Species Status Assessment Report for
Bradshaw's lomatium
(*Lomatium bradshawii* (Rose ex. Math.) Mathias & Constance)
Version 1.0

(Photo by Jeff Dillon, U.S. Fish and Wildlife Service)

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Pacific Region (Region 1)
U.S. Fish and Wildlife Service
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This document was prepared by Tom Brumbelow. Kim Garner and Paul LaFemina contributed to earlier versions of this report.

Additionally, [add acknowledgment of peer reviewers here].

Throughout this document, words that appear in **bold type** are defined in the Glossary.

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EXECUTIVE SUMMARY

[this section will be added once peer review comments have been incorporated]

Contents

I. INTRODUCTION

Bradshaw's lomatium (*Lomatium bradshawii*) is a perennial herb that occurs in wet prairie habitats in the Willamette Valley of western Oregon and adjacent southwestern Washington. This species was listed by the U.S. Fish and Wildlife Service (Service) as endangered under the Endangered Species Act of 1973, as amended (ESA) in 1988 (53 Federal Register (FR) 38448-38451).

This Species Status Assessment report (SSA) is a comprehensive review of Bradshaw's lomatium, which will be used to inform the 5-year review of the species' status under the ESA and to guide continued recovery efforts for the species. This SSA will also provide information to guide other potential future actions for Bradshaw's lomatium under the ESA, such as recovery plan revisions, if needed, and consultation with other Federal agencies.

The SSA framework summarizes the best available scientific and commercial data to conduct an in-depth review of a species' biology, needs, and the stressors it faces in order to evaluate its biological status and long-term **viability**. For the purpose of this assessment, we define viability of Bradshaw's lomatium as its ability to sustain multiple resilient populations distributed across its range in the wild over time. Using the SSA framework, we will evaluate viability in terms of **resiliency**, **redundancy**, and **representation**.

- **Resiliency** refers to the ability of a population to endure or withstand stochastic events (Shaffer and Stein 2000, pp. 307-310). Resilient populations are better able to recover from losses due to demographic stochasticity (such as fluctuations in population growth rate) or environmental stochasticity (such as variations in annual weather patterns). It can be thought of as the ability to withstand the normal range of variability in demographic or environmental factors. Common metrics used to measure resilience include population size, growth rate, and structure (*e.g.*, sex ratios, age classes).

- **Redundancy** is assessed at the species level, and refers to the ability of a species to withstand catastrophic events; it is typically a measure of the number and distribution of populations (Shaffer and Stein 2000, pp. 307-310). Catastrophic events are typically rare and of finite duration, causing severe impacts to one or more populations.

- **Representation** refers to the evolutionary capacity of a species to adapt to change (Shaffer and Stein 2000, pp. 307-310), and is measured by the breadth of environmental and genetic diversity among and within populations.

The SSA is intended to be a strictly scientific review of the conservation status of Bradshaw's lomatium, and does not pre-determine any decision by the Service in regards to protection under the ESA. Any decisions regarding a change in classification under the ESA will be made following a review of this document, any supporting analyses, other scientific information, and all applicable laws, regulations, and policies. Should a change in classification be recommended on the basis of the 5-year review, that change will be published in the *Federal Register* as a proposed rule and will be open for public comment. The results of any subsequent decision will be published in the *Federal Register*.

II. SPECIES INFORMATION

Bradshaw's lomatium or Bradshaw's desert-parsley is a perennial herb listed as endangered, without critical habitat, on September 30, 1988 (53 FR 38448-38451). A Recovery Plan for the Prairie Species of Western Oregon and Southwestern Washington, which included Bradshaw's lomatium, was published in 2010 (U.S. Fish and Wildlife Service 2010, entire). This recovery plan supersedes the original recovery plan for Bradshaw's lomatium, which was published in 1993 (U.S. Fish and Wildlife Service 1993, entire).

DESCRIPTION

Bradshaw's lomatium is an erect, **glabrous**, perennial herb that grows from a long, slender **taproot** to a height of 20 to 50 centimeters (cm) (12 to 20 inches (in)) with its **caudex** 3 to 5 cm (1 to 2 in) below the surface. Leaves are typically 2 to 6, chiefly basal, 10 to 20 cm (4 to 8 in) in length, more vertical than horizontal (Jackson 1996), and ternately-pinnately divided into linear or filiform segments 2 to 12 mm (0.08 to 0.5 in) long. **Inflorescences** are flat-topped **umbels**, comprised of 5 to 14 **umbellets** less than 1 cm (0.4 in) across, supported by rays branching from a **peduncle**. Umbellets are subtended by ternately or bi-ternately divided involucel bracts. Flowers are light yellow, with petals approximately 1 mm long (Jackson 1996). Fruits are **glabrous schizocarps**, 8 to 13 mm (0.3 to 0.5 in) long by 5 to 7 mm (0.20 to 0.28 in) wide, with

Figure II-1. Bradshaw's lomatium – Photo by Jeff Dillon, U.S. Fish and Wildlife Service.

corky, thickened wings (Natural Resources Conservation Service 2010). Identification of Bradshaw's lomatium is most often confused with common lomatium (*Lomatium utriculatum*), which can be distinguished by the presence of well-developed (entire, rather than pinnate) involucel bracts (Natural Resources Conservation Service 2010).

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Figure II-2. Bradshaw's lomatium umbellet, with ternately and bi-ternately divided involucel bracts. Photo by Jeff Dillon, U.S. Fish and Wildlife Service.

Figure II-3. Bradshaw's lomatium fruits (schizocarps). Photo by Jeff Dillon, U.S. Fish and Wildlife Service

TAXONOMY

Bradshaw's lomatium is a member of the Apiaceae, the umbel or parsley family. The genus is a North American group with its center of distribution in the western United States. The genus is composed of taprooted or tuberous perennial herbs with large, winged fruits. Bradshaw's lomatium was first collected by J.C. Nelson near Salem, Oregon, in 1916. The type specimen was collected in 1920, in Eugene, by R.V. Bradshaw, for whom the species was named by Mildred Mathias in 1934. It was originally described as *Leptotaenea bradshawii* Mathias, and was renamed *Lomatium bradshawii* (Rose ex. Math.) Math. & Constance in a 1942 revision of the genus (Mathias and Constance 1942). The taxonomy of this species is well-accepted and not in dispute. The currently accepted classification is:

Clade: Asterids
Order: Apiales
Family: Apiaceae
Genus: *Lomatium*
Species: *L. bradshawii*

LIFE HISTORY

The leaves of Bradshaw's lomatium emerge as early as February. Plants bloom in the spring, usually in April and early May. The flowers have a spatial and temporal separation of sexual phases, presumably to promote outcrossing, resulting in **protandry** on a whole plant basis, and **protogyny** within the flowers. Bradshaw's lomatium produces both male-only and hermaphroditic flowers, and typically produces one or two umbels per year (Kagan 1980). The first umbel is typically composed of all male flowers, while the second contains some hermaphroditic flowers. On umbels with both hermaphroditic and male flowers, the hermaphroditic flowers bloom first. This results in a temporal separation of flower maturity between male and hermaphroditic flowers, reducing the likelihood of self-fertilization (Kaye 1992).

A typical population is composed of many more vegetative plants than reproductive plants (Silvernail *et al.* 2016). Plants may show regression and commonly express dormancy for 1 to 4 growing seasons, though the stimulus is unknown (Drew 2000, p. 48). Mortality is most common at the seedling stage. The lifespan of Bradshaw's lomatium is unknown, though inspection of root crown scars on a single herbarium specimen indicated an age of approximately 15 years (Darrach, personal communication). Other *Lomatium* species in Oregon and Washington are estimated to live on average 5 to 20 years, with some individuals approaching 100 years old (Committee on the Status of Endangered Wildlife in Canada 2008, p. 13; Darrach and Wagner 2011, p. 433; Darrach 2014, p. 11; Darrach and Hinchliff 2014, p. 2).

Commented [A2]: NOTE TO REVIEWERS: I would appreciate your comments, if any, on the reliability of counting root crown scars to age herbaceous perennials, as well as the utility of this information. – Tom B

In a pollinator exclusion experiment, Kaye and Kirkland (1994) observed that self-fertilization in Bradshaw's lomatium is rare, indicating that pollinator-mediated outcrossing is required for reproduction. Pollination of Bradshaw's lomatium is completed by a variety of insects. Over 30 species of solitary bees, flies, wasps and beetles have been observed visiting the flowers (Kaye 1992, Kaye and Kirkland 1994, Jackson 1996). The very general nature of the insect pollinators may help buffer Bradshaw's lomatium from the population swings of any one pollinator species. Kaye (1992) observed a change in relative abundance of pollinator functional groups visiting Bradshaw's lomatium during years in which weather conditions favored one group over another.

Bradshaw's lomatium does not reproduce asexually and depends exclusively on seeds for reproduction (Kaye 1992). Reproductive plants may produce 1 to 20 seeds per year, with variations by year, site conditions, and disturbance regime. Seeds mature in late May to June (Kagan 1980) and may persist on the plant until October or November before falling to the ground (Jackson 1996). The large fruits have corky thickened wings, and usually fall to the

ground fairly close to the parent. Fruits appear to float somewhat, and may be distributed by water. The fine-scale population patterns at a given site appear to follow seasonal microchannels, but whether this is due to dispersal, habitat preference, or both, is not clear (Kaye 1992, Kaye and Kirkland 1994). The seeds either germinate the following spring or die, and do not form a persistent seed bank (Kaye *et al*. 2001).

In a genetic study that included five populations of Bradshaw's lomatium, the species displayed little population differentiation but the level of diversity across the species was comparable to the more common cous biscuitroot (*Lomatium cous*) and Gray's lomatium (*L. grayi*) (Gitzendanner and Soltis 2001). Isolated populations in Washington appear to have lower levels of diversity, but they do not appear to be genetically differentiated from the other populations of the species, consistent with historical gene flow among all populations, and a recent bottleneck in the Washington populations.

The species generally responds positively to disturbance. Low intensity fire appears to stimulate population growth of Bradshaw's lomatium. The belowground portion of Bradshaw's lomatium is able to survive fires, allowing aboveground vegetation to resprout. One study showed that flower and seed production was 5 to 7 times higher on burned plants relative to unburned plants (Wilson *et al*. 1993). Pendergrass *et al.* (1999) showed increased density and abundance of reproductive plants following fires, although monitoring showed that the effects dissipated after 1 to 3 years. Frequent burns may be required to sustain population growth, as determined from population models (Caswell and Kaye 2001, Kaye *et al.* 2001). Annual fall mowing has significantly increased the number of individual Bradshaw's lomatium plants persisting in the City of Eugene's Amazon Park, from 10,134 individuals in 1995 to 31,252 individuals in 2005 (Trevor Taylor, City of Eugene, *in litt*. 2008, p. 2).

HABITAT CHARACTERISTICS

Bradshaw's lomatium is restricted to wet prairie and oak savannah habitats. These sites have heavy, sticky clay soils or a dense clay layer below the surface that results in seasonal **hydric soils**. Most of the known Bradshaw's lomatium populations occur on seasonally saturated or flooded prairies, which are found near creeks and small rivers in the southern Willamette Valley (Kagan 1980). The soils at these sites are dense, heavy clays with a slowly permeable clay layer located between 15 and 30 cm (6 and 12 in) below the surface. This slowly permeable clay layer, which results in a perched water table in winter and spring, allows soils to be saturated to the surface or slightly inundated during the wet season. The soils include Dayton silt loams, Natroy silty clay loams or Bashaw clays; other soils on which the species has been found include

Amity, Awbrig, Coburg, Conser, Courtney, Cove, Hazelair, Linslaw, Oxley, Panther, Pengra, Salem, Willamette, and Witzel.

Figure II-4. Typical wet prairie habitat at Green Mountain site in southwestern Washington, May 2003; yellow flowers in this photo are Bradshaw's lomatium. Photo by Kathy Pendergrass, U.S. Fish and Wildlife Service.

Less frequently, Bradshaw's lomatium populations are found on shallow, basalt areas in Marion and Linn County near the Santiam River. The soil type is characterized as Stayton Silt Loam; it is described as well drained, in alluvium underlain by basalt (U.S. Fish and Wildlife Service 1993, p. 8). The shallow depth to bedrock, 50 cm (20 in) or less, results in sites that are poorly suited to agriculture. This soil type occurs at scattered locations in sites with deeper soils belonging to the Nekia-Jory association, which were originally vegetated by grassland and oak savanna (Alverson 1990, p. 108). Bradshaw's lomatium at these sites occurs in areas with very shallow soil, usually in vernal wetlands or along stream channels.

POPULATION TRENDS AND DISTRIBUTION

Bradshaw's lomatium has a range extending from the southern Willamette Valley near Creswell, Oregon, north to southwestern Washington in the town of Camas. Populations are found in Lane, Linn, Benton, Polk, and Marion Counties in Oregon, and Clark County in Washington.

During the early stages of Euro-American migration to the Willamette Valley in the mid-19th century, wet prairie comprised approximately 55,554 hectares (ha) (137,277 acres (ac)), accounting for approximately 10 percent of the area in the Willamette Valley overall (Christy and Alverson 2011, pp. 100-101). Wetland prairie was more prevalent in the southern portion of the valley and west of the Willamette River, and patchier east of the river and north of the Santiam River (Taft and Haig 2003, pp. 54-55). Wet prairie in the Willamette Valley currently covers less than 2,024 ha (5001 ac) (Christy and Alverson 2011, pp. 100-101), about 3.6 percent of its historical extent, and approximately 0.15 percent of the Willamette Valley overall. Conversion to agriculture has been the largest driver of loss of prairie habitats in the Willamette Valley (Johannessen *et al*. 1971, p. 292; Hulse *et al.* 2002, pp. 78-81). Approximately 50 percent of the modern Willamette Valley is in agricultural production (Morlan *et al*. 2011, p. 11). Residential, commercial, and infrastructure development have also contributed to the decline in wet prairie (Hulse *et al.* 2002, pp. 78-81).

On the remainder of wet prairie not yet converted to agriculture or subjected to urbanization or other development, natural succession to woody species contributes to a loss of this habitat type. Prior to Euro-American settlement in the Willamette Valley, widespread and frequent fires maintained a mosaic of prairie and open Oregon white oak (*Quercus garryana*) savannahs and woodlands. Fires were caused by a combination of intentional burning by Native American peoples and lightning strikes. Johannessen *et al*. (1971) compiled writings from early settlers and explorers detailing their observations of these fires. In the absence of disturbance cause by these fires, native and nonnative trees and shrubs encroach on prairies. Conversion of prairie to woodland habitat occurs as these woody species become dominant (Pendergrass *et al.* 1998).

The historical range and abundance of Bradshaw's lomatium is unknown. The species has historically been overlooked and poorly documented. Bradshaw's lomatium was initially collected in 1916 in the vicinity of Salem, Oregon, after significant losses of wet prairie had likely already occurred in the Willamette Valley.

From 1920 through 1941, at least 10 unique collections of Bradshaw's lomatium were made at locations throughout Lane County (Consortium of Pacific Northwest Herbaria Database 2017). There were no known collections of Bradshaw's lomatium between 1942 and 1964, contributing

to the assumption that the taxon might have gone extinct. No record describing the search effort for Bradshaw's lomatium during this period is available, so it is difficult to draw reliable conclusions about population size and extent. By 1980, eight occurrences had been located, six of which contained greater than 100 plants each (Kagan 1980). When Bradshaw's lomatium was listed as endangered in 1988, 11 occurrences were known, including at least one site with greater than 10,000 plants (53 FR 38448-38451). When the first Recovery Plan for the species was completed in 1993, 14 sites were known with a total of 52,250 plants (U.S. Fish and Wildlife Service 1993, p. 6). When the current Recovery Plan was completed in 2010, the Service was aware of 62 sites containing greater than 1,000,000 plants total (U.S. Fish and Wildlife Service 2010; See Figure II-5). A new occurrence of Bradshaw's lomatium was discovered on private property in Linn County in 2010 (Jarod Jebousek, pers. Comm. 2017), and it is likely more unknown occurrences exist. At present, 71 sites are known to the Service, with greater than 11,000,000 plants. The majority of plants are found in southwestern Washington, while the majority of sites are found toward the southern portion of the species' distribution in Oregon.

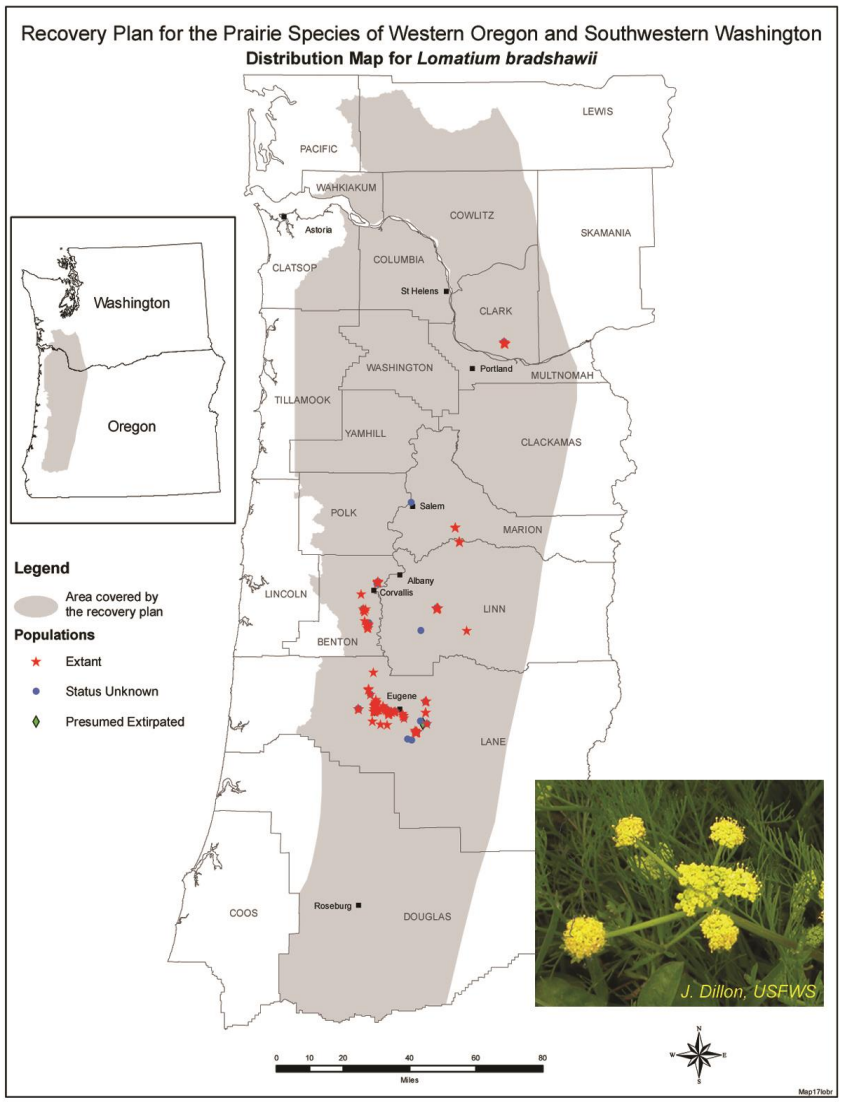

Figure II-5 – Distribution map of *L. bradshawii*, adapted from U.S. Fish and Wildlife Service (2010, p. II-15).

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III. SUMMARY OF INDIVIDUAL, POPULATION, AND SPECIES REQUIREMENTS

REQUIREMENTS OF INDIVIDUALS

Bradshaw's lomatium grows primarily in wet prairies and open oak savannah. These seasonally wet habitats may be flooded in the spring, or have soils saturated at or near the surface. Seasonal moisture may be due to heavy precipitation in winter and spring, flooding, and poor drainage.

A high light environment is important for Bradshaw's lomatium to complete its life cycle and reproduce, as reduced sunlight is associated with lower flower and seed production (Alverson1993, unpublished data). Sites with more open space and less canopy cover appear to support more robust populations.

Bradshaw's lomatium is often associated with tufted hairgrass (*Deschampsia cespitosa*), and frequently occurs on and around the small mounds created by senescent tufted hairgrass plants. In wetter areas, Bradshaw's lomatium occurs on the edges of tufted hairgrass or sedges in patches of bare or open soil. In drier areas, it is found in low areas, such as small depressions, trails or seasonal channels, with open, exposed soils.

REQUIREMENTS OF POPULATIONS

To be resilient, populations of Bradshaw's lomatium need sufficiently large numbers of individuals so that they are able to withstand stochastic events (expected levels of variation in environmental or demographic characteristics). For example, populations must be large enough to withstand annual variation in levels of vole predation on seeds. No quantitative analysis has been completed to determine a minimum viable population size for Bradshaw's lomatium. Experts on the Recovery Team for the prairie species of western Oregon and southwestern Washington (Recovery Team) defined eight Recovery Zones within the range of Bradshaw's lomatium, and set population level goals for each (U.S. Fish and Wildlife Service 2010, entire; see Figure III-2). Within each Recovery Zone, they set a goal of at least 10,000 plants in a minimum of two populations, and at least two of the populations contain greater than 2,000 plants each. Smaller scattered populations of at least 200 plants within pollinator flight distance (3 kilometer [km] (2 miles [mi])) of each other were deemed stable enough to contribute to overall goals.

Sufficient annual seed production is necessary to offset mortality of mature Bradshaw's lomatium plants within a population. Bradshaw's lomatium does not maintain a persistent seed bank in the soil. Though some fruit survives in the soil for one year, the seeds are not viable (Kaye *et al*. 2001).

Open habitats with relatively high sunlight and low canopy cover are important for successful reproduction necessary to sustain Bradshaw's lomatium populations, due to the observed correlation between reduced sunlight and lowered flower and seed production (Alverson, unpublished data 1993). In the absence of disturbance to set back succession, wet prairies in the Willamette Valley are subject to woody species encroachment, gradually transitioning into shrub or woodland habitat. Periodic disturbance, such as fire or fall mowing, are necessary to maintain the open, high light wet prairie habitats Bradshaw's lomatium populations depend on. Flowering and seed production have been shown to be 5- to 7- times greater in plants that have been burned relative to those that have not (Wilson *et al.* 1993). Pendergrass *et al.* (1999) also noted increased flower and fruit production by Bradshaw's lomatium in response to fire. Overall, fire has a substantially positive effect on population growth rate and population viability, though multiple studies show the magnitude of effect varies by site (Pendergrass *et al*. 1999, Caswell and Kaye 2001, Kaye *et al.* 2001).

Populations of Bradshaw's lomatium need habitat with intact wetland hydrology and protected from adjacent hydrological changes that may affect wet prairie characteristics. Land use changes on adjacent sites or flood control can alter the hydrology and soil conditions of nearby Bradshaw's lomatium populations. Bradshaw's lomatium requires a hydrologic regime of flooding, precipitation, poor drainage, and unaltered topography/hydrology (i.e. no development, no drainage ditches), resulting in seasonally wet prairie. Poorly draining soil types such as heavy clay or shallow soil with underlying basalt result in soil saturation, standing water, vernal pools, or a perched water table, providing the type of habitat required to support Bradshaw's lomatium. Population growth and reproduction are positively correlated with higher September to February precipitation at some sites (Drew 2000, p. 49). Both reproductive potential and plant height are higher on wetter sites (Drew 2000, p. 50).

High population densities on sites with poor soil may result in small plants, low seed production, and lower leaf length and umbel number. Lower plant densities with adequate soil tend to result in larger plants with high seed production (Kaye 1992, p. 2).

Bradshaw's lomatium is an obligate outcrossing species, and is dependent on the presence of pollinators during its early spring bloom period for successful sexual reproduction. In Bradshaw's lomatium populations composed of multiple discontinuous sites, insect pollinators

are also important for ensuring gene flow between sites. Numerous species from multiple functional groups of insects have been observed pollinating Bradshaw's lomatium, and annual variations in weather appear to influence the relative abundance of certain insect pollinator functional groups (Kaye 1992, Kaye and Kirkland 1994, Jackson 1996). In order to ensure the presence of pollinators each year, it is important that habitats supporting Bradshaw's lomatium provide sufficient resources to support an abundance and diversity of pollinator species and functional groups. Native bee species have been observed showing preference for native plant species, and a diversity of native flowering plants is important for supporting pollinator populations (Morandin and Kremen 2013, pp. 28-31). Flowering plant richness is positively correlated with pollinator abundance, species richness, functional group diversity, and frequency of pollinator flower visits (Ebeling *et al*. 2008, pp 1810-1811; Orford *et al*. 2016, pp. 909-911).

Table III-1. Key life history and resource needs of Bradshaw's lomatium

- Pollinators (obligate outcrossing)
- Bare substrate for seed germination
- Open habitats (High levels of sunlight, low canopy, woody cover)
- Water and nutrients
- Seasonally moist, hydric soils; intact wetland hydrology

Figure III-1 presents a conceptual model summarizing the key population needs for Bradshaw's lomatium. Additionally, this model incorporates stressors that may influence these resource needs, and thus affect the resiliency of Bradshaw's lomatium. These stressors are discussed further in Section IV of this document, Summary of Stressors Affecting the Species.

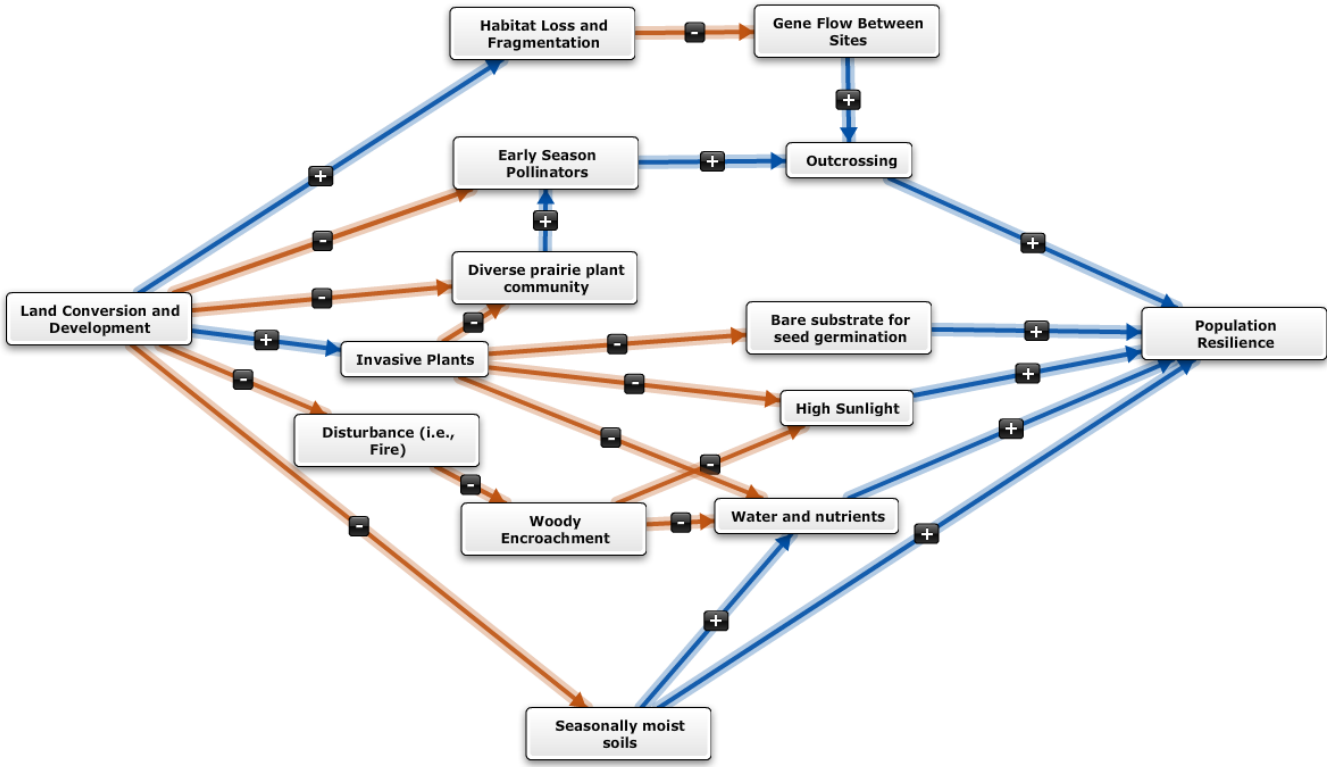

Figure III-1 – Conceptual model showing relationships of factors influencing *Lomatium bradshawii* population resiliency. Blue and Red arrows show the direction and type of relationship between two factors (red arrows represent reductions and blue arrows represent increases). For example, Land Conversion and Development increases Habitat Loss and Fragmentation, and reduces Disturbance.

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REQUIREMENTS OF THE SPECIES

To be considered **viable**, Bradshaw's lomatium should have a sufficient number of secure, resilient populations well-distributed throughout its geographic range, and representing the range of ecological settings in which the species is known to exist. The number and distribution of resilient populations must be sufficient for the species to withstand catastrophic events.

Bradshaw's lomatium is endemic to the Willamette Valley of Oregon and Clark County in southwestern Washington. Though its historical extent and distribution are not precisely known, the species was likely more abundant, widespread, and contiguously distributed prior to the loss and fragmentation of seasonally wet prairies throughout the region due to land conversion and development. We do not have information to indicate, however, that the species ever occurred in a diverse range of ecological environments, nor do we have information suggesting any genetic structure between populations of Bradshaw's lomatium.

No quantitative analysis has been completed to determine the minimum number of populations necessary for Bradshaw's lomatium to be viable as a species. However, experts on the Recovery Team delineated Recovery Zones throughout the range of Bradshaw's lomatium (Figure III-2), and set goals for the desired number of populations per Recovery Zone based upon their best professional judgement (Table III-2). The intent of these goals was to ensure the distribution of resilient populations of the species across its historical range and thus achieve redundancy in populations as well as adequate ecological and genetic representation. The Recovery Team did not set goals for the Portland and Salem West Recovery Zones, because we do not have any historical records to indicate that the species occurred in those zones, or if so, where they may have occurred.

Table III-3 presents a summary of the fundamental requirements of Bradshaw's lomatium at the individual, population, and species level.

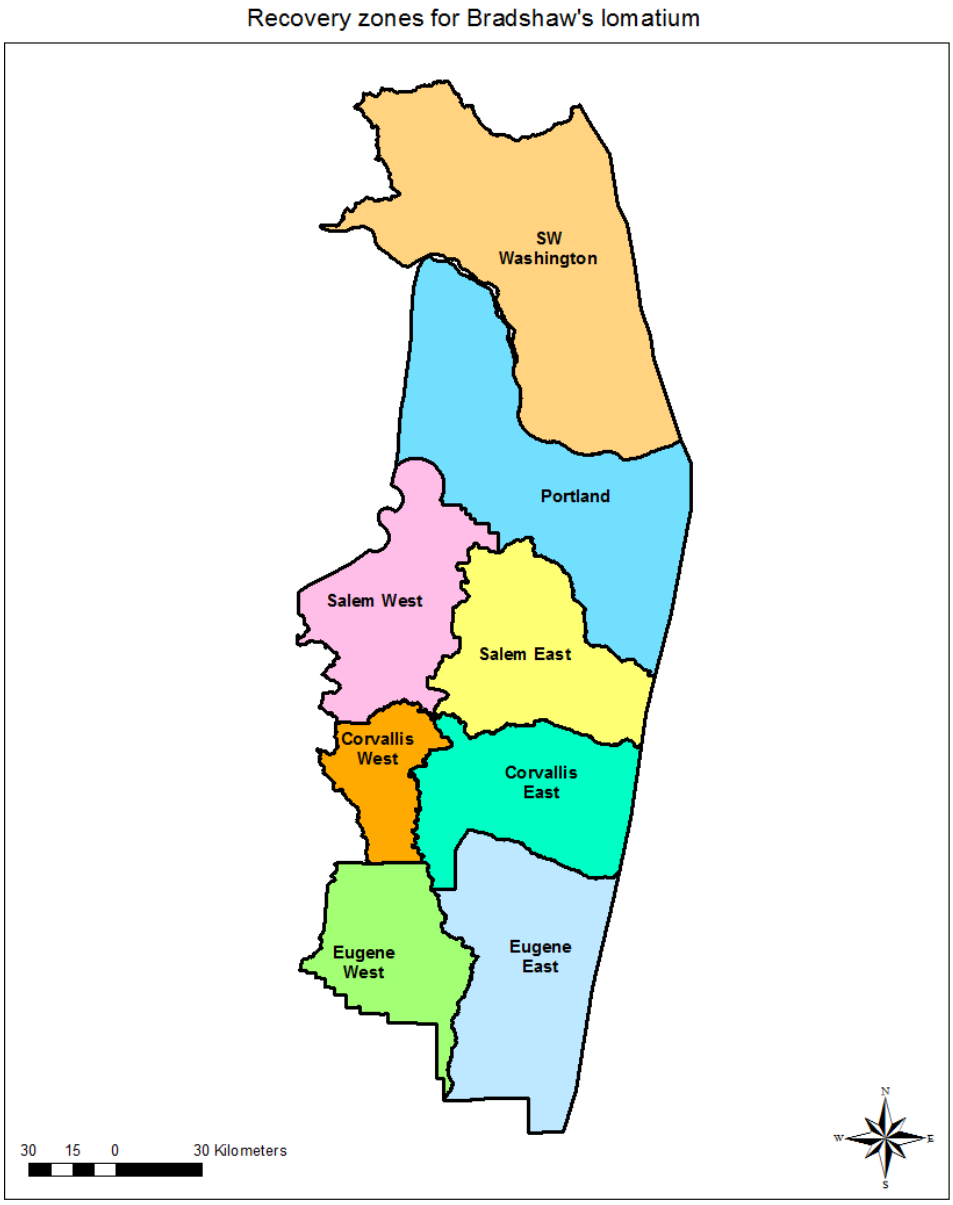

Figure III-2 – Map of Recovery zones for Bradshaw's lomatium .

Distribution and Abundance Goals for Bradshaw's lomatium				
Recovery Zone	**Downlisting Goals**		**Delisting Goals**	
	Minimum # of Populations / Zone	**Target # of Plants / Zone**	**Minimum # of Populations / Zone**	**Target # of Plants / Zone**
SW Washington	1	5,000	2	10,000
Portland	0	0	0	0
Salem East	1	5,000	2	10,000
Salem West	0	0	0	0
Corvallis East	2	10,000	3	15,000
Corvallis West	2	10,000	2	10,000
Eugene East	1	5,000	3	15,000
Eugene West	3	15,000	3	15,000
+ Additional Populations (may occur in any Recovery Zone within range of *L. bradshawii*)	2	10,000	5	25,000
Total	12	60,000	20	100,000

Table III-2 – Recovery targets for number and distribution of Bradshaw's lomatium populations, as well as population size, as determined by the Recovery Team. Adapted from the Recovery Plan for the Prairie Species of Western Oregon and Southwestern Washington (U.S. Fish and Wildlife Service 2010).

Requirements of Bradshaw's lomatium		
Individuals	Populations	Species
• Wet prairie or oak savannah habitat • High light environment	• Sufficiently large populations to withstand stochastic events (at least 2000 plants) • Sufficient annual seed production to offset mortality (no persistent seed bank) • High quality prairie or oak savannah habitat • Regular disturbance (fire, mowing) to maintain open conditions. • Early season pollinators for outcrossing.	• Sufficient number of resilient populations well distributed across the range • Downlisting target in Recovery Plan: 12 populations / 60,000 plants • Delisting target: 20 populations, 100,000 plants • Sufficient genetic diversity to adapt to change over time

Table III-3 – Summary of requirements of Bradshaw's lomatium at individual, population, and species levels.

IV. SUMMARY OF STRESSORS AFFECTING THE SPECIES

HABITAT LOSS AND FRAGMENTATION

The abundance and distribution of Bradshaw's lomatium prior to Euro-American settlement is not known, but was likely far greater than at the present time. Historically, wet prairie habitat that could have supported Bradshaw's lomatium comprised approximately 10 percent of the Willamette Valley at an estimated 55,554 ha (137,277 ac) (Christy and Alverson 2011, pp. 100-101). Wet prairie currently occupies approximately 3.6 percent of its historic extent, at 2,024 ha (5,001 ac) (Christy and Alverson 2011, pp. 100-101). Conversion to agriculture has been the largest driver of loss of prairie habitats in the Willamette Valley (Johannessen *et al.* 1971, p. 296; Hulse *et al.* 2002, pp. 78-81). Approximately 50 percent of the modern Willamette Valley is in agricultural production (Morlan *et al.* 2011, p. 11). Residential, commercial, and infrastructure development have also contributed to the decline in wet prairie (Hulse *et al.* 2002, p. 78-81).

Activities associated with land use change and development that impact Bradshaw's lomatium habitats are wetland draining, infill, paving, and other hydrologic alterations. These activities result in mortality of individuals, loss of habitat, and loss of genetic connectivity between remaining populations. This stressor occurs rangewide, and affects all life stages of Bradshaw's lomatium. The greatest exposure of Bradshaw's lomatium to habitat loss is historical, though ongoing development pressure may cause additional periodic losses.

WOODY ENCROACHMENT

In the absence of certain types of disturbance, wet prairies in the Willamette Valley and southwestern Washington are subject to natural succession involving encroachment of trees and shrubs. Historically, wildfires and active burning by native peoples maintained open prairie habitats throughout the region. The end of native burning, as well as landscape fragmentation and active fire suppression, have allowed succession to shrub- and tree-dominated habitats to progress rapidly in prairie ecotypes.

Succession to woody species causes a shift in plant community structure and composition, and alters the light environment in the herbaceous layer. Substrate availability may be reduced for all life stages of Bradshaw's lomatium. Reductions in light availability may result in reduced flower and fruit production, causing a reduction in recruitment. The increased shading and resource competition associated with woody encroachment results in reduced growth, survival, and

reproduction in Bradshaw's lomatium. Historically, woody encroachment was not likely a significant stressor to Bradshaw's lomatium populations due to the frequency of widespread fires prior to Euro-American settlement in the Willamette Valley. Presently, woody encroachment is a regular and recurring stressor to Bradshaw's lomatium throughout its range. Active management, such as prescribed fire and mowing, can help to reduce exposure of Bradshaw's lomatium to this stressor. Woody species of particular management concern were identified by the Recovery Team (U.S. Fish and Wildlife Service 2010, entire), and are listed in Table IV-1.

Woody Species of Management Concern	
Scientific Name	**Common Name**
Crataegus monogyna	oneseed hawthorne
Crataegus suksdorfii	Suksdorf's hawthorne
Cytisus spp.	nonnative brooms (*e.g.*, Scotch broom, Spanish broom, and others)
Pyrus communis	feral common pear
Rosa eglanteria	sweetbriar rose
Rosa multiflora	multiflora rosa
Rubus armeniacus	Armenian blackberry
Rubus laciniatus	cutleaf blackberry
Toxicodendron diversilobum	poison oak

Table IV-1 – Select woody species of management concern in Bradshaw's lomatium habitats, as determined by the Recovery Team. Adapted from the Recovery Plan for the Prairie Species of Western Oregon and Southwestern Washington (U.S. Fish and Wildlife Service 2010).

Commented [MJW(CUC(5]: Haha, how did we miss *Fraxinus latifolia*?

INVASIVE PLANTS

Human-mediated dispersal of nonnative plant species has resulted in established populations of invasive plants. Though specific definitions vary, for our purposes an invasive plant is defined as a plant species not native to a specific geographic area, which is likely to cause ecological or economic harm. At least 700 nonnative plant species are reported to occur in the Willamette Valley (Albert 2015), though not all are classified as invasive. A partial list of nonnative plants found in Willamette Valley can be found in Table IV-2.

Nonnative invasive plants have established and spread within many habitats supporting Bradshaw's lomatium, leading to increased direct competition for resources such as light, water,

nutrients, and open substrate for germination. A decrease in available light, water, and nutrients results in reduced growth, survival, and reproduction in Bradshaw's lomatium.

Exposure of Bradshaw's lomatium to invasive plants has occurred in the past, is ongoing, and is likely to continue into the future. In cases where invasive plants may be eliminated from within a Bradshaw's lomatium population, propagules from nearby source populations may continue to arrive. The degree of nonnative invasive plant infestations varies by site (Silvernail *et al.* 2016).

Non-native Plant Species in Willamette Valley Wet Prairies[1]	
Invasive Plants of Management Concern	
Scientific Name	Common Name
Arrhenatherum elatius	tall oatgrass
Brachypodium sylvaticum	false-brome
Centaurea X *pratensis*	meadow knapweed
Cytisus scoparius	Scotch broom
Phalaris arundinacea	reed canarygrass
Pyrus communis	feral common pear
Rubus armeniacus	Armenian blackberry
Rubus ~~vestilus~~vestitus	European blackberry
Other Common Non-native Plants	
Scientific Name	Common Name
Agrostis capillaris	colonial bentgrass
Agrostis stolonifera	creeping bentgrass
Alopecurus pratensis	meadow foxtail
Anthoxanthum odoratum	sweet vernalgrass
Briza minor	little quakinggrass
Centaurium erythraea	European centaury
Cerastium viscosum	sticky chickweed
Dipsacus fullonum	Fuller's teasel
Galium parisiense	wall bedstraw
Holcus lanatus	common velvetgrass
Hypericum perforatum	St. John's wort
Hypochaeris radicata	hairy cat's ear
Leontodon nudicaulis	lesser hawkbit
Leucanthemum vulgare	oxeye daisy
Lolium perenne	perennial ryegrass
Lysimachia nummularia	creeping jenny
Mentha pulegium	pennyroyal
Myosotis discolor	changing forget-me-not
Parentucellia viscosa	yellow glandweed

[1] Partial listing

Commented [MJW(CUC(6]: I think the bentgrasses, *Anthoxanthum, Holcus, Hypochaeris, Leucanthemum*, are of great concern as well esp. in wet prairie…

Commented [MJW(CUC(7]: Now *Centaurea jacea* nothosubsp. *pratensis*

Scientific Name	Common Name
Plantago lanceolata	narrowleaf plantain
Prunella vulgaris ssp. *vulgaris*	common self-heal
Schedonorus arundinaceus	tall fescue
Seneceo jacobaea	tansy ragwort
Trifolium dubium	suckling clover
Vicia sativa	garden vetch
Vicia tetrasperma	lentil vetch

Table IV-2 – A partial list of non-native plants found in Willamette Valley wet prairies. Species of management concern are adapted from U.S. Fish and Wildlife Service (2010). Other non-native species are adapted from Wilson (1998) and Silvernail *et al.* (2016).

A summary of the stressors that may influence the viability of Bradshaw's lomatium are summarized in Table IV-3.

Factors affecting survival of Bradshaw's lomatium		
Individuals	Populations	Species
• Shade from encroaching trees likely reduces vigor and reproduction. • Competition from invasive plants likely reduces survival.	• Habitat loss and fragmentation causes reduced availability of habitat, reduced connectivity • Ongoing development pressure may threaten some sites. • Natural succession in the absence of active management causes loss of habitat. • Invasive plants reduce habitat quality.	• Habitat loss and fragmentation reduces number and connectivity of populations throughout the range. • Habitat degradation due to invasive plants or succession to woody species reduces resilience of populations.

Table IV-3. Stressors that have a negative effect on the individual, population, and species-level needs of Bradshaw's lomatium.

V. CONSERVATION EFFORTS

Extensive research has been conducted on the ecology and population biology of Bradshaw's lomatium, effective methods for habitat enhancement, and propagation and reintroduction techniques (Kagan 1980, Kaye 1992, Kaye and Kirkland 1994, Caswell and Kaye 2001, Kaye and Kuykendall 2001, Kaye *et al.* 2003). The results of these studies have been used to direct the management of the species at sites managed for wet prairies.

Propagation studies have found that long-term (8 weeks) cold stratification was necessary to fully break dormancy in this species (Kaye *et al.* 2003b). Bradshaw's lomatium plants can be grown from seed in a greenhouse environment (Kaye *et al.* 2003b). Plants may be successfully established at existing populations or new locations through outplanting of greenhouse-grown plants. Fertilizing transplants may have a negative effect on survival in some cases. Direct seeding has a relatively high success rate (17 to 38 percent), and is improved by removal of competing vegetation (Kaye and Kuykendall 2001, Kaye *et al.* 2003). Seeds of this species have been banked at the Rae Selling Berry Seed Bank at Portland State University, as well as the University of Washington Botanic Garden.

Studies of the effects of cattle grazing on Bradshaw's lomatium populations show mixed results. Grazing in the springtime, when the plants are growing and reproducing, can harm the plants by biomass removal, trampling and soil disturbance; however, late-season livestock grazing, after fruit maturation, has been observed to lead to an increase in emergence of new plants, and the density of plants with multiple umbels, although it did not alter survival rates or population structure (Drew 2000). Observed increases in seedlings may be due to small disturbances in the soil, a reduction of shading by nearby plants, and reduced herbivory by small mammals.

Populations of Bradshaw's lomatium occur on public lands or lands that are managed by a conservation organization at many sites including, but not limited to, the Service's William L. Finley and Oak Creek units of the Willamette Valley National Wildlife Refuge Complex, the U.S. Army Corps of Engineers at Fern Ridge Reservoir, the Bureau of Land Management at the West Eugene Wetlands, The Nature Conservancy at Willow Creek Natural Area and Kingston Prairie Preserve, Lane County at Howard Buford Recreation Area, Greenbelt Land Trust at Courtney Creek, and McKenzie River Trust at Coyote-Spencer Wetlands. All of these parcels have some level of management for native prairie habitat values (for example, regular mowing or prescribed burning to control woody succession). A number of privately-owned sites are also enrolled in the Natural Resources Conservation Service's Wetland Reserve Program, the Service's Partners for Fish and Wildlife Program, or both.

A habitat conservation plan that addresses conservation of Bradshaw's lomatium within Benton County was completed in 2010 (Benton County 2010, entire). Habitat conservation plans are also in place for Yamhill County road maintenance activities (Yamhill County 2013, entire) and routine road maintenance by the Oregon Department of Transportation (Oregon Department of Transportation 2015, entire). The Oregon Department of Transportation also manages a number of Special Management Areas (SMAs) where Bradshaw's lomatium sites are present in rights-of-way.

A range wide assessment of Bradshaw's lomatium was completed by the Institute for Applied Ecology in 2016 (Silvernail *et al.* 2016), providing more current data on abundance and habitat quality at many sites considered important for recovery of the species.

Under a cooperative agreement with the Service, the Institute for Applied Ecology also maintains an active seed production program to provide seeds of Bradshaw's lomatium and other native prairie plant species to land managers for population augmentation and restoration projects. In 2016, this program produced 17,300 Bradshaw's lomatium plugs that were outplanted at two sites (Getty 2017, p. 14).

VI. ASSESSMENT OF CURRENT CONDITION

ANALYTICAL APPROACH

Delineation of Populations

Sites of Bradshaw's lomatium, which are typically delineated by ownership or management unit, are distributed across a highly fragmented landscape. After over 150 years of habitat loss, suitable wet prairie habitat is discontinuous throughout the Willamette Valley.

A population of a species is a group of individuals of that species that are demographically and/or genetically connected with each other, and are disjunct from other groups or individuals of that species. In previous assessments of Bradshaw's lomatium, the individual site has commonly been the unit of analysis, without consideration of proximity and potential connectivity to other nearby sites. Analysis at the site level is useful for recovery planning due to differences in ownership and management of nearby sites. The Recovery Team for the Prairie Species of Western Oregon and Southwestern Washington determined that a population of Bradshaw's lomatium may be composed of several smaller subpopulations if they are within pollinator distance of one another, which they defined as 3 km (2 mi) (U.S. Fish and Wildlife

Service 2010). Frequent pollinator-mediated genetic exchange between subpopulations may not be necessary, as models have shown that as little as one migrant per generation may be sufficient to prevent the negative effects of inbreeding in disjunct subpopulations of sites (Newman and Tallmon 2001, Wang 2004). For the purposes of this SSA, a population of Bradshaw's lomatium is defined as any number of Bradshaw's lomatium sites within the previously agreed-upon pollinator flight distance of 3 km (2 mi) of each other, regardless of site ownership.

Analysis of Population Condition

No quantitative population viability assessment models currently exist that calculate extinction probabilities for Bradshaw's lomatium populations. In this SSA, we utilize the best available scientific data to score the current condition of each population as High, Moderate, or Low based upon our assessment of how well the needs of the population are being met, as detailed here. We evaluated each population in a two-stage process considering overall wet prairie habitat condition, management, site protection, and abundance of Bradshaw's lomatium (see Figure VI-1).

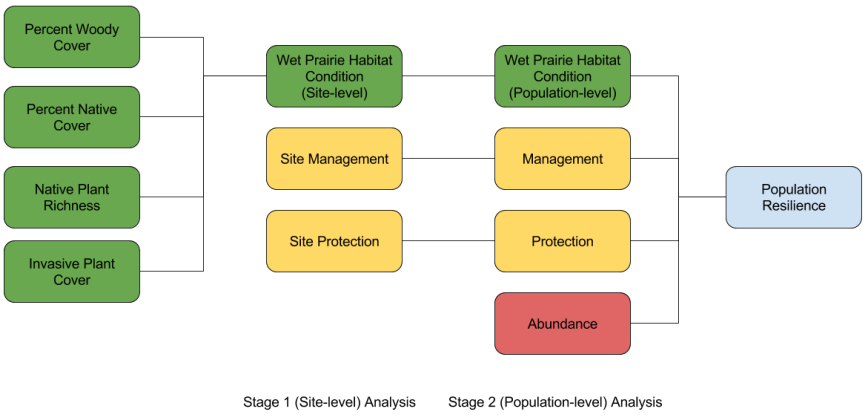

Figure VI-1. Factors used to assess resiliency of Bradshaw's lomatium populations. Green boxes are for factors related to habitat condition. Yellow boxes reflect ownership and management factors. Red represents plant abundance.

The evaluation at Stage 1 is at the site level, and includes an assessment of wet prairie habitat condition, management, and protection. Wet prairie habitat condition is scored based upon the following measurable factors that are likely to influence Bradshaw's lomatium population resiliency: percent woody cover, percent native cover, native plant richness, and invasive plant cover. These factors were selected as important habitat quality criteria due to their effects on

Bradshaw's lomatium as described in Sections III and IV of this SSA. For each site where data on these criteria are available, a score of 1 (Poor), 2 (Fair), or 3 (Good) was given based upon guidelines for assessing prairie quality developed by the Recovery Team (U.S. Fish and Wildlife Service 2010, entire), the best available scientific data, and the best professional judgment of Service staff. A summary of the site-level habitat scoring criteria we used is presented in Table VI-1.

Site-Level Habitat Quality Analysis Criteria				
Score	**Woody cover**	**Native cover**	**Native Richness**	**Invasive Plants**
3 (Good)	<5% woody cover	Relative cover ≥ 50%	Total native species richness >10	0 Invasive species of concern* ≥5% cover **-AND-** No single non-native plant species >50% cover
2 (Fair)	5-15% woody cover	Relative cover 25-50%	Total native species richness 5-10	1 Invasive species of concern* ≥5% cover **-OR -** Any single non-native plant species >50%
1 (Poor)	>15% woody cover **-OR-** Any woody species of management concern* >5% cover	Relative cover <25%	Total native species richness <5	1 Invasive species of concern* ≥5% cover and any single non-native plant species >50%; **-OR-** ≥ 2 Invasive species of concern* ≥5% cover

Table VI-1. Summary of site-level habitat analysis criteria.
* A list of invasive species of concern can be found in Table IV-2 of this document

Due to the potential losses of Bradshaw's lomatium populations to development or natural succession to woody habitats in the absence of disturbance, management and site protection that serve to offset the negative effect of these stessors are included in this analysis of current population condition. Because these factors vary within populations based upon ownership,

initial analysis is conducted at the site-level. Management and protection at the site-level are scored as 1 (Poor), 2 (Fair), or 3 (Good) based upon their level of management for the open prairie habitat required by Bradshaw's lomatium and type of land protection in place. A summary of site-level management and site protection criteria is available in Table VI-2 below.

Site-Level Management and Protection Analysis Criteria		
Score	**Management**	**Site Protection**
3 (Good)	Managed for prairie conditions, management plan in place	Public or Private Conservation Organization ownership
2 (Fair)	Generally managed for prairie, management plan not in place	Private with conservation easement or similar program (i.e., the Service's Partners for Fish and Wildlife Program, Natural Resources Conservation Service Wetland Reserve Program)
1 (Poor)	Not managed for prairie conditions **-OR-** Unknown	Private with no conservation easement

Table VI-2. Summary of site-level management and site protection criteria used in this analysis.

Stage 2 is a population-level analysis, and evaluates the current condition of Bradshaw's lomatium populations. In this stage, a mean of site-level scores for habitat quality, management, and site protection is calculated across all sites within a population. For each of these criteria, the population condition is classified as High (mean score ≥2.5), Moderate (mean score 1.75-2.49), or Low (mean score <1.75). Abundance is scored based upon the total number of plants across all sites within a population at the most recent survey as High (≥5,000 plants), Moderate (2,000-

4,999 plants), or Low (<2,000 plants). Abundance data and survey year for sites are available in Appendix A. Overall condition is determined as an average of the individual factors, with Management weighted twice as much as the other factors due to its relative importance to long-term population resiliency (U.S. Fish and Wildlife Service 2010, pg. IV-5).

Commented [MJW(CUC(8]: Given this weighting, it is important to discuss factors which may influence the likelihood and intensity of management, such as funding, listing status, etc., and link these various scenarios to future site quality.

Except where otherwise noted, data for this analysis are sourced from the Threatened and Endangered Plant Geodatabase (Version 05/16/2017), developed by the Institute for Applied Ecology under a cooperative agreement with the Service to track the status of ESA-listed species in the Willamette Valley. The details for the analysis of each site are provided in Appendix A.

RESULTS

Southwest Washington Recovery Zone

In the Southwest Washington Recovery Zone (Table VI-3), two adjacent sites comprise one population (WA1) in Moderate condition. This privately-owned population contains the largest number of Bradshaw's lomatium individuals of any population (10,790,640 plants), with the vast majority occurring in one site (Camas Meadows). The second, smaller site (Lacamas Prairie Natural Area Preserve) is owned and managed by the Washington Department of Natural Resources and is actively managed for wet prairie conditions, but no formal management plan is in place (Carlo Abbruzzese, pers. comm. 2017).

Population	# of Sites	Abundance	Habitat	Protection	Management	Current Condition
WA1	2	10,790,640	2.875	2	2	Moderate
		High	High	Moderate	Moderate	

Table VI-3. Summary of current condition of Bradshaw's lomatium in the Southwest Washington Recovery Zone.

With one population and over 10 million plants, the Southwest Washington Recovery Zone currently meets the downlisting goal for minimum number of populations (1) and exceeds the downlisting goal for number of plants (5,000). Although both sites within the population currently experience management that is compatible with the maintenance of conditions for Bradshaw's lomatium, the larger Camas Meadows site is not under permanent or long-term protection.

Salem East Recovery Zone

The Salem East Recovery Zone (Table VI-4) currently contains three known Bradshaw's lomatium populations. Population SE1 is comprised of a single site and occurs on private property. Though no formal management plan is in place for the property, the owners have begun proactively managing for Bradshaw's lomatium (Jeff Dillon, pers. comm. 2017; Chris Seal, pers. comm. 2017). Population SE2 is owned and managed by The Nature Conservancy and SE3 is protected by a permanent conservation easement. A fourth population, where the species was originally collected in 1916, is considered extirpated.

Population	# of Sites	Abundance	Habitat	Protection	Management	Current Condition
SE1	1	10,680 (Jeff Dillon, pers. comm. 2017)	No Data	1	2	Moderate
		High		Low	Moderate	
SE2	1	46,385	2.5	3	3	High
		High	High	High	High	
SE3	2	5,539	2.5	2	3	High
		High	High	Moderate	High	

Table VI-4. Summary of current condition of Bradshaw's lomatium in the Salem East Recovery Zone.

The Salem East Recovery Zone currently has three populations and more than 60,000 plants, which exceeds the delisting goals for minimum number of populations (2) and target number of plants (10,000). Two of the three populations are permanently protected, and positive management is underway at the third population site.

Corvallis East Recovery Zone

The Corvallis East Recovery Zone (Table VI-5) contains four known Bradshaw's lomatium populations, each of which is composed of a single site. Abundance is relatively low at population CE1, but habitat quality is high, receives management, and the site is protected by a Wetland Reserve Program conservation easement. In 2016, 15,500 Bradshaw's lomatium plugs were planted in this population (Getty 2017, p. 14), but establishment has not yet been monitored. Populations CE2 and CE3 are publicly owned and score high for all categories of this assessment. For population CE4, no data are currently available to evaluate resilience.

Population	# of Sites	Abundance	Habitat	Protection	Management	Current Condition
CE1	1	1,535	2.5	2	3	Moderate
		Low	High	Moderate	High	
CE2	1	169,254	2.75	3	3	High
		High	High	High	High	
CE3	1	8,673	2.75	3	3	High
		High	High	High	High	
CE4	1	No Data	No Data	No Data	No Data	No Data

Table VI-5. Summary of current condition of Bradshaw's lomatium in the Corvallis East Recovery Zone.

The Corvallis East Recovery Zone contains four Bradshaw's lomatium populations and nearly 180,000 plants. Of these four populations, three are permanently protected and are managed for habitat conditions that support Bradshaw's lomatium. This Recovery Zone meets the delisting goals for number of populations (3) and exceeds delisting goals for number of plants (15,000).

Corvallis West Recovery Zone

The Corvallis West Recovery Zone (Table VI-6) contains four populations across 11 sites. Population CW1 contains two sites in protected ownership, but with low abundance. A third site within pollinator flight distance of these two sites is presumed extirpated. Population CW2 has low abundance and is in private ownership with no known management or protection. Population CW3 contains two sites, with the majority of plants (all but one) occurring at a privately-owned, unmanaged site. The second site in population CW3 contained a single Bradshaw's lomatium plant at the most recent survey, but receives habitat management and is protected by a Wetland Reserve Program conservation easement. Population CW4 contains six sites, five of which occur on William L. Finley National Wildlife Refuge and receive active management. Little data is available for the sixth site in population CW4, which occurs on private land.

Population	# of Sites	Abundance	Habitat	Protection	Management	Current Condition
CW1	2	166 Low	2.375 Moderate	3 High	3 High	Moderate
CW2	1	20 Low	No Data	1 Low	1 Low	Low
CW3	2	3,445 Moderate	2.25 Moderate	1.5 Low	2 Moderate	Moderate
CW4	6	14,040 High	2.75 High	2.67 High	2.67 High	High

Table VI-6. Summary of current condition of Bradshaw's lomatium in the Corvallis West Recovery Zone.

The Corvallis West Recovery Zone contains four populations, two of which are large enough to meet or exceed the delisting criteria for populations (2) and number of plants (10,000). Of these two, one receives permanent protection at most sites and one receives proactive management through the Service's Partners for Fish and Wildlife Program. Bradshaw's lomatium abundance is too low at the remaining two populations to reliably contribute to recovery criteria.

Commented [A9]: Cutler Lane in CW3. Jenny Getty wrote in an email that this site is enrolled in Partners, but it isn't listed as such in the geodatabase. I'm currently awaiting a call back from Jarod Jebousek for confirmation of enrollment status. - Tom

Eugene East Recovery Zone

The Eugene East Recovery Zone (Table VI-7) contains three Bradshaw's lomatium populations. Population EE1 is made up of two separate sites owned and managed by Lane County. A third site in the vicinity of EE1 had been reported at Mt. Pisgah Arboretum, but this report is considered erroneous (Ed Alverson, pers. comm. 2017). Population EE2 contains a single site with very low abundance, but which has high quality habitat and is protected by a Wetland Reserve Program conservation easement and is enrolled in the Partners for Fish and Wildlife program. Population EE3 was recently discovered (Jarod Jebousek, pers. comm. 2017) and has been acquired by Greenbelt Land Trust for the purpose of conserving Bradshaw's lomatium; it supports a substantial population estimated at approximately 25,000 plants.

Population	# of Sites	Abundance	Habitat	Protection	Management	Current Condition
EE1	2	9,556 High	3 High	3 High	3 High	High
EE2	1	10 Low	2.75 High	2 Moderate	3 High	Moderate
EE3	1	25,000 High	No Data	3 High	2 Moderate	High

Table VI-7. Summary of current condition of Bradshaw's lomatium in the Eugene East Recovery Zone.

The Eugene East Recovery Zone contains three populations and nearly 35,000 plants. Two of these populations are ~~sufficiently~~ large enough to exceed downlisting goals for number of populations (1) and number of plants (5,000), but not to meet delisting goals for number of populations (3).

Eugene West Recovery Zone

The Eugene West Recovery Zone (Table VI-8) contains nine Bradshaw's lomatium populations, made up of 43 sites. Population EW1 is estimated at over 100,000 plants and contains 25 sites with a mix of ownership, including the U.S. Army Corps of Engineers, Bureau of Land Management, Oregon Department of Transportation, City of Eugene, The Nature Conservancy, and private landowners. Of the 25 extant sites in this population, 23 are in ownership that confers some degree of protection and management. Four additional sites within pollinator flight distance are presumed extirpated. Overall current condition of population EW1 is high. Population EW2 is composed of 4 sites with overall high current condition. Bradshaw's lomatium at one of these sites had been reduced to a single plant, but has recently been planted with 1750 Bradshaw's lomatium plants by the U.S. Army Corps of Engineers (Wes Messinger, pers. comm. 2017). Population EW3 contains a single site owned by the City of Veneta and is enrolled in the Partners for Fish and Wildlife Program. This population was augmented with 1,800 Bradshaw's lomatium plugs in 2016 (Getty 2017), but establishment has not been monitored yet. Population EW4 contains two sites owned and managed by McKenzie River Trust and one site in private ownership. Population EW5 contains two privately owned sites with low abundance, no known management or protection, and no available habitat data. Population EW6 contains three sites, two of which are owned and managed by the City of Eugene and one of which is privately owned. Population EW7 consists of a single site with low abundance, and for which no habitat, ownership, or management data are available. Population EW8 consists of two sites, one of which is within an Oregon Department of Transportation Special Management

Area, and the other of which is owned and managed by Lane County. Population EW9 consists of three sites, one of which is owned by the City of Creswell, and two of which are privately owned. One of the privately owned sites is enrolled is protected by a Wetland Reserve Program conservation easement and contains the majority of individuals in this population (1,091 plants).

Population	# of Sites	Abundance	Habitat	Protection	Management	Current Condition
EW1	25	141,978 High	2.68 High	3 High	2.54 High	High
EW2	4	7,924 High	2.67 High	2.67 High	2.67 High	High
EW3	1	3,690 Moderate	No Data	3 High	2 Moderate	Moderate
EW4	3	3,769 Moderate	2.38 Moderate	2.33 Moderate	2 Moderate	Moderate
EW5	2	28 Low	No Data	1 Low	1 Low	Low
EW6	3	32,225 High	2.5 High	2.33 Moderate	1.67 Low	Moderate
EW7	1	21 Low	No Data	No Data	1 Low	Low
EW8	2	2,007 Moderate	2.75 High	3 High	2.5 High	High
EW9	3	1,116 Low	3 High	1.5 Low	1.67 Low	Low

Table VI-8. Summary of current condition of Bradshaw's lomatium in the Eugene West Recovery Zone.

The Eugene West Recovery Zone contains nine Bradshaw's lomatium populations and greater than 190,000 plants. Six of these populations contain sufficiently high abundance of plants to exceed delisting criteria (5 populations; 25,000 plants). These six populations are composed of 37 sites with diverse ownership, 33 of which are in protective ownership or conservation easement.

SUMMARY OF CURRENT RESILIENCY, REDUNDANCY, AND REPRESENTATION

Resiliency and Redundancy

Resiliency refers to the ability of populations to withstand stochastic events, and is commonly determined as a function of metrics such as population size, growth rate, or habitat quality and quantity. In this assessment, we determined the resiliency of Bradshaw's lomatium populations using measures of population size, current habitat conditions, protections from loss to development, and whether the site is managed to restore and maintain appropriate habitat condition.

Redundancy is defined as a species' ability to withstand catastrophic events, and is determined as a function of the number and resilience of populations, as well as their distribution and connectivity. The Recovery Plan (U.S. Fish and Wildlife Service 2010, entire) established recovery criteria of having 12 populations / 60,000 individuals for the species to be downlisted to threatened, and 20 populations / 100,000 individuals for the species to be considered for delisting, with criteria for how these populations should be distributed across the species' range. Habitat quality targets were also set in the Recovery Plan.

There are currently approximately 11,277,700 Bradshaw's lomatium individuals across 24 known populations, made up of 71 known sites with multiple different ownerships. Of the 71 known sites, 51 are in either public ownership, public right-of-way, or are owned by a conservation-oriented non-governmental organization. Of the 20 remaining sites, 8 are under conservation easement or are enrolled in the Service's Partners for Fish and Wildlife Program. The vast majority of known Bradshaw's lomatium individuals (10,790,000 plants) occur at a single site, the Camas Meadows population WA1. Outside of this site, there are approximately 487,700 Bradshaw's lomatium plants at the most recent count, distributed across 69 sites.

Commented [A10]: Possibly 9, pending response about Cutler Lane site in CW from Jarod Jebousek.

Of the 24 known populations, 4 are currently in low condition, 9 are in moderate condition, and 10 are in high condition. One population, CE4, had no available data on which to analyze current condition. Populations occur from Camas, Washington, at the northern extent of the range, to Creswell, Oregon, at the southern extent, and occur in all Recovery Zones for the species that have population goals (See Figure VI-1, Table VI-9 below).

Populations with low condition (CW2, EW5, EW7, and EW9) are concentrated in the southwestern portion of the species' range, including the southernmost known population (EW9). Low abundance, unprotected ownership, and lack of management for prairie conditions are the main drivers of low condition for these populations. Populations with moderate and high condition are fairly evenly distributed throughout the range, with the exception of the Portland and Salem West Recovery Zones which contain no known Bradshaw's lomatium populations. Though these Recovery Zones are within the range of Bradshaw's lomatium, as noted earlier, they were assigned no specific targets by the Recovery Team.

No single factor stands out as a primary driver of reduced condition of Bradshaw's lomatium populations throughout the range of the species. For populations CE1, CW1, and EE2, increasing the population size to above 2,000 individuals each would be sufficient to improve their overall condition from moderate to high. For WA1, EW3, and EW4, improvements to management and site protection could change their condition to high. Populations CW2, CW3, EW4, EW5, EW7, and EW9 would require improvements across multiple factors to receive a high condition score.

In assessing the current condition of Bradshaw's lomatium relative to the recovery goals set in the Recovery Plan, to be conservative we decided to consider only populations that we ranked as high or moderate in condition, and with abundance greater than 200 plants. When we apply these criteria, we found that at present, four of the six Recovery Zones with population targets (all except SW Washington and Eugene East) support population numbers that meet or exceed both the downlisting and delisting criteria for the species (Table VI-9). In SW Washington, the abundance criterion is exceeded by more than 10,000,000 plants, but all of these occur in a single large population, and the Recovery Team established a target of two populations in this zone as the delisting goal. In Eugene East, the abundance criterion for delisting is exceeded by more than 15,000 plants. There are three populations in this zone, but one population contains only 10 plants and is vulnerable to stochastic events. The downlisting criteria for number of populations and abundance for SW Washington and Eugene East are currently met.

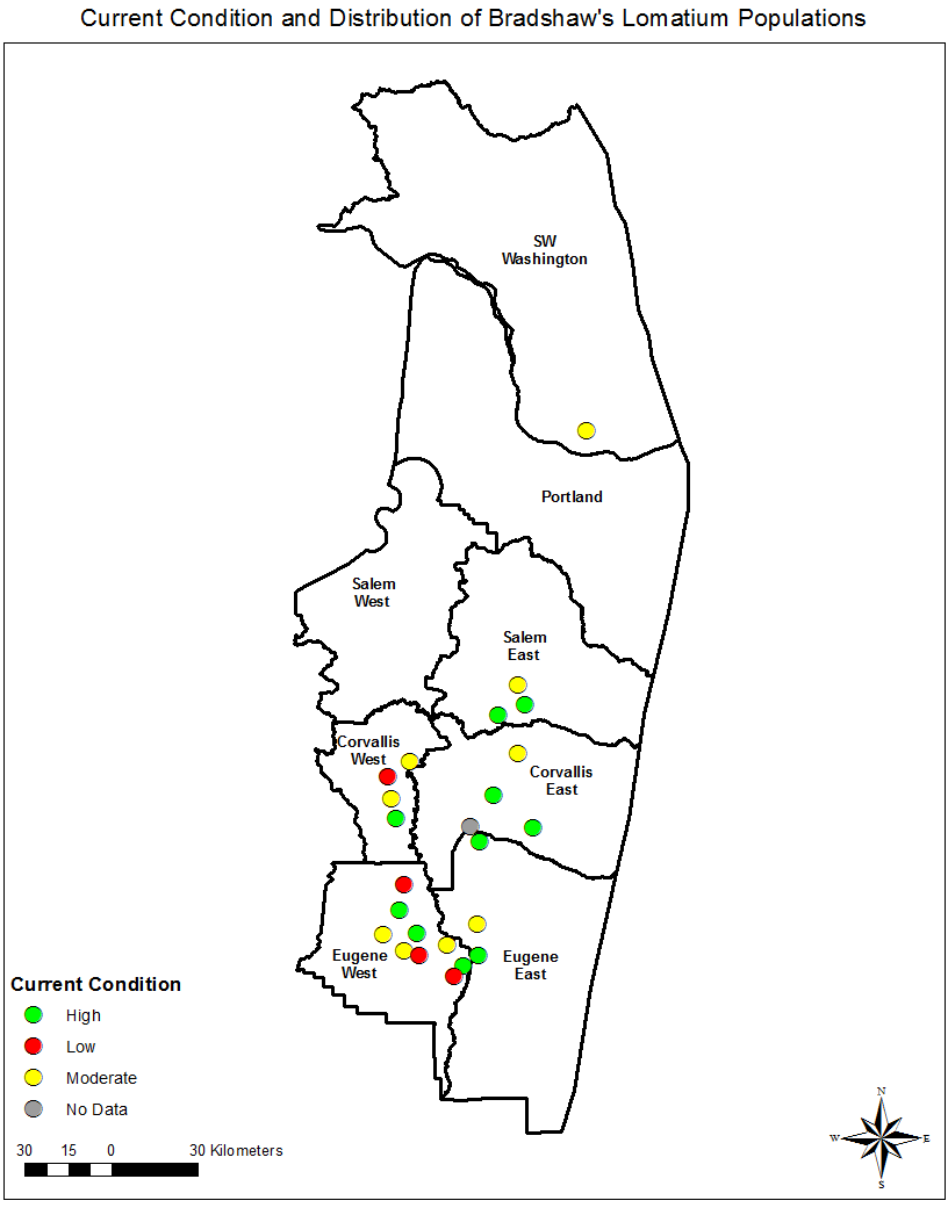

Figure VI-1. Map showing the distribution and current condition of known Bradshaw's lomatium populations.

Commented [DJ11]: Seems odd to arrange list has High then Low then Moderate.

Commented [A12]: Jeff: Arcmap did this automatically by sorting them alphabetically. I haven't been able to figure out how to correct it, but can work with Larry before the final version goes out. - Tom

Distribution and Abundance of Bradshaw's lomatium						
	Downlisting Goals		Delisting Goals		Current Condition	
Recovery Zone	Minimum # of Populations / Zone	Target # of Plants / Zone	Minimum # of Populations / Zone	Target # of Plants / Zone	# Populations Qualifying Toward Recovery Criteria	# of Plants in Populations Qualifying Toward Recovery Criteria
SW Washington	1	5,000	2	10,000	1	10,790,640
Portland	0	0	0	0	0	0
Salem East	1	5,000	2	10,000	3	62,604
Salem West	0	0	0	0	0	0
Corvallis East	2	10,000	3	15,000	3	179,462
Corvallis West	2	10,000	2	10,000	3	17,651
Eugene East	1	5,000	3	15,000	2	34,556
Eugene West	3	15,000	3	15,000	6	191,593
+ Additional Populations (may occur in any Recovery Zone within range of Bradshaw's lomatium)	2	10,000	5	25,000		
Total	12	60,000	20	100,000	**19**	**11,276,516**

Table VI-9. Summary of recovery goals and current condition of known Bradshaw's lomatium populations. ***Populations with overall low current condition or with fewer than 200 plants are not likely stable enough to qualify toward recovery of the species, and are not presented here.*** Recovery zones highlighted in grey meet or exceed downlisting and delisting goals in terms of numbers of populations and target number of plants.

Representation

Representation refers to the ability of a species to adapt to change, and is based upon considerations of geographic, genetic, ecological, and niche diversity.

The 24 known populations of Bradshaw's lomatium span approximately 196 km (122 mi) from Camas, Washington in the north to Creswell, Oregon in the south. Populations are more prevalent west of the Willamette River and south of Salem in Oregon. Populations are more dispersed east of the Willamette River in Oregon, and only one population is known in Washington. The historical distribution of populations is largely unknown.

Throughout its range, Bradshaw's lomatium is restricted to remnant wet prairie and open oak savannah habitats, which are highly fragmented due to a history of land conversion and natural succession following alterations to disturbance cycles. The species is sensitive to any hydrologic alterations that reduce early season moisture, as well as to shading due to encroachment of woody species. Overall, ecological diversity is naturally low for the species. Bradshaw's lomatium grows only in wet prairie or oak savannah habitats with either a slowly permeable clay layer or shallow soils overlaying basalt, and is unable to colonize other habitats. Bradshaw's lomatium thus appears to retain the breadth of its historical ecological representation.

Genetic diversity of Bradshaw's lomatium is relatively high, being comparable to the much more widespread *Lomatium* species cous biscuitroot. Genetic diversity was lowest at a site in the WA1 population, which is the most isolated Bradshaw's lomatium population, at approximately 100 km (62 mi) from the nearest population (Gitzendanner and Soltis 2001). Based on the data available to us, it does not appear that Bradshaw's lomatium has lost a significant component of its genetic representation.

The current conditions of Bradshaw's lomatium are summarized in Table VI-10, below. Overall, most populations show good resiliency, with abundant numbers of individuals. Redundancy is good, with multiple populations occurring in all Recovery Zones for the species. Representation is also good, with populations distributed across the historical range of the species. There is a large gap between the extremely large population in southwest Washington and the remainder of the populations in Oregon's Willamette Valley, but we have no data to indicate the potential historical distribution of the species across the Portland and Salem West Recovery Zones.

Current conditions of Bradshaw's lomatium		
Individuals	Populations	Species
• Greater than 11,000,000 individuals across the range of the species. • Invasive plants and woody encroachment likely causing mortality and reduced reproduction at some sites. • Data lacking on seed production / reproductive rates.	• Habitat data lacking for 27 of 71 sites, and for seven entire populations. • Some degree of habitat management within 57 of 71 sites at 20 populations. • Seven populations rated low for abundance (<2000 plants), making them more susceptible to stochastic events. Of these, five have <200 plants.	• 24 populations (10 high condition, 9 moderate, 4 low, 1 not analyzed). • Recovery targets for minimum number and size of populations met or exceeded in each recovery zone. • Genetic diversity relatively high for a rare species.

VII. VIABILITY

In this section, we consider the viability of Bradshaw's lomatium 25 to 50 years into the future, taking into consideration the current condition of the species and the identification of any new stressors not considered at the time of listing or recovery plan development.

ASSUMPTIONS

Conservation Support

Conservation support for Bradshaw's lomatium is high among government agencies, non-governmental conservation organizations, and some private landowners. No decline in support is anticipated, and it is expected that the funding and execution of priority recovery actions will continue at approximately the current pace.

Commented [MJW(CUC(13]: As you know, it is often much easier to procure funding to manage ESA-listed species than

Management

Management of existing sites for the restoration or maintenance of habitat conditions necessary to support Bradshaw's lomatium (*e.g.*, removal of invasive plants and encroaching woody vegetation) are expected to continue at the same level. Efforts to formalize management plans will continue where they are not currently in place, and to update them as necessary into the future based upon new information and changing conditions.

Site Protection

Sites currently in public or non-governmental conservation organization ownership or under conservation easements are expected to remain so. Ongoing efforts by government agencies and non-governmental conservation organizations to acquire existing sites on unprotected lands or to establish additional conservation easements are expected to continue, possible leading to higher degrees of protection. Some unprotected sites may face development pressure in the future.

CONSIDERATION OF ADDITIONAL STRESSORS

Climate Change

In the Pacific Northwest, temperature increases of 3 to 6°C (5.4 to 10.8°F) are predicted by the end of the 21st century. Winter precipitation is predicted to increase, though increased summer temperatures are expected to cause increased evapotranspiration, thus causing reduced growing season soil moisture (Bachelet *et al.* 2011, p. 414). Bradshaw's lomatium is hydrologically sensitive, and reduced soil moisture could stress individuals and populations of the species. Existing climate vulnerability assessments of Bradshaw's lomatium have rated it as moderately vulnerable (Steel *et al.* 2011, pp. 25, 89) or moderately- to highly vulnerable (Kaye *et al.* 2013, p. 20) to the effects of climate change. We therefore evaluated the viability of Bradshaw's lomatium over a range of time 25 to 50 years into the future, which is the length of time over which we conclude we can make reliable predictions about the anticipated effects of climate change. We do not have any quantitative estimates of how climate change may affect populations of Bradshaw's lomatium, only the aforementioned assessments that estimate the species will be moderately to moderately-to-highly vulnerable to its effects. To be conservative in our projections, we assumed that under the anticipated effects of climate change and the assumptions outlined above, all populations of Bradshaw's lomatium would be reduced by 50 percent within a period of 25 to 50 years. We then reassessed population condition applying the same methodology we used for assessing current condition.

Commented [A14]: NOTE TO REVIEWERS: We would appreciate your thoughts and comments on this assumption. Given the lack of explicit data on site-by-site hydrology and the uncertainty of the impact of climate change on site hydrology, can you recommend a future prediction with stronger scientific backing? – Tom B

RESULTS

Resiliency

Five populations (CW1, CW2, EE2, EW5, EW7) have very low abundance of Bradshaw's lomatium plants, and are highly vulnerable to stochastic events. These populations carry a relatively higher risk of extirpation in the future due simply to their small size and subsequent vulnerability to both stochastic and catastrophic events. Climate change impacts compound the risk to these populations and have the potential to negatively affect habitat quality and abundance at all Bradshaw's lomatium populations, leading to reductions in resiliency throughout the range of the species. Populations with very high abundance, such as SE2 (46,386 plants) and CE2 (169,254 plants) are likely to maintain higher resiliency into the future than those with fewer plants such as SE3 (5,539 plants), as their higher numbers buffer them from stochastic variation in environmental conditions and potential extirpation from catastrophic events.

A significant point of uncertainty is the future status of those populations currently rated as moderate condition. Declines in abundance and habitat quality due to climate change impacts and stochastic events may drive some of these populations to low condition in the future, though active adaptive management may help mitigate some declines.

A high degree of uncertainty surrounds the magnitude of impacts that can be expected due to climate change. Due to this uncertainty, we do not seek to predict a distinct magnitude of decline for each population. Rather, as described above, to be conservative we use a standard 50 percent reduction in individuals for forecasted future abundance predictions.

Redundancy

The possible extirpation of five populations (CW1, CW2, EE2, EW5, EW7), combined with the possible decline of some populations from moderate to low condition due to climate change impacts, may reduce the number of known Bradshaw's lomatium populations from the current condition of 19 in moderate or high condition to 14 to 16 throughout the range. The Corvallis West recovery zone would be left with only two known populations, one of which (CW3) is at risk of declining to low condition overall. Future losses may be offset by active augmentation of existing populations or the establishment of new populations in high quality habitats where Bradshaw's lomatium is currently absent. There is also the potential for more Bradshaw's lomatium populations to be discovered, as has happened in recent years (Jarod Jebousek, pers. comm. 2017). Estimates of the possible future abundance and distribution of Bradshaw's lomatium under the assumptions described above for assessing the potential effects of climate change are presented in Table VII-1.

Representation

No major changes are predicted regarding the genetic or ecological diversity of Bradshaw's lomatium as a result of the effects of climate change. The species is likely to continue to occupy wet prairie and oak savannah habitats throughout its range, though some degree of range contraction may occur.

Viability

Under the possible effects of climate change as evaluated here, Bradshaw's lomatium may experience some reductions in resiliency and redundancy. We concluded that populations currently in low condition or with very low abundance may be extirpated due to the combined effects of climate change impacts and stochastic events; this translates to an estimated loss of up to 5 small populations, with other populations reduced in size. However, even with a 50 percent reduction in abundance under the conditions of climate change, at least 14 to 16 populations in moderate or high condition are expected to persist on the landscape with ongoing management. We do not anticipate any significant effect on representation. In addition, we did not consider that ongoing efforts to improve population sizes and habitat quality have the potential to increase the number of resilient populations of Bradshaw's lomatium. We conclude that overall viability of the species is moderate. Many stressors to the species are being addressed through habitat management and population augmentation, but ongoing management is necessary to maintain resilient populations throughout the species' range.

Recovery Zone	Downlisting Goals		Delisting Goals		Current Condition		Predicted Future Condition	
	Minimum # of Populations / Zone	**Target # of Plants / Zone**	**Minimum # of Populations / Zone**	**Target # of Plants / Zone**	**# of Populations with Moderate or High Condition**	**# of Plants in Populations with Moderate or High Condition**	**# Populations Qualifying Toward Recovery Criteria**	**# of Plants in Populations Qualifying Toward Recovery Criteria**
SW Washington	1	5,000	2	10,000	1	10,790,640	1	>5,000,000
Portland	0	0	0	0	0	0	0	0
Salem East	1	5,000	2	10,000	3	62,604	3	>30,000
Salem West	0	0	0	0	0	0	0	0
Corvallis East	2	10,000	3	15,000	3	179,462	2 -3	>90,000
Corvallis West	2	10,000	2	10,000	3	17,651	1	>9,000
Eugene East	1	5,000	3	15,000	3	34,566	2	>17,000
Eugene West	3	15,000	3	15,000	6	191,593	5-6	>95,000
+ Additional Populations (may occur in any Recovery Zone within range of Bradshaw's lomatium)	2	10,000	5	25,000				
Total	12	60,000	20	100,000	19	11,276,516	**14-16**	**>5,241,000**

Table VII-1. Distribution and abundance goals for Bradshaw's lomatium recovery, along with current and predicted future abundance and distribution of populations rated as moderate or high condition. Populations with overall low current condition or with fewer than 200 Bradshaw's lomatium plants are not likely stable enough to qualify toward recovery of the species, and are not presented here.

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I. GLOSSARY

Caudex – A short, vertical stem at or just below the surface of the ground

Filiform – Slender, threadlike

Glabrous – Smooth, without glands or hairs

Hydric soils – Soils formed under conditions of saturation, flooding, or ponding long enough during the growing season to develop anaerobic conditions in the upper part.

Inflorescence – The floral cluster of a plant

Peduncle – The stalk of a solitary terminal flower, or of an inflorescence

Protandry – Maturation of male flowers before female flowers on a single plant

Protogyny – Maturation of female flowers before male flowers on a single plant

Redundancy – Having a sufficient number of populations for the species to withstand occasional catastrophic events. Redundancy is a function of the number and resilience of populations, as well as their distribution and connectivity.

Representation – The capacity of a species to adapt to environmental change, based upon considerations of geographic, genetic, ecological, and niche diversity. Representation overlaps with the measure of redundancy.

Resiliency – Having sufficiently large populations for the species to withstand stochastic events (random variation in environmental or demographic factors, such as variability in rainfall or changes in sex ratios).

Schizocarp – A fruit which splits into its separate carpels at maturity

Taproot – A large, main root

Umbel – A flat-topped or convex inflorescence with pedicels arising from a common point

Umbellet – An ultimate umbellate cluster of a compound umbel

Viability – The ability of a species to maintain multiple (redundant) self-sustaining (resilient) populations distributed across a range that captures the ecological and genetic diversity of the species (representation).

APPENDIX A – Site level analysis for current condition. (Abbreviations: BLM- Bureau of Land Management; GLT – Greenbelt Land Trust; MRT – McKenzie River Trust; ODOT – Oregon Department of Transportation; PFW – Partners for Fish and Wildlife; TNC – The Nature Conservancy; USACE – U.S. Army Corps of Engineers; USFWS – U.S. Fish and Wildlife Service; WNHP – Washington Natural Heritage Program; WRP – Wetland Reserve Program)

Population	Site	Count	Habitat	Protection	Management	Ownership	Easement, Other	Count source
WA1	Camas Meadows	10790000	2.75	1	2	Private		Report 2010
	Lacamas Prairie Natural Area Preserve	640	3	3	2	WNHP		Field Survey 2016
SE1	Sublimity Grasslands	10,680	No Data	1	2	Private		Field Survey 2017 (Jeff Dillon, p.c.)
SE2	Kingston Prairie Preserve	46385	2.5	3	3	TNC		Report 2008
SE3	Kirkwood WRP NE	1797	2.5	2	3	Private	WRP	Field Survey 2016
	Kirkwood WRP SW	3742	No Data	2	3	Private	WRP	Field Survey 2014
CE1	Fish Hatchery Drive	1535	2.5	2	3	Private	WRP	Field Survey 2016
CE2	Oak Creek	169254	2.75	3	3	USFWS		Report 2007
CE3	Sweet Home - Hobart Park	8673	2.75	3	3	City of Sweet Home		Field Survey 2012
CE4	Brownsville	No Data	No Data	No Data	No Data	Private		No Survey data

Commented [A15]: NOTE TO REVIWERS: Do you have any recommendations for changing the naming of WRP sites in this table to best protect the privacy of landowners? – Tom B

Population	Site	Count	Habitat	Protection	Management	Ownership	Easement, Other	Count source
CW1	Jackson-Frazier Wetland	165	2	3	3	Benton Co., City of Corvallis		Field Survey 2012
	Owens Farm	1	2.75	3	3	GLT		Field Survey 2012
	Conifer Blvd	0						ORBIC 2005
CW2	Holmes	20	No Data	1	1	Private		FWS data 2008
CW3	Cutler Lane	3444	2.75	1	1	Private		Field Survey 2016
	Private WRP	1	1.75	2	3	Private	WRP	Field Survey 2012
CW4	Buchanan Rd	20	No Data	1	1	Private		IAE data 2007
	Finley NWR Field 1	4106	2.75	3	3	USFWS		Field Survey 2016
	Finley NWR, Field 31	7573	2.75	3	3	USFWS		Field Survey 2016
	Finley NWR, Muddy Creek Middle	50	No Data	3	3	USFWS		ORBIC 2005
	Finley NWR, North Road	2251	2.75	3	3	USFWS		Field Survey 2016
	Finley NWR, Willamette Floodplain RNA	40	No Data	3	3	USFWS		ORBIC 2005

Commented [A16]: Awaiting confirmation of new information that this site may be enrolled in Partners for Fish and Wildlife program. –Tom B

Population	Site	Count	Habitat	Protection	Management	Ownership	Easement, Other	Count source
EE1	Buford Park Main Patch	2101	3	3	3	Lane Co.		Field Survey 2011
	Buford Park Satellite Patches	7455	3	3	3	Lane Co.		Field Survey 2013
EE2	Mohawk River	10	2.75	2	3	Private	WRP, PFW	Field Survey 2013
EE3	Courtney Creek	25000	No Data	3	2	GLT		Field Survey 2015

Population	Site	Count	Habitat	Protection	Management	Ownership	Easement, Other	Count source
EW1	Amazon Dike #2 (Fern Ridge Resevoir)	21236	2.5	3	3	USACE		Field Survey 2014
	Balboa	234	3	3	3	BLM		Field Survey 2015
	Fern Ridge East Coyote Dikes	2180	2.25	3	3	USACE		Field Survey 2014
	Amazon Canal ROW (Fir Butte)	446	No Data	3	1	City of Eugene		Report 2012
	Fisher Butte (Fern Ridge)	11113	3	3	3	USACE		Field Survey 2014
	Fisher Butte - ODOT SMA East	62	2.25	3	3	ODOT		Field Survey 2014
	North Fisher Butte	211	3	3	3	USACE		Field Survey 2014
	North Greenhill - Ash Grove	83	2.75	3	3	BLM		Field Survey 2015
	North Greenhill - IAE Introduced	593	2.75	3	3	BLM		Field Survey 2015
	Oak Patch	370	2.75	3	2	City of Eugene		Report 2014
	Fern Ridge Rose Prairie	5456	2.25	3	3	USACE		Field Survey 2014
	Rosy	562	3	3	3	BLM		Field Survey 2015
	Royal Amazon RNA	74433	3	3	3	USACE		Field Survey 2014
	Fern Ridge Green Oaks South	2086	2.25	3	3	USACE		Field Survey 2014

Commented [MJW(CUC(17]: Is this the North Amazon unit exclusive of Rose Prairie? If so, perhaps best to combine as 'North Amazon incl. Rose Prairie"

Population	Site	Count	Habitat	Protection	Management	Ownership	Easement, Other	Count source
EW1, cont.	Speedway East / Cuddeback Unit	423	2.75	3	3	TNC		Field Survey 2015
	Dragon Fly Bend	1	No Data	No Data	1	BLM		ORBIC 2000
	Greenhill / Royal	18270	2.5	3	3	TNC		Report 2011
	Bertelsen Road	23	No Data	No Data	1			ORBIC 1991
	Greenhill / Royal	0				City of Eugene		ORBIC 2005
	Wallis St	450	No Data	No Data	1	Private		ORBIC 2005
	Neilsen Road Substation	160	No Data	No Data	1	USACE		ORBIC 2005
	Fern Ridge Fisher Butte West					USACE		
	Vinci	2	No Data	No Data	3	BLM		ORBIC 2004
	Nielson	2	No Data	No Data	3	BLM		ORBIC 2004
	Spectra Physics	0			3	BLM		Field Survey 2015
	Oxbow East	1	No Data		3	BLM		ORBIC 2003
	Oxbow West	0			3	BLM		Report 2010
	Fisher Butte - ODOT SMA West	3573	2.75	3	2	ODOT		Field Survey 2012
	Willow Corner Annex	8	No Data	3	3	BLM		Field Survey 2015

Population	Site	Count	Habitat	Protection	Management	Ownership	Easement, Other	Count source
EW2	Lomatium Prairie	5814	2.75	2	2	Private	MRT, PFW	Report 2013
	Long Tom River ACEC	1440	2.75	3	3	BLM		Field Survey 2014/5
	North Taylor	670	2.5	3	3	BLM		Field Survey 2015
	Fern Ridge Resevoir - Kirk Pond	0	No Data	3	3	USACE		ORBIC 2002
EW3	Veneta	3690	No Data	3	2	City of Veneta	PFW	Field Survey 2016
EW4	Bloomer	311	2.5	3	2	MRT		Field Survey 2014
	Coyote-Spencer Wetlands	3371	2.25	3	3	MRT		Field Survey 2012
	Petzold Road	87	No Data	No Data	1	Private		ORBIC 1990
EW5	Spencer Creek North	28	No Data	No Data	1	Private		ORBIC 1991
	Spencer Creek South	No Data	No Data	No Data	1	Private		ORBIC 1990

Population	Site	Count	Habitat	Protection	Management	Ownership	Easement, Other	Count source
EW6	Amazon Park	31200	2.5	3	2	City of Eugene		Report 2012 (In Silvernail 2016)
	19th & Pearl	25	No Data	1	1	Private		ORBIC 2005
	Amazon & 35th	1000	No Data	3	2	City of Eugene		Steek, p.c. 2017
EW7	High Pass Road	21	No Data	No Data	1	Unknown		ORBIC 2005
EW8	Camas Swale	1375	3	3	3	ODOT		Field Survey 2014
	Short Mountain Landfill	632	2.5	3	2	Lane Co.		Field Survey 2016
EW9	Creswell (Wastewater Treatment Plant)	20	No Data	No Data	1	City of Creswell		ORBIC 2005
	Danville Rd	5	No Data	1	1	Private		ORBIC 1990
	Private WRP	1091	3	2	3	Private	WRP	Field Survey 2014