, and essentially beyond restoration in the face of certain types of habitat degradation. Every effort should be made to prevent the degradation of the quality and quantity of water reaching habitat of *U. minor*.

Primary Conservation Elements, Management Implications and Considerations

Much of the basic biology and ecology of *Utricularia minor* is unstudied and unknown. However, it is known that this species is very sensitive to changes in water quality. Therefore, to contribute to the persistence of *U. minor*, management activities should make every effort to maintain water quality. This includes establishing management buffers around known locations of *U. minor* and regulating and monitoring hydrological modifications, domestic grazing, and motor vehicle use in the watershed of *U. minor* occurrences. Current understanding of its sensitivity to local environmental change suggests that it should remain a species of concern and that land management personnel should focus on expanding our knowledge of its biology and its habitat.

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INTRODUCTION

This species assessment for *Utricularia minor* is one of many being produced for the Species Conservation Project of the Rocky Mountain Region (Region 2) of the USDA Forest Service (USFS). *Utricularia minor* is the focus of an assessment because it is listed as a sensitive species in Region 2. Within the National Forest System, a sensitive species is a plant or animal whose population viability is identified as a concern by a Regional Forester because of significant current or predicted downward trends in abundance and/or significant current or predicted downward trends in habitat capability that would reduce its distribution (U.S. Forest Service Manual (FSM) 2003; 2670.5(19)). A sensitive species requires special management considerations, so knowledge of its biology and ecology is critical.

This assessment addresses the biology of *Utricularia minor* throughout its range in Region 2 (**Figure 1**). The broad nature of the assessment leads to some constraints on the specificity of information for particular locales. This introduction defines the goal of species assessments, outlines their scope, and describes the process used in their production.

Goal of Assessment

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

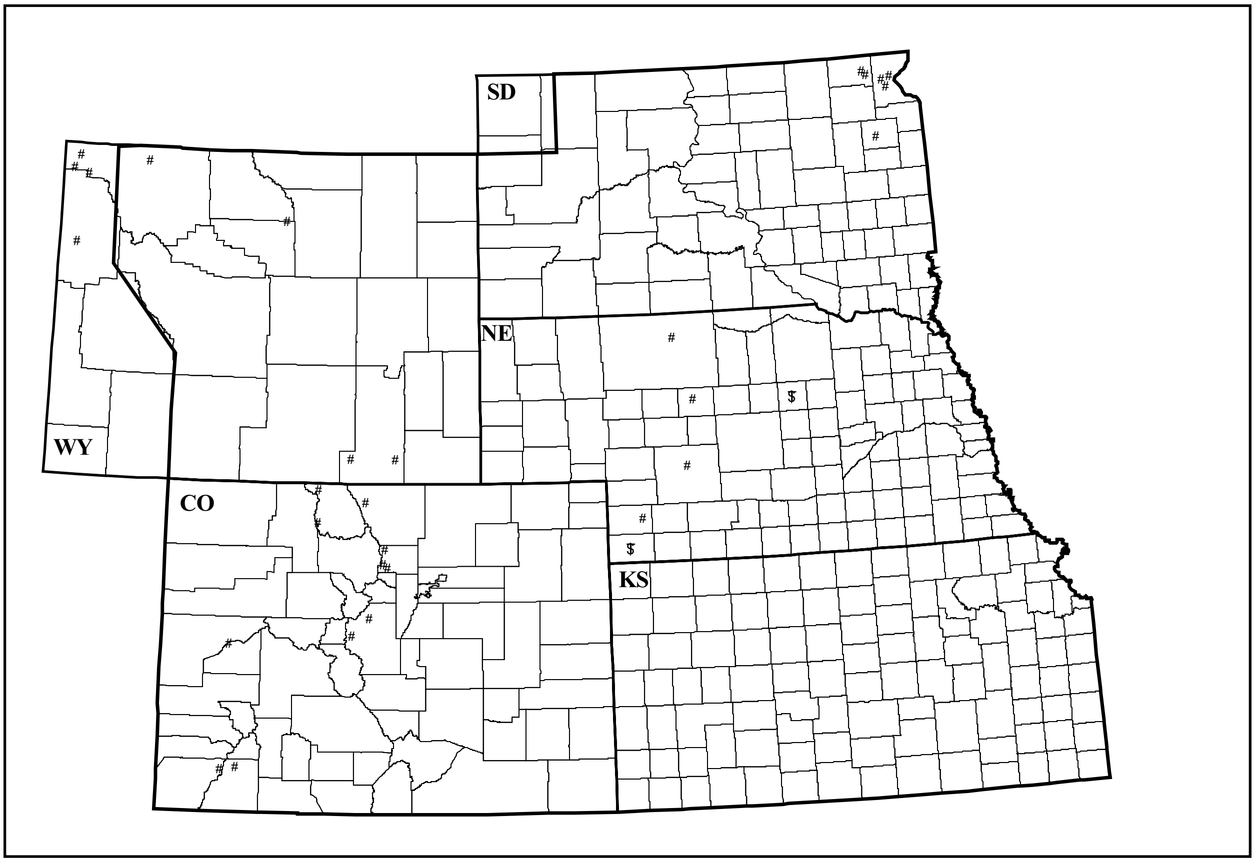

Figure 1. Distribution of *Utricularia minor* occurrences in the states of USDA Forest Service Region 2. Circles represent locations to second precision. Triangles denote general precision.

and examines the success of those recommendations that have been implemented.

Scope of Assessment

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

In producing the assessment, refereed literature, non-refereed publications, research reports, and data accumulated by resource management agencies were reviewed. While there are no refereed publications devoted entirely to *Utricularia minor*, it is mentioned in a variety of sources. Refereed and non-refereed literature on the genus *Utricularia* and its species is quite extensive and varied in scope. Not all publications on *U. minor* or other *Utricularia* species are referenced in the assessment, nor were all published materials considered equally reliable. *Utricularia* is a very large genus of herbaceous species, some of which have aquatic growth habits while others have terrestrial growth habits. Some publications on non-native *Utricularia* species were included if the species were aquatic, like *U. minor*. These references provide information more relevant to *U. minor* than publications on native, terrestrial *Utricularia* species. Certain material was not referred to if it only briefly mentioned *U. minor* without providing new information. The assessment emphasizes refereed literature because this is the accepted standard in science. Non-refereed publications or reports were regarded with greater skepticism. However, some non-refereed literature, including reports prepared by and for state and federal agencies, online articles, and student research, was used in the assessment due to the lack of refereed material directly pertaining to *U. minor*. Unpublished data (e.g., Natural Heritage Program records) were important in estimating the geographic distribution. These data required special attention because of the diversity of persons and methods used in collection.

As a worldwide species, *Utricularia minor* has been studied by scientists from around the globe. Peer-reviewed publications concerning *U. minor* have been written in at least eight languages. These could not be adequately assessed given the time constraints of this project. However, *Utricularia* species are carnivorous plants, and so while a great deal of focus has been placed on the genus as a biological and ecological novelty, much of the research focuses on the function of carnivorous organs, which is less applicable to management considerations. As an aquatic species, *U. minor* has received far less scientific and conservation attention relative to terrestrial species. Therefore, many aspects of its biology, ecology, and management considerations are unknown.

Treatment of Uncertainty in Assessment

Science represents a rigorous, systematic approach to obtaining knowledge. Competing ideas regarding how the world works are measured against observations. However, because descriptions of the world are always incomplete and our observations 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, strong inference, as described by Platt, suggests that experiments will produce clean results (Hillborn and Mangel 1997), as may be observed in physics. The geologist, T.C. Chamberlain (1897) suggested an alternative approach to science where multiple competing hypotheses are confronted with observation and data. Sorting among alternatives may be accomplished using a variety of scientific tools (e.g., experiments, modeling, logical inference). Ecology is, in some ways, similar to geology because of the difficulty in conducting critical experiments and thus the reliance on observation, inference, good thinking, and models to guide understanding of the world (Hillborn and Mangel 1997). Confronting uncertainty, then, is not prescriptive. In this assessment, the strength of evidence for particular ideas is noted, and alternative explanations described when appropriate. While well-executed experiments represent a strong approach to developing knowledge, alternative approaches such as modeling, critical assessment of observations, and inference are accepted as sound approaches to understanding.

Aquatic plant species and associated systems have received far less inventory attention than terrestrial species. *Utricularia minor* can be difficult to detect because it is a small, affixed, aquatic species. It can also be difficult to survey for *U. minor* due to the nature of its habitat; it often occurs in the wettest portions of fens and marshes, which can be difficult to maneuver and survey. The positive identification of *U. minor* can be difficult; its diminutive stature appears similar to immature specimens of more common *Utricularia* species. Until a wider understanding of identifying characteristics of *U. minor* is achieved by professionals and amateurs alike, the full extent of *U. minor* distribution, threats to its occurrence and persistence, as well as its management status and any management implications cannot be fully determined.

Treatment of This Document as a Web Publication

To facilitate the use of species assessments in the Species Conservation Project, they are being published on the Region 2 World Wide Web site (www.fs.fed.us/r2/projects/scp/assessments/index.shtml). Placing the documents on the Web makes them available to agency biologists and the public more rapidly than publishing them as reports. More important, Web publication will facilitate their revision, which will be accomplished based on guidelines established by Region 2.

Peer Review of This Document

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

MANAGEMENT STATUS AND NATURAL HISTORY

Management Status

Utricularia minor is a sensitive species in Region 2 USFS (USDA Forest Service Region 2 2005). There are 28 documented occurrences of this species in 19 counties within the states encompassed by Region 2 (**Table 1**). *Utricularia minor* is widely distributed geographically both in North America and around the globe, but it is generally considered uncommon or rare throughout its range (NatureServe 2006). It is not listed with special status in other regions of the USFS or by the Bureau of Land Management (BLM). It is not listed as threatened or endangered on the federal endangered species list and has never been a candidate for listing.

NatureServe considers *Utricularia minor* to be globally secure (G5). A conservation status rank of G5 suggests the taxon is "demonstrably secure globally, though it may be quite rare in parts of its range, especially at the periphery" (NatureServe 2006). See **Table 2** for an explanation of conservation status ranks. Within the states of Region 2, *U. minor* is considered imperiled (S2) in Colorado, Nebraska, and Wyoming. It is reported but not ranked in South Dakota where it occurs "sparingly in shallow waters over the state" (Over 1932) as well as in more specialized habitat (**Table 1**). *Utricularia minor* is not currently or historically known to occur in Kansas. *Utricularia minor* is known to occur in 27 additional states outside of Region 2. It is either not ranked or its rank is under review in 12 of these states; this implies that either it is not considered to be under threat or not enough information is known about the species to rank it in these areas. However, 15 states that rank *U. minor*, it is listed as rare (S3) in three states (California, New York, Ohio), imperiled (S2) in three states (North Dakota, Oregon, Washington), critically imperiled (S1) in five states (Illinois, Indiana, Iowa, New Jersey, Utah), and historical or extirpated in three states (Delaware, North Carolina, Rhode Island). Since 2004, *U. minor* has been down-ranked in two states (Oregon and Pennsylvania) as a result of inventory work identifying additional occurrences. In Oregon, the state conservation rank of *U. minor* changed from S1 to S2, and in Pennsylvania it changed from S2 to S4. *Utricularia minor* is known from all Canadian provinces. It is considered critically imperiled (S1) or imperiled (S2) in four provinces (New Brunswick, Prince Edward Island, Saskatchewan, Yukon Territories), demonstrably secure (S4 or S5) in three, maybe four provinces (Alberta, British Columbia, Nova Scotia, Ontario; it is listed as S3S5 in Newfoundland), and not ranked or under review in the remaining six provinces. See **Table 2** for a list of state/province ranks for *U. minor*.

Existing Regulatory Mechanisms, Management Plans, and Conservation Strategies

No management plans or conservation strategies are known to have been written specifically for *Utricularia minor*, but several federal regulations address this species and impacts to its habitat.

Table 1. Summary table of verified occurrences of *Utricularia minor* in the states within USDA Forest Service Region 2. Verified by herbarium records or Natural Heritage Element Occurrence Records. Herbarium acronyms: COLO – University of Colorado, Boulder, CO; CSCN – Chadron State College, Chadron, NE; KDH – Kalbach Herbarium, Denver, CO; NEB – University of Nebraska, Lincoln, NE; RM – University of Wyoming, Laramie, WY; SDU – South Dakota State University, Vermillion, SD

	State County	Location	Land ownership	Elevation (ft.)	Year last observed	Population size	Habitat and notes	Source ID
1	CO Boulder	2 miles north of Nederland	Private	8,400	1999	Unknown	Floating in small pools. Peaty fen in broad, gently sloping valley.	❁ Herbarium specimen: Lederer, N. #99-67 (COLO)
2	CO Boulder	Silver Lake (just east of)	USDA Forest Service (USFS), Roosevelt National Forest, Boulder Ranger District	10,000	1973	Unknown	Submerged and attached to peat bank [on] the side of a pool in a *Betula* bog.	❁ Herbarium specimen: Weber, W.A. and C. LaFarge #15007 (COLO)
3	CO Boulder	Wild Basin, St. Vrain Creek	National Park Service, Rocky Mountain National Park	8,360	1988	Unknown	Shallow water at edge of beaver pond with *Eleocharis palustris* and *Utricularia vulgaris*. Substrate: willow twigs, debris, and mud over glacial alluvium.	❁ Herbarium specimen: Yeatts, L. and V. Richards #1921 (KDH)
4	CO Delta	Skinned Horse Reservoir	USFS, Grand Mesa National Forest, Grand Valley Ranger District	10,194	2004	15 individuals	In small openings between *Carex* plants in water tracks through fen.	❁ Unpublished sensitive plant species report (Austin 2004) ❁ CNHP EO*002
5	CO Jackson	Big Creek Lake	USFS, Medicine Bow-Routt National Forest, Parks Ranger District	~9,000	1999	“Un-common”	Fen. Plants emergent from shallow water (3-4 cm). Growing with *Carex livida*, *Carex* spp., *Sphagnum* sp., and *Drosera rotundifolia*.	❁ Herbarium specimen: Abbott, R. #445 (COLO)
6	CO Jackson	Sawmill Lake South	USFS, Medicine Bow-Routt National Forest, Parks Ranger District	9,000	2005	“Hundreds+?”	Low spots in basin fen with *Spiranthes romanzoffiana*, *Pedicularis groenlandica*, *Drosera rotundifolia*, and *Eriophorum gracile*.	❁ Proctor 2005
7	CO La Plata	Haviland Lake	USFS, San Juan National Forest, Columbine Ranger District; and State of Colorado, Haviland Lake State Wildlife Area	8,200	2005	Unknown	In small creek within alkaline wetland with *Carex viridula*.	❁ Lyon personal communication 2005
8	CO Larimer	Nunn Creek	Private (adjacent to Roosevelt National Forest, Canyon Lakes Ranger District)	8,500	1996	“Locally very common”	In shallow water and mud between hummocks dominated by *Eleocharis quinquefolia* and *Triglochin palustris* in and near a small alkaline seep.	❁ Herbarium specimen: Sanderson, J. #1418 (COLO)

Table 1 (cont.).

	State County	Location	Land ownership	Elevation (ft.)	Year last observed	Population size	Habitat and notes	Source ID
9	CO Montezuma	Near Grindstone Lake	USFS, San Juan National Forest, Mancos-Dolores Ranger District	10,950	1999	Loosely filling one small pool (2mx1m)	Terraced fen with *Pediuclaris groenlandica*, *Rhodiola integrifolia*, *Swertia perennis*, *Eriophorum angustifolium*, *Eleocharis quinqueflora*, and *Listera cordata*.	❁ Rohman and Rohman 1999 ❁ CNHP EO*001 ❁ Specimen: Rohman, M.J. #3438
10	CO Park	Jefferson, South Park	Private	9,500	1960	Unknown	Wet meadows. Plants emergent on drying meadow floors.	❁ Herbarium specimen: Weber, Porsild, Holmen #11093 (COLO)
11	CO Park	Warm Springs Ranch	Private	10,000	1995	“Locally common”	In water between sedge hummocks in peat of extremely rich fen.	❁ Herbarium specimen: Sanderson, J. #1080 (COLO)
12	NE Chase	Sand Creek Valley	Unknown	~3,400	1941	Unknown	In swamp.	❁ Herbarium specimen: Tolstead, W. (NEB)
13	NE Cherry	Niobrara River	USFS, McKelvie National Forest	~2,700	1995	“Common”	Clear, cool, shallow standing water among emergent vegetation (*Typha* etc.) in seepage meadow.	❁ Herbarium specimen: Rolfsmeier, S. #11606 (NEB)
14	NE Dundy	Unknown	Unknown	~3,000	Unknown	Unknown	None.	❁ Herbarium specimen: Nebraska Game and Parks Commission
15	NE Garfield	Burwell	Private	~2,280	2000	“Locally common”	Wetland depression through interdunal Sandhills prairie meadow. Sandy loam soil in roadside ditch.	❁ Herbarium specimen: Rolfsmeier, S.B. #15753 & R.F. Steinauer. In process (NEB, CSCN)
16	NE Lincoln	North Platte	Unknown	~2,800	1951	Unknown	Shallow water among cattails.	❁ Herbarium specimen: Kiener, W. #27230 (NEB)
17	NE Thomas	Thedford	Unknown	~2,845	1889 Historic	Unknown	None.	❁ Herbarium specimen: Webber, H. (NEB)
18	SD Coddington	Lake Kampeka	City of Watertown	1,680	1958	Unknown	Marsh.	❁ Herbarium specimen: 1958 (SDU)
19	SD Marshall	Northeast of Eden	City of Watertown	Unknown	1996	Common	In shallow depressions of a rich fen in firm muck. Associated with *Carex aquatilis*, *C. utriculata, Lysimachia thyrsiflora*, and *Salix candida*.	❁ Herbarium specimen: Leoschke, M. #1663
20	SD Marshall	Northeast of Eden (2)	Private	Unknown	1996	Hundreds of plants	Channel in rich fen/ marsh complex. Growing in open water or on loose sediment deposited by a stream.	❁ Herbarium specimen: Leoschke, M. #1663

Table 1 (concluded).

	State County	Location	Land ownership	Elevation (ft.)	Year last observed	Population size	Habitat and notes	Source ID
21	SD Roberts	Near Sisseton	Private	Unknown	1996	“dense clumps”	Large floating mat of rich fen in depressions about 12 cm deep with *Carex aquatilis* and *Typha angustifolia*.	❁ Herbarium specimen: Leoschke, M. #1663
22	SD Roberts	Northwest of Summit	Private	Unknown	1996	Hundreds	Shallow depressions in the floating mat of a rich fen. Associated with *Carex aquatilis*, *C. lasiocarpa*, *C. utriculata*, *Equisetum fluviatile*, *Lemna minor*, *Lysimachia thyrsiflora*, and *Typha latifolia*.	❁ Herbarium specimen: Leoschke, M. #1680
23	SD Roberts	Northwest of Summit (2)	Private	Unknown	1996	Unknown	Sedge mat zone of a calcareous fen. Found in shallow pools and mud flat pools. Associated with *Eleocharis pauciflora*, *Lobelia kalmii*, *Rhynchospora capillacea*, *Scirpus americanus*, and *Triglochin maritima*.	❁ Herbarium specimen: Loeschke, M. #1696
24	WY Albany	Firebox Lake	USFS, Medicine Bow National Forest, Laramie Ranger District	9,610	2003	“Locally common in few small pools”	Small pools, mostly within *Carex limosa* habitat, some directly connected to small lakes in large fen complex.	❁ WYNND-EO-006 ❁ Heidel, B. #2433 & J. Proctor, G. Jones, K. Carsey
25	WY Albany	Laramie Basin, “Saratoga Valley”	State of Wyoming	7,600	1900 Historical	Unknown	Stagnant pools.	❁ WYNND EO-002 ❁ Herbarium specimen: Nelson, A. #7723 (RM)
26	WY Albany	Laramie Range, “Pole Mountain Region”	USFS, Medicine Bow National Forest, Laramie Ranger District	8,200	1959	Unknown	Muddy shore of a beaver pond in water at edge of pond.	❁ WYNND EO-003 ❁ Herbarium specimen: Porter, C.L. and M.W. Porter #8047 (RM)
27	WY Park	Swamp Lake, Clark’s Fork Valley	USFS, (Shoshone National Forest, Clarks Fork Ranger District, Swamp Lake Special Botanical Area	6,700	1996	“Appears small”	Flooded marl deposits amid small floating/ quaking mats dominated by *Triglochin* and *Eleocharis*. Occurs with *Thalictrum alpinum*, *Carex livida*, *C. limosa*, and *C. interior*.	❁ WYNND EO-005 ❁ Herbarium specimen: Fertig, W., J. Walford, S. Mellmann-Brown #16797 (RM)
28	WY Washakie	Big Horn Mountains	USFS, Bighorn National Forest, Powder Ranger District	8,600	1963	Unknown	Bog lake. Occurs with *Carex*, *Nuphar*, and *Menyanthes*.	❁ WYNND EO-001 ❁ Herbarium specimen: Porter, C.L. and M.W. Porter #9368 (RM)

Table 2. Distribution and conservation ranks of *Utricularia minor* in North America listed (NatureServe 2004).

Country	State	SRank
United States		
	AK	SNR
	CA	S3
	CO	S2
	CT	SNR
	DE	SX
	ID	SNR
	IL	S1
	IN	S1
	IA	S1
	ME	SNR
	MA	SNR
	MI	SNR
	MN	SNR
	MT	SNR
	NE	S2
	NV	SNR
	NH	SNR
	NJ	S1
	NY	S2
	NC	SH
	ND	S2S3
	OH	S3
	OR	S2
	PA	S4
	RI	SH
	SD	SNR
	UT	S1
	VT	SNR
	WA	S2?
	WI	SNR
	WY	S2
Canada		
	AB	S4
	BC	S5
	LB	SNR
	MB	S3
	NB	S2
	NF	S3S5
	NT	SNR
	NS	S4
	Nun	SNR
	ON	S5
	PE	S1
	QC	SNR
	SK	S2S3
	YT	SNR

Explanation of Ranks (Colorado Natural Heritage Program 2004)

S1 Critically Imperiled
Critically imperiled because of extreme rarity or because of some factor(s) making it especially vulnerable to extirpation or extinction. Typically 5 or fewer occurrences or less than 1000 remaining individuals.

S2 Imperiled
Imperiled because of rarity or because of some factor(s) making it very vulnerable to extirpation or extinction. Typically 6 to 20 occurrences or between 1,000 and 3,000 remaining individuals.

S3 Vulnerable
Vulnerable either because 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 or extinction. Typically 21 to 100 occurrences or between 3,000 and 10,000 remaining individuals.

S4 Apparently Secure
Uncommon but not rare, and usually widespread. Possible cause of long-term concern. Usually more than 100 occurrences and more than 10,000 individuals.

S5 Secure
Common, widespread, and abundant. Perpetually secure under present conditions. Typically with considerably more than 100 occurrences and more than 10,000 individuals.

SX Presumed Extirpated or Extinct

SH Possibly Extirpated or Extinct

S? Unranked
Rank not yet assessed.

S#S# Range Rank
A numeric range rank (Example: S2S3) is used to indicate the range of uncertainty about the exact status of the element. Ranges cannot skip more than one rank (Example: SU is used rather than S1S4).

Current regulations and directives

Utricularia minor is a wetland species. According to the National Wetlands Inventory of the U.S. Fish and Wildlife Service, the national status of this species is an obligate wetland plant (OBL). Obligate wetland species almost always occur (with >99% estimated probability) in wetlands under natural conditions. This indicator status reflects the best scientific judgment of a panel of experts estimating the percent of the total number of individuals that occurs in wetlands (Reed 1988, U.S. Fish and Wildlife 1996).

Current federal regulations and direction that address impacts to the wetland habitat of *Utricularia minor* are Section 404 of the Clean Water Act, National Environmental Policy Act review, and Executive Order 11990. Within the USFS there are additional policies and parameters for management of wetland habitat as well as directives on sensitive species listing and management. Also, one occurrence of *U. minor* on National Forest System land occurs within a Special Botanical Interest Area, an area designation that offers some attention to and protection for plant species, and thus for *U. minor*. Finally, some occurrences of *U. minor* occur in wetlands classified as peatlands, which receive special attention from the U.S. Fish and Wildlife Service (USFWS).

Section 404 of the Clean Water Act addresses the filling of wetlands (33 CFR328.3(b)). Any activity that could impact wetland water quality from the discharge of dredged or fill materials into waters of the United States requires a Section 404 permit from the U.S. Army Corps of Engineers (USACE). However, certain wetlands with occurrences of *Utricularia minor* may fall into the category of isolated wetlands in the United States, or those not connected to a water of the United States. Under the SWANCC decision (Solid Waste Agency of Northern Cook County v. US Army Corps of Engineers, 2001), the Supreme Court rendered an opinion that certain isolated wetlands may no longer fall under the jurisdiction of Section 404; these must be reviewed on a case-by-case basis to determine 404 permitting requirements. Additionally, some locations with known occurrences of *U. minor* have historic water rights that preclude the requirement of the holder to apply for wetland permits through the USACE (Austin personal communication 2004). However, where modifications to wetlands resulting from historic water rights occur on National Forest System land, a special use permit is required.

Wetlands also receive attention via the National Environmental Policy Act (NEPA) (U.S. Congress 1982). Specific procedures to be followed for NEPA are provided in regulations of the Council on Environmental Quality (40 CFR 1500-1508) and in the U.S. Forest Service Handbook (FSH 1909.15). Federal regulation under NEPA requires an assessment of potential environmental impacts associated with federal projects. The NEPA process also documents the consideration of alternatives, mitigation for environmental impacts, interagency coordination, and public involvement. *Utricularia minor* has sensitive species status within USFS Region 2 and as such should receive attention in any NEPA analysis on these lands. However, no other federal agency lists *U. minor* as a sensitive species. Thus, any NEPA analysis on U.S. Fish and Wildlife Service, Bureau of Indian Affairs, National Park Service lands, and Bureau of Land Management lands might not identify *U. minor* at the species level in the course of their analysis. They will address wetlands, which may or may not have *U. minor*.

For wetlands occurring on public lands, federal agencies receive direction from Executive Order 11990. Executive Order 11990, as amended, requires federal agencies exercising statutory authority over federal lands to "provide leadership and take action to preserve and enhance the natural and beneficial values of wetlands" in conducting federal activities and programs affecting land use and "to avoid to the extent possible, the long- and short-term adverse impacts associated with the destruction or modification of wetlands." In addition, the federal government has adopted the policy of "no net loss" of wetlands since the late 1980's.

Within the suite of federal agencies managing public lands, the USFS has additional directives and guidelines. The USFS is required to achieve ecosystem and species diversity (36 CFR §219.20) and has policy aimed at managing for threatened, endangered, and sensitive species (FSM 2670.2(21 and 22)). Biological evaluations are required to assess any project impacts to sensitive species on National Forest System lands (USDA Forest Service 1995). Impacts to sensitive species and their suitable habitat by any USFS projects are determined, disclosed, and may be mitigated. The Region 2 Threatened, Endangered, and Sensitive (TES) Plant Management Strategy provides guidance for biological evaluations of TES plant species and also outlines long-term strategies to complement other USFS programs in achieving stewardship of "healthy, diverse ecosystems on National Forests and Grasslands"

(Austin et al. 1999). Also, sensitive species may not be collected on National Forest System lands without a permit (USDA Forest Service 1995).

In addition, the USFS in Region 2 has Watershed Conservation Practices in the Forest Service Handbook (FSH) that guide management practices in and adjacent to wetlands (FSH 2509.25). These practices are designed to maintain long-term ground cover, soil structure, water budgets, and flow patterns of wetlands. Among the design criteria are standards for keeping vehicles, roads, trails, and buried utilities and pipelines out of wetlands. Additionally, there is direction to "avoid long-term reduction in organic ground cover and organic soil layers in any wetland (including peat in fens)" and to "avoid the loss of any rare wetlands such as fens and springs."

One occurrence of *Utricularia minor* in Wyoming occurs in the Swamp Lake Special Botanical Interest Area in the Clarks Fork Ranger District on the Shoshone National Forest. Special Interest Areas are designated to protect and manage National Forest System lands for unique botanical, zoological, geological, scenic, and archaeological interests (FSM 2360). A botanical area is defined as "a unit of land that contains plant specimens, plant groups, or plant communities that are significant because of their form, color, occurrence, habitat, location, life history, arrangement, ecology, rarity, or other features" (FSM 2372.19). Management of these areas is mandated to allow for public enjoyment, provided it does not interfere with the primary values for which the area was established. Developments, such as roads, trails, and other facilities, and the levels of usage of those developments are kept to the minimum necessary to maintain the plant specimens, groups, or communities.

Certain wetland habitats of *Utricularia minor* are categorized as peatlands; these include bogs, poor fens, and extremely rich fens. USFWS Region 6 (Mountain-Prairie Region), which corresponds with USFS Region 2, has designated peatlands as Resource Category 1 (Federal Register, Vol. 46, No. 15, February 4, 1981; U.S. Fish and Wildlife Service 1998). Resource Category 1 has the mitigation goal of "no loss of existing habitat value." Also, the USFWS Region 6 policy maintains that "every reasonable effort should be made to avoid impacting fens."

Adequacy of current laws and regulations and their enforcement

Although wetland regulatory mechanisms are in place, it is uncertain how effective they are at minimizing impacts to known occurrences of *Utricularia minor* and its habitat. Federal regulations and evaluation policies assess, and at times permit, impacts to wetlands. Thus, they do not automatically confer land protection or management for biological conservation. The National Research Council Committee on Mitigating Wetland Losses (2001) suggested that the permitting process for Section 404 of the Clean Water Act is still resulting in a net loss of wetland functions despite progress in the 1980's. They found that mitigation projects required by Section 404 permits (i.e., wetland creation, enhancement, and restoration activities) are often not undertaken or fail to meet permit conditions. Failure to complete mitigation project results in wetland loss, and failure to meet permit conditions has produced a disparity in the hydrogeological equivalence of wetland types (i.e., wetland types are not being mitigated in-kind).

On private land, enforcement of Section 404 permit violations is the responsibility of the USACE. However, the USACE has restricted budget and staff for this purpose (National Research Council 2001). On National Forest System lands, the USACE generally relies on the USFS to enforce wetland policies, except for major construction actions such as ski areas (Roche personal communication 2004). Enforcement of wetland regulations and special permits on National Forest System lands acquired via historic water rights are also the responsibility of the USFS. There is no direct evidence to suggest that failure to enforce any existing regulations has resulted in the extirpation of an occurrence of *Utricularia minor* in Region 2. However, a net loss of wetlands does decrease potential habitat for *U. minor*. Furthermore, if *U. minor* is found in an isolated wetland, it may no longer be protected under the Clean Water Act.

Peatlands are a primary habitat type for *Utricularia minor* in Region 2. Their recognition as Resource Category 1 by the USFWS suggests greater scrutiny for land management practices in and around these wetlands and implies some protection for them and the wetland species they contain. Similarly, designation of land management areas to a higher level of protection, like Special Botanical Interest Areas by the USFS, implies greater protection for plant species as management decisions are made with specific species in mind.

A potentially confounding and conflicting message on the habitat value of peatlands is presented in the designation of peat as a commodity, renewable resource, and alternative fuel by the U.S. Department of the Interior (Secretary of the Interior 1994, USDI Bureau of Mines 1994). As such, the U.S. Department of Energy promotes peat mining for energy by guaranteeing a market and by conducting research. Its designation as an alternative fuel allows special tax incentives for major research, development, and construction investment. The extent of influence of these policies in Region 2 is unknown. Peat is also considered a saleable mineral and is mined as a commodity (FSM 2822.1). As will be discussed later in this document, peat mining threatens the habitat of *Utricularia minor* in Region 2. The inherent loss of wetland habitat value associated with peat mining is in direct conflict with the Resource Category 1 designation of the USFWS. On private land peat is both saleable and leasable. The USFS has authority over mineral materials that occur on National Forest System lands where peat is saleable but not leasable. The presence of a threatened, endangered, or sensitive species like *U. minor* would be cause to refuse to sell peat to a willing buyer, but the absence of such species may leave potential habitat available for peat mining. Rectification of the conflicting nature of wetland protection regulations in light of federal incentives for allowable resource usage would be helpful.

Biology and Ecology

Classification and description

Utricularia minor is a member of the bladderwort family (Lentibulariaceae), one of nine (possibly 11) plant families with carnivorous species (Ellison and Gotelli 2001). The Lentibulariaceae is in the Dicot group of flowering vascular plants, subclass Asteridae, and order Scrophulariales (Heywood 1993, USDA Natural Resources Conservation Service 2004). This subclass and order have a high proportion of derived characteristics and are considered highly evolved within the plant kingdom (Heywood 1993). The Lentibulariaceae is a small family, with only three genera (Muller et al. 2004). The two most common genera in this unique plant family are *Utricularia* (bladderworts) and *Pinguicula* (butterworts). The third genus, *Genlisea* (corkscrew plant), occurs in the tropics (Heywood 1993).

The genus *Utricularia* comprises 37 percent of the species classified as carnivorous (Schlauer 1997). Carnivory in plants is an alternative strategy for obtaining mineral nutrients (Schnell 2002). Characteristics of carnivorous plants stem from the habitat they occupy, which tends to be wet, low-nutrient soils with low oxygen concentration and high organic matter. The low redox potential of these soils restricts the availability of nutrients (Adamec 1997). Carnivorous plants tend to be weakly rooted; investment in roots declining in favor of specialized structures for luring, trapping, and digesting prey for mineral nutrients. This trade-off makes them poor competitors in other environments. In the case of *Utricularia*, however, there are no roots at all. Members of this general are well known for their suction-trap bladders, in which a wide variety of organisms are captured. Investment in bladders is approximately equivalent to investment in roots of terrestrial plants growing in moderately nutrient-poor environments (Richards 2001).

A worldwide genus. *Utricularia* is a large genus comprised of 221 species throughout the world. Although species occur on every continent except Antarctica and range from the tropics to the Arctic, a majority of them are distributed in the tropics (Taylor 1989, 1991). Of the 221 species recognized globally, only 19 occur in the United States and Canada. Historically there were 20 species, but one species previously known from Florida is now presumed extirpated (Rice personal communication 2005). Species diversity of *Utricularia* is greatest in the eastern and southern coastal zones where there are five endemic species (Taylor 1991). However, several species, including *U. minor*, occur in north temperate latitudes, many of which are circumboreal.

Members of the genus *Utricularia* are all herbaceous and affiliated with wet habitat. A range of life forms, from aquatic to more terrestrial, exist within the genus. “Terrestrial” species, which comprise 60 percent of the genus, are still obligate wetland species and grow in saturated soils, usually peat or sand. This substrate is usually inundated during wet seasons, but little or no surface water occurs by the time of flowering. Aquatic species of *Utricularia* grow submerged in more or less open water and have both free-floating and affixed habits. Affixed aquatics have a majority of their bladders on specialized shoots that are anchored in substrate. *Utricularia minor* is a small, perennial, affixed aquatic species (Taylor 1989).

A note on *Utricularia* terminology. Technically speaking, individuals in the genus *Utricularia* are rootless, leafless, stemless dicotyledonous plants that lack cotyledons (Kondo et al. 1978, Juniper et al. 1989, Taylor 1989). *Utricularia* is among several genera that exhibit “fuzzy” morphology where vegetative tissue forms a continuum of tissues rather than distinct organs (Rutishauser 1999). “Leaves” of species with “fuzzy” morphology are developmental mosaics that are partially homologous to shoots, so the vegetative body of the plant has both stem and leaf characteristics (Rutishauser and Isler 2001). These vegetative structures do not follow standard developmental pathways; there are no root or shoot primordia in seed embryos. Areas of concentrated cell division arise in several areas of the undifferentiated embryo resulting in root-like, shoot-like, and leaf-like structures. Each of these vegetative structures can grow continuously and be transformed into any of the other vegetative structures (Kondo et al. 1978). Adventitious buds can appear on any of these vegetative structures. Given the lack of any valid morphological terminology for the vegetative structures, various researchers have coined phrases in many papers. The leaf-like structures have been called “primary leaves”, “foliar units,” “lateral foliar units”; the stem-like structures, “air-shoots,” “stonoliferous rhizomes,” “primary vegetative shoots,” and “stolons”; and the root-like structures, “rhizoids.” For convenience in this species assessment, “leaf” and “leaf segment”, and “stem” or “stolon” will be used as they have been used in many studies as well. *Utricularia minor* lacks rhizoids and air shoots.

In stark contrast to the leaf and stem vegetative structures, the bladders in *Utricularia* are highly differentiated (**Figure 2**). The trapping mechanism in *Utricularia* is an intricate endeavor as well as a biological marvel and will be discussed below. Many synonyms for bladders exist including urceoli, ampullae, vesiculae, utriculae, pitchers, and traps (Lloyd 1942). Bladder and trap will be used throughout this assessment. The intricacy of the trap and its long history of study have led to a cacophony of terms used to describe every facet of trap structure. Resounding themes in these terms are related to doorways (door, hinge, threshold, selvage, chink, vestibule, and buttress) or to facial characters (lips, cheeks, hood, hairs, face, and mouth). For purposes of this assessment, the bladder opening is referred to as the mouth of the bladder or the door of the trap.

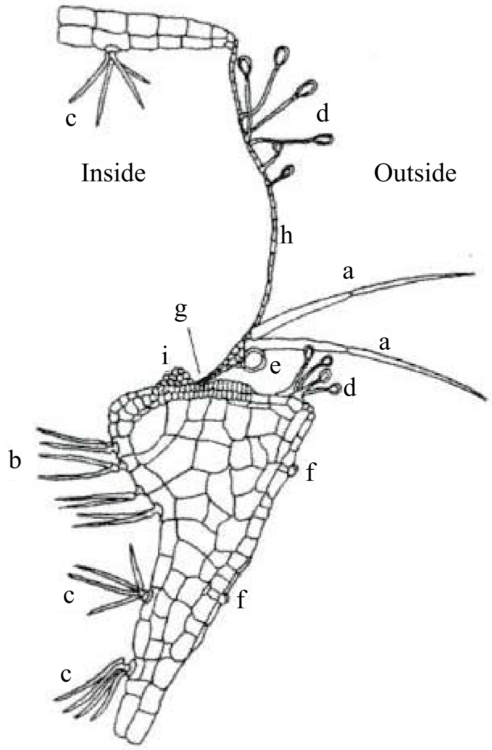

Fig. 10. An anterior saggital section through a bladder. Apart from the sensitive hairs (*a*), at least five other types of specialized cells are shown: two-armed hairs (*b*), four-armed hair (*c*), stalked cells (*d*), large stalked cells (*e*), and paired cells (*f*). The free edge (*g*) of the trapdoor (*h*), is shown resting in a shallow groove formed by rows of cells (*i*), below which are the throat cells (*j*).

Figure 2. Diagram of a *Utricularia bladder*. Reproduced with permission from the Australian Journal of Plant Physiology vol. 2: 3350351 (P H Sydenham & G P Findlay). Copyright CSIRO 1975. Published by CSIRO PUBLISHING, Melbourne Australia. On-line journals website (http://www.publish.csiro/au/journals/fpb).

Bladders are adorned with several types of specialized cells and structures. For example, the mouth of the bladder is adorned with two types of multicellular trichomes, branched and unbranched; these are the trigger hairs that trip the trap. Branched trichomes are also called antennae, and unbranched trichomes are called bristles. These terms were coined by Darwin who thought *Utricularia* bladders resembled aquatic microcrustaceans (Meyers and Strickler 1979). The size and shape of the trichomes differs among species of *Utricularia* (Taylor 1989). The bladders also have several types of glands. Two types that adorn the inside of the bladder are structures having one or two pair of arms, called bifids and quadrifids, respectively. Bifids occur just inside the door while quadrifids have a more uniform distribution throughout the whole bladder. The size and shape of quadrifid glands are one of the most definitive taxonomic characteristics in some groups of *Utricularia*. Other gland types adorn the exterior of the bladders; some are stalked, and some are sessile. The size and shape of these can also differ between species. Stalked glands occur on the trapdoor and generally produce mucilage (Lloyd 1942, Juniper et al. 1989).

Species description

The bulk of the following description is condensed from Taylor (1989) although additional sources were used for certain features as noted. *Utricularia minor* is a small, perennial, yellow-flowered, aquatic bladderwort that grows affixed to substrate. It has fine, smooth, thread-like stolons (stems) that have leaf and bladder segments alternating along them. The stolons grow to 30 cm long but are generally less than 1 mm wide. Portions of stolons in *U. minor* are buried and anchor the plant to substrate while the remainder of the plant floats suspended in the water column. Buried portions are colorless and have a greater number of bladders than the green stolon segments floating within the water column. Compared to other *Utricularia* species, leaves are relatively small, reaching only 0.2 to 1.5 cm long. They are dichotomously branched in such a way as to appear palmately divided with 7 to 22 leaflets. The end segments are moderately flattened, but this is only most readily apparent under some magnification. Lateral setulae (small bristles) are absent, and apical setulae are microscopic. *Utricularia minor* exhibits leaf dimorphism; leaves buried in substrate differ in appearance from aquatic leaves in that they are reduced to one or two elongate leaflets. Bladders of *U. minor* are stalked, oval-shaped, and 0.8 to 2.5 mm long. The mouth of the bladder is opposite the stalk that attaches the bladder to the plant. It has two, long, branched appendages (antennae) that curl backward over it. Additionally, the mouth is sparsely adorned with simple hairs (bristles). The two pairs of arms comprising the quadrifids in *U. minor* are unequal in length. The arms of the longer pair are almost parallel. The shorter pair of arms forms an obtuse angle and is reflexed, bending back toward the longer pair (illustrations and pictures of these glands can be found in Taylor (1989) and Glossner (1993)). Flowers of *U. minor* are borne on a single, narrow stem (or scape) that emerges from the water surface. The entire stem can be 2.5 to 25 cm long but only 0.5 to 0.8 mm thick. Two to four scales are equally spaced along the length of the scape below the terminal raceme of two to six flowers. Compared to other *Utricularia* species, the flowers are pale or dull, dirty yellow. They are bilaterally symmetrical, with five corolla lobes fused into two lips. Each has two sepals, 2 to 3 mm long, with the top one being wider than the bottom. The lower lip of the corolla is larger and longer than the upper one. The upper lip is roughly egg-shaped and wider near the base than at the tip, and it has an acute, slightly notched tip. The lower lip is broad and oval-shaped with the sides curving downward over a spur-like petal, which is not as well-developed as in other *Utricularia* species. *Utricularia minor* has two stamens borne on the petals. Pollen grains are spindle-shaped (i.e., longer than wide) and have 11 to 18 elongate but rounded longitudinal colporate (compound) furrows, with inner apertures arranged perpendicularly to the outer aperture. The outer surface of the pollen (exine) is rough and has an elaborate 3-dimensional pattern (i.e., it is tectate) (Thanikaimoni 1966, Huynh 1968). Stigmas are long, with two unequal lobes. The lower lobe is oval-shaped with a reflexed tip and a fringe of hairs, and the upper lobe is smaller and triangular in shape. The ovary is superior, with two fused carpels and a single locule. Fruit is a small (2 to 3 mm) round capsule. Seeds are numerous and small (<1 mm in length and width), polygonal at the base, and rounded on top. Photographs of vegetative specimens of *U. minor* are shown in **Figure 3** and **Figure 4**.

History of knowledge

Utricularia has an extensive history of study as it has long been considered a biological novelty. Early observers were captivated by carnivorous plants in general and *Utricularia* in particular due to the bladders. Lloyd (1942) has extensively outlined concurrent observation and experimentation by scientists on several continents. Charles Darwin and his contemporaries were utterly fascinated by their observations that bladders of *Utricularia* trapped animals. Mrs. Mary Treat of New Jersey demonstrated that the digestion of invertebrates occurred within 48

Figure 3. Photograph of *Utricularia minor* by Joe Rocchio, Colorado Natural Heritage Program.

Figure 4. Photograph of *Utricularia minor in situ* by Joe Rocchio, Colorado Natural Heritage Program.

hours. Upon witnessing this, she described that she "was forced to the conclusion that these little bladders [were] in truth like so many stomachs, digesting and assimilating animal food" (Lloyd 1942, p. 235). With the advent of using electron microscopy to study plant anatomy, a new flurry in the study of *Utricularia* began. These studies revealed fine details of the anatomy and cellular ultrastructure, especially of *Utricularia* traps (Fineran and Lee 1975, Fineran and Lee 1980, Glossner 1993). They also elucidated mechanisms and cellular pathways of physiological and mechanical processes involved in bladder function. In recent decades, research on *Utricularia* has shifted to ecological studies. *Utricularia* has been used as a model system to study predator-prey interactions. Cost-benefit analyses of *Utricularia*'s investment in carnivory abound (Juniper et al. 1989, Knight and Frost 1991, Knight 1992, Ulanowicz 1995, Richards 2001). With such attention to specific details of carnivory, much of the basic biology and ecology of *Utricularia* remains unstudied and unknown; to date there are still many mysteries associated with *Utricularia* and its autecology.

Taxonomically, a comprehensive natural classification of *Utricularia* long eluded systematists until relatively recently. The size of the genus and its worldwide distribution left many early efforts incomplete (Taylor 1989). In Species Plantarum (1753), Linnaeus described seven species of *Utricularia* from three continents; half of these were terrestrial, and half were aquatic. *Utricularia minor* was one of these seven species. Within 50 years, the number of recognized species nearly quintupled. Vahl listed 34 species in 1804 and was the first to arrange the species into sections, which were based on leaf characteristics. The early 1800's saw expeditions to the far reaches of the globe. Botanical exploration of the tropics elucidated many new species of *Utricularia*. In 1844, De Candolle presented a comprehensive treatment of the genus in which he recognized 131 species arranged in five sections based on growth habit (two aquatic, two affixed to substrate, and one epiphytic). The next century saw continued botanical exploration in various regions of the world, resulting in several regional treatments of *Utricularia*. In 1949, Peter Taylor made his first observation of the genus *Utricularia*; it was the beginning of a lifetime of study. Stationed at Kew Gardens in England, Taylor became a repository for specimens and discussion on the genus and participated in many expeditions. The results of forty years of study were assimilated and published in a monumental monograph of the genus in 1989, corralling the remarkably large and variable genus. He recognized 214 species in 35 sections. No infraspecific taxa were recognized although admittedly several species are highly plastic and variable, "some excessively so." Taylor's classification approach was a classical one, and sectional and species delimitation were based on morphology with some reference to geography. Sections and species were differentiated based largely on morphology of bladders and all their intricate features; some floral characters were included.

Taylor (1989) places *Utricularia minor* in the Section *Utricularia*, one of the more advanced sections. Characteristics shared by the 34 species in this section include aquatic habit, oval-shaped bladders that have a trapdoor adorned with appendages, basally-affixed floral bracts that lack bracteoles, and dehiscent capsules. This section also has more derived pollen characteristics relative to more primitive sections. See **Table 3** for the full classification of *U. minor*. There are no recognized synonyms for this species in North America.

Several authors have studied and classified pollen characteristics of *Utricularia*. Thanikaimoni (1966) studied pollen of 30 species in India and arranged them into three pollen groups that corresponded to three different habitats. These results, however, cannot be extrapolated to the genus as a whole (Huynh 1968). Huynh (1968) sampled pollen from 143 species and arranged them into five groups, but these do not match taxonomic groups based on other morphological characters of the genus.

Genera in the Lentibulariaceae have been variously merged and split over the years. At most, five genera have been recognized: *Utricularia*, *Pinguicula*, *Genlisea*, *Biovularia*, and *Polypompholyx* (Lloyd 1942). Taylor (1989) and Muller (2003) have lumped *Biovularia* and *Polypompholyx* into *Utricularia*. Heywood (1993) recognizes *Polypompholyx* as a separate genus.

Similar species in Region 2

When in flower, *Utricularia minor* is readily distinguished from all sympatric species. Flowers of *U. minor* are distinct due to the lower lip being larger than the upper lip, its dull yellow color (relative to brighter yellows in other species), and the lack of a well-defined spur. However, strictly vegetative material can be more difficult to differentiate from immature specimens of other aquatic *Utricularia* species. In Region 2, *U. minor* is most often confused with immature plants of *U. macrorhiza*. Immature leaves of *U. macrorhiza* lack bladders and have bristles on the sides of their leaf segments whereas leaf segments of *U. minor* are smooth and without bristles. There is also

Table 3. Classification of *Utricularia minor* after USDA Natural Resources Conservation Service 2004, with sources of certain portions cited below.

Kingdom	Plantae (Plants)
Subkingdom	Tracheobionta (Vascular Plants)
Superdivision	Spermatophyta (Seed Plants)
Division	Magnoliophyta (Flowering Plants)
Class	Magnoliopsida (Dicotyledons)
Subclass	Asteridae
Order	Scrophulariales
Family	Lentbulariaceae (Bladderwort Family)
Genus	Utricularia
Subgenus	Utricularia[1]
Section	Utricularia[1]
Species	*Utricularia minor* L.

[1] Taylor 1989

similarity between *U. minor* and immature specimens of *U. ochroleuca*, especially given the possibility that *U. ochroleuca* may be a hybrid between *U. intermedia* and *U. minor*. The geographic ranges of *U. minor* and *U. ochroleuca* overlap in Colorado. *Utricularia ochroleuca*, like *U. macrorhiza*, has bristles on its leaf segments. Also, the quadrifid glands of *U. ochroleuca* are distinct from those of *U. minor* in that both pairs are divergent. Elsewhere, *U. minor* is most often confused with *U. intermedia*, a common associated species, or with *U. gibba* (Voss 1996). Like *U. macrorhiza*, *U. intermedia* has several diminutive bristles on the sides of their leaf segments that are lacking in *U. minor*. Also, the two pairs of arms on the quadrifid glands of *U. intermedia* are parallel and level whereas the shorter arms of *U. minor* quadrifids are reflexed. Also *U. minor* has marked shoot dimorphism, and *U. gibba* does not. The hair-like leaf segments of *U. gibba* are mostly forked one or two times whereas *U. minor* has flat leaf segments (especially under some magnification) forked three or four times (Gleason and Cronquist 1991, Voss 1996). However, the latter character can be less reliable as some vigorous specimens of *U. gibba* can have more segments.

Published descriptions and other sources

A comprehensive technical description of *Utricularia minor* is available in Taylor (1989). Less technical, more abbreviated descriptions are available in Fernald (1950), Gleason (1952), Hulten (1968), Cronquist et al. (1984), Great Plains Flora Association (1986), Thor (1988), Gleason and Cronquist (1991), Voss (1996), and Schnell (2002). Line drawings can be found in Rossbach (1939), Fassett (1940), Cronquist et al. (1986), Thor (1988), Taylor (1989), Voss (1996), and Weber and Whittman, and they are available online from PLANTS database (reprinted from Gleason 1952; USDA Natural Resources Conservation Service 2004). Several additional photographs are available online at CalPhotos (2004), Digital Flora of Texas Vascular Plant Image Library (Digital Flora of Texas 1999), Wisconsin Botanical Information System (2004), and BioImages (2004).

Distribution and abundance

Utricularia minor is a circumboreal species found throughout the northern hemisphere. It roughly occurs north of the 40th parallel in North America and Europe (although its distribution creeps south in North America in California and in the Intermountain states), and north of the 30th parallel in Asia, occurring down to the Himalaya in northern India, Nepal, and Bhutan. The few known records of *U. minor* in the southern hemisphere occur at high elevations in New Guinea. Hulten (1968) has the most complete distribution map for *U. minor* in the northern hemisphere.

Prior to 1944, *Utricularia minor* was known in the United States only from New England, Michigan, Indiana, and Illinois (Muenscher 1944). Its current distribution includes Alaska (including north of the Arctic Circle) and the northern tier of states. *Utricularia minor* dips south into California, the Intermountain Basin states, and Colorado (Taylor 1989). It is also documented in Arizona (Ricketson 1989, Rice personal communication 2004). It is historically known from Rhode Island, North Carolina, and Delaware, and it is presumed extirpated from Delaware (NatureServe 2006).

In Region 2, *Utricularia minor* occurs in every state except Kansas (**Table 2**). The distribution of known occurrences of *U. minor* within the states of Region 2 is shown in **Figure 1**. It occurs in five counties in Colorado (Lyon personal communication 2005, CU Museum 2006), six counties in Nebraska (Kaul personal communication 2004), four in South Dakota (Leoschke personal communication 2005), and five in Wyoming (although the Teton County and Yellowstone National Park occurrences in Wyoming are outside of Region 2; Whipple personal communication 2004, Wyoming Natural Diversity Database 2004). Great Plains Flora Association (1977) lists additional specimens for two counties in Nebraska (Dawson and Rock counties). However, these were based on misidentified specimens of *U. macrorhiza* (Kaul personal communication 2004). The Wyoming Natural Diversity Database program is performing an element distributional model for *U. minor* that will identify predicted locations for the species (Beauvais et al. in prep). Results of this computer model are pending.

Four known occurrences of *Utricularia minor* have counts of individuals. One occurrence has a count of 15 individuals (Delta County, Colorado), and three occurrences have estimates of "hundreds" (Jackson County, Colorado and Marshall and Roberts counties, South Dakota). Excluding the records just mentioned, only 10 occurrences have any comment on abundance, and these are only general, qualitative statements (e.g., "common," "locally abundant," "rare"). The rest of the records have no information on population size.

Population trend

There is no information on trends within individual populations of *Utricularia minor* and little or no information about trends for the species as a whole throughout its global range. In North America, *U. minor* was formerly known from Delaware, North Carolina, and Rhode Island. However, *U. minor* is presumed extirpated from Delaware and is only known from historical populations (ones that have not been seen since 1975) in Rhode Island and North Carolina; this demonstrates a decline from its historic geographic range.

There are no long-term studies of any *Utricularia minor* occurrences to date. There are only two records of repeat visits to any occurrences of *U. minor* in Region 2, both of which are in Wyoming. However, neither of these occurrences has specific counts of individuals. The remaining occurrences have no record of repeated visits and presumably have been observed only once, on the day they were discovered.

Habitat

Utricularia minor is an affixed (as opposed to free-floating) aquatic species that grows in a variety of low-energy aquatic environments. It grows in shallow water (up to approximately 12 inches deep) with a penetrable substrate (Taylor 1991, Rice personal communication 2004). Individuals tend to grow in places like inundated mudflats or areas with emergent vegetation. *Utricularia minor* is documented from oligotrophic and dystrophic lakes as well as bog pools (Ceska and Bell 1973) and in montane fens plus eutrophic ponds and sloughs (Christy 2004) in the Pacific Northwest. In Montana, *U. minor* has been documented from flarks in a rich, patterned fen (Lesica 1986). In Yellowstone National Park, it grows in wetland complexes associated with geothermal features (Whipple personal communication 2004). It is found in wet swales, pools, ruts, or animal tracks within fens, sedge mats, marshes, open wet thickets, and peaty lake margins in the upper Midwest (Voss 1996). In New England, *U. minor* is noted to occur in relatively enriched areas such as calcareous ponds or in water tracks within fens (Rossbach 1939). Although more often associated with peatland habitat, *U. minor* has also been documented from beaver ponds and from roadside ditches (**Table 1**). The unifying characteristics of these habitats are low nutrient status and/or low oxygen levels.

In Region 2, *Utricularia minor* is generally associated with two different types of wetland systems. It is associated with montane fen ecological systems (Rondeau 2001) and in small localized seeps at higher elevations in Colorado and Wyoming, whereas it is associated with freshwater marsh systems at lower elevations and in the Plains states. These systems correspond to the Rocky Mountain Subalpine-Montane Fen and North American Arid West Emergent Marsh ecological systems of NatureServe (2003), respectively. Montane fen and freshwater marsh systems are "small patch" systems. Small patch systems are local in scale, usually have distinct boundaries, require specific environmental conditions, and are strongly linked to and dependent upon the landscape around them (Anderson et al. 1999). Both of these habitat types have distinct hydrologic regimes dictated by their surrounding landscape and underlying bedrock.

Fens and seeps usually form where groundwater intercepts the soil surface, often at low points within the landscape or on slopes (Crum 1988, Mitsch and Gosselink 1993, Rondeau 2001, Sjors and Gunnarson 2002). In fens, groundwater flow maintains the water level at near constant temperatures and levels, at or near the soil surface. Water moves through these systems slowly, flowing down very low slope gradients. The constant soil saturation provided by upwelling groundwater creates anaerobic conditions. The lack of oxygen combined with cold temperatures dramatically slows or inhibits decomposition, leading to the accumulation of organic material in soils, or the formation of peat (Mitsch and Gosselink 1993). Seeps are fed by groundwater and are constantly saturated by flowing water. They generally do not develop deep peat due to greater aeration of the soil allowing decomposition to keep pace with plant production.

Freshwater marsh systems, although local in character, are more widespread. They occur in depressional areas that intersect the water table within the landscape, like ponds or swales. They can also occur as fringes around lakes and along slow-flowing streams and rivers. Although water levels may fluctuate throughout the growing season, freshwater marsh systems are frequently or continually inundated to various depths. They are composed of mosaics of open water and emergent vegetation often characterized by graminoids (Mitch and Gosselink 1993, Rondeau 2001). Most of the marshes occupied by *Utricularia minor* are dominated by *Typha* species (**Table 1**). Marshes can also result from beaver activity. Vegetation patterns of beaver meadows follow successional pathways following flooding and abandonment by beavers. *Utricularia macrorhiza* (=*U. vulgaris*) commonly colonizes deep water areas immediately after flooding (McMaster and McMaster 2000). In Minnesota, *U. minor* did not appear to be among early colonizers, but it was found in mid-successional stages in intermediate-aged (11 to 40 year old) beaver ponds (Ray et al. 2001). This species was noted in late successional stages in ponds along the Rhone River in France (Delarze and Ciardo 2002).

Fens occupied by *Utricularia minor* in Region 2 range from poor to extremely rich. The intricate relationship of environmental conditions that maintain fens in Region 2 stems from landscape position, groundwater, and climate. Poor fens have low pH (generally below pH 4.5) and are dominated by *Sphagnum* mosses. Extremely rich fens differ in that the groundwater feeding the system is mineral rich, pH tends to be high (generally above pH 6.5), and dominant species are non-sphagnous brown mosses and calciphiles, calcium tolerant plant species. In Region 2, groundwater of extremely rich fens percolates through enriched bedrock, dolomites, and limestones high in calcium, magnesium bicarbonates, and sulfates (Cooper 1996, U.S. Fish and Wildlife Service Region 6 1997, Sjors and Gunnarsson 2002, Heidel and Laursen 2003). Both low pH of acidic fen environments as well as the high pH produced by enriched groundwater seepage limit plant growth (McBride 1994) and attract different suites of highly specialized plant species that can tolerate the harsh conditions. Extremely rich fens are less common than poor fens in Region 2 and elsewhere.

The microtopography of fens consists of hummocks, hollows, strings, and other patterns on the soil surface. This pattern is derived from how water flows through a fen and from vegetation development. Patterned fens form where groundwater flows slowly through broad, gently sloped peatlands; this forms a series of peat ridges, called strings, separated by hollows (or flarks). Strings and flarks are arranged perpendicularly to the flow of water through the peatland and can form a regular pattern of parallel ridges and hollows or an intricate, anastamosing pattern (Glaser 1987). Unpatterned fens show no regular pattern of hummocks and hollows. Hummocks are remnants of past plant growth; perennial species add layers of vegetation that build up peat above the permanently saturated zone comprised by hollows; this allows a wider variety of species to colonize peatlands, contributing to the species diversity of these wetlands.

On USFS land in Wyoming, *Utricularia minor* occurs on the Medicine Bow, Shoshone, and Bighorn national forests (**Table 1**). On the Medicine Bow National Forest, it occurs in small pools within a poor fen complex in the montane zone. Dominant plant species include *Sphagnum* and *Carex limosa*. The uplands are characterized by typical spruce-fir forest (Proctor personal communication 2004, Proctor 2005). There is also a historic record of *U. minor* (dated 1959) from a beaver pond, but it is unknown whether this population has persisted (Wyoming Natural Diversity Database 2004). On the Shoshone National Forest, *U. minor* occurs in the Swamp Lake Special Botanical Interest Area. The Swamp Lake wetland is an extremely rich fen occurring in the montane zone along the Clarks Fork of the Yellowstone River. The wetland is fed by many seeps and springs within a landscape that overlies bedrock high in calcium bicarbonates (Heidel and Laursen 2003). *Utricularia minor* occurs in pools within flooded marl deposits amid small floating or quaking mats comprised of the Arrowgrass – Spikerush (*Triglochin – Eleocharis*) vegetation type. The floating mats are dominated by *Triglochin maritimum* (seaside arrowgrass), *Kobresia simpliciuscula* (simple bog sedge), *Thalictrum alpinum* (alpine meadow-rue), *Aster junciformis* (northern bog aster), *Eleocharis rostellata* (beaked spikerush), *Salix candida* (sageleaf willow), and various mosses (Fertig and Jones 1992).

On USFS land in Colorado, *Utricularia minor* is known from both poor and extremely rich fens as well as enriched seeps and beaver ponds. It occurs on the Routt, San Juan, and Grand Mesa national forests as well as on land adjacent to both the Pike and Roosevelt national forests. On the Routt National Forest, *U. minor* occurs in poor fen and marsh habitat associated with montane lakes. At one poor fen site with *U. minor*, the wetland is dominated by *Sphagnum* species and *Carex livida* (livid sedge) among other *Carex* (sedge) species. *Drosera rotundifolia* (round-leaved sundew), another carnivorous plant, also occurs at this site. At another fen, *U. minor* is growing in shallow water with *Spiranthes romanzoffiana* (hooded lady's tresses), *Pedicularis groenlandica* (elephanthead lousewort), *D. rotundifolia*, and *Eriophorum gracile* (slender cottongrass). On the Grand Mesa National Forest, *U. minor* grows in rich fen habitat characterized by *C. limosa* (Mud Sedge) Herbaceous Vegetation, a globally rare plant community (Carsey et al. 2003). *Carex limosa* (mud sedge) is dominant and associated species include *C. saxatilis* (rock sedge), *Menyanthes trifoliata* (buckbean), *Comarum palustre* (purple marshlocks), and *Sphagnum squarrosum* (sphagnum). *Utricularia minor* is currently documented from one location but was discovered in the vicinity in at least three other sites in similar habitat during 2004. On the San Juan National Forest, *U. minor* occurs in a small creek that is the outflow from a lake. The creek winds through an alkaline wetland with *C. viridula* (little green sedge). Adjacent to the Pike National Forest in South Park, Colorado, *U. minor* occurs in extremely rich fen habitat. The known occurrence occupies hollows within a fen fed by a constant flow of highly calcareous groundwater. It occurs near the head waters of High Creek Fen, the largest fen complex in South Park. Plant associations in which *U. minor* occurs include Bellardi bog sedge – Alpine meadowrue (*Kobresia myosuroides – Thalictrum alpinum*) Extreme Rich Fen, and Simple bog sedge – (Rolland bulrush) (*K. simpliciuscula* – (*Trichophorum pumilum*)) Extreme Rich Fen, globally rare natural community types tracked by the Colorado Natural Heritage Program. These associations form the hummocks that rise out of the rills and water tracks common in these unique wetlands. *Utricularia minor* tends to occur in the wet hollows between hummocks. Species associated with *U. minor* in South Park include *Salix candida* (sageleaf willow), *K. simpliciuscula* (simple bog sedge), *K. myosuroides* (Bellardi bog sedge), and many other calciphiles (Cooper 1996, Sanderson and March 1996, Cooper 1996, Carsey et al. 2003, Johnson and Steingraeber 2003). Near the Roosevelt National Forest, *U. minor* has been documented from an alkaline seep within a montane willow carr. Here, *U. minor* occurs in wet hollows between hummocks formed by Few-flowered Spikerush (*Eleocharis quinquefolia*) Herbaceous Vegetation, which is dominated by *E. quinquefolia* (spikerush) and *Triglochin palustris* (marsh arrowgrass).

On USFS land in Nebraska, *Utricularia minor* occurs on the Samuel R. McKelvie National Forest. It occurs in a slough along the Niobrara River. The site is a seepage meadow with cool, clear standing water. *Utricularia minor* is growing in an emergent marsh dominated by *Typha* (cattail) species and others. The Niobrara River has a meandering, braided channel with a mosaic of floodplain forest, oxbow/slough emergent marsh, and tallgrass prairie.

Habitat availability relative to known occupied habitat

The scale of available habitat for *Utricularia minor* can vary dramatically from site to site, depending on hydrological conditions. Further, *U. minor* appears to occur locally within sites in Region 2 and does not form large mats. The amount of available but unoccupied habitat has not been estimated or evaluated at any known location of *U. minor*. Furthermore, due to its diminutive stature and affixed, aquatic habit, *U. minor* is easily overlooked. Therefore, it is difficult to precisely evaluate available but unoccupied habitat and tease apart whether a lack of information confers absence. Extremely rich fens have been extensively inventoried in South Park in Colorado, and *U. minor* is known from only one location. It is possible that it has been overlooked at other fen sites, again due to its small stature and aquatic habitat.

Reproductive biology and autecology

Very little is known about the autecology or reproductive biology of *Utricularia minor*. Little is known about life history traits of *Utricularia* in general (Taylor 1989, Brewer 1999, Schnell 2002). *Utricularia* as a whole is presumed to consist of annuals or short-lived perennials (Schnell 2002) although little is known about the longevity of aquatic species. *Utricularia* *minor* is an aquatic perennial that over-winters via turions (vegetative hibernacula). It is a stress tolerator (Grime 2001) that grows in relatively stable, nutrient-poor habitat. Its primary mode of reproduction is presumably vegetative although its sexual reproductive features are largely unstudied. There is little or no information on phenology, reproductive success, or seed longevity for *U. minor*, and there have been no studies of pollinating vectors published for any aquatic *Utricularia* species (bird pollination has been noted for epiphytic *Utricularia* in South America). However, flower and pollen characteristics of the genus suggest pollination via insects. Trap mechanism, pollen characteristics, vegetative propagules, growth rates, and life history strategies will be discussed.

Trap mechanism

As mentioned previously, the trap mechanism is an intricate and well-studied biological feature in *Utricularia* (**Figure 2**). When the trap is set, the bladder is laterally concave in shape due to negative internal pressure maintained by active ion transport mechanisms in certain cell types (Sydenham and Findlay 1973). The trap is sprung when a trichome adorning the trapdoors is triggered. The springing of *Utricularia* traps is one of the two fastest plant movements known in the world (Sydenham and Findlay 1973, Juniper et al. 1989). Cinematography has shown that the trap door opens and shuts in approximately 1/500 seconds, but the exact time has yet to be unequivocally determined (Juniper et al. 1989). Resetting the trap requires energy from respiration (Sydenham and Findlay 1975, Sasago and Sibaoka 1985b). Mass flow processes remove water from the bladder lumen through bifid trichomes on the inner bladder surface near the door. The water then exits through the threshold (pavement epithelial cells) against which the trapdoor rests. In laboratory studies, traps begin to reset immediately after artificial springing; full reset processes take approximately 15 to 20 minutes or longer depending on temperature (Sydenham and Findlay 1973). When organisms are caught in the traps, materials are absorbed through quadrifid glands that filter the contents within the trap (Fineran and Lee 1975, Fineran and Lee 1980). Build up of presumably indigestible material, like chitin in invertebrate exoskeletons, decreases trap efficiency and is ejected with trap senescence. Trap longevity is approximately 32 days (Friday 1989). The fate of prey is still the subject of controversy. Although an uptake pathway has been elucidated (Fineran and Lee 1975, Fineran and Lee 1980) and it has been shown that aquatic *Utricularia* species take up considerable proportion of nitrogen and phosphorus from captured prey (Lollar et al. 1971), few digestive enzymes have been discovered to date in *Utricularia* species and evidence of bacterial digestion of prey within bladders is equivocal (Lloyd 1942, Juniper et al. 1989). Furthermore, "prey" at times have been observed to freely move within bladders for days (Richards 2001) while at other times they are consumed within 48 hours (Lloyd 1942).

Pollination

There are no studies of natural pollination vectors for any aquatic *Utricularia* species in North America. However, characteristics of both pollen and flowers of these species suggest the genus is insect-pollinated. Colporate apertures and tectate exine features of *U. minor* pollen grains are adaptations for insect pollination. Likewise, yellow-color and bilateral symmetry of *U. minor* flowers are also adaptations for insect-pollination (Raven et al. 1992).

Thanikaimoni (1966) observed that flowers of *Utricularia minor* produce only small amounts of pollen. *Utricularia* species often have both chasmogamous flowers (open) and cleistogamous flowers (never open, obligate self-pollination) (Juniper et al. 1989, Taylor 1989). To date, *U. minor* is known only to have chasmogamous flowers (Taylor 1989). There have been no studies on pollen viability or mating systems in *U. minor*.

Reproduction

There are no specific studies on reproduction in *Utricularia minor*. Reproduction in aquatic plants primarily relies on vegetative propagation (Barrett et al. 1993, Grace 1993). Mutation within reproductively isolated populations of *U. australis*, a free-floating aquatic species of bog pools in Japan, has been shown to result in both male-sterile and bisexually sterile populations. Male-sterile populations have no viable pollen, and bisexually sterile populations have neither viable pollen nor presence of ovules capable of developing seeds. These populations exhibit clonal dominance and are entirely comprised of one or few clones (Araki 2000). Genetic studies of populations showed variation between populations, but rarely within populations. Pollination experiments showed low rates of self-pollination as well as low rates of outcrossing, the primary reproductive mechanism being vegetative. Seed set within populations was poor, and seed and seedling survival was rare in natural populations (Araki and Kadono 2003).

The clonal dominance exhibited by *Utricularia australis* allowed study of metapopulation dynamics. Genetic analysis of 47 populations showed that genetic clones were distributed in a mosaic pattern across the landscape, evidence of dispersal of vegetative propagules (Araki and Kadono 2003). The dispersal mechanism proposed was transport via waterfowl.

The current knowledge of the distribution of *Utricularia minor* in Region 2 suggests that the majority of populations are reproductively isolated. Some unpredictable exceptions may occur given that waterfowl are hypothesized to be the primary dispersal mechanism for *Utricularia*.

Vegetative propagules

Turions are vegetative structures formed by many aquatic plant species to endure environmental stress (Winston and Gorham 1979a, Winston and Gorham 1979b, Juniper et al. 1989, Adamec 1999). They are modified shoot apices in which a small segment of stem tissue and tightly appressed leaves (with rudimentary bladders) are tightly twisted or telescoped within itself into a small globose or ovoid structure. This tight construction plus the presence of copious mucilage produced by gland-like trichomes allow survival through adverse conditions by achieving a dormant and protected state. The primary function of a turion is its role as a vegetative over-wintering structure. The term "winter bud" is often used, but this is technically an anatomical misnomer (Juniper et al. 1989). Turions also form in response to desiccation or drought (Adamec 1999), but this dormancy differs from that of over-wintering (Winston and Gorham 1979a). Turion formation induced by adverse growing conditions that occur during the growing season can be readily reversed once environmental conditions ameliorate. When favorable conditions return, the turion begins normal growth again. Dormancy involved in over-wintering is controlled by other internal factors such that growth will not happen even if conditions become favorable. This type of dormancy is triggered by daylength (Winston and Gorham 1979a). Processes involved in dormancy are intricately controlled and maintained by the balance of numerous plant hormones (Winston and Gorham 1979b, Villanueva et al. 1985). At the end of the growing season, turions form in response to decreasing daylength. This occurs when air temperatures are still warm, flowering is mostly completed, and fruit is being produced. Turions of most temperate *Utricularia* species are less dense than water; once released, they will float to the surface. By the time the parent plant decomposes in temperate regions, the surface is often covered with ice. Turions are green to black in color and will absorb solar radiation and melt pathways to the ice surface in early spring (Winston and Gorham 1979a). Turions of *U. minor* are buoyant but are maintained at the lake bottom by antler-like branched leaves that form a basket around the turion. When the parent plant senesces, it sinks and drags the turion and basket to the bottom with it. In autumn, the turion breaks free from the parent plant but remains entangled in the basket, which keeps it below the ice. The turion floats to the surface only after the basket decomposes (Adamec 1999). When water temperatures begin to equilibrate with air temperatures, turions will germinate and commence rapid apical growth to form new juvenile plants (Winston and Gorham 1979a).

Turions of various macrophytes have been found in the feathers of waterfowl. This is evidence of a dispersal mechanism for the vegetative propagules (Araki and Kadono 2003). It is also speculated that turions are transported in waterways (Victorin 1940) although this would be less of a factor for species, like *Utricularia minor*, which grow in slow moving or stagnant water.

Growth rates

Effects of various environmental parameters on growth rates of *Utricularia* species have been studied (Moeller 1980, Friday 1989, Juniper et al. 1989, Richards 2001, Pagano and Titus 2004). Friday (1989) demonstrated that growth rate in *U. vulgaris* was a function of air temperature and day length. She noted that plants emerge from dormant turions and develop fully functional bladders within two weeks and each leaf had several bladders of different ages. Individual leaves persisted on the plants for approximately 50 days while bladders senesced within 32 days. Trapping efficiency of bladders was greatest at one to six days and declined rapidly with bladders greater than 19 days old exhibiting few captures. Moeller (1980) studied *U. purpurea* at different depths in a thermally-stratified lake system. He showed uptake of mineral nutrients (i.e., nitrogen, phosphorus, calcium, magnesium, sodium, potassium) coincided with biomass production although not in over-wintering tissue. Biomass production was limited by total phosphorus.

Pagano and Titus (2004) showed increased relative growth rate in *Utricularia macrorhiza* (=*U. vulgaris*) with dissolved inorganic carbon enrichment. Carbon availability for photosynthesis in freshwater systems is dictated by pH (Wetzel 2001). Under acidic conditions, carbon dioxide is the prevalent form of carbon, and at higher pH levels, bicarbonate is available. However, *Utricularia* species are unable to utilize bicarbonate for photosynthesis (Juniper et al. 1989), so under basic conditions, availability of dissolved inorganic carbon may limit growth.

Although the actual digestion mechanism is still unclear, Friday and Quarmby (1994) traced mineral nutrient utilization in *Utricularia vulgaris* by hand-feeding prey labeled with ^{15}N (radioactively-labeled nitrogen) and ^{32}P (radioactively-labeled phosphorus) to leaves of known age under near natural conditions. Both elements were taken up rapidly within the plants. ^{15}N was preferentially translocated to newly growing areas of the plants, whereas ^{32}P was primarily back-translocated to older side shoot meristems and to flowers rather than allocated to newly growing tissue. It is speculated that carnivorous plants are able to assimilate nutrients in the form of proteins from prey, precluding a need to expend energy to assemble them via internal biochemical pathways (Juniper et al. 1989). However, this has not been tested.

Finally, Knight and Frost (1991) used reciprocal transplant experiments with *Utricularia macrorhiza* to demonstrate carnivory investment, measured as the number of bladders per leaf. When placed in more nutrient-rich environments, plants from oligotrophic ponds increased the number of bladders per leaf. Turions exhibited less flexibility; the plant had to fully expand (approximately one week) before it responded to the new environment, suggesting that starch reserves in the turion sustain the plant until bladders become fully functional.

Life history strategy

The life history strategy of *Utricularia minor* is considered to be that of a stress tolerator that exhibits some characteristics of competitive traits (Murphy et al. 1990, Weiher et al. 1994, Grime 2001). *Utricularia minor* exhibits stress tolerance in life history and physiological traits. For example, *U. minor* has intermittent flowering over its life span and devotes a small proportion of its resources to seed production. Physiologically, *U. minor* has a mechanism to store photosynthates and nutrients. *Utricularia minor* and all *Utricularia* species can opportunistically take up mineral nutrients, in the form of prey that is uncoupled from vegetative growth. Acclimation of photosynthesis, mineral nutrition, and tissue hardiness have been shown to change with seasonal differences in light and moisture supply in several aquatic *Utricularia* species (Moeller 1980, Knight and Frost 1991). *Utricularia minor* tends to occur in relatively stable, nutrient-poor habitats, and it grows with several other stress tolerant plant species. Competitive strategies include the ability to rapidly respond to environmental changes such as the alteration of bladder number per leaf (Friday 1989).

Hybridization

Utricularia minor has long been recognized as a species although it is quite similar to several other species. While no genetic work has been completed to verify morphological observations and hypotheses, it has been suggested that *U. ochroleuca* is the result of hybridization between *U. minor* and *U. intermedia* (Rossbach 1939, Ceska and Bell 1973).

Demography

Little is known about the population genetics of *Utricularia minor*, and there are no specific demographic data for this species in Region 2. Known populations in Region 2 are generally geographically isolated from one another although a few are within close proximity (**Figure 1**). A lack of information on population size and density, as well as an incomplete understanding of the distribution of this species, precludes any ability to address demographic questions and implications.

A generalized lifecycle diagram for *Utricularia minor* is found in **Figure 5**. The basic structure starts from seed germination and proceeds to juvenile vegetative plants (A), continues with the persistence and survival of juveniles to flowering (B), to the probability of successful pollination and seed set (C). Vegetative reproduction can occur in both vegetative and flowering plants as the formation of turions. V_1 represents the probability of environmental stress inducing turion formation, and V_2 represents the probability of mature plants forming turions due to progression of the growing season. Rates of mortality at various life cycle stages are represented by M_1-M_3. Without specific demographic studies on *U. minor*, probabilities of reaching and persisting at various stages are not known and can only be roughly estimated. To complete a population viability analysis, probabilities of survival through each life cycle stage would need to be determined.

Given a lack of specific information on the demography of *Utricularia minor*, general tenets of population viability analysis are applicable. As summarized by Nelson (2000), minimum viable populations (MVP) are those assumed to be large enough to maintain evolutionary potential in the face of

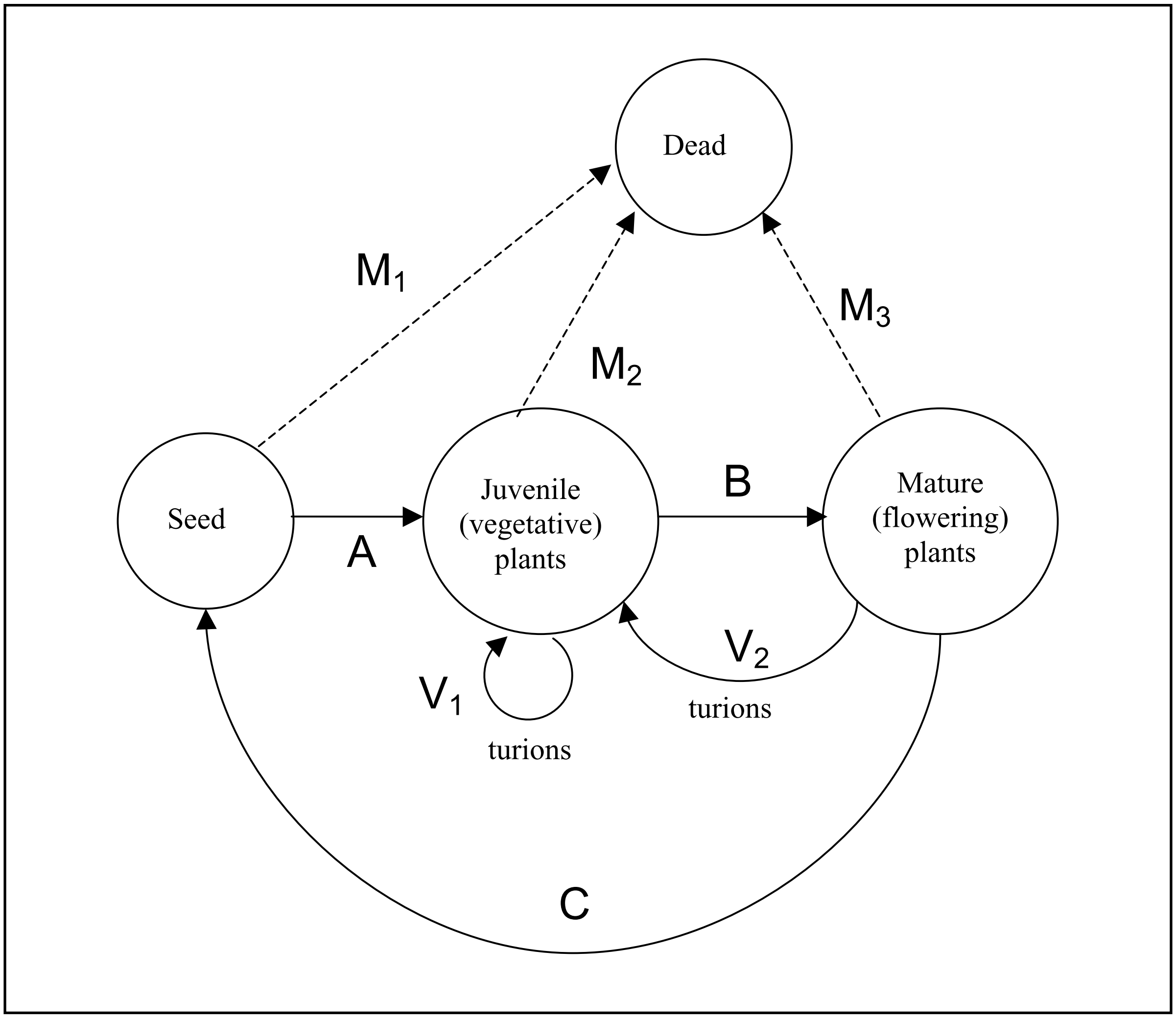

Figure 5. Generalized lifecycle diagram of *Utricularia minor*. Letters denote probabilities of reaching the next life cycle phase (A-C), probability of forming turions (V_1-V_2), or of mortality (M_1-M_3).

various stochastic risks. Four basic kinds of stochasticity are environmental stochasticity (the normal range of environmental variability at a site), natural catastrophe (disastrous local events affecting entire populations), demographic stochasticity (chance events affecting survival and reproduction of individuals), and genetic stochasticity (founder effects, inbreeding depression) (Menges 1991). Various estimates of MVP size are suggested by various authors (Frankel and Soule 1981, Menges 1991, Given 1994). Environmental stochasticity and natural catastrophe dictate MVP's substantially greater than demographic and genetic stochasticity. Suggested MVP for environmental stochasticity and natural catastrophe is one thousand to one million individuals. For demographic and genetic stochasticity, suggested MVP's are 50 and 50 to 500, respectively. As cited in Nelson (2000), Constance Miller, Geneticist for the USFS Pacific Southwest Research Station (Albany, CA) suggests that there is no rule of thumb for choosing absolute numbers for viable population sizes other than more is better. Miller assesses the value in classifying the four classes of stochasticity as providing a framework for evaluating different risks. Demographic and genetic concerns will be easily assuaged by conserving populations sufficient for surviving environmental and catastrophic stochasticity. However, given the possibility that many occurrences of *Utricularia* species are clonal, the genetic and demographic concerns may need to be addressed in another manner.

Community ecology

Utricularia species are presumably carnivorous plants; they trap other organisms in their bladders and are able to derive nutrients from them. However, evidence that *Utricularia* is an obligate carnivore is equivocal, and a digestive mechanism has yet to be elucidated. Knight (1992) summed up the current state of knowledge by noting that exactly how *Utricularia* benefits from carnivory is still a matter of contention. However, energetic cost of producing and operating bladders has been well-established, and it is assumed that the plant must receive some net return on its investment in order to persist.

A wide variety of organisms interact with *Utricularia*, but the exact nature of these interactions is yet to be determined. Organisms are trapped in the bladders of *Utricularia*. Some of the organisms are consumed in some fashion while others are not. Inventories of epiphytes have produced lists of diverse species assemblages, but it is unknown whether or how *Utricularia* may benefit from the relationships. Whether *Utricularia* species actively or passively attract organisms, both prey and periphyton, and how they may do so, are unknown save for one example involving *U. purpurea*. The example is a species-specific relationship that may shed light on the potential interaction between *Utricularia* and other organisms as well as more fully define its ecological niche. Whether *Utricularia* species have the ability to switch between mutualistic and carnivorous nutrient uptake has yet to be determined, but it is a viable hypothesis for their success in nutrient-poor environments.

Although there are no reports of what organisms may occur within traps of *Utricularia minor*, organisms observed within bladders of other aquatic *Utricularia* species include insect larvae, cladocerans, copepods, oligochaetes, rotifers, ostracods, paramecia, fish, algae, and vascular plants such as *Wolffia* species (Lloyd 1942, Roberts 1972, Meyers and Strickler 1979, Friday 1989, Richards 2001). Among animals, crawling and substrate-dwelling organisms are captured more frequently than swimmers (Meyers and Strickler 1979). Meyers and Strickler (1979) observed that organisms graze on epiphytes attached to bristles and antennae, and some organisms use them as a platform for filter feeding. Through experimental manipulation, branched antennae were shown to be twice as important as the filamentous bristles for enhancing capture rate. Thus, they showed that antennae and bristles serve as a funnel, directing organisms toward the bladder. Antennae and bristles vary greatly among *Utricularia* species. In aquatic species, these structures are considered to be elaborations of the trapping mechanism.

In assessing trapping efficiency of *Utricularia purpurea* in the Florida Everglades, Richards (2001) demonstrated that the number of occupied bladders increased exponentially with leaf age. Bladder contents included blue-green algae, diatoms, green algae, photosynthetic protists, as well as rotifers, copepods, cladocerans, and oligochaetes. The observation of several rotifers swimming freely within bladders, plus the ubiquitous presence of a cadre of "photosynthetic tenants," led her to hypothesize that *U. purpurea* exhibits mutualism rather than a predator-prey interaction. Thus, if *U. purpurea* benefits more from by-products of its internal community than from carnivory, it would play a role in the detrital link of the food chain. The microenvironment within bladders serves as a vessel to contain breakdown products and to prevent their diffusion, providing *Utricularia* with "a monopoly on released nutrients." Ingestion of organisms for direct mineral nutrition was deemed incidental. This hypothesis does provide a possible explanation for the fact that *Utricularia* occurring in more eutrophic habitats have greater investment in bladders. However, bladder investment by species in more nutrient-poor habitat, such as that occupied by *U. minor*, has been shown to decrease with increased nutrients (Sorenson and Jackson 1968).

Other studies have demonstrated a significant association between *Utricularia* species and epiphytic algae and other organisms (periphyton). In Tanzania, Wagner and Mshigeni (1986) showed that a wide variety of blue-green algae, diatoms, green algae, and microorganisms grew epiphytically on aquatic *Utricularia* plants as well as inside the bladders; the lacy structure of *Utricularia* leaves provided large surface areas for colonization. Although they found no blue-green algae free-floating in the lake water, seven genera were found associated with *Utricularia*. One species was found only epiphytically; three species were found both epiphytically and within bladders; three species were found only inside the bladders. The blue-green algae had twice the dry weight of the plants themselves. The authors hypothesized that *Utricularia* was benefiting from the nitrogen fixation of the cyanobacteria.

Similarly, Botta (1976) found nine species of cyanobacteria, plus a wide variety of other organisms within *Utricularia* bladders in Argentina. Animals within the bladders were digested, but algae survived inside the traps and were "released" when bladders and leaves decomposed. Certain green algae and protists (*Euglena* and *Ciliala*) were found in greater abundance inside the bladders than in the external environment, suggesting that bladders provide a favorable environment for these organisms. Woelkerling (1976) also found a greater diversity of periphyton (diatoms alone) associated with *Utricularia* relative to other aquatic macrophytes in both acidic and alkaline fens in Wisconsin. Further, *Utricularia* hosted greater population densities as well as greater species diversity. Weber and Whittman (2001) mention encrustations of diatoms on *Utricularia* species in Colorado.

The progression of colonization by epiphytic algae has frequently been observed and studied. Friday (1989) described a build up of epiphytic algae in *Utricularia vulgaris* growing in nutrient-poor environments in the United Kingdom. Within five days of turion emergence, sparse but continuous cover appeared; this was followed by thick coatings of diatoms, filamentous green algae, sessile rotifers, protozoa, chironomid larvae, and tubicolous caddis within 17 days. *Utricularia* and its associated periphyton share the same fate when environmental conditions worsen, which suggests a possible mutual relationship. Further, Brock (1970) demonstrated that epiphytic algae contribute significantly to primary production, but did not show a mechanism by which *Utricularia* may benefit from the increased productivity.

Ulanowicz (1995) proposed a positive feedback model to illustrate the self-maintenance of a niche for *Utricularia* species to persist and thrive in nutrient-poor environments that are otherwise marginal for non-carnivorous macrophytes. The model recognizes *Utricularia* and its associated assemblage of periphyton as a self-organizing unit in which *Utricularia* harnesses the production of periphyton, thus providing advantage to *Utricularia* over other macrophytes. Again, the model does not define a mechanism. The assumed feedback loop is such that *Utricularia* provides the physical substrate for periphyton growth. The periphyton is grazed by zooplankton, which provides nourishment for *Utricularia* when those organisms are consequently trapped. The model predicts that a moderate predation rate on zooplankton is optimal; too high of a predation rate leads to an increase in periphyton, which chokes out *Utricularia*. Although admittedly the model requires field testing to elucidate reasonable parameters to ground its assumptions, it does suggest that *Utricularia* benefits from a certain level of periphyton growth and that as nutrient levels increase in the environment, the advantage gained by this positive feedback lessens to such a degree that at a certain threshold *Utricularia* will be outcompeted by non-carnivorous macrophytes, a phenomenon demonstrated repeatedly as will be discussed later.

Attraction of organisms to *Utricularia* bladders has been the subject of much conjecture. Juniper et al. (1989) speculates that the translucence of the trapdoor may attract organisms. While the walls of the bladder contain chlorophyll, the door does not, and the differential light transmission is proposed to act as a spotlight that may attract organisms. Olfactory attractants have also been hypothesized but have yet to be isolated and tested for specificity. However, Wallace (1978) did find a species-specific chemotactic response by larvae of the sessile rotifer *Ptygura beauchampii* to a chemical produced by *U. macrorhiza* (=*U. vulgaris*). As a sessile rotifer, *P. beauchampii* is restricted to its substrate based on larval selection of habitat. *Ptygura beauchampii* larvae colonized the area behind the 3-celled glandular trichomes that cover and surround the trapdoors of the largest bladders of *U. macrorhiza*. They never attached to *U. gibba*, *U. inflata*, or *U. purpurea* plants growing in close proximity. Studies of the distinct stages of development of the glandular trichomes indicate that the trichomes produce both mucilage that covers the gland surface and an allelochemical stimulant that is maintained in the mucilage. As prey capture by *Utricularia* is unaffected by rotifer colonization, a commensal relationship between *P. beauchampii* and *U. macrorhiza* is hypothesized; the trapdoor provides *P. beauchampii* refuge from predation, as aquatic insects that would eat *P. beauchampii* are consumed by the *Utricularia* trap before reaching the rotifers. Predators were found in the traps while a thriving sessile rotifer population remained on the trapdoor. Loss of rotifers dislodged by water suction or by abrasion during prey capture was minor relative to predation on non-refuge substrates. Further, prey discrimination by *U. macrorhiza* was documented as *P. beauchampii* larvae were observed touching trigger hairs without consequence. Also, adult *P. beauchampii* attach to trigger hairs if the door area is densely crowded. The specificity of the kairomonic (cue for larval settlement; Brown et al. 1970) allelochemical stimulant is proposed as a potential mechanism for niche separation between sympatric *Utricularia* species. Such specificity allows different species to attract and utilize different prey species. Similar niche separation has been documented for pitcher plant (*Sarracenia*) species (Juniper et al. 1989).

There are no documented diseases of *Utricularia* species recognized from natural environments. Powdery mildew infection of *Utricularia* has been documented in greenhouse environments (Lebeda et al. 2001). Aphids have been observed attacking inflorescences of *U. inflata* and *U. purpurea* in Florida and *U. macrorhiza* in California (Rice personal communication 2005).

CONSERVATION

Threats

Direct threats to *Utricularia minor* are hydrologic impacts and invasive species. Indirect threats include land use practices that impact water quality and habitat integrity, such as hydrologic alteration, peat mining, livestock grazing, and fire (catastrophic). Global climate change is a serious potential threat to fen habitat occupied by *U. minor* and will be discussed. As more details about the biology and ecology are elucidated, additional threats may be identified that supercede or augment those presented here.

Impacts to hydrology

As an aquatic species, the greatest threat to the persistence of *Utricularia minor* is an impact to the hydrology of the wetland in which it occurs. Impacts to hydrology include degradation of water quality and hydrologic alteration. Degradation of water quality can occur through nutrient loading, cattle grazing, or peat mining, among others. Hydrologic alteration encompasses any impact to how water flows through wetland systems or to the water balance supplied by surface and groundwater. Hydrologic alteration can occur through straightening or diverting streams, ditching, reservoir creation, or any land use changes that increase runoff. Increased runoff from road building, timber harvest, blowdowns, or wildfires can increase turbidity and sedimentation, both of which can be detrimental to *U. minor* occurrences. Some hydrologic alteration may result in habitat loss.

Degradation of water quality eliminates occurrences of *Utricularia minor* and other aquatic *Utricularia* species. Field observations of *U. minor* and *U. macrorhiza* populations show a decline or localized elimination of populations with trampling by cattle, humans, or motorized vehicles (Austin field survey 2004, Rice personal communication 2004). The mechanism of this decline is unclear, but *U. minor* does not appear to tolerate certain levels of turbidity. It is not known how much turbidity *U. minor* can tolerate nor how long such conditions must persist before occurrences of *U. minor* are impacted. However, as trampling by cattle has eliminated populations of *U. macrorhiza*, a species that is less sensitive to environmental perturbation than *U. minor*, within one growing season (Rice personal communication 2004), impacts to *U. minor* may be greater.

Livestock grazing has demonstrably impacted wetlands in Colorado (Sanderson and March 1996, Austin field survey 2004). Trampling by cattle degrades surface water quality through sheet, rill, and bank erosion, which increases turbidity. Although cattle tend to avoid the softest, wettest substrate areas, their trampling has impacted local populations of *Utricularia minor* in Region 2. Greater impacts from grazing have been noted in smaller fens in Colorado that have more limited groundwater resources (**Table 1**). Larger fens generally are not utilized as heavily by livestock if sufficient pasture is available (Sanderson and March 1996). Disturbance to peat soils by trampling also creates opportunity for invasive plants, like Canada thistle (*Cirsium canadensis*) and purple loosestrife (*Lythrum salicaria*), which will be discussed below.

Although the exact mechanism is unclear, nutrient loading is known to eliminate populations of aquatic *Utricularia* species. Chiang et al. (2000) added nutrients (nitrogen and phosphorus in separate experiments) to wetland systems in the Florida Everglades. *Utricularia macrorhiza* biomass declined by 90 percent within the first year and was eliminated within three years. Similarly, lake liming practices to support fisheries severely decreased percent cover of *U. purpurea* in New York (Weiher et al. 1994). In each case, *Utricularia* species were replaced by other macrophytes. The decline of *Utricularia* as nutrient levels increase is predicted in the positive feedback model of Ulanowicz (1995). Nutrient loading also results from soil erosion and from municipal and agricultural runoff.

All wetland habitat occupied by *Utricularia minor* is threatened by hydrologic alteration. Any change in water quality or quantity affects these habitats. Fens tend to be more susceptible to impacts than seeps and marshes although all are adversely affected. Alterations can result from either anthropogenic or natural causes. Straightening or diverting streams, ditching, building stock ponds and reservoirs, and road building alter both water flow through wetland systems and the proportion of water supply between groundwater and surface flow. Alteration to vegetative cover within the watershed can increase the amount of surface flow into associated wetlands. For fens especially, shifting the balance between surface and groundwater sources can be detrimental. Pumping groundwater for municipal use may also alter the hydrology of wetland systems by lowering the water table and decreasing the amount of groundwater flowing to wetlands.

Straightening or diverting streams and ditching moves water through these systems more efficiently and can lead to drying out of the wetlands. This can ultimately result in habitat loss. Ditches and diversions can lower the water table. This can directly dry out pools, hollows, and shallow water areas occupied by *Utricularia minor*. It also may alter vegetation composition within the wetland since lowering the water table can allow shrubs to colonize areas previously occupied by more hydrophytic herbs (Glaser et al. 1981). As *U. minor* is primarily found in open, shallow water habitat, increased shade from shrubs may be detrimental to *U. minor* occurrences over time.

Creation of reservoirs inundates vegetation and dramatically changes the hydrology of wetland systems. Such inundation destroys the intricate balance of water chemistry that maintains fens. Furthermore, if peatland vegetation is grounded (as opposed to occurring on a floating mat), flooding will destroy the vegetation and the microhabitats within it that are occupied by *Utricularia minor*. As an affixed aquatic species that grows in shallow water, flooding can destroy habitat depending on the geomorphology of the basin. If shorelines are not gentle, shallow slopes, then *U. minor* is unlikely to establish or persist as the water levels may become too deep. Livestock ponds are smaller versions of the same impact. Although they potentially could increase shallow water habitat, the impact of livestock trampling makes colonization and habitat unsuitable.

Transportation corridors near or in wetlands alter site hydrology. Roads near wetlands can increase and intensify water flow due to the runoff from relatively impervious surfaces. This reduces percolation and aquifer recharge as well as increases erosion, which degrades water quality (Forman and Alexander 1998). Alternatively, roads can also impede drainage, backing up water flow and increasing surface water levels. This has occurred at Swamp Lake in Wyoming where a culvert was placed above local water levels during highway reconstruction and has potentially increased water retention in the lake basin (Heidel and Laursen 2003). If water retention is increased beyond shallow depths, *Utricularia minor* may be adversely impacted.

Disturbance within the watershed can also affect hydrology and water quality in wetlands. Deforestation in the immediate vicinity of wetlands can increase surface runoff and cause erosion, which in turn alters nutrient cycles and hydrologic regimes, and increases sedimentation and turbidity. Forest fires have had similar effects on surface water quality. A forest fire in the Clarks Fork Ranger District on the Shoshone National Forest in Wyoming burned much of the Swamp Lake watershed in 1988. Debris flows from subsequent erosion have had notable impacts to the wetland below including increased sedimentation and detrimental changes in water quality (Heidel and Laursen 2003). Likewise, the Hayman Fire in Colorado has increased sediment loads reaching the South Platte River in the southeastern portion of Park County, Colorado (Pikes Peak Area Council of Governors 2004). The impact of the Hayman Fire can serve as a model for how forest fires affect erosion and the consequent impact on water quality.

Groundwater removal is implicated as a primary threat to extremely rich fens (Sanderson and March 1996), but this applies to seeps and poor fens as well. Drought has exacerbated this threat; loss of surface water leads to a greater reliance on groundwater resources, which themselves are noticeably lower due to drought. Groundwater pumping has not yet had a measurably significant impact to water sources feeding fens in portions of Region 2, but it remains an important long-term threat that will require monitoring (Sanderson and March 1996).

Peat mining can detrimentally impact peatlands. It destroys fen habitat through removal of substrate and irrevocably alters its hydrology. These effects alter soil and groundwater chemistry and impair wetland functioning (Johnson 2000). Peat mining reduces vegetation cover and species richness, alters species composition and edaphic properties, and eliminates microtopography. The elimination of microtopography removes hollows that are the primary microhabitat within fens where *Utricularia minor* occurs. Due to its slow accumulation rates (10-41 cm per 1,000 years; U.S. Fish and Wildlife Service Region 6 1997), it is questionable whether peat should be considered a renewable resource.

Peat mining has significantly impacted potential habitat of *Utricularia minor* in Region 2, where commercial peat mining is permitted and ongoing only in Colorado (USDI Bureau of Mines 1994, U.S. Fish and Wildlife Service Region 6 1997, Colorado Division of Minerals and Geology 2004). Peat is primarily mined for horticultural use, to be sold as mountain peat, as well as to reclaim land for pasture and to create fishing ponds (Cooper and MacDonald 2000, Sanderson et al. in prep). However, the purchase and use of mountain peat has been boycotted in Colorado by the Denver Water Board, Colorado Garden Club, and others. The boycott is based on the poor quality of mountain peat as a soil amendment in addition to the recognition that the mining practices destroy critical and sensitive habitat (U.S. Fish and Wildlife Service Region 6 1997).

Invasive species

Although no exotic invasive species have been noted in *Utricularia minor* populations in Region 2, appearance of certain invasives would be cause for concern. Due to the relatively harsh growing conditions in fens, this type of habitat is less susceptible to invasion by exotics if the system is functioning naturally. However, the marsh and slough habitat occupied by *U. minor* in portions of Region 2 can be highly susceptible to certain invasive species. Appearance of purple loosestrife or non-native strains of *Phragmites australis* (common reed), *Phalaris arundinacea* (reed canarygrass), or cattail species would be of concern. These species are aggressive colonizers that are difficult to eradicate once established at a site. Non-native, invasive, aquatic species are also an insidious threat to populations and habitat of *U. minor*. Species like Eurasian water milfoil (*Myriophyllum spicatum*) and waterthyme (*Hydrilla verticillata*) can expand rapidly within freshwater systems and form dense mats that choke out other macrophytes. Waterthyme is yet to be detected and documented in Region 2, but it is on the noxious weed list in Colorado (USDA Natural Resources Conservation Service 2004). Both the wawterthyme and Eurasian water milfoil reproduce vigorously via vegetative propagation and can grow profusely from small plant fragments. Control of these weeds is difficult, and eradication is currently not possible without causing detrimental effects to the system. Displaced or unnatural expansion of native species may also be of concern. *Utricularia inflata*, which is native to the eastern United States, has been introduced in the Pacific Northwest where it is aggressively colonizing many wetlands where favorable conditions for this species exist. This is also happening in its native range (Rice personal communication 2005). This type of invasion has the potential to displace *U. minor* populations. Control measures devised for non-native infestations of *U. inflata* may impact *U. minor* (Rice personal communication 2004).

Certain hydrologic alterations may create more favorable conditions for exotic plant invasion. Drawdown of water table and consequent drying of the soil may allow less hydrophytic species to colonize and establish. Nutrient loading from fertilizer or pollutant run-off can alter the pH of a fen and make it more vulnerable to invasion.

Global climate change

Although global climate change is possibly the most serious threat to the wetland habitat in Region 2, it is found last on the list of priority threats because of the uncertainty about its regional effects and severity. Global climate change is likely to have wide-ranging effects in the near future for all habitats, but the direction of projected trends is yet to be determined and predictions vary based on environmental parameters used in predictive models. For example, Manabe and Wetherald (1986) demonstrate projections based on current atmospheric CO_2 trends that suggest that average temperatures will increase while precipitation will decrease in the West. However, Giorgi et al. (1998) showed that temperature and precipitation increased under simulated doubling of atmospheric CO_2 levels. Either scenario could significantly affect the hydrology of wetlands, especially fens, in Region 2. Changes in precipitation patterns would also affect wetlands. Decreased precipitation will dry out the water sources and make the wetlands susceptible to invasion by shrubs, trees, and less hydrophytic herbs. Increased precipitation will impact rich and extremely rich fens to a greater degree than poor fens or marshes. Increased precipitation may lessen the aridity of climate that maintains the high concentrations of minerals in extremely rich fens through evaporation (see Cooper 1990 as cited in Sanderson and March 1996). Adjustment in element concentrations can subtly alter substrate pH and make fens a less harsh environment and more available to competitive species.

Conservation Status of <u>Utricularia minor</u> in Region 2

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

Although no specific prescribed monitoring of individual populations of *Utricularia minor* has occurred in Region 2, the distribution and abundance of *U. minor* habitat can be considered to be in decline. Habitat degradation and loss of wetland habitat has been well-documented; the rate of wetland habitat loss in recent decades in the continental United States is estimated at 58,500 acres per year (Dahl 2000. Within Region 2 states, approximately 39 percent of original wetland habitat is estimated to have been lost. Wetland loss has been specifically characterized in South Park in Colorado, where water diversion has caused desiccation and reservoir creation has caused inundation (Sanderson and March 1996).

Do habitats vary in their capacity to support this species?

It is unknown whether habitats vary in their capacity to support *Utricularia minor*. This species occupies a small variety of habitats from poor fens, enriched fens, and alkaline seeps to marshes and sloughs. The unifying characteristic of the microhabitat within these habitats is the presence of shallow water. This niche can be more distinct in peatlands where pools, hollows, and water tracks tend to be relatively stable due to slow velocity of water flow through the system. This niche may be affected by succession within the habitat; it may be filled in as peat or sediment accumulates within particular sites. Smaller fens and marshes are subject to greater edge effects and possibly to greater fluctuations in water levels that preclude sufficient peat development.

Although not within Region 2, the unique geothermally-influenced habitat in Yellowstone National Park supports large populations of *Utricularia minor*. Whether this may be a function of the size of the wetland complexes or related to the geothermal influence is unknown.

Vulnerability due to life history and ecology

The lack of specific knowledge of life history stages, successional status, dispersal mechanisms and distance, and environmental niche occupied by *Utricularia minor* precludes specific statements on the vulnerability of the species to demographic or environmental stochasticity. However, the decline of *U. minor* and many aquatic *Utricularia* species in response to water quality alteration or degradation has been well-documented.

Certain habitat types occupied by *Utricularia minor* are vulnerable to habitat alteration and environmental stochasticity. The fen habitat occupied by *U. minor* is limited in its distribution and abundance. It is also sensitive to any impacts in hydrology as well as to certain land uses such as grazing as reviewed in the Threats and Community ecology sections of this document.

Evidence of populations in Region 2 at risk

Currently there is no evidence that known occurrences of *Utricularia minor* in Region 2 are at risk due to land management. However, any land use or activity that degrades water quality may impact populations of *U. minor*. The population at Skinned Horse Reservoir on the Grand Mesa National Forest may be threatened by water quality degradation from cattle trampling and ATV use. Expansion of the reservoir is also a potential threat (Austin field survey 2004). At Swamp Lake Special Botanical Interest Area, surface water levels are increasing due to a new culvert being placed above local water levels during highway reconstruction (Heidel and Laursen 2003).

Management of <u>Utricularia minor</u> in Region 2

Implications and potential conservation elements

Populations of *Utricularia minor* in Region 2 are probably the most vulnerable to changes in water quality. Management activity that maintains the natural hydrologic regime and prevents water quality degradation will benefit populations of *U. minor*; projects designed to avoid undesired hydrological modifications are preferable. Regulation of hydrologic modifications and resource consumption as well as monitoring of domestic grazing, ATV use, timber harvest, and road building adjacent to wetlands with *U. minor* may mitigate potential impacts. Unfortunately, hydrologic modifications are common throughout the range of *U. minor* in Region 2 where water is an important commodity and drainage has been altered for a variety of historic and modern land uses. Natural environmental changes can affect the wetland and fen habitat of *U. minor* in Region 2. Natural disturbance, such as forest fires, within watersheds occupied by *U. minor* can alter hydrology, which may be detrimental to its persistence. In these areas, land management policies focusing on the mitigation of these effects where at all possible would be beneficial. For example, detrimental effects from domestic grazing can be mitigated by fencing wetland areas including an upland buffer, to prevent any soil erosion into the wetland, and by providing alternative water supply structures (Pikes Peak Area Council of Governors 2004). Any land management strategies that focus on maintaining or restoring natural hydrologic regimes would be a positive contribution to the conservation of *U. minor*.

Desirable environmental parameters for freshwater marsh and fen systems, and thus *Utricularia minor* populations, are outlined by Rondeau (2001). The most important feature for the persistence of these wetland types is an intact natural hydrological regime ideally in a large area of unfragmented habitat that is comprised of unmodified natural ecological systems. Several authors describe desirable vegetation composition and structure of extremely rich fens (Cooper 1996, Carsey et al. 2003, Johnson and Steingraeber 2003) and marshes (Rondeau 2001, Carsey et al. 2003). Wetlands that have similarly high diversity of native species are desirable. An intact natural hydrologic regime is indicated by a site with little or no evidence of wetland alteration, and no drainage modifications, mining, clearing, or unnatural nutrient inputs. In fens, certain native species increase with disturbance or with changes in hydrology or nutrient status (e.g., *Deschampsia cespitosa* and *Carex aquatilis*). These species naturally occur in fens at a particular frequency and abundance typical of diverse communities. If these species are present in expansive stands, it may indicate hydrologic alteration. Unfragmented habitat is where roads or other anthropogenically-induced fragmentation is very limited (ideally impacting less than 1 percent of the wetland). As discussed in the Threats section, transportation corridors and any kind of development can alter the hydrology of an area and impede water flow connecting wetland complexes. A surrounding landscape that is free of recent clearcuts, mining activity, heavily grazed pasture, or roads or municipal development will eliminate the potential impacts to wetland habitat for which these land uses are implicated.

Tools and practices

Species and habitat inventory

Ideally, species inventories would thoroughly search all potential habitats, locate and map all populations, accurately census each population, and repeat this effort at regular intervals. Because this process is usually prohibitively expensive and time consuming, especially for aquatic plants, inventory work normally concentrates on obtaining reasonable estimates of population numbers and species distribution. Inventory methods based on a standard, repeatable protocol suitable for the scale and purpose of the project are desirable. The National Park Service Guidelines for Biological Inventories (National Park Service 1999) provides an excellent protocol for both species and habitat monitoring. Elzinga et al. (1998) is another comprehensive reference on monitoring plant populations. Brand and Carpenter (1999) devised a vegetation, habitat, and groundwater monitoring program for High Creek Fen in Colorado, which can serve as a model for *Utricularia minor* monitoring. The New York Natural Heritage Program has also developed field forms expressly for surveying aquatic plant communities (http://www.dec.state.ny.us/website/dfwmr/heritage/).

Personnel who conduct the surveys optimally would be familiar with *Utricularia* taxonomy and *U. minor* identification, as well as detailed methods of soil and habitat characterization, and able to use topographic maps and/or GPS units for accurate data collection of location and population and habitat extent. Recognizing that the extremely wetland habitat that supports *U. minor* is sensitive to perturbations, care should be taken to limit trampling of these fragile areas during surveys. Sharing information about the extent of occurrences and critical habitat characteristics will prevent duplication of survey effort and will allow multiple stakeholders (e.g., state and federal agencies, natural heritage programs, local and regional experts, interested members of the public) to devise protection and management strategies.

Vegetative characteristics are diagnostic for *Utricularia minor*, but floral characters, which are also easier to observe in *U. minor*, make identification unequivocal. However, flowering in *U. minor* is rare and varies with geographic location as well as within a site (Rice personal communication 2005). Inventory efforts need not take place while plants are flowering. Collecting detailed data on population size is extremely difficult and time consuming due to the affixed, aquatic habit of *U. minor*. However, even rough population estimates based on spatial extent would be useful as baseline information from which to begin to determine population trends.

Many populations of *Utricularia minor* have not been revisited. Ideally, these populations would be revisited by trained professionals who are familiar with the nuances of *U. minor* identification. Collection of voucher specimens has occurred at all known occurrences except for new sites on the Grand Mesa and San Juan national forests. Extreme care should be taken when surveying for *U. minor* as impacts to water quality from trampling are detrimental to the plants, and maneuvering within the site can be difficult for surveyors.

Population monitoring

Information on basic population size, structure, and density is lacking for *Utricularia minor*. This information plus parameters of spatial distribution within habitats would be helpful in developing an appropriate monitoring plan for *U. minor*. A population monitoring program that addresses growth patterns, recruitment, seed production, plant longevity, and population variability would generate data useful to managers and the scientific community. Population monitoring would allow the detection of population trends under different management prescriptions and land use patterns. Monitoring the different types of habitat occupied by *U. minor* under a variety of land use scenarios will help to identify appropriate management practices for this species throughout Region 2 and will help managers to understand its population dynamics and structure.

Quantitative data from annual monitoring of established plots or transects over the course of several decades would be a useful method of generating information on population dynamics of *Utricularia minor*. Commitment to such a long time frame is suggested since so little is known about basic life cycle parameters of *U. minor*. The frequency of monitoring is suggested due to the observed sensitivity of *U. minor* to changes in water quality. Furthermore, portions of the habitat of *U. minor* in Region 2, extremely rich fens, are under high development pressure; the South Park population should be visited as often as possible in order to note any environmental perturbations prior to any subsequent impact on *U. minor*. Also, at certain locations (e.g., the vicinity of Skinned Horse Reservoir), fens have dried up due to the prolonged drought. Frequent monitoring during these conditions will provide information on the behavior of populations under extreme stress and elucidate tolerance levels that may inform management under less stressful environmental conditions.

Habitat monitoring

For sites with *Utricularia minor*, habitat monitoring would ideally be conducted concurrently with population monitoring. Monitoring only habitat is preferred to no monitoring if population monitoring is deemed too costly or time consuming. The fen and alkaline seep habitat types of *U. minor* often support other regionally rare species and communities; habitat monitoring would be the most efficient way to detect impacts and population trends for a suite of important biological resources. Monitoring the water table and water chemistry would be useful for this species. Documenting the scope and severity of any habitat disturbance would also be useful for documenting potential impacts to *U. minor* populations. Correlation of this sort of habitat information with population trends would greatly enhance our present understanding of the habitat requirements and management needs of *U. minor*.

Habitat monitoring of sites with known populations of *Utricularia minor* will alert managers to any new impacts from grazing or recreational use. Early detection of damage will allow proactive management changes to be implemented in time to prevent serious damage to *U. minor* populations. Demographic response to changes in environmental variables may not be immediate; repeated sampling of select environment variables may help to identify underlying causes of population trends. Geographic Information System (GIS) technology can provide a powerful tool in the analysis of the scope and severity of habitat impacts.

Beneficial management actions

At the species level, continuing to list *Utricularia minor* as a sensitive species will maintain an effective conservation tool for this species. The primary consideration for any management action in or around *U. minor* habitat is to prevent degradation of water quality and to preserve the natural hydrology of the wetland containing the occurrence as well as its surrounding watershed. In general, management actions that maintain the hydrology of wetlands and promote natural levels of connectivity between them will tend to benefit occurrences of *U. minor*. Implementing and improving standards and guidelines in USFS Land and Resource Management Plans, as well as changing management area allocation to one with more protection, would likely help the conservation status of *U. minor*. In order to minimize anthropogenic disturbance to *U. minor* habitat, limiting or eliminating grazing access by domestic animals whenever possible will decrease trampling of sensitive wetland habitat. Careful scrutiny of the effects of off-road vehicle use in the immediate habitat and in the surrounding watershed may reveal a potential need for restricting this recreational use in these areas due to adverse hydrologic impacts. Likewise, evaluating the effects of other management activities, such as logging, mining, road construction, and ditching or other water diversions that may impact hydrology and/or cause sedimentation of wetland habitat, both in the immediate habitat as well as the surrounding watershed is warranted. Creation of buffers or no-management zones surrounding wetlands may be appropriate. Investigating land exchange or purchase with willing partners as well as the designation of additional protected areas that are managed for the conservation of *U. minor* may be useful conservation strategies for this species.

Information Needs

Distribution

The distribution of *Utricularia minor* in Region 2 is not well-understood. This species is documented from a variety of wetland types, all of which are known to be more widespread than the current known distribution of *U. minor*. Given its general habitat parameters, there is a great deal of potential habitat. The diminutive stature and affixed, aquatic habit of *U. minor* makes it easily overlooked. Therefore, it is difficult to precisely evaluate available but unoccupied habitat and tease apart whether a lack of information confers absence. More specific information on the niche(s) occupied by *U. minor* will assist in estimating or evaluating the amount of available but unoccupied habitat at known locations of *U. minor* as well as more specifically target future inventory efforts.

Peatlands receive considerable inventory attention, but they are inherently difficult environments to survey comprehensively, especially the wet pools occupied by *Utricularia minor*. However, systematic survey of wet hollow microenvironments in known peatlands should be performed to confirm presence or absence and aid in discerning any more specific niche occupied by *U. minor* in Region 2. Extremely rich fens have been inventoried in South Park in Colorado (Cooper 1990, Cooper 1996, Sanderson and March 1996, Johnson and Steingraeber 2003), and the Swamp Lake site has been mapped and characterized in Wyoming (Fertig and Jones 1992, Heidel and Laursen 2003). *Utricularia minor* is known from only one location in extremely rich fen habitat in Colorado. It is possible that it has been overlooked at the other known sites. Until the distribution of *U. minor* is confirmed with more confidence, the true degree of its rarity in Region 2 cannot be known. However, regardless of how widespread it may be, *U. minor* is sensitive to changes in water quality wherever it may occur.

Lifecycle, habitat, and population trend

No phases of the life cycle of *Utricularia minor* have been characterized or quantified except for turion formation (Adamec 1999). No information exists for *U. minor* on phenology of flowering, pollination vectors, pollen viability, mating systems, reproductive success of flowers, seed viability and longevity, or on viability parameters for turions, juveniles, and adult plants. Priority should be given to the investigation of flowering phenology and pollinators. Phenology parameters will aid in planning inventories during the field season, and elucidating pollination vectors will add valuable information on conservation measures to protect this species. Also, investigating the relative importance of reproduction through vegetative growth compared to sexual reproduction in this species will have important implications for the population dynamics and persistence of the species. It will also inform the development of appropriate inventory methods for this species. Further, addressing the degree to which *U. minor* may rely on other organisms for its survival or persistence at a site would provide useful information.

The specific niche occupied by *Utricularia minor* within both montane fen and freshwater marsh ecological systems has been observed but not specifically studied. Research that focuses on clarifying the exact hydrologic, chemical, and microtopographic tolerances of the species, and how to recognize these in the field would be informative. *Utricularia minor* is also found in beaver ponds. However, the successional stage or stages occupied by *U. minor* are unknown in Region 2, and elucidating its position along this pathway will provide information on how to address occurrences in beaver pond habitat relative to other habitat types. It will also illustrate whether *U. minor* can be expected to persist in this type of habitat, and, if so, whether a complex of functioning beaver wetlands is necessary for long-term occupancy at a site.

Characteristics of the fen habitat where *Utricularia minor* is found are well-documented. However, the intricacy of interaction among environmental parameters is still under investigation. These characteristics are complex and require continued study in order to achieve a comprehensive understanding from which to devise conservation strategies.

Response to change

Utricularia minor declines in response to degradation of water quality, but it is not known why. Investigation of tolerance limits to turbidity and changes in water chemistry is necessary in order to understand the impact that management actions and natural disturbance may have on populations of *U. minor* in Region 2. Variation in environmental parameters may affect plant growth, reproductive rates, dispersal mechanisms, and probability of establishment to an unknown degree. It may also affect the composition of epiphytic organisms as well as potential prey species that may play a role in sustaining populations of *U. minor*. Without knowing these effects, implications of habitat change in response to management or disturbance are difficult to evaluate. Detailed information on the microhabitat requirements of *U. minor* will provide a basis for understanding the potential effects of disturbance and management actions.

Metapopulation dynamics

As the distribution of *Utricularia minor* is elucidated further, implications of metapopulation dynamics may become important. For example, if *U. minor* is discovered in additional extremely rich fens in South Park, it is likely that subpopulations would have some interaction that may be important to maintain. Metapopulation dynamics may be different for populations in South Park, a large intermountain basin, than they would be for clusters of kettlehole ponds in forested areas. Investigation of pollinators, mechanisms for seed and turion dispersal, as well as requirements for establishment of both seeds and turions is necessary for a full understanding of metapopulation dynamics for *U. minor*.

Demography

There is currently no information on the demography of *Utricularia minor*. Investigations of vital rates of recruitment, survival, lifespan of individuals, proportion of populations that reproduce as well as environmental factors that influence these life history traits are necessary for addressing demographic questions. Assessing the genetic variability within populations and of possible metapopulations is also of interest. Analysis of factors that limit population growth, including competition and lack of prey or potentially mutualistic organisms, would provide information regarding the persistence of *U. minor* at particular sites.

Population trend monitoring methods

Population sizes of *Utricularia minor* occurrences from both within and outside of Region 2 range from tens of plants to thousands of plants. Dense populations of vegetative plants may be difficult to estimate, especially in aquatic plant species. Line intersect methods have been used for fine-leaved and branched aquatic plants with success (Sidorkewicj and Fernandez 2000) and may be useful for evaluating large populations of *U. minor*. As *U. minor* grows in shallow water, plants can be readily counted by wading or perhaps from a boat without destructive sampling. However, excessive trampling of the habitat during the process of sampling may be detrimental to local water quality. Care should also be taken by the observer as these habitats can be difficult to navigate on foot.

Restoration methods

Very little is known about restoration of aquatic plant communities; restoration efforts in aquatic systems have primarily focused on animal components. As *Utricularia minor* persists in areas where water quality is maintained, its presence may be useful as an indicator of achieving water quality goals where it occurs. However, the sporadic distribution of this species hinders its reliability as an indicator since its absence would not necessarily indicate poor water quality. This relationship with water quality would mean that *U. minor* would not be an initial component in any restoration plan, but instead would require introduction after the restoration was complete. Reciprocal transplant studies have shown differences in the ability of whole plants versus vegetative propagules to adjust to new environmental conditions. This may be a factor to consider if such action were to be taken. Relationships of *U. minor* to epiphytes and to potential prey would also need to be considered in any restoration effort.

More is known about restoration of the habitat occupied by *Utricularia minor*. For example, certain impacts to fen habitat of *U. minor* are dire and cause irreparable damage considering reasonable time frames and budgets of most restoration efforts. Peat mining causes severe damage to the substrate and hydrological dynamics at fen sites in South Park, Colorado. Sanderson et al. (in prep) describes restoration protocols attempted for restoring fen habitat after peat mining. The peat was regraded, seeds were broadcast, and limited live plant material was transplanted over the restoration area. However, after eight years of monitoring, the restoration effort failed to re-establish the characteristic wetland vegetation found in extremely rich fens, although some improvement was noted. Because of the complexity of fen habitat, development of restoration methods for this wetland type should concentrate on mitigation of damage *in situ*, and not on the creation of new habitat.

Less damaging impacts to fen habitat, such as those from trampling, may be mitigated. Exclusion of cattle from wetland areas immediately adjacent to and upstream from known populations of *Utricularia minor* is suggested until disturbance tolerance parameters for *U. minor* can be investigated. Overgrazing in areas around wetlands can also impact surficial water quality through erosion. Investigation of specific parameters of rotational and deferred grazing is recommended for sites impacted by this land use.

Research priorities for Region 2

The most important research priorities for *Utricularia minor* in Region 2 are investigation of specific water quality impacts due to drought and to both anthropogenic and natural disturbance. Secondarily, the investigation of basic life cycle parameters and any specificity of its ecological niche is warranted. Additional research topics include location of additional populations.

DEFINITIONS

Definitions are drawn from Allaby (1998) unless noted otherwise.

Active trap – carnivorous plant trap in which movement of plant parts takes place during the trapping process (Schnell 2002).

Carnivory – a plant that subsists on nutrients obtained from the breakdown of animal tissues.

Commensal relationship – a relation between two kinds of organisms in which one obtains food or other benefits from the other without damaging or benefiting it (Merriam-Webster On-line 2004).

Dystrophic lake – acidic, shallow bodies of water that contain much humus and/or other organic matter; contain many plants but few fish.

Exine – outer layer of the pollen wall, which is highly resistant to strong acids and bases and is composed primarily of sporopollenin.

Homologous – organs or chromosomes thought to have the same evolutionary origin.

Inquiline – animal/organism living within "aquatic system" within a plant structure such as a pitcher plant (*Sarracenia*) leaf or a bladderwort (*Utricularia*) trap (Schnell 2002).

Kairomone – an allelochemical agent that is a cue for larvae to settle (Brown et al. 1970)

Macrophyte – an aquatic plant

Mutualism – a mutually beneficial association between different kinds of organisms (Merriam-Webster On-line 2004).

Phytotelm – "aquatic system" within a plant structure such as a pitcher plant (*Sarracenia*) leaf or a bladderwort (*Utricularia)* trap (Schnell 2002).

Primordium – early cells that serve as precursors of a plant organ into which they later give rise.

Redox potential – scale that indicates the reduction (addition of electrons) and oxidation (removal of electrons) for a given material.

Setulae – minute bristles (Schnell 2002).

Stolon – an elongate, horizontal stem.

Trichome – plant hair.

Turion – winter bud; overwintering structure. Consists of a small stolon segment with tightly compacted series of leaves wrapped in a tight ball (Schnell 2002).

Velum – a membranous structure for secondary trap closure; this structure rests below the door against the threshold (Schnell 2002).

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