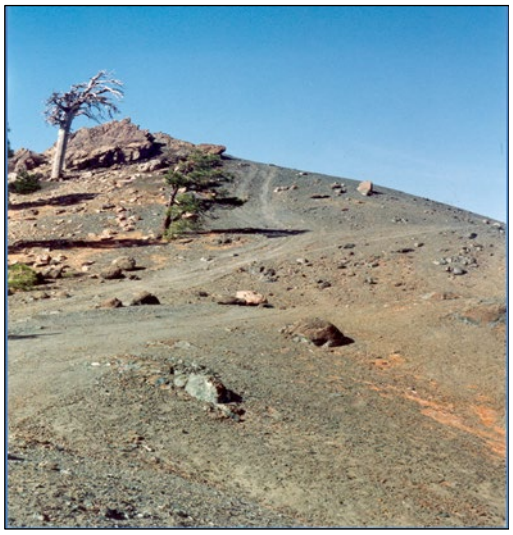
LASSICS LUPINE CONSERVATION STRATEGY 2020



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Date

Lassics Lupine Conservation Strategy

Region 5, Six Rivers National Forest, Mad River Ranger District

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Acknowledgements

In 1979, Thomas Nelson obtained his Master's Degree at Humboldt State University by completing his thesis "A Flora of the Lassics, Humboldt and Trinity Counties, California". His work brought to light the unique flora of this region and a few years later he described a new species endemic to this region, the Lassics lupine (*Lupinus constancei*; T.W. Nelson & J.P. Nelson). Since its discovery, partnerships were established to better understand the ecology of this species to inform and guide conservation measures from Lassics lupine monitoring to small mammal studies.

Six Rivers National Forest:

- John McRae, assistant forest botanist, coordinates in-situ and ex-situ conservation studies and drafted the document "Lassics lupine (*Lupinus constancei*) seed banking and plant propagation conservation studies and guidelines," which is cited in this document.
- Tracy Cline, district wildlife biologist, conducted one of the earliest studies to identify the main seed predators of the Lassics lupine.

California Native Plant Society, North Coast Chapter:

- Bob Wunner, botanist working under a cost-share agreement with the Six Rivers National Forest undertook plant inventories of the Lassics Region to map and describe rare species, their habitats and plant communities in the area.
- Sydney Carothers, working under a cost-share agreement with the Six Rivers National Forest is the lead botanist for the demographic monitoring and associated data analyses, and she has also documented the fire history of the Lassics Region and participates in in-situ seed studies.
- David Imper participates in demographic monitoring, caging, wildlife studies and initiated in-situ planting studies in unoccupied habitat and continues the collection of climate data and associated data summaries.
- Gary Falxa implements small mammal capture studies by habitat and subsequent data summary, and also initiated a Lassics lupine caged/uncaged experiment.

Humboldt State University:

- Dr. Erik Jules, Professor, Department of Biological Sciences, has been involved in various conservation studies related to the Lassics lupine. A primary focus was associated with the design of the annual demographic monitoring protocol and the use of the monitoring data to support graduate student research related to population viability analyses of the Lassics lupine.
- Dr. Dan Barton, Associate Professor-Chair, Department of Wildlife, is involved in sampling, data collection and associated analyses of mammal species associated with predation and herbivory of the Lassics lupine. This investigation has also involved graduate student research.

- Dr. Jeff Kane, Associate Professor – Fire Ecology and Fuels Management, is involved in studying the role fire, specifically heat and smoke, plays in the germination of Lassics lupine. This investigation supports graduate student research.

U.S. Fish and Wildlife Service:

- David Imper, botanist, was responsible for the sampling and analysis of soils and climate data relative to the Lassics lupine and documentation of this study and findings.
- Gary Falxa, wildlife biologist, was responsible for small mammal capture studies to assess the species and their abundance in association with the Lassics lupine occurrences.
- Jenny Hutchinson, biologist, helped to secure funding for population viability analysis and wildlife studies, and assists in demographic monitoring and caging, as well as planning partnership meetings.

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Introduction

Background and Conservation Issues

- Lassics lupine (Lupinus constancei) is a narrow endemic. The entire range of the species is an area less than 1 square kilometer and consists of one population. One sub-population (>90% of individuals) occurs in the Mt. Lassic Wilderness and the second sub-population occurs in the adjacent Lassics Botanical and Geological Area on the Mad River Ranger District of the Six Rivers National Forest (SRNF) in northwest California.
- Lassics lupine is ranked by the California Natural Diversity Database as G1/S1 meaning the species is "Critically Imperiled at the Global and State level, at very high risk of extinction due to extreme rarity, very steep declines or other factors". The species is currently listed by SRNF as "Forest Sensitive", defined as species for which management decisions will not result in a trend towards federal listing and loss of viability (USDA 1997). In April 2018, the California Fish and Game Commission found that the information on the species status warranted listing as endangered under the California Endangered Species Act (CDFW 2018). As of 2020, the US Fish and Wildlife Service (USFWS) is conducting a status review to determine if listing is warranted under the Federal Endangered Species Act.
- In 2012, a population viability analysis (PVA) of Lassics lupine was completed by Humboldt State University (HSU) graduate student, Helen Kurkjian (Kurkjian 2012a). The analysis was based on lupine demographic monitoring data conducted annually by the USFS in partnership with the California Native Plant Society (CNPS) that began in 2001. The PVA indicated that in the absence of active management, the species has a high risk of going extinct within 50 years. At the time of the PVA development the population estimate was 620 individuals.
- Since the PVA model, the population overall increased for two years then began to decline in 2014 from approximately 807 individual plants at the end of the sampling season to 350 individuals counted in July of 2015. Drought conditions—low winter snowpack, relatively higher summer temperatures—influenced this decline. In late August 2015 and into September, the Lassics Wildfire (Mad River Complex) burned through two of the three occurrences/concentrations of the lupine. Demographic monitoring since the wildfire has indicated a positive response, not only in the stimulation of the seed bank resulting in seedlings, but also the rate at which seedlings developed into reproductive individuals (Carothers 2020). The response of the Lassics lupine to the wildfire has triggered investigations into the role of fire in the species' long-term population viability.
- Threats to the species vary and are cumulative as well as inter-related: from seed predation by small mammals (granivores), plant herbivory, vegetative succession whereby trees and shrubs grow into once open or barren habitat (habitat associated with Lassics lupine) and stochastic environmental events related to changes in solar radiation, soil moisture and precipitation that can and have resulted in plant desiccation.

Goal and Objectives of the Conservation Strategy

This conservation strategy was developed to aid in the recovery of the Lassics lupine population to a level that best ensures long-term viability of the species. The strategy objectives are to a) document past and ongoing conservation actions, key findings, and of those – which to continue, to adapt, or to end, b) identify additional conservation measures needed to best ensure population viability, c) identify any

research needs to fill data gaps and guide conservation efforts, and d) clarify roles/responsibilities of the respective agencies and other partners. Partners supporting monitoring, studies and research include the California Department of Fish and Wildlife (CDFW), CNPS, and HSU Departments of Biological Sciences and Forestry and Wildland Resources.

Lassics Lupine – Species Information

Biology and Habitat

The Lassics lupine (*Lupinus constancei*) was first described in 1980 (Nelson 1980). Lassics lupine is a short-lived perennial; individual plants have been observed to live eight up to 12 years. Plants are tap-rooted with a woody base, grow close to the ground in a matted habit, and may reach a diameter of approximately 12 inches. The flowering stalk emerges from the matt of hairy leaves and supports a dense cluster of pink to dark rose and white flowers (Figure 1). Flowers are pollinated primarily by yellow-faced bumble bees (*Bombus vosnesenskii*) and mason bees (Osmia spp.).

Figure 1. Lassics lupine (Lupinus constancei). Photo: D. Imper.

On average, a reproductive plant develops 4 inflorescences that support 10 to 11 pods each and each pod contains 2 seeds for a total of around 80 seeds per reproductive plant (Carothers 2016). At maturity, the capsules break along the suture and seeds may fall close to the parent plant or project several feet away. Studies to date indicate that seeds can remain viable in the soil for at least 5 years; however, germination rates decline notably after the first year (Carothers 2013).

Geographic Distribution and Habitat

Lassics lupine is endemic to two peaks of the Lassics Range in Humboldt and Trinity counties on the Mad River Ranger District of the SRNF. The species' entire range consists of two sub-populations: one at the base of Red Lassic Peak and the other about 0.7 miles away on Mt. Lassic, between at about 5,200 to 5,700 feet elevation. Combined, the occupied habitat covers between 3 and 5 acres. Lassics lupine is most commonly associated with shallow serpentinized peridotite, characterized by sparce vegetation and thus little to no organic layer (Alexander 2008). The soils supporting Lassics lupine, compared to adjacent unoccupied soils, have in common the following characteristics: soil texture and similar concentrations of carbon, nitrogen, magnesium, lead and nickel (USFWS 2012).

The largest lupine occurrence is on Mt. Lassic on a serpentine saddle and adjacent north-facing slope. The saddle and adjacent habitat are primarily barrens with rock outcrops and scattered patches of buckbrush (*Ceanothus cuneatus*), stunted Jeffrey pine (*Pinus jeffreyi*) and incense cedar (*Calocedrus decurrens*) trees. The slope ranges from 0 to 80 percent. Further down the north slope of Mt. Lassic, a small number of lupines occur under a canopy of Jeffrey pine with incense cedar in deep needle litter among scattered Lassic sandwort *(Sabulina decumbens)* plants, a Forest Sensitive plant species. The presence of trees and associated shade (albeit less so after the 2015 fire) and litter accumulation distinguish this site from others.

The Red Lassic occurrence is isolated from the Mt. Lassic occurrences both in terms of distance, aspect and surrounding unsuitable habitat (e.g., steep slopes, shrub dominated communities, different soil type) (USFWS 2012). Plants are concentrated beneath an open canopy of old-growth Jeffrey pine trees, most of which were killed in the Lassics Fire. Aspect at this site is southwesterly. Over the span of demographic monitoring, this occurrence has supported the fewest number of plants.

Land Allocation

Both the Red Lassic and Mt. Lassic occurrences are within the Lassics Botanical and Geologic Area Special Interest Area (SIA) of SRNF. With the designation of the Mt. Lassic Wilderness in 2006, the Mt. Lassic occurrence now coincides with the Wilderness (Figure 2).

Special Interest Areas

Special Interest Areas were established by the *Six Rivers National Forest Land and Resource Management Plan* (Forest Plan; USDA 1995) to protect unique ecological, botanical, cultural, and geologic features across the forest and to promote public use, education and enjoyment consistent with the values of each area. The Forest Plan provides overall direction for management of SIAs and specific management for each SIA is directed by the *Special Interest Area Management Strategy* (USDA 1998). The primary goal for the SIA is to manage for the full complement of species and plant communities as well as the natural processes that support them.

Wilderness

As a part of the Northern California Coastal Wild Heritage Wilderness Act, approximately 7,000 acres (11 square miles) of the Mt. Lassic Range was incorporated into Wilderness in 2006. The orientation of the 2006 Act is—in keeping with the earlier Wilderness bills—to preserve wild and natural features of these landscapes, protect the diverse array of ecosystems (plants, animals, geologic/hydrologic structures), retain and enhance scientific research, and promote the recovery of Threatened and Endangered Species.

While there was the orientation toward "preservation" there was also recognition that the status quo for some of these wildernesses is not in keeping with conservation of the natural values for which the areas were established. For example, active management, such as prescribed fire, may be required to re-establish vegetation disturbance-succession processes (USDI/USDA 2006) that maintain the open, barren habitat suitable for Lassics lupine. Appendix A summarizes the policy and direction for research and management in the Wilderness.

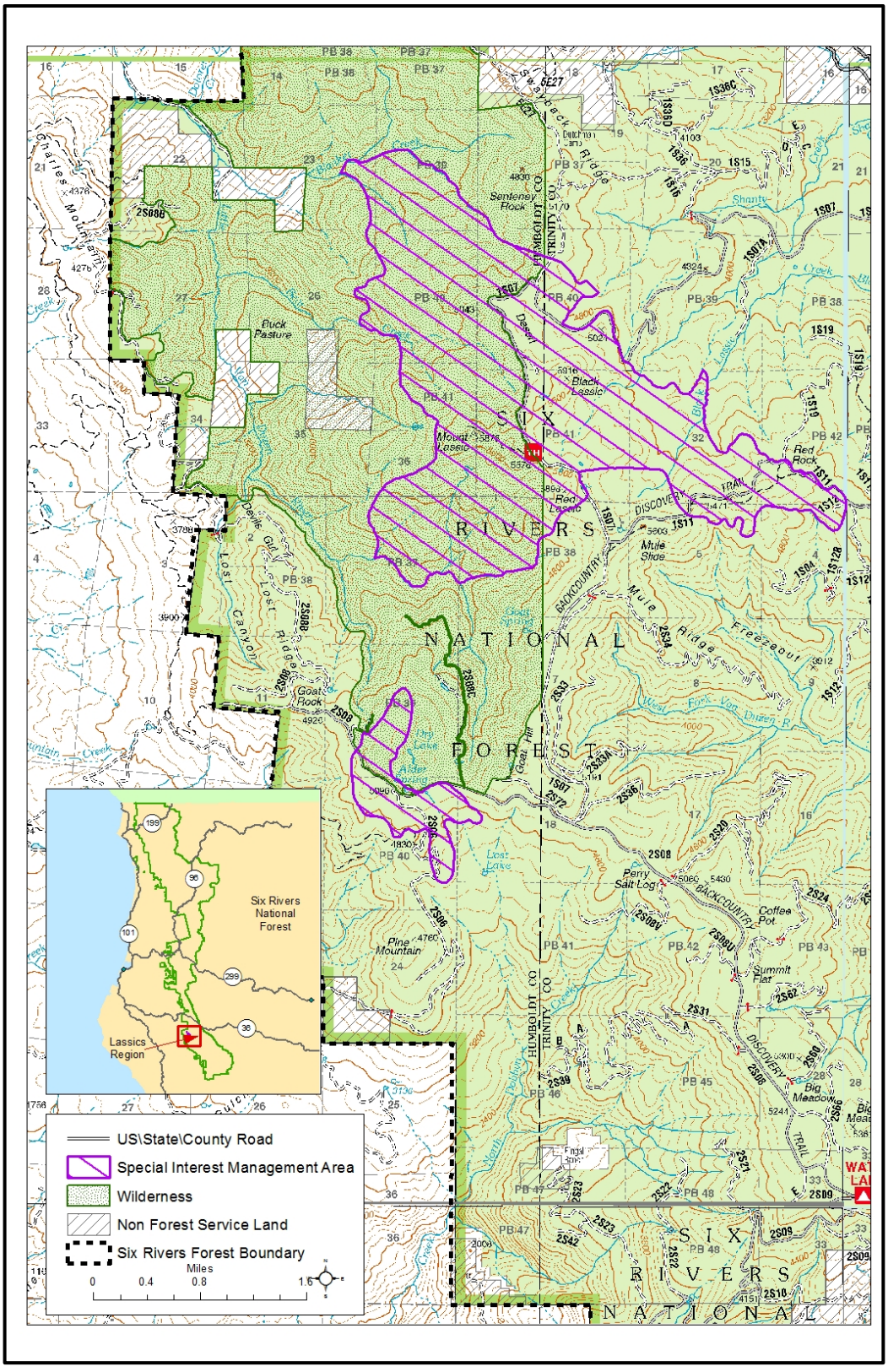

Figure 2. Lassics Region.

Monitoring, Research, Studies & Management Actions to Date

Lassics lupine:

- Lupine population demographic monitoring and trends led by Sydney Carothers, contract Botanist with the CNPS, from 2001-2020, at three transects: Lassics Saddle, North Slope Forest, and Red Lassic. A fourth transect was added in 2016 to capture plants located near the top of Lassic Peak—the Terrace transect.
- Genetics (Wilson and Hipkins 2004).
- Pollination study (Crawford and Ross 2003).
- Seed production and factors influencing the number of seeds produced per plant (Kurkjian 2012, Carothers 2016).
- Using demographic data, a population viability analysis was completed for the Lassics lupine (Kurkjian 2012).
- Fire effects on seed germinability (Lopez et al. 2019, ongoing).

Studies to define characteristics of lupine habitat:

- Soil survey to characterize soils associated with Lassics lupine and identify other sites in the area (sample area of 123 acres) with soil attributes similar to those of Lassics lupine (Alexander 2008).
- Soil chemistry studies comparing macro- and micronutrients and heavy metal concentrations in occupied and unoccupied Lassic lupine habitat areas (USFWS 2012).
- Multi-year environmental measurements including precipitation, temperature and snowmelt and their effects on plant mortality (USFWS 2012, Imper 2020).
- Historic aerial photo analysis and review of fire history records (and associated management actions), to document the influence of fire, or lack thereof, on vegetative succession into once barren habitat (Carothers 2008, Carothers 2017).

Small mammal and seed predation studies and monitoring:

- Small mammal monitoring since 2004 using wildlife camaras, live-trapping, and track plates to determine the species, abundance of small mammals by habitat type, herbivory and seed predation sampling (Cline 2004, USFWS 2013, Barton 2018).
- Pre-seed dispersal studies comparing extent of predation/herbivory between caged reproductive (wire mesh cages) and uncaged reproductive plants from 2003 to present (USFWS 2013, Barton 2018).
- Seed production study to determine a) the relationship between the number of inflorescences, pods per inflorescence and seeds produced, b) factors that may influence seed production and c) predation rates comparing caged and uncaged reproductive plants in 2010 and 2011 (Kurkjian 2012) and continued through 2016 (Carothers 2016).
- Small mammal movements between chaparral, forest and open/barren habitats in relation to the influence of distance between habitat and the risk of pre-dispersal seed predation (granivory; Cate 2016).

In-situ, ex-situ seed planting studies and seed banking:

- Buried seed study (Jules 2008) to determine seed bank viability (Carothers 2013).
- Un-scarified seed in-situ planting at unoccupied settings with suitable soils from 2003 to 2009 and subsequent monitoring.
- Paired in-situ planting of scarified seed proximal to reproductive plants (Carothers 2015). Experiment designed to compare germinability of robust, full seeds versus indented, less robust seeds.
- Post-wildfire planting of scarified seed in "micro" transects 2017 and 2018 proximal to Lassics lupine plants.
- Ex-situ propagation experiments at Berry Botanical Garden (2007), two nursery locations in NW California (Blue Lake in 2015 and Freshwater CA in 2017), Leach Botanical Garden (Portland OR) in 2015, and UC Botanical Garden (Berkeley, CA) in 2017.
- For the purpose of conservation seed banking, Lassics lupine seed was sent to the National Laboratory for Genetic Resource Preservation in Colorado for long-term storage in 2015 and 2019.
- Incorporating information developed by the Center for Plant Conservation (Menges et al. 2004), seed guidelines were drafted for the use of seed for in-situ and ex-situ purposes as well as seed banking and research (USDA 2020).

Land management actions:

- 1995: Decommissioned a non-system road within the area and converted road to a non-motorized trail only.
- 2003-present: Installed seasonal plant exclosures (wire-mesh cages) to reduce seed loss to small mammals, and to reduce browsing by deer, rabbits, or other mammals.
- 2004-2006: Installed boulders at various sites off Forest Service Road 1S07 to prevent cross-country vehicle travel into the Lassics into lupine habitat.
- 2004: Developed a trailhead and hiking trail, which directs hikers away from the Lassics saddle, where the majority of plants exist.
- 2017 to current: Installed directional trail markers to deter hikers from walking cross-country through occupied Lassics lupine habitat.

Key Findings from Research, Studies & Monitoring

Lupine Population Trends and Related Plant Studies

- Demographic monitoring has occurred at least annually at Mt. Lassic and Red Lassic since 2001. With seasonal exclosures (caging) on a subset of reproductive plants (since 2003), population size has increased from the very low numbers prior to cage installation yet the population size has also fluctuated since 2006. The smallest population sizes at the end of the sampling season measured were in 2007, 2010, and 2015, with 362, 358, and 350 plants, respectively, and the highest population sizes were in 2012, 2014, 2019, and 2020 with 984, 807, 844, and 1233 plants, respectively (Carothers annual demographic monitoring reports 2001-2020). Demographic monitoring in 2020 represents the largest population estimate in 20 years of monitoring.

- The PVA of 2012 indicated that without exclosures and at the current rate of seed predation, the population would decline at all sites, with a greater than 68 percent chance of all populations going extinct within 50 years **(**Kurkjian 2012a). Even with caging at the recent level, the PVA found some risk of extinction. The PVA recommended that caging of reproductive plants be continued in the short-term while long-term measures are sought to reduce seed predation.
- The PVA also recommended an examination of the relationship between seed predation and the proximity of the encroaching forest and chaparral edges, with the goal of determining whether the elevated seed predation rate is driven by vegetation change. (See next sections relative to wildfire and small mammal studies).
- The pollination system of Lassics lupine does not appear to contribute to its population decline. The rate of pollinator visits is high and the bees that frequent it appear to be effective pollinators. Furthermore, it is suspected (not confirmed) that Lassics lupine may be capable of self-pollination, as fruit development was observed in some flowers that were not hand-pollinated or visited by pollinators (Crawford and Ross 2003).
- The genetic study of Lassics lupine (Wilson & Hipkins 2004) indicated the two geographically distinct occurrences—Red Lassic and Mt. Lassic—are very similar as measured by isozymes, therefore; due to this similarity, there appears to be no reason not to move plants between the two populations.
- Seed production and predation studies (2010-2016) indicated that the average number of inflorescences were 3.5 per reproductive plant, with 10.6 pods per inflorescence supporting 1.9 seeds per pod (Carothers 2016).
- The buried seed/seed banking investigation indicated that Lassic lupine seed can remain viable in the soil for at least five years (Carothers 2013).

Changes in Vegetation Pattern: wildfire and natural succession

- The mean fire interval across the range of the Jeffrey pine vegetation type is 20 years with a range from 8 to 28 years but may be longer for relatively open stands with low understory fuels, such as over serpentine substrates (Munnecke 2005). Fire records for the Six Rivers date back to 1909. Before the 2015 Lassics fire, seven fires had been recorded in the vicinity of Mt. Lassic[1] (Table 1) since the earliest US Forest Service record in 1909. In 1953, four lightning-caused fires were recorded. Initiation and extent of suppression activities varied across fires. The Lassics Wildfire of 2015 burned through the Lassic lupine occurrences at Red Lassic and on the lower slope of the Mt. Lassic occurrence.

Table 1. Fire records in the vicinity of Mt. Lassic pre-2015.

Fire Name	Year Recorded	Size in Acres	Cause	Distance from Saddle (miles) when recorded
Black Lassic	1953	78.0	Lightning	1.1
Signal Peak	1953	42.0	Lightning	0.2
Bear Creek	1953	30.0	Lightning	1.1
Red Lassic	1953	1.0	Lightning	0.6
Signal Peak	1969	6.0	Lightning	0.8

[1] "Recorded" – documented in the fire record and within a mile of Mt. Lassic saddle.

Fire Name	Year Recorded	Size in Acres	Cause	Distance from Saddle (miles) when recorded
Lassic	1987	0.1	Incendiary	0.4
Lassic	2003	0.5	Uncertain	0.8

- A review of historical aerial photography from the 1930s and 1940s to 2008 indicate that the formerly barren northeast slope of Mt. Lassic is now covered with young conifer trees (Figure 3 and Figure 4). Furthermore, patches of buckbrush (*Ceanothus cuneatus*) have expanded on the south slope and saddle into lupine habitat (Carothers 2008).
- The role of fire suppression activities and thus departure from historic fire return intervals in the vicinity of Mt. Lassic, allowing succession of young conifers and chaparral into once barren habitat, is not straightforward. The low productivity associated with ultramafic substrates, resulting in low vegetative cover interspersed with barrens and rock outcrops serve as natural fuel breaks; therefore, direct fire effects can be highly fragmented. The relatively large fire (42 acres) recorded in 1953, within 0.2 miles south of the Mt. Lassic saddle, may have burned primarily on the west slope, away from the relatively more open habitat of the eastern slope, much in the way the 2015 fires burned.
- Review of fire return interval departures from pre-settlement fire return intervals corresponding with the Lassics region are 70 to 80 percent less frequent than before fire suppression policies were strongly in place (Safford & Van de Water 2014). This departure is based upon analysis of the US Forest Service's (USFS) CALVEG classification. The classification includes a Yellow Pine vegetation type, which is dominated by Jeffrey and ponderosa pine, yet this vegetation type does not capture characteristics of the Lassics' Jeffrey pine and chaparral vegetation on ultramafic substrates. The low site productivity and low fuel level of these vegetation types cannot support the very high fire frequencies associated with the Yellow Pine fire return interval, thus, the high positive return interval departure for such areas is likely an overestimate of departure (Safford & Van de Water 2014).
- While one cannot directly crosswalk analysis of fire return intervals of Jeffrey pine and chapparal habitat in non-ultramafic settings to determine missed fire return intervals in an area like the Lassics, the severity of the 2015 Lassics Fire, where it did burn, likely reflects a departure from fire interval due to 62 years of accumulated fuels and increased vegetation density since 1953, thus a more severe fire than would have occurred otherwise (Carothers 2017). Furthermore, private property supporting mixed conifer forest exists within approximately one mile of the Lassics region to the north, northeast and west; therefore, any wildfire in the area would likely have been subject to suppression activities.
- Forest succession into once barren habitat changes habitat conditions by increasing the litter layer, which appears to impede lupine seed germination in some settings (e.g., forest transect has had traditionally low counts of lupine plants; Imper 2012). Forest cover also decreases insolation (solar radiation). Given that the largest occurrences of the lupine are in very exposed settings, insolation reduction may negatively influence the reproductive capacity of the lupine.
- When chaparral vegetation expands into barren habitat it not only out-competes the lupine and influences insolation values but also provides habitat for the small mammals that consume lupine seeds (Cate 2016).

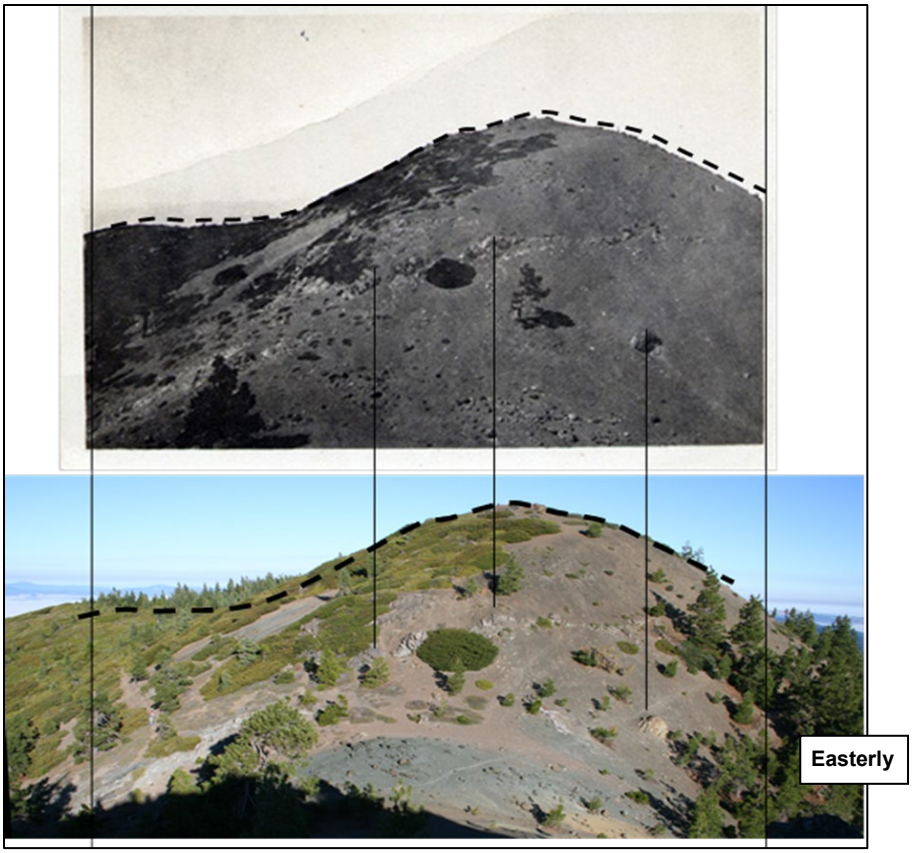

Figure 3. Vegetation on northeast slope of Mt. Lassic looking west from the saddle: in 1930s (top photo: V. Coleman); in 2008 (bottom photo: D. Imper). Lines reference landmarks present at both time periods (Carothers 2008).

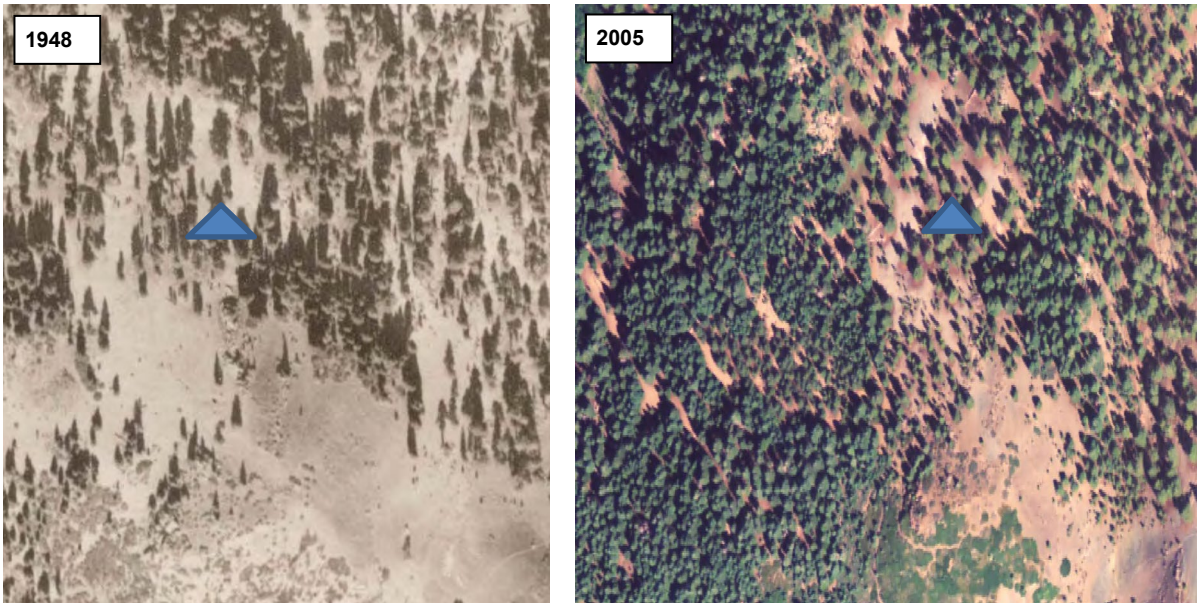

Figure 4. Comparison of Mt. Lassic aerial photos showing extent of previous and current open habitat (Imper 2012).

Small Mammals and Seed Predation:

Pre-wildfire findings

- Pre-fire sampling indicated that the main seed predators in order of abundance were deer mice (*Peromyscus spp.*), chipmunks (*Tamias spp.*), followed by California ground squirrels (*Otospermophilus spp.*) and black tailed jackrabbit (*Lepus californicus*) (Cline 2004, USFWS 2013).
- Small mammal abundance varies between years, but on average, potential seed predators are most commonly associated with chaparral habitat (Figure 5).
- Ground squirrels appear to have expanded in the lupine area since 2005 and because of their large size (compared to mice and chipmunks), a few individuals can take many seeds.
- The expansion of chaparral, the preferred habitat of the small mammals, into barren habitat, the preferred habitat of the lupine, likely increased seed predation pressures, by reducing the consumer movement distance to a preferred food source. Distance travelled by primary consumers to a preferred food source was generally less than 100 meters (Cate 2016).
- Some flowers are browsed by deer and black-tailed jack rabbits, but small mammal seed predation has had a larger impact on seed production.
- Pre-dispersal seed predation by small mammals has significantly affected the viability of Lassics lupine (Kurkjian et al. 2016). The caged-uncaged study of that time indicated that without exclosures seed predation rates were high.

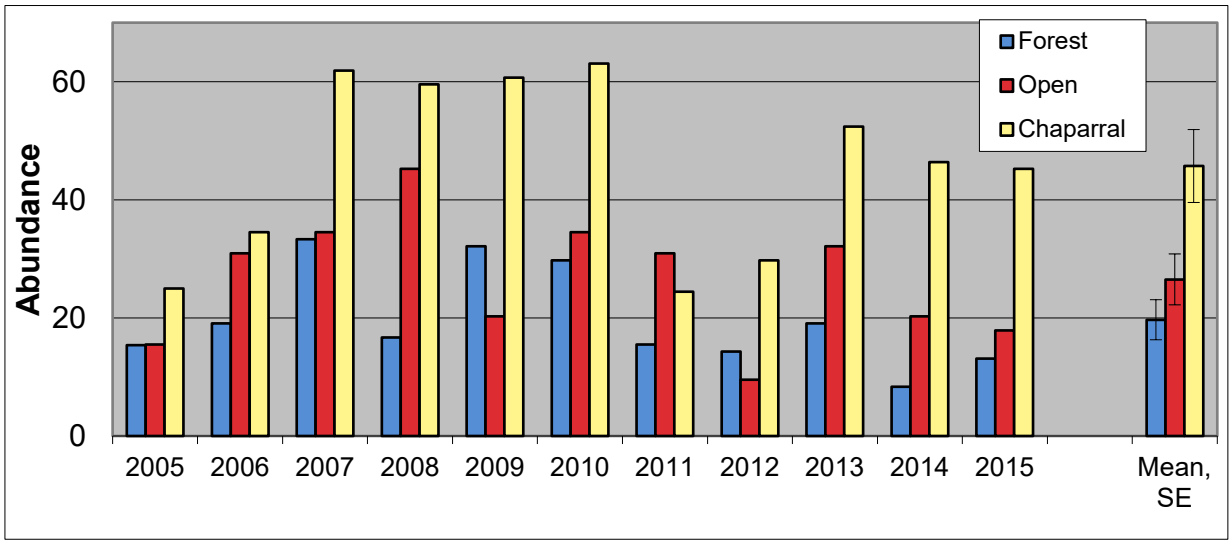

Figure 5. Pre-fire total small mammal abundance by year and habitat (USFWS 2016).

Post-wildfire findings

- Given the association with chaparral habitat, density estimates of deer mice and chipmunks increased in the patches of unburned chaparral immediately after the fire (Barton 2016).
- Post-wildfire effects on abundance and distribution of small mammals relative to the extent of herbivory/seed predation on Lassics lupine appear to indicate, in the short-term, that where small mammal habitat burned (i.e., chaparral vegetation; Figure 6), the capture rate was reduced from previous years (Falxa 2015).

- Sampling of fruit predation on uncaged plants in 2018 indicated that 61 percent of the plants sampled had 0 to 5 percent of fruits predated compared to 11 percent of the uncaged plants with greater than 75 percent predation (Falxa 2018). While variables may include the number of inflorescences and location (proximity of small mammal habitat to the plants), predation was not significant on most of the plants.
- Camara trapping indicates that deer mice and chipmunks were the primary consumers of lupine pre-fire, yet post-fire; California ground squirrel and rabbit predation of the lupine was relatively more common than prior to the fire (Figure 7; Barton 2020a).
- Initial caged-uncaged comparisons of the effect of seed predation on seed production (Kurkjian 2012) continued by Carothers into 2016 have not yet been compared with wildlife caged-uncaged studies (Barton 2019). Results of the latter in 2020 show that of the 20 caged and 20 uncaged plants, no predation occurred in association with caged plants and 11 or 50 percent of the uncaged plants were subject to predation (Barton 2020).
- It is apparent that the 2015 wildfire has affected small mammal abundance and species composition in the area, as well as small mammal distribution. Effects on predation rates since the wildfire have yet to be analyzed; however, with chaparral recovery these affects will likely be short-lived.

Figure 6. 2014 chapparal vegetation pre-burn, 2015 same site post-burn. Photos: Dan Barton, HSU.

Figure 7. California ground squirrel consuming Lassic lupine seeds. HSU wildlife camera, July 7, 2019.

Post-fire seed germination and population status

- After the Lassics Wildfire of 2015, sampling (Table 2) of all transects resulted in a notable increase in seedlings in 2016 with relatively high germination continuing into 2020 (Carothers 2020).

Table 2. Seedling counts pre- and post-2015 Lassics Wildfire by transect area.

Transect	Monitoring Year				
	2015-Pre-fire	2016	2017	2018	2019
Red Lassic	0	68	53	9	24
Saddle	n/a	334	192	22	130
Forest	0	30	54	9	6
Terrace	n/a	72	35	6	42

- In addition to the high post-fire seedling information, the population as a whole increased post-fire, particularly associated with the saddle and slope settings (Figure 8).

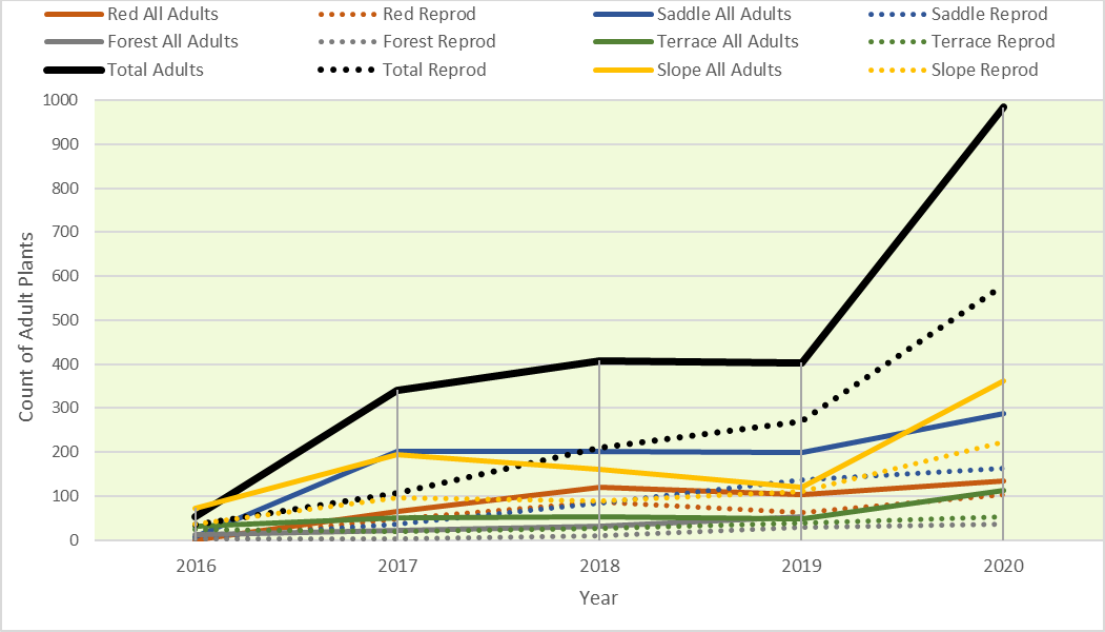

Figure 8. Post-fire fluctuations in the adult cohort of Lassics lupine. Solid lines represent all adults (Carothers 2020).

- In light of the seedling flush post-wildfire and the increase in the population size overall, a study was initiated in partnership with HSU on fire-related cues and the germination response of Lassics lupine related to heat and smoke (Lopez et al. 2019).

Climate: precipitation, snow melt and temperature

- Variation in regional climate over the past six years indicates a high degree of variability in weather conditions between years and within a season (the greatest variation in soil moisture occurs in June and July).
- Measurements of various climatic data sets when compared to Lassics lupine population monitoring data indicate climate-induced lupine mortality is most closely associated with lack of summer rainfall, followed by summer high temperatures, and early snow melt (USFWS 2012).

- Optimum lupine habitat, as represented by the saddle and upper slope of Mt. Lassic, is characterized by high light (insolation) and relatively flat topography which in combination with a shallow soil layer above the bedrock, help to retain available moisture near the surface relatively late in the season (USFWS 2012).
- Figure 9 (Imper 2020) displays the variation over the years including the very early snow melt and low precipitation in 2015 preceding the Lassics Wildfire in the fall of that year.

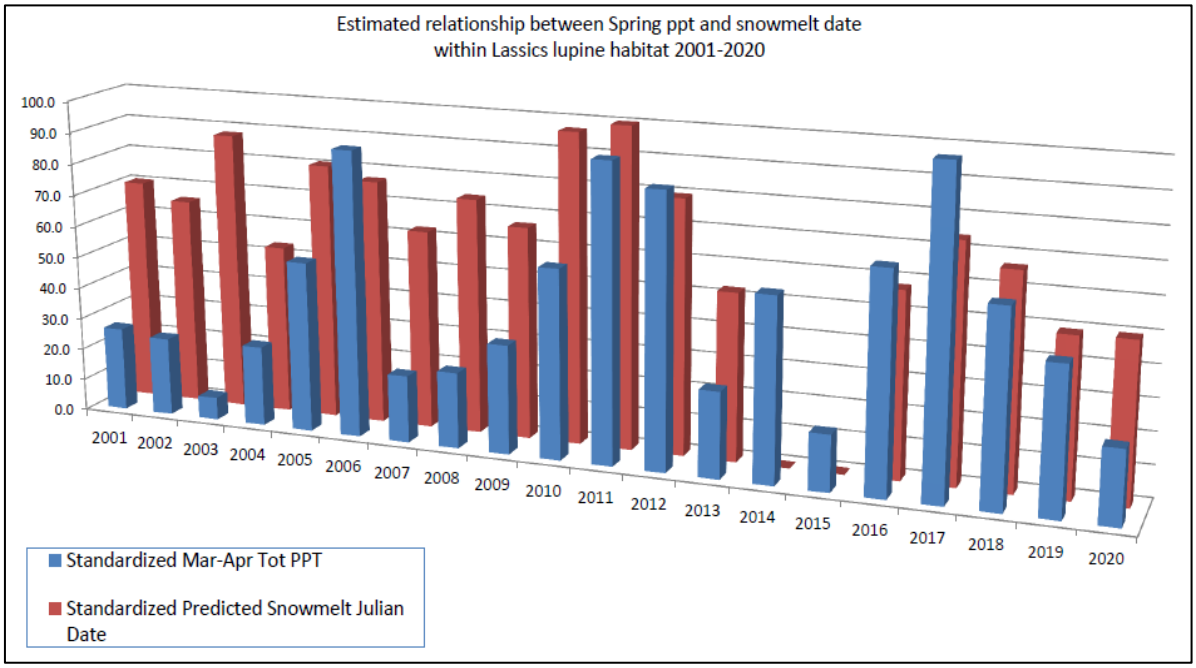

Figure 9. Comparison of spring precipitation measurements and snow melt (Y axis in inches) (Imper 2020).

Soils:

- Incorporating soil units based upon the original soils survey of the Lassics area (Alexander 2008), subsequent analysis was done to identify soil characteristics associated with occupied and unoccupied habitat (USFWS 2012).
- Based upon this original soils' descriptions, subsequent analysis was undertaken and it was determined that for the most part, soils with Lassics lupine had in common soil texture and uniform concentrations of carbon, nitrogen, magnesium, lead and nickel (Imper 2012).
- Expanded soil sampling identified areas with similar soil characteristics that were not occupied by Lassics lupine. These areas were mapped and guided subsequent in-situ planting experiments.

In-situ Seed Studies:

- Overall, the in-situ plantings in occupied habitat from 2003-2009 have not yielded robust results in increasing seedlings, let alone seedlings reaching reproductive stage. It is suspected that the lack of seed scarification prior to planting was the cause for poor germination. These studies have been discontinued.
- The 2015 paired in-situ plantings proximal to Lassics lupine plants did not show much difference in germination rate between the robust seed and indented seeds but the experiment layout (planting in the immediate vicinity of reproductive plants) also did not facilitate getting accurate

counts of planted seed versus seed that may have originated from the seed bank. These experiments have been discontinued.

- In response to the experimental design issues of the 2015 in-situ propagation experiment, in 2017, in-situ plots were planted with scarified seed in a micro-transect design to help distinguish the planted seeds from the banked seeds. Results were promising. Additional seed was planted in 2018. This experiment will continue into the near future.
- Based upon monitoring the results of the in-situ planting at four transects in areas with soils similar to occupied unoccupied lupine habitat (USFWS 2012), sampling of the north face of Mt. Lassic Peak 1 transect has yielded the best results as far as germination and plants advancing to a reproductive stage (Imper 2020a). In-situ planting is included in the guiding document for the Mt. Lassic Peak 1 transect but discontinued elsewhere.

Ex-situ Seed Propagation Studies and Seed Banking:

- The objectives of ex-situ studies were to 1) learn about seed propagation and 2) grow seed in a nursery setting to produce first generation seeds that would subsequently be used for in-situ planting experiments (thereby reducing if not eliminating the removal of seed from reproductive plants for experimental use).
- An ex-situ propagation study at Berry Botanical Garden in 2007 indicated the importance of seed scarification and use of native soil for off-site seed germination.
- Ex-situ propagation attempts at two local nurseries and Leach Botanical Garden did not yield positive results in seed germination or growth to reproductive stage. Variables that may have influenced the results include pre-seed planting treatments (i.e., lack of scarification), infection by fungal pathogens, soils used, and climatic differences.
- At UC Botanical Garden in 2017, 50 seeds and local soil were delivered to the botanical garden and a total of 48 seeds germinated and of those 9 plants survived to reproductive age produced 376 seeds. These seeds were that delivered to SRNF in 2019 and used for in-situ planting and smoke and heat effect lab experiments on seed germination.
- For seed banking, seed submittal to the National Laboratory for Genetic Resource Preservation in Colorado is encouraged every 3 to 5 years. Prior to submittal, a subset of the seeds would be subject to viability testing at the USFS National Seed Laboratory in Georgia to ensure the stock being sent for long-term storage are viable (USDA 2020).

Conservation Strategy – Key Elements

Overview

Key conservation elements for the Lassics lupine are inter-related; none exist on their own. Components include the relationship of small mammal seed predation, habitat changes, wildfire, and climatic variables relative to the population. Understanding each of these and their interactions is paramount to the conservation of Lassics lupine.

The integration of post-wildfire demographic monitoring into an updated population viability analysis (PVA) with information about wildfire effects and climatic influences will help guide experiments, studies and actions—their continuation, adaptation, or their end. Expected completion date is May of 2022.

The following key elements are drawn from what we have learned from 2001-2020 monitoring, experiments, studies and research as discussed in Section IV. It is recognized that, as we proceed with any of the actions listed, adaptive management is inherent as we continue to learn about the Lassics lupine.

Key Element 1: Continue baseline monitoring and studies that can contribute to recovery and guide management actions.

Demographic monitoring should continue until such time there is population stability at a level that constitutes recovery of the species (as influenced by the updated PVA). Small mammal predation studies related to abundance, predation rates and habitat changes (i.e., re-growth of the chaparral that was burned in the 2015 wildfire) should also continue in keeping with considerations identified under Key Element 2. Snow melt, precipitation and summer temperature data collection are other metrics that influence the survivability of Lassics lupine and warrant continued measurement. Integration of the annual demographic monitoring results with the results of both small mammal studies (species capture, habitat utilization) and climate monitoring is needed to best guide future management actions.

Key Element 2: Continue to assess the role of seasonal caging of reproductive lupines and integration with small mammal habitat and predation levels.

Installation of cages will continue on a seasonal basis prior to fruit production. The extent of caging and caging locations will be evaluated periodically as we continue to monitor the population in subsequent years.

Information is needed to link habitat utilization in a post-wildfire setting (Figure 10), habitat proximity to Lassic lupine plants, predation rates (and by which mammal species) and seed production to inform future management, such as the use of prescribed fire as well as the extent of caging needed. Caging is not a sustainable action over the long-term; thus, the relationship of predation rates to vegetative habitat changes resulting from fire needs further integration. As stated in the Journal of Applied Ecology article that covered seed predation of the Lassics lupine, "…with continued management to limit the effects of seed predation in the short-term and investigation into the ultimate drivers of this high seed predation rate in the long-term, the Lassics lupine population could be restored to a robust rate of growth" (Kurkjian et al. 2016). It is developing an understanding of the drivers that will influence future management actions.

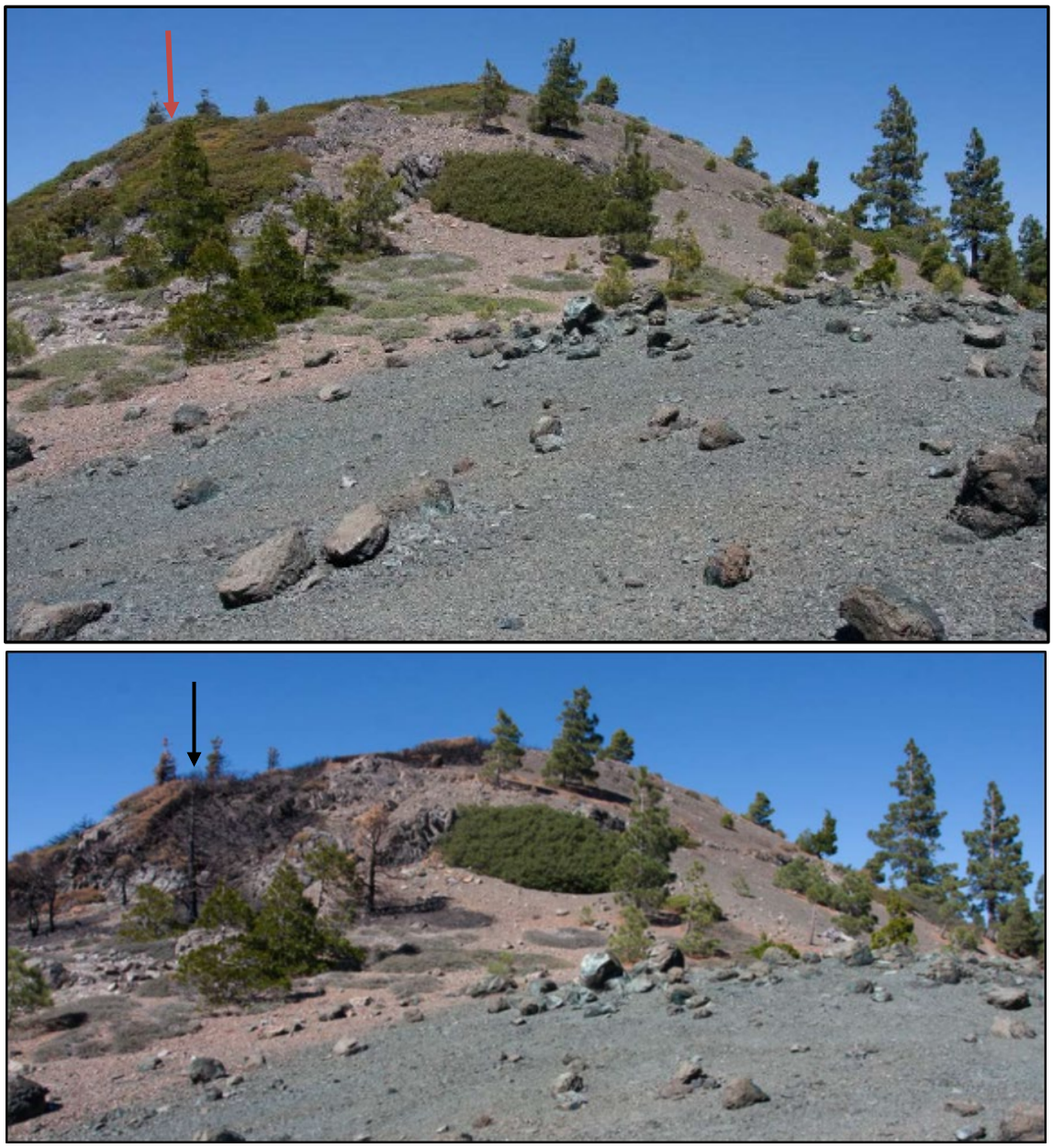

Figure 10. Looking away from the saddle, to the northwest. Top image is pre-2015 Lassics wildfire. Bottom image is 2015 post-wildfire. Note blackened chaparral on the ridge. Photos: Dan Barton.

Key Element 3: Assess the role of fire in the recovery and sustainability of the Lassics lupine.

The landscape of the Lassics area is complex. Serpentine barrens are immediately adjacent to such forest types as Jeffrey pine and White fir or chaparral with a mix of ceanothus and manzanita. As a result of this vegetative-barren variation, application of fire return intervals to this landscape can be difficult to crosswalk with intervals assigned to dominant vegetation types. While the mean fire interval across the range of the Jeffrey pine vegetation type is 20 years with a range from 8 to 28 years, it is recognized that this interval may be longer for relatively open stands with low understory fuels, such as over serpentine substrates (Munnecke 2005). How much longer? Prior to 2015, the largest and closest fire to the Lassics lupine population was in 1953 (Table 1)—62 years before the 2015 Lassics Wildfire—a span of time over twice that of the maximum range for the Jeffrey pine vegetation type.

Any influence of fire suppression activities on potentially "missed" fire events in the Mt. Lassic region is not straightforward or documented in the fire record. However, the habitat occupied by Lassics lupine is approximately 2 miles from the Forest border to the west and 0.5 to 1 mile away from various private inholdings. With this proximity to private lands, suppression of any fires would likely have occurred and very well may have influenced vegetation succession in the Lassics region.

Given the positive effects on seed germination and predation rates immediately after the 2015 Lassics wildfire, it appears fire does play a role in the ecology and sustainability of the Lassics lupine. Prescribed burning is a management tool that could be used in this area and should be undertaken experimentally with associated monitoring. See Key Element 5 regarding research associated with fire effects.

Key Element 4: Continue seed banking and seed propagation studies.

The seed banking and plant propagation guidelines were developed based upon CPC recommendations and the best available information—the latter drawing upon local in-situ and ex-situ investigations to date. It is recognized that adaptive management may result in a shift in how seed would be distributed.

First Priority

The seed banking and plant propagation document developed by Six Rivers Botanist John McRae (USDA 2020) will serve as a guide to efforts to ensure that an adequate proportion of Lassics lupine seed is left in the wild. Based upon recommendations from the Center for Plant Conservation (CPC), no more than 10 percent of an individual plant's reproductive output and no more that 10 percent of the population's reproductive output in one season should be removed from the wild for conservation banking (CPC 2018). In a year timed with the seed banking schedule (3 to 5 years), when seed production is relatively low but above the 10 percent threshold, conservation banking is identified as the priority for use of any seed collected (Figure 11).

With this CPC guideline in place, seed collected will be submitted to the USFS National Seed Laboratory for viability testing and pending results, the seed would be sent for long-term storage at the National Laboratory for Genetic Resource Preservation. Seed submittal is recommended every 3 to 5 years. A second long-term storage facility may also be identified, funding dependent (e.g., Rancho Santa Ana Botanical Garden in Santa Barbara CA).

Second Priority

The next priority (with adequate seed production) would be in-situ seed propagation experiments and associated monitoring. Of the current propagation trials, the following would be continued in the near future in order to better substantiate the value of such actions in population recovery:

- Micro-transect planting and monitoring using freshly collected seed. In addition to scarification, hot water stratification, Rhizobium bacteria inoculation (Bowles & McBride 1997) would be incorporated. Fresh seeds (current year's seed) would be sown shortly after collection following ground soaking rains.
- Continue planting at the Mt. Lassic Peak 1 transect yet using scarified seed for the purpose of further testing experimental population expansion to suitable habitat and without the full seed preparation identified for the micro-transects.

Third Priority

Given that ex-situ propagation experiments, setting-dependent, did yield positive results (e.g., Berry Botanic Garden, UC Botanical Garden), identification of a local, established garden or nursery could be an option for the future. Such propagation, with well-defined protocols, could provide first generation seed that could be used in *in-situ* propagation trials instead of using seed collected from the wild. Ex-situ seed use is also related to research. Use of seed for research purposes is also identified as a priority, in particular in relation to understanding the variables associated with germination and germination triggers such as heat from wildfire.

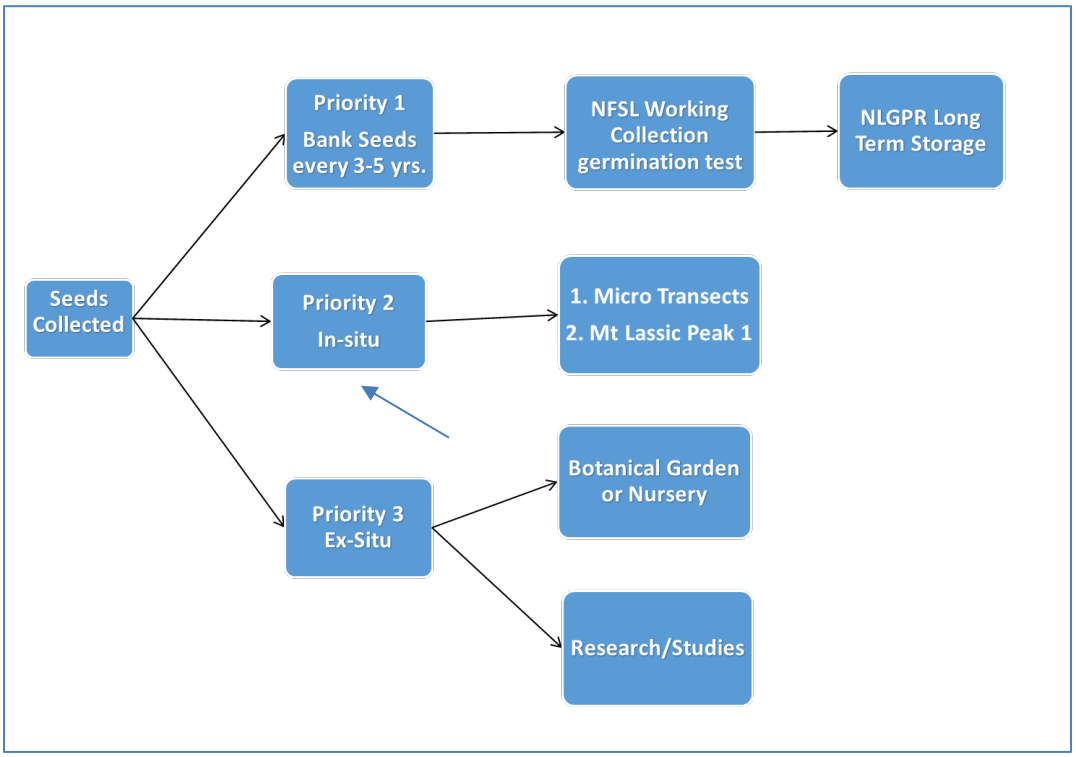

Figure 11. Flowchart for seed distribution.

Key Element 5: Research and Management Needs

Questions are likely to arise that will warrant academic research or academic involvement at some level.

For the time being, the following includes existing research with expanded components or design considerations as well as new topics related to management actions.

Identify fire-related cues of Lassics lupine seed germination

- Continue research on the role of fire in the germination response of Lassics lupine. If there is adequate seed production in a given year, shift seed distribution priorities to accommodate further lab-based germination trials regarding fire-related cues (i.e., heat, smoke) and the germination response of Lassics lupine.
- Other elements of this research could include (Kane 2020):
    - From the seed subject to lab-based germination trials, examine the effect of seed planting depth on germination/survival.

- Apply smoke and heat treatment and assess in-situ germination tests in native soil under local weather conditions to see if the treatment yields better germination results than other in-situ planting experiments.

Review existing studies/research and re-design to facilitate integration

Another area of research needed is the integration of demographic monitoring, small mammal/predation studies (including habitat succession) and climatic changes. While there has been inciteful information garnered from respective studies and analysis, what is the relationship across the respective studies (e.g., predation/herbivory data collected during demographic monitoring compared to the extent of small mammal captures or germination rate and precipitation levels; caged versus uncaged reproductive plants proximal to burned and unburned chaparral)? Are the current study designs such that the respective studies can be cross-referenced to determine any relationship?

Prescribed burning and monitoring of effects on lupine germination, survival and population expansion

There is evidence that in some settings, post-fire small mammal predation was less than pre-wildfire levels and germination rates were high. Fire played a role in reducing the availability and distribution of chaparral habitat for small mammal utilization and either smoke or heat facilitated germination. In addition, the habitat for Lassics lupine on the northeast slope below the saddle has experienced considerable succession of incense cedar in the understory of a Jeffrey pine forest, increasing ground cover and stand density. Plants of Lassics lupine occur in this area but are few in number. Optimal habitat for Lassics lupine is characterized by high light (insolation), yet plants do exist in settings with partial shade. To retain the habitat variation for Lassics lupine, prescribed fire may also be needed in some of the forest settings where the lupine occurs.

Expanding partnership to include the USFS-USDI Interagency Fire Management Staff and possibly fire ecologists affiliated with the USFS Research Station is needed to develop a prescribed burn plan for the area that includes both chaparral and forested areas that did not burn in 2015. The plan would include subsequent prescribed burning at intervals in keeping with that of Jeffrey pine forest and chaparral vegetation types but customized to account for the ultramafic substrate—likely a longer period between fires for these vegetation types than fire intervals on non-ultramafic substrates.

Partners/Responsible Party/Funding the Conservation Strategy

Partners in association with the SRNF include the USFWS, CDFW, CNPS (State and North Coast Chapter) and HSU Departments of Biological Sciences, Wildlife, and Forestry and Wildland Resources. With interest in the use of prescribed fire, other potential partners include USFS-USDI Interagency Fire Management Staff and USFS Southwest Research Station.

The Lassics lupine is currently listed as Endangered by the State. Its status relative to any Federal listing is under development. The SRNF is currently the lead agency for management of the Lassics lupine which includes components within the Conservation Strategy. Implementation of key elements identified in this document would be coordinated through the USFS with the CDFW, Eureka, CA office. Partners will meet at least annually to discuss study and research results, field season needs, coordination (e.g., caging season) and funding. With the Conservation Strategy in place, a logical next step would be the development of a Conservation Agreement with partners to further codify roles and responsibilities into the future.

Of the key elements, the following are currently supported fiscally a) through agreements, b) through participation of respective agency staff members and c) participation of specialists associated with partner organizations:

- Demographic monitoring in partnership with the CNPS (USFS funded, all partners participate)
- Caging installation and removal (all partners participate in installation, removal by USFWS and USFS)
- CNPS updating the ACCESS database to facilitate a new population viability analysis to be undertaken by HSU (USFS funded)
- Population viability analysis update (USFWS funded, HSU participation)
- Small mammal studies in coordination with HSU (USFWS funded, HSU participation)
- Fire cues for lupine seed germination (CNPS, North Coast Chapter funded)
- In-situ seed germination studies in micro-transects (USFS funded and participation); in-situ seed germination studies in suitable habitat on Mt. Lassic (North Coast Chapter CNPS participation)
- Ex-situ propagation experiments (USFS participation)
- Conservation seed banking (USFS funded and participation).

Of the actions above, it is anticipated that demographic monitoring and seed banking would continue on an annual basis. Extent of caging will be adaptive in nature, pending study results and demographic monitoring. Continuation of in-situ and ex-situ experiments will be subject to results and the research and studies listed which are intended to inform and guide management in the future would be of relatively short-duration.

Funding Needs

In addition to the aforementioned, if determined to move forward, funding sources for the following will be needed:

- Key Element #5 Research Needs
    - Essential work for fire related studies including continued work on the heat and smoke triggers for germination (lab and in-situ plantings) and the addition of prescribed fire implementation and monitoring.
    - Funding to develop wildlife studies that best capture predation rates relative to habitat settings including those settings subject to the 2015 wildfire. As a part of this, integrate the cumulative effects of small mammal predation, climate, habitat changes, and seed production levels which would be linked to caging efficacy.

Appendix B displays current and an anticipated funding estimate to implement the Conservation Strategy.

Appendix A. Wilderness Act: Applicable Direction & Policy

The Northern California Coastal Wild Heritage Wilderness Act of 2006, which designated the Lassics area as Wilderness, includes the following objectives:

- Preserve the unique wild and natural features of these landscapes;
- Protect a diverse array of ecosystems, plants, animals, geologic structures and hydrologic features that represent the natural splendor of California;
- Retain and enhance opportunities for scientific research in pristine ecosystems; and
- Promote the recovery of threatened and endangered species.

The following Forest Service Manual (FSM) direction (USDA 2006) pertains to research and studies in Wilderness and aims to show consistency of conservation measures in the Lassics Wilderness with wilderness direction to preserve a diverse array of ecosystems while allowing for scientific research and habitat alterations to alleviate threats to a globally-imperiled species endemic to the Lassics region:

- FSM 2320.2 – Objective: Gather information and carry out research in a manner compatible with preserving the wilderness environment to increase understanding of wilderness ecology, wilderness uses, management opportunities, and visitor behavior.
- FSM 2320.3 – Policy: Gather necessary information and carry out research programs in a manner that is compatible with the preservation of the wilderness environment.
- FSM 2323.31 – Objective: Provide protection for known populations and aid recovery in areas of previous habitation, of federally listed threatened or endangered species and their habitats.
- FSM 2323.37 – Policy: Installations, such as temporary shelters for cameras and scientific apparatus, and enclosures of exclosures… may be approved on a case-by-case basis.
- FSM 2324.41 – Objective: To provide appropriate opportunity for scientific studies that are dependent on wilderness environment.

Relative to fire in the Wilderness, according to the Policies and Guidelines for Fish and Wildlife Management in National Forest and Bureau of Land Management Wilderness (AWFA et al. 2006):

"The objectives of fire management in wilderness are to: (a) permit lightning-caused fires to play, as nearly as possible, their natural ecological role within wilderness and (b) reduce, to an acceptable level, the risks and consequences of wildfire within wilderness or escaping from wilderness. Fire ignited by lightning may be permitted to burn or will be suppressed as prescribed in an approved plan. Prescribed fires may be permitted to reduce unnatural buildup of fuels only if necessary to meet objectives (a) and (b) above and require approval from the Federal administering agency."

Policies and Guidelines for Fish and Wildlife Management in National Forest and BLM Wildernesses (June 2006):

- The National Wilderness Preservation System will be managed to ensure that ecological succession, including fire and infestation of insects, operate as freely as possible with only minimal influence by humans.
- Proposed State fish and wildlife management activities that would involve uses generally prohibited under §4(c) of the Wilderness Act will be considered and may be authorized by the Federal administering agency. The US Forest Service (USFS) and Bureau of Land Management (BLM) will consult closely with the States and give careful consideration to State fish and

wildlife interests when considering these proposed activities, subject to applicable National Environmental Policy Act (NEPA) review, where determined through the Minimum Requirements Decisions Process (MRDP) to be a necessary action (Attachment A Step 1).

- Facility development and habitat alteration may be necessary to alleviate adverse impacts caused by human activities on fish and wildlife, including human/wildlife conflicts, and to conserve fish and wildlife resources in wilderness.
- Actions necessary to conserve or recover threatened or endangered species, including habitat manipulation and special conservation measures, that involve uses generally prohibited under Section 4 (c) of the Wilderness Act, will be considered and may be authorized by the Federal administering agency through application of the MRDP as outlined in Section E., General Policy.
- The objectives of fire management in wilderness are to: a) permit lightning-caused fires to play, as nearly as possible, their natural ecological role within wilderness and b) reduce, to an acceptable level, the risks and consequences of wildfire within wilderness or escaping from wilderness. Fire ignited by lightning may be permitted to burn or will be suppressed as prescribed in an approved plan. Prescribed fires may be permitted to reduce unnatural buildup of fuels only if necessary to meet objectives (a) and (b) above and require approval from the Federal administering agency.

Minimum Requirement Decisions Process Outline for (MRDP) for actions in the Wilderness:

- Step 1a: Determine if the action proposed by the State agency or Federal administering agency, to meet conservation objectives for fish and wildlife, is necessary to manage the area as wilderness. For example, determine whether the proposed action is necessary for the purpose of wilderness (i.e., how would the proposed action support the public purposes for wilderness of recreation, scenic, scientific, education, conservation and historical uses?).
- Step 1b: Conclusion: Is the Action Necessary?
- Step 2a: Determine the minimum tool.
- Step 2b: Decision – What is the Minimum Tool?

Appendix B. Planning Budget Estimate for Annual Program of Work

Table 3 displays an estimate of annual costs associated with conservation studies and monitoring in light of the past few years work.

Table 3. Estimated annual costs associated with conservation studies and monitoring.

Activity	Annual Cost	Partner	Funding Entity
Demographic Monitoring/Data Entry/Reporting	$5,500	CNPS	USFS
	$2,600	USFS, USFWS Staff Salary	Base Salary
Wildlife Studies	$20,000	HSU	USFWS
	$3,800	USFWS Staff Salary	Base Salary
Caging	$2,600	USFS, USFWS Staff Salary	Base Salary
Fire Seed Lab Experiment	$5,000	HSU	TBD
Climate/Temp Sampling		CNPS – North Coast Chapter	TBD
In-Situ/Ex-Situ Seed Studies and Propagation	$1,000	CNPS	USFS
	$4,000	USFS Staff Salary	Base Salary
TOTAL	$44,500		

Data collection and reporting on climate and temperature for the Lassics Region has been undertaken voluntarily in the past few years. It is recognized that this data collection will be an ongoing need and will likely warrant funding in the future.

Other areas of possible study or research expansion include:

- Sowing of the fire cued seeds in the Lassics;
- Implementing a watering-study in conjunction with fire-cued treatments to isolate the relative importance of each relative to germination of Lassics lupine seed; and
- More detailed analysis of soils in the Lassics region for in-situ planting.

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