Lupinus lepidus var. *cusickii* population monitoring in Denny Flat, Baker County, Oregon

2012

Report to the Bureau of Land Management, Vale District

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Institute for Applied Ecology

PREFACE

This report is the result of a cooperative Challenge Cost Share project between the Institute for Applied Ecology (IAE) and the Bureau of Land Management. IAE is a non-profit organization dedicated to natural resource conservation, research, and education. Our aim is to provide a service to public and private agencies and individuals by developing and communicating information on ecosystems, species, and effective management strategies and by conducting research, monitoring, and experiments. IAE offers educational opportunities through 3-4 month internships. Our current activities are concentrated on rare and endangered plants and invasive species.

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Cover photograph: Lisa VanTieghem, Charlotte Trowbridge, and Roger Ferriel (BLM) monitoring *Lupinus lepidus* var. *cusickii* at ORV Hill. Inset: Cusick's lupine (*Lupinus lepidus* var. *cusickii*).

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REPORT TO THE BUREAU OF LAND MANAGEMENT, VALE DISTRICT

INTRODUCTION

Figure 1. *Lupinus lepidus* var. *cusickii* inflorescence.

Lupinus lepidus var. *cusickii*, Cusick's lupine, is a BLM Special Status Species. In addition, it is listed as endangered by the Oregon Department of Agriculture, and it is considered a Species of Concern by the U.S. Fish and Wildlife Service. The Oregon Biodiversity Information Center (ORBIC) considers *L. lepidus* var. *cusickii* to be threatened or endangered throughout its range (ORBIC 2010). *Lupinus lepidus* var. *cusickii* (Figure 1) is a narrow endemic, restricted to only five small populations in Baker County, Oregon (Meinke et al. 1990). These populations are located southeast of the Blue Mountain foothills within Denny Flat, near the town of Unity, Oregon. *Lupinus lepidus* var. *cusickii* is part of the *Lupinus caespitosus-lepidus* complex, a polymorphic species group which is widely distributed throughout western North America (Broich and Morrison 1995). *Lupinus* populations with the epithet *cusickii* have been treated in a variety of ways including as a subspecies, a variety, or a synonym for *Lupinus lepidus* (Broic and Morrison 1995, ODA 2010); we refer to Cusick's lupine as *L. lepidus* var. *cusickii,* consistent with the treatment of Broich (1989) and others (Broich and Morrison 1995, Oregon Flora Project, ODA 2010, ORBIC 2010).

Although *L. lepidus* var. *cusickii* was first located in Oregon in 1886, relatively little is known about the species (Meinke et al. 1990). Despite previous studies, which have identified taxonomic problems (Broich 1989, Broich and Morrison 1995), inventoried for additional populations, and described natural history of the species (Meinke et al. 1990), we are only now beginning to gain an understanding of the species' population dynamics and long-term trends. Population monitoring was initiated in 1993 and conducted annually until 1998. Monitoring was intended to continue every three years, but has since been repeated in 2002, 2009, and 2012. Previously, we (Massatti et al. 2009) found that population density and plant performance varied considerably between years, apparently in response to annual climatic variation. In addition, we found no effect of exclosures (to eliminate cattle and off-road recreational vehicles (ORV)) on *L. lepidus* var. *cusickii* population dynamics or plant size.

The purpose of this project was to locate and resample the previously established *L. lepidus* var. *cusickii* monitoring plots. Specifically, we compared current population size and plant performance with data from previous years and analyzed differences between plots that were fenced and plots that were open to ORVs and cattle. This will provide the BLM with important information to assess management plans for the conservation of this sensitive species.

The flowers of *L. lepidus* var. *cusickii*, which bloom in July, are potentially cross-pollinated by a variety of visitors, primarily bumblebees and small solitary bees (Meinke et al. 1990). It is not known if *L. lepidus* var. *cusickii* is genetically self-compatible, and no asexual reproduction via vegetative means occurs in the species. The production of large crops of seed may be dependent on well-timed summer rainfall to support ovule development (Meinke et al. 1990). No studies have been performed on germination ecology or seed longevity, but it is suspected that seeds germinate in the winter or spring if seed coat scarification has occurred. Seedlings are present at least as early as May (observed during a preliminary spring visit to sites). As there is no vegetative reproduction in this species, seed production is vital for population maintenance and growth.

Known *L. lepidus* var. *cusickii* populations are found on eroding, tuffaceous hillsides at elevations around 4000 feet. *Lupinus lepidus* var. *cusickii* occurs in areas of sparse vegetation, but is generally associated with occasional junipers and low-growing perennials such as *Eriogonum* spp., *Allium* spp., and *Lomatium* spp. Associated annual species include *Mimulus nanus*, *Phacelia lutea*, *Spraguea umbellata*, and *Camissonia* sp. (Meinke et al. 1990). Other species sometimes observed with *L. lepidus* var. *cusickii* include *Artemisia tridentata*, *Astragalus* sp., *Phlox* sp., and *Silene* sp. (Broich 1989). The average annual precipitation in the area is 30-40 cm. All populations of the species fall within the Blue Mountains physiographic province (Franklin and Dyrness 1984).

METHODS

Site locations and sample plots

Fences were erected at three subpopulations of *L. lepidus* var. *cusickii* in fall 1993 to exclude off road vehicles (ORVs) and livestock from portions of each subpopulation. Randomly placed permanent plots were established and sampled inside and outside of these exclosures to evaluate the hypothesis that fencing improves plant growth and population dynamics by limiting ORV and cattle access (null hypothesis: fencing has no effect). The three subpopulations are within pastures managed for livestock on a rest rotation grazing schedule (each pasture rested every three years). ORV Hill and Elms Reservoir were within one pasture and Ampitheater was within another, so the grazing schedule differed between sites.

A total of twenty-four plots were established at three different locations (subpopulations) in the vicinity of Unity in Baker County, Oregon. Plots were numbered 1-in, 2-in, 3-out, 4-out, and so on, with "in" indicating the plot is inside an exclosure, and "out" indicating the plot is outside an exclosure. Descriptions of the site locations and the sample plots are as follows:

Elms Reservoir: This site is located about 1.5 miles east of Unity, and about 0.25 miles northwest of Elms Reservoir (Figure 2), T13S R37E S10 SW1/4 SE1/4. The site is best reached by turning left (northeast) off of Highway 26 onto a dirt road located about one mile beyond the eastern boundary of Unity (it is the first road after Elms Reservoir that is visible on the left). After about 0.4 miles, turn left. Continue 0.2 miles to park by a large juniper. A small hill on the right (north) side of the road marks the beginning of the site, beyond which plots 1 through 4 are located a few meters from the right (north) roadside, and plots 5 and 6 are located 30 to 40 meters from the left roadside (Appendix A). Plots 1 and 2 are located within a fenced exclosure and are referred to as "Elms-in"; plots 3 – 6 are referred to as "Elms-out." A gully runs roughly through the middle of the site, between plots 2 and 3 on the north side of the road, and Elms Reservoir is clearly visible to the south.

ORV Hill: This site is bisected by a road into two areas (Area 1 and Area 2), and plots were assigned randomly on each side. Area 1 was partially fenced (3 plots inside fencing, 3 plots outside fencing) and Area 2 was completely fenced. This site is treated as one "block" in the experimental analysis.

> Area 1: This site is located about one mile northeast of the Elms Reservoir site, on a steep, southeast facing slope, T13S R37E S11 NW1/4 SW1/4. To reach this site, drive as you would to reach the Elms Reservoir site, turning left (northeast) off of Highway 26 onto a dirt road located about one mile from the eastern boundary of Unity (Figure 2). After about 0.4 miles, take a right (a left would take you to Elms Reservoir). After about 1 mile take a left. At 1.3 miles, you will reach the site as it passes between two hills and turns to the northeast. The site is located upon the southeast-facing slopes of the conspicuous, ashy, white hill located on the left (northwest) side of the road. Plots 7, 8, and 9 (referred to as ORV Hill 1-in) are located within an exclosure a few meters west from plots 10, 11, and 12 (referred to as ORV Hill 1-out), which are unfenced (Appendix A). All plots run roughly parallel with the slope of the hill.

> Area 2: This site is located on a low hill directly across the road (southeast) from ORV Hill 1 (Figure 2), to which it is connected by a dirt trail. Plots 13, 14, 22, 23, and 24 are located on the south side of the hill and plot 15 is located on the north side of the hill (Appendix A); all plots run parallel to the slope. All six plots are located within an exclosure and are referred to as "ORV Hill 2-in."

Amphitheater: NOTE: This site requires a 4WD vehicle for access! This site is located about 1.25 miles northwest of the ORV Hill 1 and ORV Hill 2 sites (Figure 2), T13S R37E S3 NE1/4 SE1/4. To reach the Amphitheater site, follow the directions to reach the ORV Hill site, and from there continue following the main road northward for about 0.75 miles and turn left (west) onto a somewhat overgrown spur road. After about 0.5 miles this spur road ends near the amphitheater site. From this point, the site lays diagonally downhill a couple of hundred meters to the north. The amphitheater (an amphitheater-shaped outcrop of white welded tuff) can be seen on the nearby steep hillside to the west. Plots 16, 17, and 21 are located within a fenced exclosure and are referred to as "Amphitheater-in," and plots 18, 19, and 20 are located outside the exclosure a few meters to the north and are referred to as "Amphitheater-out" (Appendix A).

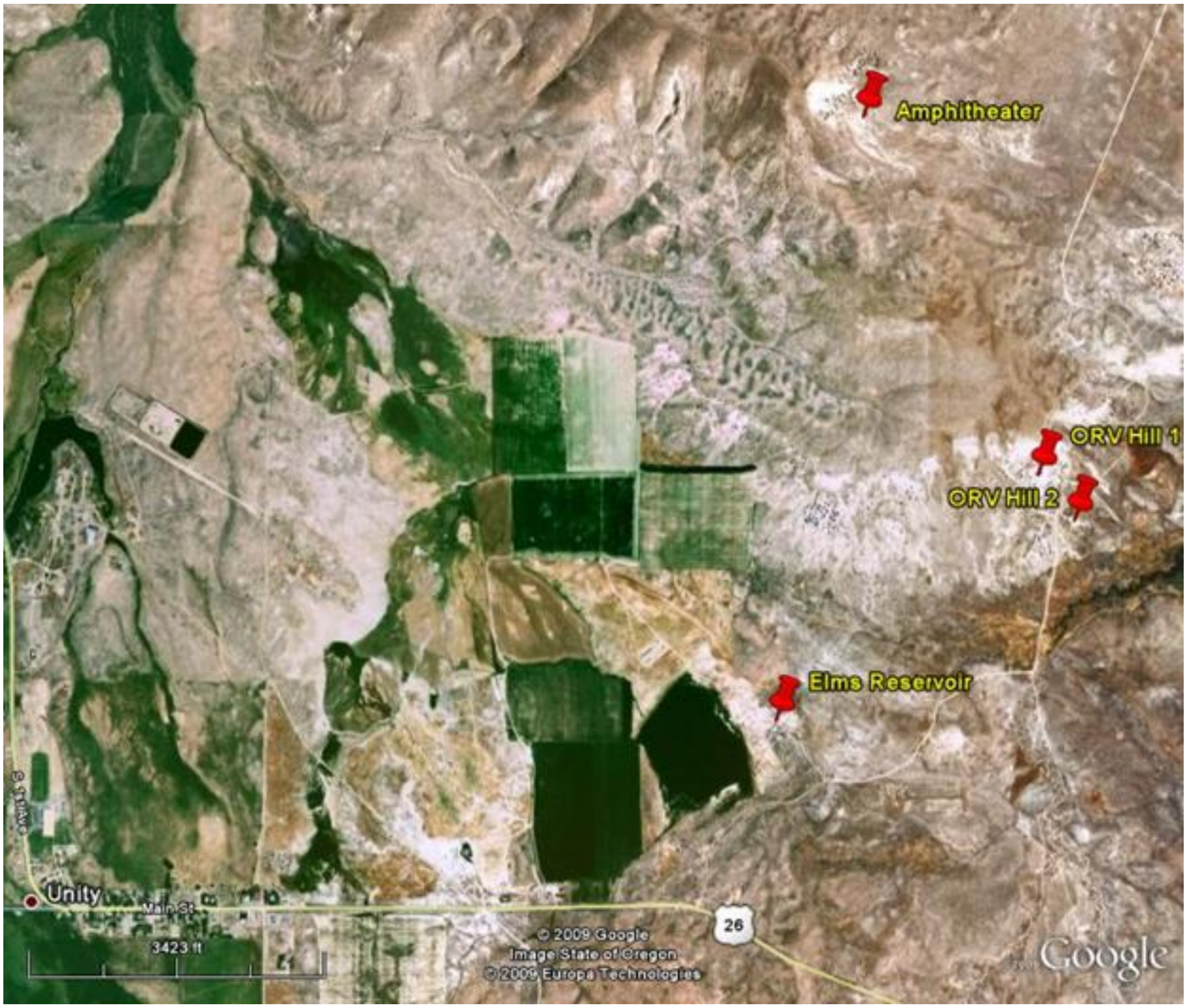

Figure 2. Locations of sampling sites relative to Unity, Oregon (bottom left). Site maps indicating plot layout are available in Appendix A. See Methods for driving directions.

All plots, whether inside or outside of an exclosure, were 10 meters in length (except for plot 24 at ORV Hill 2, which was 8 meters) and marked permanently with iron rebar posts anchored at each end. The origin and identification number of each plot was marked by a copper tag attached to one of the iron rebar posts. Exact placement of the plots at each site was determined randomly within the sampling areas; at the Elms Reservoir site plot locations were determined by dividing the sampling area into numbered unit areas and then using a random number generator to pick six numbers, each representing a plot location. At ORV Hill 1, ORV Hill 2, and Amphitheater sites, random compass bearings and distances were used to establish plot locations.

Each plot was divided into ten contiguous 1 x 1 meter subplots in which plants were measured. In 1994, three new plots (numbers 22-24; all 10 meters long except #24, which was 8 meters) were added at ORV Hill 2 to increase the number of marked individuals. To locate the subplots for sampling, a meter tape was run between the two rebar posts at each end of the plot, beginning at the origin, and each one meter segment of meter tape formed the lower edge of each subplot. A 1 x 1 meter frame was then placed on the ground (with one edge along the meter tape) to delineate the subplot. Each subplot was given a numerical value for purposes of identification, consisting of two numbers. The first was the number of the plot (1 through 24) along which the subplot was located, and the second was a number between one and ten, representing consecutive 1 meter sections along the plot. For example, subplot 14-6 would be located in plot #14, with its lower right corner located at the 6 meter mark on the measuring tape run between the origin and end of the plot. The maps in Appendix A indicate (via arrows) the side of the tape on which measurements should be recorded.

All twenty-four plots at the sites were sampled mid-July each year from 1993-1998 and in 2002, 2009, and 2012. Data on plant height (cm), diameter (cm), perpendicular width (cm), number of inflorescences, and presence of herbivory were recorded. In some years, the sampling area of some subplots was reduced due to the high density of *L. lepidus* var. *cusickii* individuals. For example, in 1993 and 1994 at the Elms Reservoir site, only plants located within the lower half of the subplot were sampled at plots 3 through 6, and subplots 2-1 through 2-7 within plot 2. At subplots 2-8 through 2-10, only the lower left quarter of each subplot was sampled. In 1995 through 1997, all portions of all plots were sampled in this area. In 1993, at ORV Hill 1 site, only the lower halves of the subplots were sampled at plots 9, 11, and 12. Because high seedling mortality in 1993 reduced our sample size, we increased the sampling area at ORV Hill 1 in 1994 and subsequent years to include the upper half of the subplots in plots 9, 11, and 12.

Seed collection

In 2012, seeds from *L. lepidus* var. *cusickii* plants were collected for conservation purposes. Collection occurred at the Elms Reservoir subpopulation on July 11th and 26th, and at the Amphitheater subpopulation on July 25th. Seeds were cleaned and counted before being deposited at the Rae Selling Berry Seed Bank in Portland, Oregon for long-term storage.

Population surveys

Field surveys for undocumented populations were conducted on July 10th and 26th, 2012 in two areas that were identified as potential habitat for *L. lepidus* var. *cusickii*. These areas, North of Unity and Windlass Gulch, were prioritized for surveys by the BLM. Areas of interest were identified based on topography and soil color. The main habitat indicator of *L. lepidus* var. *cusickii* is tuffaceous soil, which is very light in color and primarily found on eroding hillsides. At each site, the Intuitive Controlled survey method (Whiteaker et al. 1998) was employed to determine the presence or absence of *L. lepidus* var. *cusickii* individuals. Survey locations were documented using a navigation grade GPS unit, and search boundaries were delineated on topographic maps. We completed GeoBOB sighting report forms for both locations. These surveys will provide accurate information about the true extent of this species' range and aid in the prioritization of management actions.

Analysis

The effect of fencing on plant performance (plant size, reproduction, and height) was tested using data collected in 2012. We used 2-factor ANOVA (R Development Core Team 2009) to test for the responses of size (log transformed) and height of *L. lepidus* var. *cusickii* (log transformed), using site and treatment (fencing vs. unfenced) as fixed factors. Responses were log-transformed to meet the assumptions of normality. To test for the response of number of inflorescences, we used a general linear model with a quasipoisson distribution, using site and treatment as predictors. We considered $P < 0.05$ to be significant.

RESULTS

Population density trends

Average population density (plants/m^2) varied from site to site and year to year between 1993 and 2012 (Figure 3). Between 1993 and 1998, population densities at each site followed comparable annual trends, but data collected in 2002, 2009, and 2012 indicate slightly greater variation in population density trends across sites and treatments. Generally, the subpopulations that increased in mean population density between 2002 and 2009 have continued to increase, while those that experienced a decrease across the same time period have continued to decline. The trends at the Amphitheater and Elms Reservoir subpopulations appear similar inside and outside fences. ORV Hill was the only subpopulation exhibiting a distinct difference between treatments, where the mean population density outside the exclosures increased and the mean population density inside the exclosures decreased.

Looking in-depth at population trends over the last two decades, 2012 densities at the Amphitheater site were the highest since 1998, averaging 3.96 plants/m^2 outside exclosures and 2.53 plants/m^2 inside exclosures, having increased from an average 0.4 plants/m^2, both outside and inside, in 2002. The year 2002 marked the lowest levels of plant densities at this site since monitoring began in 1993, but subsequent monitoring has shown that densities are rebounding (Figure 3). At the Elms Reservoir site, average plant density outside the exclosure has dropped from 13.20 plants/m^2 to 7.73 plants/m^2 over a 10-year time period, while densities within the exclosure have remained fairly stable (currently 1.50 plants/m^2). Finally, the ORV Hill site is the only site where plant densities across treatments have not followed a consistent general trend. Plant densities outside the exclosures have increased since 2002 to an average of 6.2 plants/m^2 while densities within the exclosure have remained stable and low (0.93 plants/m^2 in 2012).

It is unknown why plant densities were consistently higher outside the fencing. It seems likely that these patterns are due to small microhabitat differences where areas outside of the exclosures may present microhabitats that *L. lepidus* var. *cusickii* are responding more favorably to, including areas of slightly increased disturbance. These areas could potentially have greater abundance of seedlings, though our study design did not test this. Plants outside of the exclosures while more abundant, could be smaller due to higher intraspecific competition.

As is common among many annual and short-lived perennial species in arid climates, variability in the weather potentially has a large effect on the population dynamics of *L. lepidus* var. *cusickii*. The huge swings in population growth rates (Kaye 2002) and variation in plant density suggest that climate may play a strong role in determining annual population growth or decline. Consistent annual monitoring data will be necessary to determine if there is a significant correlation between climatic variables (such as timing and amount of seasonal precipitation) and population dynamics.

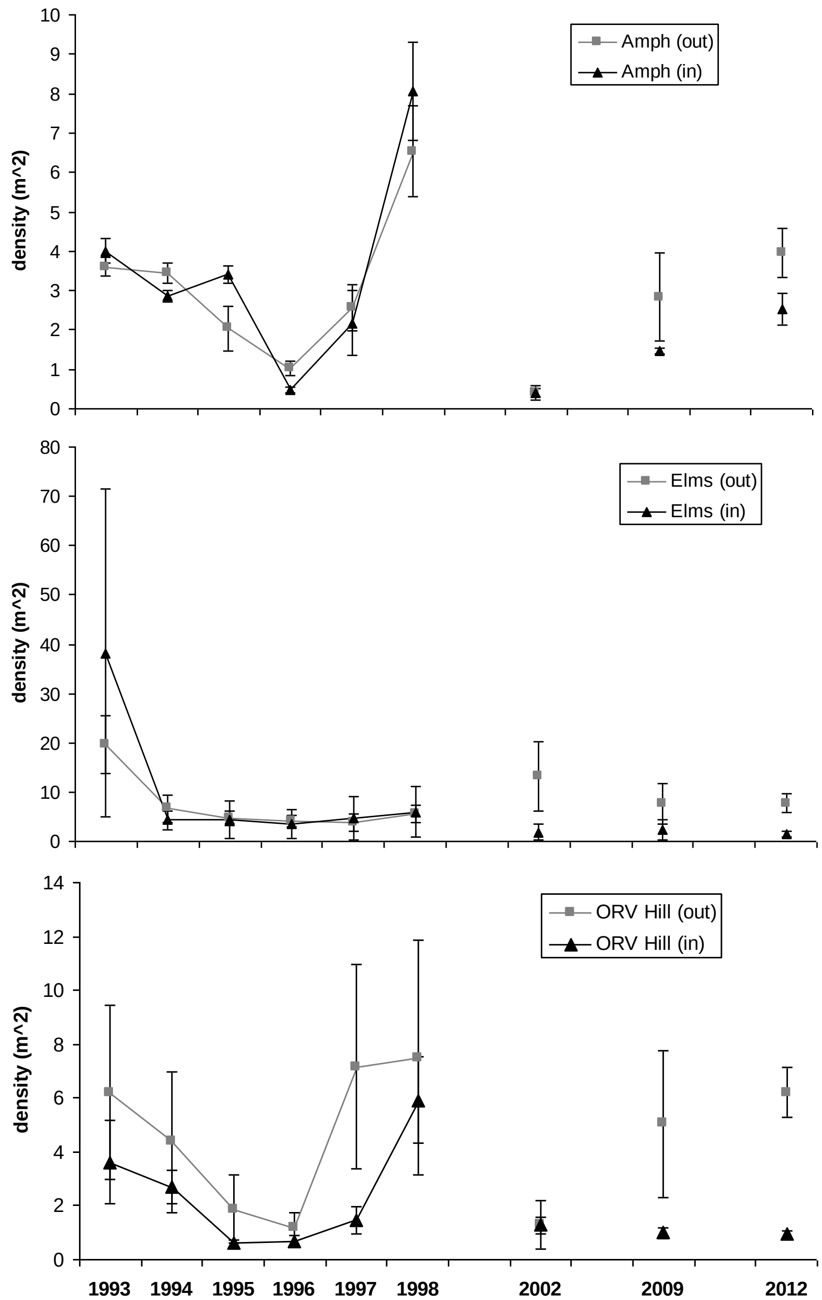

Figure 3. Population density trends of *L. L. lepidus* var. *cusickii* at three subpopulations: Amphitheater (top), Elms Reservoir (middle), and ORV Hill (bottom). Plot sampling did not occur from 1999-2001, 2003-2008, and 2010-2011. Error bars represent ± 1 SE.

Plant performance trends

Plant characteristics varied between sites and by treatment (inside or outside of the exclosures; Figure 4, Appendix B). Because the different sites represent geographically distinct (albeit closely neighboring) areas, such differences are not necessarily surprising or meaningful from an ecological perspective. For instance, there might be genetic differences between sites (despite their proximity) that differentially influence the response of inflorescence production to annual climatic variability. Alternatively, differences may simply be attributable to subtle environmental variability between sites.

In 2012, the average number of inflorescences per plant was greater inside the fencing compared to outside the fencing (means = 13 and 8, respectively; $P = <0.001$), and these trends were consistent across all sites. Data collected in 2009 had similar trends, but they were not statistically significant. In 2012, mean plant area and plant height were significantly affected by the interaction between site and treatment ($P < 0.001$), but no consistent trend is apparent across site or treatment (Figure 4). For example, mean height was greater outside of the exclosures when compared to those inside at ORV Hill and Elms Reservoir, but at Ampitheater mean height was greater inside the exclosures. Also, plants were significantly larger outside of the exclosures at ORV Hill, but were smaller outside of exclosures at Ampitheater. Interestingly, plant size and number of inflorescences did not follow similar trends, indicating that greater plant size did not necessarily translate to greater reproductive ability at the time of our sampling.

At the Amphitheater subpopulation, trends in plant performance characteristics between the treatments were noticeably different than at Elms Reservoir and ORV Hill. Averages for number of inflorescences, plant height, and plant area were consistently greater for plants located inside the exclosures in comparison with plants located on transects outside the exclosures. These site-specific trends are consistent with the results from monitoring in 2009. This is most likely due to the microhabitat in which the transects were located and could be a function of the local topography. The exclosure at the Amphitheater site sits in a small topographic basin, which could be providing slightly more protection than experienced by plants outside the fencing, which are located on the periphery of the basin. Mean inflorescence production was also significantly higher among plants inside of the Ampitheater exclosure compared to the other study sites in 2012, suggesting that soil moisture or some other variable might have been more favorable in this defined area.

While results suggest that reproductive ability might be positively affected by exclosures providing slightly more protection from recreation than unfenced areas, the lack of consistent trends associated with plant size (both height and area) suggest that microclimate and site differences might be driving these significant effects rather than recreational use. It is difficult to correlate observed trends with fencing effects per se, since plants were not randomly assigned fencing treatments, and significant effects noted do not have a consistent outcome. During 2012 data collection, we noticed herbivory by insects at all three subpopulations and some evidence of mammal grazing was observed at Elms Reservoir, both within and outside of the exclosures; the observed grazing within the exclosures was likely due to small mammals as exclosures remain intact. Additionally, population damage due to ORV use was not noted at any of the *L. lepidus* var. *cusickii* sites, and it is unclear how long ago the land around the sites was actively used.

These data indicate that while ORV use might impact populations of *L. lepidus* var. *cusickii*, the likely causes for changes in population density and plant performance trends are likely site and microhabitat specific. This is consistent with the variability in plant density observed over the course of this study and plant characteristics varying between site and treatment. ORV use and illegal dumping have decreased in the Denny Flat area in the past 15 years, reducing the relative threat of these issues for the time being (R. Ferriel, *personal communication*). While these threats have decreased, we noted illegal dumping in and around *L. lepidus* var. *cusickii* habitat, and ORV tracks outside of the exclosures at Elms Reservoir. Invasive species including *B. tectorum* were noted in the surrounding areas of all study sites. Anthropogenic disturbances in *L. lepidus* var. *cusickii* habitat could act as a conduit for invasion of annual grasses. Activities such as seed banking will aid in the potential for reintroduction of this rare species, if needed. Likewise, additional surveys of potential habitat will enable us to obtain a population estimate that will represent the entirety of the species and enable land managers to effectively mitigate for changes in the future.

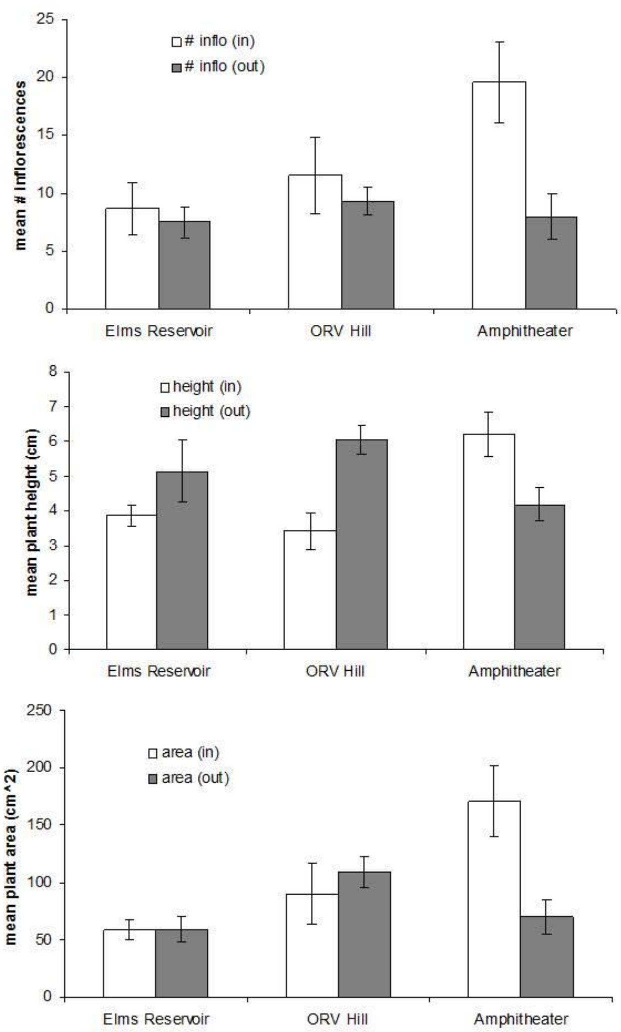

Figure 4. Mean number of inflorescences per reproductive plant (top), mean plant height (middle), and mean plant area (bottom) of *Lupinus lepidus* var. *cusickii* at three subpopulations: Elms Reservoir, Amphitheater, and ORV Hill. White bars are averages of data taken within fenced plots, while grey bars are averages of data taken outside of fenced plots. Error bars represent ± 1 SE.

Seed collection

Seed collected will be stored at the Rae Selling Berry Seed Bank in Portland, Oregon, for long-term storage. A total of 1,441 seeds were collected from the Amphitheater and Elms Reservoir subpopulations. Our seed collection indicates that seed can be collected over a period of time and quality and quantity of seed may be variable by site.

Table 1. *Lupinus lepidus var. cusickii* seed collection, 2012.

SUBPOPULATION	COLLECTION DATE(S)	NUMBER OF SEEDS COLLECTED
Amphitheater	7/25/2012	349
Elms Reservoir	7/11/2012, 7/26/2012	1092

Population surveys

During the 2012 field season, approximately 1400 acres of potential habitat were surveyed in the vicinity of Unity in Baker County for *Lupinus lepidus* var. *cusickii* (Appendix C). At the North of Unity area of interest, several areas of appropriate habitat were located, but no *L. lepidus* var. *cusickii* plants were observed (Appendix B). At the Windlass Gulch area of interest, the eastern portion was physically surveyed while the western portion was visually surveyed to detect appropriate habitat, none of which was found. An additional physical survey of the western portion is recommended (Appendix C).

FUTURE ACTIVITIES

Population dynamics of *L. lepidus* var. *cusickii* exhibit extreme annual variability, which is likely a response to climate differences between years. Plants in this arid system must adapt to harsh conditions, including times of prolonged drought and limited water. *Lupinus lepidus* var. *cusickii* behaves like many other arid species and has a much shorter lifespan than other legumes (Kaye 2002). This life-history adaptation may enable the species to utilize microhabitats that are more favorable, including areas that may retain soil moisture for prolonged periods, or those that might provide protection in this harsh habitat. We documented that within populations, *L. lepidus* var. *cusickii* demonstrates high variability in density, size, and reproduction suggesting that this species might be more sensitive to microclimate than previously thought. Understanding the underlying function of these discreet habitat differences would enable land managers to target specific areas for seed collection and, if needed, reintroduction efforts.

In 1990 and 1992, surveys were conducted of approximately 2500 acres near Unity Reservoir and Denny Flat and 1500 acres in the vicinity of Stinkingwater Creek. In 2010, IAE staff revisited all areas originally surveyed in 1990 and 1992, excluding the Stinkingwater area where the taxon had never been found. In addition, IAE worked with the BLM to prioritize areas for surveying unmonitored populations. While some of these populations were surveyed, additional surveys are needed to fully assess all suitable habitat for presence of this rare species. In 2014, IAE staff will coordinate with BLM staff to prioritize survey areas. Locations within Baker County include Cottonwood Creek, Happy Camp, and areas north of Unity. Potential habitat has been identified to the southeast in Malheur County, and includes areas north of North Willow and northwest of Ironside. If any of these areas are on private land, we will work with BLM staff to identify and contact landowners to gain permission to access their property. In addition, we will resurvey extant subpopulations in Denny Flat (those surveyed in 2010), to yield updated information on the status and extent of this population, and to prioritize areas for placement of long-term monitoring plots, which is planned for 2015. In total, approximately 4000 acres of potential *L. lepidus var. cusickii* habitat will be surveyed. All visited populations will be GPSed to determine geographic extent of populations. We will also complete GeoBOB sighting report forms for all populations. Completed GPS files and GeoBOB field forms will be input into GeoBOB by BLM staff to document and track these locations. These surveys will provide accurate information about the true extent of this species' range and aid in the prioritization of management actions.

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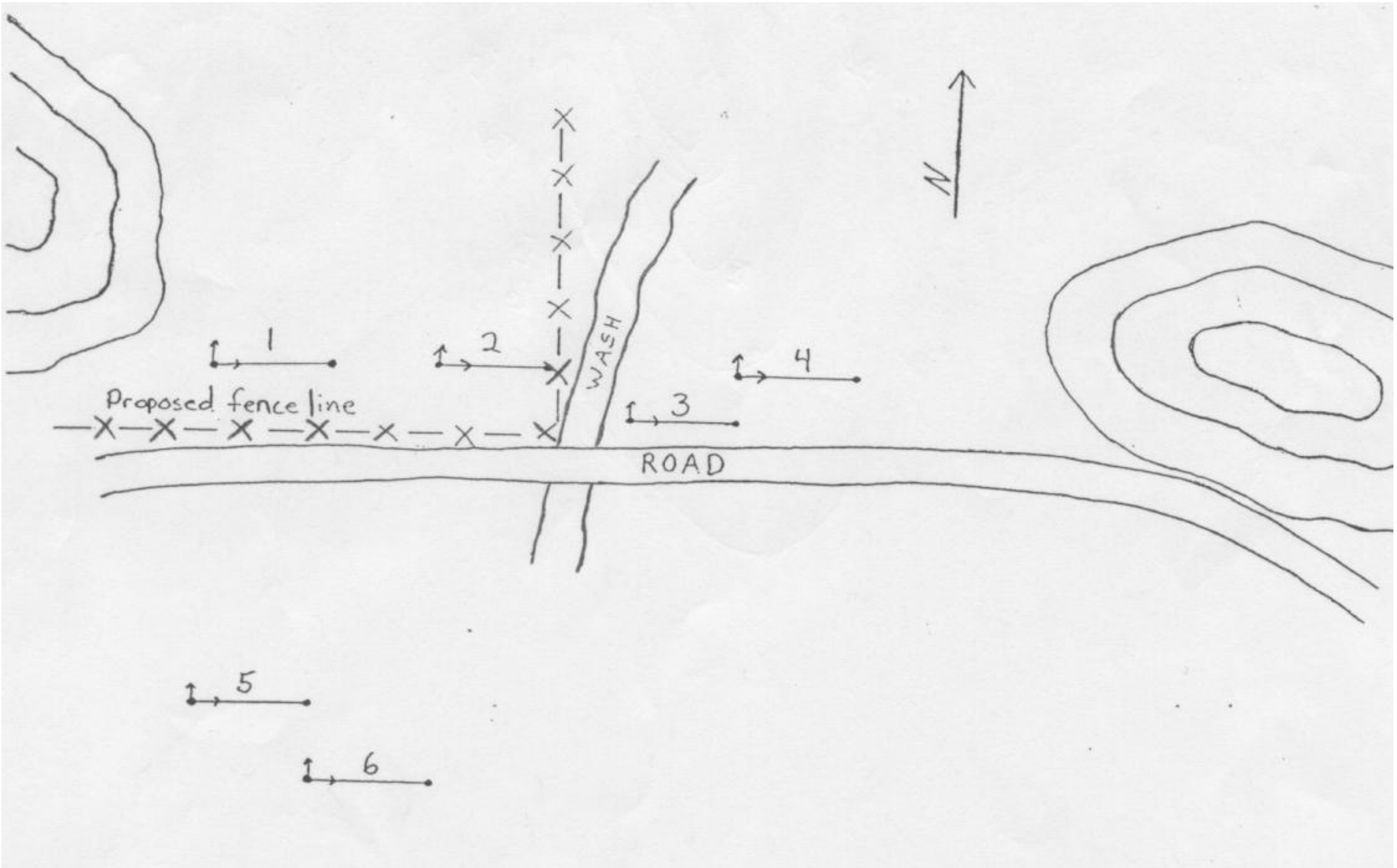
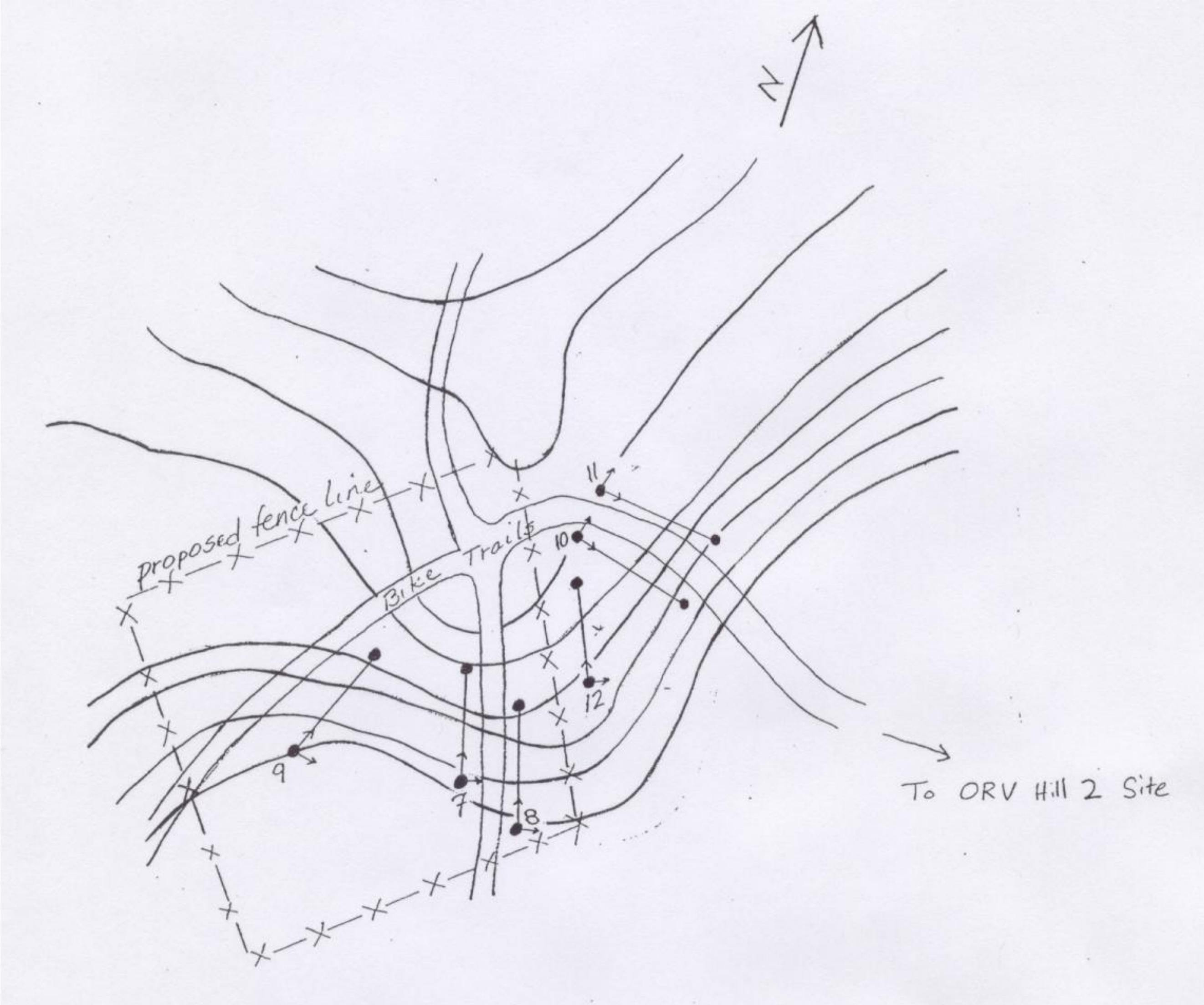
APPENDIX A. SITE MAPS AND LOCATION INFORMATION

Table 2. Lat/Long coordinates (hddd°mm.mmm') for plots. All coordinates are in the WGS 84 datum. Plots can be located without the use of GPS coordinates, see Appendix A for descriptive site maps. Accuracy ± 25 feet.

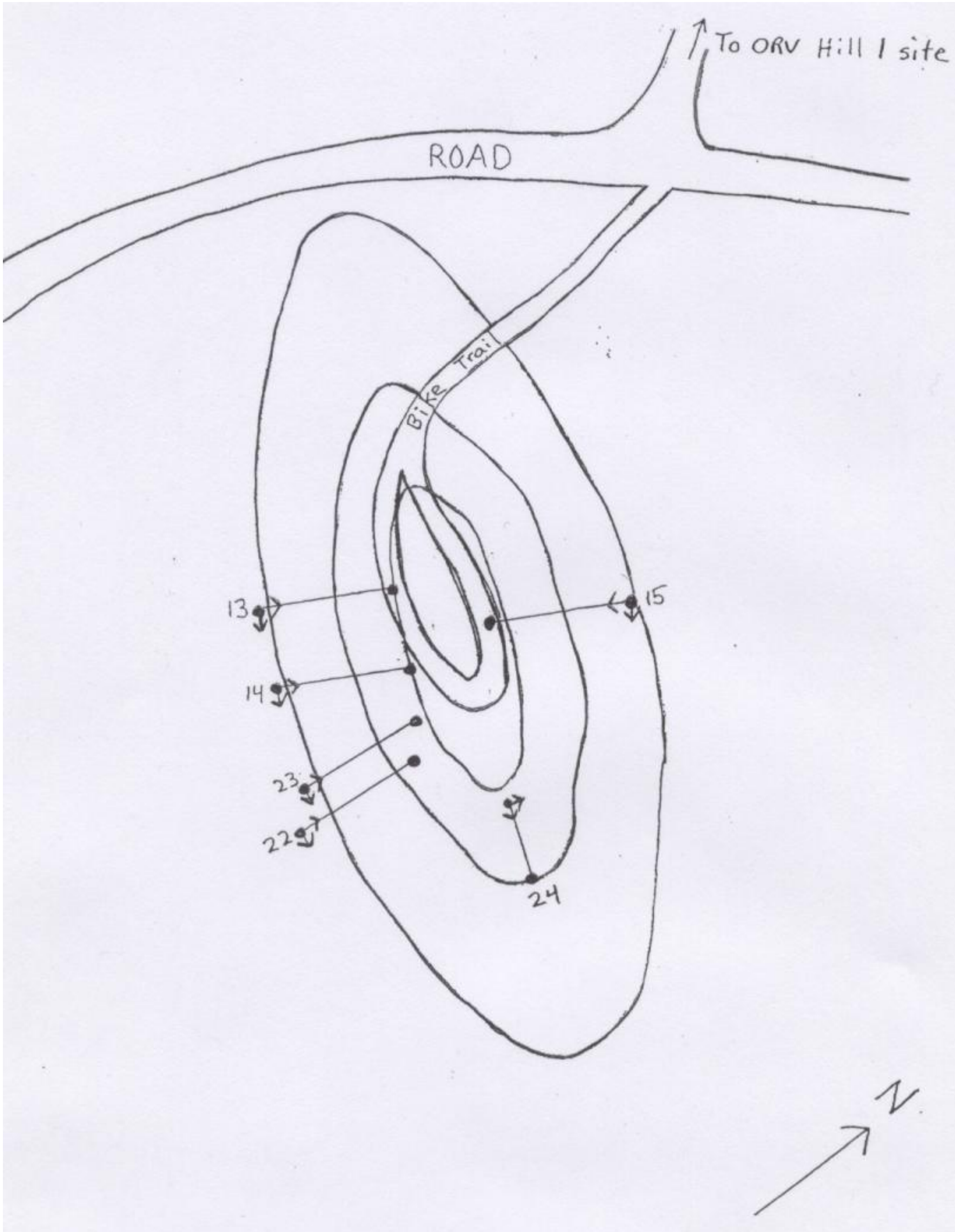
Site	Plot #	Latitude (North)	Longitude (West)
Elms Reservoir	1	44 26.597	118 09.587
	2	44 26.596	118 09.567
	3	44 26.579	118 09.548
	4	44 26.577	118 09.541
	5	44 26.591	118 09.616
	6	44 26.583	118 09.614
ORV Hill 1	7	44 27.049	118 08.887
	8	44 27.045	118 08.885
	9	44 27.056	118 08.902
	10	44 27.063	118 08.861
	11	44 27.064	118 08.862
	12	44 27.058	118 08.865
ORV Hill 2	13	44 26.958	118 08.782
	14	44 26.956	118 08.780
	15	44 26.977	118 08.770
	22	44 26.958	118 08.770
	23	44 26.958	118 08.773
	24	44 26.964	118 08.764
Amphitheater	16	44 27.719	118 09.343
	17	44 27.720	118 09.342
	18	44 27.729	118 09.342
	19	44 27.734	118 09.355
	20	44 27.736	118 09.343
	21	44 27.725	118 09.362



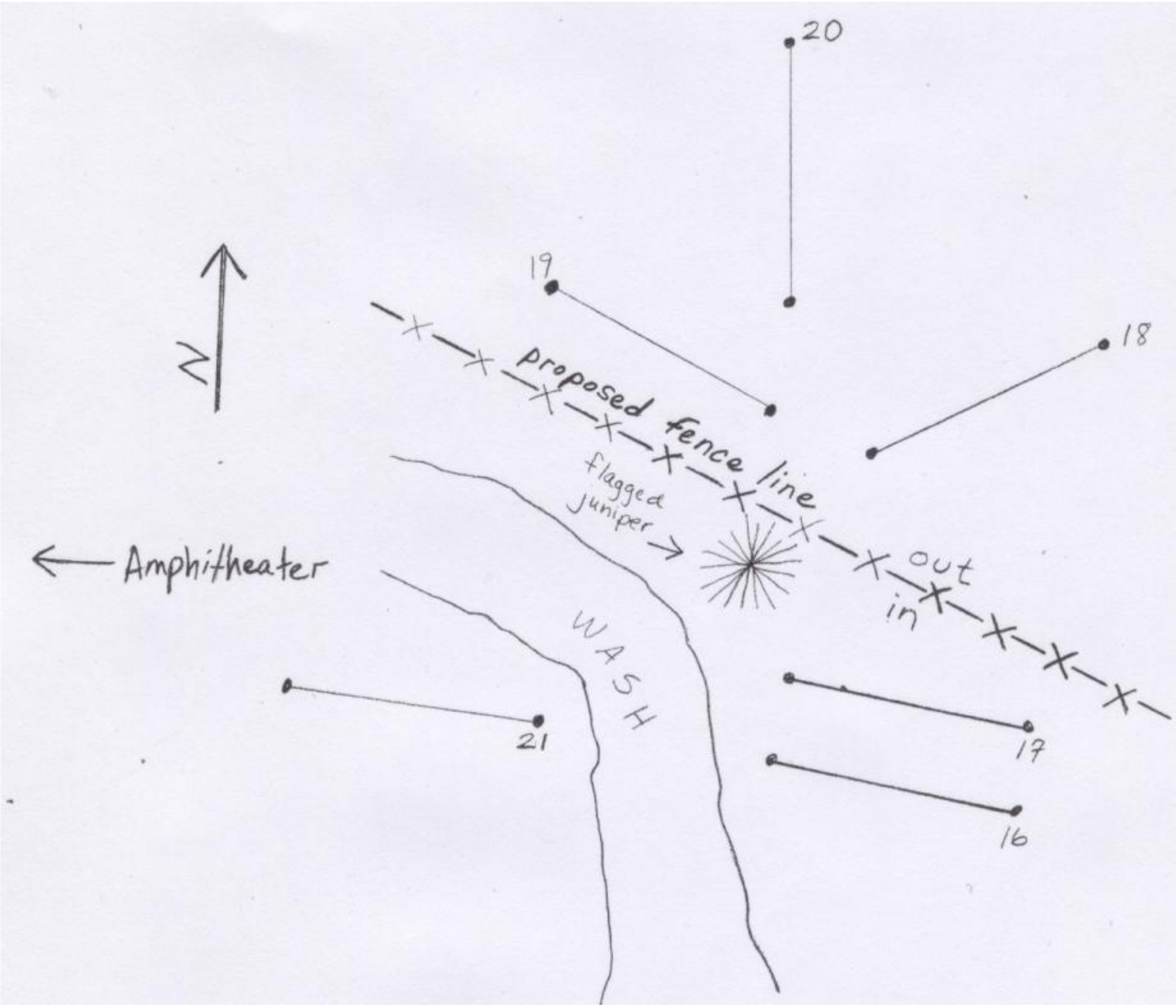
Elms Reservoir *Lupinus lepidus* var. *cusickii* sampling site.



ORV Hill 1 *Lupinus lepidus* var. *cusickii* sampling site.



ORV Hill 2 *Lupinus lepidus* var. *cusickii* sampling site.



Amphitheater *Lupinus lepidus* var. *cusickii* sampling site.

APPENDIX B. STATISTICAL ANALYSES FOR PLANT PERFORMANCE TRENDS OF *L. LEPIDUS* VAR. *CUSICKII*, 2012

Table 3. Two factor analysis of variance (ANOVA) table for the height (cm; log-transformed) of *L. lepidus* var. *cusickii* by site and treatment (fenced or unfenced). Predictors with a *p*-value ≤ 0.05 are in bold.

	Df	SS	MS	F value	*P* value
Site	2	2.79	1.39	2.94	**0.05**
Treatment	1	29.12	29.12	61.42	**<0.001**
Site:Treatment	2	33.32	16.66	35.15	**<0.001**
Residuals	891	422.42	0.47		

Table 4. Two factor analysis of variance (ANOVA) table for the size (cm^2; log-transformed) of *L. lepidus* var. *cusickii* by site and treatment (fenced or unfenced). Predictors with a *p*-value < 0.05 are in bold.

	Df	SS	MS	F value	*P* value
Site	2	4.95	2.48	3.47	**0.03**
Treatment	1	18.48	18.48	25.87	**<0.001**
Site:Treatment	2	45.75	22.88	32.02	**<0.001**
Residuals	891	636.50	0.71		

Table 5. General linear model for number of inflorescences of *L. lepidus* var. *cusickii* by site and treatment (fenced or unfenced). Predictors with a *p*-value ≤ 0.05 are in bold.

	Estimate	SE	T- value	*P* value
Intercept	2.97	0.13	22.59	**<0.001**
Elms Res.	-1.15	0.35	-3.25	**<0.001**
ORV Hill	-0.43	0.19	-2.34	**0.02**
Treatment: Unfenced	-0.84	0.21	-3.99	**<0.001**
Elms Res: Unfenced	1.00	0.40	2.48	**0.01**
ORV Hill: Unfenced	0.54	0.28	1.95	**0.05**

APPENDIX C. INFORMATION FOR *L. LEPIDUS* VAR. *CUSICKII* SURVEYS, 2012.

North of Unity

Survey date: July 10, 2012

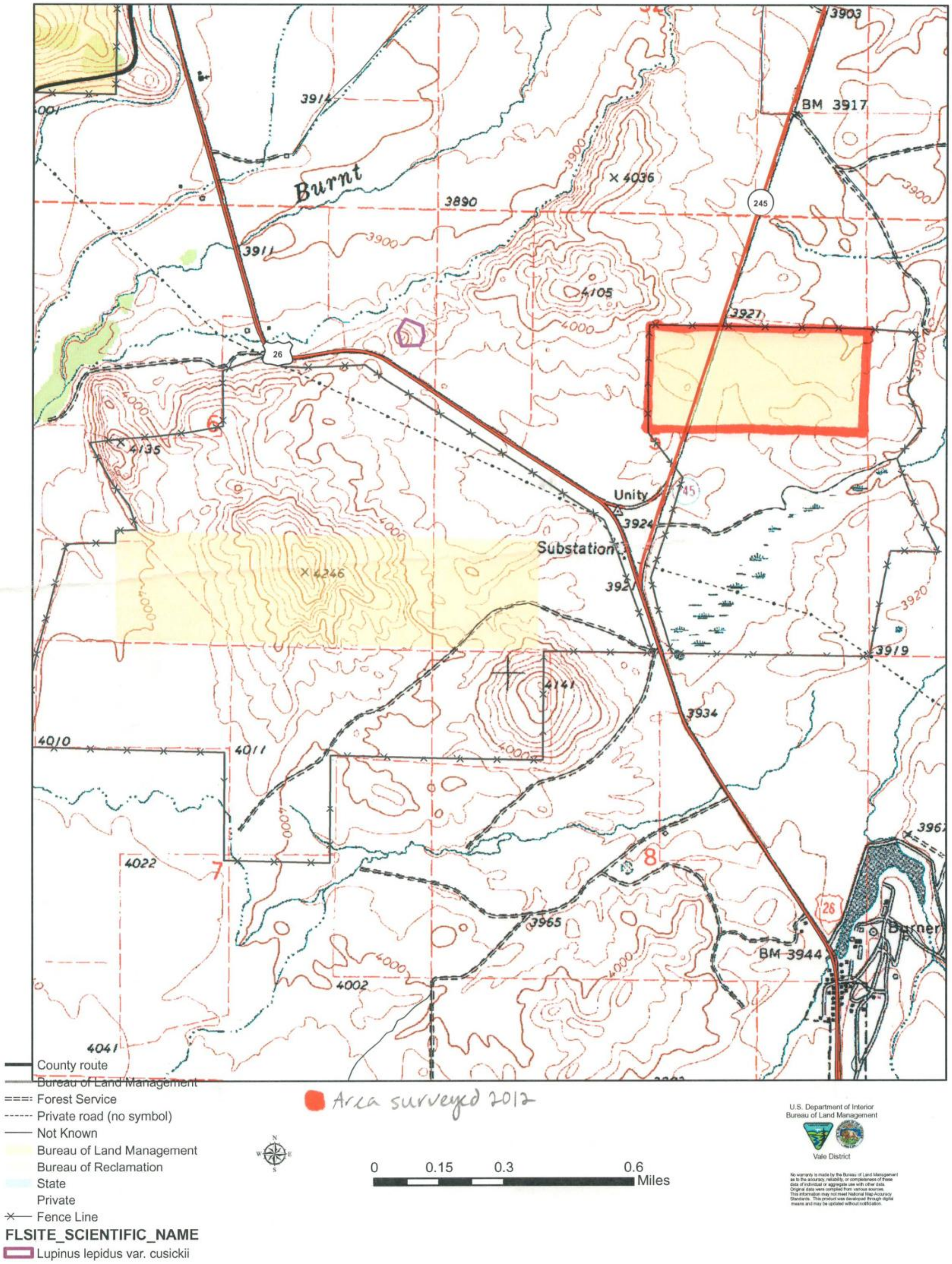
Observers: Lisa VanTieghem, Erin Gray, Charlotte Trowbridge, Guy Banner, and Eduardo Ramirez.

Location information: North of Unity, Denny Flat, Baker County. USGS 7.5' quad: Unity. Follow US-245 north from Unity approximately 0.2 miles. Survey area is bisected by US-245. Latitude: 44.469575. Longitude: -118.198958.

Survey information: This area was selected for surveying based on aerial photographs and topography maps. No evidence of a *Lupinus lepidus* var. *cusickii* population was observed.

Habitat information: The North of Unity site is a relatively flat area with little topographic variation. Plant species found within this habitat include *Artemisia tridentata* ssp. *wyomingensis*, *Ericameria nauseosa*, *Festuca idahoensis*, *Bromus tectorum,* and *Eriogonum* sp.

North of Unity potential survey area Cusick's lupine



Windlass Gulch

Survey date: July 26, 2012

Observers: Lisa VanTieghem and Guy Banner

Location information: Denny Flat, Baker County. T13S R38E S5. USGS 7.5' quad: Hereford. Follow US-26 West from Unity, OR. Take a slight right onto US-245 North and continue for 6.8 miles. Turn right onto Hereford Loop Road and continue for 4.2 miles to reach the site. Latitude: 44.4695. Longitude: -118.1989.

Survey information: This area was selected for surveying based on aerial photographs and topography maps. The eastern portion of the area was physically surveyed and the western portion was visually surveyed from the highest point. No appropriate habitat was observed in the western portion and, although the eastern portion had some isolated slopes with white ash substrate, there was no evidence of *Lupinus lepidus* var. *cusickii* throughout the entire site.

Habitat information: The Windlass Gulch site is located on rolling hills with slope ranging from 5% to 45%. Plant species occurring in this habitat include *Artemisia tridentata* ssp. *wyomingensis, Ericameria nauseosa, Poa secunda, Bromus tectorum, Achnatherum hymenoides,* and *Lupinus argenteus*. There was evidence of grazing and several areas appeared to be significantly trampled.

Windlass Gulch Area potential for Cusick's lupine