Cymopterus evertii Hartman & Kirkpatrick (Evert's springparsley): A Technical Conservation Assessment

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

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COVER PHOTO CREDIT

Cymopterus evertii (Evert's springparsley). Photograph by Walter Fertig. Used with his permission.

SUMMARY OF KEY COMPONENTS FOR CONSERVATION OF *CYMOPTERUS EVERTII*

Status

This is a species assessment for *Cymopterus evertii* (Evert's springparsley) produced as a part of the Species Conservation Project. This species is designated a Special Status Species by the Bureau of Land Management (BLM) in Wyoming, but is not designated as a sensitive species by the USDA Forest Service in Region 2 (USDA Forest Service 2003). It was designated a Category 2 species by the US Fish and Wildlife Service under the Endangered Species Act in 1985 but dropped from the list in 1990 based on surveys conducted on the Shoshone National Forest. *Cymopterus evertii* is globally ranked between imperiled and vulnerable (G2G3; NatureServe 2002). This species is a regional endemic that is found in only two states: Wyoming and Utah. It is considered between imperiled and vulnerable (S2S3) by the Wyoming Natural Diversity Database. Outside USFS Region 2, it is ranked imperiled (S1) by the Utah Natural Heritage Program. Concern for the viability of *C. evertii* is based on its limited global distribution. It is restricted to two geographic areas in Wyoming (the Bighorn Basin and the Absaroka Range), with a disjunct occurrence 200 miles to the south in northeastern Utah.

The majority of *Cymopterus evertii* occurrences are located in subalpine and montane habitats, with additional occurrences in alpine and foothill communities. It is found in coarse volcanic soils (occasionally on sandstone) on moderate to steep, exposed, rocky ridge tops within sparsely vegetated cushion plant communities or in openings of subalpine and montane forests. It occurs at elevations ranging from 1,768 to 3,292 meters.

Wyoming Natural Diversity Database reports 20 occurrences of *Cymopterus evertii*. Two occurrences are located outside USFS Region 2, on lands administered by the USFS Ashley National Forest in Utah. No estimates of abundance are available for the Utah occurrences. The total Wyoming population number is estimated at 30,000 individuals. This number is based on general field observations and not actual counts. The number may over- or underestimate the actual population number by tens of thousands. There are no population trend data.

No federal protected areas have been designated that include the conservation of this species or its habitat as an explicit goal. Fourteen occurrences of the species are located on lands managed by the Shoshone National Forest, including six occurrences in the Washakie Wilderness. Six occurrences are located on lands administered by the BLM, including two occurrences in the Carter Mountain Area of Critical Environmental Concern. The remaining four occurrences are on BLM lands managed for multiple uses. No occurrences have been identified on private lands. No specific management or conservation plans are in place for protection of this species on USFS or BLM lands.

Primary Threats

Current threats to *Cymopterus evertii* appear to be limited largely due to its remote locations and inaccessible habitat. Management activities that could potentially impact the species include prescribed fire, livestock grazing, and recreation. Few factors limiting the population growth of *C. evertii* have been investigated. At present, natural fire is the only known process to affect the population growth of the species and knowledge of fire response is limited to information from one demographic monitoring site. Other potential threats to the species include extreme weather conditions, global warming and air pollution.

Fire may pose a threat to those occurrences located in forested communities; however, evidence from monitoring results suggests *Cymopterus evertii* may have the ability to survive natural fire except in areas of high fire intensity. We found no information to suggest that a recurring fire regime is necessary to maintain *C. evertii* occurrences.

Palatability of this species has not been documented, however, the plant's low stature and preference for sparsely vegetated habitats may provide some protection from herbivory. Secondary grazing impacts are possible, including changes in plant species composition (e.g., spread of invasive species) or soil compaction and erosion.

Recreation use in the proximity of occurrences located on the Shoshone National Forest primarily consists of off road vehicle use in areas located outside wilderness boundaries and hiking and horse use in both wilderness and

non-wilderness areas. There is potential for individuals or occurrences to be threatened should there be an increase in recreational use on the Shoshone National Forest. Global warming and increased nitrogen deposition may provide a potential threat to *Cymopterus evertii* in the long-term.

There is little direct evidence to indicate whether or not specific occurrences of *Cymopterus evertii* in USFS Region 2 or rangewide are at risk as a result of management activities or natural disturbances.

Primary Conservation Elements, Management Implications and Considerations

Cymopterus evertii is a species of the foothills and mountains that occurs in a range of habitats. The species is a regional endemic of northwestern Wyoming and northeastern Utah. Population viability is a concern based on limited global distribution of the species. The small amount of data available concerning population numbers does not allow us to know whether occurrences are increasing or decreasing. A majority of the known occurrences (14 of 20) are located on the Shoshone National Forest. Therefore, conservation of those occurrences is important to the conservation of the species. Protection of occurrences and the habitat in which they occur are necessary for maintaining *C. evertii* viability in USFS Region 2. Avoiding direct impacts and disturbance to the species and its habitat will be beneficial to the species' persistence. Land managers could more effectively manage occurrences and habitat of *C. evertii* with more information (1) regarding the distribution, biology and ecology of the species, including surveying for new occurrences, (2) regarding current population sizes of known occurrences, (3) evaluating reproductive and ecological characteristics (e.g. pollination mechanisms, seed germination, seedling establishment, herbivory, flowering/fruiting, dispersal vectors, etc.), (4) describing demographics (life history stages, population structure, longevity, mortality, etc.), and (5) determining impacts to population viability from management activities and natural disturbances.

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INTRODUCTION

This assessment is one of many being produced to support the Species Conservation Project for the Rocky Mountain Region (Region 2) of the USDA Forest Service (USFS). *Cymopterus evertii* (Evert's springparsley) is the focus of an assessment because it is a rare species whose population viability is identified as a concern based on its limited global distribution. A species of concern may require special management, so knowledge of its biology and ecology is critical. This assessment addresses the biology of *C. evertii* throughout its entire range, most of which is in USFS Region 2. This introduction defines the goal of the assessment, outlines its scope, and describes the process used in its production.

Goal

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

Scope and Information Sources

This assessment examines the biology, ecology, conservation status, and management of *Cymopterus evertii* with specific reference to the geographic and ecological characteristics of the USFS Rocky Mountain Region. Where supporting literature used to produce this species assessment originated from investigations outside the region (e.g., studies of related species), this document places that literature in the ecological and social context of the central Rockies. Similarly, this assessment is concerned with reproductive behavior, population dynamics, and other characteristics of *C. evertii* in the context of the current environment. The evolutionary environment of the species is considered in conducting the synthesis, but placed in a current context.

In producing the assessment, the authors reviewed refereed literature, non-refereed publications, research reports, and data accumulated by resource management agencies. The assessment emphasizes refereed literature because this is the accepted standard in science. Non-refereed publications or reports were regarded with greater skepticism. Some non-refereed literature is utilized in the assessments, however, when information was unavailable elsewhere. Unpublished data used included the state natural heritage element occurrence records, the 1999 status report for *Cymopterus evertii* (Fertig et al. 1999), and the demographic monitoring of *C. evertii* following the 2000 Enos fire (Heidel 2002). Unpublished information obtained from surveys conducted by the Wyoming Natural Diversity Database (WYNDD) were important in estimating the geographic distribution and provided preliminary information regarding the species' response to fire. These data required special attention because of the diversity of persons and methods used to collect the data. Data for the species assessment were obtained primarily by secondary sources through state natural heritage programs including WYNDD, herbarium specimen label data, scientific literature, and with individuals knowledgeable of the species. Fifty-three herbaria within USFS Region 2 and surrounding states were contacted. Six responded with pertinent data concerning *C. evertii* including the Rocky Mountain Herbarium (RM), USFS Region 4 Herbarium (OGDF), Intermountain Herbarium (UTC), University of Montana (MONTU), R. L. McGregor Herbarium (KANU), and University of Colorado Museum (COLO). Literature of closely related taxa was reviewed and inferences were drawn where reasonable and when a basis could be established for application to *C. evertii*. The authors present no empirical data.

Treatment of Uncertainty

Science represents a rigorous, systematic approach to obtaining knowledge. Competing ideas regarding how the world works are measured against observations. However, because our descriptions of the world are always incomplete and 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, it is difficult to conduct experiments that produce clean results in the ecological sciences. Often, observations, inference, good thinking, and models must be relied on to guide our understanding of ecological relations. Confronting uncertainty then is not prescriptive. In this assessment, the strength of evidence for particular ideas is noted, and alternative explanations are described when appropriate.

Little information exists concerning specific population trend data for *Cymopterus evertii* and information concerning life history stages, population structure, longevity, mortality, pollination biology and seed biology are not available (Fertig 2000). Few factors limiting the population growth of *C. evertii* have been identified. Currently, no empirical data exist identifying factors such as seed predation, competition, habitat destruction or fragmentation, barriers to dispersal or any other factor limiting population growth. Future evaluation of factors controlling species response to management objectives and natural disturbance will provide guidelines for formation of a conservation strategy.

Publication of Assessment on the World Wide Web

To facilitate use of species assessments in the Species Conservation Project, assessments are being published on the USFS Region 2 World Wide Web site. Placing the documents on the Web makes them available to agency biologists and the public more rapidly than publication as a book or report. More important, revision of the assessments will be facilitated. Revision will be accomplished based on guidelines established by USFS Region 2.

Peer Review

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

MANAGEMENT STATUS AND NATURAL HISTORY

Management Status

Cymopterus evertii was designated a Category 2 species under the Endangered Species Act in 1985. The designation included all species "being considered by the Secretary for listing as an endangered or threatened species but not yet the subject of a proposed rule" (50 C.F.R. § 424.02(b)). *Cymopterus evertii* was dropped from the Category 2 list in 1990 based on surveys conducted on the Shoshone National Forest (US Fish and Wildlife Service 1985). *Cymopterus evertii* is globally and nationally ranked between imperiled and vulnerable (G2G3, N2N3; NatureServe Explorer 2002). This species is a regional endemic that is found only in Wyoming and Utah. It is considered between imperiled and vulnerable (S2S3) by the Wyoming Natural Diversity Database. Outside USFS Region 2, it is ranked imperiled (S1) by the Utah Natural Heritage Program. This species is designated a Special Status Species by the Bureau of Land Management (BLM) in Wyoming, but is not designated as a sensitive species by the USFS in Region 2.

Existing Regulatory Mechanisms, Management Plans, and Conservation Strategies

The Wyoming Natural Diversity Database (WYNDD) reports 20 element occurrence records (EORs) for *Cymopterus evertii* in Wyoming. Six of the EORs are located on lands administered by the BLM, including two occurrences located within the Carter Mountain Area of Critical Environmental Concern (ACEC). The management objective of the Carter Mountain ACEC is to protect areas of unique alpine tundra and fragile soils. Management actions occurring in the ACEC include full suppression of wildfire, possible introduction of prescribed fire, livestock grazing, exploration and development of leasable minerals, and use of vehicles only on designated roads and trails. Management on BLM lands, including lands managed for multiple use and lands within ACECs, may not be protective of the species. Fourteen EORs are located on lands managed by the Shoshone National Forest including six occurrences within the Washakie Wilderness. Lands within the Washakie Wilderness are designated for preservation and protection of natural status and include restrictions on use of motor vehicles, motorized equipment and motorboats. Management within the Washakie Wilderness may be beneficial for the species. Two occurrences are located on lands outside USFS Region 2 administered by the Ashley National Forest in Utah. No occurrences have been found on private lands.

Management on Shoshone National Forest lands is administered under the Shoshone National Forest Land and Resource Management Plan (Forest Plan) approved in 1986, as amended (USDA Forest Service 1986). Although *Cymopterus evertii* is not considered a sensitive species on the Shoshone National Forest, the National Forest Management Act of 1976 requires the Forest Service to sustain habitats that support healthy populations of existing plant and animal species on the national forests and grasslands. National Environmental Policy Act compliance does not require evaluation

of project alternatives with respect to *C. evertii* occurrences. No specific management or conservation plan is in place for protection of this species on Forest Service lands.

Management on BLM lands with occurrences of *Cymopterus evertii* is currently accomplished according to the Resource Management Plan for the Grass Creek Planning Area and the Cody Resource Area (Bureau of Land Management 1990, 1998). BLM Manual 6840 establishes Special Status Species policy for plant species and the habitat on which they depend. Management guidelines that apply to species on the BLM Wyoming Sensitive Species List, including *C. evertii*, are to avoid or minimize adverse impacts. No conservation strategies or management plans are in place for protection of this species on BLM lands.

Existing laws, regulations, management and enforcement of the same do not adequately protect occurrences on Forest Service lands, because no species-specific protective mechanisms are in place. The remote location of occurrences may provide some protection. However, there is a lack of knowledge concerning reproductive and ecological characteristics, demographics, and impacts to population viability from management activities and natural disturbances.

Biology and Ecology

Systematics and general species descriptions

Cymopterus evertii is a member of the family Apiaceae (Umbelliferae), a family that produces many food and spice products throughout the world. *Cymopterus evertii* is also grouped with several genera of plants that make up an interesting part of the western North American flora, termed the "Rocky Mountain umbellifers" (Downie et al. 2000). This refers to several uniquely diverse members of this family that primarily occur in dry, alkaline, sandy regions, and often at high elevations. *Cymopterus evertii* is a relatively recently described taxon (Hartman and Kirkpatrick 1986). It is a member of a select group of newly described umbels including *Shoshonea pulvinata* Evert & Constance, *C. williamsii* Hartman & Constance, *C. davisii* Hartman, and others, most of which are endemic to the Rocky Mountain region.

David L. Martin first discovered *Cymopterus evertii* in 1981 in Park County, Wyoming. Mr. Martin brought the discovered specimen to Ronald L. Hartman, curator of the Rocky Mountain Herbarium (RM), where it was recognized as a new species. It was formally described by Ronald L. Hartman and Robert S. Kirkpatrick in 1986. *Cymopterus evertii* was named after Erwin F. Evert, in honor of his contributions to the knowledge of the flora of Park County, Wyoming (Hartman and Kirkpatrick 1986). **Table 1** summarizes the current classification of *C. evertii.*

The genus *Cymopterus* consists of approximately 45 species found in western and central North America (Cronquist et al. 1997). The systematics of the genus are controversial and have been historically and recently split into several genera including *Oreoxis*, *Pseudocymopterus*, and *Pteryxia* (Cronquist et al. 1997). The Intermountain Flora (Cronquist et al. 1997) documents 32 species in the Great Basin, Dorn (1992) recognizes 13 species in Wyoming, Weber and Wittmann (1992) recognizes nine species in Colorado, and Welsh et al. (1993) identifies 19 species with nine associated varieties in Utah.

Historically, *Cymopterus* is included in the subfamily Apioideae, within the tribe Peucedaneae (Drude 1897-1898). Recent molecular studies of the Apioideae have found evidence to support seven tribes instead of Drude's eight tribes (Downie et al. 2000). Within the subfamily Apioideae, the Rocky Mountain umbellifers, (including *Cymopterus*) are only weakly supported as monophyletic using internal transcribed spacer (ITS) data (Downie et al. 1998). In addition, the Apioideae was not supported as a monophyletic lineage using plastid genome data (Downie et al. 2000). Further phylogenetic studies are warranted before any conclusions can be drawn concerning the placement of the genus *Cymopterus* within the Apioideae. Preliminary results using both morphological and molecular data show that *Cymopterus*, *Lomatium*, *Aletes*, *Musineon*, and *Oreoxis* are not monophyletic lineages (Sun et al. 2000).

Cymopterus evertii is closely related to four other species in the genus including: *C. nivalis* S. Wats. (a synonym of *C. bipinnatus*), *C. aboriginum* M.E. Jones, *C. longilobus* (Rydb.), and *C. cinerarius* Gray. Of these, *C. nivalis*, which is from Oregon, Nevada, Idaho, Montana, and Wyoming, is presumed to be the closest relative of *C. evertii* (Hartman and Kirkpatrick 1986). The range of *C. nivalis* overlaps *C. evertii* in Park County, Wyoming. *Cymopterus aboriginum* and *C. cinerarius* both occur in east-central California and adjacent Nevada (Hartman and Kirkpatrick 1986). *Cymopterus evertii* is morphologically associated with *C. hendersonii* (Coult. & Rose) Cronq. in the Intermountain Flora, but is considered closer

Table 1. Classification of *Cymopterus evertii*.

Cymopterus evertii Hartman & Kirkpatrick
Family: Apiaceae (Umbelliferae)
Genus: Cymopterus
Species: *Cymopterus evertii* Hartman & Kirkpatrick (Hartman and Kirkpatrick 1986)
Synonyms: None
Vernacular Name: Evert's springparsley, Evert's waferparsnip
Type: United States, Wyoming. Park Co.: N side of Squaw Teats Rd., ca 3.2 air km E of Hwy 120, ca 1,800 m, sandstone outcrop on hills with *Pinus flexilis*, 27 May 1981, R. L. Hartman 12799 (HOLOTYPE: RM; ISOTYPES NY, UC) (Hartman and Kirkpatrick 1986).

phylogenetically to *C. nivalis* (Cronquist et al. 1997). *Cymopterus hendersonii* is a synonym of *C. longilobus* (Rydb.) W.A. Weber; in this report, the taxon will be referred to as *C. longilobus* according to Dorn (Dorn 1992, Nelson and Hartman 1992).

Cymopterus evertii is a tufted perennial herb arising from a freely-branching caudex clothed in persistent petioles and leaf bases from previous years. Leaves are herbaceous, 1.5 to 13.0 cm long, 0.5 to 1.6 cm broad, once or twice pinnately compound with five to eight pairs of pinnae. Crushed foliage is strongly aromatic of orange peels. The inflorescence is a compact umbel of white flowers born on a leafless stalk that exceeds the leaves at maturity. Fruits are flattened dorsally, reddish-brown to purplish with thick stout white ribs, and the ovary and fruit are scabrous (Hartman and Kirkpatrick 1986, Dorn 1992, Cronquist et al. 1997, Fertig et al. 1999). Hartman and Kirkpatrick (1986) note that fruits may occasionally lose the muriculate feature on the mericarps. They attribute this to wind-blown sand abrasion that occurrences restricted to a sandy-substrate in the Bighorn Basin experience.

The chromosome number for *Cymopterus evertii* is unknown. The majority of western North American umbels, including the genus *Cymopterus*, have a diploid number of 2n = 22 (Hartman personal communication 2003). It is interesting to note that the disjunct occurrences in Ashley Gorge, Utah, are weakly (if at all) aromatic and occur only on limestone (Welsh et al. 1993). **Figure 1** is a field photograph and **Figure 2** is a line drawing of *C. evertii*.

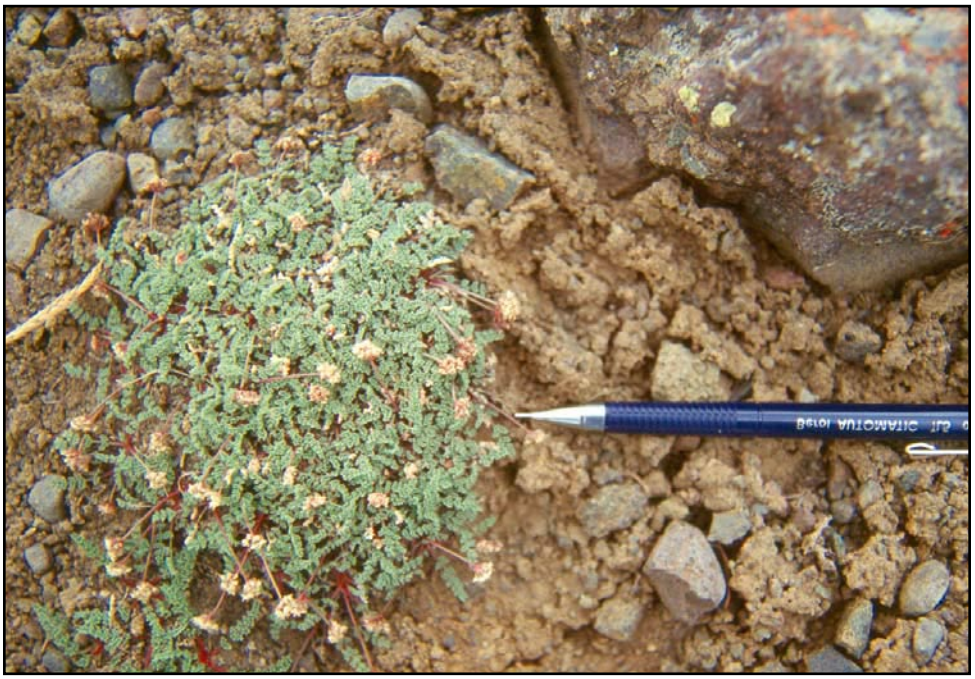

Figure 1. Photograph of *Cymopterus evertii* (Fertig 2000).

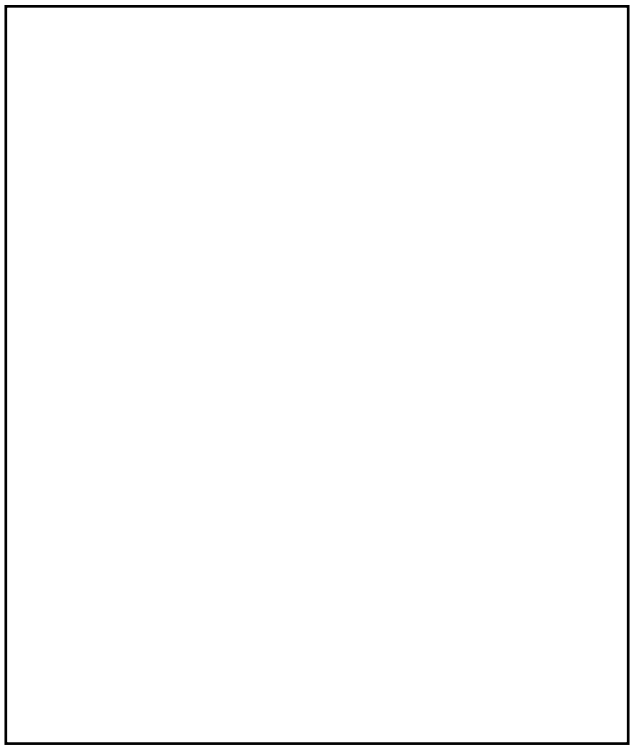

Figure 2. Line drawing of *Cymopterus evertii* by Walter Fertig (Fertig 2000).

Within USFS Region 2, *Cymopterus evertii* closely resembles *C. longilobus* and *C. nivalis*. Both *C. nivalis* and *C. longilobus* differ from *C. evertii* in having glabrous, evidently-winged fruits, a well-developed carpophore, and lack of odor. In addition, *C. longilobus* has glabrous foliage, leaf blades over five cm long with sharp-tipped leaflets and yellow flowers. *Cymopterus nivalis* has glabrous ovaries and fruits with thin-winged margins (Dorn 1992, Cronquist et al. 1997).

Distribution and abundance

Global distribution of *Cymopterus evertii* is restricted to the floristic region defined by Takhtajan (1986) as the Rocky Mountain Province of the Holarctic Kingdom. This taxon is a relatively recent discovery; therefore no global, regional, or local distribution and abundance data are available prior to 1981.

Cymopterus evertii is considered a regional endemic of northwestern Wyoming and northeastern Utah. Within USFS Region 2, *C. evertii* can be characterized as narrowly endemic, with a disjunct occurrence located in northeastern Utah. *Cymopterus evertii* exhibits a discontinuous pattern of distribution restricted to roughly two geographic areas within Wyoming, the Big Horn Basin/Owl Creek Mountains and the Absaroka Range. **Figure 3** shows the distribution of *C. evertii* within Wyoming (USFS Region 2) and adjacent Utah.

The Wyoming Natural Diversity Database (WYNDD) reports 20 element occurrence records (EORs) for *Cymopterus evertii* in Wyoming. The majority of the EOR locations are represented by voucher specimens, deposited at the Rocky Mountain Herbarium (RM), USFS Region 4 Herbarium (OGDF), Intermountain Herbarium (UTC), University of Montana (MONTU), R. L. McGregor Herbarium (KANU), and University of Colorado Museum (COLO). The type locality for *C. evertii* is in the Big Horn Basin, straddling the Hot Springs - Park county line southeast of Meeteetse, Wyoming. Other Hot Springs County occurrences are located in the Owl Creek Mountain area along the north fork of Owl Creek, and two are located in the Enos Creek area. The majority of the records for *C. evertii* are located in the Shoshone National Forest scattered throughout the Absaroka Mountains. Specific areas include the Upper Greybull River and Carter Mountain areas. Outlying occurrences are also documented in the Boulder Ridge, Foster Reservoir, and Wapiti Range areas. **Table 2** summarizes the EOR data, including land management, abundance, area, and number of occurrences.

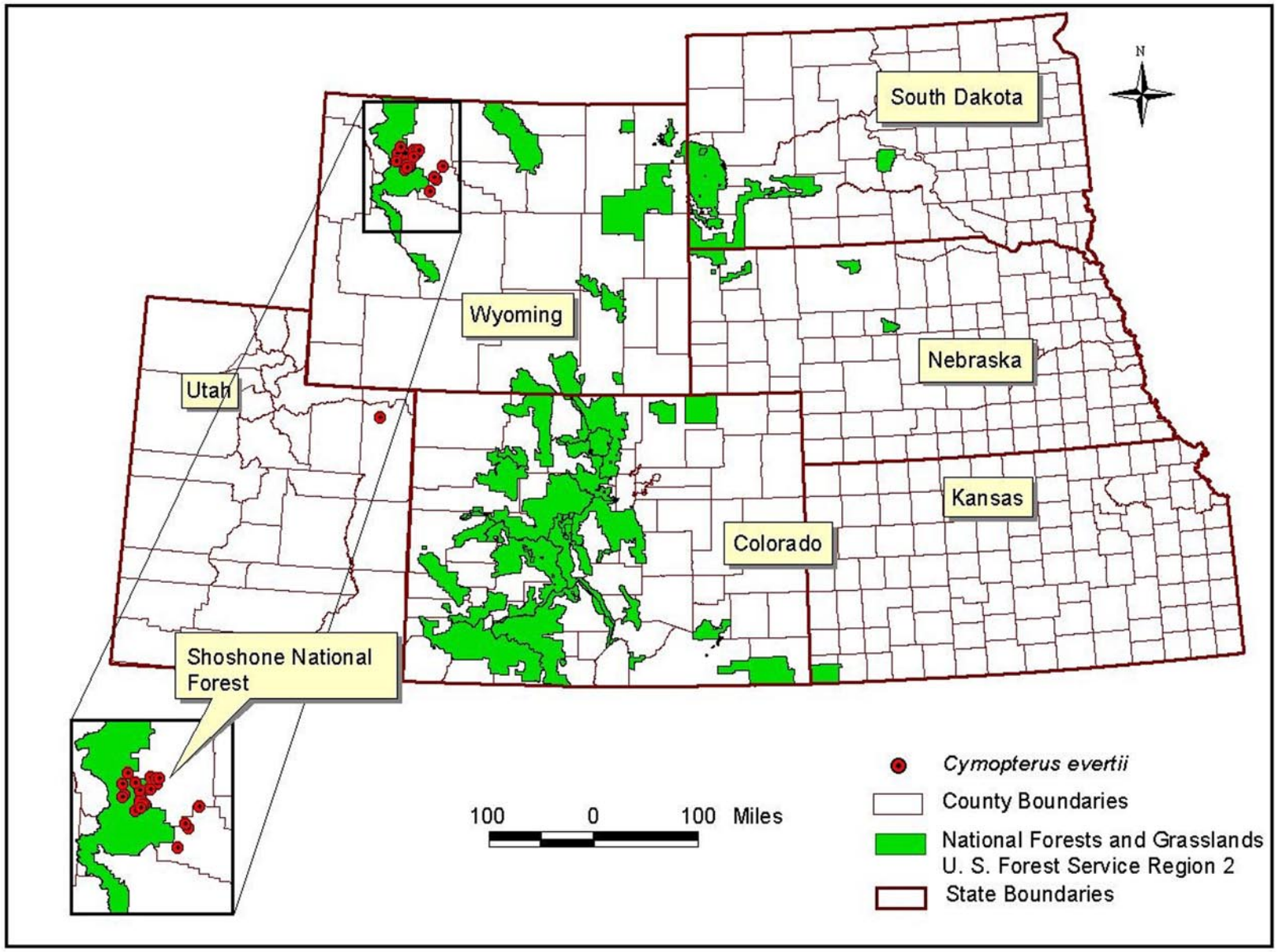

Figure 3. General location of *Cymopterus evertii* occurrences in Wyoming (USFS Region 2) and adjacent Utah.

Table 2. Summary of element occurrence record and habitat data for *Cymopterus evertii* in Wyoming. Habitat information taken from EOR data forms (Wyoming Natural Diversity Database 2002), herbarium specimen labels, and USGS 7.5 minute topographic maps.

EOR Number	General Location Name	County	Area (Ha)	Number of occurrences	Number of Plants	Land Management	Elevation (m)/aspect	Soils/geology	Slope (%)	Total Cover	Habitat
001	Hillary Rim	Hot Springs, Park	54	5	4,800 to 5,660	BLM (Worland Field Office) (type locality)	1,768 to 1,798/south-facing	Coarse sandy soils, Lance and Fort Union Formations	5 to 10	Sparse	*Pinus flexilis*, *Juniperus scopulorum*, *Artemisia tridentata.*
002	Phelps Mountain	Park	1+	3	Hundreds	Shoshone National Forest (Greybull Ranger District)	2,804 to 3,002/west-facing	Not available (N/A)	10 to 15	Sparse	Open slopes bordered by *Picea engelmanii*, alpine slopes, and somewhat disturbed sparsely vegetated sagebrush grassland.
004	Greybull River	Park	Not available (N/A)	Not available (N/A)	Not available (N/A)	Shoshone National Forest (Greybull Ranger District)	2,499 to 2,560/east-northeast-facing	Quaternary alluvium or Wiggins Formation of Absaroka Volcanics Supergroup	8 to 10	Not available (N/A)	Meadows along river.
005	Carter Mountain	Park	18+	3	200 to 300	BLM (Cody Field Office, Carter Mountain Area of Critical Environmental Concern)	2,987 to 3,170/east-facing	Eocene Wiggins Formation (Absaroka Volcanics Supergroup)	20 to 30	Sparse to moderate	Sparsely to moderately vegetated and alpine fellfields and slopes with rocky soils.
006	Greybull River	Park	N/A	N/A	N/A	Shoshone National Forest (Greybull Ranger District)	2,865 to 2,926/ southeast-facing	Wiggins or Sundance formations of the Eocene Absaroka Volcanics Supergroup	20 to 25	N/A	Rocky ridge.
007	Shoshone River	Park	4	1	Tens of thousands	Shoshone National Forest (Wapiti Ranger District, Washakie Wilderness)	2,195 to 3,140/ northwest-facing	Wiggins Formation of the Absaroka Volcanics Supergroup	10 to 15	Sparse to moderate	Open areas with cushion and matted plants, Occasional on disturbed soil along trail on northwest side of ridge. Open, rocky habitat.
008	Meeteetse Creek	Park	N/A	N/A	N/A	BLM (Cody Field Office, Carter Mountain Area of Critical Environmental Concern)	2,195 to 2,805/ southeast-facing	Aycross or Wiggins formations of the Eocene Absaroka Volcanics Supergroup	25 to 30	N/A	Alpine meadows.

Table 2 (cont.).

EOR Number	General Location Name	County	Area (Ha)	Number of occurrences	Number of Plants	Land Management	Elevation (m)/aspect	Soils/geology	Slope (%)	Total Cover	Habitat
010	Carter Mountain	Park	N/A	N/A	N/A	Shoshone National Forest (Greybull Ranger District)	3,230 to 3,292/ northeast-facin	Aycross or Wiggins formations of the Eocene Absaroka Volcanics Supergroup	45 to 50	N/A	Alpine meadows.
011	Carter Mountain	Park	2	1	Locally abundant	Shoshone National Forest (Wapiti Ranger District, Washakie Wilderness)	2,683 to 2,804/west-southwest-facing	Bare brown andesite rocky scree and loose sandy clay derived from the Eocene Trout Peak or Wiggins formations of the Absaroka Volcanic Supergroup	55 to 60	Sparse	Sparsely vegetated openings in *Pseudotsuga menziesii*, *Pinus flexilis* woods. On rimrock slopes below palisades.
012	Carter Mountain	Park	N/A	N/A	Thousands of plants	Shoshone National Forest (Wapiti Ranger District, Washakie Wilderness)	2,682 to 2,804/west-southwest-facing	Coarse volcanic conglomerate soil derived from the Sundance or Wiggins formations of the Absaroka Volcanics Supergroup	15 to 20	Sparse	Sparsely vegetated areas in open meadow.
013	Carter Mountain	Park	N/A	2	N/A	Shoshone National Forest (Greybull Ranger District)	2,682 to 3,040/ southeast facing	Eocene Sundance or Wiggins formations of the Absaroka Volcanics Supergroup	35 to 40	N/A	Rocky and grassy open areas.
014	Sage Creek	Park	N/A	N/A	N/A	Shoshone National Forest (Greybull Ranger District)	2,682 to 2,743/south-southeast-facing	N/A	15 to 20	N/A	Usually in rocky open areas.
016	Shoshone River	Park	N/A	N/A	Thousands of plants	Shoshone National Forest (Wapiti Ranger District, Washakie Wilderness)	3,040 to 3,108/ northeast-facing	Very coarse volcanic soil with cobbles to 12” diameter in places Substrate derived from the Wiggins Formation of the Absaroka Volcanics Supergroup	10 to 15	N/A	In open areas with cushion and matted plants.
017	Greybull River	Park	N/A	N/A	100 to 200	Shoshone National Forest (Greybull Ranger District)	2,377 to 2,500/north-northwest-facing	Volcanic soil of Aycross Formation of the Absaroka Volcanics Supergroup	65 to 70	Sparse	Sparsely-vegetated on north-northwest facing slope adjacent to trail. Absent from similar habitat further upslope.

Table 2 (concluded).

EOR Number	General Location Name	County	Area (Ha)	Number of occurrences	Number of Plants	Land Management	Elevation (m)/aspect	Soils/geology	Slope (%)	Total Cover	Habitat
019	Irish Rock	Park	N/A	N/A	Thousands of plants	Shoshone National Forest (Greybull Ranger District)	3,230 to 3,292/east-northeast-facing	Rocky volcanic conglomerate soil (often with very coarse cobbles) of Wiggins Formation	35 to 40	N/A	Not available (N/A).
020	Owl Creek	Hot Springs	N/A	N/A	N/A	BLM (Worland Field Office)	2,438 to 2,500/south-facing	Volcanic substrate probably the Tepee Trail or Aycross formations of the Absaroka Volcanics Supergroup	45 to 50	N/A	South-facing ridge.
021	Boulder Ridge	Park	N/A	N/A	N/A	Shoshone National Forest (Wapiti Ranger District, Washakie Wilderness)	3,040 to 3,108/east-southeast-facing	N/A	20 to 25	Sparse	Open, rocky habitats along ridge crest.
022	Twin Buttes	Hot Springs	14	4	1,200 to 2,500	BLM (Worland Field Office)	1,981 to 2,134/south-facing	N/A	10 to 15	Sparse to moderate	Occurs in two main habitats: (1) flat, barren rock outcrops, broad ridge crests, and sedimentary slopes or (2) in semi-shade of juniper woodlands or meadows within a matrix of limber pine and juniper.
023	Wapiti Ridge	Park	N/A	N/A	N/A	Shoshone National Forest (Wapiti Ranger District, Washakie Wilderness)	2,500 to 2,560/west-north-facing	Volcanic soils of Wapiti Formation of the Absaroka Volcanics Supergroup	30 to 35	Sparse	Ridge top on rocky slopes.
024	Enos Creek	Hot Springs	5	4	1,100 to 1,350	BLM (Worland Field Office, Enos Creek fire monitoring site)	2,73 to 2,164/east-southeast-facing	Coarse sandy red soil. Aycross Formation	5 to 10	Sparse	Rocky sandstone ridge crest and steeper slopes small patches, in open limber pine/sage savanna with juniper.

A collective total of the EOR data results in an estimate of the total Wyoming population at about 30,000 individuals comprising at least 36 sub-occurrences, covering approximately 120 hectares (Marriott 1988, Fertig et al. 1999, Wyoming Natural Diversity Database 2002). These population estimates are based on general field observations, not actual counts and are therefore, imprecise (the numbers may over- or underestimate the actual population by tens of thousands). Ten of the twenty occurrences have been observed more than once since the species was discovered in 1981. Individual occurrences generally exhibit a clumped pattern varying from 0.1 to 11 plants per square meter (Marriott 1988, Fertig et al. 1999). The largest sub-occurrence covers approximately 24 hectares. Casual observations of reproductive status and abundance were noted at a few locations, thus the estimates are of limited value. No estimates of abundance were available for the Utah occurrence; however, site visits indicated the occurrence was abundant on a narrow band of limestone (Axel personal communication 2003). Until consistent population monitoring is established, it is impossible to accurately estimate *Cymopterus evertii* abundance or to measure changes in abundance. Based upon available information to date, the total rangewide population number for *C. evertii* as a whole is loosely estimated to be 30,000 to 35,000 individuals.

Population trend

There are very few data that can be used to draw conclusions concerning the trend for individual occurrences of *Cymopterus evertii*. Population sizes for most of the documented occurrences were casually estimated since the discovery of the species in 1981. Three population monitoring transects were established during the 1998 surveys done by Welp (Fertig et al. 1999). Two of these are located at the type locality (EOR 001) and the other is located at the Enos Creek occurrence (EOR 024).

Only the Enos Creek demographic monitoring transect has been revisited. The Enos Creek site burned during the 2000 Enos fire. Bonnie Heidel (2002) of WYNDD re-read the transect in 2002, and concluded that there was a 9.7 percent net reduction in the total number of *Cymopterus evertii* plants in the permanent belt transect between 1998 and 2000. She also reported a tenfold drop in the number of large plants (>10 cm diameter) and a threefold increase in the number of small plants (0 to 3 cm diameter).

Heidel suggests that the fire removed much of the vegetation cover and that the plants were difficult to discern during monitoring before the fire in 1998, due to litter and vegetation cover. The transect was not read one year after the fire, therefore it is difficult to conclude precisely whether the increase in the density of small plants was due to resilience of established plants or an episode of germination and establishment (Heidel 2002).

Habitat

Cymopterus evertii is a species of the foothills and mountains that occurs in a range of habitats. Occurrences of *C. evertii* are more numerous and larger in the higher, cooler elevations of the Absaroka Mountains (Fertig et al. 1999). The majority of the known occurrences are located in subalpine and montane habitat, with additional occurrences in alpine and foothill communities. It can be found primarily growing in coarse volcanic soils, on moderate to steep exposed rocky ridge tops within a sparsely vegetated cushion plant community or in openings of subalpine and montane forests. EOR site data, including vegetation, elevation, substrate, slope, and aspect for each occurrence are presented in **Table 2**.

In the alpine, *Cymopterus evertii* is known to occur on scree slopes, fell fields and open wind-blown rocky ridges. It has been associated with the *Geum rossii-Trifolium nanum* vegetation type as described within the Carter Mountain Area of Critical Environmental Concern (ACEC), where it occupies drier, less vegetated slopes (Thilenius and Smith 1986, Jones 1991). Herbarium label data document two collections located in transition meadows between sub-alpine forests and alpine tundra (*R.L. Hartman 17000 & 16883*).

Aspect, slope, and elevation data were taken from EORs and herbarium labels when available, and estimated from USGS 7.5 minute topographic maps when there was no direct source. This species occurs on a broad range of aspects. Typically, it occurs on moderate to steep slopes (25 to 70 percent), or high exposed rocky ridges (slope five to 20 percent). Occurrences of *Cymopterus evertii* in the Absaroka Mountains range from 2,194 to 3,292 meters. The Owl Creek Mountain occurrence is found at 2,438 to 2,500 meters and the foothills occurrences are located between 1,768 and 2,164 meters in elevation. The known range is 1,768 to 3,292 meters.

Cymopterus evertii appears to be restricted to sparsely vegetated areas. Nearly all habitat descriptions for this species indicate a structural community

preference for open, rocky areas. Documented habitat descriptions consistently note that this species occurs on coarse substrates comprised of large cobble and/or gravelly soils derived from various pyroclastic andesites, including the Aycross, Trout Peak, Wapiti, Sundance, and Wiggins formations of the Eocene aged Absaroka Volcanics Supergroup (Hartman and Kirkpatrick 1986, Fertig et al. 1999, Wyoming Natural Diversity Database 2002). At low elevations, it inhabits similar coarse textured, sandy substrates, derived from the Lance or Fort Union formations, or occasionally on clay-derived soils (Fertig et al. 1999). In Utah, this species has been observed on a narrow band of limestone (Axel personal communication 2003). It does not appear to be restricted to a particular soil type, but does appear to prefer the well-drained gravelly, rocky substrates.

In the subalpine and montane habitats, colonies tend to occur in rocky, sparsely vegetated openings of limber pine *Pinus flexilis* (limber pine), *Picea engelmannii* (Engelmann spruce), and *Pseudotsuga menziesii* (Douglas-fir) dominated stands. **Figure 4** provides a photograph of the forested habitat type known for *Cymopterus evertii*.

Other associated trees and shrubs include *Juniperus scopulorum* (Rocky Mountain juniper), *J. communis* (common juniper), and two varieties of big sagebrush - *Artemisia tridentata* var. *tridentata* and *A. tridentata* var. *vaseyana* (Marriott 1988, Mills and Fertig 1996, Fertig et al. 1999, Wyoming Natural Diversity Database 2002). In the foothills, *Cymopterus evertii* can be found on sandstone talus slopes, coarse gravelly ridges, and rim rock pavement in areas dominated by the *Pinus flexilis-Juniperus scopulorum* woodland association (Hartman and Kirkpatrick 1986, Fertig et al. 1999). This species is also documented to occur on *Artemisia tridentata-Festuca idahoensis* grasslands (Fertig et al. 1999).

Cymopterus evertii tends to occupy openings in forest climax communities, especially in *Pinus flexilis* woodlands, which is considered climax on extremely harsh sites on wind-swept ridges and steep slopes. At higher elevations, this species occupies openings in *Picea engelmannii* forests, also considered a climax species (Knight 1994, Jones and Ogle 2000, Welp et al. 2000). **Figure 5** illustrates representative alpine habitat for the species. It is difficult to determine whether alpine cushion plant communities ever develop a stable climax ecosystem (Knight 1994). However, some ecologists have identified clear succession in alpine ecosystems (Churchill and Hanson 1958). Stable alpine ecosystems can occur in areas with very little soil water and consequently little cryoturbation (such as boulder fields and some fell fields) (Knight 1994). Based upon the evidence that *C. evertii* tends to occur in dry, rocky, and wind swept areas, it is possible that this species is a member of the alpine climax community.

Figure 4. Representative forested habitat of *Cymopterus evertii* (photograph courtesy of Laura Welp).

Figure 5. Representative alpine habitat of *Cymopterus evertii* (photograph by Hollis Marriot, WYNDD).

Forbs and grasses known to occur with *Cymopterus evertii* are presented in **Table 3**. Forbs and grasses listed in the table were obtained from herbarium specimen labels, status reports, and EORs (Fertig et al. 1999, Fertig 2000, Wyoming Natural Diversity Database 2002).

Microhabitat variables were identified and recorded in three belt monitoring transects located in EORs 001 and 024 (Fertig et al. 1999). It was suspected that low total vegetative cover and degree of shading were factors affecting habitat preference. The majority of the herbarium label data recorded observations of low vegetation cover. One herbarium label estimated vegetation cover to be five to 10 percent (*W. Fertig 17627*). No cover estimates were recorded for other species identified in the plots (Fertig et al. 1999, Heidel 2002).

Baseline monitoring was conducted in the belt transects to determine whether shading is a factor affecting habitat preference or abundance. During the 1998 monitoring, a greater abundance of plants were observed under trees than in the openings. It was thought that shading provided a microhabitat for *Cymopterus evertii*. Observations were recorded for each plot based upon whether or not it was fully, partially, or not shaded at the midpoint of day (Fertig et al. 1999). No conclusions were drawn concerning the effect of shading. In 2000, the Enos fire significantly reduced shading in the occurrence vicinity by removing trees (Heidel 2002). There are no conclusive data from the post-fire monitoring to determine whether shading is a factor affecting habitat preference or abundance. The baseline data recorded in 1998 show a total mean vegetative cover as 17 percent, 21 percent, and 28 percent for the three transects (Fertig et al. 1999). The 28 percent cover figure was recorded at the Enos Creek site. It must be noted that vegetation cover was only recorded in plots where *C. evertii* was present. Total mean vegetation cover in the Enos Creek belt transect was 9.3 percent two years after the fire. No follow-up data were taken on the other two transects.

Recently, WYNDD prepared a statistical model using geology, precipitation, land cover, relief, and various other identified variables to predict likely areas of distribution of *Cymopterus evertii* (Fertig personal communication 2003). This statistical model predicts that *C. evertii* occurs in areas with a bedrock geology of Eocene volcanic extrusives, with less then 74 wet days per year, with over 300 cm of July precipitation, and a GAP land cover vegetation of limber pine woodland/ scrub plus mountain big sage. Several other variables were identified, but of primary interest is the resulting map shown in **Figure 6**. Results were presented as a likelihood class, categorized as either high (blue), medium (green) or low (red) shown on **Figure 6**. High likelihood indicates areas where higher quality habitat is expected, medium and low likelihood would illustrate

Table 3. Associated taxa documented to co-occur with *Cymopterus evertii*. Taken from EOR data forms and herbarium specimen labels (Wyoming Natural Diversity Database 2003).

Associated Species	Vernacular name
Achillea millefolium L.	common yarrow
Agropyron spicatum (Pursh) Scribn. & J.G.	bluebunch wheatgrass
Allium geyeri S. Wats.	Geyer's onion
Andropogon scoparius Michx.	little bluestem
Antennaria rosea Greene	rosy pussytoes
Artemisia tridentata Nutt. ssp. *tridentata*	basin big sagebrush
Artemisia tridentata Nutt. ssp. *vaseyana* (Rydb.) Beetle	mountain big sagebrush
Astragalus aboriginorum Richards	Indian milkvetch
Astragalus kentrophyta Gray	spiny milkvetch
Astragalus miser Dougl. var. *decumbens* (Nutt. ex Torr. & Gray) Cronq.	timber milkvetch
Cerastium arvense L.	field chickweed
Elymus lanceolatus (Scribn. & J.G. Sm.) Gould	streambank wheatgrass
Eremogone nuttallii Pax	sandwort
Erigeron caespitosus Nutt.	tufted fleabane
Erigeron compositus Pursh	cutleaf daisy
Eriogonum spp.	buckwheat
Festuca idahoensis Elmer	Idaho fescue
Geum rossii (R. Br.) Ser.	Ross' avens
Haplopappus macronema (Nutt.) Gray	whitestem goldenbush
Juniperus scopulorum Sarg.	Rocky Mountain juniper
Koeleria macrantha (Ledeb.) J.A. Schultes	prairie junegrass
Lepidium spp.	pepperweed
Leucopoa kingii (S. Wats.) W.A. Weber	spike fescue
Linum kingii S. Wats.	King's flax
Linum lewisii Pursh	prairie flax
Lupinus argenteus Pursh	silvery lupine
Monolepis nuttalliana (J.A. Schultes) Greene	Nuttall's povertyweed
Musineon spp.	wildparsley
Penstemon caespitosus Nutt. ex Gray	mat penstemon
Penstemon laricifolius Hook. & Arn.	larchleaf beardtongue
Phlox hoodii Richards.	spiny phlox
Phlox muscoides Nutt.	Wherry musk phlox
Pinus flexilis James	limber pine
Poa secunda J. Presl	Sandberg bluegrass
Potentilla ovina Macoun ex J.M. Macoun	sheep cinquefoil
Schizachyrium scoparium (Michx.) Nash	little bluestem
Sedum lanceolatum Torr.	spearleaf stonecrop
Stipa nelsonii Scribn.	needlegrass
Taraxacum officinale G.H. Weber ex Wiggers	common dandelion
Tetraneuris acaulis (Pursh) Greene var. *acaulis*	stemless four-nerve daisy
Tragopogon dubius Scop.	yellow salsify
Vicia americana Muhl. ex Willd.	American vetch

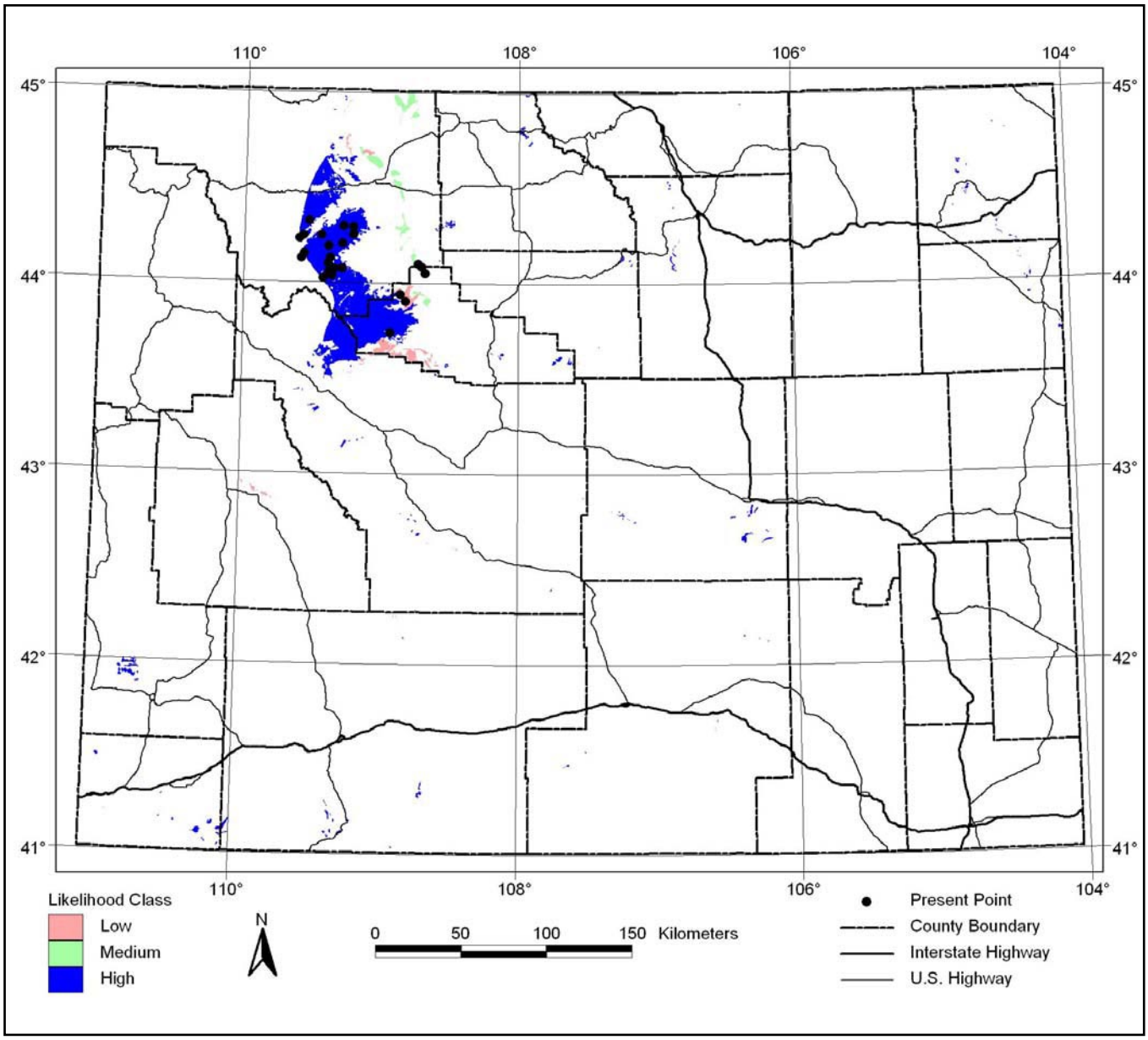

Figure 6. Predicted distribution of *Cymopterus evertii* using classification tree analysis (Fertig and Thurston 2003).

areas with marginal habitat. Fertig and Thurston (2003) note that in all probability this model does an excellent job of predicting where this species is not likely to occur, and a good job of predicting where it is likely to occur. Nevertheless, the model identifies target areas for future surveys.

Based upon the above discussion on habitat and on the results of the modeling project, high quality habitat for *Cymopterus evertii* can be found in sparsely vegetated areas, at elevations between 2,286 and 3,048 meters, on coarse volcanic substrates, moderate to steep slopes and rocky ridges, and often in openings of *Pinus flexilis* and *Picea engelmannii* climax forests and woodlands. Marginal habitat would occur at the lower elevations (1,676 to 2,438 meters) in foothill regions, on exposed sandstone outcrops and coarse substrates, within sparsely vegetated openings of *Pinus flexilis* woodland or *Artemisia tridentata*-grassland associations.

Reproductive biology and autoecology

An extensive literature search resulted in no empirical data describing the ecological strategies for *Cymopterus evertii*. Grime (1979) developed a system of classifying plant strategies based on three basic stress

responses. He termed these responses competitor, stress tolerant, or ruderal. Grime proposed four guidelines to aid in classifying plant stress responses: morphology, life-history, physiology, and miscellaneous (litter and palatability). No information was identified concerning the guidelines to make any inferences regarding ecological strategies.

The morphology of *Cymopterus evertii* (relevant to Grime's system) includes the tufted herbaceous perennial life-form and leaf morphology described as moderate to densely pubescent, somewhat glandular, and once or twice pinnately compound (Hartman and Kirkpatrick 1986). These morphological characteristics suggest that this species is suited to surviving in a harsh environment because it grows low to the ground, and has leaves that minimize desiccation through small size and vestiture (Grime 1979, Barbour et al. 1987).

The life-history of *Cymopterus evertii* has not been investigated, however, we do know that it is a perennial, with the perennating bud located at the root crown one to nine cm below the surface (Hartman and Kirkpatrick 1986). This species possesses a thick woody caudex, indicating a mechanism for surviving harsh winters and periodic droughts. *Cymopterus evertii* flowers from May through July, with seeds present from June to August. It is not known whether the same individuals flower year after year. The amount of annual production devoted to seeds is also not known. Heidel's (2002) monitoring survey conducted two years after the Enos fire indicated there were seedlings present at the time of survey. A persistent seed bank may or may not have been maintained. In addition, Heidel confirmed a relatively high rate of survivorship following fire (ca 50 percent) in the one observation period. Despite the gaps in the knowledge of the life history of *C. evertii*, the perennial habit and thick woody caudex indicate an ability to successfully occupy a resource limited environment (Grime 1979).

There are no published data describing the physiology of this species or a closely related species. The only inference that can be made is that the storage of photosynthate mineral nutrients occurs in the woody crown. Palatability of this species is not known.

Grime's (1979) system is not a foolproof method of classifying autecological strategies for individual species. In reality, species can take on any combination of characteristics of ruderals, competitors, and stress tolerant responses. There are not enough data to classify *Cymopterus evertii* definitively. Based upon the above discussion, *C. evertii* demonstrates a greater number of stress tolerant responses than characteristics of the other strategies.

Data on disturbance processes other than fire that may affect survivorship of *Cymopterus evertii* are nonexistent. Heidel's demographic monitoring two years following the 2000 Enos fire provides some information about the ability of *C. evertii* to survive a dramatic disturbance (Heidel 2002). Without additional monitoring data, little can be inferred as to the species' response to fire. General observations noted were that similar reproductive levels occurred between the 1998 and the 2002 survey. However, no data on seed set were recorded and many of the 2002 flowering stalks appeared to be aborted flowers. The data gathered during the 2002 field study will increase in value as follow-up censuses are accomplished.

There is no morphological evidence to suggest that *Cymopterus evertii* reproduces vegetatively or exhibits clonal growth (Hartman and Kirkpatrick 1986). *Cymopterus evertii* is mostly andromonoecious (producing both staminate and perfect flowers). The inflorescence is a compound umbel; the umbellets are comprised of two to 11 perfect flowers and three to seven staminate flowers. *Cymopterus evertii* flowers from May through July, with undispersed fruits present from June through September (Hartman and Kirkpatrick 1986, Mills and Fertig 1996). There have been no empirical studies to show that *C. evertii* is either self-compatible or an obligate outcrosser. However, most members of the Apiaceae are self-compatible (Bell 1971, Webb 1981, Richards 1986) and it is likely that *C. evertii* is also. A 2002 study by Schlessman and Graceffa investigated another member of the Apioideae, *Pseudocymopterus montanus* (A. Gray) Coulter & Rose. This species was found to be both andromonoecious as well as protogynous (pistillate flowers mature before the anthers dehisce). They also documented multiple cycles of protogyny as the terminal and lateral umbels matured sequentially. In *P. montanus*, strong protogyny within perfect flowers prevented self fertilization, while weak protogynous flowers within and among umbels allowed for the possibility of geitonogamous self pollination (self pollination between different flowers on the same plant). This suggests a mechanism to self-pollinate if cross-pollination is unsuccessful. However, geitonogamous self pollination requires a pollinator to distribute pollen between the flowers on the same plant, eliminating the possibility of self-pollination within the same flower. *Cymopterus evertii* is known to be andromonoecious, but has not been documented as protogynous although it is highly likely that it is.

Since *Cymopterus evertii* is likely self-fertilizing through a geitonogamous pollination event, a mechanism to ensure reproductive success would exist, giving this species a reproductive advantage in the short term through increased seed set and a prolonged flowering time. On the other hand, in the long term, selfing may promote homozygosity and possibly reduce fitness and the plants' ability to adapt to changing environmental conditions (inbreeding depression) (Menges 1991, Weller 1994). *Cymopterus evertii* is andromonoecious, thus it is also likely an outcrosser and would also have a long-term reproductive advantage by maintaining higher heterozygosity through increased pollinator visits. Andromonoecious plants have greater pollen availability and larger inflorescences resulting in increased pollinator visitation (Schlessman et al. 2004). In the short-term, any loss of pollinators could theoretically reduce seed set (Weller 1994).

No specific studies have been accomplished to characterize *Cymopterus evertii*'s pollinators. Nevertheless, there is literature documenting pollination in other apioid species with similar andromonoecious and protogynous breeding systems. Most apioid plants are fertilized by solitary bees such as members of the Andrenidae, Halictidae, Colletidae and others. Syrphid and muscoid flies are also noted pollinators of apioid species (Lindsey 1984, Lindsey and Bell 1985).

No information is available about the germination, establishment, or biology of the seeds or seedlings of *Cymopterus evertii*. Moreover, no data exist concerning the fertility or viability of the seeds. Fertig et al. (1999) speculated that *C. evertii* may favor establishment of seedlings in sparsely vegetated microsites. In 1998, Welp observed that smaller, younger individuals were more abundant under trees then out in the open (Fertig et al. 1999). Heidel noted abundance was greater in areas with less vegetative cover (Heidel 2002). She speculated that younger individuals may benefit from the shade provided by trees, especially for occurrences that are located in the lower elevations along the periphery of their range, whereas the more mesic mountain occurrences tend to be more abundant in sparsely vegetated areas with little or no tree cover. No conclusive evidence exists to support the existence of any site preference for seedling establishment.

No investigations into seed dispersal have been accomplished for this species. The seeds separate into flattened short-winged mericarps (Hartman and Kirkpatrick 1986). The weakly winged fruits of *Cymopterus evertii* are one of the characters that distinguish it from other members of *Cymopterus*. Wind dispersal is likely, but it has been speculated that the seeds probably fall near their parents (Fertig et al. 1999). No investigations have been made concerning seed predation of *C. evertii* fruits. The reproductive structures of apioids are frequently attacked by Lepidoptera (Thompson 1994). There are no other known cryptic phases in the *C. evertii* life history.

Current literature indicates that relationships commonly exist between most higher plants and mycorrhizal fungi and in fact, this is a growing area of scientific study. It is possible that a relationship between *Cymopterus evertii* and mycorrhizal fungi does exist, but there are currently no documented or observed mycorrhizal associations for *C. evertii.*

Genetic characteristics play an important part in the reproductive fitness of plants. There have been no studies to date investigating the genetic characteristics of *Cymopterus evertii*, or other related species. There is little evidence of hybridization between any species of western North American umbels, therefore it is highly unlikely that *C. evertii* shows evidence of hybridization (Hartman personal communication 2003). Given the lack of evidence, no inferences can be made by the authors concerning inbreeding and outbreeding depression, or any other genetic issue possibly associated with *C. evertii.*

Demography

The life history of *Cymopterus evertii* remains uninvestigated at this time. No information concerning vital rates, recruitment, survival, reproductive age, lifespan or proportion of populations reproducing has been documented. The three belt transects established in 1998 by Welp (Fertig et al. 1999) were established to monitor the number of individuals grouped into size classes and degree of shading within each plot. Percent of individuals with fruiting heads at the three transects were 8 percent, 1 percent, and 10 percent, with the highest number observed at the Enos Creek site. Unfortunately, there are no comparable data from the other transects to establish any quantitative figure that would be useful for predicting population growth. Future monitoring of these transects will provide valuable information concerning recruitment, mortality, overall population trend, and whether or not degree of shading influences the density of *C. evertii*. Regrettably, a component investigating seeds and seedling establishment was not included in this investigation. In addition, Heidel (2002) notes that data comparing the fate of individuals over time are not possible to quantify because the plants were mapped at a +/- 20

cm precision, they were not monitored for consecutive years, and the only prospective survivors in the transect were in clusters where there was almost always more than one plant per 20 cm.

A demographic projection matrix provides valuable information about the vital rates of a species, and is determined by tracking the fate of individuals over time. Only two data sets exist for the Enos Creek site; therefore a meaningful life cycle diagram based on probability of attaining the next phase in the life cycle as per Caswell (2001) could not be constructed for *Cymopterus evertii* at this time. In addition, it is beyond the scope of this assessment to calculate population matrices for developing a life cycle diagram. Nevertheless, a simple life cycle diagram illustrating what is known about *C. evertii* is presented in **Figure 7**. Three stage classes were defined in the original demographic monitoring study set up by Welp in 1998 (Fertig et al. 1999). Size (diameter in cm) was used to designate plants as small (1.0 to 3.0 cm), medium (3.1 to 10.0 cm), or large (>10.1 cm). Number of reproductive plants and the number of fruiting heads per reproductive plant were recorded. **Figure 7** depicts a simple lifecycle diagram for *C. evertii* based upon the first collection of data at the three baseline monitoring belt transects established in 1998 (Fertig et al. 1999). It is not known whether immature stages exist. However based upon one data set, it appears that individuals in the small stage do not flower. If this is a juvenile stage, it appears that individuals must attain the next size class (3.1 to 10 cm in diameter) before they can become reproductive. It is not known if reproductive adults revert to a vegetative state. Seed bank dynamics (recruitment rates, seed longevity, abundance) are unknown, but are represented in the diagram by a question mark between seed bank and seed. No information is available on germination rate or seedling survival, depicted in the diagram by a question mark between seed and seedling.

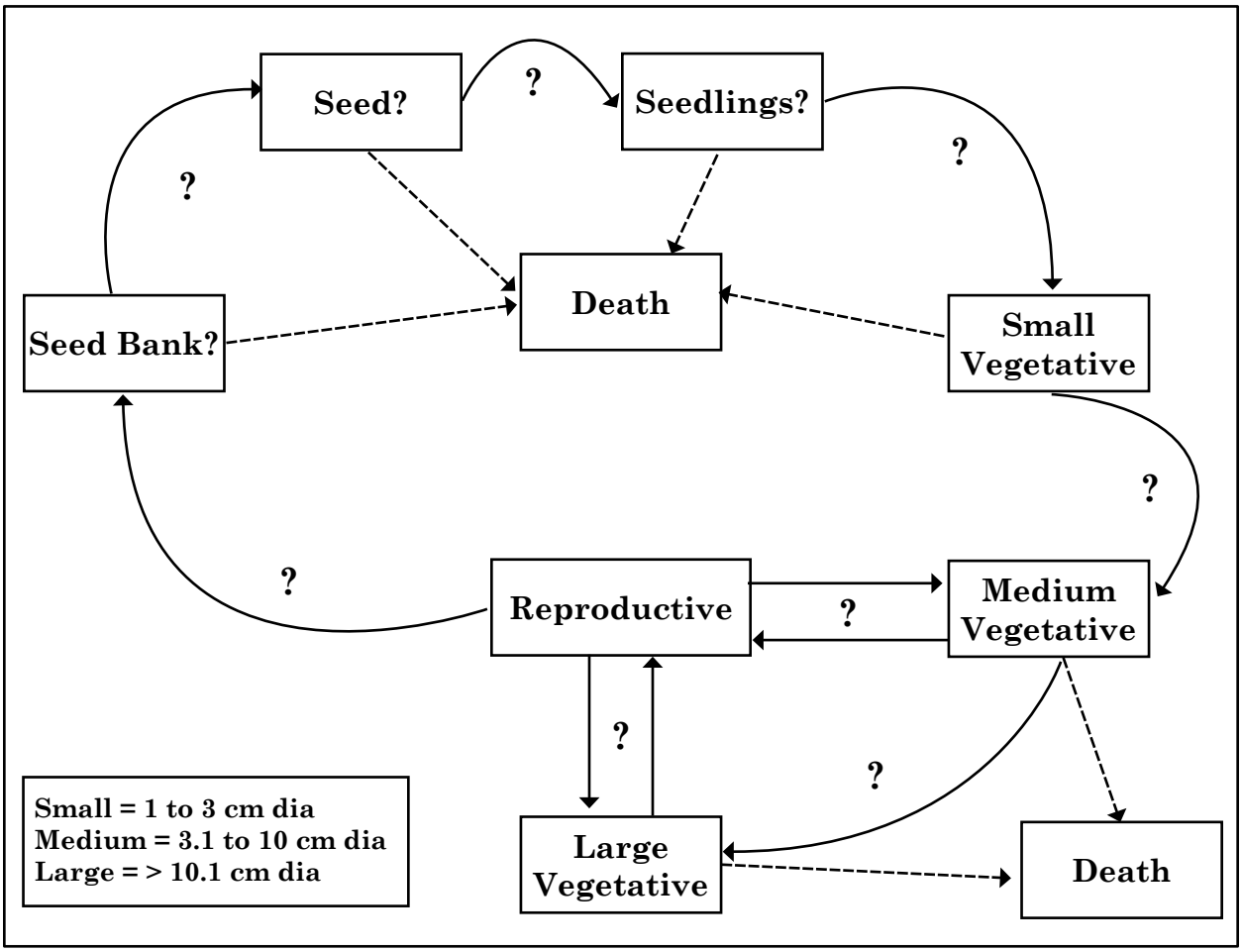

Figure 7. Life cycle diagram of *Cymopterus evertii*. Question marks reflect lack of understanding of the mechanisms between stages or the percent recruitment from one stage to the next. The dashed indicate lack of specific knowledge.

A population viability analysis is a rigorous quantitative analysis using demographic data to predict the future status of a given species. A literature search for Population Viability Analysis (PVA) models for this species was performed. An estimate of the minimum viable population (MVP), or the minimum population size necessary to have an acceptably low extinction probability, can provide useful information for management purposes. It has been suggested that demography is of more immediate importance then genetics in determining the MVP of a plant population (Landes 1988, Menges 1991). Menges (1991) suggests that if a plant population is able to buffer environmental stochasticity, then it will be sufficient to protect the genetic integrity. No PVA has been accomplished or MVP determined for *Cymopterus evertii* at this time.

Information concerning the demographic spatial characteristics for this species is limited. Less than half of all known locations have abundance estimates. Refer to **Table 2** for detailed occurrence and habitat data.

Few factors limiting the population growth of *Cymopterus evertii* have been identified. At the present, fire is the only known process to affect the population growth of this species and our knowledge of this is restricted to one demographic monitoring site (Heidel 2002). If monitoring of this site continues over the next few years, factors limiting population growth might be identified. Currently, no empirical data exist to provide a basis for identifying such factors, which may include seed predation, competition, habitat destruction, habitat fragmentation, barriers to dispersal or any other factor that may limit population growth.

Community ecology

Cymopterus evertii is generally located in remote areas, which provide a degree of isolation from interactions with invasive species. Two invasive species, including common dandelion (*Taraxacum officinale*) and yellow salsify (*Tragopogon dubius*), were observed at the Enos Creek site following the fire (Heidel 2002). It is unknown whether interactions with native species have any effect on the distribution or abundance of *C. evertii*. The species occupies a broad range of habitats and is associated with a large number of annuals and perennials (**Table 3**). No positive or negative correlations can be made concerning native plant interactions.

There have been no investigations of interactions between *Cymopterus evertii* and herbivores. Welp (Fertig et al. 1999) noted a small caterpillar on the leaves of an individual in one of the monitoring transects located southeast of Meeteetse, Wyoming. The reproductive structures of apioids are frequently attacked by Lepidoptera (Thompson 1994). No observations were recorded as to presence of leaf damage.

There have been no investigations concerning any parasites or diseases that may affect *Cymopterus evertii*, nor have there been any observations of symbiotic or mutualistic interactions. It is conceivable that these interactions exist, and in all probability, a mutualistic relationship with mycorrhizal fungi is likely (Barbour et al. 1987).

Cymopterus evertii is adapted to the extremes of the cold, arid Rocky Mountain west. There have been no investigations defining the interactions between *C. evertii* and its habitat. Further study based upon a holistic view of the environment surrounding *C. evertii* may identify factors that have an effect upon the success of this species within its range.

An envirogram is a useful tool for evaluating the relationship between the environment and a single species. It traces the environmental factors that affect a species from the most indirect (distal) interactions to factors that have a direct (proximal) effect (Andrewartha and Birch 1984). Traditionally, it is most often applied to animal/environment interactions. An example of an envirogram constructed for the sugar pine (*Pinus lambertiana* Douglas) showed that the same principles used to construct one for animals could be equally applied to plants (Schlesinger and Holst 2000). The envirogram is a series of webs that converge upon a centrum. The centrum consists of the basic components of environment that cause an increase, decrease, or no change in the expected fecundity and survivorship of a species. It is the most proximal level of the envirogram, and directly affects the target species (Andrewartha and Birch 1984). For plants, the centrum consists of resources (light, soil moisture, and nutrients), reproduction (flowering/fruiting, growth and development, and seedling establishment), and malentities (fire, extreme weather, and herbivory).

The envirogram is constructed as a modified dendrogram, with the centrum placed at the most proximal level to the species. From each of the centrum components, a web is constructed distally, illustrating factors that affect the centrum component, termed Web 1. Web 2 consists of factors that affect Web 1 and Web 3 consists of factors that affect Web 2 and so on. One of the primary functions of an envirogram is to identify areas of research and propose hypotheses (Andrewartha

and Birch 1984). As with all analytical tools, the best envirogram is based upon a complete data set. An envirogram was constructed for *Cymopterus evertii*, despite the lack of ecological and environmental data. Entries with a question mark denote areas in need of further research, such as pollination mechanisms, safe sites, herbivory, flowering/fruiting, and dispersal vectors. **Figure 8** provides the resource centrum, **Figure 9** provides the reproduction centrum and **Figure 10** provides the malentities portion of the envirogram for *C. evertii*. Web 4 levels and above (Web *n*) generally identify areas beyond the ecological and biological scope of the species.

The resources centrum for *Cymopterus evertii* is made up three proximal factors, soil moisture, light, and nutrients. Soil moisture is affected by precipitation, soil porosity (permeability), soil water retention, and runoff. Light can be affected by aspect or vegetation cover, which in turn can be modified by disturbance. The nutrient centrum is affected by parent material and the addition or subtraction of organic materials (e.g. decomposition of coarse woody debris or manure). The reproduction centrum consists of factors affecting flowering and fruiting (pollination, weather, seed dispersal), seedling establishment (possible safe sites, substrate, temperature, and exposure), and growth and development (weather, light, substrate). Within each web unknown factors may effect reproduction either positively or negatively. The malentities centrum identifies factors that may negatively affect *C. evertii*. These include such things as extreme weather conditions, for example drought or unusually cold weather during the flowering and fruiting season. Herbivory may cause damage through trampling, seed predation, introduction of invasives, or leaf damage. Damage may result from either domesticated livestock or native fauna including mammals and insects. Anthropogenic impacts include recreational activities such as ORV use, hiking (pedestrian or horse) and introduction of invasive species. Nitrogen or particulate deposition can result from air pollution. High intensity fire is a threat for this species, and can be the result of either natural or human causes. Fire may affect mortality, cover, and moisture availability for *C. evertii.*

CONSERVATION

Threats

Concern for *Cymopterus evertii* is a result of its restricted global distribution. Its restricted geographical range makes *C. evertii* vulnerable to both human and natural disturbances, even though occurrences are isolated and difficult to access (Fertig et al. 1999). Viability considerations for *C. evertii* are loss of occurrences due to management activities or natural disturbances that may impact habitat or occurrences.

Of the management activities that typically occur or are planned for the Shoshone National Forest, prescribed or natural fire, livestock grazing, and recreation may have a potential impact on *Cymopterus evertii* occurrences. Due to the remote locations of the *C. evertii* occurrences, no commercial timber harvest or mechanical fuels treatment are planned in areas with *C. evertii*. Other potential threats to the species include extreme weather conditions, herbivory, competition from invasive species, global warming and air pollution. No research has been conducted evaluating whether the species has been utilized for commercial, recreational, scientific or educational purposes or threatened by disease or predation or other natural or manmade factors that affect its continued existence.

Prescribed or natural fire

The effects of fire on vegetation are difficult to quantify as effects are variable and spatially heterogeneous (Brown and Brown 2000). Little knowledge is available to determine the degree of threat posed by natural or prescribed fire. Alpine occurrences of *Cymopterus evertii* would not be affected by prescribed or natural fire. Evidence concerning response of *C. evertii* to natural fire was obtained by the monitoring of an occurrence burned in the 2000 Enos fire (EOR 24; Heidel 2002). Overall effects of the fire included a net reduction in the total number of *C. evertii* plants in the permanent belt transect between 1998 and 2000, a reduction in the number of large plants (>10 cm diameter), and an increase in the number of small plants (0 to 3 cm diameter). Evidence from the monitoring results suggests *C. evertii* may have the ability to survive a natural fire. However, Heidel (2002) noted that no survivors were identified in areas of high intensity fire. No information was identified that suggested that a recurring fire regime is necessary to maintain *C. evertii* occurrences. No prescribed fire is planned in the vicinity of *C. evertii* occurrences (Kent Houston personal communication 2003).

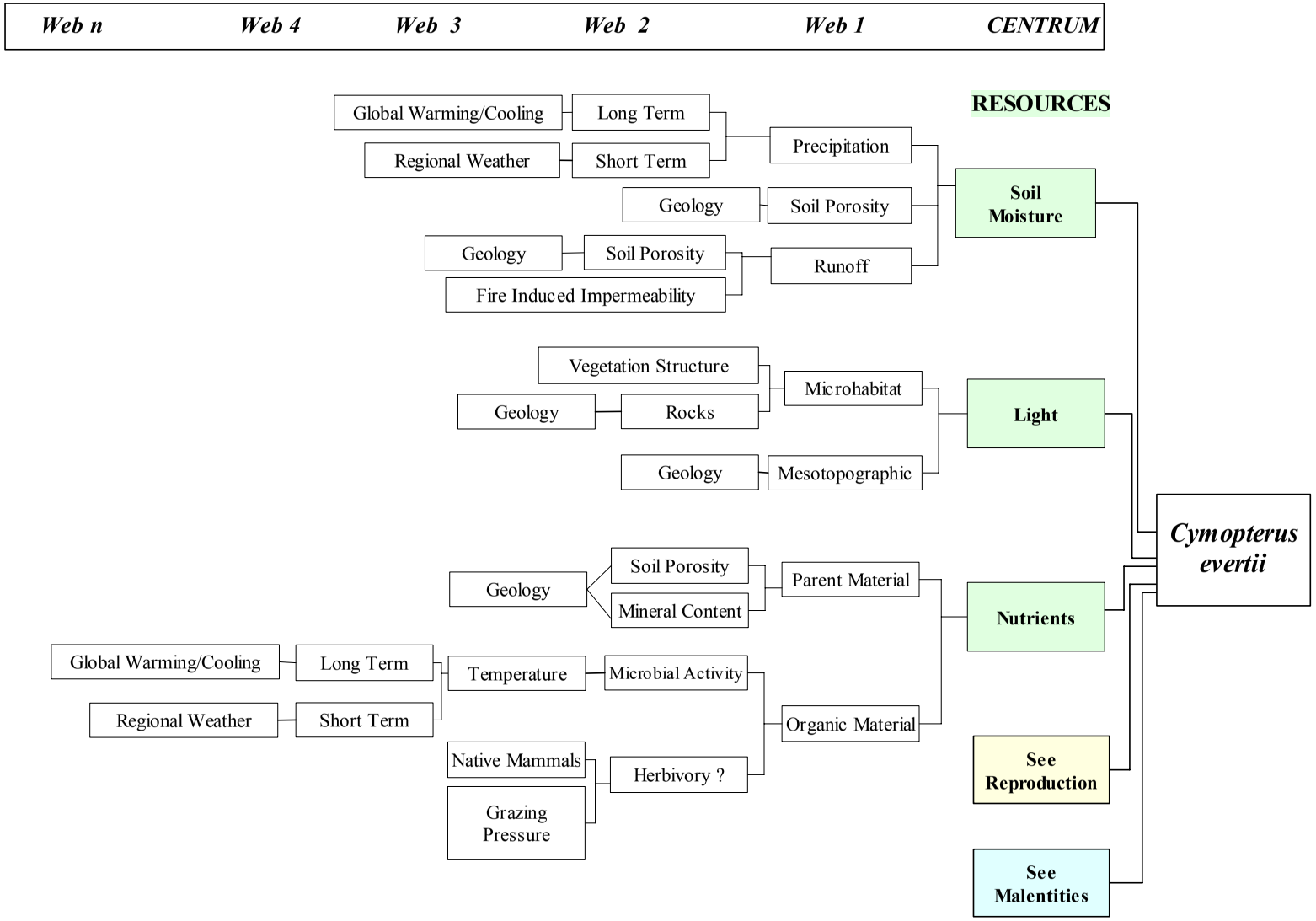

Figure 8. Resource centrum of the environgram for *Cymopterus evertii*.

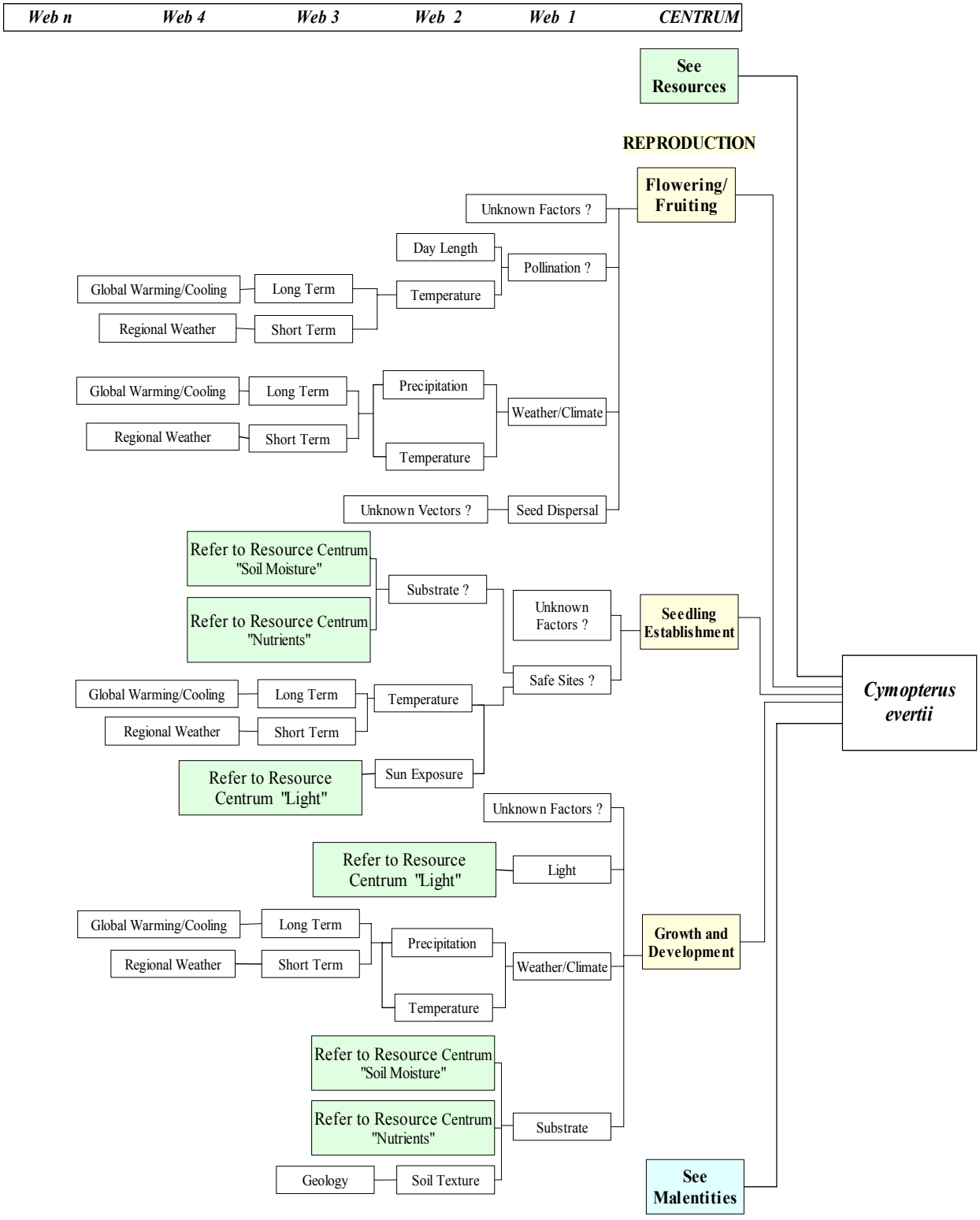

Figure 9. Reproduction centrum of the envirogram for *Cymopterus evertii*.

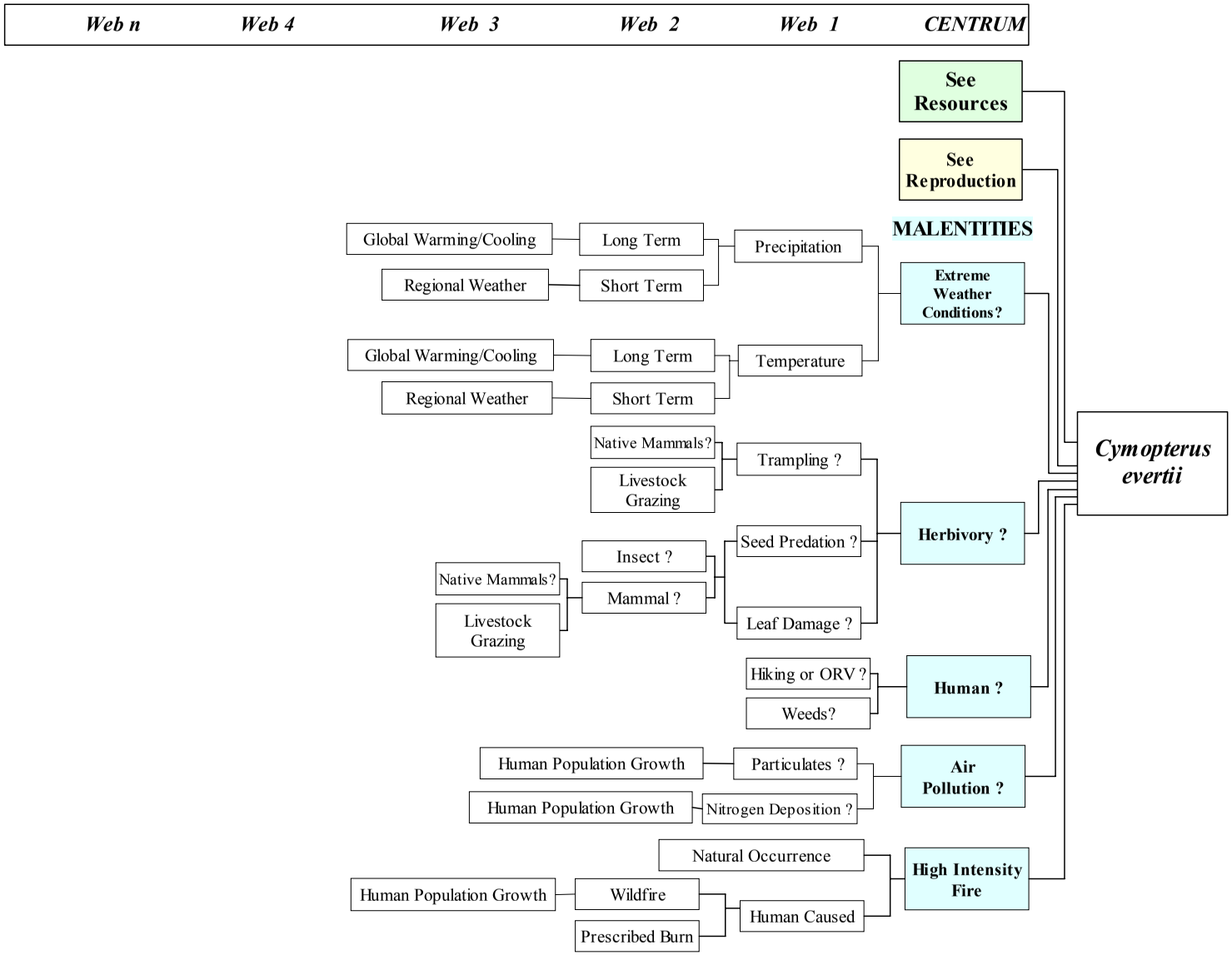

Figure 10. Malentities centrum of the envirogram for *Cymopterus evertii*.

A bibliography of fire effects on threatened and endangered species can be found in Hessl and Spackman (1995) and effects on plant species in general in Brown's publication concerning wildland fire in ecosystems and effects of fire on flora (Brown and Brown 2000). No references were identified in these publications specifically concerning *Cymopterus evertii*. Little knowledge is available to determine the degree of threat posed by natural or prescribed fire. Due to the sparsely vegetated habitats in which the species occurs, it is not likely that fire poses a threat to occurrences located outside forested communities. Fire line access and construction have potential to impact individuals or occurrences through trampling, destruction of individual plants, or habitat fragmentation. The degree of threat posed by fire line construction could be higher than the threat of fire itself. Fire may pose a threat to those occurrences located within forested communities.

Grazing and herbivory

Impacts from grazing have not been observed nor investigated for this species at any of the known locations. Livestock usage of *Cymopterus evertii* habitat appears to be low, however, due to the lack of available water and sparse forage (Fertig 2000). Palatability of this species to horses or cattle has not been documented (Kent Houston personal communication 2003). However, the plant's aromatic nature in Wyoming occurrences and sparsely vegetated habitat may provide some protection from herbivory. Secondary impacts from grazing include changes in plant species composition (including spread of invasive species), soil compaction and erosion. The magnitude of impact to *C. evertii* would be based on the levels and timing of grazing in proximity to occurrence centers.

Cattle form trails or bovine terraces (Trimble and Mendel 1995), which may result in erosion and habitat fragmentation. The low porosity of trails can result in a low infiltration rate, resulting in concentrated runoff that creates gullies (Rostagno 1989). Formation of cattle trails can cause disruption of the hydrology of site and result in habitat fragmentation of microhabitats in which *Cymopterus evertii* occurs (Stuth 1991).

Trampling increases soil compaction and erosion by breaking the aggregate structure due to the force applied by hooves, thereby reducing pore space and decreasing infiltration and percolation. These impacts may increase runoff and encourage erosion (Stuth 1991, Trimble and Mendel 1995). The degree of impact associated with trampling depends on soil type, soil water content, seasonal climate conditions and vegetation type.

Grazing can induce an alteration of plant species composition with a resulting loss of diversity, net primary production and groundcover (Archer and Smeins 1991). Grazing could potentially result in the replacement of perennial species by annual or invasive species. Plant species composition can be altered when a specific intensity, frequency, and/or seasonality of grazing alters the competitive advantage of one group of plants over another (Briske 1991). Livestock can potentially contribute to an increase in the distribution of invasive species as a result of the transportation of weed seeds into uninfested sites; preferential grazing of native species over weed species; creation of patches of disturbed soils that act as seedbeds for weeds; potential alteration of soil surface and horizons; reduction/increase of soil mycorrhizae; and accelerated soil erosion (Briske 1991). It is unknown if interactions with native species have any effect on the distribution or abundance of *Cymopterus evertii.*

Water developments (stock ponds and pipelines for water supplies) for cattle are present in the area. No information was available regarding exact locations of water developments in relation to occurrences. Water sources are the principal focus around which cattle orient their travel patterns and foraging strategies. Optimum grazing area for cattle is defined by a circle whose radius is generally not over 1.6 km from the water source (Stuth 1991). Pipelines potentially could fragment habitats or disrupt individuals within the community. No information was available regarding exact locations of water developments in relation to occurrences (Kent Houston personal communication 2003).

All occurrences of *Cymopterus evertii* on the Shoshone National forest are in active grazing allotments. Little knowledge is available to determine the degree of threat posed by grazing specifically in relation to *C. evertii*. Grazing may pose a threat to those occurrences located outside forested communities.

Herbivory may occur from native fauna including mammals (such as rodents, antelope, deer or elk) and insects. Native herbivory could result in seed predation or leaf damage. No observations documented impacts from native herbivory. However, in extreme drought years native mammals may forage for less palatable species such as *Cymopterus evertii*.

Recreation

Recreation use in the proximity of occurrences located on the Shoshone National Forest primarily consists of ORV use in areas located outside wilderness boundaries and hiking and horse use in both the wilderness and non-wilderness areas. Recreation conflicts with rare plant species in wilderness areas may include trampling within occurrences, collecting of flowers or seeds, and habitat degradation (Hamilton and Lassoie 1986).

ORV use occurs on the Shoshone National Forest, however *Cymopterus evertii* occurrences are located on steep, rocky exposed slopes not favored by ORV use. No information was available to determine the extent of impacts to the species from recreation use. Currently no data are available to identify the level of existing threat to the species, however there is potential for individuals or occurrences to be threatened by an increase in recreational use on the Shoshone National Forest.

Weed control

Herbicide application has potential to impact individual plants or occurrences. Historical efforts to control *Delphinium* species (larkspur) have been conducted in the vicinity of *Cymopterus evertii* occurrences utilizing TORDON® in the 1970s and early 1980s. It is unknown where or how much herbicide was applied; however, larkspur typically occurs on deeper, moister soils than *C. evertii*. This program has been discontinued (Kent Houston personal communication 2003). Herbicide application could pose a threat to individuals or occurrences by altering plant community composition or increasing individual mortality. No information was available to determine the level of impacts resulting from past application of herbicides on the viability of *C. evertii* on the Shoshone National Forest.

Other threats

Other potential threats to the species include extreme weather conditions, global warming and air pollution. Unusually cold springs may delay flowering and seed set. Global warming has been identified as a potential threat to forested communities. In Wyoming, potential impacts to forested communities include alteration of species composition, geographic range, health and productivity. In alpine ecosystems, global warming could result in an alteration of timberlines encroaching on alpine habitats (U. S. Environmental Protection Agency 1998). Global warming could cause severe drought or other modification of climate regimes affecting survivorship or ability to reproduce. Nitrogen emissions from fixed, mobile and agricultural sources have increased dramatically along the Front Range of the Rocky Mountains (Baron et al. 2000). Possible effects of nitrogen deposition on a terrestrial ecosystem include premature abscission of pine needles, alteration of mycorrhizal fungi, loss of lichen communities, enhancement of non-native species invasions, and alteration of fire cycles by increasing fuel loads (Fenn et al. 2003). A study of nutrient availability, plant abundance and species diversity in alpine tundra communities determined that addition of nitrogen resulted in an increase in species diversity in a dry meadow (Theodose and Bowman 1997). Global warming and increased nitrogen may provide a potential threat to *Cymopterus evertii* in the long term.

Conservation Status of the Species in Region 2

Cymopterus evertii is a plant of the foothills and mountains that occurs in a range of habitats. The species is a regional endemic of northwestern Wyoming and northeastern Utah whose population viability is identified as a concern based on limited global distribution. A majority of the known occurrences (14 of 20) are located on the Shoshone National Forest. The conservation of those occurrences is important to the conservation of the species.

The nominal amount of data available concerning population numbers does not allow us to infer whether populations are increasing or decreasing. The only inference that can be made is that *Cymopterus evertii* is persistent at those locations that have been revisited over the past twenty years and occurred at least once at those locations that have not been revisited. While the species does appear to be persisting at the revisited locations it is difficult to determine the ability of occurrences to adapt to risk from environmental stochasticity or natural catastrophes (extreme weather conditions, global warming, wildfire, and air pollution) or management changes (prescribed fire, livestock grazing, and recreation). The remote location of occurrences may provide some protection from these impacts.

Known occurrences of *Cymopterus evertii* are located in habitats ranging from alpine to foothill communities across a wide range of slopes, elevations, and aspects. Potential suitable habitat for the species exists throughout USFS Region 2, especially those areas in Wyoming indicated by blue in **Figure 6** (see Habitat section). High quality habitat for *C. evertii* can be found

in sparsely vegetated areas, at elevations between 2,286 and 3,048 meters, on coarse volcanic substrates, moderate to steep slopes and rocky ridges, and often in openings of *Pinus flexilis* and *Picea engelmannii* climax forests and woodlands. Marginal habitat would occur at the lower elevations (1,676 to 2,438 meters) in foothill regions, on exposed sandstone outcrops and coarse substrates, within sparsely vegetated openings of *Pinus flexilis* woodland or *Artemisia tridentata*-grassland associations. No information is available that indicates that habitat for the species in increasing or decreasing. The adaptation of the species over a broad range of habitats may provide protection from risk from habitat change or alteration over time. The life-history of *C. evertii* has not been investigated, however, we do know that it is a perennial, with the perennating bud located at the root crown one to nine cm below the surface. This species possesses a thick woody caudex, indicating a mechanism for surviving harsh winters and periodic droughts. No information is available about the germination, establishment, or biology of the seeds or seedlings of *C. evertii*. Moreover, no data exist concerning the fertility or viability of the seeds.

Occurrences of *Cymopterus evertii* may also be at risk from environmental stochasticity or natural catastrophes based on the size of occurrences. Minimum viable population size has not been determined for this species; however, general inferences can be made. Factors increasing risk include sessile growth habits and geographically isolated occurrences. Seedling recruitment may be a factor limiting population growth particularly in the alpine and dry foothills. Factors buffering *C. evertii* occurrences from stochastic risks include adaptability to disturbance (i.e. fire), adaptation to a variety of microsites, a possible mixed breeding system, and evidence of seed bank stability.

No information was identified that indicated that any occurrences located in USFS Region 2 are at risk from environmental stochasticity or natural catastrophes (extreme weather conditions, global warming, wildfire, and air pollution) or land management practices (prescribed fire, livestock grazing, and recreation).

Potential Management of the Species in Region 2

Implications and potential conservation elements

Detailed biological and ecological studies of *Cymopterus evertii* and associated habitat have not been conducted. The species does appear to be persisting at the revisited locations occurring across a broad range of habitats. No information was identified that indicated that any occurrences located on USFS Region 2 lands are at risk from environmental stochasticity, natural catastrophes or land management practices. Protection of population numbers and the habitat in which they occur are elements necessary for maintaining viable populations of *C. evertii* on USFS Region 2 lands.

Activities potentially occurring on Forest Service lands that may pose a threat (or possible benefit) to individuals or occurrences of *Cymopterus evertii* include grazing, recreation and competition from invasive species. The consequences of management actions may include habitat fragmentation, soil compaction, erosion, trampling of individuals, loss of fitness and alteration of habitat. No evidence was found that indicated that any occurrences of *C. evertii* were at risk from these management activities. Avoiding direct impacts and disturbance to the species and its habitat will be beneficial to the species' persistence.

Land managers would benefit from studies focused on: identifying basic information concerning the distribution, biology and ecology of the species including surveying for new occurrences, gathering current population census information on known occurrences, evaluating reproductive and ecological characteristics (e.g. pollination mechanisms, seed germination, seedling establishment, herbivory, flowering/fruiting, dispersal vectors, etc.), gathering information on demographics (life history stages, population structure, longevity, mortality, etc.), and determining impacts to population viability from management activities and natural disturbances.

Tools and practices

As mentioned in the habitat section, *Cymopterus evertii* appears to be restricted to sparsely vegetated areas across a broad range of elevations, aspects, geological formations, soil types and vegetation types. Given the broad range of habitat variables there is potential for additional occurrences in the Rocky Mountain Region. Continued survey efforts in the location of other occurrences when both fruit and flowers are present may provide additional information concerning distribution and abundance of the species.

As discussed in the habitat section, Fertig and Thurston (2003) are working on using GIS to model the potential distribution of BLM sensitive and USFWS threatened and endangered plant species in Wyoming. Field reconnaissance of those areas with a

high or medium likelihood of occurrence could yield the discovery of additional occurrences. A complete inventory of the flora of the Rocky Mountains is in progress (Hartman 1992); the known regional distribution of *Cymopterus evertii* may expand upon completion of this survey work. Species or habitat surveys should be conducted during June or July when there is the greatest likelihood of both flowers and fruits being present.

Population monitoring should be designed to ascertain the species' life history parameters, including generation time, net reproductive rate, age distribution and potential reproductive output lost to abortion and predation. Periodic estimates of population size alone may not provide adequate information for management decisions (Elzinga et al. 1998). The monitoring methodology utilized by Fertig (1999) and Heidel (2002) for measuring the Enos Creek occurrence (EOR 24) in 2002 was based on techniques for monitoring non-rhizomatous, perennial plant species in permanent belt transects (Lesica 1987). This approach provides quantitative demographic data. Evaluation of the methodology for quadrat sizes with respect to the species distribution is important. Lesica (1987) recommends a one square meter quadrat, but this is for utilization with plant species with low to moderate densities (0.2 to 10 plants per meter). Individual occurrences of *Cymopterus evertii* generally exhibit a clumped pattern and are as small as three to 11 plants per square meter (Fertig et al. 1999) up to thousands per hectare (Marriott 1988). Fertig (1999) and Heidel (2002) suggested the use of a 0.5 square meter quadrat for sampling *C. evertii.*

The three existing transects established on BLM land are located in foothill communities (*Pinus flexilis*, *Juniperus scopulorum*, and *Artemisia tridentata*). Fertig (1999) recommends measuring the transects annually or biennially until a trend is established. Once a trend is established, information would be available to make an assessment of further work (Palmer 1987). Establishment of additional transects throughout the species' range on the Shoshone National Forest would be vital to understanding the species.

Additional quantitative data that document the condition of the communities where *Cymopterus evertii* occurs including the plant composition, structure and function, would make information available on existing conditions should and increase or decline in *C. evertii* occurrences take place. This information may also provide clues as to possible limiting factors controlling the distribution of the species. Common variables to be measured include cover or density of all plant species, demographic parameters of important species, soil surface conditions, fuel loads, and animal signs. Monitoring could form the basis for a long-term ecological study to document rates and types of change that can occur in response to natural process such as succession and disturbance (Elzinga et al. 1998).

Habitat monitoring describes how well an activity meets the objectives or management standards for the habitat (Elzinga et al. 1998). Establishing a minimum total vegetative plant cover and type of forage species in a grazing allotment would be an example. Habitat monitoring is most effective when research has shown a clear link between a habitat parameter and the condition of a species (Elzinga et al. 1998). Without additional knowledge of factors controlling the growth and distribution of *Cymopterus evertii*, it would be difficult to utilize this type of monitoring program. Collection of quantitative data relevant to community structure and composition as mentioned above would provide a baseline for use of this methodology.

Based on potential demographic, environmental, genetic and natural stochastic risk to *Cymopterus evertii*, information concerning minimum viable population size could be utilized to identify protection needs. In addition to determining minimum population numbers, protection of diverse occurrences across the range of habitats and elevations may also be important in the preservation of genetic diversity (Karron 1987).

Information Needs

Topics for further study include:

- Continued surveys near known occurrences may provide additional information concerning distribution and abundance of the species and assist in the formulation of conservation strategies for USFS Region 2

- Collection of quantitative data relevant to habitat would provide a baseline for use in future monitoring efforts

- Establishment and monitoring of belt transects (Lesica 1987) on the Shoshone National Forest would provide population trend information and fill gaps concerning its life history including generation time, net reproductive rate, percent germination, net seedling establishment, age distribution and

potential reproductive output lost to abortion and predation

- Evaluation of the reproductive and ecological characteristics of the species including pollination mechanisms, seed germination, seedling establishment, herbivory, flowering/ fruiting, and dispersal vectors, would provide a basis to assess further factors controlling the growth of *Cymopterus evertii*

- Addressing basic demographic questions (vital rates, recruitment, survival, reproductive age, lifespan or proportion of populations reproducing, seed viability, seed bank dynamics, longevity) in population viability studies would allow management to be designed to benefit the species

- Continued monitoring of the Enos Creek and other occurrences could provide additional information concerning plant mortality, fire resistance, flower production, phenology, vegetative regeneration, seed dispersal and viability

- Collection of information concerning response of the species to management alternatives, including establishment of permanent monitoring transects, could serve to provide baseline information for determination of impacts to the species

- Conducting biological evaluations of impacts of management to the species would reduce potential for causing significant downward trends in occurrences or habitats

- Identification of a sponsor for placing plant material with the Center for Plant Conservation; the lack of knowledge concerning the species may warrant preservation of genetic material

- Genetic investigation to determine degree of heterozygosity among/within occurrences would help estimate the potential threat of inbreeding or outbreeding depression

- Determination of breeding system, i.e. self-compatible, outcrosser or both, would allow for better management decisions

DEFINITIONS

Carpophore: A slender prolongation of the receptacle between the carpels as a central axis, as in the fruits of some members of the Umbelliferae and the Geraniaceae. (Harris and Harris 1994).

Cryoturbation: The physical mixing of soil materials by the alternation of freezing and thawing (Lincoln et al. 1982).

Generation time: The mean period of time between reproduction of the parent generation and reproduction of the first filial generation (Lincoln et al. 1982).

Geitonogamous: self pollination between different flowers on the same plant (Lincoln et al. 1982).

Inbreeding: Mating or crossing of individuals more closely related than average pairs in the population (Lincoln et al. 1982).

Inbreeding depression: Reduction of fitness and vigor by increased homozygosity as a result of inbreeding in a normally outbreeding population (Lincoln et al. 1982).

Heterozygosity: Having two different alleles at a given locus of a chromosome pair (Lincoln et al. 1982).

Homozygosity: Having identical alleles at a given locus of a chromosome pair (Lincoln et al. 1982).

Longevity: The average life span of the individuals of a population under a given set of conditions (Lincoln et al. 1982).

Mericarp: A section of a schizocarp; one of the two haves of the fruit of the Apiaceae (Harris and Harris 1994).

Monophyletic: Derived from the same ancestral taxon; used of a group sharing the same common ancestor (Lincoln et al. 1982).

Muriculate: Rough, with very fine, sharp projections or points (Harris and Harris 1994).

Outbreeding depression: Reduction of fitness and vigor in the progeny when individuals mate from distant source populations (Lincoln et al. 1982).

Outcrossing: Mating or crossing of individuals that are either less closely related than average pairs in the population, or from different populations (Lincoln et al. 1982).

Polyphyletic: Derived from two or more distinct ancestral lineages; used of a group comprising taxa derived from two or more different ancestors (Lincoln et al. 1982).

Self-compatible: A plant that can self-fertilize (Lincoln et al. 1982).

Selfing: Self-fertilizing or self pollinating (Lincoln et al. 1982).

Stochastic: Based on a mathematical model founded on the properties of probability so that a given input produces a range of possible outcomes due to chance alone (Lincoln et al. 1982).

Vestiture: General descriptive term of degree and type of pubescence on a plant (Harris and Harris 1994).

Vital rates: The class-specific annual rates of survival, growth, and fecundity (Morris et al. 1999).

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