OREGON DEPARTMENT OF AGRICULTURE

NATIVE PLANT CONSERVATION PROGRAM

Conservation Status Assessment for *Limnanthes floccosa* ssp. *bellingeriana* (Bellinger's meadowfoam):

Population Monitoring and Evaluating Threats and Recruitment Potential

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Introduction

Bellinger's meadowfoam (*Limnanthes floccosa* ssp. *bellingeriana*) is a rare member of the Limnanthaceae family that can be found in high-elevation vernal pool wetlands in the Cascade Range and foothills of southern Oregon and northern California. The restricted range of this taxon, limited suitable habitat, relatively few known occurrences, and threats facing it across its range prompted its consideration for administrative protection. This taxon was previously listed as a Species of Concern by the U.S. Fish and Wildlife Service and is currently listed as a Sensitive species by Oregon Bureau of Land Management and U.S. Forest Service (ISSSSP 2015). The documented threats facing this taxon, including grazing, hydrologic alteration, non-native weeds, land management activities, and off highway vehicle (OHV) activity, in part prompted the Oregon Department of Agriculture (ODA) to formally list this taxon as a Candidate that requires further study, with the potential for listing as Threatened or Endangered in the future. According to Oregon Biodiversity Information Center (ORBIC) data, 68 *L. f.* ssp. *bellingeriana* occurrences have been documented in Oregon (ORBIC 2015), and due to potentially redundant occurrence data, it is likely that fewer occurrences actually exist. ORBIC retains *L. f.* ssp. *bellingeriana* on its List 1, signifying the taxon is endangered or threatened throughout its range.

Monitoring of *L. f.* ssp. *bellingeriana* populations in Klamath County, Oregon in 2012 and 2013 detected substantial declines in the number of plants present, and a startling abundance of noxious weeds, provoking concern for the overall status of the subspecies across its range. This project provides updated population information, including updated plant counts and mapped plant distributions, as well as population-specific threat documentation to help inform future management decisions. Data on fruit production and germination rates was also collected from a subset of the monitored populations during this project to help identify sites with reproductive failure and help formulate estimates of population viability. Information on germination requirements, developed during this project, will also help support the development of cultivation protocols if transplanting (or the like) is needed in the future.

Species Description

L. f. ssp. *bellingeriana* is a modest-sized (8-15 mm tall) annual plant with a range of growth habits (Figure 1): from erect single-stemmed plants with few flowers to decumbent many-stemmed plants with numerous (200+) flowers. Leaves are glabrous, alternate, and pinnately lobed into 5-7 segments, but can appear as a basal rosette on small vegetative specimens. Stems are glabrous, either branched or unbranched, and either erect or decumbent; many red-stemmed specimens were observed during this study. The inconspicuous urn-shaped flowers are born singly in the axils of leaves as plants flower in April and May (Ornduff & Morin 2012). Although the perianth of many flowers of this taxon will not open completely (even at peak flowering), the self-compatible (autogamous) nature of this taxon still allows for successful pollination and fruit production in the absence of outcrossing (Arroyo 1973). The relatively small flowers have five white petals (5.5-7.5 mm long), with no hairs at the base, and five glabrous to sparsely hairy sepals (5.5-8 mm long). Flowers can produce up to five (single-seeded) fruits, but usually only one or two mature. The surface texture of the fruit, which is diagnostic of the subspecies, contains small plate-like projections (tubercles) that are triangular and pointed, and mostly concentrated near the apex of the fruit (Ornduff & Morin 2012). Often, as plants senesce in May through July, their fruits are retained within the calyces, which dries to a reddish and then brown color.

From far away, narrow leaved miner's lettuce (*Montia linearis*) may be considered a look-alike of *L. f.* ssp. *bellingeriana* by some, with its small, orb-shaped perianth, but upon close inspection, numerous characters distinguish the two.

Figure 1. *Limnanthes floccosa* ssp. *bellingeriana* plants observed during 2015-2016 monitoring at the Antelope Creek 1 (at left) and Klamath Rim 1 (at right) sites.

Habitat and Range

Limnanthes floccosa ssp. *bellingeriana* has a restricted range and is only known to occur in Jackson and Klamath Counties in southern Oregon and in Shasta County, California. In Oregon, it occurs in high-elevation vernal pool and wet meadow habitat, generally between 1,100-1,200 meters (3,600-3,900 feet) in elevation; California occurrences are found at lower elevations, between 290-1,100 meters (950-3,600 feet). Occupied habitat often consists of rocky shallow soils that are generally inundated in winter and spring, but dry in late spring and summer (Figure 2). Occupied habitat often occurs within a mosaic of vernal pool and drier grassland habitat (often near forest edges), but some occurrences are located within seasonally-wet openings in shrubland or forest habitat. *L. f.* ssp. *bellingeriana* sites traditionally supported a suite of vernal pool plant associates.

Some common native plant associates of *L. f.* ssp. *bellingeriana* sites observed during this project were ponderosa pine (*Pinus ponderosa*), Oregon white oak (*Quercus garryana*), buckbrush (*Ceanothus cuneatus*), and narrow leaved miner's lettuce. Common non-native plants associated with *L. f.* ssp. *bellingeriana* habitat include cheatgrass (*Bromus tectorum*), medusahead (*Taeniatherum caput-medusae*), yellow star-thistle (*Centaurea solstitialis*), bristly dogstail grass (*Cynosurus echinatus*), and bulbous bluegrass (*Poa bulbosa*). While characterizing *L. f.* ssp. *bellingeriana* habitat was not a goal of this project, additional site characterizations and vegetation community information was collected but not included here; historical Bureau of Land Management Special Status plant site forms are reliable sources of site vegetation and characterization information.

Objective

Complete a conservation assessment of selected populations of *Limnanthes floccosa* ssp. *bellingeriana* from across its range in Oregon that includes the collection of updated population monitoring data and the evaluation of site-specific threats, reproductive capacity, germination rates, and recruitment potential.

Site Monitoring

Monitoring in 2015 and 2016 allowed for the collection of updated population and threat information for a subset of Bellinger's meadowfoam occurrences across its range in Oregon. Prior to this project, limited historical data was available for *L. f.* ssp. *bellingeriana*: many occurrences hadn't been monitored recently (many not since the 1990's; BLM 2015, ORBIC 2015) and much of the occurrence spatial data that was available appeared vague and/or inaccurate. Determining the conservation status of *L. f.* ssp. *bellingeriana* without current and relevant information was not feasible. Updated information on population size, extent, reproductive output and recruitment potential (as indicators of viability), and threats collected during this project will contribute to better understanding the current conservation status of *L. f.* ssp. *bellingeriana* and help inform conservation decisions in the future.

Site Selection

In cooperation with Medford and Lakeview District Bureau of Land Management (BLM), a series of 25 *L. f.* ssp. *bellingeriana* occurrences were selected for monitoring in 2015, and another twelve occurrences were selected for monitoring in 2016 (Tables 1 & 2, Figure 3). The occurrences selected for monitoring in both 2015 and 2016 were selected from *L. f.* ssp. *bellingeriana* occurrence records and spatial data from ORBIC and BLM (ORBIC 2015, BLM 2015); unpublished Special Status plant site forms, which contained past survey and monitoring information, were provided by BLM and referenced when available. Several criteria were considered when selecting occurrences for monitoring, including relative location, population size, most recent monitoring date, and site accessibility. To insure monitoring was distributed across the range of the subspecies, an approximately equal number of occurrences were prioritized for monitoring across the three geographic regions that constitute its range. Populations of differing size were prioritized for monitoring in an attempt to inform whether population size may be associated with problematic conditions or poor status (e.g., do small populations seem more prone to extirpation or reproductive failure?). Occurrences without recent population monitoring information were priorities to visit, but sites that hadn't been relocated, and were possibly extirpated, were avoided. Remote occurrences that would require substantial time to access were deprioritized (to reduce the time spent travelling and maximize the time spent monitoring).

Table 1. The *Limnanthes floccosa* ssp. *bellingeriana* sites monitored in 2015.

Region	Site name	EO_ID	FLSITE_ID
Antelope Creek	Antelope Creek 1	26437	3904
Antelope Creek	Antelope Creek 2	26437	3905
Antelope Creek	Antelope Creek 3	26437	4617
Antelope Creek	Antelope Creek 4	26437	4618
Antelope Creek	Antelope Creek 5	26437	4620
Antelope Creek	Antelope Creek 6	26437	4621
Antelope Creek	Dead Indian Memorial Road	30173	12461
Butte Falls Resource Area	Beekman Ridge Complex	34396	13677
Butte Falls Resource Area	Dog Creek Complex 1	24992	2161
Butte Falls Resource Area	Dog Creek Complex 2	24992	2162
Butte Falls Resource Area	Dog Creek Complex 3	24992	2163
Butte Falls Resource Area	Dog Creek Complex 4	24992	2023
Butte Falls Resource Area	Double Day Road	24990	1946
Butte Falls Resource Area	Fredenberg Road Complex	34395	13674
Butte Falls Resource Area	Geppert Butte	32069	8972
Butte Falls Resource Area	Geppert Butte Complex	32069	8973
Butte Falls Resource Area	Poverty Flat	8825	78,295
Cascade-Siskiyou National Monument	Jenny Creek Complex	17061	291, 72
Klamath Falls Resource Area	Klamath Rim 1	20394	400511_LIFLB_ HAYDENFOX
Cascade-Siskiyou National Monument	Mountain View Complex	14282	355
Cascade-Siskiyou National Monument	Pinehurst Airport Complex East	14282	354, 8153
Cascade-Siskiyou National Monument	Pinehurst Airport Complex West	14282	354, 8153

Table 2. The *Limnanthes floccosa* ssp. *bellingeriana* sites monitored in 2016.

Region	Site name	EO_ID	FLSITE_ID
Klamath Falls Resource Area	Klamath Rim 2	8446	KFRA_LIFLB_05231996 _POKE7
Klamath Falls Resource Area	Pokegama Road 1	10666	PLANTS_LIFLB_HF_2012 _LMV_GV01
Klamath Falls Resource Area	Pokegama Road 2	10666	PLANTS_LIFLB_HF_2012 _LMV_GV04
Klamath Falls Resource Area	Pokegama Road 3	10666	PLANTS_LIFLB_HF_2012 _LMV_GV03
Klamath Falls Resource Area	Pokegama Road Complex 1	10666	KFRA_LIFLB_05251996 _POKE2
Klamath Falls Resource Area	Pokegama Road Complex 2	10666	KFRA_LIFLB_05251996 _POKE1
Klamath Falls Resource Area	Ward Road 1	17094	LIFLB_HAYDENFOX_2013 _JDS13-228
Klamath Falls Resource Area	Ward Road 2	17094	KFRA_LIFLB_05251996 _POKE1, KFRA_LIFLB_05251996 _POKE2, LIFLB_HAYDENFOX_2013 _JDS13-224
Klamath Falls Resource Area	Ward Road 3	17094	KFRA_LIFLB_05251996 _POKE3
Klamath Falls Resource Area	Grizzly Flat	16097	KFRA_LIFLB_05112005 _POKE1

Populations of *L. f.* ssp. *bellingeriana* in Oregon are clustered in three geographic regions: the Antelope Creek region, the Butte Falls Resource Area region, and the Oregon-California Border region. The Antelope Creek region occurrences are located in the hills directly east of Medford and Ashland and are on Ashland Resource Area BLM land. The Butte Falls Resource Area region occurrences are generally located in west and northwest of the town of Butte Falls, on Butte Falls Resource Area BLM land. The Oregon-California Border region occurrences are located north of the border between the Green Springs Highway / Oregon Route 66 and the border to the south. The Oregon-California Border region occurrences cross administrative boundaries, occurring on Ashland Resource Area BLM land west of the Jackson-Klamath county line, and on Klamath Falls Resource Area BLM land east of the county line; the Jackson-Klamath county line also serves and boundary between Medford and

Lakeview BLM Districts. The sites monitored in the Oregon-California Border region were later assigned to regions that help clarify their administrative association: occurrences on Ashland Resource Area land were assigned to the Cascade-Siskiyou National Monument (CSNM) region and occurrences on Klamath Falls Resource Area land were assigned to the Klamath Falls Resource Area region. The four sites assigned to the CSNM region occur within current Monument boundaries.

In 2015, monitoring sites were selected in collaboration with Ashland, Butte Falls, and Klamath Resource Area BLM botanists (Table 1, Figure 3): seven occurrences were selected in the Antelope Creek region, twelve occurrences were selected in the Butte Falls region, and six occurrences were selected in the Oregon-California border region (five in the Cascade-Siskiyou National Monument region and one in the Klamath Falls Resource Area region). Initially, a greater number of monitoring sites were selected within the Klamath Falls Resource Area, but BLM staff was not available to coordinate project logistics (such as occurrence locations and access routes) in 2015, so additional sites in other regions were visited instead.

In 2016, with the goal of better characterizing the status of *L. f.* ssp. *bellingeriana* on the Klamath Falls Resource Area, an additional twelve occurrences were selected for monitoring in that region (Table 2, Figure 3). In 2015, BLM botany staff had identified priority occurrences for monitoring on the Klamath Falls Resource Area (Blanchard 2015, personal communication) and those priorities guided final selections, which were made in collaboration with the Klamath Falls Resource Area botanist.

Figure 2. The vernal pool and wet meadow habitat, and shallow rocky soils encountered at Poverty Flat are representative of the habitat at the majority of selected monitoring sites.

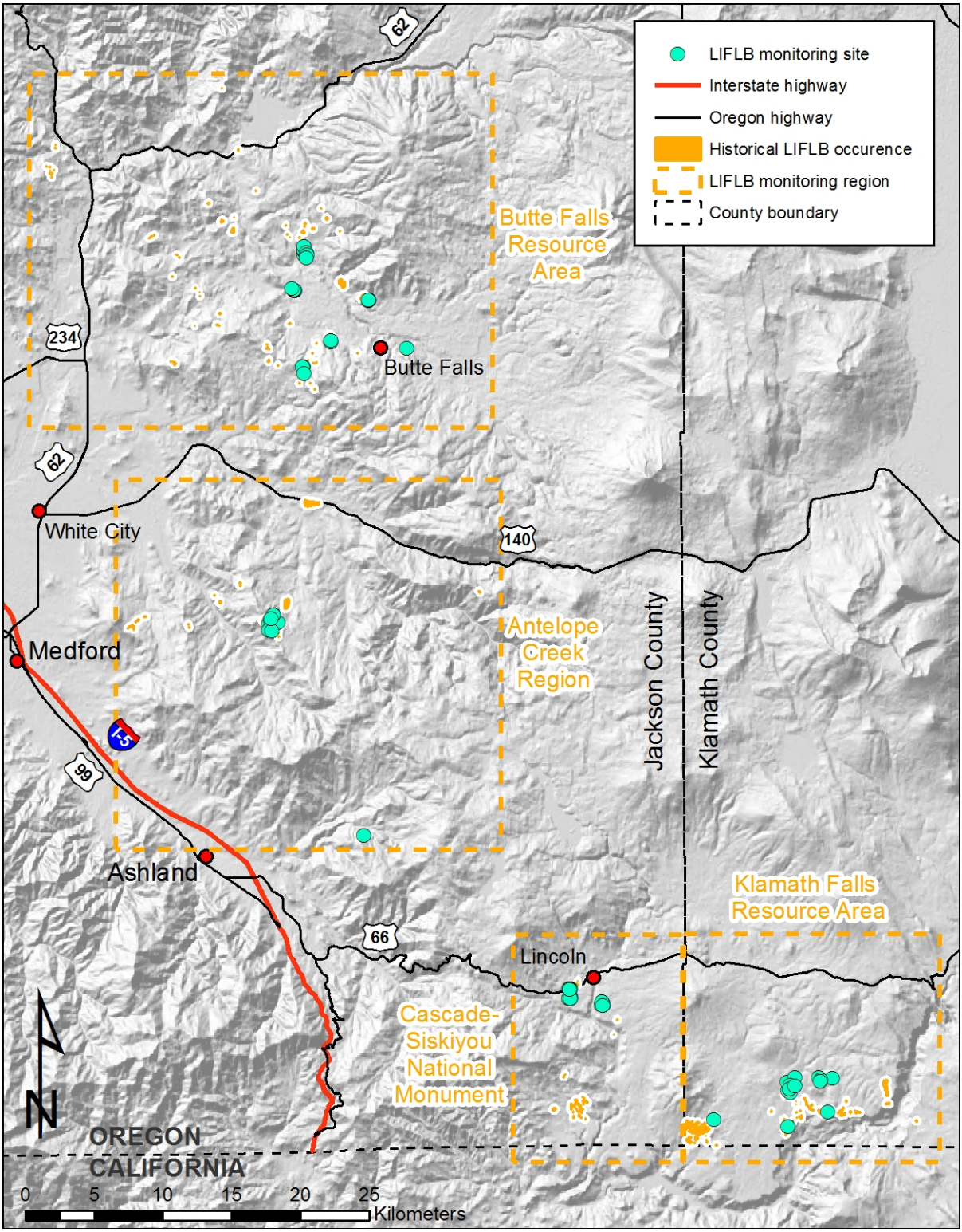

Figure 3. The 2015-2016 *Limnanthes floccosa* ssp. *bellingeriana* (LIFLB) monitoring regions and sites spanning the taxon's range in Oregon.

Monitoring Methods

Site monitoring was conducted from April 21st through 30th in 2015 and from April 26th through May 5th in 2016. The areas monitored within a site were generally defined by location and extent of historical occurrences (e.g. a singular *L. f.* ssp. *bellingeriana* patch occupying a vernal pool meadow), and often included a buffer of adjacent unoccupied grassland up to a defined boundary of unsuitable habitat. In multiple cases, single historical occurrences consisted of multiple patches of *L. f.* ssp. *bellingeriana* in relatively close proximity to one another within a matrix of unoccupied habitat, and determining sites boundaries in these cases was less straightforward. In this case, a patch is defined as a single continuous occurrence of *L. f.* ssp. *bellingeriana*. Splitting multi-patch occurrences into multiple sites and grouping patches into a single site was based on assumptions of site hydrology. Occurrence patches that seem to share hydrology, based on observations of flow pattern, topography, and vegetation, were generally grouped together in a single site. Patches without apparent connectivity were generally considered separate sites. Surrounding woody vegetation, including buckbrush (*Ceanothus cuneatus*) and trees, were good indicators of site boundaries. In this project, a single site containing multiple patches is called a complex.

The first step of monitoring involved delineating the boundaries of the target *L. f.* ssp. *bellingeriana* occurrence by carefully scouting the outer limits of patch and marking the edges with pin flags. Occurrence boundaries were documented by walking the marked edge with a GPS (Garmin GPS 60) set to collect a high resolution track; point locations were also documented using GPS as needed. All location data collected using GPS was digitized and served as a spatial reference for the drafting of final occurrence spatial data (polygons and points) in ArcMap (ArcGIS software by Environmental Systems Research Incorporated [ESRI]).

Generally, occurrences with fewer than 1,500 plants were censused, meaning all individual plants were directly counted, but the spatial extent and number of plants at some sites made a complete census not feasible. At many sites, the number of plants was carefully estimated using a sampling method. Monitoring staff would carefully count a subsample (or several subsamples) of *L. f.* ssp. *bellingeriana* plants that appeared to be relatively representative of the size and density of plants across the occurrence. The subsample count served as base unit

for estimating a running total of plants as the monitoring staff walked through the occupied area (careful to avoid *L. f.* ssp. *bellingeriana* whenever possible). Occurrences were often divided amongst multiple monitoring staff to expedite the plant counting or estimating. Thorough coverage of the entire occurrence was important to account for differing plant densities and other differences across sites.

At each site, the percent (of the entire population) of *L. f.* ssp. *bellingeriana* plants in each of three phenological stages was estimated: vegetative (no floral structure present), flowering (floral structures without an obvious fruiting body), and fruiting (the presence of an obvious fruit within the floral structure). Soil moisture was recorded as an estimated percentage of the total site and included four classes: inundated (presence of standing water), saturated (presence of pooling water when a depression is made), moist (wet, and a lack of water when depressions are made), and dry (lack of any moisture). Plant communities and associated species were often recorded, but detailed characterization of the habitat and plant community was not the focus of this project.

Threat characterization and documentation took place throughout monitoring visits as staff walked through occupied areas and the surrounding unoccupied habitat. The extent of a threat was documented as the estimated percent of the occupied *L. f.* ssp. *bellingeriana* habitat affected. Threats were documented in the following categories: invasive weeds, hydrological alteration, land management practices and activities (such as logging or road maintenance), grazing, OHV activity, and tree and shrub encroachment. When multiple invasive weed threats were characterized independently, their threat severity scores were averaged or integrated in a way to best reflect the overall threat from invasive weeds at the site. Occasionally, the estimated density (estimated percent cover) of non-native and invasive plants was also documented. In addition to documenting realized threats that were observed during monitoring, potential threats that could cause a problem in the future were also documented when noticed. When applicable, threats were also characterized and documented as a percent of unoccupied habitat that is impacted, or percent of the site expected to be impacted (if the threat is a potential threat), or by the proximity of the threat to occupied habitat. In addition to this simplified documentation of threats, descriptive notes

were recorded to highlight relevant details and photo documentation of threats was always encouraged.

Monitoring Results

A total of 25 *Limnanthes floccosa* ssp. *bellingeriana* occurrences were monitored in 2015, constituting 22 ODA-designated sites (Tables 3 - 8). In April and May of 2016, an additional twelve *L. f.* ssp. *bellingeriana* occurrences were monitored, constituting ten ODA-designated sites (Tables 9 & 10). Excluding the two apparently extirpated sites, the number of plants in a single site ranged from 20 to ~20,000 and occupied areas ranged from 30 m^2 to ~87,000 m^2. Although this annual taxon may occupy slightly different areas from year to year, spatial data generated during this project represent more accurate occurrence boundaries than were previously available (Appendix E); the locations of approximate center points of the occurrences documented during this project were provided to BLM (see Appendix D). Complete spatial data and monitoring records have been provided to BLM and ORBIC.

The average number of *L. f.* ssp. *bellingeriana* individuals in the sites monitored during the two years of this project, excluding the two apparently extirpated sites, was 2,761 plants. On average, the populations monitored in the Antelope Creek region were the largest, averaging 6,096 plants, while populations monitored in the Butte Falls Resource Area were the smallest, averaging 441 plants. The average population size of sites monitored in the Oregon-California Border region, excluding the two apparently extirpated sites, was similar to the overall average, at 2,751 plants. Although most sites had been surveyed at least once before this project, in some cases, the quality of the data limits the comparisons we make with historical data and the trends that we can extract. Population sizes reported as “many” plants, patch counts that were combined together, and inaccurate patch boundaries are examples of some of the problems encountered in the historical data.

The *L. f.* ssp. *bellingeriana* habitat and plant community shared some basic similarities across the taxon’s range (see the Habitat and Range section), and every extant population was threatened by infestations of invasive weeds. The most abundant and seemingly problematic weeds are cheatgrass (*Bromus tectorum*), medusa head (*Taeniatherum caput-medusae*), yellow star-thistle (*Centaurea solstitialis*), bristly dogstail grass (*Cynosurus echinatus*), and

bulbous bluegrass (*Poa bulbosa*). Additional weedy grasses were encountered in early stages of development, and without sufficient features they were unidentifiable.

After threats from weeds, roads that intersect populations seem to be the second most significant threat. These roads can act as barriers, interfering with, and altering site hydrology in addition to directly eliminating *L. f.* ssp. *bellingeriana* habitat and disrupting patch connectivity; a developed logging landing and pull-out area, encountered at two separate sites, likely have similar impacts. Anticipated maintenance of such infrastructure poses a potential threat if steps aren't taken to avoid the destruction and damage of *L. f.* ssp. *bellingeriana* plants and habitat. Other land management activities, including, but not limited to grazing, fuels reductions treatments, and logging, pose a threat if not properly coordinated. Seemingly minor activities might have the potential to irreparably alter the hydrology that maintains the seasonally wet habitat that *L. f.* ssp. *bellingeriana* relies on. The hydrologic alterations reported here are

Evidence of grazing was observed at numerous sites, but the minor to moderate damage to *L. f.* ssp. *bellingeriana* that was observed doesn't appear to be an immediately critical threat; the long-term effects of grazing on *L. f.* ssp. *bellingeriana* and its associated plant communities are not known. Grazing can result in the reduction of palatable plants and promote the proliferation of unpalatable weeds. Several of the most common weeds that threaten *L. f.* ssp. *bellingeriana* sites are generally considered unpalatable for livestock: bristly dogtail grass, cheatgrass, medusahead, and yellow star-thistle. Grazing might exacerbate some of these infestations, potential resulting in the conversion of suitable *L. f.* ssp. *bellingeriana* habitat into non-suitable habitat.

OHV activity was observed in numerous sites, but generally the damage appeared to be from a single event that was confined to a relatively small area, and lasting impacts are expected to be relatively minor. Damage from more regular or widespread OHV activity within a site would be more cause for concern. Encroachment and shading from trees and shrubs were documented as potential threats at several sites, but direct impacts haven't been verified.

The digitized boundaries of the occurrences documented in 2015 and 2016 were used to generate the amount of area occupied at each site (see Appendix C). The inaccuracy of the

previous mapping of occurrences precluded the need to compare the amount of historically occupied area with that documented during this project. Occurrence areas documented here can serve as baseline data for the comparison of occupied areas in the future. The estimated percent of *L. f.* ssp. *bellingeriana* plants in each phenological stage within a site, and the characterization of site soil moisture within a site, is not presented here; that data has been submitted to BLM.

Antelope Creek Region Monitoring Results

A total of seven *L. f.* ssp. *bellingeriana* sites were monitored in the Antelope Creek region (in the Ashland Resource Area) in 2015 (Tables 3 & 4). The six Antelope Creek sites are located within about 1.2 kilometers of each other while the Dead Indian Memorial Road site is about 16 kilometers to the south. All but one of the populations at the Antelope Creek sites increased, in varying amounts, since last monitoring; the Antelope Creek 5 site decreased from 25,000 plants in 2014 to 2,700 plants in 2015. The Antelope Creek 5 sites was monitored a second time in 2016 and the number of plants had increased to 4,620, which is still far below the 2014 plant count. The Dead Indian Memorial Road site also increased substantially from about 250 plants in 2007 to about 1,150 plants in 2015.

All of the sites monitored in this region are threatened by infestations of invasive weeds that include (Figure 4): yellow star-thistle (*Centaurea solstitialis*), medusahead (*Taeniatherum caput-medusae*), bulbous bluegrass (*Poa bulbosa*), and bristly dogtail grass (*Cynosurus echinatus*). Additional weeds, including redstem stork's bill (*Erodium cicutarium*), non-native annual grasses, and others weedy forbs, are often present, but less abundant. In general, weeds appeared to be less abundant in the areas occupied by *L. f.* ssp. *bellingeriana*. Three cases of relatively minor OHV activity were observed at the Antelope Creek 1, 2, and 4 sites; more substantial OHV disturbance was observed at the Antelope Creek 6 site. Established roads intersect the Antelope Creek 5 site twice and the Antelope Creek 6 site once. The roads interfere with site hydrology and anticipated road maintenance has the potential to damage and destroy *L. f.* ssp. *bellingeriana* plants and detrimentally alter hydrology.

Table 3. Antelope Creek region *Limnanthes floccosa* ssp. *bellingeriana* monitoring results from 2015.

Site name	EO_ID	FLSITE_ID	Previous plant count	2015 plant count
Antelope Creek 1	26437	3904	800	5,000
Antelope Creek 2	26437	3905	4,500	6,000+
Antelope Creek 3	26437	4617	1,030	7,650
Antelope Creek 4	26437	4618	4,200	19,450
Antelope Creek 5	26437	4620	25,000	2,700
Antelope Creek 6	26437	4621	450	720
Dead Indian Memorial Road	30173	12461	250	1,150

Figure 4. The thatch visible at the Antelope Creek 1 site (shown here) is indicative of the yellow star-thistle and non-native grass infestations that most threaten the sites in this region.

Table 4. Documented threats and management recommendations from Antelope Creek Region (BLM Ashland Resource Area) *L. f.* ssp. *bellingeriana* site monitoring in 2015.

Site name	Threat Description	Management Recommendation
Antelope Creek 1	Invasive weeds: ~70% of the site is infested with CESO3, TACA8, CYEC, and POBU; weeds are more prevalent in unoccupied areas	Conduct trial weed management treatments, continue monitoring, and prioritize the treatment of declining populations
	OHV activity: one set of tire tracks crossed the center of the LIFLB patch; vehicle access is generally difficult	Check for evidence of OHV activity during future visits; if incursions from OHVs continues, consider installing barriers to off-road vehicle travel
	Land management: the site appears to be used for recreation (possibly and informal disc golf course); no signs of substantial human traffic; minimal impact is expected	Monitor for signs of heavy human traffic through the site; take steps to discourage access if the population shows signs of decline
Antelope Creek 2	Invasive weeds: ~80% of the site is infested with CESO3, CYEC, TACA8, and annual grasses	Conduct trial weed management treatments, continue monitoring, and prioritize the treatment of declining populations
	OHV activity: one set of tire tracks crossed the center of the LIFLB patch; LIFLB is growing well in the tire tracks, which are holding water	Check for evidence of OHV activity during future visits; if incursions from OHVs continues, consider installing barriers to off-road vehicle travel
Antelope Creek 3	Invasive weeds: ~80% of the site is infested with annual grasses, CESO3, CYEC, TACA8, POBU, and ERCI6; weeds are more prevalent in unoccupied areas	Conduct trial weed management treatments, continue monitoring, and prioritize the treatment of declining populations
Antelope Creek 4	Invasive weeds: ~of the site is infested with CESO3 and TACA8	Conduct trial weed management treatments, continue monitoring, and prioritize the treatment of declining populations
	OHV activity: a deeply rutted OHV track crosses the east end of the site	Check for evidence of OHV activity during future visits; if damage from OHVs continues, consider installing barriers to off-road vehicle travel where the road intersects the north end of the meadow
	Hydrologic alteration: a rutted OHV track is impacting water flow in a relatively small portion of the site	Carefully inspect for evidence of OHV during future visits

Table 4. (Continued)

Site name	Threat Description	Management Recommendation
Antelope Creek 5	Invasive weeds: ~70% of the site is infested with CESO3 and TACA8	Prioritize trial weed management treatments followed by larger-scale site treatments and continued monitoring
	Hydrologic alteration: an established graveled road intersect this population twice, interfering with natural water flow	Consider upgrading culvert infrastructure to encourage unconstrained water flow across the road
	Land management: anticipated road maintenance would likely result in the loss of LIFLB plants along the road	Coordinate with road maintenance staff to avoid LIFLB, when possible, and minimize damage to occupied areas; plan seed LIFLB collections and re-seeding of impacted roadside occurrences as need
Antelope Creek 6	Invasive weeds: ~70% of the site is infested with CESO3 and TACA8; weeds are more prevalent in unoccupied areas	Conduct trial weed management treatments, continue monitoring, and prioritize the treatment of declining populations
	Hydrologic alteration: an established graveled road intersect this population, interfering with natural water flow	No immediate action required; consider decommissioning this dead end road
	OHV activity: major tire ruts and ground disturbance was encountered in occupied habitat adjacent to the road	Install barriers to off-road vehicle travel along the roadside edges through this accessible meadow
	Land management: anticipated road maintenance would likely result in the loss of LIFLB plants along the road	Coordinate with road maintenance staff to avoid LIFLB, when possible, and minimize damage to occupied areas; plan seed LIFLB collections and re-seeding of impacted roadside occurrences as need
Dead Indian Memorial Road	Invasive weeds: ~50% of the site is infested with CESO3, TACA8, and POBU; weeds are most prevalent in unoccupied areas	Conduct trial weed management treatments, continue monitoring, and prioritize the treatment of declining populations

Butte Falls Resource Area Monitoring Results

A total of ten *L. f.* ssp. *bellingeriana* sites, that included twelve occurrences, were monitored across the Butte Falls Resource Area region in 2015 (Tables 5 & 6); the Dog Creek Complex 1 and Poverty Flat sites each encompass two occurrences. The changes in population size since last monitoring were mixed amongst these sites. The number of plants at the Beekman Ridge Complex and Dog Creek Complex 1 and 4 populations increased modestly. The Dog Creek Complex 2 appears to have increased substantially from 135 plants in 2002 to 783 plants in 2015; the inclusion of additional *L. f.* ssp. *bellingeriana* patches in this occurrence in 2015 may account for this documented increase. The number of *L. f.* ssp. *bellingeriana* plants at the Geppert Butte site also appears to have substantially increased from the 80 plants reported in 2008 to 1,275 plants in 2015 (Figure 5). However, the 2008 Geppert Butte record may only be a partial count or underestimate (it differs substantially from ORBIC records), which could result in the detection of artificially inflated increases, as may be the case here. Declines in population size were documented at five sites, with only minor decline at the Dog Creek 3 site, and more substantial declines at the Double Day Road, Fredenberg Road Complex, Geppert Butte Complex, and Poverty Flat. It appears likely that BLM's previous *L. f.* ssp. *bellingeriana* plant counts from the Geppert Butte and Geppert Butte Complex sites (FLSITE_ID 8972 and 8973; BLM 2015) may have been accidentally switched from previous ORBIC records and misapplied.

Once again, all sites were threatened by invasive weeds, although Double Day Road and Fredenberg Road Complex were threatened least of all by weeds. Medusahead, bulbous bluegrass, bristly dogtail grass, and other weedy annual grasses were the most prevalent weed threats. Common mullein (*Verbascum thapsus*), redstem stork's bill, *Centaurea* sp. (unidentifiable during monitoring), and other weedy forbs were also occasionally present, potentially exacerbating the threat from weeds in certain sites. Cutleaf teasel (*Dipsacus laciniatus*) and Himalayan blackberry (*Rubus armeniacus*) were documented adjacent to the Geppert Butte Complex. Relatively minor OHV activity was observed at Double Day Road and Geppert Butte Complex, but corrective action doesn't seem needed at this time; OHV activity at Beekman Ridge Complex is addressed below. The hydrology of the Geppert Butte Complex has likely been altered by the road that intersects the site, and at Poverty Flat a gravel pullout has likely altered hydrology. Land management activities associated with the

road that intersects the Geppert Butte Complex, and gravel placement at Poverty Flat, were identified as potential threats. Appropriate planning with road maintenance staff at Geppert Butte Complex, and users of the Poverty Flat pull-out area, could reduce the risk of damage to these populations. The Double Day Road and Fredenberg Road Complex sites were noted being potentially threatened by encroachment as a result of shading by adjacent mature forest and also shrubs at Fredenberg Road Complex. Both sites are relatively confined and contain perennial grasses that may be competing with *L. f.* ssp. *bellingeriana*. In light of their population declines, these sites should be monitored more frequently and trial habitat improvements should be considered.

The Beekman Ridge Complex was one of the more disturbed sites monitored during this project. It appears to have been developed as a logging landing, seems to be utilized by recreationalists, and shows signs of OHV activity. Based on the composition and prevalence of weeds at this site, traffic is likely responsible for some of the introductions. The past development of the site, which appears to have included the removal of vegetation, grading, installation of a road, and spreading of gravel, has likely altered site hydrology, but *L. f.* ssp. *bellingeriana* plants still persist here. The sparse northern patch at this site, which coincides with the previously mapped occurrence, only contains 55 plants. If originally this was the only occurrence at this site, then it has declined substantially, but losses in that patch have been offset by plants in the southern patch. Weeds at this site should be treated and decommissioning the spur road that allows for vehicle access to the site should be considered to help protect this population from human traffic.

The Dog Creek Complexes 1, 2, 3, and 4 are all within one kilometer of one another and share similar site conditions and threats. All sites appear to be grazed and signs of cattle were observed. Direct damage to *L. f.* ssp. *bellingeriana* was moderate to minimal; other indirect effects associated with cattle, such as proliferation of weeds and reductions in seed output, may be problematic. Future grazing should be scheduled for after *L. f.* ssp. *bellingeriana* sets seed to best avoid interference with reproductive processes. There were signs of past fuels reduction treatments in this area, which likely benefited *L. f.* ssp. *bellingeriana* by reducing competition; future management actions such as this should be coordinated to minimize damage to *L. f.* ssp. *bellingeriana* populations and habitat.

Table 5. Butte Falls Resource Area *Limnanthes floccosa* ssp. *bellingeriana* monitoring results from 2015.

Site name	EO_ID	FLSITE_ID	Previous plant count	2015 plant count
Beekman Ridge Complex	34396	13677	150	175
Dog Creek Complex 1	24992	2161	60	67
Dog Creek Complex 2	24992	2162	135	783
Dog Creek Complex 3	24992	2163	106	95
Dog Creek Complex 4	24992	2023	850	870
Double Day Road	24990	1946	400	250
Fredenberg Road Complex	34395	13674	630	195
Geppert Butte	32069	8972	80	1,275
Geppert Butte Complex	32069	8973	10,000	660
Poverty Flat	8825	78, 295	200	40

Figure 5. Although the *L. f.* ssp. *bellingeriana* population at the Geppert Butte site (shown here) appears to have grown, the greatest number of apparently declining populations were documented in the Butte Falls Resource Area; questionable historical records make the determination of population trends difficult at this site as well as others.

Table 6. Documented threats and management recommendations from Butte Falls Resource Area *L. f.* ssp. *bellingeriana* site monitoring in 2015.

Site name	Threat Description	Management Recommendation
Beekman Ridge Complex	Invasive weeds: ~60% of the site is infested with VETH, BRTE, ERCI6, and other weedy annual grasses and forbs (including an unidentified *Centaurea* sp.); history of traffic at this site likely contributed to infestations	Treatment is needed to eliminate this somewhat discreet infestation of several types of weeds that threaten the LIFLB population and is acting as a point source of weed seeds for the area
	Hydrologic alteration: large areas have been scoured of vegetation and/or graveled, likely altering site hydrology	No immediate action required; consider decommissioning this landing to minimize future damage and encourage the recovery of the natural habitat
	OHV activity: some of the occupied areas appear to be used as a vehicle turn-around spot; numerous tire tracks are present through muddy portions of the site	This site is used by recreational visitors; consider decommissioning this landing to minimize future damage and encourage the recovery of the natural habitat
	Land management: the site appears to have been used as a logging landing, resulting in disturbance and weed introductions	Consider decommissioning this landing to minimize future damage and encourage the recovery of the natural habitat
Dog Creek Complex 1	Invasive weeds: ~70% of the area is infested with TACA8, non-native forbs, and annual grasses	Conduct trial weed management treatments, continue monitoring, and prioritize the treatment of declining populations
	Grazing: evidence of pervasive grazing appears to be from cattle; direct damage to plants was moderate to minimal	If populations begin to decline, consider removing managed grazing from these areas; eliminate managed grazing during LIFLB flowering and fruiting; take precautions to ensure that managed grazing does not introduce additional weeds
	Land management: there is evidence of past fuels reduction activities; although likely an overall benefit to the population, plants may have been damaged	Future habitat treatments should be coordinated to minimize the risk of damage to plants and the surrounding plant community

Table 6. (Continued)

Site name	Threat Description	Management Recommendation
Dog Creek Complex 2	Invasive weeds: ~80% of the area is infested with TACA8, non-native forbs, and annual grasses	Conduct trial weed management treatments, continue monitoring, and prioritize the treatment of declining populations
	Grazing: evidence of pervasive grazing appears to be from cattle; direct damage to plants was moderate to minimal	If populations begin to decline, consider removing managed grazing from these areas; eliminate managed grazing during LIFLB flowering and fruiting; take precautions to ensure that managed grazing does not introduce additional weeds
	Land management: there is evidence of past fuels reduction activities; although likely an overall benefit to the population, plants may have been damaged	Future habitat treatments should be coordinated to minimize the risk of damage to plants and the surrounding plant community
Dog Creek Complex 3	Invasive weeds: ~70% of the area is infested with TACA8 and annual grasses	Prioritize trial weed management treatments followed by larger-scale site treatments and continued monitoring
	Grazing: evidence of pervasive grazing appears to be from cattle; direct damage to plants was moderate to minimal	If populations begin to decline, consider removing managed grazing from these areas; eliminate managed grazing during LIFLB flowering and fruiting; take precautions to ensure that managed grazing does not introduce additional weeds
	Land management: there is evidence of past fuels reduction activities; although likely an overall benefit to the population, plants may have been damaged	Future habitat treatments should be coordinated to minimize the risk of damage to plants and the surrounding plant community

Table 6. (Continued)

Site name	Threat Description	Management Recommendation
Dog Creek Complex 4	Invasive weeds: ~70% of the area is infested with TACA8, VETH, and annual grasses	Conduct trial weed management treatments, continue monitoring, and prioritize the treatment of declining populations
	Grazing: evidence of pervasive grazing appears to be from cattle; direct damage to plants was moderate to minimal	If populations begin to decline, consider removing managed grazing from these areas; eliminate managed grazing during LIFLB flowering and fruiting; take precautions to ensure that managed grazing does not introduce additional weeds
	Land management: there is evidence of past fuels reduction activities; although likely an overall benefit to the population, plants may have been damaged	Future habitat treatments should be coordinated to minimize the risk of damage to plants and the surrounding plant community
Double Day Road	Invasive weeds: ~20% of the site is infested with TACA8 and POBU; other weedy grasses may also be present	Prioritize trial weed management treatments followed by larger-scale site treatments and continued monitoring
	OHV activity: tire tracks run through portions of the occupied area	Check for evidence of OHV activity during future visits; if incursions from OHVs continues, consider installing barriers to off-road vehicle travel
	Tree encroachment: this population is confined in a partially-shaded meadows surrounded by mature conifers	No immediate action required
Fredenberg Road Complex	Invasive weeds: ~30% of the site is infested with annual grasses	Prioritize trial weed management treatments followed by larger-scale site treatments and continued monitoring
	Tree and shrub encroachment: this population is confined and surrounded by a dense stand of CECU and mature and conifers that partially shade the site	Consider implementing fuels reduction treatments that involve thinning adjacent trees and shrubs

Table 6. (Continued)

Site name	Threat Description	Management Recommendation
Geppert Butte	Invasive weeds: ~70% of the site is infested by CYEC and TACA8	Conduct trial weed management treatments, continue monitoring, and prioritize the treatment of declining populations
Geppert Butte Complex	Invasive weeds: ~40% of the site is infested with TACA8, CYEC, and other annual grasses; the presence of DILA4 and RUAR9 in adjacent unoccupied habitat poses a threat	Prioritize trial weed management treatments followed by larger-scale site treatments and continued monitoring
	Hydrologic alteration: an established road bisects this site and impacts the flow over water to the area below the road	Consider upgrading culvert infrastructure to encourage unconstrained water flow across the road
	OHV activity: tire tracks run through the southern portion of the population	Check for evidence of OHV activity during future visits; if incursions from OHVs continues, consider installing barriers to off-road vehicle travel
	Land management: anticipated road maintenance may negatively affect site hydrology and directly damage plants	Coordinate with road maintenance staff to avoid actions that can alter site hydrology; plants are not located on the roadside edge and should be safe from direct damage during maintenance
Poverty Flat	Invasive weeds: ~50% of the site is infested with annual grasses and non-native forbs; weeds are most prevalent in unoccupied areas	Prioritize trial weed management treatments followed by larger-scale site treatments and continued monitoring
	Hydrologic alteration: the hydrology of the LIFLB occurrence on BLM land is potentially threatened by changes in the management or placement of gravel in the adjacent pull-out area	Consider conducting outreach to the neighboring property owners to coordinate plans to minimize disturbance to LIFLB site hydrology
	Land management: changes in the management and placement of gravel in the adjacent pull-out area could potentially destroy the occurrence	Consider installing barriers to help prevent ground disturbance near the LIFLB patch

Cascade-Siskiyou National Monument Region Monitoring Results

A total of four *L. f.* ssp. *bellingeriana* sites were monitored in the Cascade-Siskiyou National Monument region of the Ashland Resource Area in 2015 (Tables 7 & 8); the Klamath Rim site (Figure 6) was monitored in conjunction with these efforts, but is covered in more detail in the Klamath Falls Area Monitoring section below. The number of plants in these populations appear to be relatively stable: the Jenny Creek Complex (consisting of two occurrences) increase slightly, Mountain View Complex increased substantially, and the two Pinehurst Airport Complex sites, previously reported as containing "many" plants in a distinctly different portion of the site, together contained 3,640 plants.

All sites were threatened by invasive weeds, primarily medusahead, bulbous bluegrass, and other non-native annual grasses; yellow star-thistle was documented at Pinehurst Airport Complex East. An underdeveloped and unidentifiable weedy annual grass has invaded the bottoms of pools at Pinehurst Airport Complex West, potentially posing a direct competitive threat to *L. f.* ssp. *bellingeriana*. Roads (including a historical roadbed) intersect the Mountain View Complex and Pinehurst Airport Complex East and West sites, potentially interfering with site hydrology. The presence of roads make these sites easily accessible and therefore, more threatened by potential OHV activity; evidence of OHV activity was observed in Pinehurst Airport Complex East. Anticipated road maintenance at Mountain View Complex and Pinehurst Airport Complex East should be coordinated to avoid actions that might be damaging to site hydrology, habitat, and plants. Tree encroachment was listed as a potential threat at the Jenny Creek Complex, where common juniper (*Juniperus communis*) trees are establishing amongst occupied habitat, and at Pinehurst Airport Complex West, where *L. f.* ssp. *bellingeriana* occurs under mature conifer cover; in the absence of clear population declines, no action is recommended.

Table 7. Cascade-Siskiyou National Monument and Klamath Falls Resource Area *Limnanthes floccosa* ssp. *bellingeriana* monitoring results from 2015; Klamath Rim 1 is the only Klamath Falls Resource Area site listed.

Site name	EO_ID	FLSITE_ID	Previous plant count	2015 plant count
Jenny Creek Complex	17061	291, 72	10,500	11,555
Klamath Rim 1	20394	400511_LIFLB_ HAYDENFOX	100,000	6390
Mountain View Complex	14282	355	50	1338
Pinehurst Airport Complex East	14282	354, 8153	"many"	1290
Pinehurst Airport Complex West	14282	354, 8153	"many"	2350

Figure 6. The Klamath Rim 1 site is host to a dense infestation of bulbous bluegrass following the 2014 Oregon Gulch Fire that burned through the site the year before monitoring in 2015; post-disturbance treatments are recommended to help minimize weed infestations.

Table 8. Documented threats and management recommendations from Cascade-Siskiyou National Monument and Klamath Falls Resource Area *L. f.* ssp. *bellingeriana* site monitoring in 2015.

Site name	Threat Description	Management Recommendation
Jenny Creek Complex	Invasive weeds: ~50% of site is infested by TACA8 and POBU; weedy grasses are most prevalent in the unoccupied areas (higher ground)	Conduct trial weed management treatments, continue monitoring, and prioritize the treatment of declining populations
	Tree encroachment: JUCO6 appears to be encroaching on the west end of the northernmost patch and may spread	Monitor the abundance of JUCO6 and consider removing a portion of established trees to eliminate the their potential contribution to site drying
Klamath Rim 1	Invasive weeds: the site (~80%) is dominated by dense POBU; substantial thatch accumulation in some areas; POBU appears less prevalent in unoccupied areas	Prioritize trial weed management treatments followed by larger-scale site treatments and continued monitoring
	OHV activity: large truck tracks are present, mostly in adjacent unoccupied areas, and pose a potential threat to occupied areas	Check for evidence of OHV activity during future visits; if incursions from OHVs continues, consider installing barriers to off-road vehicle travel
	Land management: the road that intersects this site directly eliminates LIFLB habitat and interferes with connectivity of additional suitable habitat across the road	Coordinate road maintenance to minimize interference with LIFLB habitat and promote unconstrained water flow across the road
	Hydrologic alteration: the road that intersects this site likely interferes with water flow	Consider upgrading culvert infrastructure to encourage unconstrained water flow across the road
	Land management: vehicle traffic and ground disturbing activities associated with powerline maintenance and salvage logging have the potential to directly damage plants and negatively impact site hydrology	Coordinate activities in the vicinity of LIFLB sites to avoid direct damage to plants, habitat, and hydrology; require reporting of incursions into LIFLB sites and conduct follow-up monitoring when possible to assess any damage

Table 8. (Continued)

Site name	Threat Description	Management Recommendation
Mountain View Complex	Invasive weeds: ~75% of this site is infested with POBU, TACA8, and other non-native annual grasses	Conduct trial weed management treatments, continue monitoring, and prioritize the treatment of declining populations
	OHV activity: the proximity to the road makes this site particularly vulnerable to inadvertent damage from vehicle traffic	Check for evidence of OHV activity during future visits; consider installing barriers to off-road vehicle travel
	Land management: anticipated road maintenance may result in the loss of LIFLB plants, and may interfere with hydrology, but the majority of the population would likely be unaffected	Coordinate with road maintenance staff to avoid actions that can alter site hydrology; plants are not located on the roadside edge and should be safe from direct damage during maintenance
Pinehurst Airport Complex East	Invasive weeds: ~40+% of the site is infested with POBU, TACA8 and non-native annual grasses; CESO3 is present in adjacent unoccupied areas	Conduct trial weed management treatments, continue monitoring, and prioritize the treatment of declining populations
	OHV activity: vehicle tracks go through the population, directly damaging plants; the area is relatively accessible for future OHV activity	Check for evidence of OHV activity during future visits; if incursions from OHVs continues, consider installing barriers to off-road vehicle travel
	Land management: anticipated road maintenance may result in direct damage to plants and altered hydrology	Coordinate with road maintenance staff to avoid actions that may divert water from occupied habitat; plants are not located on the roadside edge and should be safe from direct damage during maintenance

Table 8. (Continued)

Site name	Threat Description	Management Recommendation
Pinehurst Airport Complex West	Invasive weeds: ~40+% of the site is infested with POBU, TACA8 and non-native annual grasses	Conduct trial weed management treatments, continue monitoring, and prioritize the treatment of declining populations
	Invasive weeds: an unidentified grass (too underdeveloped) is invading the bottoms of pools, possibly posing a much more direct competitive threat in LIFLB occupied areas	Prioritize this site for additional monitoring, determine the identity of the unknown grass, and reevaluate the threat it poses
	OHV activity: an old roadbed goes through the site, potentially encouraging vehicle traffic and associated damage	Check for evidence of OHV activity during future visits; consider installing barriers to off-road vehicle travel
	Land management: timber harvest activities (if pursued) could result in damage to the population and site	Coordinate timber harvest, or other land management activities, to minimize damage to the LIFLB population, hydrology, and the site
	Tree encroachment: patches on the west end of the site are partially shaded by mature conifers, potentially posing a threat to long-term persistence	No immediate action required; if LIFLB plant counts decline at the site, consider removing a portion of the trees in an attempt to relieve competition

Klamath Falls Resource Area Monitoring Results

A total of eleven *L. f.* ssp. *bellingeriana* sites, that included thirteen occurrences, were monitored in the Klamath Falls Resource Area region in 2015 and 2016 (Tables 7, 8, 9 & 10). The Klamath Rim 1 site was thoroughly monitored in 2015 and the steep decline in number of plants at this site, from the [presumably estimated] count of 100,000 plants in 2014, to 6,390 plants in 2015, is reason for concern. Of the sites monitored in 2016, two appear to be extirpated, one appears to have declined, one appears to be stable, and the six remaining sites appear to have increased substantially.

Based solely on past records, the *L. f.* ssp. *bellingeriana* populations at Pokegama Road 2 and 3 appear to be extirpated, but the vague location information associated with the past records may be unreliable. The apparent extirpation of the Pokegama Road 2 population seems feasible since the site is in the vicinity of suitable habitat and the establishment of roads around and through the previously mapped occurrence location could have easily resulted in the destruction and disappearance of suitable *L. f.* ssp. *bellingeriana* habitat at this location. Alternately, the occurrence may have been previously mapped incorrectly and should actually be included in one of the several other surrounding occurrences. The apparent extirpation of the Pokegama Road 3 site is likely not valid, and is rather a result of spatial or plant identification inaccuracies from the 2012 record; the occurrence is located in mature conifer forest that likely hasn't supported suitable *L. f.* ssp. *bellingeriana* habitat in many years.

Previous records for the Ward Road 3 site lack details: a record, listing the number of plants "estimated in the thousands" in 1996, appears to group the counts from the Ward Road 2 occurrence with that of Ward Road 3. Based on the large of extent of the previously mapped occurrence at Ward Road 3, and in the absence of reliable previous plant counts, we should assume that this population has declined, dwindling to only 20 plants in 2016. The questionable quality of previous occurrence data and confusion with combined occurrence records have the potential to result in what may be overly inflated population increases reported here in the Ward Road 1 and 2 sites. Alternatively, the 200 plants reported at the Ward Road 2 site in 2013 may be an accurate plant count from a "bad" year, while the 1,590 plants documented in 2016 may be an accurate representation of the population size in a "good" year. The population at Ward Road 1 appears to have increased from 50 plants in 2013 (150 plants in 2012; BLM 2015) to 570 plants in 2015.

The remaining sites monitored in the Klamath Falls Resource Area showed signs of population increases (except for Pokegama Road Complex 1, addressed in further detail below), with Grizzly Flat, Klamath Rim 2 (Figure 7), and Pokegama Road Complex 2 all containing thousands of plants. The Pokegama Road 1 population also increased substantially, from 230 plants in 2012 to 935 plants in 2016. The population trend at

Pokegama Road Complex 1 is not as clear, but is assumed to be relatively stable; previous records estimated thousands of plants in 1996 and 3,660 plants were observed in 2016.

Invasive weeds were documented as a threat at all occupied sites, with medusahead, bulbous bluegrass, and other weedy annual grasses being the most common. Roads run directly through the Pokegama Complex 1 and 2 sites, and also through the historically occupied area at Ward Road 3. In addition to eliminating *L. f.* ssp. *bellingeriana* habitat, these roads can act as barriers to water flow, altering site hydrology and interfering with patch connectivity. If the historical location information for Pokegama Road 2 is accurate, then the installation of roads, adjacent to, and through this site, is the likely cause for extirpation. In addition to the roads, a pond had been excavated near the site, and all these features have the potential to alter site hydrology, rendering once-suitable habitat no longer suitable for *L. f.* ssp. *bellingeriana*. OHV activity was observed adjacent to the Klamath Rim 1 and Ward Road 2 sites, but doesn't appear to be a substantial threat in this region. Evidence of moderate to low level grazing was observed at most sites in this region, and although it doesn't appear to be a severe threat at this time, the full extent of impacts from grazing are not known and may manifest gradually over time. Lastly, if the historical location information for Pokegama Road 3 is accurate, then the occurrence was likely extirpated as a result of tree encroachment and conversion of habitat to conifer forest. It is exceedingly unlikely that this could have occurred in the short time since the occurrence was documented in 2012. It is more likely that this occurrence was mapped incorrectly and was actually found in the wetland habitat situated about 100 meters either east or west of the reported location.

Table 9. Klamath Falls Resource Area *Limnanthes floccosa* ssp. *bellingeriana* monitoring results from 2016.

Site name	EO_ID	FLSITE_ID	Previous plant count	2016 plant count
Klamath Rim 2	8446	KFRA_LIFLB_05231996 _POKE7	200	4,720
Pokegama Road 1	10666	PLANTS_LIFLB_HF_2012 _LMV_GV01	230	935
Pokegama Road 2	10666	PLANTS_LIFLB_HF_2012 _LMV_GV04	60	0
Pokegama Road 3	10666	PLANTS_LIFLB_HF_2012 _LMV_GV03	20	0
Pokegama Road Complex 1	10666	KFRA_LIFLB_05251996 _POKE2	thousands	3,660
Pokegama Road Complex 2	10666	KFRA_LIFLB_05251996 _POKE1	65	4,340
Ward Road 1	17094	LIFLB_HAYDENFOX_2013 _JDS13-228	50	570
Ward Road 2	17094	KFRA_LIFLB_05251996 _POKE1, KFRA_LIFLB_05251996 _POKE2, LIFLB_HAYDENFOX_2013 _JDS13-224	200	1,590
Ward Road 3	17094	KFRA_LIFLB_05251996 _POKE3	thousands	20
Grizzly Flat	16097	KFRA_LIFLB_05112005 _POKE1	1,000	2,500

Figure 7. The largest *L. f.* ssp. *bellingeriana* population encountered in 2016 was at the Klamath Rim 2 site, which also hosts a dense infestation of non-native grasses since burning in the 2014 Oregon Gulch Fire.

Table 10. Documented threats and management recommendations from Klamath Falls Resource Area *L. f.* ssp. *bellingeriana* site monitoring in 2016.

Site name	Threat Description	Management Recommendation
Grizzly Flat	Invasive weeds: ~70% of the site is infested with TACA8 and an unidentifiable grass	Conduct trial weed management treatments, continue monitoring, and prioritize the treatment of declining populations
Klamath Rim 2	Invasive weeds: ~90% of the site is infested with POBU, TACA8, ERCI6, and other weedy grasses	Conduct trial weed management treatments, continue monitoring, and prioritize the treatment of declining populations
	Land management: the road that runs through this site eliminates LIFLB habitat and interferes with patch connectivity	Conduct trial weed management treatments, continue monitoring, and prioritize the treatment of declining populations
	Hydrologic alteration: the road intersecting this site acts as a barrier to water flow	Conduct trial weed management treatments, continue monitoring, and prioritize the treatment of declining populations
Pokegama Road 1	Invasive weeds: ~50% of the site is infested with POBU	Conduct trial weed management treatments, continue monitoring, and prioritize the treatment of declining populations
Pokegama Road 2	Land management: roads intersect and surround the previously mapped location; no LIFLB habitat present at this location	No immediate action required
Pokegama Road 3	Tree encroachment: the previously mapped location is located in mature forest habitat; no LIFLB habitat present this location	No immediate action required
Pokegama Road Complex 1	Invasive weeds: ~70% of the site is infested with POBU and TACA8	Conduct trial weed management treatments, continue monitoring, and prioritize the treatment of declining populations
	Land management: Pokegama Rd. runs through the population, directly eliminating LIFLB habitat and interfering with patch connectivity	No immediate action required
	Hydrologic alteration: Pokegama Rd. acts as a barrier to water flow	Consider upgrading culvert infrastructure to encourage unconstrained water flow across the road

Table 10. (Continued)

Site name	Threat Description	Management Recommendation
Pokegama Road Complex 2	Invasive weeds: ~70% of the site is infested with POBU and TACA8	Conduct trial weed management treatments, continue monitoring, and prioritize the treatment of declining populations
	Land management: Pokegama Rd. runs through the population, directly eliminating LIFLB habitat and interfering with patch connectivity	No immediate action required
	Hydrologic alteration: Pokegama Rd. acts as a barrier to water flow	Consider upgrading culvert infrastructure to encourage unconstrained water flow across the road
Ward Road 1	Invasive weeds: ~60% of the site is infested with POBU	Conduct trial weed management treatments, continue monitoring, and prioritize the treatment of declining populations
Ward Road 2	Invasive weeds: ~70% of the site is infested with POBU and TACA8	Conduct trial weed management treatments, continue monitoring, and prioritize the treatment of declining populations
	OHV activity: truck tire ruts were present in the adjacent unoccupied wet meadow habitat	Check for evidence of OHV activity during future visits; consider installing barriers to off-road vehicle travel
Ward Road 3	Invasive weeds: ~70% of the site is infested with TACA8 and POBU	Prioritize trial weed management treatments followed by larger-scale site treatments and continued monitoring
	Land management: Road 40-6E-31.2 runs through the historic occupied area, eliminating potential LIFLB habitat	No immediate action required
	Hydrologic alteration: Road 40-6E-31.2 likely interferes with site hydrology	Consider upgrading culvert infrastructure to encourage unconstrained water flow across the road

Evaluating Recruitment Potential

In addition to collecting updated information on *L. f.* ssp. *bellingeriana* population size and threats, reproductive output was measured, and seed was germinated in-lab, from a selection of populations to determine their recruitment potential.

Plant Collection Methods

During April 2015, a subset of sixteen robust *L. f.* ssp. *bellingeriana* populations monitored during this project was selected to be evaluated for recruitment potential (Table 11); two distinctly separate *L. f.* ssp. *bellingeriana* patches at the Jenny Creek Complex were evaluated separately here. This evaluation process required the collection of entire plant specimens, so small and highly threatened populations were not included to avoid unnecessary loss of seed from these already precarious populations. The following sites were not included in this phase of the project: Antelope Creek 6, Dog Creek Complex 1 and 4, and Poverty Flat. Plants were sustainably collected from across the population, included plants of varying size, and collections did not exceed 10% of the total population. During site monitoring, entire plants were carefully enclosed within breathable, synthetic fine-mesh bags meant to minimally interfere with plant growth; organza bags were used on small plants and pollinator exclusion bags were used on larger plants (Figure 8). The exclusion of pollinators was not expected to result in much reduced seed set compared to non-bagged plants because they are highly autogamous (self-compatible), which allows plants to produce viable seed in the absence of pollinators (Arroyo 1973). In an attempt to avoid effects from pollinator exclusion, we bagged plants that already appeared to be developing fruits. Bagged plants were marked with pin-flags for easy relocation and were left to continue growing for the remainder of the season. After plants senesced, the bags, which contained all the flowers and seeds produced by the enclosed plant, were collected. All plant specimens used in the evaluation of recruitment potential were collected on June 24, 2015 and returned to Oregon State University for processing. A minimum of approximately ten plants were bagged at each site, but many were no longer present at the time of collection, reducing the amount of plant material available for evaluation. Bagged plants should be better secured to avoid this during future plant collections.

Additional plants were collected from the Klamath Rim 2, Pokegama Road 1, and Pokegama Road Complex 1 and 2 sites in 2016. The 2015 germination and evaluation of recruitment potential had already been completed (Figure 9), and site monitoring was the focus of work in 2016, so these seeds collected in 2016 were not included in the evaluation of recruitment potential. Instead, the subsequent 2016 seed accessions were submitted to the Rae Selling Berry Seed Bank & Plant Conservation Program, based at Portland State University, for long-term storage.

Figure 8. In order to evaluate reproductive output and recruitment potential, entire *L. f.* ssp. *bellingeriana* were bagged to insure that no flowers or fruits were lost prior to their collection after the plant had senesced. The breathable mesh of the pollinator exclusion bags and organza bags (see inset) allowed the flowers and fruits to develop throughout the season.

Table 11. ***Limnanthes floccosa* ssp. *bellingeriana* plant collections, including total flower and fruit yields, used for determining recruitment potential.**

Site name	Number of plants collected	Total number of flowers	Total fruit yield
Antelope Creek 1	4	155	147
Antelope Creek 2	2	42	35
Antelope Creek 3	9	112	100
Antelope Creek 4	16	221	182
Antelope Creek 5	20	408	383
Beekman Ridge Complex	4	105	100
Dead Indian Memorial Road	4	100	93
Dog Creek Complex 2	6	64	61
Dog Creek Complex 3	5	21	21
Double Day Road	8	143	127
Fredenberg Road Complex	13	120	103
Geppert Butte	9	102	94
Geppert Butte Complex	11	131	110
Jenny Creek Complex (N. patch)	8	48	29
Jenny Creek Complex (S.W. patch)	10	110	111
Klamath Rim 1	17	881	787
Mountain View Complex	10	94	57
Pinehurst Airport Complex East	10	86	68
Pinehurst Airport Complex West	8	41	34

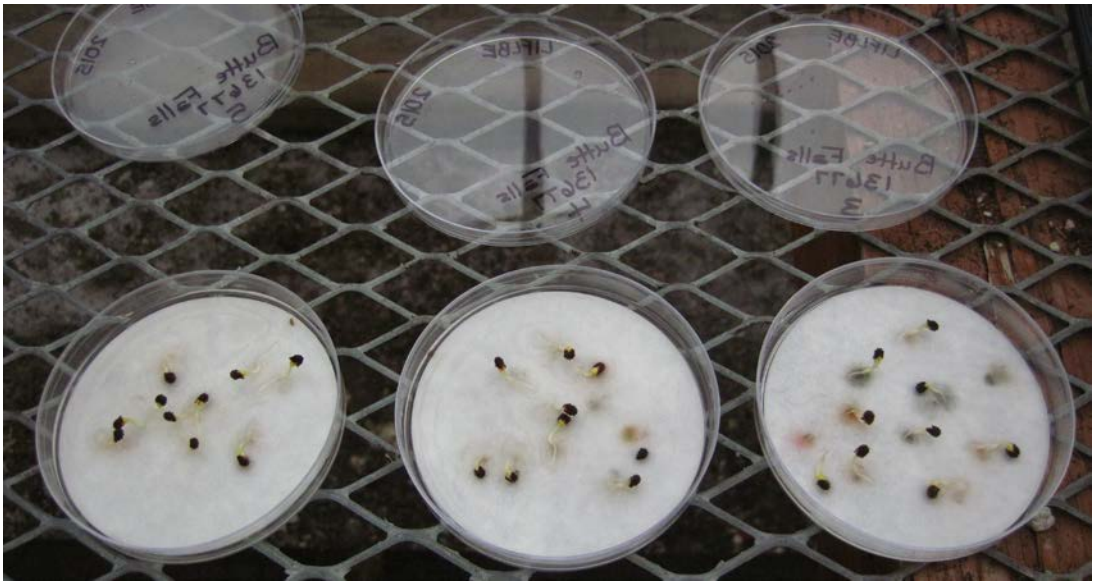

Figure 9. Germination testing of seeds yielded from *Limnanthes floccosa* ssp. *bellingeriana* plant collections helped informed the determination of site-specific recruitment potential.

Determining Recruitment Potential

Plants collected from each of the nineteen sites selected for evaluation of recruitment potential were first evaluated for reproductive capacity. The number of flowers produced by each plant was counted along with the number of fruits produced per flower. The persistent calyces and tendency of fruits to remain within the calyx even after the plant had senesced made counting flowers per plant and fruits per flower easy. Flower remnants and fruits that had separated from the senesced plants were sometimes loose, but contained, in the bags. During this process, fruits were separated from their parent plant material and were set aside for later germination testing. The flower and fruit counts were used to determine the mean number of flowers produced per plant and the mean fruit production per flower for the sites where plants were collected. The reproductive capacity of a population, or estimated total number of fruits produced, is a product of multiplying the total number of plants documented in a population, the mean number flowers produced per plant (in that population), and the mean number of fruits produced per flower (in that population).

Not all fruits contain viable seeds and accounting for the percent of non-viable seeds provides a more accurate representation of the recruitment potential of a population if natural site conditions are ideal for germination and establishment of plants. Germination testing provided germination rates of a representative sample of seeds from a population, which was used to calculate recruitment potential. Multiplying the percent of germinable seeds from a population by the reproductive capacity provides a calculated number of seeds expected to be able to germinate and potentially establish (recruit) within a population.

Germination Methods

Germination rates were determined for each population being evaluated for recruitment potential by germinating a representative sample of 50 seeds from each site's plant collections. For each site, the contribution of seeds from each collected plant to the final 50 seeds undergoing germination testing was directly proportional to the collected plant's percent contribution to the overall seed yield from all our plant collections from that site (e.g., if a plant contributed 10% of the total seed collected from a site, 5 of its seeds would be included in the 50-seed germination test). When calculated seed contributions (for the

germination test) were not whole numbers, they were rounded up or down depending on whether the calculated contribution was above or below 0.5 seeds, respectively. In cases where less than 50 seeds were yielded from a site, all the seeds collected from the site were germination tested. For each site, five petri dished with ten randomly assigned seeds were set up for germination.

Following protocols modified from those previously developed by ODA for seeds of *L. f.* ssp. *grandiflora*, cleaned and sorted seeds were treated with a 24-hour soak in a 0.2 % potassium nitrate (KNO_3) and .05% gibberellic acid (GA_3) solution to break dormancy. This involved spreading seeds across the bottom of filter-paper-lined standard petri-dishes before wetting them with the KNO_3 / GA_3/distilled H_2O solution. Another filter paper was placed on top of the seeds and wetted with the solution to keep seeds submerged. After 24 hours, the seeds were rinsed with distilled water and placed in clean filter-paper-lined petri-dishes before being wetted with distilled water. These pre-treated seeds were placed directly into a dark cold room, stratified at 10°C, and germination began after about a week; germination was defined as the emergence of the radicle by 2 millimeters. Once germination was observed, the date of germination was recorded and the seed was removed from the petri dishes and planted. Non-germinated seeds continued to be returned to the cold room until germination occurred. Germination rates were calculated as the percent of seeds that germinated.

Seedlings were successfully cultivated at the Oregon State University greenhouses in four-inch pots containing Metro-Mix® potting soil that was kept relatively saturated. Large-grained quartz was used to top dress the pots to discourage the establishment of fungus gnats that had damaged some plant stock. Bottom watering was employed to minimize conditions that would otherwise promote fungal growth on the foliage.

Recruitment Potential Results

Of the eighteen sites where plants were bagged for collection (Table 11), only sixteen sites yielded a sufficient number of seeds for inclusion in the determination of recruitment potential (Table 12); Antelope Creek 2 and Dog Creek Complex 3 were not included.

Table 12. Recruitment potential and reproductive parameters for select *L. f.* ssp. *bellingeriana* occurrences* monitored in 2015-2016.

Site name	Mean number of flowers	Mean seeds per flower	Germination rate	Recruitment per plant	Population size	Potential recruitment for each population
Antelope Creek 1	38.75	0.96	0.42	**15.57**	5,000	**77,832.5**
Antelope Creek 3	12.44	0.99	0.54	**6.68**	7,640	**51,003.5**
Antelope Creek 4	13.81	0.79	0.46	**5.05**	19,450	**98,136.6**
Antelope Creek 5	20.45	0.97	0.42	**8.33**	2,700	**22,479.7**
Beekman Ridge Complex	26.25	0.83	0.92	**20.13**	175	**3,521.9**
Dead Indian Memorial Road	25.00	0.93	0.60	**14.01**	1,150	**16,113.9**
Dog Creek Complex DC3	10.67	0.90	0.60	**5.77**	363	**2,092.8**
Double Day Road	17.88	0.84	0.82	**12.38**	250	**3,094.4**
Fredenberg Road Complex	9.23	0.87	0.72	**5.79**	195	**1,128.7**
Geppert Butte	11.33	0.95	0.08	**0.86**	1,275	**1,095.0**
Geppert Butte Complex	11.91	0.85	0.52	**5.27**	660	**3,479.2**
Jenny Creek Complex CNSM 1	6.00	0.55	0.80	**2.62**	10,000	**26,211.2**
Jenny Creek Complex CNSM 3	11.00	1.00	0.62	**6.80**	1,500	**10,199.4**
Klamath Rim 1	51.82	0.82	0.78	**32.98**	6,390	**210,737.2**
Mountain View Complex	9.40	0.68	0.64	**4.11**	1,338	**5,494.9**
Pinehurst Airport Complex East	8.60	0.84	0.86	**6.25**	1,290	**8,060.7**
Pinehurst Airport Complex West	5.13	0.85	0.66	**2.86**	2,350	**6,719.1**

*Insufficient data were available for the Antelope Creek 2 and Dog Creek Complex 3 *L. f.* ssp. *bellingeriana* populations - they are not included.

Reproductive parameters varied widely among populations (Table 12, Figures 10, 11, & 12). Overall, the plants collected for our study produced a mean of 16.75 flowers per plant. The highest mean number of flowers produced per plant occurred at Klamath Rim 1, with 51.8 flowers per plant, and the lowest occurred at Dog Creek Complex 3, with only 4.2 flowers per plant. This measure of plant size and potential fecundity varied within, and among populations, but most among-population differences were not significant ($p<0.05$ from ANOVA in XLSTAT; Figure 10). Small plants were not necessarily characteristic of small populations.

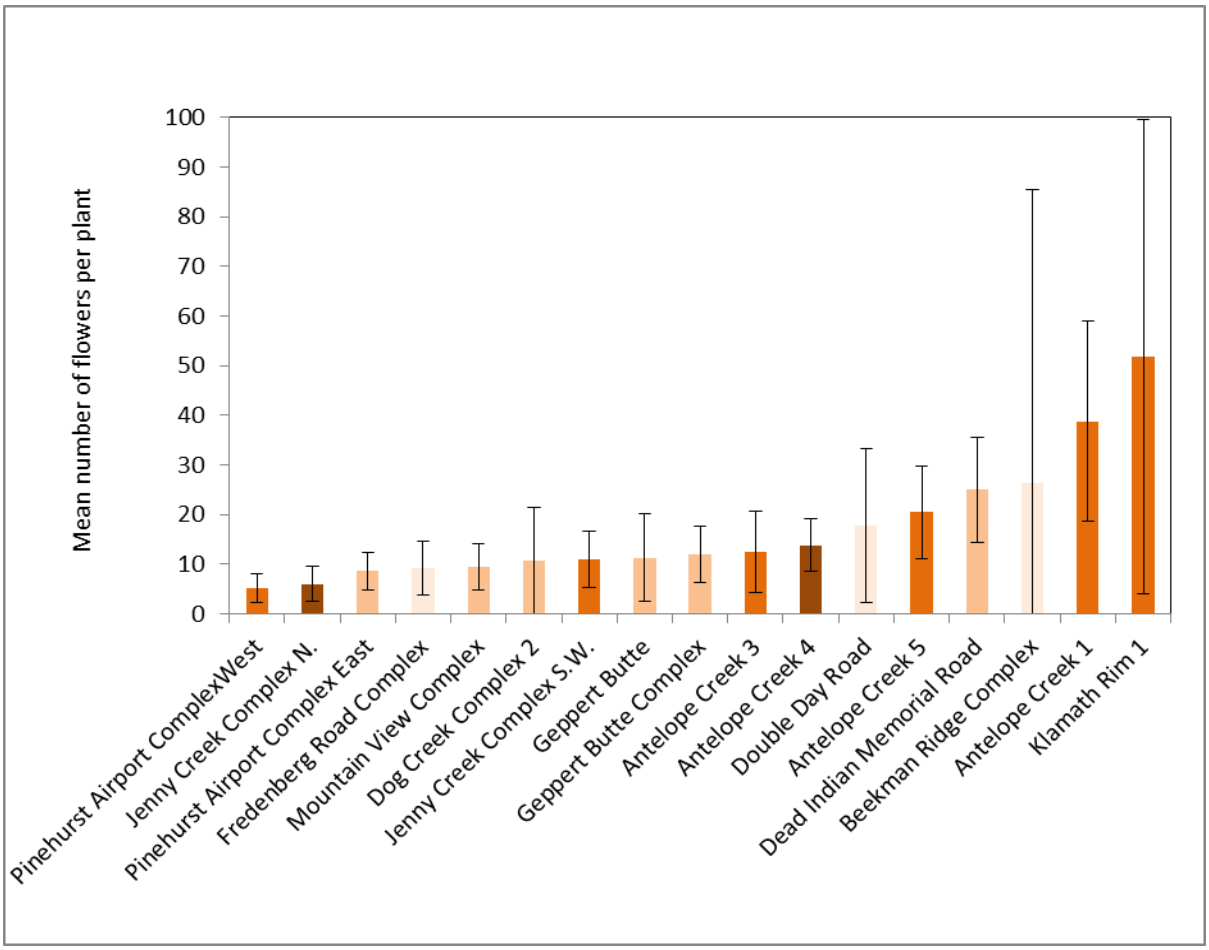

Figure 10. The mean number of flowers produced per plant varied among populations. Between four and 20 plants were collected in all populations. Error bars represent 95% confidence intervals. Bar color is darker for larger populations.
□ = populations with <500 plants; □ =500-1,499 plants; ■ = 1,500-9,999 plants; ■ = ≥10,000 plants.

The mean number of seeds produced per flower varied from 0.6 at the north *L. f.* ssp. *bellingeriana* patch of the Jenny Creek Complex to 1.01 at the southwest *L. f.* ssp. *bellingeriana* patch of the Jenny Creek Complex (Table 12). The group of seven populations producing the most seeds per flower produced significantly more than the population producing the least (Jenny Creek Complex north patch); other differences were not significant (p=0.05 from ANOVA in XLSTAT). Low seed set was not associated with small population sizes (Figure 11).

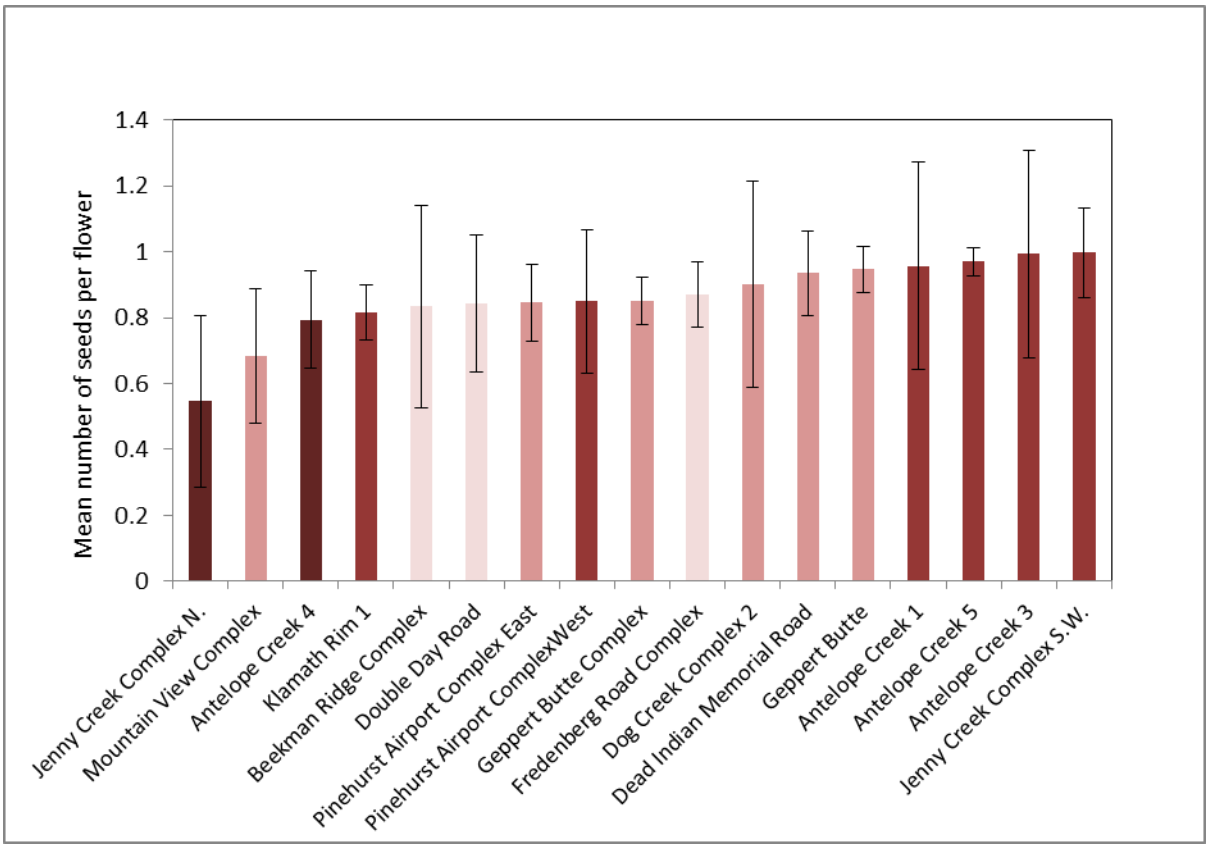

Figure 11. The mean number of seeds produced per flower varied among populations. Between four and 20 plants were collected in all populations. Error bars represent 95% confidence intervals. Bar color is darker for larger populations.
□ = populations with <500 plants; ■ =500-1,499 plants; ■ = 1,500-9,999 plants; ■ = ≥10,000 plants.

A total of 905 seeds from eighteen sites (including 19 separate accessions) underwent germination testing, and after one month, 59.9% of the seeds had germinated. The percentage of seed germination varied among populations (Table 12 & Figure 12), with seeds from Beekman Ridge Complex germinating best (92%), and those collected from Geppert Butte germinating at the lowest rate (8%). Although seeds collected from the populations in the Antelope Creek and Geppert Butte groups germinated more poorly than other populations, differences between any pair of germination rates were generally not significant ($p<0.05$ from ANOVA in XLSTAT) and germination rates were not associated with population size (Figure 12).

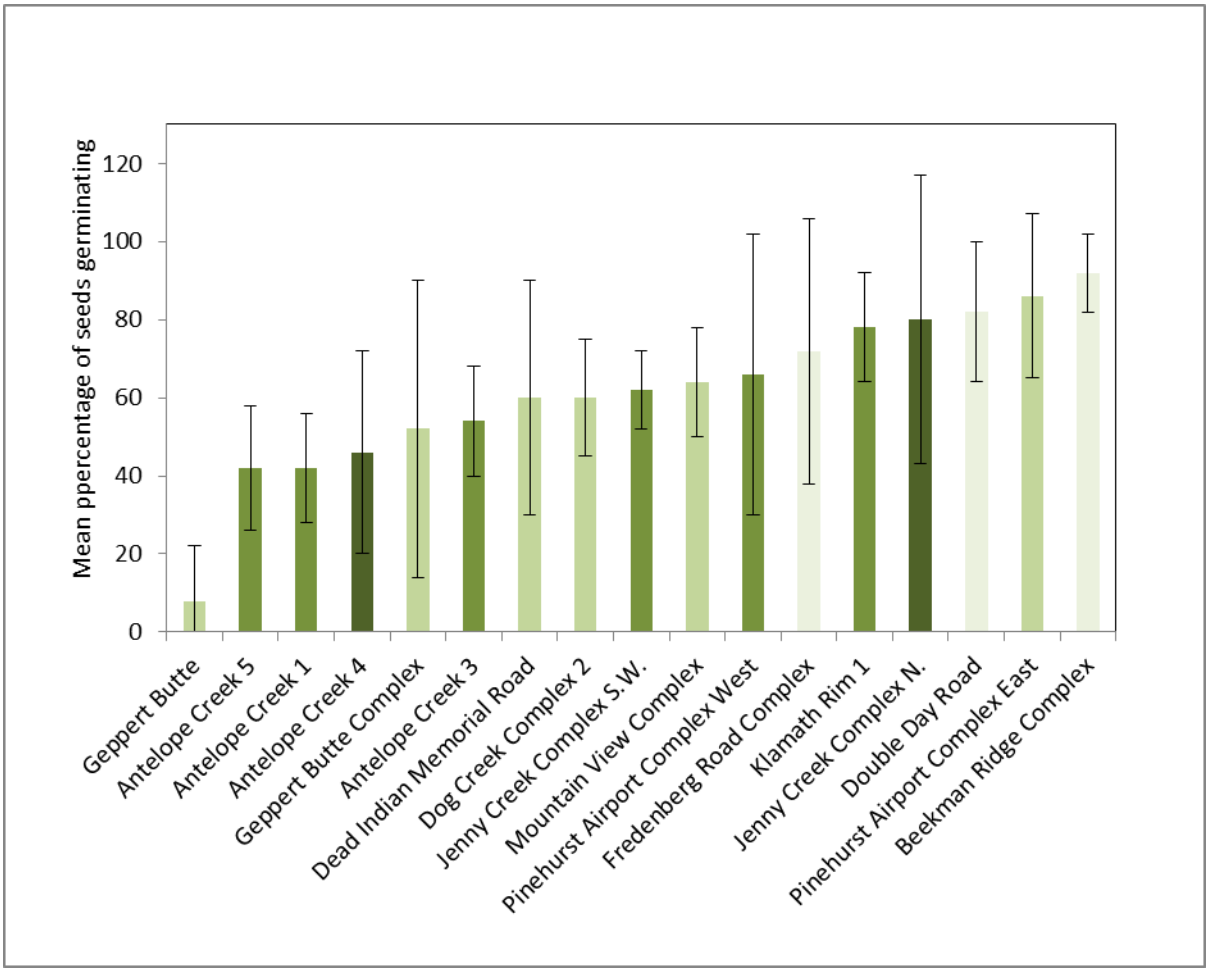

Figure 12. The mean percentage of seeds germinating (n=5) varied among populations. Error bars represent 95% confidence intervals. Bar color is darker for larger populations. □ = populations with <500 plants; □ =500-1,499 plants; ■ = 1,500-9,999 plants; ■ = ≥10,000 plants.

Seed Banking

Following the evaluation of reproductive capacity and recruitment potential for each of the populations where plants and seeds were collected in 2015, a subset of the remaining collected seeds were submitted to the Rae Selling Berry Seed Bank & Plant Conservation Program, based at Portland State University. The surplus seed collected in 2015 represents a total of 177 maternal-line accessions from 20 occurrences, all of which were submitted for long-term storage.

Additional plants were collected from the Klamath Rim 2, Pokegama Road 1, and Pokegama Road Complex 1 and 2 sites in 2016. The entire seed accessions from these sites, representing 35 maternal lines from the four occurrences, were submitted to the Rae Selling Berry Seed Bank & Plant Conservation Program for long-term storage.

Morphological Observations

Limnanthes floccosa ssp. *bellingeriana* plants that we encountered during monitoring had varying amounts of pubescence on the sepals and calyces, from glabrous to sparsely hairy, as several descriptions state (Peck 1961, Morin 2010, and Ornduff & Morin 2012). In several cases we encountered plants with more abundant and/or more prominent hairs on the sepals than typically observed, such that the pubescence was easily visible without close inspection; clusters of these hairier plants usually seemed to be localized to only a portion of a population. Occasionally, the calyx pubescence that we observed in the field seemed intermediate between descriptions of *L. f.* ssp. *bellingeriana* and the closely related *Limnanthes floccosa* ssp. *floccosa*.

The Dead Indian Memorial Road population contained plants that were not completely glabrous, with hairs on the sepals, and this characteristic had previously been reported at this site (on a BLM Special Status Plant Site Form). Greenhouse-grown plants from seeds from this site had sparsely hairy sepals and herbage. Plants with hairy calyces were also encountered at Antelope Creek 2, 3, and 5, and at the Pokegama Road Complex 2. Greenhouse grown plants from seeds collected at Geppert Butte Complex were quite hairy on the calyces and herbage. Additional *L. f.* ssp. *bellingeriana* populations may include similarly villous specimens that were not encountered during monitoring.

The spectrum of calyx pubescence observed during this project draws into question the previous determination of a lack of intermediate characters between the two subspecies (Southworth & Seevers 1997). It may be possible that these two subspecies are overlapping and capable of producing hybrids as previously reported (Ornduff 1971). A taxonomic review of *L. f.* ssp. *bellingeriana* and ssp. *floccosa* may help reconcile the observed morphological variation and identity of the two taxa.

Discussion and Recommendations

Although significant threats face *L. f.* ssp. *bellingeriana* at nearly all the sites monitored during this project (Tables 4, 6, 8, & 10), stable or increasing populations (compared to previous plant counts; see Tables 3, 5, 7 & 9) were documented at the majority of sites (22 of 32 sites). Ten sites (about one third of those monitored here) harbored populations that had declined compared to previous plant counts, and most declined drastically. The *L. f.* ssp. *bellingeriana* populations at two sites, Pokegama Road 2 and 3, appear to be extirpated (questionable spatial records are involved in both perceived extirpations) while populations at Antelope Creek 5, Geppert Butte Complex, Klamath Rim 1, and Ward Road 3 declined to ~10%, or less, of their previously reported plant counts. The four remaining population declines ranged from modest, with a ~10% decrease at Dog Creek Complex 3 and 37.5% decrease at Double Day Road, to severe, with ~70% and 80% decreases at Fredenberg Road Complex and Poverty Flat, respectively.

Population size of an annual plant can be expected to vary from year to year, but the context of documented threats at all sites indicate that the more drastic declines and extirpations may not be due to annual variation alone. In another study that included multiple years of monitoring select occurrences of *L. f.* ssp. *bellingeriana* on the Klamath Falls Resource Area, a steady decline in the number of individuals in each subpopulation was observed from 2014-2017 (Byrne 2018, personal communication; Byrne 2017). While population increases and stability documented during this project are encouraging, the documented declines and pervasive threats to this taxon should be taken seriously. Continued monitoring at regular intervals, an expansion of monitoring efforts to include more populations, and the initiation

of trial habitat restoration treatments are top priorities for improving our ability to effectively conserve this taxon.

Continued Monitoring and Data Management

The variety of approaches used to estimate *L. f.* ssp. *bellingeriana* population size and the (sometimes) unknown quality of historical data impairs our ability to accurately determine the status of this taxon. The discrepancies we see in the number of plants documented during 2015-2016 monitoring and previous plant counts, highlight the difficulty of accurately estimating the number of individuals of this taxon. Although we can't definitively comment on the validity or accuracy of past occurrence records here, our experiences during monitoring demonstrated how population size could be easily misjudged based on limited localized sampling. It was rare that *L. f.* ssp. *bellingeriana* plants would fully utilize apparently suitable habitat, so quick population size estimations that assume fully occupied habitat likely overestimate the number of plants present. Conversely, some of the occurrences are expansive and include more area than is first apparent, potentially resulting in an underestimation of population size during a quick estimation.

The preferred thorough monitoring conducted during this project is important when documenting baseline conditions, but might not always be feasible with limited time and resources. A consistent and simplified monitoring protocol should be adopted to make monitoring more attainable and to generate a more consistent and reliable dataset. A description of monitoring methods and monitoring areas need to be included with monitoring data, and plant counts should be recorded independently for each patch to improve the resolution and maximize the usefulness of records. A review of the original historical monitoring records, with these goals in mind, might yield details that can better inform population trends and site history.

Additional monitoring will help resolve several issues: the inability to determine accurate population trends based on vague and sometimes questionable historical records, the need to determine how much year-to-year variation can be expected within a population, the need to determine whether localized declines, documented here (presumed to be the result of unfavorable conditions, including the threats described in this report), are indicative of more

widespread declines resulting from the accumulation and severity of threats present across the region. Other natural *L. f.* ssp. *bellingeriana* populations in the vicinity of diminished populations should be prioritized for monitoring in order to detect additional declines in the region, if they should occur. Additional monitoring is needed to help determine what degree of annual variation can be expected within a site, and whether or not documented declines represent an early reaction to unfavorable conditions that may eventually manifest in other populations.

- Continue monitoring populations at regular intervals, prioritizing populations that have shown signs of decline (as well other populations in their immediate vicinity), populations that are highly threatened, and populations subject to a recent major disturbance (such as fire).

- Expand monitoring to include additional populations to better inform the taxon's status across its range and help determine what proportion of populations appear to be in decline and how many have been extirpated. Monitoring priorities should take into account how recently a population has been monitored (with older monitoring data being more of a priority to update) in addition to prioritization criteria listed above. Based on recommendations from BLM staff, the 2016 monitoring of Klamath Falls Resource Area *L. f.* ssp. *bellingeriana* sites focused on populations that had recently been confirmed present; populations that haven't been relocated recently and were burned (in wildfires) since last monitoring should be priorities in this area.

- Develop standard site names, standardize the spatial extent of sites, and collect monitoring data accordingly to improve the organization and consistency of data, allowing for more meaningful comparisons over time.

- Develop standardized monitoring protocols to improve the consistency of monitoring data. In large populations, consider establishing sampling protocols (such as transect or plot monitoring) that can help track *L. f.* ssp. *bellingeriana* abundance and distribution, without conducting a more time consuming monitoring of the entire population.

- Record *L. f.* ssp. *bellingeriana* plant counts on a per patch basis to maximize the resolution of the data.

- When possible, document the spatial extent of occurrences to allow us to track occupied area over time; reductions in occupied area may be indicative of otherwise cryptic threats, such as competition from surrounding vegetation and loss of suitable wet habitat.

- Conduct a review of the original documentation of occurrence records that are questionable and/or vague (e.g., apparent gross overestimates, apparently inaccurate location information, and grouped plant counts of spatially distinct or distant patches). The 100,000 plants documented at the Klamath Rim 1 site in 2014 is just one example of a record that needs to be verified by a review of the original documentation, and other records need a similar review.

Population Size and Recruitment Potential

Based on our analysis, the plant size and potential fecundity (based on flower production) varied within, and among populations, but small plants were not necessarily characteristic of small populations. Low seed set was not associated with small population sizes and germination rates were not associated with population size, suggesting that smaller populations do not have inherently reduced recruitment potential. The self-pollinating breeding system of this taxon probably protects it from some of the detrimental effects of small population size. However, small populations are more at risk from certain genetic and stochastic hazards, and increasing habitat fragmentation may eventually affect the ability of the species to persist.

The actual number of *L. f.* ssp. *bellingeriana* plants ranged from ~3% (at Klamath Rim 1) to ~38% (at Jenny Creek N.) of the calculated potential recruitment for populations included in this portion of the study. Reproductive parameters, recruitment potential, and actual *L. f.* ssp. *bellingeriana* population size within sites should be further evaluated within the context of the threats facing the sites to help determine which threats are associated with reduced reproductive success.

Invasive Weeds

Weeds have invaded all sites monitored during this project, are the dominant vegetation at most sites, and the potential for new weed introductions in the future remains (Tables 4, 6, 8, & 10; see Appendix B for a list of Noxious weeds of Southern Oregon). At numerous sites, we observed a higher prevalence of invasive grasses and other weeds in the unoccupied habitat surrounding *L. f.* ssp. *bellingeriana* occurrences than within the occupied habitat. While the dynamics between co-occurring weeds and *L. f.* ssp. *bellingeriana* is not known, weeds likely impose some level of direct competitive pressure on *L. f.* ssp. *bellingeriana*. Weed infestations can also serve as a barrier to the spread and establishment of *L. f.* ssp. *bellingeriana*, possibly interfering with patch connectivity and metapopulation dynamics that contribute to the persistence of this species on the landscape. To be prudent in the conservation of this taxon, weeds should be maintained at moderate levels within occupied areas to help encourage the persistence of *L. f.* ssp. *bellingeriana* as it exists today.

Thatch accumulation (resulting from several ubiquitous weeds), which was observed at most sites, has been shown to negatively affect the recruitment and diversity of native species (Mariotte et al. 2017), and those effects may apply to *L. f.* ssp. *bellingeriana*. In addition to being unfavorable for germination of native species, thatch accumulation has been shown to promote invasive grasses, causing a positive feedback that can result in the dominance of invasive grasses (Faist & Beals 2018). Thatch accumulation also has the potential to increase the severity of wildfire in areas that may have historically supported less vegetation cover. Increased fire intensity has the potential to expedite the depletion of the seed bank, putting the recruitment of future generations further at risk. The increased prevalence of weeds and thatch in surrounding unoccupied habitat may serve as a physical barrier, or zone of unsuitable habitat, that prevents the spread and establishment of *L. f.* ssp. *bellingeriana* in new areas, which can further threaten its ability to persistence on the landscape.

- Conduct trial habitat restoration treatments to help determine the most effective practices for reducing weeds and promoting native vegetation, habitat restoration trial treatments should be implemented. Effective management techniques developed for restoring and maintaining other vernal systems can be used as models for managing *L. f.* ssp. *bellingeriana* habitat.

- Controlled burns, herbicide applications, and seeding with native plant associates should be applied independently, and in combination, in a scientific manner to determine how these treatments affect *L. f.* ssp. *bellingeriana*, its habitat, and the associated vegetation community. Initial trials can be conducted in unoccupied vernal pool habitat to reduce the risk of negatively impacting the target species.

- Post-fire restoration actions that include herbicide treatments and seeding with native plant species should be prioritized in an attempt to break the positive feedback cycle of invasive annual grasses and wildfire.

- Include estimates of the percent cover of weeds within infested portions of a site and documentation of thatch accumulation (extent and approximate depth) in future monitoring efforts. This additional data will better characterize site threats and can help identify priorities for management.

Hydrologic Alterations

Potential threats to site hydrology were reported when development within or adjacent to *L. f.* ssp. *bellingeriana* occupied areas was encountered. Ground moving activities that alter topography or compact soil have the potential to change that way water flows above and below the soil surface. No recent development was encountered within sites and conditions appear to have stabilized where development has taken place. The validity of these potential threats to hydrology and the effects of the historical development on hydrology and *L. f.* ssp. *bellingeriana* populations are not known; generally, impacts are not expected to be drastic because suitable hydrology seems mostly dependent on perched water, rather than flowing water that could more readily be rerouted by ground disturbance. In some cases, development and infrastructure may continue to limit *L. f.* ssp. *bellingeriana* populations, and in others, it may enhance site hydrology and benefit a population. Restoring unconstrained site hydrology doesn't rank as a top priority with other immediate threats facing populations (most prominently, noxious weeds), the apparently stabilized nature of the reported hydrologic alterations, and assumed high cost of hydrologic restoration. The effects of these types of hydrologic alterations may be exacerbated if sites dry out as a result of climate

change. If populations subjected to altered hydrology decline, hydrologic restoration should be considered.

Roads were most commonly associated with this threat category, accounting for eight of the eleven reported threats. A variety of road types were encountered: simple compacted dirt track, elevated road prism built up with crushed rock, crushed rock road bed cut into a hillside, and paved highway. The different types of road construction may vary in their permeability and alter hydrology differently. Ditching along the roads (to help channel water away) and the presence of functioning culverts are also important factors influencing how a road impacts site hydrology. Threat from hydrologic alteration was also reported in relation to grading and gravelling (of a logging landing), potential gravel spreading, and deep tire ruts that divert and hold water. Most of the potential hydrologic alterations can be avoided with proper planning that reduces the chance of detrimental action.

- The hydrologic alterations reported here should be evaluated by a hydrologist to determine the validity of these potential threats. When necessary, they can inform the development of management plans with the goal of optimizing site hydrology for *L. f.* ssp. *bellingeriana* within the currently developed conditions, and provide recommendations for changes to developed areas and infrastructure that may best benefit the population.

- Site specific management plans should be provided to road maintenance and site maintenance staff, outlining specific responsibilities determined to most benefit *L. f.* ssp. *bellingeriana* (e.g., not clearing roadside ditches or culverts to maintain a site's water holding capacity, or clearing culverts to maintain patch connectivity).

Land Management

A variety of land management threats were identified in this category, including potential problems associated with anticipated road maintenance, fuels reduction activities, timber harvest, powerline maintenance, management of a pullout area, recreational use; grazing is discussed separately below. The historical installation of roads through *L. f.* ssp. *bellingeriana* occurrences, and anticipated road maintenance, are the most prevalent problems identified in this category, having been reported at eleven sites. Most roads that

intersect *L. f.* ssp. *bellingeriana* occurrences eliminate suitable habitat. Associated road maintenance has the potential to destroy plants and alter hydrology, which could result in broader impacts. Other management activities associated with the apparent logging landing at Beekman Ridge Complex, pull-out area at Poverty Flat, powerline maintenance and salvage logging at Klamath Rim 1, fuels reduction treatments at the Dog Creek Complex sites (1-4), and potential timber harvest at Pinehurst Airport Complex West can similarly destroy *L. f.* ssp. *bellingeriana* plants and render suitable habitat unsuitable. Proper planning can help avoid and minimize impacts of sanctioned actions. Recreation use was only observed at Antelope Creek 1 and impacts appeared to be minimal, so mitigating this type of threat is not a priority.

- Occurrences of *L. f.* ssp. *bellingeriana* that are intersected by infrastructure, development, and management activities need to be well documented, including both occupied and unoccupied habitat that may be impacted.

- Management plans that address anticipated management and maintenance activities should be drafted to provide guidance for best avoiding unanticipated impacts to *L. f.* ssp. *bellingeriana* occurrences.

- Management activities within *L. f.* ssp. *bellingeriana* habitat should be scheduled for after the plants senesce (approximately in July), to allow plants to set seed, but before autumn rains saturate a site, to avoid unnecessary ground disturbance (tire ruts) that would more likely occur when soils are wet.

- *Limnanthes floccosa* ssp. *bellingeriana* seed should be collected before potentially damaging activities are scheduled to ensure the *ex-situ* (off-site) conservation of the occurrence in question; collected seeds can be used to augment the occurrence as needed following the disturbance.

Grazing

Grazing was not identified as a prominent or immediate threat at any of the sites visited during monitoring. However, impacts from grazing were observed at two thirds of the sites where *L. f.* ssp. *bellingeriana* was found and may be occurring at more sites. Most signs of

grazing consisted of moderately damaged plants that had flowers and upper portions of the stems removed; *L. f.* ssp. *bellingeriana* doesn't appear to be preferentially grazed, but rather inadvertently browsed with surrounding vegetation. We observed plants that had survived browsing and continued to grow and flower, likely still producing seed (albeit reduced) later in the year. We are not able to quantify how many plants may be entirely lost to grazing, or the extent to which grazing reduces flower and seed production within a population. Potential indirect effects of grazers, including, but not limited to, their ability to break down accumulated thatch, ability to promote the establishment and spread of weeds, and ability to promote *L. f.* ssp. *bellingeriana* germination and establishment (via hoof mediated "planting" of seeds), are also poorly understood.

Most evidence of grazing could not be definitively attributed to wild herbivores or domesticated livestock. Only at the Dog Creek Complex sites (1-4) were signs of cattle obvious. While it appears that wild herbivores and domesticated livestock impact *L. f.* ssp. *bellingeriana*, it is not currently feasible (or warranted) to control native grazers. Efforts to reduce grazing impacts should first focus on domesticated livestock grazing, which is already managed, and can be coordinated to minimize damage.

- Compile an inventory of active grazing allotments containing *L. f.* ssp. *bellingeriana* occurrences to better understand what proportion of public-land occurrences are subjected to controlled grazing.
- Domesticated livestock grazing should be avoided within *L. f.* ssp. *bellingeriana* occupied areas during their growing season and limited to late summer and fall; after plants have fully developed seeds in July and August, and ending prior to seed germination.
- In the absence of other weed control, grazing of within *L. f.* ssp. *bellingeriana* sites should not be completely eliminated because it likely promotes the breakdown of accumulating thatch that may otherwise.
- The Pokegama Herd Management Area appears to include the majority of Oregon *L. f.* ssp. *bellingeriana* occurrences along the state border, on both Ashland and Klamath Falls Resource Areas. Although their impact on *L. f.* ssp. *bellingeriana* is not known, the horses' ability to bite close to the ground could result in greater grazing damage to plants.

Unmanaged feral horses can graze year-round, unlike most managed cattle grazing, which has the potential to result in greater impacts to the vegetation community and increased indirect effects on *L. f.* ssp. *bellingeriana*. Removing the non-native feral horses, or limiting their access to *L. f.* ssp. *bellingeriana* sites, especially during the plant's growing season, should be considered.

Off Highway Vehicle Activity

Although OHV activity can damage and destroy plants, and disturb the habitat (perhaps irreparably in extreme cases), the effects of OHV activity observed during this study do not appear to constitute a substantial threat to *L. f.* ssp. *bellingeriana*. There were eight instances of OHV activity documented within *L. f.* ssp. *bellingeriana* occupied areas, most involving only one set of tire tracks, but in some cases involving several sets of tire tracks; four sites were threatened by potential OHV activity, where evidence of vehicle activity was observed in adjacent unoccupied habitat. These apparently limited disturbances don't appear to have much of a lasting impact on a site; the resulting disturbed areas were already being recolonized by plants, occasionally including *L. f.* ssp. *bellingeriana*. Vehicle-caused changes to site topography have the potential to be detrimental or beneficial: tire ruts can negatively impact habitat by promoting excessive drainage, but can also create low areas that hold water and are better suited for *L. f.* ssp. *bellingeriana*. Periodic disturbance can create areas of bare soil where *L. f.* ssp. *bellingeriana* might establish with limited competition, potentially helping to promote persistence within a site; conversely, OHV disturbance may promote infestations of noxious weeds.

The partially exposed broken pumice cobbles that are intermixed with soils at many of the sites may discourage OHV activity by posing a hazard to vehicle tires. Sites without rocky substrates may be more regularly utilized by OHV enthusiasts.

- Continue to check for evidence of OHV activity during future monitoring.
- The installation of OHV barriers should be considered for sites where repeated or extreme OHV-related disturbances occur. Currently, the installation of barriers should be considered for Antelope Creek 6 and Beekman Ridge Complex.

- Although vehicle traffic at the Antelope Creek sites may be restricted by the gate on Road 37-2E-7.1, evidence of OHV activity was encountered at four of our six monitoring sites. The source and entry point of this OHV traffic should be determined in order to have the option to manage it.

Encroachment

Limnanthes floccosa ssp. *bellingeriana* grows amongst high elevation vernal pools, often in the shallow soils of rocky meadows. The habitat usually contains sparse trees, if any, and sparse shrubs (mostly buckbrush [*Ceanothus cuneatus*]) that most often occur in adjacent unoccupied habitat that is slightly higher a drier. The abundance and presence of woody vegetation was documented as a potential threat at four sites where either open habitat is relatively restricted, shading occurs at above-normal levels, or trees are establishing within occupied habitat. Encroachment was also reported from the Ward Road 2 site, which is located in forested habitat, but incorrect location information is likely responsible for this reported threat. The impact of encroaching woody vegetation on *L. f.* ssp. *bellingeriana* is not known, but it can increase transpiration rates, canopy cover, and shading of low-growing forbs within a site.

- If *L. f.* ssp. *bellingeriana* populations decline at a site that is encroached upon by trees and/or shrubs, then trial thinning treatments should be applied in an attempt to relieve competition.

- The *L. f.* ssp. *bellingeriana* populations at the Double Day Road and Fredenberg Road Complex sites, which appear to have already declined, are good candidates for fuels reduction treatments. Removing some of the peripheral shrubs and trees may relieve these populations if they have been suffering from shading.

- The previously mapped occupied area at the Ward Road 3 site is mostly overgrown with buckbrush (the population appears to have declined) and common juniper (*Juniperus communis*) is establishing in portions of occupied habitat at the Jenny Creek Complex. These two sources of encroaching woody vegetation should be removed to restore and maintain open habitat, and reduce transpiration that can dry a site.

Miscellaneous

- Proactively initiate a comprehensive *ex situ* conservation plan for *L. f.* ssp. *bellingeriana* that involves collecting seeds for long-term storage in a regional seed bank; additional seed collections can contribute to augmentation and reintroduction efforts as well. Seed accessions should be collected from across the taxon's range and seed collections of other vernal pool associates should be included as deemed worthwhile. Sustainable collection practices must be followed to minimize impacts to seed-source populations.

- Climate change was reported as a potential threat at several sites where observed dry conditions sparked some concern. It has been shown that invasive weed invasion of vernal pools can increase in dry years (Faist & Beals 2018), potentially resulting in increased thatch accumulation that can initiate a positive feedback that has a lasting impact of promoting invasion by weeds. This dynamic may already be affecting *L. f.* ssp. *bellingeriana* sites, and if inundation regimes change, this might become a more prominent problem.

- Develop site-specific management plans that provide guidance to managers for highly threatened *L. f.* ssp. *bellingeriana* populations that show signs of decline.

- Investigate the longevity of the *L. f.* ssp. *bellingeriana* seed bank and recruitment potential from the seed bank to provide information on the ability of populations to rebound and recover on their own.

- At a small number of the monitored sites, portions of the *L. f.* ssp. *bellingeriana* occurrences extended onto private land. Although the plants on private land did not appear to be threatened, they are not protected and may be inadvertently lost. Sites where ownership division is a factor could be considered for informational outreach to neighbors to promote the conservation of the occurrence.

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Appendix A: Monitoring Data Collection Form

Limnanthes floccosa ssp. *bellingeriana* - status evaluation monitoring

Date: **Data collectors:**

Site name: **Site #:** BLM (FLSiteID)
ORBIC (EO_ID)

Population group:

Directions:

Locations Label
Latitude: N
Longitude: W
Accuracy ±

Number of plants: estimation or census

Area occupied (estimated in meters): **Boundary mapped** [ ]
Track Name:

Phenology: % fruiting: % flowering: % veg:

Plant community & associated species:

Moisture %: flowing, saturated, moist, dry

Non-native & invasive species threats:

Additional threats: (% of occupied area, severity, % unoccupied habitat, proximity)
Hydrology
Grazing
Off-road vehicles
Land management

Appendix B: Noxious Weeds of Southern Oregon

Oregon state-listed noxious weeds of Jackson and Klamath Counties

Species Name	Common Name	Weed Class
Acroptilon repens	Russian knapweed	B
Alliaria petiolata	Garlic mustard	B
Cardaria draba	White top (Hoary cress)	B
Cardus nutans	Musk thistle	B
Carduus acanthoides	**Plumeless thistle**	**A**
Carduus phycnocephalus	Italian thistle	B
Centaurea calcitrapa	**Purple starthistle**	**A**
Centaurea diffusa	Diffuse knapweed	B
Centaurea pratensis	Meadow knapweed	B
Centaurea solstitialis	Yellow starthistle	B
Centaurea stobe	Spotted knapweed	B
Centaurea virgata	**Squarrose knapweed**	**A**
Chondrilla juncea	Rush skeletonweed	B
Cirsium arvense	Canada thistle	B
Cirsium vulagre	Bull thistle	B
Conium maculatum	Poison hemlock	B
Convolvulus arvensis	Field bindweed	B
Cynoglossum officinale	Houndstounge	B
Cytisus scoparius	Scotch broom	B
Dipsacus laciniatus	Cutleaf teasel	B
Euphorbia esula	Leafy spurge	B
Geranium lucidum	Shiny geranium	B
Hedera helix	English ivy	B
Hieracium aurantiacum	**Orange hawkweed**	**A**
Hypericum perforatum	St. Johnswort	B
Iris pseudacorus	Yellow flag iris	B
Isatis tinctoria	Dyer's woad	B
Kochia scoparia	Kochia	B
Lathyrus latifolius	Perennial pea	B
Lepidium latifolium	Perennial pepperweed	B
Linaria dalmatica	Dalmatian toadflax	B
Linaria vulgaris	Yellow toadflax	B
Lythrum salicaria	Purple loosestrife	B
Nardus stricta	**Matgrass**	**A**
Onopordum acanthium	Scotch thistle	B
Onopordum tauricum	Taurian thistle	B
Polygonum cuspidatum	Japanese knotweed	B
Potentilla recta	Sulfur cinquefoil	B
Rubus armeniacus	Himalayan blackberry	B
Salvia aethiopis	Mediterranean sage	B
Senecio jacobaea	Tansy ragwort	B
Spartium junceum	Spanish broom	B
Taeniatherum caput-medusae	Medusahead rye	B
Tamarix ramosissima	Saltcedar	B
Tribulus terrestris	Puncturevine	B
Xanthium spinosum	Spiny cocklebur	B

Appendix C: Occurrence Areas from 2015-2016 *Limnanthes floccosa* ssp. *bellingeriana* Monitoring

Table C1. Amounts of *Limnanthes floccosa* ssp. *bellingeriana* occupied area in the 2015 monitoring sites.

Region code*	Site name	EO_ID	FLSITE_ID	Occupied area (m^2)
AC	Antelope Creek 1	26437	3904	13,800
AC	Antelope Creek 2	26437	3905	5,485
AC	Antelope Creek 3	26437	4617	9,681
AC	Antelope Creek 4	26437	4618	18,406
AC	Antelope Creek 5	26437	4620	22,628
AC	Antelope Creek 6	26437	4621	1,406
AC	Dead Indian Memorial Road	30173	12461	3,118
BF	Beekman Ridge Complex	34396	13677	843
BF	Dog Creek Complex 1	24992	2161	289
BF	Dog Creek Complex 2	24992	2162	592
BF	Dog Creek Complex 3	24992	2163	71
BF	Dog Creek Complex 4	24992	2023	1,855
BF	Double Day Road	24990	1946	2,008
BF	Fredenberg Road Complex	34395	13674	869
BF	Geppert Butte	32069	8972	14,127
BF	Geppert Butte Complex	32069	8973	2,832
BF	Poverty Flat	8825	78,295	236
CSNM	Jenny Creek Complex	17061	291,72	6,530
KF	Klamath Rim 1	20394	400511_LIFLB _HAYDENFOX	86,831
CSNM	Mountain View Complex	14282	355	1,244
CSNM	Pinehurst Airport Complex East	14282	354, 8153	1,203
CSNM	Pinehurst Airport Complex West	14282	354, 8153	656

* AC = Antelope Creek; BF = Butte Falls Resource Area; CSNM = Cascade-Siskiyou National Monument; KF = Klamath Falls Resource Area

Table C2. Amounts of *Limnanthes floccosa* ssp. *bellingeriana* occupied area in the 2016 monitoring sites; all sites located on Klamath Falls Resource Area.

Site name	EO_ID	FLSITE_ID	Occupied area (m^2)
Grizzly Flat	16097	KFRA_LIFLB_05112005 _POKE1	13,028
Klamath Rim 2	8446	KFRA_LIFLB_05231996 _POKE7	38,161
Pokegama Road 1	10666	PLANTS_LIFLB_HF_2012 _LMV_GV01	1,351
Pokegama Road 2	10666	PLANTS_LIFLB_HF_2012 _LMV_GV04	68
Pokegama Road 3	10666	PLANTS_LIFLB_HF_2012 _LMV_GV03	159
Pokegama Road Complex 1	10666	KFRA_LIFLB_05251996 _POKE2	13,970
Pokegama Road Complex 2	10666	KFRA_LIFLB_05251996 _POKE1	29,325
Ward Road 1	17094	LIFLB_HAYDENFOX_2013 _JDS13-228	196
Ward Road 2	17094	KFRA_LIFLB_05251996 _POKE1	1,520
Ward Road 3	17094	KFRA_LIFLB_05251996 _POKE3	31

Appendix D: Occurrence Locations from 2015-2016 Monitoring

Available upon request.

Appendix E: *Limnanthes floccosa* ssp. *bellingeriana* Distribution Maps from 2015-2016 Monitoring

Available upon request.