

**STATUS OF *MUSINEON VAGINATUM* (SHEATHED MUSINEON),
BIGHORN MOUNTAINS, NORTH-CENTRAL WYOMING**



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ABSTRACT

The highest concentration of *Musineon vaginatum* (sheathed musineon) populations in Wyoming are on Bighorn National Forest, where it is at the southern and eastern limits of its distribution, and at the highest elevations of its distribution. Twelve of its 16 populations in the state are on the Forest, including ten that were surveyed on the Forest in 2010, four of which were new. Based on the results of this project, *M. vaginatum* has been found to be widespread across the northern Bighorn Mountains in the Medicine Wheel and Tongue River Ranger Districts in a range of habitats, but geographically restricted to this area, and with limited vulnerability to most land management practices. There are challenges in determining numbers and extent, so that a conservative stance has been taken in assessing species' viability and status, and it remains on the Wyoming plant species of concern list.

ACKNOWLEDGEMENTS

The 2010 surveys for *Musineon vaginatum* (sheathed musineon) were conducted with the assistance of Stephanie and Jim Zier. Herbarium records of Montana State University were kindly provided courtesy of Dr. Matt Lavin. The facilities and resources of the Rocky Mountain Herbarium and expertise of Dr. Ronald Hartman and B.E. Nelson are gratefully acknowledged. Emily Elliott (University of Wyoming) provided a highlight of collection information from her thesis in progress. The coordination of Bernie Bornong, Bighorn National Forest, was instrumental at all stages. Annie Munn (Wyoming Natural Diversity Database; WYNDD) assisted in preparations before the field season and in digitizing survey routes. This study was one in a set of botanical studies conducted through a challenge cost-share agreement between Bighorn National Forest and Wyoming Natural Diversity Database, University of Wyoming.

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TABLE OF CONTENTS

INTRODUCTION	1
METHODS	1
RESULTS - SPECIES INFORMATION	2
Classification.....	2
Present legal or other formal status.....	2
Description.....	3
Geographical distribution.....	7
Habitat.....	10
Population biology and demography	15
Reproductive biology	16
Population ecology.....	18
ASSESSMENT AND MANAGEMENT RECOMMENDATIONS	19
Potential threats to currently known populations.....	19
Management practices and response.....	20
Conservation recommendations.....	20
LITERATURE CITED	21

FIGURES AND TABLES

- Figure 1. Illustration of *Musineon vaginatum*
- Figures 2 and 3. Specimens of *Musineon vaginatum*
- Figure 4 and 5. Fruits of *Musineon vaginatum*
- Figure 6. *Musineon vaginatum* in flower
- Figure 7. Rangelwide and statewide distribution of *Musineon vaginatum*
- Figure 8. Geology of *Musineon vaginatum* habitat in Bighorn National Forest
- Figure 9. *Musineon vaginatum* in *Pseudotsuga menziesii* forest
- Figure 10. *Musineon vaginatum* in mixed conifer forest
- Figure 11. *Musineon vaginatum* in *Potentilla fruticosa* meadow
- Figure 12. *Musineon vaginatum* in forest opening
- Figure 13. *Musineon vaginatum* in 1970's crownfire
- Figure 14. *Musineon vaginatum* vegetative and in bud
- Figure 15. *Musineon vaginatum* with aborted and mature fruits

Table 1. Characteristics that distinguish *Musineon vaginatum* from other species in the same genus and family

Table 2. Location information for *Musineon vaginatum* in Wyoming

Table 3. Species associated with *Musineon vaginatum*

Table 4. Size and extent of *Musineon vaginatum* populations

APPENDICES

Appendix A. Element occurrence records and maps for *Musineon vaginatum*

Appendix B. Updated species evaluation for *Musineon vaginatum*

Appendix C. Updated state species abstract for *Musineon vaginatum*

INTRODUCTION

Musineon vaginatum (sheathed musineon) is a regional endemic of western and south-central Montana and the Bighorn Mountains of north-central Wyoming. It reaches its southern and eastern limits of global distribution in this area of Wyoming. Prior to 2010, there were no concerted surveys for the species and the threats were unknown.

Musineon vaginatum was first discovered in Wyoming in 1968 on the Bighorn National Forest. Most of the subsequent collections in the state have been on or near the Forest. It is on the current Species of Local Concern list maintained by the Forest (USDA Forest Service 2005). This project was undertaken in collaboration with Bighorn National Forest to provide systematic survey and address the most pressing information needs for *M. vaginatum*.

METHODS

At the start of this project, information on the habitat and distribution of *Musineon vaginatum* was compiled and reviewed (Heidel and Fertig, Rocky Mountain Herbarium 2010, Wyoming Natural Diversity Database 2010). A three-pronged approach was taken in conducting 2010 field surveys.

1. Populations represented by specimen collections were relocated and surveyed to map their extent, population numbers, and habitat conditions on the landscape.
2. Digital color infrared orthophotography (2000) was used to compare *Musineon vaginatum* habitat signatures with other areas on the Forest having calcareous limestone bedrock, identifying major areas of similar habitat not previously surveyed.
3. Finally, known distribution was overlain with a compilation of calcium carbonate-rich bedrock formations (Love and Christiansen 1985) to compare known distribution with geology as basis for interpolation and extrapolation.

The fieldwork was conducted simultaneously with surveys for two other rare calciphilic plants, *Physaria didymocarpa* var. *lanata* (woolly twinpod) and *Pyrrocoma clementis* var. *villosa* (hairy tranquil goldenweed) in order to pursue Forest-wide surveys of all three would be more efficient than either alone.

In preparation for fieldwork, digital orthophotographs with species' distribution superimposed were printed out onto 8 ½ x 11 paper, representing about the same scale as 1:24,000 USGS topographic maps. The aerials and maps were both used for reference in setting field survey priorities and navigation in the field.

Surveys for *Musineon vaginatum* were conducted by three botanists working between 6 June and 25 July, with low success as late as 8 September. When *M. vaginatum* was found in a survey area, the first tasks were to estimate its numbers, determine extent, and describe occupied habitat including topography, vegetation, and plant associates. Coordinates were recorded from GPS

units for georeferencing population boundaries, later used to digitize polygonal population boundaries into the WYNDD database. Information was compiled and recorded onto WYNDD sensitive plant survey forms, and later entered in the WYNDD database.

RESULTS - SPECIES INFORMATION

Classification

Scientific name: *Musineon vaginatum* Rydb.

Synonyms: None.

Common name: Sheathed musineon

Family: Apiaceae (previously referred to as Umbelliferae; Parsley family)

Size of genus: One of ten species in the *Musineon* genus, three of which are in Wyoming. This genus was described by Constantine Samuel Rafinesque and is typically characterized by laterally-compressed fruits with ribs but not wings, presence of carpophores, and lack of stylopodium. The inflorescence does not have involucre (whorl of bracts directly below flowers) but does have involucel (whorl of bracts at base of umbel branches). The leaves are pinnately-dissected (Dorn 2001, Hitchcock and Cronquist 1961).

Phylogenetic relationships: The above-mentioned suite of morphological characteristics is part of a much larger set considered to be “homoplastic” (derived from parallel or convergent evolution) among the perennial, western North American Apiaceae subfamily Apioideae. Morphological traits closely parallel molecular data for the subfamily, and support the case for re-evaluating genus treatments throughout (Sun and Downie 2010). Thus, phylogenetic relations between *Musineon* species and between species in other genera in Apioideae are unclear pending re-evaluation of taxonomic circumscription.

Present legal or other formal status

U.S. Fish & Wildlife Service status: None.

U.S. Forest Service status: It is on the current Species of Local Concern list maintained by Bighorn National Forest (USDA Forest Service 2005).

Global Heritage rank: G3G4. This indicates that the species may be either globally vulnerable or potentially secure across its entire range.

State Legal status: None.

State Heritage rank: S2 in Wyoming. This indicates that the species is potentially imperiled in the state. In Montana, it is ranked S3, vulnerable.

History of Taxon: The type specimen was collected by P.A. Rydberg (4626 NY) with E.A. Bessey on 15 June 1897 in the Bridger Mountains of Montana, and later described by him (Rydberg 1900). The first Wyoming collection was made on 5 August 1968 by Larry A. Forbis (s.n. RM) on “Dry Fork Creek, ca 3 miles north of Burgess Ranger Station near Burgess Junction” where it was reported as “common under both limber pine and spruce-fir overstory.” It was surveyed in the Bighorn Canyon NRA (Heidel and Fertig 2000) but all locations for it were in the Montana portion of the NRA and it has not otherwise been the subject of status reports in Montana or Wyoming.

Description

General non-technical description: Sheathed musineon is a multi-branched perennial herb with a stout taproot. The leafy stems are 15-30 cm tall at maturity and often purplish at the base. Leaves are alternate and ternately divided into narrow, linear entire segments, with the lower pair of pinnae on slender stalks. The base of the lowermost leaf forms a broad sheath, hence the species' name. The inflorescence is a compact umbel 1-1.5 cm wide borne on a stem that equals the leaves during flowering, but which becomes elongated in fruit. Flowers have 5 yellow or white petals and lack a stylopodium. Fruits are ovate, unflattened, 3-4 mm long schizocarps with glabrous to slightly roughened small ribs (Dorn 2001; Hitchcock and Cronquist 1961; Figures 1-6).

Technical description: Perennial from a stout taproot, generally surmounted by a short branched caudex; stems several, clustered, slender, commonly purple toward the base and lower petioles; leaves basal and cauline, distinctly alternate, ternate-pinnately dissected into more or less linear ultimate segments, at least the lowest pair or primary segments distinctly slender-stalked, peduncles slender, equaling or surpassing the leaves at anthesis and becoming longer in fruit, inflorescence mostly 1-1.5 cm wide at anthesis, slightly larger in fruit, the flower yellowish (white), the fruit ovate-oblong, 3-4 mm, glabrous to scaberulous or granular-roughened and receptacle prolonged into a carpophore beyond the point that the perianth attaches (Hitchcock and Cronquist 1961).

Local field characters: The purplish stem base and pronounced leaf sheaths are distinctive (Figure 6), though the purplish stem base is not always present. The species is most conspicuous in flower. The linear shape of the leaflets is different from most other umbels in the flora (Figures 1-3). The species can be fairly inconspicuous even in low vegetation cover, the flowers are short-lived and vegetative plants often outnumber flowering ones. The inflorescence branches and flowering stalks elongate as fruits mature, so that the species has a different stature at different stages (Figures 2-3).

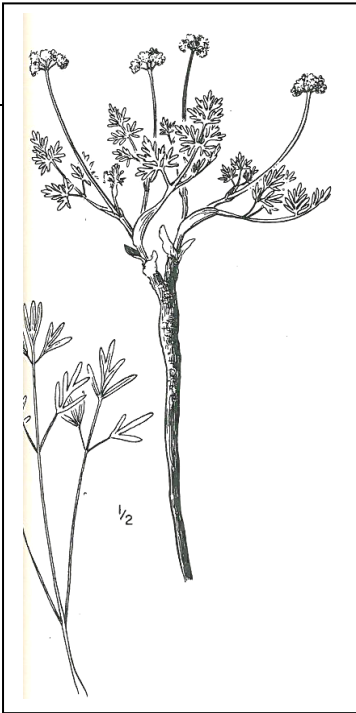
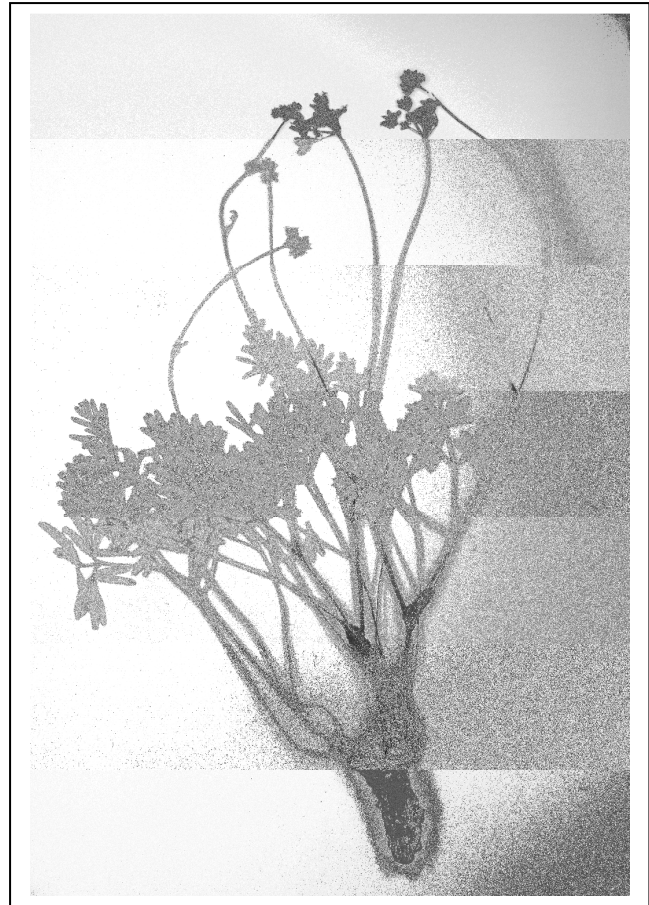
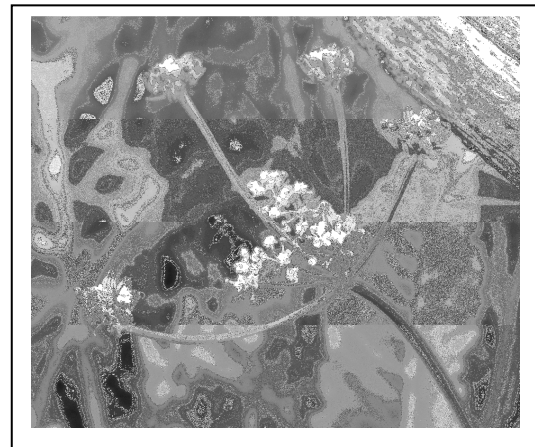


Figure 1. Illustration of *Musineon vaginatum*. By Jeanne R. Janish, from: Hitchcock, C.L. and A. Cronquist. 1961. Pt.3. Saxifragaceae to Ericaceae. In: C.L Hitchcock, A. Cronquist, M. Ownbey, and J.W. Thomas. Vascular Plants of the Pacific Northwest.



Figures 2 and 3. *Musineon vaginatum* specimens: (left) young plant in flower; (right) old plant in fruit



Figures 4 and 5. Fruits of *Musineon vaginatum* (left) pressed specimen, and (right) in the field

Table 1. Characteristics that distinguish *Musineon vaginatum* from other species in the same genus and family (Dorn 2001, Hitchcock and Cronquist 1961)

	Outline of young fruits	Carpophore	Inflorescence surface	Involucre / involucl	Flower color	Leaf positions	Leaf divisions
<i>Musineon vaginatum</i>	Flattened at a right angle to commissure, with ribs but not wings	Present	Scaberulous, sometimes minutely so	Lacking/ present	Yellow, white	On flower stalks or above pseudoscape; alternate	Ternately-pinnately dissected into linear ultimate segments
<i>Musineon divaricatum</i>	Flattened at a right angle to commissure, with ribs but not wings	Present	Scaberulous, sometimes minutely so	Lacking/ present	Yellow	On flower stalks or above pseudoscape; mostly subopposite	Deeply pinnatifid, in deeply cleft or toothed segments
<i>Musineon tenuifolium</i>	Flattened at a right angle to commissure, with ribs but not wings	Present	Scaberulous, sometimes minutely so	Lacking/ present	Yellow, white	All basal	1- to 3-pinnate, dissected into linear ultimate segments
<i>Lomatium cous</i>	Flattened parallel to commissure, smooth	Absent	Often glabrous or otherwise hairy	Lacking/ present but with bractlets distinctly oblanceolate to obovate or elliptic	Yellow	W/o stem leaves, pseudoscape absent	Pinnately or ternately-pinnately dissected, highly variable but not linear
<i>Cymopterus</i> spp.	Flattened parallel to commissure, with wings	Absent	Often glabrous or otherwise hairy	Variable/ present	Yellow, white, purple	W/o stem leaves, pseudoscape generally present	Ternately to more often pinnately dissected



Figure 6. *Musineon vaginatum* in flower (insert: flower and fruit close-up). By B. Heidel.
Note: linear leaflets, reddish sheath, and new shoot (arrows, top to bottom).

Similar species: *Musineon divaricatum* has essentially opposite leaves with deeply lobed and toothed pinnae. *Musineon tenuifolium* lacks stem leaves. *Shoshonea pulvinata* forms low, dense mats, lacks stem leaves, and has prominently scabrous ovaries and fruits. *Cymopterus* and *Lomatium* species have flattened fruits with or without prominent wings (Dorn 2001; Table 1).

In the Bighorn Mountains, *Musineon divaricatum* sometimes grows in habitat that directly adjoins *Lomatium cous*, and they are also reported growing together at some Montana sites. Their inflorescences look almost identical and they have very similar growth form and stature when in flower. At this stage, the elongate, linear leaflets of *M. vaginatum* most readily distinguish it from *L. cous*.

Geographical distribution

Range: *Musineon vaginatum* is a regional endemic of south-central and western Montana and north-central Wyoming. Reports from northern Utah (Mathias and Constance 1944) are thought to be based on misidentified specimens. In Wyoming, it is known only from the northern end of the Bighorn Mountains, in Big Horn and Sheridan counties, representing the southern and eastern extent of its global distribution. Most but not all populations are north of the Tongue River fault (north of U.S. Highway 14), except for two populations south of Sheridan on the eastern flanks of the Bighorn Mountains. Wyoming distribution may be conditioned by the geological history of thrust faulting or associated landform/erosion patterns.

A rangewide distribution map was prepared as part of this project to put the Wyoming distribution of *Musineon vaginatum* into context (Figure 7). Collection records from the University of Montana were acquired on-line and converted into data points. Collection records from Montana State University were provided courtesy of a databasing project currently underway. Rocky Mountain Herbarium records for Montana were also available on-line.

Extant sites: *Musineon vaginatum* is now known from 16 extant populations in Wyoming (Table 2, Figure 4). As a result of this study, four new populations were added and six of those previously-known were greatly expanded, including three very extensive populations. Complete occurrence records and site maps are in Appendix A. It is also known from at least 29 collection records in Montana. More recently it was collected in three Stillwater County, Montana sites as part of floristic documentation (Elliott 2011 personal communication). Hitchcock and Cronquist (1961) said that it is “seldomly collected” and most collections of it have been made in more recent years.

Historical sites: None in Wyoming.

Unverified/Undocumented reports: None known.

Sites where present status not known: The 2010 surveys did not address habitat outside Bighorn National Forest boundaries. In cases of populations immediately outside of Forest boundaries, surveys were usually conducted on adjoining Forest lands to determine if the population extended into the Forest if there was suitable substrate and access.

Areas surveyed but species not located: Appendix A of the *Physaria didymocarpa* var. *lanata* status report (Handley and Heidel 2011) represents all locales surveyed for either or both target species. In addition, it was previously sought but not found in the Mann Creek and Dry Fork Research Natural Areas (RNAs) (Welp et al. 1998, Jones and Fertig 1998).

Table 2. Location information for *Musineon vaginatum* in Wyoming

EO#	Location	County	Legal Description	Elev. m (ft)	USGS 7.5' Quad	Agency/ Ownership
001	Smith Creek, north of	Sheridan	T57N R87W Sec. 20, 21	1524 (5000)	Dayton North Columbus Peak	Pvt.
002	Little Mountain	Big Horn	T57N R93W Sec. 8	1829 (6000)	Simmons Canyon	Pvt.
003	Little Bighorn River Canyon	Sheridan	T58N R90W Sec. 25	1646-1829 (5400-6000)	Bull Elk Park	Bighorn NF
004	Boyd Ridge	Sheridan	T57N R90W Sec. 10, 19, 20, 21, T58N R90W Sec. 35	2255-2658 (7400-8720)	Bull Elk Park Boyd Ridge	Bighorn NF
005	Steamboat Point, Herdrick Ridge, Horseshoe Mountain, Elephant Foot, Tongue Butte	Sheridan	T55N R87W Sec. 2, 11, 12; T56N R87W Sec. 21, 22, 23, 27, 28, 29, 34	1432-2414 (4700-7920)	Dayton South	Bighorn NF
006	Dry Fork of the Little Bighorn River, Dry	Sheridan	T56N R88W Sec. 7, 8; T56N R89W Sec. 12	2103-2316 (6900-7600)	Skull Ridge Burgess Junction	Bighorn NF
007	Cottonwood Canyon	Big Horn	T56N R93W Sec. 3	1920 (6300)	Simmons Canyon , Cottonwood Canyon	BLM, state
008	Fool Creek Basin, north of Burgess Junction	Sheridan	T56N R89W Sec. 22, 25, 26, 34	2377-2536 (7800-8320)	Burgess Junction	Bighorn NF
009	Freeze Out Point, Peak 7834	Sheridan	T56N R88W Sec. 3; T57N R88W Sec. 34, 35	2252-2531 (7389-8305)	Skull Ridge Columbus Peak	Bighorn NF
010	Amsden Creek Wildlife Refuge	Sheridan	T57N R87W Sec. 35	1402 (4600)	Dayton North Dayton South	State
011	Red Grade Road area	Sheridan	T54N R85W 27, 28, 33, 32	1829-2170 (6000-7120)	Little Goose Peak Beaver Creek Hills	Bighorn NF, state
012	Cookstove Basin and Trout Creek, southwest	Big Horn	T58N R92W Sec. 34	2560-2618 (8400-8590)	Mexican Hill	Bighorn NF
014	Dry Fork Ridge	Sheridan	T57N R89W Sec. 6	2100-2149 (6890-7050)	Bull Elk Park	Bighorn NF
015	Alden, Soldier and Red Canyon creeks, headwaters of	Sheridan	T55N R86W Sec. 18, 19, 20	2316-2518 (7600-8260)	Walker Mountain	Bighorn NF
016	Lodge Grass and Pumpkin creeks, divide between	Sheridan	T57N R91W Sec. 3, T58N R90W Sec. 30; T58N R91 W Sec. 25, 35	2499-2829 (8200-9280)	Boyd Ridge	Bighorn NF
017	Horse Creek Ridge	Sheridan	T56N R87W Sec. 7; T56N R88W Sec. 12	1950-2286 (6400-7500)	Skull Ridge	Bighorn NF

Land ownership: Twelve of the 16 Wyoming populations of *Musineon vaginatum* are mainly or entirely on Bighorn National Forest (Table 2). Three populations occur outside the Forest in the Amsden Creek Big Game Range, Little Mountain Area of Critical Environmental Concern (ACEC), and a Nature Conservancy conservation easement. Populations are also known in the Montana portion of Bighorn Canyon National Recreation Area (Lichvar et al. 1984, 1985; Heidel and Fertig 2000). All other known populations are on public lands managed for multiple use.

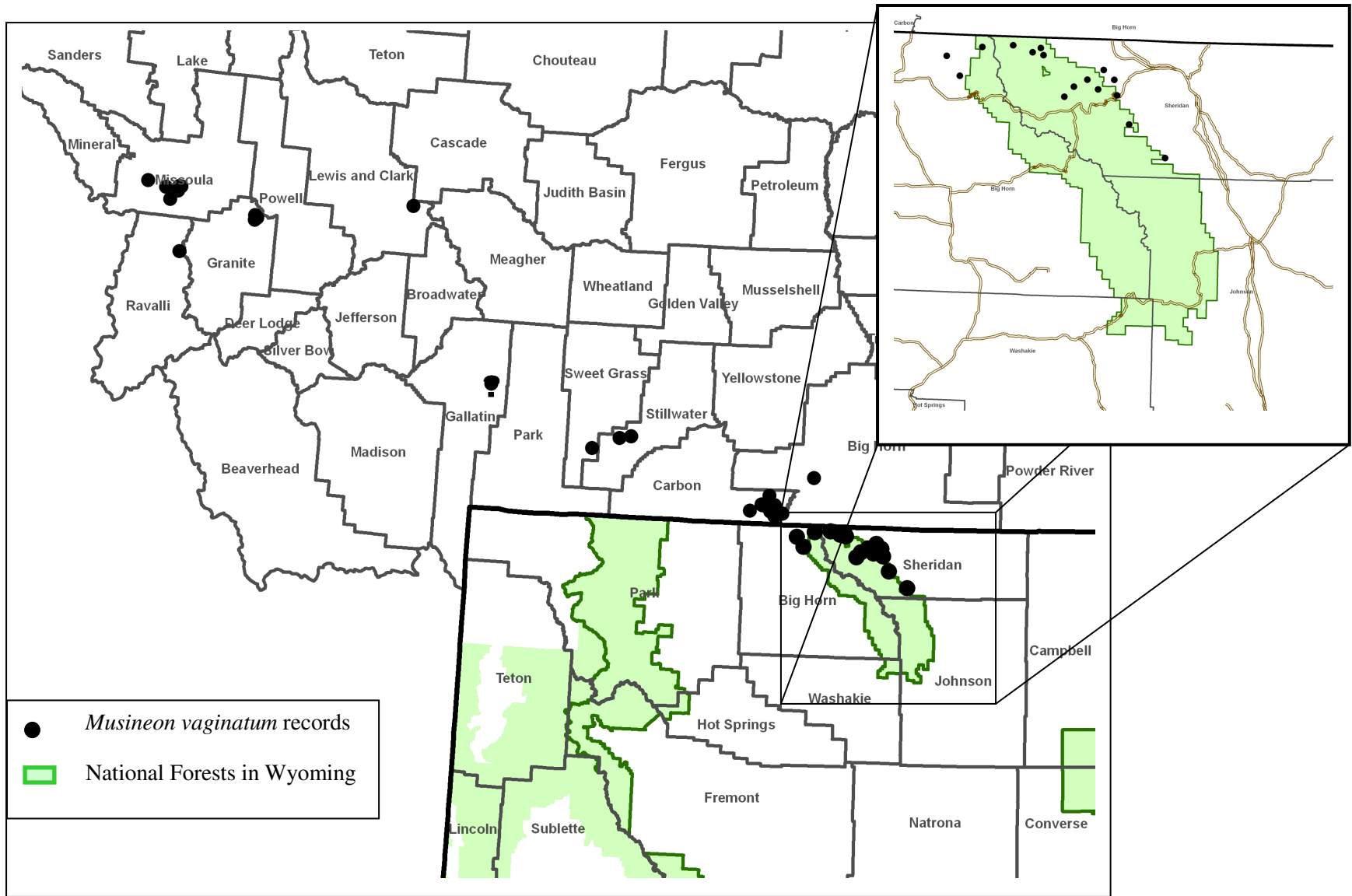


Figure 7. Rangewide and statewide distribution of *Musineon vaginatum*

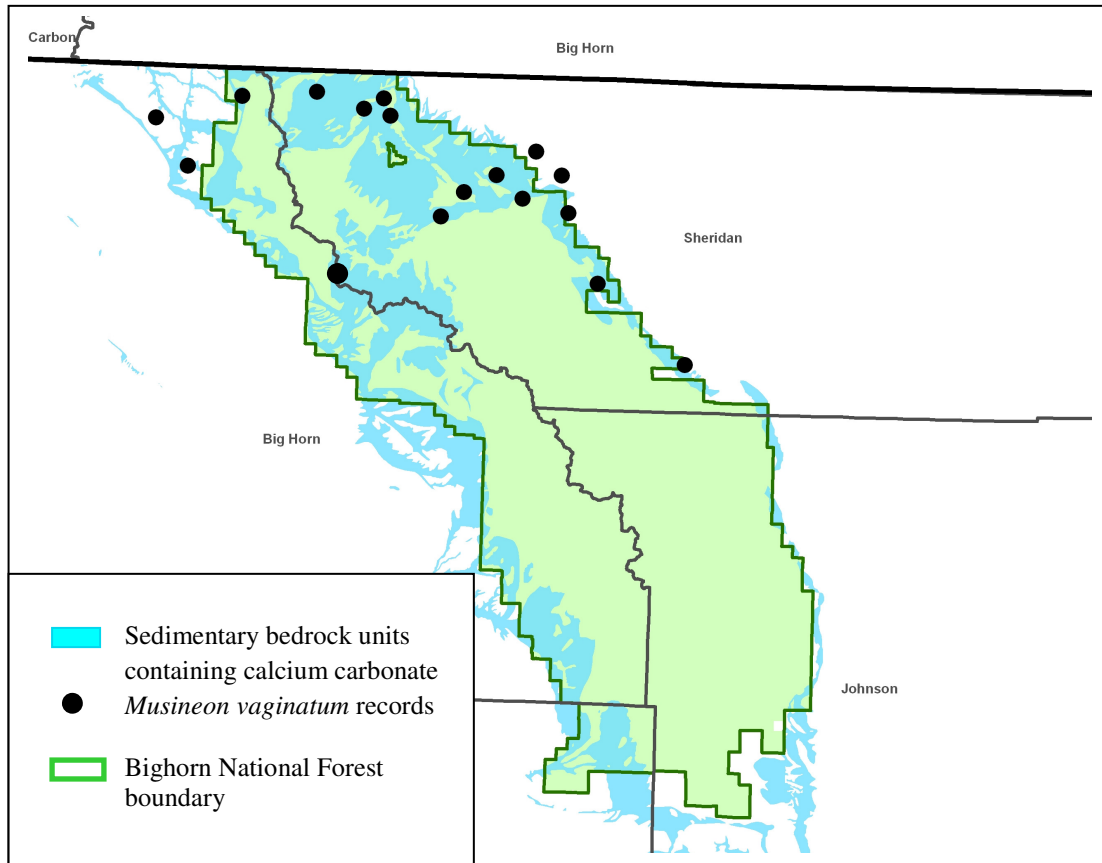


Figure 8. Geology of *Musineon vaginatum* habitat in Bighorn National Forest

Habitat

The habitat of *Musineon vaginatum* was previously described as rocky slopes, meadows, aspen groves, and ponderosa pine communities (O’Dea and Fertig 2001). On the Bighorn National Forest, *M. vaginatum* is also found in limber pine and lodgepole pine woodlands, dry Engelmann spruce forest, and in dry shrublands dominated by shrubby cinquefoil and mountain big sagebrush. The unifying characteristic is calcium carbonate-rich substrate (Figure 5). It occupies prevailing habitats in places, while in other settings it is in small pockets or bands of habitat such as woodland openings and margins (Figures 9-12). It is often in settings of partial light, but also in direct sunlight or complete shade. It spans elevations of 1402-2829 m (4600 - 9280 ft) in Wyoming. In Montana, it occurs as low as 960 m (3250 ft.; University of Montana 2010). The breadth of habitat is even greater considering that it persists under levels of ground fire and crown fire (Figure 13), discussed in the section on fire response. In general, *M. vaginatum* has broad ecological amplitude in the northern Bighorn Mountains.

Frequently associated species: *Musineon vaginatum* has been reported in association with many species, depending on elevation and vegetation. However, there are relatively few sites with robust associated species lists, so lists assembled in 2010 surveys have not been culled to highlight frequently-associated species (Table 3). Calciphilic species like *Anemone multifida*

Table 3. Species associated with *Musineon vaginatum*¹

Scientific name	Common name	On Bighorn NF?
<i>Abies bifolia</i> (<i>A. lasiocarpa</i>)	Subalpine fir	YES
<i>Allium cernuum</i>	Nodding onion	YES
<i>Anemone multifida</i>	Red windflower	YES
<i>Antennaria microphylla</i>	Small-leaf pussytoes	YES
<i>Arnica cordifolia</i>	Heart-leaved arnica	YES
<i>Artemisia tridentata</i> var. <i>vaseyana</i>	Mountain big sagebrush	YES
<i>Astragalus miser</i>	Timber milkvetch	YES
<i>Balsamorhiza incana</i>	Hoary balsamroot	YES
<i>Balsamorhiza sagitata</i>	Arrowleaf balsamroot	YES
<i>Claytonia perfoliata</i>	Miner's lettuce	YES
<i>Clematis columbiana</i> var. <i>tenuiloba</i>	Columbia virgin's-bower	YES
<i>Collinsia parviflora</i>	Blue-eyed Mary	YES
<i>Cryptantha celosioides</i>	Buttecandle	NO
<i>Eremogone congesta</i>	Ball-head sandwort	YES
<i>Eriogonum flavum</i>	Yellow buckwheat	NO
<i>Festuca idahoensis</i>	Idaho fescue	YES
<i>Galium boreale</i>	Northern bedstraw	YES
<i>Geranium richardsonii</i>	White crane's-bill	YES
<i>Goodyera oblongifolia</i>	Western rattlesnake-plantain	YES
<i>Hymenoxys acaulis</i>	Stemless four-nerve-daisy	YES
<i>Juniperus communis</i>	Common juniper	YES
<i>Leucopoa kingii</i>	False fescue	YES
<i>Lithophragma parviflorum</i>	Prairie woodlandstar	YES
<i>Lomatium dissectum</i>	Fern-leaved desert-parsely	YES
<i>Mahonia repens</i>	Oregon grape	YES
<i>Oxytropis campestris</i>	Northern yellow locoweed	YES
<i>Pediomelum esculentum</i> (<i>Psoralea esculenta</i>)	Indian breadroot	NO
<i>Penstemon eriantherus</i> var. <i>eriantherus</i>	Fuzzy-tongue beardtongue	NO
<i>Penstemon montanus</i>	Cord-root beardtongue	YES
<i>Pentaphylloides floribunda</i> (<i>Potentilla fruticosa</i>)	Shrubby cinquefoil	YES
<i>Phlox hoodii</i>	Hood's phlox	YES
<i>Phlox multiflora</i>	Rocky Mountain phlox	YES
<i>Physaria curvipes</i> (<i>Lesquerella alpina</i> misappl.)	Bighorn bladderpod	YES
<i>Physaria didymocarpa</i> var. <i>lanata</i>	Woolly Twinpod	YES
<i>Physocarpus monogynus</i>	Mountain ninebark	YES
<i>Pinus contorta</i>	Lodgepole pine	YES
<i>Pinus flexilis</i>	Limber pine	YES
<i>Pinus ponderosa</i>	Ponderosa pine	YES
<i>Piperia unalaskensis</i>	Alaska rein orchid	YES
<i>Poa pratensis</i>	Kentucky bluegrass	YES
<i>Potentilla gracilis</i>	Slender cinquefoil	YES
<i>Prosartes trachycarpum</i>	Drops of gold	YES
<i>Pseudotsuga menziesii</i>	Douglas-fir	YES
<i>Sedum lanceolatum</i>	Stoncrop	YES
<i>Symphoricarpos albus</i>	Snowberry	YES
<i>Thalictrum dasycarpum</i>	Purple meadow-rue	YES

¹ Nomenclature generally follows Dorn (2001). Synonyms with the PLANTS database are in parentheses.



Figure 9. *Musineon vaginatum* habitat in *Pseudotsuga menziesii* on north-facing slope (Red Grade Road). This is perhaps the most consistently occupied habitat on the Forest. By B. Heidel.



Figure 10. *Musineon vaginatum* habitat in mixed conifer forest on north facing slope (Red Grade Road, 0.5 mile below the photo above). This is exceptionally high vegetation cover. By B. Heidel.



Figure 11. *Musineon vaginatum* habitat in *Potentilla fruticosa* meadow (Burgess Junction area).
By S. Zier.



Figure 12. *Musineon vaginatum* habitat in forest opening (Boyd Ridge). By B. Heidel.



Figure 13. *Musineon vaginatum* habitat in 1970's crown fire (above Pumpkin Creek). Occupied habitat is on the rocky crest. By B. Heidel.

(red windflower), *Arnica cordifolia* (heartleaf arnica) and *Clematis columbiana* var. *tenuiloba* (Columbian virgin's-bower) are often present in woodland settings. Plains species associates of *M. vaginatum* are not present on Bighorn National Forest. No non-native species were found in direct association.

Associated species of concern: There is partial overlap of *Musineon vaginatum* and *Physaria didymocarpa* var. *lanata* in the Bighorn Mountains, in the same sections or townships, but few places such as Dry Fork Ridge where they occupy the same habitat zones. *Physaria didymocarpa* var. *lanata* is apparently absent from large areas in the center of the northern Bighorn Mountains where the former is present. In Montana, *Musineon vaginatum* has also been collected in association with *Eritrichum howardii* (Howard's forget-me-not; tracked as a species of concern in Wyoming and a Species of Local Concern on the Bighorn National Forest) and *Physaria lesicii* (Lesica's bladderpod; a Montana endemic immediately north of the state line, not known from Wyoming).

Topography: *Musineon vaginatum* occupies a variety of well-drained topographic settings, from gentle ridge tops, rims and breaks to midslopes. It is often at breaks in topography, whether because these settings are well-drained, or because they have vegetation ecotones favored by the species.

Soil relationships: The soils where *Musineon vaginatum* is found are variously alfisols or mollisols with gravelly loam mantled by litter and duff. They are deep soils, or overlying disintegrating or highly fractured bedrock. These conditions may be required for seedling establishment and for the taproot to draw subsurface moisture during the growing season.

Regional climate: The montane climate of the Bighorn Mountains is best represented by meteorological data from Burgess Junction (USDI NOAA 2010; Station 481220; collected from 9/18/1960 to 12/31/2005). Annual precipitation averages 53.3 cm (21.0 in). Snowfall is a major contribution to total annual precipitation, with an average of 6.2 m (242.8 in) amounting to about 53% of mean annual precipitation. April and May are the months of highest precipitation, much of which falls as snow. July is the warmest month (12.9 °C; 55.2 °F mean monthly temperature) and January is the coldest (-8.5 °C; 16.7 °F mean monthly temperature). There is a 50% probability of having a 40-day period during the growing season when temperatures are at or above freezing.

There is a rain shadow pattern associated with the Bighorn Mountains where moisture-bearing systems come out of the east. This is well-documented in foothills settings in comparing annual precipitation of Buffalo and Sheridan on the east side as 33.8 cm and 37.1 cm (13.3 in and 14.6 in, respectively) versus Shell and Worland on the west side as 25.5 cm and 19.6 cm (9.9 in and 7.7 in, respectively; USDI NOAA 2010). The east-west differences may be ameliorated by the shorter growing season at higher elevations but still exist. There was heavy, late spring snowfall before the start of the 2010 growing season, so plant phenology was generally late and moisture content in the ground high.

Local microclimate: The diverse habitats of *Musineon vaginatum* have variable microclimate conditions (light exposure, wind exposure, water budgets) but all have moisture-retaining soils. The availability of subsurface moisture during flowering and seed maturation may be particularly important.

Population biology and demography

Phenology: Flowers from mid-June to early-July; in fruit from July-early August, depending on elevation. The different inflorescences on a plant mature at staggered times (Figure 7). Fruit production can be very low in some years and fruits readily dehisce once mature. Where it occurs in woodlands, it is among the earlier species to flower, and its flowering activity may be at the same time as leaf-out of shrubs.

Population size and condition: Based on 2010 surveys, *Musineon vaginatum* has total population numbers and extent estimated at 15,000-50,000 plants, spanning 1,500-10,000 acres (Table 4). There was almost no data on population size and condition prior to 2010 surveys. These are highly conservative figures because it is challenging to estimate the population numbers and to

delimit extent and frequency across the landscape. Vegetative plants often greatly outnumber flowering plants and are easily overlooked or obscured by other vegetation. The fine leaves may be difficult to discern under bright light or mottled light, or blend in with many other species having dissected leaves (Figure 14). Plants that have finished flowering are nearly as inconspicuous as vegetative plants unless in the open (Figure 15). It occurs in a wide array of population densities and vegetation, often in recurrent patterns across the landscape, so that it is particularly difficult to determine its extent without extensive survey. There is no evidence of habitat loss or degradation, which is the basis for inferring that *Musineon vaginatum* numbers are probably stable at sites surveyed in 2010. Nevertheless, this is limited basis for evaluating trend because there have been no complete census counts or robust estimates much less repeated visits with counts.

Table 4. Size and extent of *Musineon vaginatum* populations

EO#	Population size	Extent ha (ac)
001	Unknown	Unknown
002	Unknown	Unknown
003	Unknown	Unknown
004	Common in one section; uncommon in three more sections	At least 120+ (300+).
005	5000+	At least 242+ (600+)
006	Less than 500 plants	At least 40+ (100+)
007	Unknown	Unknown
008	500+	At least 24+ (60+)
009	6000+	At least 97+ (240+)
010	Unknown	Unknown
011	At least low hundreds	Unknown
012	Unknown	Unknown
014	Very common	Less than 4 (10)
015	Abundant	40+ (100+)
016	At least low 1000's	Less than 12 (30)
017	100+	At least 40+ (100+)
TOTAL	15,000-50,000	900-4000 (2000-10,000)

Reproductive biology

Type of reproduction: All members of the family Apiaceae reproduce sexually (Koul et al. 1993). The taproot of *Musineon vaginatum* often produces more than one flowering stalk, but the taproot does not divide to reproduce vegetatively. Information on both reproductive biology and life history of *M. vaginatum* is sketchy.

Pollination biology: Members of the family Apiaceae have relative uniformity in the flower and inflorescence structure, in which most pollen transfer is carried out by insects (Koul et al. 1993).



Figure 14. *Musineon vaginatum* vegetative and in bud. It is easiest to estimate population size in forested settings when viewed from above, under diffuse lighting, in low vegetation cover. There are seven plants above. By B. Heidel.



Figure 15. *Musineon vaginatum* with aborted and mature fruits. Overall, it is easiest to estimate population size in open settings. Corresponds with habitat shot in Figure 13. By B. Heidel.

The flowers offer nectar and pollen attractive to a variety of insects, generally including flies, bees, wasps, ants, beetles and some hemipteran insects. Visitation is affected by environmental conditions, particularly light and temperature. The members exhibit diverse breeding systems ranging from completely selfing to obligately outcrossing. Generally speaking, many exhibit a blend of self- and cross-pollination. The small, less conspicuous inflorescences tend to have greater degrees of self-pollination (Koul et al. 2993).

Musineon vaginatum has small, relatively inconspicuous inflorescences but its inflorescence develops in such a way that may favor outcrossing. Observations in the field and herbarium suggest that the flowers of *M. vaginatum* in the outermost umbels flower first, and they are described as perfect (both pistillate and staminate parts). It appears as though the male and female parts of the same flower do not mature at the same time. In addition, the flowers in inner umbels flower later and are mostly or entirely staminate (Figures 5 and 6). This too decreases the likelihood of self-pollination. This phenological characterization, involving perfect flowers and staminate flowers on the same plant, provides a preliminary interpretation of pollination (Heidel pers. obs.)

The number of flowers produced per inflorescence varies greatly but it is not known whether this is because the number of perfect flowers vary greatly, or because the level of pollination and abortion varies greatly. See Figures 5 and 6 to compare two inflorescences with few/many fruits produced per inflorescence.

Seed dispersal and biology: Seeds readily dehisce as they mature and dry. There are no known dispersal vectors but the seeds are palatable.

Population ecology

General summary: *Musineon vaginatum* is a perennial. There are no available data on its life history, or a way to characterize the age or life history stage of individual plants, either in the field or in the herbarium. It is possible, but not proven, that the taproot diameter or vestiges of leaf sheathes reflect age.

Competition: *Musineon vaginatum* grows in plant communities that vary greatly in understory vegetation cover, from about 15%-90%. It is most consistently found at the low end of the vegetation cover spectrum but may not be constrained by competition for light or water. It flowers relatively early in the growing season and might be most affected by competition at this stage when many other plants, at least in woodland settings, are still leafing out or bolting. As a taprooted perennial that grows under different light conditions, it seems to be a versatile, interstitial member of different plant communities rather than constrained by competition.

Herbivory: Few signs of herbivory were observed on *Musineon vaginatum* plants in the field or on herbarium specimens, though flowering stalks were occasionally broken off (Figure 15). The resinous oil glands throughout all parts of vegetative and reproductive plants may deter herbivory.

Hybridization: No evidence.

ASSESSMENT AND MANAGEMENT RECOMMENDATIONS

Potential threats to currently known populations

Grazing: No signs of grazing or browsing were observed on individual *Musineon vaginatum* plants with the possible exception of a flowering stem occasionally broken off. Evidence of trampling was not observed. Grazing can sometimes be associated with habitat degradation and associated vegetation shifts. However, the habitat occupied by *M. vaginatum* is generally distant from water, so the grazing pressure and habitat alterations are generally low unless affected by placement of fences and salt blocks.

It appeared that cattle *Musineon vaginatum* was on cattle allotments in most places where it was surveyed. If it extends into sheep allotments, the species may be under greater grazing pressure.

Logging: There is no direct evidence of *Musineon vaginatum* response to logging, although old clearcuts were checked directly adjoining occupied habitat on Boyd Ridge and it was not found. In these areas, the species may not have been impacted by canopy removal so much as mechanical damage to the surface associated with skidding activity and by conversion of the plant community to non-native grasses.

Roads: Motorized vehicles are restricted to open, designated roads or motorized trails during the growing season in nearly all areas occupied by *Musineon vaginatum*, although people can drive up to 300' off of the road for a specific purpose such as camping (Motor Vehicle Use Map Bighorn National Forest, 2010). The road corridors are not colonized by *M. vaginatum*, although its occupied habitat extends to the edge in places. The Forest Service road corridors are managed to control species on state or county noxious weed lists. Herbicide drift is a potential concern only where these weeds may be present or there is indiscriminate spraying, and where populations reach the road corridor edge, such as on Boyd Ridge.

Weeds: There were no noxious weeds found in 2010 surveys of *Musineon vaginatum* and very few non-native species in the vicinity. In the short-term, this species could be more affected by vegetation encroachment than by noxious weed invasion. The Bighorn National Forest has an active cooperative noxious weed control program with the Big Horn County Weed and Pest District.

Fire: *Musineon vaginatum* might possibly have lost habitat under intense crown fires when severe erosion ensued or if the burn area was planted into, or encroached by, tall grasses such as *Dactylis glomerata* (orchard grass), *Bromus inermis* (smooth brome) *Phleum pratense* (timothy) or non-native *Agropyron* spp. and *Elymus* spp. (wheatgrasses). However, *M. vaginatum* was found to persist in two areas of burned habitat, including a woodland margin where recent ground fire passed above the Red Grade Road (#011), and in relative abundance on the rockiest portion of a ridge top where crown fire burned prior to 1971 above Pumpkin Creek (#016), in what had previously been a woodland margin habitat that remains largely unforested at present.

Other: Other recreational threats have not been identified.

Management practices and response

There have been no studies of management practices and associated *Musineon vaginatum* responses. It would be insightful to document before-and-after conditions for any new management actions implemented in occupied habitat (prescribed burning, logging, grazing developments). Even more so, it would be insightful to set up a study with a control plot containing a portion of the population that is excluded from treatment.

Conservation recommendations

Recommendations regarding present or anticipated activities: The interpretation of its susceptibility to clearcut logging may warrant further evaluation with regard to current logging practices. Skidding during logging operations is a potential threat to *M. vaginatum* populations, as is reseeding disturbed areas, especially with non-native species. The occurrence maps provided in electronic format and with this report (Appendix A) are to be used as indication of presence in the section rather than extent within the section.

Notification of U.S. Forest Service personnel of locations on national forest: To prevent inadvertent impacts to known *Musineon vaginatum* populations, all appropriate USFS personnel and cooperators involved in planning and on-the-ground land management activities, including grazing, weed control, prescribed burn and logging, should have access to species information and location data. Towards this end, the updated Forest Service species evaluation (Appendix B) and state species abstract (Appendix C) are updated, accompanied by GIS files of all currently known element occurrences records as representing populations.

Status recommendations: Bighorn National Forest populations of *Musineon vaginatum* represent the highest known concentration of populations at the southern and eastern limits of species' distribution and the highest elevation populations throughout its range. It may be appropriate to

retain as a Species of Local Concern to ensure that agency actions do not contribute to its imperilment in Wyoming unless it is unaffected by current logging practices or proves to be much more widespread.

Summary: The information collected in 2010 surveys provides the primary source for evaluating the status of *Musineon vaginatum* in the state and in Bighorn National Forest. There are challenges in determining *M. vaginatum* population numbers and extent, so numbers presented in this document are preliminary and conservative in characterizing viability and status. No immediate threats were identified and *M. vaginatum* occupies a much wider range of habitats at the northern end of the Forest than previously known. Thus, it has low vulnerability to most land management practices.

LITERATURE CITED

- Dorn, R.D. 2001. Vascular Plants of Wyoming, 3rd ed. Mountain West Publishing, Cheyenne, WY. 412 pp.
- Elliott, E. 2011. Personal communication to B. Heidel. County collection information from her floristic thesis in progress, Beartooth and Absaroka Mountains, Montana and Wyoming. University of Wyoming, Department of Botany.
- Heidel, B. and W. Fertig. 2000. Rare Plants of Bighorn Canyon National Recreation Area. Unpublished report prepared for National Fish and Wildlife Foundation and Bighorn Canyon National Recreation Area, National Park Service by Montana Natural Heritage Program and Wyoming Natural Diversity Database.
- Heidel, B. 2007. Wyoming plant species of concern. Wyoming Natural Diversity Database, Laramie, WY.
- Hitchcock, C.L. and A. Cronquist. 1961. Pt.3. Saxifragaceae to Ericaceae. In: C.L Hitchcock, A. Cronquist, M. Ownbey, and J.W. Thomas. Vascular Plants of the Pacific Northwest. University of Washington Publication in Biology 17(12): 1-597.
- Jones, G.P. and W. Fertig. 1998. Ecological evaluation of the Mann Creek potential research natural area within the Bighorn National Forest, Sheridan County, Wyoming.
- Koul, P., N. Sharma and A.K. Koul. Pollination biology of Apiaceae. Current Science 65(3):219-222.
- Lichvar, R.W., E.I. Collins, and D.H. Knight. 1984. Checklist of vascular plants for the Bighorn Canyon National Recreation Area. Report prepared for the University of Wyoming National Park Service Research Center and Bighorn Canyon National Recreation area.
- Lichvar, R.W., E.I. Collins, D.H. Knight. 1985. Checklist of the vascular plants for the Bighorn Canyon National Recreation Area, Wyoming and Montana. Great Basin Naturalist 45(4): 734-746.

- Love, J. D. and A. C. Christiansen. 1985. Geologic map of Wyoming, explanation for the geologic map, and principal sources of geologic data and references cited for geologic map of Wyoming. U.S. Geologic Survey, 1985. Reston, VA. Digital version.
- Mathias, M. and L. Constance. 1944. Umbelliferae. North American Flora 28B.
- Montana State University Herbarium. 2010. Specimen label data provided courtesy of Matthew Lavin, Curator. Bozeman, MT.
- O'Dea, K. and W. Fertig 2000. State Species Abstract: *Musineon vaginatum*. Wyoming Natural Diversity Database. Available on the internet at www.uwyo.edu/wyndd
- Rocky Mountain Herbarium. 2010. Collection records, including RM Specimen Database on-line at: [http://www.rmh.uwyo.edu/University of Wyoming, Laramie, WY](http://www.rmh.uwyo.edu/University%20of%20Wyoming,%20Laramie,%20WY).
- Rydberg, P.A. 1900. Catalogue of the flora of Montana and the Yellowstone National Park. Memoirs NY Botanical Garden 1:1-492.
- Sun, F.-J. and S. R. Downie. 2010. *Phylogenetic* analyses of morphological and molecular data reveal major clades within the perennial, endemic western North American Apiaceae subfamily Apioideae. Journal of the Torrey Botanical Society 137: 133-156.
- University of Montana Herbarium. 2010. Collection records, including all on-line records posted at: <http://herbarium.dbs.umt.edu/>. University of Montana, Missoula, MT.
- USDA Forest Service. 2005. Bighorn National Forest – Revised Land and Resource Management Plan. Posted electronically at: <http://www.fs.usda.gov/>. Sheridan, WY.
- USDI National Oceanic and Atmospheric Administration. 2010. Wyoming Climate Summaries. Western Regional Climate Center. Posted electronically at: <http://www.wrcc.dri.edu/summary/climsmwy.html>
- Welp, L., W. Fertig, and G. Jones. 1998. Ecological Evaluation of the potential Dry Fork Research Natural Area within the Bighorn National Forest, Sheridan County, Wyoming. Unpublished report prepared by the Wyoming Natural Diversity Database, Laramie, WY. Unpublished report prepared for the Bighorn National Forest, USDA Forest Service by the Wyoming Natural Diversity Database. Laramie WY.