

**OREGON DEPARTMENT OF AGRICULTURE
NATIVE PLANT CONSERVATION PROGRAM**

**Developing recovery protocols for
the federally-listed species
*Lomatium cookii***



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PREFACE

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TABLE OF CONTENTS

Preface.....	ii
Acknowledgments.....	ii
Table of Contents	iii
List of Figures	iv
List of Tables.....	iv
Introduction	1
Goal and objectives.....	2
Methods.....	2
Direct seeding.....	2
French Flat.....	2
Reeves Creek.....	3
Agate Desert.....	4
Transplanting.....	12
French Flat.....	14
French Flat.....	15
Agate Desert Preserve	15
Plot sampling.....	15
Direct Seeding.....	15
Transplanting.....	15
Analysis.....	15
Results.....	16
Direct seeding.....	16
French Flat.....	16
Agate Desert	16
Transplanting.....	17
French Flat.....	17
Agate Desert	18
Discussion	20
Seeding and transplanting	20
Is there evidence for local adaptation in <i>L. cookii</i> ?.....	20
Implications for recovery	21
Literature cited	22
Appendix A. Cultivation history of transplanted <i>Lomatium cookii</i>	23
Appendix B. Datasheets.....	27
Appendix C. Directions to sites and site maps	39

LIST OF FIGURES

- Figure 1.** *Lomatium cookii* at French Flat in 2005.
- Figure 2.** Example of a gray conduit post with aluminum tag used to mark 1 m² plot corners.
- Figure 3.** Aerial photo of French Flat showing locations of planting areas at the North and South subpopulations of *Lomatium cookii*.
- Figure 4.** *Lomatium cookii* direct seeding plots at French Flat, 2006.
- Figure 5.** *Lomatium cookii* direct seeding plots at French Flat, 2007.
- Figure 6.** Plot layout at French Flat North, 2009.
- Figure 7.** Site photo at French Flat North showing 2009 plot locations.
- Figure 8.** Examples of 2009 seeding plots at French Flat North showing control (left) and litter removal (right) treatments.
- Figure 9.** Aerial photo of the Reeves Creek area showing general GPS locations of seeding plots in six adjacent groups surrounding a wild patch of *Lomatium cookii*.
- Figure 10.** Plot layout at Reeves Creek.
- Figure 11.** Aerial photo of Agate Desert Preserve, with *Lomatium cookii* populations and vernal pools.
- Figure 12.** Example of orientation of labeled and unlabeled plot markers at Agate Desert.
- Figure 13.** Orientation of twenty planting locations within 1 m² transplant plots at French Flat and Agate Desert.
- Figure 14.** Scenes from *Lomatium cookii* reintroduction experiments.
- Figure 15.** Seedling establishment from direct seeding by site and planting date and observed 2007 - 2009.
- Figure 16.** Overall percentage survival of transplants at French Flat and Agate Desert as of April, 2009.

LIST OF TABLES

- Table 1.** Summary of seeding and transplanting information for each site and year.
- Table 2.** Plot group, number, seed source and litter treatment at the Reeves Creek site.
- Table 3.** Number of transplants, number surviving (2008 & 2009), and total percentage survival to 2009 of transplants with seven different cultivation histories at French Flat ACEC and Agate Desert Preserve

INTRODUCTION

Lomatium cookii (cover photo, Figure 1), Cook's desert-parsley, is listed as endangered by the State of Oregon and the U.S. Fish and Wildlife Service (USFWS). *Lomatium cookii* is endemic to southwestern Oregon. Two population centers are known, one in Josephine County in the Illinois Valley and one in Jackson County in the Agate Desert north of the Medford Plains (Kagan 1994). The species is closely related to *L. bradshawii*, an endangered species found in the Willamette Valley of western Oregon.

Population augmentation and reintroduction are identified in the Draft Recovery Plan for the species as necessary steps toward recovery. Recovery Action 4.12 targets development of offsite and onsite cultivation and propagation techniques as a priority 1 activity, and Action 2.4.4 calls for reintroduction of the species to suitable habitat. This project contributes to these recovery actions by conducting research into field cultivation of *Lomatium cookii*.



Figure 1. *Lomatium cookii* at French Flat.

Background

Lomatium cookii was first discovered in 1981 in the Agate Desert. This habitat is characterized by a series of vernal pools and mounds that create a patterned ground surface. *Lomatium cookii* occupies a seasonally wet zone on the margins of vernal pools. The dominant vegetation consists of annual grasses (*Deschampsia danthonioides*, *Bromus hordeaceus*, *Alopecurus saccatus*, and *Taeniatherum caput-medusae*) and herbaceous annuals and perennials (*Lasthenia californica*, *Plectritis congesta*, *Collinsia grandiflora*, and *Limnanthes flocossa* ssp. *grandiflora*).

The largest federally-owned population of *L. cookii* occurs at French Flat on the Medford District BLM. Areas around this population were placer-mined for many years. Populations in this area have been monitored annually since 1993 (Massatti et al. 2009). These populations are found in moist, grassy meadows dominated by *Danthonia californica* (Kaye and Blakeley-Smith 2002). Other associated species include *Deschampsia cespitosa*, *Camassia quamash*, *Ranunculus occidentalis*, *Hesperochiron occidentalis*, *Downingia yina*, *Horkelia daucifolia*, *Isoetes nuttallii*, *Calochortus nudus*, and *Viola hallii*. Trees and shrubs, such as *Pinus ponderosa*, *Pinus jeffreyi*, *Arctostaphylos* spp., and *Ceanothus cuneatus* border these grassy meadows. The soils at French Flat are moderately serpentine, which restricts the growth of many plant species. In contrast, the soils at the Medford Airport population of *L. cookii* are non-serpentine.

Previous cultivation research

Lomatium cookii greenhouse cultivation practices were investigated by Silvernail (2008), who found that seed dormancy was broken after 12 weeks of cold stratification followed by

warm conditions to promote germination. Seeds collected from wild plants in the Agate Desert had higher germination and plants grown from them were larger than those from Illinois Valley populations. Plants from both seed sources grew best on well drained potting soil augmented with native soil and fertilizer (Silvernail and Meinke 2008). We used the plants grown by Silvernail for his research in our study to compare field survival and growth of greenhouse grown plants with different cultivation histories (Silvernail et al. 2010).

Goal and objectives

The goal of this project is to develop reintroduction techniques for *Lomatium cookii* to support recovery of the species. The specific objectives are to:

1. Determine seedling establishment rate for seeds sown into suitable habitat and document variation among years and sites,
2. Measure field survival and growth of bare root plugs grown under various greenhouse conditions.

METHODS

Direct seeding

Direct seeding was conducted at four locations: two at French Flat ACEC, Reeves Creek, and Agate Desert Preserve. French Flat ACEC and Reeves Creek are on land managed by the Medford District BLM. Agate Desert Preserve is owned and managed by The Nature Conservancy. Seeds were sown in 2006, 2007 and 2009 (Table 1; see Silvernail et al. 2010 for additional details of 2006-2008 work). Seeds were sown into 1 m² plots marked with gray PVC conduit in two corners, one of which was tagged with an aluminum tag (Figure 2). Results from seeds sown in 2006 and 2007 are analyzed here. Seeds sown in 2006 and 2007 were collected by Silvernail while those sown in 2009 were collected by Kaye and others. Prior to field sowing, all seeds were cleaned and backlit to ensure they were filled with an embryo.

French Flat

2006 -- On December 1, 2006, 30 1 m² plots (3 rows of 10 plots each) were established at the south end of the south meadow at French Flat (Figure 3). Plots were spaced 1 m apart and were marked in the northwest and southeast corners with gray PVC conduit, emerging from the soil 10 – 20 cm. Posts in the northwest corner were marked with a yellow cap and pre-numbered aluminum tags (#901-930). Ten plots were randomly assigned to receive seeds from the Medford Airport population and 20 plots received seed from the local population at French Flat (Figure 4). Seventy-five seeds were sown by hand, scattered evenly over each plot.

2007 -- On December 3, 2007, 20 1 m² plots (2 rows of 10 plots each) were established at the south end of the south meadow at French Flat adjacent to the 2006 seeding plots. Rows were established approximately perpendicular to the 2006 seeding plots (Figure 3). Plots were spaced 1 m apart (Figure 5) and were marked in the northeast and southwest corners with gray PVC conduit, emerging from the soil 12 – 20 cm. Posts in the northeast corner were marked with a yellow cap and pre-numbered round aluminum tags #61-80. All plots received seventy-five seeds collected from French Flat. An even distribution of seeds across each plot was attempted. However, areas of the plot where water was actively flowing were avoided (at the time of seeding standing water was pooled on the soil surface in places and it was raining).



Figure 2. Example of a gray conduit post with aluminum tag used to mark 1 m² plot corners.

2009 – Seeding was conducted on November 16, 2009 at the French Flat North area (Figure 3).

Experimental plots were placed on the perimeter of the existing population of *Lomatium cookii* at this location. Sixteen 1 m² plots were placed in three rows 1 m apart (Figure 6). We put the plots adjacent to an oak (*Quercus kelloggii*) tree that had dropped leaves over the soil surface (Figure 7). To test the effects of tree litter removal on seedling establishment, we removed all litter from 8 randomly selected experimental plots prior to seeding, leaving the remaining 8 plots as undisturbed controls (Figure 8). Litter was removed by scraping the soil surface with the side of a boot, which was very effective despite its low-tech characteristic. A total of 100 seeds were sown by hand into each 1 m² plot. All seeds sown in the plots were collected from the French Flat Middle subpopulation in 2009 (a bulk collection from over 40 plants).

Reeves Creek

2009 – Seeding at Reeves Creek was conducted on November 17, 2009. A total of 26 1 m² plots were sown with 60 seeds each. Seeds were available from the local Reeves Creek population of *Lomatium cookii* sufficient to seed 6 plots. The remaining 20 plots were sown with seed from French Flat ACEC collected in 2009. Habitat at this site consists of hill slopes with patchy forested vegetation and small openings. *Lomatium cookii* occurs naturally in this area in forest openings as well as under trees and seeding plots were placed in both habitat types. To test for the effect of leaf litter on seedling establishment, plots were randomly assigned to a litter removal treatment or undisturbed control. Litter removal was conducted by scraping the soil surface with the side of a boot, and/or manually to remove most litter. Existing vegetation on the soil surface was not removed. Finally, plots were placed in six general groups adjacent to one another and surrounding an existing patch of *L. cookii* (Table 2, Figures 9 & 10).

Agate Desert

2007 – On 4 December, 2007, twenty 1 m² plots on the perimeter of four vernal pools were established in The Nature Conservancy’s Agate Desert Preserve. Plots were located on the margins of Pools Z, 2, A1, and AD22 near UTM 10T 0508947E, 4697130N, Nad27 (Figure 11). At this site, *L. cookii* occurs on upper margins of vernal pools. As this habitat type is not linearly distributed, we were not able to establish rows of plots as at French Flat, but instead placed plots along the edges of the pools in habitats where *L. cookii* is typically found (Figure 12). Similar to French Flat, we chose an area of Agate Desert that has habitat apparently suitable for *L. cookii*, but was unoccupied. Plots were spaced in order to have sufficient habitat available for 2008 transplant plots. Plots were marked in two diagonal corners with gray PVC conduit, emerging from the soil 12 – 20 cm. The corner on the left closest to the pool was marked with a yellow cap and pre-numbered oblong aluminum tags #81-100. All plots received seventy-five seeds collected from a population at the Medford Airport in summer 2007. Seeds were scattered evenly over each plot. However, areas of the plot where water was actively flowing were avoided (the water table was fairly high and it was raining heavily).

Table 1. Summary of seeding and transplanting information for each site and year.

Site	Year planted	Seed source	No. seeds or plants per plot	No. plots (1 m ²)
Seeding				
<i>French Flat ACEC, South Area</i>				
	2006	French Flat	75	20
	2006	Medford Airport	75	10
	2007	French Flat	75	20
<i>French Flat ACEC, North Area</i>				
	2009	French Flat (Middle)	100	14
<i>Reeves Creek</i>				
	2009	Reeves Creek & French Flat	60	26
<i>Agate Desert Preserve</i>				
	2007	Medford Airport	75	20
Transplants				
<i>French Flat ACEC, South Area</i>				
	2008	French Flat	≤20	20
<i>Agate Desert Preserve</i>				
	2008	Medford Airport	≤20	20

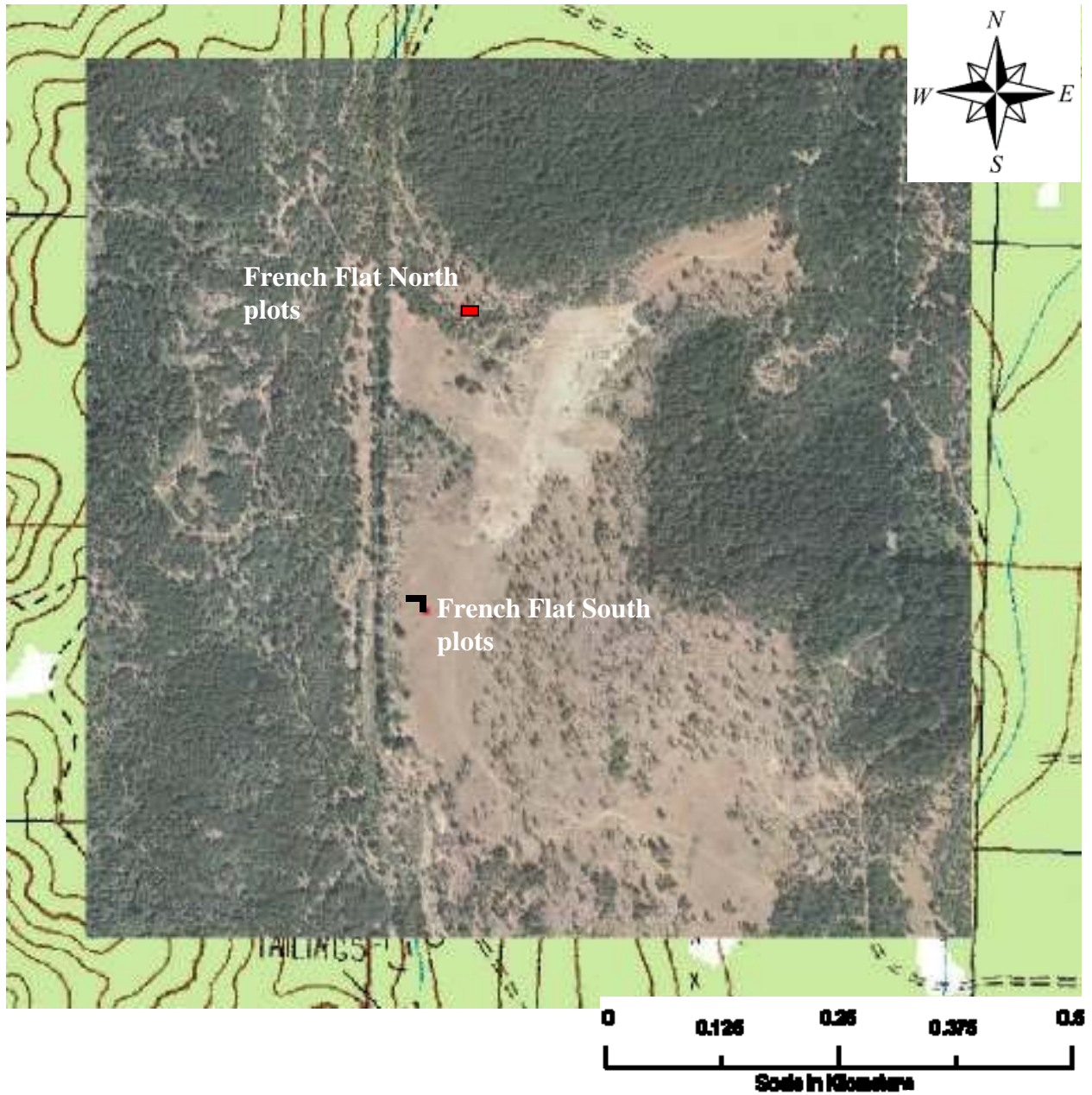


Figure 3. Aerial photo of French Flat showing locations of planting and seeding areas at the North and South subpopulations of *Lomatium cookii*. The map scale is 1:7,000.

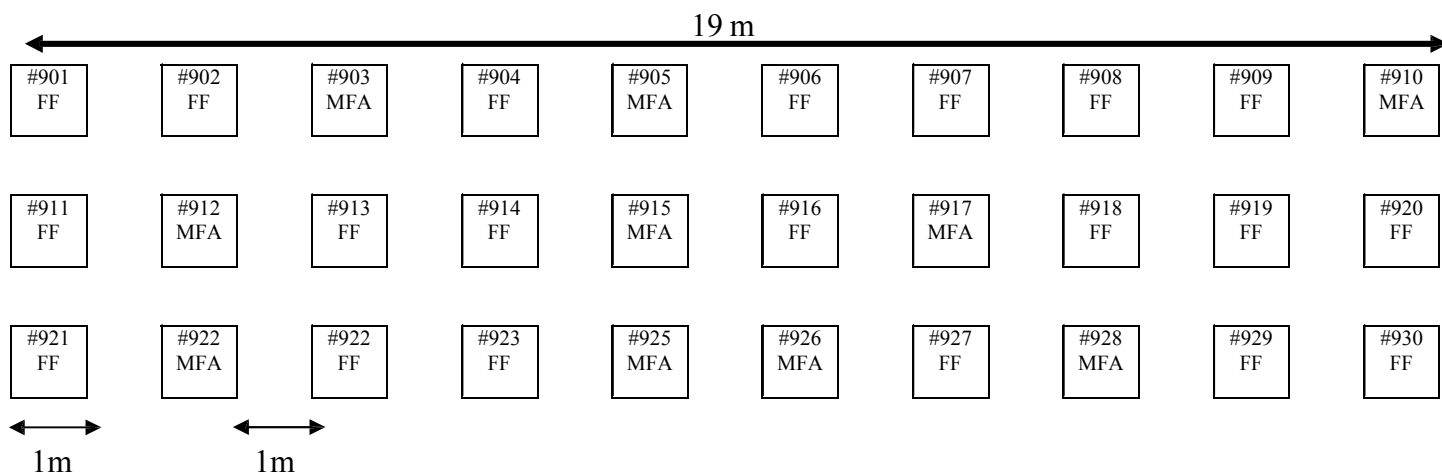


Figure 4. *Lomatium cookii* direct seeding plots at French Flat, 2006 (see Silvernail et al. for details of 2006-2008 work). Plots are numbered with printed metal tags in the northwest corner. FF indicates plots that received French Flat seeds; MFA indicates plots that received Medford Airport seeds.

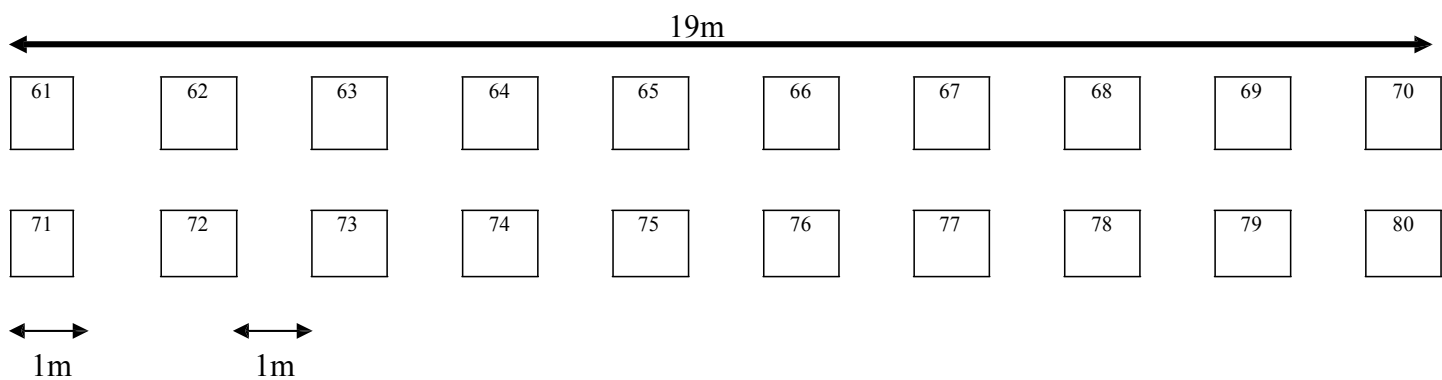


Figure 5. *Lomatium cookii* direct seeding plots at French Flat, 2007 (see Silvernail et al. 2010 for details of 2006-2008 transplanting). Plots are numbered with printed metal tags in the upper left corner. All seeds were collected from French Flat.

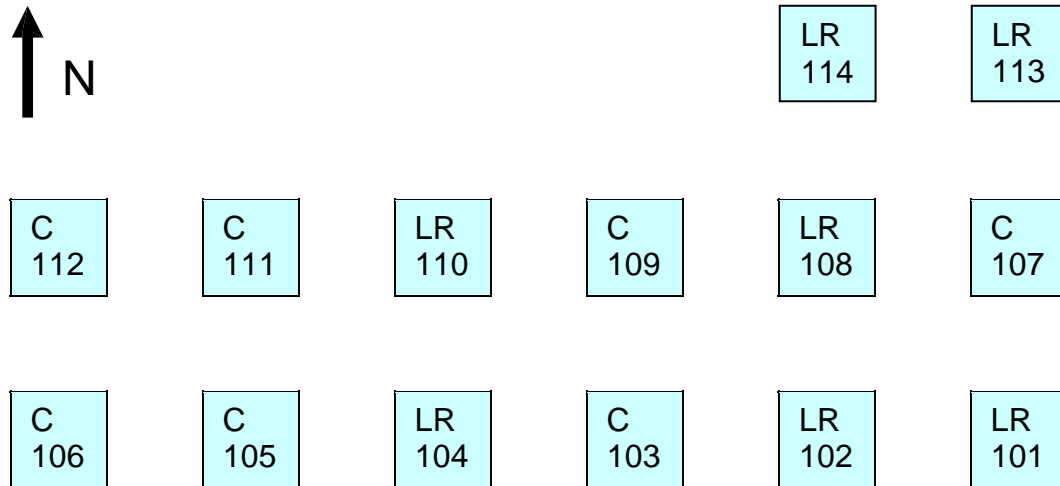


Figure 6. Plot layout at French Flat North, 2009. Plots were 1 m² and spaced 1 m apart. Treatment type (LR=litter removed, C=control) and tag number are shown for each plot.



Figure 7. Site photo at French Flat North showing 2009 plot locations.

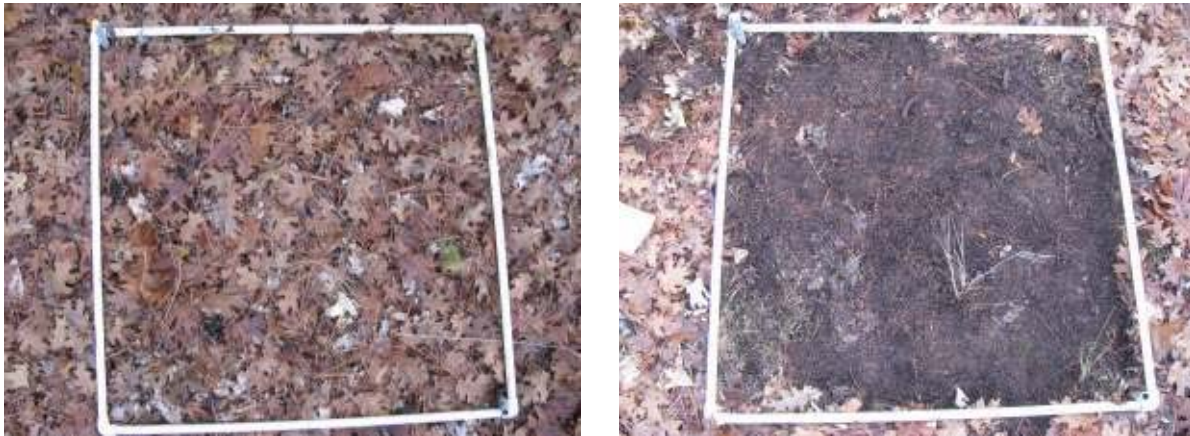


Figure 8. Examples of 2009 seeding plots at French Flat North showing control (left) and litter removal (right) treatments.

Table 2. Plot group, number, seed source and litter treatment at the Reeves Creek site. Seed source codes are FF=French Flat (Middle subpopulation) and RC=Reeves Creek.

Group	Plot (tag no.)	Seed source	Litter removal	Habitat
1	115	FF	N	open
1	116	FF	Y	open
1	117	RC	N	open
1	118	FF	Y	open
2	119	FF	N	forest
2	120	FF	Y	forest
2	121	FF	N	forest
2	122	FF	Y	forest
2	123	RC	N	forest
3	124	FF	Y	forest
3	125	RC	N	forest
3	126	FF	Y	forest
3	127	FF	N	forest
4	128	FF	Y	open
4	129	FF	N	open
4	130	FF	Y	open
4	131	RC	N	open
4	132	FF	Y	open
5	133	FF	N	open
5	134	FF	Y	open
5	135	RC	N	open
5	136	RC	Y	open
5	137	FF	N	open
6	138	FF	Y	forest
6	139	FF	N	forest
6	140	RC	Y	forest



Figure 9. Aerial photo of the Reeves Creek area planted in 2009 showing general GPS locations of seeding plots in six adjacent groups surrounding a wild patch of *Lomatium cookii*. The map scale is 1:1000.

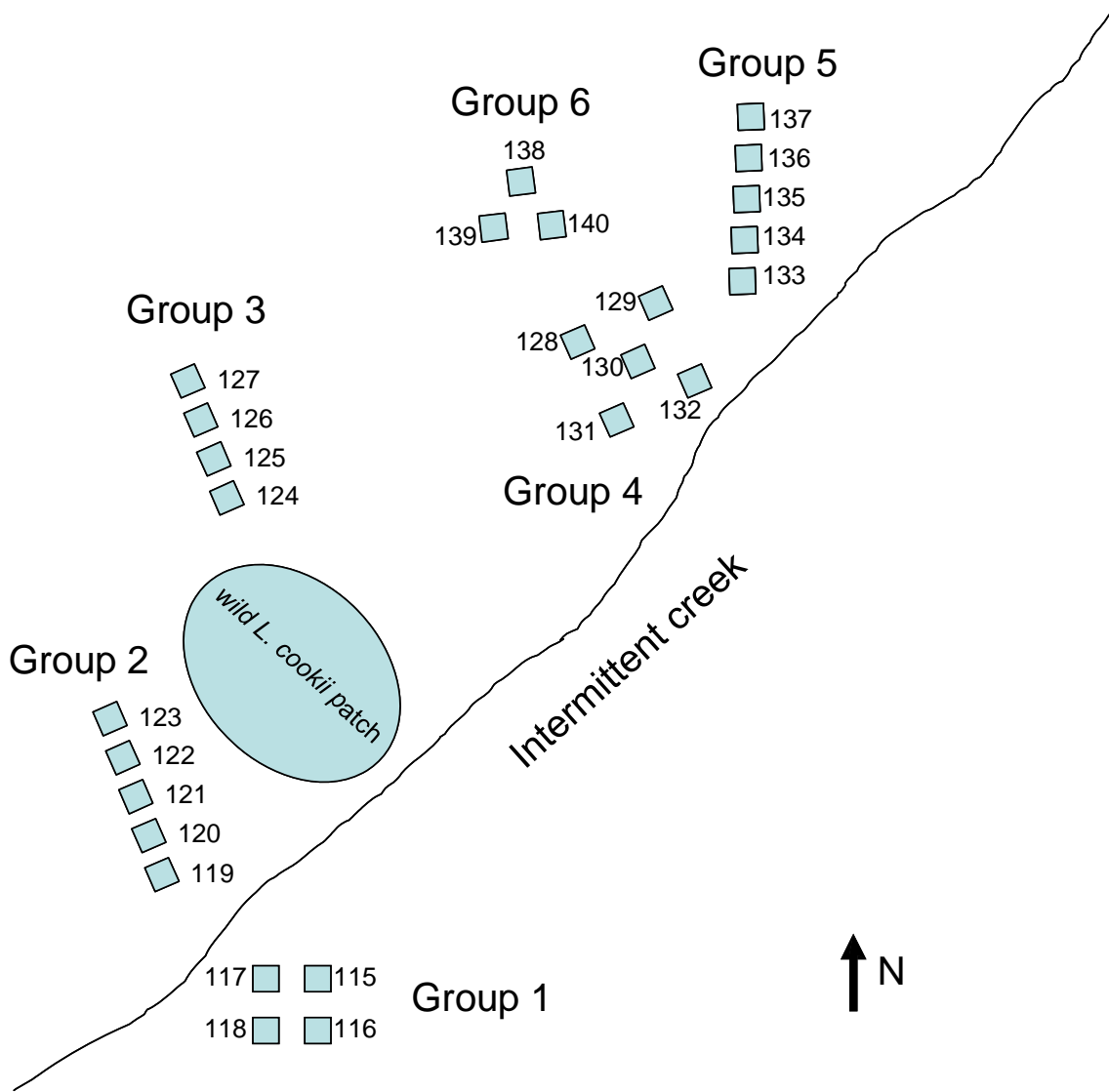


Figure 10. Plot layout at Reeves Creek used in 2009. Six groups of plots were distributed across the site. Each plot was 1 m x 1 m in size, and in most groups the plots were 1 m apart. Each plot was marked in the lower right and upper left corners (facing uphill) with gray PVC conduit. The upper left post was tagged with a pre-numbered aluminum tag. Tag numbers are shown next to each plot. The map is not to scale.

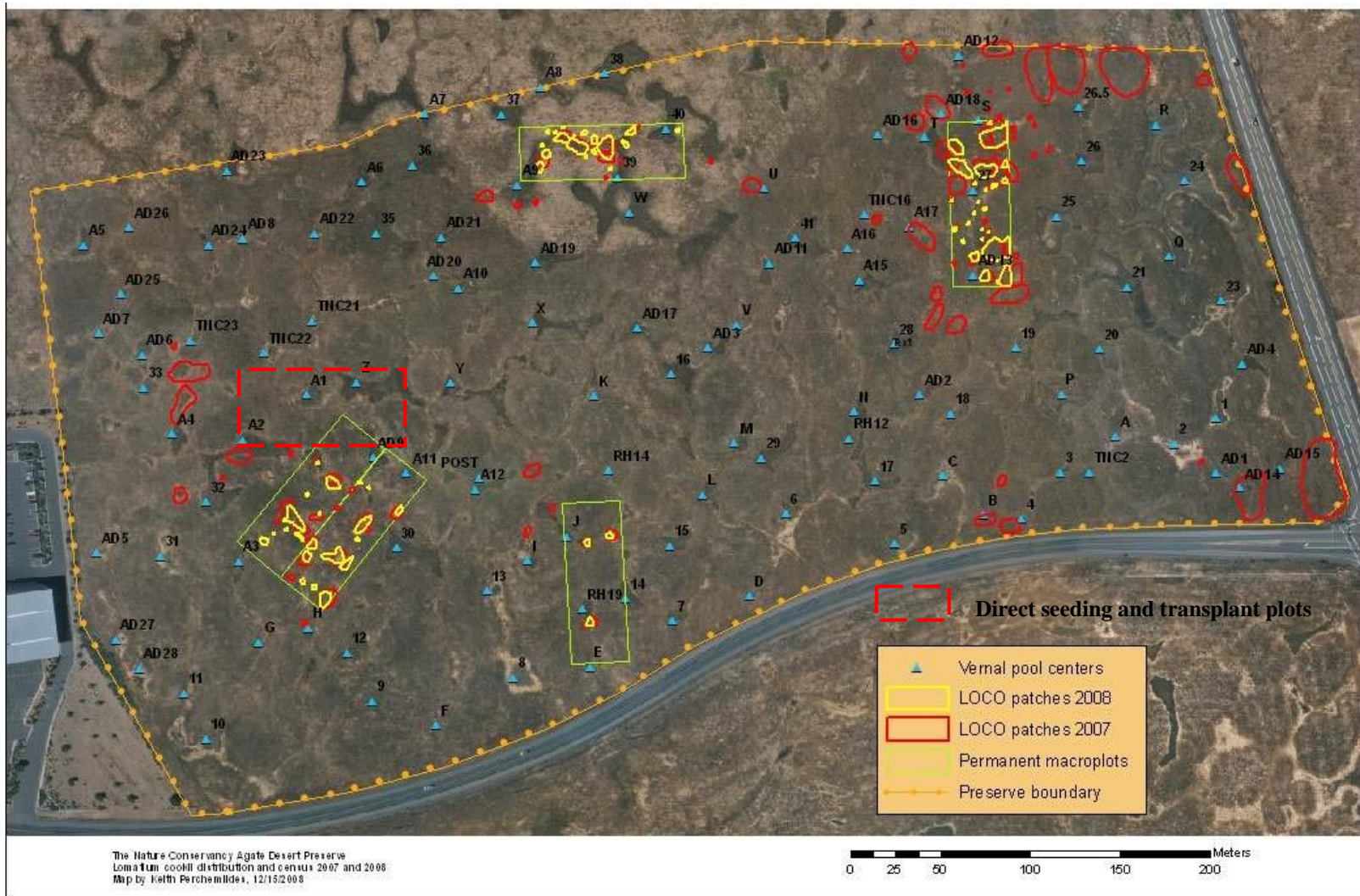


Figure 11. Aerial photo of Agate Desert Preserve, with *Lomatium cookii* populations and vernal pools (see Silvernail et al. 2010 for additional details of 2006-2008 transplant work).

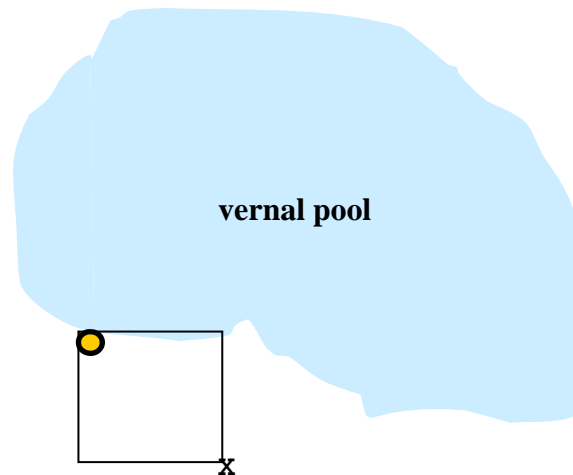


Figure 12. Example of orientation of labeled and unlabeled plot markers at Agate Desert. As you are facing the pool, the labeled post (yellow circle) is in the pool-side left corner; the unlabeled post is in the right corner closer to the mound.

Transplanting

Transplanting was conducted at French Flat ACEC and Agate Desert Preserve in 2008 with plants grown from 0 to 3 years in the greenhouse. At both sites, twenty 1 m² plots were established in appropriate habitat adjacent to or within established wild populations (Table 1). Each plot was subdivided into twenty planting locations (Figure 13). Position 1 was located 20 cm to the right of the edge of the plot and 10 cm below the top of the plot.

Plants with different greenhouse cultivation histories were distributed across all plots. In total, plants from seven different cultivation categories were used. Full details of cultivation history and 2006-2008 transplanting methods can be found in Silvernail and Meinke 2008 and Silvernail et al. 2010.

1. 3 week old seedlings
2. 1 year old tap-roots cultivated in 3:3:2 (coir fiber:compost:perlite) nursery mix
3. 2 year old tap-roots cultivated in 3:3:2 nursery mix
4. 2 year old taproots cultivated in Illinois Valley soil with monthly supplemental fertilization
5. 2 year old taproots cultivated in Illinois Valley soil without supplemental fertilization
6. 2 year old taproots cultivated in Rogue Valley soil with monthly supplemental fertilization monthly
7. 2 year old taproots cultivated in Rogue Valley soil without supplemental fertilization

Because there were different numbers of plants in each greenhouse cultivation category, the sequence in which plots were planted was randomized in order to avoid the last plots having numerous empty positions. The cultivation history of a plant placed in a particular position within a plot was randomized as well. The cultivation history of all individual plants within all plots at French Flat can be found in Appendix A.

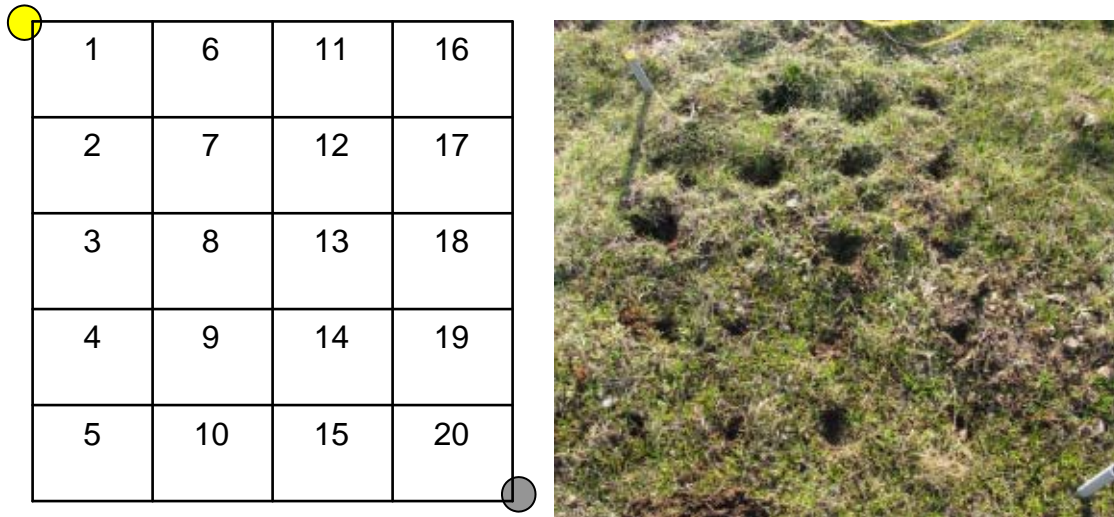


Figure 13. Orientation of twenty planting locations within 1 m² transplant plots at French Flat and Agate Desert. Left: Diagram showing planting locations. The yellow circle represents the post containing a yellow plastic cap. Right: plot with posts in opposite corners and holes dug with dibble prior to planting.



Figure 14. Scenes from *Lomatium cookii* reintroduction experiments: a) a three week old seedling immediately prior to planting at French Flat ACEC in 2008, b) transplant emerging at Agate Desert Preserve in 2009, c) transplanting at Agate Desert Preserve, d) TNC staff assisting with transplanting at Agate Desert, e) Ian Silvernail with bare root plant ready for planting.

French Flat

Transplanting occurred on March 11, 2008. (See Silvernail et al. 2010 for additional details on transplanting methods.) One row of ten plots was located immediately south of and parallel to the 2006 direct seeding plots. Another row of ten plots was located immediately west of and adjacent to the 2007 direct seeding plots (Figure 3). Plots were spaced 1 m apart and each was labeled with a pre-numbered tag. Plots #601-610 were marked in the northeast and southwest corners with gray PVC conduit, emerging from the soil 12 – 20 cm. Posts in the northeast corner were marked with a yellow cap. Plots #611-620 were marked in the northwest and southeast corners with gray PVC conduit, with the posts in the northwest corner receiving a yellow cap.

Agate Desert Preserve

Transplants were planted on March 10, 2008. (See Silvernail et al. 2010 for additional details on transplanting methods.) Since *L. cookii* habitat is not linearly distributed at Agate Desert, plots were placed along the margins of vernal pools in appropriate habitat. Vernal pools were chosen in the immediate vicinity of other pools where direct seeding plots were located (Figure 11). Plots were marked with pre-numbered aluminum tags #621-640 placed on gray PVC conduit, emerging from the soil 12 – 20 cm (Figures 12 & 13). Refer to Appendix A for the cultivation histories of plants within each planting position across all plots.

Plot sampling

Direct Seeding

The number of plants found in each plot at French Flat was recorded on May 9, 2007, April 29, 2008, and April 28-30, 2009. Agate Desert was visited on April 21, 2008 and 2009, and the same information was recorded. The location of each plant was also mapped during the 2008 and 2009 monitoring dates to track individual plants through time. In 2009, additional data recorded included the number of leaves and length of the longest leaf for each plant.

Because seedlings were not mapped in 2007 at French Flat, all plants mapped in 2008 from the 2006 seeding were assumed to be second year seedlings. In 2009, some additional seedlings were discovered that had not been previously mapped (seedlings of *L. cookii* may be difficult to locate because of their small size), and these were assumed to have established in their first spring after seeding, unless specifically noted otherwise on the datasheets.

Transplanting

Transplants were monitored on April 21, 2008 and 2009 at Agate Desert and April 29, 2008 and April 27-28, 2009 at French Flat. For each plant, the leaf number, maximum leaf length, presence of herbivory, and number of reproductive stems was recorded. See Appendix B for a copy of the data sheets used for gathering this information.

Analysis

To test for an effect of seed source on seedling establishment at French Flat, we used a 2-tailed Wilcoxon sign-rank test with data from 2009. We used logistic regression to test for an effect of cultivation history on plant survival.

RESULTS

Direct seeding

Seeding resulted in establishment of plants at French Flat ACEC and Agate Desert Preserve. As of 2009, the total number of seedlings established through these experimental efforts was 338 at French Flat and 100 at Agate Desert Preserve.

French Flat

In 2007, first year seedling establishment at French Flat was 12.9% from the local source seed, and 11.6% for seed from Medford Airport (Figure 15). By 2009, however, plant establishment in the seedling plots declined because of mortality to 10.1% for plants from French Flat and 6.0% from Medford Airport seed. This 2009 establishment rate for Medford Airport seeds was significantly ($p=0.042$) lower than establishment of local seeds. In 2009, most plants had two or three leaves, and leaf number ranged from one to five; no reproductive plants were observed.

Seeds sown in 2007 had a first year establishment rate in 2008 of 11.9%, dropping slightly due to mortality to 9.4% in 2009 (Figure 15).

Agate Desert

First year establishment in 2008 at Agate Desert was 39.8%, substantially higher than at French Flat in the same year. By 2009, however, establishment in these plots had declined to 6.7% (Figure 15). In 2009, all plants remained small (1-3 leaves) and none had become reproductive.

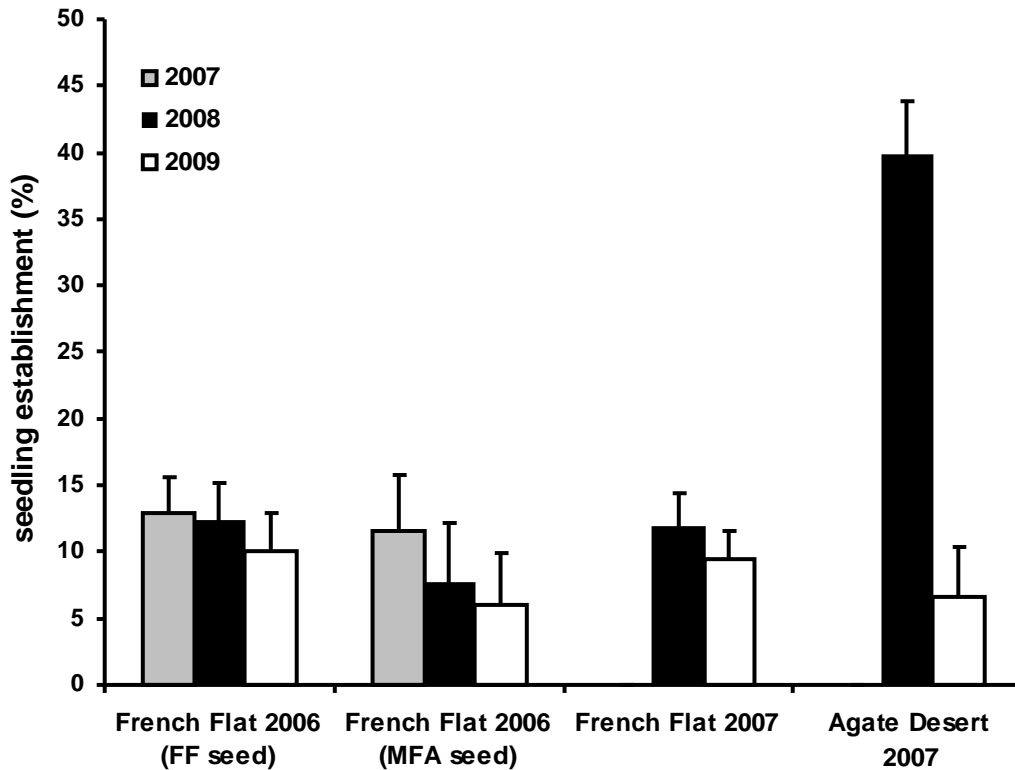


Figure 15. Seedling establishment from direct seeding by site and sowing date. Seed sources are identified in Table 1; FF refers to French Flat ACEC seed and MFA refers to Medford Airport seed. Error bars represent a 90% confidence interval.

Transplanting

French Flat

At French Flat, cultivation history had a significant effect on plant survival ($p=0.028$). Seedlings and one year old plants had approximately 40% survival, while most two year old tap roots fared much better, with 52% - 62% surviving, depending on the cultivation conditions. Two year old plants grown in potting soil inoculated with native soil and fertilized were the exception, having only 44% survival (Table 3, Figure 16).

Most mortality occurred in the first month after transplanting in 2008 (see Silvernail et al. for details). No plants died between 2008 and 2009 that were grown in Illinois Valley or Rogue Valley soils, and only two plants died in each of the greenhouse 3:3:2 soil mix categories. These results suggest that after initial mortality due to transplant shock, established plants may persist at high rates. A total of 159 transplants remained alive in 2009.

Agate Desert

Transplant survival at Agate Flat was much lower than at French Flat. Cultivation history had a strong effect on transplant survival ($p < 0.0001$). Only 4 seedlings (2.5%) remained in 2009, down from 87 in 2008. No one year old tap-roots survived and only 2.6% to 22.2% of two year old plants could be relocated (Table 3, Figure 16). Cultivation histories with the highest survival rates were the two-year greenhouse 3:3:2 soil mix (20%, 2 out of 10) and two year old plants in Illinois Valley soil with fertilizer (22.2%, 8 out of 36, Table 3). Only 24 transplants were still present in 2009.

Table 3. Number of transplants, number surviving (2008 & 2009), and total percentage survival to 2009 of transplants within seven different cultivation histories at French Flat ACEC and Agate Desert Preserve (IV = Illinois Valley and RV = Rogue Valley).

Transplant type	French Flat				Agate Desert			
	# planted	2008 survival	2009 survival	Total % survival	# planted	2008 survival	2009 survival	Total % survival
Seedling	158	104	64	40.5	160	87	4	2.5
1 yr, 3:3:2 soil	28	13	11	39.3	29	3	0	0.0
2 yr, 3:3:2 soil	22	11	9	40.9	10	6	2	20.0
2r, IV soil	23	11	12	52.2	39	22	1	2.6
2r, IV soil fertilized	36	16	21	58.3	36	24	8	22.2
2r, RV soil	37	23	23	62.2	37	28	4	10.8
2r, IV soil fertilized	43	19	19	44.2	36	27	5	13.9
Total	347	197	159	45.8	347	197	24	6.9

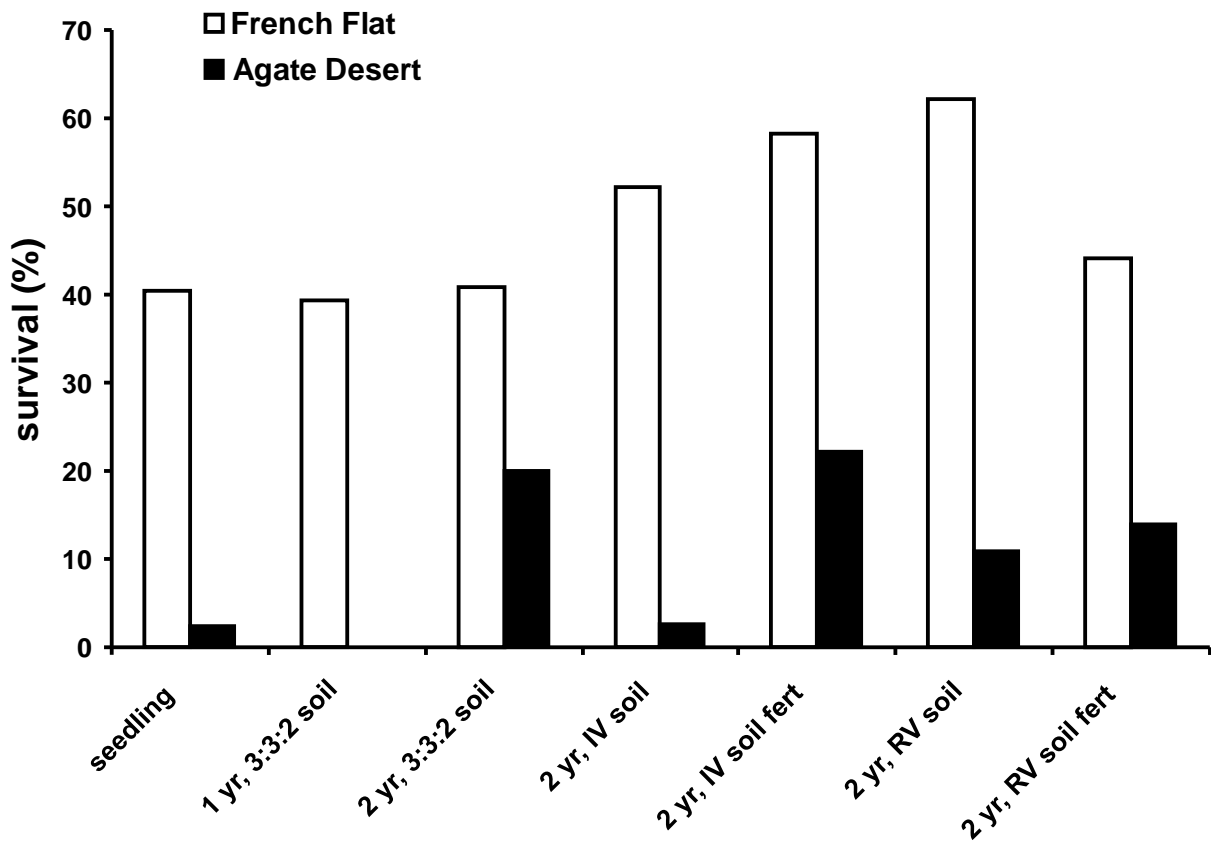


Figure 16. Overall percentage survival of transplants at French Flat and Agate Desert as of April, 2009.

DISCUSSION

Seeding and transplanting

Direct seeding and transplanting appear to be useful methods for reintroducing populations of *Lomatium cookii*. The augmentations conducted in this study at two locations, French Flat ACEC and Agate Desert Preserve, resulted in establishment, survival, and growth of substantial numbers of plants. After the 2010 field season these plants can be compared with healthy, wild populations to determine if their vital rates (survival and growth) are similar. Similarity in demographic behavior between wild and reintroduced populations is one measure of reintroduction success (Menges 2001, Kaye 2008).

So far, first year plant establishment from seed has varied from 11.9-12.9% at French Flat to 39.8% at Agate Desert. Mortality of seedlings after the first year, however, has been much lower at French Flat than Agate Desert. While second year survival of plants from seed declined slightly to about 10-12% at French Flat, it dropped substantially to about 7% at Agate Desert. Strong competition with annual plants and dry soil conditions in 2008 may explain the rapid decline at Agate Desert, but additional observations will be necessary to understand which factors control seedling survival at that site.

Transplants also fared better at French Flat than Agate Desert from 2008 to 2009. At French Flat, all transplants had 40% survival or better, with up to 60% survival of two year old plants grown with native soil inoculum. In contrast, transplants at Agate Desert had less than 23% survival, and some age classes, such as seedlings and one year old plants, had below 3% survival. The cobbly soil at Agate Desert was a noticeable challenge during planting in 2008. The dibbles used to prepare the planting hole frequently encountered rocks and had to push these aside in the soft mud. Moving soil back into the planting hole after the bare roots were planted was also difficult. These planting issues could explain much of the difference in transplant survival at Agate Desert compared to French Flat, where no large rocks were present in the soil; other factors, such as plant competition and dry soils later in the season (as mentioned above), may also have affected the plants. In general, older plants survived better, especially if they had been fertilized while grown in the greenhouse (and therefore had higher biomass) or were grown in potting soil inoculated with local soil (Figure 16).

Effects of leaf litter on seedling establishment can be evaluated with results from plantings in 2009 at French Flat North and Reeves Creek after sampling in 2010 and 2011.

*Is there evidence for local adaptation in *L. cookii*?*

When seeds from French Flat and Agate Desert were both sown at French Flat on serpentine-influenced soils, first year establishment was nearly equal (~12%). However, mortality since 2007 has been higher for seeds from Agate Desert (Figure 15), suggesting that there may be some local adaptation of French Flat plants to the serpentine environment. This result is in contrast to some previous findings from a greenhouse experiment that showed Agate Desert plants achieved *better* growth (height) on serpentine-influenced soils compared to the local genotype from French Flat (Silvernail 2008). In the same study, Agate Desert plants had higher survival overall than plants from French Flat. The interaction between genotype and the serpentine environment, which is characterized by soils that have low concentrations of essential nutrients, low calcium-magnesium ratios, and high concentrations of the heavy metals, may result in effects at different life history stages. Seedling survival may be reduced for nonlocal

genotypes, while growth of larger plants may be unaffected. Other factors may also be at play, such as herbivory from voles, which is frequently very high at French Flat (Massatti et al. 2009). If nonlocal plants are more palatable to voles at French Flat then seedling survival could be reduced relative to the local genotype. Regardless of the mechanisms involved, at this time it appears that there is some evidence for local adaptation of *L. cookii* to conditions at French Flat.

Implications for recovery

A necessary step to restore and recover populations of *L. cookii* is to evaluate cultivation and propagation techniques and establish standard procedures and protocols (USFWS 2006). Doing so will enable a larger number of partners to participate in recovery through plant production and outplanting. Our results to date suggest the following implications for *L. cookii* recovery.

- Both direct seeding and transplanting of greenhouse-grown bare root stock are feasible methods for establishing *Lomatium cookii*.
- Transplants may be most successful with larger individuals grown with native soil and/or fertilizer in the greenhouse potting mix.
- Transplanting may also be most successful at sites without large rocks in the soil and high cover from competing vegetation.
- Direct seeding with large numbers of seeds may be the most cost-effective method for establishing new populations. Production of *L. cookii* seeds in cultivation could release wild populations from seed collection pressure and provide large numbers of seeds for restoration.
- Evidence of local adaptation in this species suggests that reintroduction success on sites with serpentine-influenced soils may be higher with seed from serpentine sites. However, the evidence for local adaptation is inconsistent and additional research is needed on this topic.

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APPENDIX A. CULTIVATION HISTORY OF TRANSPLANTED *LOMATIUM COOKII*

Cultivation history of individual plants transplanted at French Flat on March 10, 2008, plots 601-610. All plants were grown from Illinois Valley seed. A blank cell indicates that no plant was placed in that planting position. Seedling = plants transplanted three weeks after emergence. 1-332 = One-year tap-root cultivated in 3:3:2 soil. 2-332 = 2-year tap-root cultivated in 3:3:2 soil. 2SOILivFERTmo = 2-year taproot cultivated in Illinois Valley soil fertilized monthly. 2SOILivFERT0 = 2-year taproot cultivated in Illinois Valley without supplemental fertilization. 2SOILrvFERTmo = 2-year taproot cultivated in Rogue Valley soil fertilized monthly. 2SOILrvFERT0 = 2-year taproot cultivated in Rogue Valley without supplemental fertilization.

French Flat plot numbers and cultivation history of plants in each planting position

Planting position	601	602	603	604	605	606	607	608	609	610
1	seedling	seedling	2SOILivFERTmo	1-332	2-332	2SOILrvFERTmo	seedling	2SOILrvFERT0	2SOILrvFERTmo	2SOILrvFERTmo
2	seedling	seedling	2SOILrvFERT0	2SOILrvFERT0	2SOILrvFERTmo	seedling	2SOILivFERTmo	seedling	seedling	seedling
3	2SOILrvFERTmo	1-332	2SOILrvFERT0	seedling		seedling	seedling	2SOILivFERT0	2SOILrvFERT0	seedling
4	seedling	seedling	seedling	2-332	2SOILivFERTmo	seedling		seedling	2SOILivFERT0	2SOILrvFERTmo
5	2SOILivFERTmo	seedling	2-332	2SOILrvFERTmo	seedling	2SOILivFERTmo	2SOILivFERTmo	seedling		seedling
6	2SOILivFERTmo	seedling	2SOILrvFERTmo	seedling	seedling	seedling	seedling	seedling	seedling	2SOILivFERT0
7		2SOILrvFERTmo	2-332	seedling	1-332	seedling	seedling	seedling	seedling	2SOILivFERTmo
8		2SOILivFERT0	seedling	seedling		seedling	2-332	2SOILrvFERT0	2SOILrvFERTmo	2-332
9	seedling	1-332	1-332	2SOILivFERTmo	seedling	2SOILivFERTmo	seedling	2SOILivFERT0	2SOILivFERTmo	seedling
10	seedling	2-332	seedling	1-332	2SOILivFERTmo			1-332		1-332
11		seedling	2SOILrvFERTmo	seedling	seedling		seedling	seedling	seedling	
12		seedling	2SOILivFERTmo	seedling	2SOILrvFERT0	2SOILrvFERT0	2SOILivFERT0	2-332	seedling	seedling
13	1-332	2SOILivFERTmo	2SOILivFERT0	2SOILivFERT0		seedling	seedling	2SOILrvFERTmo	1-332	seedling
14	2SOILrvFERT0	2SOILrvFERTmo	seedling	2SOILivFERTmo	2SOILivFERT0	2SOILrvFERT0	1-332		seedling	seedling
15	2SOILivFERT0	2-332	seedling	2SOILrvFERT0	2SOILrvFERTmo	1-332	2SOILrvFERTmo	2SOILivFERTmo	seedling	1-332
16	seedling	2SOILrvFERT0	seedling	2-332	seedling		2SOILrvFERTmo	seedling	seedling	2SOILrvFERT0
17	2SOILivFERT0	2SOILrvFERT0	1-332	2SOILivFERT0	seedling	2SOILivFERT0		2SOILivFERTmo		seedling
18	seedling	2SOILivFERT0	seedling	seedling	2SOILrvFERT0	seedling	2SOILrvFERT0		2SOILrvFERT0	2SOILrvFERT0
19	seedling	seedling	2SOILivFERT0	2SOILrvFERTmo	seedling	2-332	seedling	2SOILrvFERTmo	2SOILivFERTmo	2-332
20	2SOILrvFERTmo	2SOILivFERTmo	seedling	seedling	seedling	2SOILrvFERTmo	2SOILrvFERT0	seedling	2-332	2SOILivFERTmo

Cultivation history of individual plants transplanted at French Flat on March 10, 2008, plots 611-620. All plants were grown from Illinois Valley seed. A blank cell indicates that no plant was placed in that planting position. Seedling = plants transplanted three weeks after emergence. 1-332 = One-year tap-root cultivated in 3:3:2 soil. 2-332 = 2-year tap-root cultivated in 3:3:2 soil. 2SOILivFERTmo = 2-year taproot cultivated in Illinois Valley soil fertilized monthly. 2SOILivFERT0 = 2-year taproot cultivated in Illinois Valley without supplemental fertilization. 2SOILrvFERTmo = 2-year taproot cultivated in Rogue Valley soil fertilized monthly. 2SOILrvFERT0 = 2-year taproot cultivated in Rogue Valley without supplemental fertilization.

French Flat plot numbers and cultivation history of plants in each planting position

Planting position	611	612	613	614	615	616	617	618	619	620
1	seedling	seedling	2SOILrvFERTmo	2SOILivFERTmo	seedling	seedling		seedling	2SOILrvFERTmo	
2	1-332	2SOILivFERTmo	seedling	2SOILivFERT0	2SOILivFERTmo	2SOILivFERTmo	2SOILrvFERT0	2-332	seedling	seedling
3	seedling	2SOILivFERT0		2SOILrvFERT0	seedling	seedling	seedling	2SOILrvFERT0	2SOILrvFERTmo	seedling
4	seedling	seedling	seedling	seedling	2SOILivFERT0	2SOILivFERT0	2SOILrvFERTmo	seedling	2SOILrvFERT0	
5	seedling	seedling	2SOILrvFERTmo	1-332			seedling	2SOILivFERTmo	seedling	seedling
6	2SOILrvFERT0	seedling	seedling	seedling	seedling	seedling		2SOILivFERTmo	seedling	2SOILrvFERTmo
7	seedling	2SOILrvFERT0		seedling	2SOILrvFERT0	2SOILrvFERT0	seedling	seedling	2SOILrvFERTmo	
8	seedling	2SOILivFERTmo		2SOILivFERTmo		2-332		1-332	2SOILrvFERT0	seedling
9	2SOILrvFERTmo	1-332	seedling	1-332	2-332	2-332		seedling	seedling	seedling
10	2SOILivFERT0	2-332	seedling	2-332	seedling	seedling		seedling	2SOILrvFERTmo	seedling
11	2SOILivFERTmo	2SOILrvFERT0		2SOILrvFERTmo		1-332		2SOILivFERT0	seedling	2SOILrvFERT0
12	2SOILrvFERTmo	seedling	seedling	seedling	2SOILrvFERTmo	2SOILrvFERTmo			2SOILrvFERT0	1-332
13		seedling		seedling	seedling	seedling	2SOILrvFERTmo	seedling	seedling	
14	seedling	2-332	seedling	2-332	seedling	seedling	seedling	2SOILrvFERTmo	seedling	
15	2-332	seedling		seedling	seedling	seedling	1-332	seedling	1-332	2SOILrvFERTmo
16	seedling	2SOILrvFERTmo	1-332	seedling	seedling	seedling	seedling	2SOILrvFERT0	2SOILrvFERTmo	2SOILivFERTmo
17		seedling	2SOILrvFERT0	2SOILrvFERT0	1-332	1-332	seedling		seedling	
18		2SOILrvFERTmo	seedling	2SOILrvFERTmo	2SOILrvFERT0	2SOILrvFERT0	seedling	2SOILrvFERTmo	1-332	
19	2SOILrvFERT0	2SOILivFERT0	2SOILivFERTmo	seedling	2SOILivFERTmo	2SOILivFERTmo	seedling		2SOILrvFERTmo	
20	2SOILivFERTmo	1-332		2SOILivFERT0	2SOILrvFERTmo	2SOILrvFERTmo	2SOILivFERTmo	seedling		

Cultivation history of individual plants transplanted at Agate Desert on March 11, 2008, plots 621-630. All plants were grown from Medford Airport and Agate Desert seed. A blank cell indicates that no plant was placed in that planting position. Seedling = plants transplanted three weeks after emergence. 1-332 = One-year tap-root cultivated in 3:3:2 soil. 2-332 = 2-year tap-root cultivated in 3:3:2 soil. 2SOILivFERTmo = 2-year taproot cultivated in Illinois Valley soil fertilized monthly. 2SOILivFERT0 = 2-year taproot cultivated in Illinois Valley without supplemental fertilization. 2SOILrvFERTmo = 2-year taproot cultivated in Rogue Valley soil fertilized monthly. 2SOILrvFERT0 = 2-year taproot cultivated in Rogue Valley without supplemental fertilization.

Agate Desert plot numbers and cultivation history of plants in each planting position

Planting position	621	622	623	624	625	626	627	628	629	630
1	seedling	seedling	2SOILivFERTmo	1-332		2SOILrvFERTmo	seedling	2SOILrvFERT0	2SOILrvFERTmo	2SOILrvFERTmo
2	seedling	seedling	2SOILrvFERT0	2SOILrvFERT0	2SOILrvFERTmo	seedling	2SOILivFERTmo	seedling	seedling	seedling
3	2SOILrvFERTmo	1-332	2SOILrvFERT0	seedling		seedling	seedling	2SOILivFERT0	2SOILrvFERT0	seedling
4	seedling	seedling	seedling		2SOILivFERTmo	seedling	1-332	seedling	2SOILivFERT0	2SOILrvFERTmo
5		seedling	2-332	2SOILrvFERTmo	seedling	2SOILivFERTmo	2SOILivFERTmo	seedling	1-332	seedling
6	2SOILivFERTmo	seedling	2SOILrvFERTmo	seedling	seedling	seedling	seedling	seedling	seedling	2SOILivFERT0
7	1-332	2SOILivFERTmo		seedling	1-332	seedling	seedling	seedling	seedling	2SOILivFERTmo
8		2SOILivFERT0	seedling	seedling	2SOILivFERT0	seedling		2SOILrvFERT0	2SOILrvFERTmo	
9	seedling	1-332	1-332	2SOILivFERTmo	seedling	2SOILivFERTmo	seedling	2SOILivFERT0	2SOILivFERTmo	seedling
10	seedling		seedling	1-332	2SOILivFERTmo	1-332	2SOILivFERT0	1-332		1-332
11	2-332	seedling	2SOILrvFERTmo	seedling	seedling		seedling	seedling	seedling	2SOILivFERT0
12	2SOILrvFERT0	seedling	2SOILivFERTmo	seedling	2SOILrvFERT0	2SOILrvFERT0	2SOILivFERT0		seedling	seedling
13	1-332	2SOILivFERTmo	2SOILivFERT0	2SOILivFERT0	1-332	seedling	seedling	2SOILrvFERTmo	1-332	seedling
14	2SOILrvFERT0	2SOILrvFERTmo	seedling	2SOILivFERTmo	2SOILivFERT0	2SOILrvFERT0	1-332	2-332	seedling	seedling
15	2SOILivFERT0	2-332	seedling	2SOILrvFERT0	2SOILrvFERTmo	1-332	2SOILrvFERTmo	2SOILivFERTmo	seedling	1-332
16	seedling	2SOILrvFERT0	seedling		seedling	2SOILivFERT0	2SOILrvFERTmo	seedling	seedling	2SOILrvFERT0
17	2SOILivFERT0	2SOILrvFERT0	1-332	2SOILivFERT0	seedling	2SOILivFERT0		2SOILivFERTmo	2SOILivFERT0	seedling
18	seedling	2SOILivFERT0	seedling	seedling	2SOILrvFERT0	seedling	2SOILrvFERT0	1-332	2SOILrvFERT0	2SOILrvFERT0
19	seedling	seedling	2SOILivFERT0	2SOILrvFERTmo	seedling	2-332	seedling	2SOILrvFERTmo	2SOILivFERTmo	2-332
20		2SOILrvFERTmo	seedling	seedling	seedling	2SOILrvFERTmo	2SOILrvFERT0	seedling	2-332	2SOILivFERTmo

Cultivation history of individual plants transplanted at Agate Desert on March 11, 2008, plots 631-640. All plants were grown from Medford Airport and Agate Desert seed. A blank cell indicates that no plant was placed in that planting position. Seedling = plants transplanted three weeks after emergence. 1-332 = One-year tap-root cultivated in 3:3:2 soil. 2-332 = 2-year tap-root cultivated in 3:3:2 soil. 2SOILivFERTmo = 2-year taproot cultivated in Illinois Valley soil fertilized monthly. 2SOILivFERT0 = 2-year taproot cultivated in Illinois Valley without supplemental fertilization. 2SOILrvFERTmo = 2-year taproot cultivated in Rogue Valley soil fertilized monthly. 2SOILrvFERT0 = 2-year taproot cultivated in Rogue Valley without supplemental fertilization.

Agate Desert plot numbers and cultivation history of plants in each planting position

Planting position	631	632	633	634	636	637	638	639	640	
1	seedling	seedling	2SOILrvFERTmo	2SOILivFERTmo	seedling	seedling	seedling	seedling		
2	1-332	2SOILivFERTmo	seedling	2SOILivFERT0	2SOILivFERTmo	2SOILivFERTmo	2SOILrvFERT0	2SOILivFERTmo	2SOILrvFERT0	seedling
3	seedling	2SOILivFERT0		2SOILrvFERT0	seedling	seedling	seedling	2SOILrvFERT0		seedling
4	seedling	seedling	seedling	seedling	2SOILivFERT0	2SOILivFERT0	2SOILrvFERTmo	seedling		
5	seedling	seedling		1-332	2SOILivFERT0	2SOILivFERT0	seedling	2SOILivFERTmo	seedling	seedling
6	2SOILrvFERT0	seedling	seedling	seedling	seedling	seedling	2SOILivFERTmo	seedling		
7	seedling	2SOILrvFERT0	2SOILivFERT0	seedling	2SOILrvFERT0	2SOILrvFERT0	seedling	seedling		2SOILivFERT0
8	seedling	2SOILivFERTmo	2SOILrvFERT0	2SOILivFERTmo						seedling
9	2SOILrvFERTmo	1-332	seedling	1-332		2SOILivFERT0	seedling	seedling		seedling
10	2SOILivFERT0		seedling		seedling	seedling	2SOILivFERT0	seedling	2SOILrvFERTmo	seedling
11	2SOILivFERTmo	2SOILrvFERT0	1-332	2SOILrvFERTmo	1-332		2SOILivFERT0	seedling		
12	2SOILrvFERTmo	seedling	seedling	seedling	2SOILrvFERTmo	2SOILrvFERTmo				
13		seedling		seedling	seedling	seedling	seedling	seedling		
14	seedling	2-332	seedling		seedling	seedling	seedling	2SOILrvFERTmo	seedling	seedling
15	2-332	seedling	2SOILivFERT0	seedling	seedling	seedling	seedling	seedling		
16	seedling	2SOILrvFERTmo	1-332	seedling	seedling	seedling	seedling	2SOILrvFERT0	2SOILivFERTmo	2SOILivFERTmo
17	1-332	seedling	2SOILrvFERT0	2SOILrvFERT0			seedling	2SOILivFERT0	seedling	
18	2SOILivFERT0	2SOILrvFERTmo	seedling	2SOILrvFERTmo	2SOILrvFERT0	2SOILrvFERT0	seedling	2SOILrvFERTmo	2SOILivFERT0	2SOILrvFERTmo
19	2SOILrvFERT0	2SOILivFERT0	2SOILivFERTmo	seedling	2SOILivFERTmo	2SOILivFERTmo	seedling		2SOILrvFERTmo	2SOILrvFERT0
20	2SOILivFERTmo	1-332	2-332	2SOILivFERT0	2SOILrvFERTmo	2SOILrvFERTmo	2SOILivFERTmo	seedling	2SOILivFERT0	seedling

APPENDIX B. DATASHEETS

Lomatium cookii direct seeding plots

Site: _____

Name(s): _____ Date: _____

Plot number:

plant #	# lvs	length

Plot number:

plant #	# lvs	length

French Flat

Lomatium cookii transplantings

Name(s): _____

Date: _____

Planting position	Plot #	leaf #/ length (cm)	# repro stems	Plot #	leaf #/ length (cm)	# repro stems	Plot #	leaf #/ length (cm)	# repro stems	Plot #	leaf #/ length (cm)	# repro stems
	601			602			603			604		
1	seedling			seedling			2SOILivFERTmo			1-332		
2	seedling			seedling			2SOILrvFERT0			2SOILrvFERT0		
3	2SOILrvFERTmo			1-332			2SOILrvFERT0			seedling		
4	seedling			seedling			seedling			2-332		
5	2SOILivFERTmo			seedling			2-332			2SOILrvFERTmo		
6	2SOILivFERTmo			seedling			2SOILrvFERTmo			seedling		
7				2SOILrvFERTmo			2-332			seedling		
8				2SOILivFERT0			seedling			seedling		
9	seedling			1-332			1-332			2SOILivFERTmo		
10	seedling			2-332			seedling			1-332		
11				seedling			2SOILrvFERTmo			seedling		
12				seedling			2SOILivFERTmo			seedling		
13	1-332			2SOILivFERTmo			2SOILivFERT0			2SOILivFERT0		
14	2SOILrvFERT0			2SOILrvFERTmo			seedling			2SOILivFERTmo		
15	2SOILivFERT0			2-332			seedling			2SOILrvFERT0		
16	seedling			2SOILrvFERT0			seedling			2-332		
17	2SOILivFERT0			2SOILrvFERT0			1-332			2SOILivFERT0		
18	seedling			2SOILivFERT0			seedling			seedling		
19	seedling			seedling			2SOILivFERT0			2SOILrvFERTmo		
20	2SOILrvFERTmo			2SOILivFERTmo			seedling			seedling		

French Flat *Lomatium cookii* transplantings

Name(s): _____

Date: _____

Planting position	Plot # 605			Plot # 606			Plot # 607			Plot # 608		
	leaf #/ length (cm)	# repro stems		leaf #/ length (cm)	# repro stems		leaf #/ length (cm)	# repro stems		leaf #/ length (cm)	# repro stems	
1	2-332			2SOILrvFERTmo			seedling			2SOILrvFERT0		
2	2SOILrvFERTmo			seedling			2SOILivFERTmo			seedling		
3				seedling			seedling			2SOILivFERT0		
4	2SOILivFERTmo			seedling						seedling		
5	seedling			2SOILivFERTmo			2SOILivFERTmo			seedling		
6	seedling			seedling			seedling			seedling		
7	1-332			seedling			seedling			seedling		
8				seedling			2-332			2SOILrvFERT0		
9	seedling			2SOILivFERTmo			seedling			2SOILivFERT0		
10	2SOILivFERTmo									1-332		
11	seedling						seedling			seedling		
12	2SOILrvFERT0			2SOILrvFERT0			2SOILivFERT0			2-332		
13				seedling			seedling			2SOILrvFERTmo		
14	2SOILivFERT0			2SOILrvFERT0			1-332					
15	2SOILrvFERTmo			1-332			2SOILrvFERTmo			2SOILivFERTmo		
16	seedling						2SOILrvFERTmo			seedling		
17	seedling			2SOILivFERT0						2SOILivFERTmo		
18	2SOILrvFERT0			seedling			2SOILrvFERT0					
19	seedling			2-332			seedling			2SOILrvFERTmo		
20	seedling			2SOILrvFERTmo			2SOILrvFERT0			seedling		

French Flat *Lomatium cookii* transplantings

Name(s): _____

Date: _____

Planting position	Plot #	leaf #/ length (cm)	# repro stems	Plot #	leaf #/ length (cm)	# repro stems	Plot #	leaf #/ length (cm)	# repro stems	Plot #	leaf #/ length (cm)	# repro stems
	609			610			611			612		
1	2SOILrvFERTmo			2SOILrvFERTmo			seedling			seedling		
2	seedling			seedling			1-332			2SOILivFERTmo		
3	2SOILrvFERT0			seedling			seedling			2SOILivFERT0		
4	2SOILivFERT0			2SOILrvFERTmo			seedling			seedling		
5				seedling			seedling			seedling		
6	seedling			2SOILivFERT0			2SOILrvFERT0			seedling		
7	seedling			2SOILivFERTmo			seedling			2SOILrvFERT0		
8	2SOILrvFERTmo			2-332			seedling			2SOILivFERTmo		
9	2SOILivFERTmo			seedling			2SOILrvFERTmo			1-332		
10				1-332			2SOILivFERT0			2-332		
11	seedling						2SOILivFERTmo			2SOILrvFERT0		
12	seedling			seedling			2SOILrvFERTmo			seedling		
13	1-332			seedling						seedling		
14	seedling			seedling			seedling			2-332		
15	seedling			1-332			2-332			seedling		
16	seedling			2SOILrvFERT0			seedling			2SOILrvFERTmo		
17				seedling						seedling		
18	2SOILrvFERT0			2SOILrvFERT0						2SOILrvFERTmo		
19	2SOILivFERTmo			2-332			2SOILrvFERT0			2SOILivFERT0		
20	2-332			2SOILivFERTmo			2SOILivFERTmo			1-332		

French Flat *Lomatium cookii* transplantings

Name(s): _____

Date: _____

Planting position	Plot #	leaf #/ length (cm)	# repro stems	Plot #	leaf #/ length (cm)	# repro stems	Plot #	leaf #/ length (cm)	# repro stems	Plot #	leaf #/ length (cm)	# repro stems
	613			614			615			616		
1	2SOILrvFERTmo			2SOILivFERTmo			seedling			seedling		
2	seedling			2SOILivFERT0			2SOILivFERTmo			2SOILivFERTmo		
3				2SOILrvFERT0			seedling			seedling		
4	seedling			seedling			2SOILivFERT0			2SOILivFERT0		
5	2SOILrvFERTmo			1-332								
6	seedling			seedling			seedling			seedling		
7				seedling			2SOILrvFERT0			2SOILrvFERT0		
8				2SOILivFERTmo						2-332		
9	seedling			1-332			2-332			2-332		
10	seedling			2-332			seedling			seedling		
11				2SOILrvFERTmo						1-332		
12	seedling			seedling			2SOILrvFERTmo			2SOILrvFERTmo		
13				seedling			seedling			seedling		
14	seedling			2-332			seedling			seedling		
15				seedling			seedling			seedling		
16	1-332			seedling			seedling			seedling		
17	2SOILrvFERT0			2SOILrvFERT0			1-332			1-332		
18	seedling			2SOILrvFERTmo			2SOILrvFERT0			2SOILrvFERT0		
19	2SOILivFERTmo			seedling			2SOILivFERTmo			2SOILivFERTmo		
20				2SOILivFERT0			2SOILrvFERTmo			2SOILrvFERTmo		

French Flat *Lomatium cookii* transplantings

Name(s): _____

Date: _____

Planting position	Plot #	leaf #/ length (cm)	# repro stems	Plot #	leaf #/ length (cm)	# repro stems	Plot #	leaf #/ length (cm)	# repro stems	Plot #	leaf #/ length (cm)	# repro stems
1				seedling			2SOILrvFERTmo					
2	2SOILrvFERT0			2-332			seedling			seedling		
3	seedling			2SOILrvFERT0			2SOILrvFERTmo			seedling		
4	2SOILrvFERTmo			seedling			2SOILrvFERT0					
5	seedling			2SOILivFERTmo			seedling			seedling		
6				2SOILivFERTmo			seedling			2SOILrvFERTmo		
7	seedling			seedling			2SOILrvFERTmo					
8				1-332			2SOILrvFERT0			seedling		
9				seedling			seedling			seedling		
10				seedling			2SOILrvFERTmo			seedling		
11				2SOILivFERT0			seedling			2SOILrvFERT0		
12							2SOILrvFERT0			1-332		
13	2SOILrvFERTmo			seedling			seedling					
14	seedling			2SOILrvFERTmo			seedling					
15	1-332			seedling			1-332			2SOILrvFERTmo		
16	seedling			2SOILrvFERT0			2SOILrvFERTmo			2SOILivFERTmo		
17	seedling						seedling					
18	seedling			2SOILrvFERTmo			1-332					
19	seedling						2SOILrvFERTmo					
20	2SOILivFERTmo			seedling								

Agate Desert *Lomatium cookii* transplantings

Name(s): _____

Date: _____

Planting position	Plot #	leaf #/ length (cm)	# repro stems	Plot #	leaf #/ length (cm)	# repro stems	Plot #	leaf #/ length (cm)	# repro stems	Plot #	leaf #/ length (cm)	# repro stems
	621			622			623			624		
1	seedling			seedling			2SOILivFERTmo			1-332		
2	seedling			seedling			2SOILrvFERT0			2SOILrvFERT0		
3	2SOILrvFERTmo			1-332			2SOILrvFERT0			seedling		
4	seedling			seedling			seedling					
5				seedling			2-332			2SOILrvFERTmo		
6	2SOILivFERTmo			seedling			2SOILrvFERTmo			seedling		
7	1-332			2SOILivFERTmo						seedling		
8				2SOILivFERT0			seedling			seedling		
9	seedling			1-332			1-332			2SOILivFERTmo		
10	seedling						seedling			1-332		
11	2-332			seedling			2SOILrvFERTmo			seedling		
12	2SOILrvFERT0			seedling			2SOILivFERTmo			seedling		
13	1-332			2SOILivFERTmo			2SOILivFERT0			2SOILivFERT0		
14	2SOILrvFERT0			2SOILrvFERTmo			seedling			2SOILivFERTmo		
15	2SOILivFERT0			2-332			seedling			2SOILrvFERT0		
16	seedling			2SOILrvFERT0			seedling					
17	2SOILivFERT0			2SOILrvFERT0			1-332			2SOILivFERT0		
18	seedling			2SOILivFERT0			seedling			seedling		
19	seedling			seedling			2SOILivFERT0			2SOILrvFERTmo		
20				2SOILrvFERTmo			seedling			seedling		

Agate Desert *Lomatium cookii* transplantings

Name(s): _____

Date: _____

Planting position	Plot #	leaf #/ length (cm)	# repro stems	Plot #	leaf #/ length (cm)	# repro stems	Plot #	leaf #/ length (cm)	# repro stems	Plot #	leaf #/ length (cm)	# repro stems
1				2SOILrvFERTmo			seedling			2SOILrvFERT0		
2	2SOILrvFERTmo			seedling			2SOILivFERTmo			seedling		
3				seedling			seedling			2SOILivFERT0		
4	2SOILivFERTmo			seedling			1-332			seedling		
5	seedling			2SOILivFERTmo			2SOILivFERTmo			seedling		
6	seedling			seedling			seedling			seedling		
7	1-332			seedling			seedling			seedling		
8	2SOILivFERT0			seedling						2SOILrvFERT0		
9	seedling			2SOILivFERTmo			seedling			2SOILivFERT0		
10	2SOILivFERTmo			1-332			2SOILivFERT0			1-332		
11	seedling						seedling			seedling		
12	2SOILrvFERT0			2SOILrvFERT0			2SOILivFERT0					
13	1-332			seedling			seedling			2SOILrvFERTmo		
14	2SOILivFERT0			2SOILrvFERT0			1-332			2-332		
15	2SOILrvFERTmo			1-332			2SOILrvFERTmo			2SOILivFERTmo		
16	seedling			2SOILivFERT0			2SOILrvFERTmo			seedling		
17	seedling			2SOILivFERT0						2SOILivFERTmo		
18	2SOILrvFERT0			seedling			2SOILrvFERT0			1-332		
19	seedling			2-332			seedling			2SOILrvFERTmo		
20	seedling			2SOILrvFERTmo			2SOILrvFERT0			seedling		

Agate Desert *Lomatium cookii* transplantings

Name(s): _____

Date: _____

Planting position	Plot #	leaf #/ length (cm)	# repro stems	Plot #	leaf #/ length (cm)	# repro stems	Plot #	leaf #/ length (cm)	# repro stems	Plot #	leaf #/ length (cm)	# repro stems
	629			630			631			632		
1	2SOILrvFERTmo			2SOILrvFERTmo			seedling			seedling		
2	seedling			seedling			1-332			2SOILivFERTmo		
3	2SOILrvFERT0			seedling			seedling			2SOILivFERT0		
4	2SOILivFERT0			2SOILrvFERTmo			seedling			seedling		
5	1-332			seedling			seedling			seedling		
6	seedling			2SOILivFERT0			2SOILrvFERT0			seedling		
7	seedling			2SOILivFERTmo			seedling			2SOILrvFERT0		
8	2SOILrvFERTmo						seedling			2SOILivFERTmo		
9	2SOILivFERTmo			seedling			2SOILrvFERTmo			1-332		
10				1-332			2SOILivFERT0					
11	seedling			2SOILivFERT0			2SOILivFERTmo			2SOILrvFERT0		
12	seedling			seedling			2SOILrvFERTmo			seedling		
13	1-332			seedling						seedling		
14	seedling			seedling			seedling			2-332		
15	seedling			1-332			2-332			seedling		
16	seedling			2SOILrvFERT0			seedling			2SOILrvFERTmo		
17	2SOILivFERT0			seedling			1-332			seedling		
18	2SOILrvFERT0			2SOILrvFERT0			2SOILivFERT0			2SOILrvFERTmo		
19	2SOILivFERTmo			2-332			2SOILrvFERT0			2SOILivFERT0		
20	2-332			2SOILivFERTmo			2SOILivFERTmo			1-332		

Agate Desert *Lomatium cookii* transplantings

Name(s): _____

Date: _____

Planting position	Plot #	leaf #/ length (cm)	# repro stems	Plot #	leaf #/ length (cm)	# repro stems	Plot #	leaf #/ length (cm)	# repro stems	Plot #	leaf #/ length (cm)	# repro stems
	633			634			635			636		
1	2SOILrvFERTmo			2SOILivFERTmo			seedling			seedling		
2	seedling			2SOILivFERT0			2SOILivFERTmo			2SOILivFERTmo		
3				2SOILrvFERT0			seedling			seedling		
4	seedling			seedling			2SOILivFERT0			2SOILivFERT0		
5				1-332			2SOILivFERT0			2SOILivFERT0		
6	seedling			seedling			seedling			seedling		
7	2SOILivFERT0			seedling			2SOILrvFERT0			2SOILrvFERT0		
8	2SOILrvFERT0			2SOILivFERTmo								
9	seedling			1-332								
10	seedling						seedling			seedling		
11	1-332			2SOILrvFERTmo			1-332					
12	seedling			seedling			2SOILrvFERTmo			2SOILrvFERTmo		
13				seedling			seedling			seedling		
14	seedling						seedling			seedling		
15	2SOILivFERT0			seedling			seedling			seedling		
16	1-332			seedling			seedling			seedling		
17	2SOILrvFERT0			2SOILrvFERT0								
18	seedling			2SOILrvFERTmo			2SOILrvFERT0			2SOILrvFERT0		
19	2SOILivFERTmo			seedling			2SOILivFERTmo			2SOILivFERTmo		
20	2-332			2SOILivFERT0			2SOILrvFERTmo			2SOILrvFERTmo		

Agate Desert *Lomatium cookii* transplantings

Name(s): _____

Date: _____

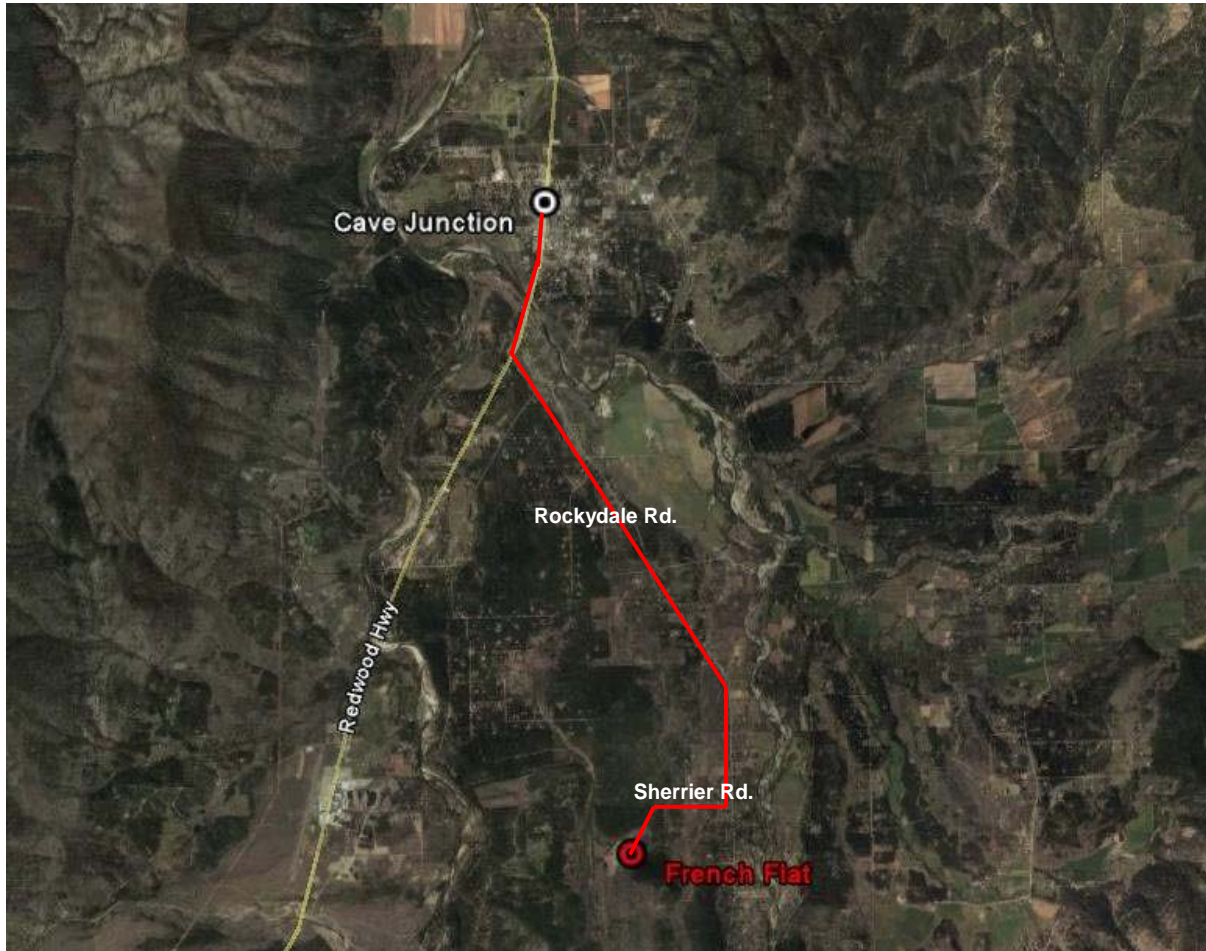
Planting position	Plot #	leaf #/ length (cm)	# repro stems	Plot #	leaf #/ length (cm)	# repro stems	Plot #	leaf #/ length (cm)	# repro stems	Plot #	leaf #/ length (cm)	# repro stems
1				seedling			seedling					
2	2SOILrvFERT0			2SOILivFERTmo			2SOILrvFERT0			seedling		
3	seedling			2SOILrvFERT0						seedling		
4	2SOILrvFERTmo			seedling								
5	seedling			2SOILivFERTmo			seedling			seedling		
6				2SOILivFERTmo			seedling					
7	seedling			seedling						2SOILivFERT0		
8										seedling		
9	2SOILivFERT0			seedling			seedling			seedling		
10	2SOILivFERT0			seedling			2SOILrvFERTmo			seedling		
11				2SOILivFERT0			seedling					
12												
13				seedling			seedling					
14	seedling			2SOILrvFERTmo			seedling			seedling		
15				seedling								
16	seedling			2SOILrvFERT0			2SOILivFERTmo			2SOILivFERTmo		
17	seedling			2SOILivFERT0			seedling					
18	seedling			2SOILrvFERTmo			2SOILivFERT0			2SOILrvFERTmo		
19	seedling						2SOILrvFERTmo			2SOILrvFERT0		
20	2SOILivFERTmo			seedling			2SOILivFERT0			seedling		

APPENDIX C. DIRECTIONS TO SITES AND SITE MAPS

French Flat

From the Junction of Hwy 199 and Hwy 46 in the town of Cave Junction, Oregon, travel south on Hwy 199 0.7 miles to Rockydale Road. Turn left on Rockydale Road and travel 3.8 miles to Sherier Road. Turn right. At this point the road becomes gravel. Travel just under 1 mile to a yellow, locked BLM gate on the left. Over this distance on Sherier Road, the road quality degrades and there are often large puddles in the road in the spring, though it usually remains passable with most vehicles. There are also several driveways on Sherier Road, some of which are marked and some of are not. Be certain to follow what appears to be the main road. Park at the yellow gate (Map 1).

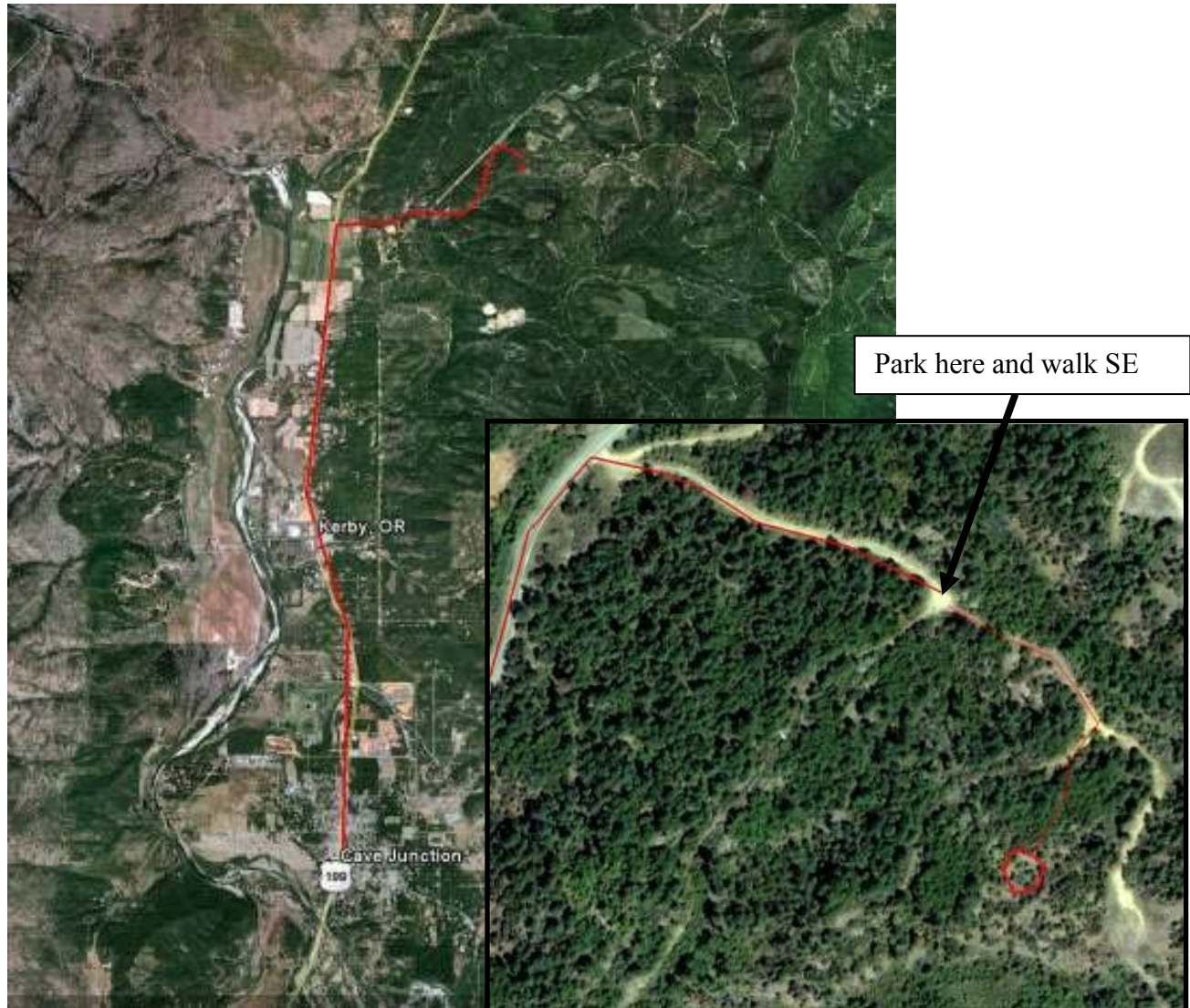
From here, the seeded and transplanted populations must be reached on foot as the BLM does not allow vehicle access beyond the gate. Walk past the gate and follow the main road. Once out of the trees (approx. 200 meters), the road will veer right and up a small hill. At the top of the hill, continue to follow the road downhill. On the left is a denuded hillside covered in mine tailings, indicated in the sketch map in Figure 2. Continue to follow the road. The north meadow will not be visible from this road. The first meadow encountered on the right is the middle meadow. Continue to follow the road south to the south meadow, the next meadow encountered on the right. A pond, not shown on the sketch map, separates the middle and south meadows. A smaller pond, also not shown on the sketch map, is located at the northern terminus of the south meadow. From this pond, cross the south meadow, walking toward the most obvious and largest *Pinus jeffreyi* on the southwest border of the meadow. Seed and transplant plots are located to the northeast of this tree on the edge of the meadow.



Map 1. Aerial photograph of French Flat and surrounding area, including Cave Junction and driving route to site.

Reeves Creek

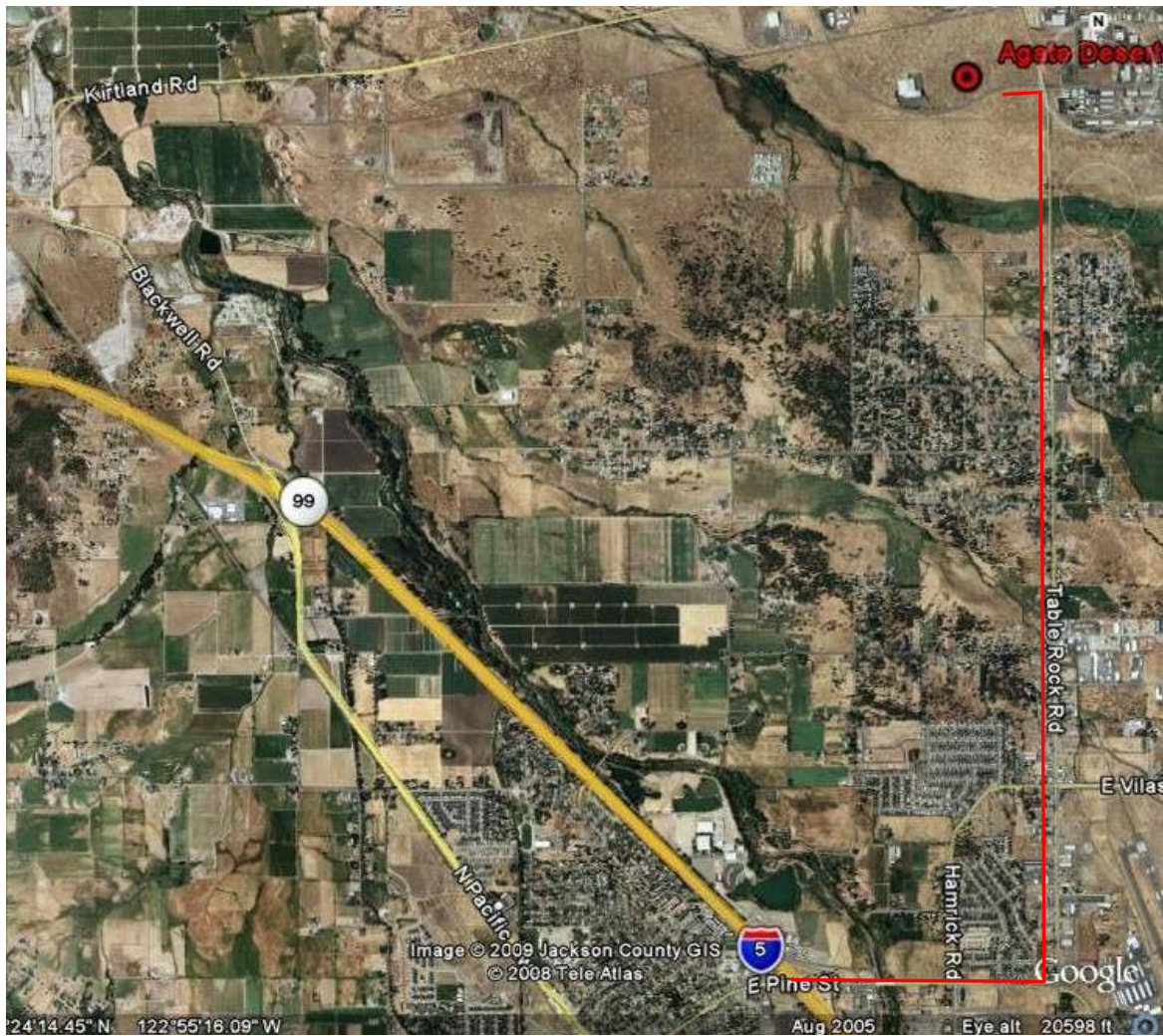
From Cave Junction, drive 3.9 miles north on Hwy 199 to Reeves Creek Rd. turn east and travel 1.4 miles to Road 38-8-27.8. Turn right and go 0.1 mile and park at wide place in the road (with large pile of garbage present in 2009). Continue on road SE past blocked area approximately 0.1 mi and watch for spur road on right. Travel route to plots is flagged from here.



Map 2. Aerial photograph of Reeves Creek and surrounding area, including Cave Junction and driving route to site. Inset shows walking route from parking spot.

Agate Desert

The Nature Conservancy's Agate Desert Preserve is located on the northwest corner of the intersection of Table Rock Road and Antelope Road in White City, Oregon, just NE of Medford. From I-5, take the Central Point Exit #33 and travel east on E Pine St. (becomes Biddle St.) approximately one mile to Table Rock Road. Turn left and travel north approximately 3.5 miles to the intersection with Antelope Road. Turn left and park on the right side of the road where the shoulder widens enough to accommodate a few vehicles.



Map 3. Aerial photograph of Medford and surrounding area. The Agate Desert site is in the upper right corner; the red line indicates a driving route from I-5 to the site.