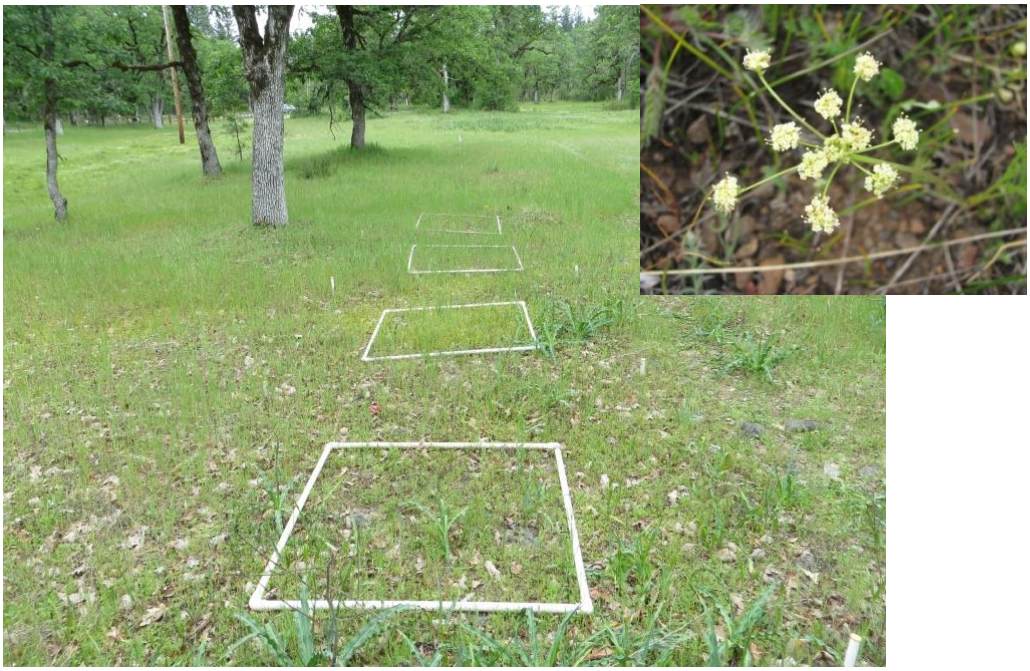
ASSESSING MANAGEMENT TECHNIQUES FOR *LOMATIUM COOKII* (COOK'S DESERT-PARSLEY)



2017

Report to the Bureau of Land Management, Medford District

Report prepared by Denise E. L. Giles, Erin C. Gray, and Matt A. Bahm

Institute for Applied Ecology

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PREFACE

This report is the result of a cooperative project between the Institute for Applied Ecology (IAE) and the Bureau of Land Management. IAE is a non-profit organization whose mission is conservation of native ecosystems through restoration, research and education. IAE provides services to public and private agencies and individuals through development and communication of information on ecosystems, species, and effective management strategies. Restoration of habitats, with a concentration on rare and invasive species, is a primary focus. IAE conducts its work through partnerships with a diverse group of agencies, organizations and the private sector. IAE aims to link its community with native habitats through education and outreach.

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Cover photos: Cook's desert-parsley (*Lomatium cookii*) plot at Illinois Forks State Park and close up of individual Cook's desert-parsley.

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EXECUTIVE SUMMARY

This document summarizes results from two studies involving habitat management techniques for *L. cookii* to support recovery of the species. The studies include 1) an evaluation of herbicide effects at Illinois Forks State Park, in areas occupied and unoccupied with *L. cookii* and 2) the effects of prescribed fire on *L. cookii* and the surrounding plant community at French Flat Middle and French Flat South. This information will inform future habitat management activities in sites that may contribute to the recovery of *L. cookii* and other associated native plant species.

Effects of Herbicide, Illinois Forks State Park

There were no clear differences in survivorship of *L. cookii* by treatment at Illinois Forks State Park in 2015, 2016, and 2017 (up to 3 years post-treatment). Height differed significantly ($P<0.001$) between herbicide treatments, where plants in the control treatment were taller than plants treated with herbicide; there were no differences in height between types of herbicide.

In occupied habitat, mean forb cover increased across all treatments from 12% in 2014 to 28% in 2017. Native and introduced graminoid cover decreased across all treatment types from 2014 to 2017 (natives: 26% to 10%; introduced: 30% to 7%). This decrease was due in large part to shifts in hydrology that led to a retreat of *Agrostis* sp. from pool edges and out of the plots.

In unoccupied habitat, forb cover increased across all plots from 2014 to 2017, from 26% to 44%. Native forbs remained similar in cover from 2014 to 2017, and introduced forbs increased across treatments. Total graminoid cover decreased from 26% to 16% from 2014 to 2017, with decreases occurring in all treatment plots. Native graminoid cover remained low and similar between 2014 and 2017. The diversity of introduced annual graminoids increased from 2014-2017. Continued monitoring will be essential to see if the impacts on introduced graminoids observed in fluazifop and glyphosate treatments continue into the future.

Effects of Fire, French Flat

Density (and population size) of *L. cookii* at French Flat Middle and French Flat South in 2014 and 2015 were among the lowest recorded at these sites since monitoring began in 1993. While the cause of this decline is unclear, competition with non-native species, increasing litter and thatch, disturbance by off-road vehicles and climatic factors may be playing a role. In the fall of 2015, approximately half of the occupied portion of each meadow was burned under the supervision of BLM staff.

In 2017, density of *L. cookii* did not differ between burned and unburned plots at French Flat Middle and South. Similarly, number of plants in each size/reproductive class did not differ between burned and unburned plots. Proportion of reproductive plants did not differ significantly between burned and unburned plots, nor were there effects of treatment on grazing of *L. cookii*.

The plant community responded similarly to the burn treatment at both sites. There was no difference between burned and unburned plots of native forb cover in either meadow. Cover of invasive grasses in both meadows was low (<2%), thus differences between burned and unburned plots were negligible with respect to total cover.

ASSESSING MANAGEMENT TECHNIQUES FOR *LOMATIUM COOKII*

REPORT TO THE BUREAU OF LAND MANAGEMENT, MEDFORD DISTRICT

INTRODUCTION

Lomatium cookii (Figure 1), Cook's desert-parsley, is listed as endangered by the State of Oregon and the U.S. Fish and Wildlife Service (USFWS) (ORBIC 2016). *L. cookii* is a member of the Apiaceae (parsley family). The species is endemic to southwestern Oregon in two population centers, 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 plants are usually less than 3 dm tall and inconspicuous except when in flower. Ternately divided leaves feature many narrow leaflets and creamy yellow flowers are produced in compound umbels on leafless stems (Figure 1). Fruits are flattened and oblong. The species was originally described by Kagan in 1986 from specimens collected in the Medford area. The species is closely related to *L. bradshawii*, an endangered species found in the Willamette Valley of western Oregon.

Figure 1. *Lomatium cookii* at French Flat.

Background

L. cookii was first described in 1981 in the Agate Desert in the Rogue River Valley. Habitats for the species in this area are characterized by patterned ground in the form of a series of vernal pools and mounds. *L. cookii* occupies a seasonally wet zone on the margins of the vernal pools. The dominant vegetation at Agate Desert 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 populations of this species are on lands managed by The Nature Conservancy and the Medford Airport (Kagan 1994).

The largest federally-owned population of *L. cookii* occurs in the Illinois Valley at the French Flat Area of Critical Environmental Concern (ACEC) managed by the Medford District Bureau of Land Management. Areas around this population were placer-mined for many years. Populations in this area have been monitored annually since 1993 (Pfingsten et al. 2016). These populations are often found in moist, grassy meadows dominated by *Danthonia californica* (Kaye and Blakeley-Smith 2002). Other associated species at French Flat include *Danthonia unispicata,*

Deschampsia cespitosa, *Camassia quamash*, *Ranunculus occidentalis*, *Hesperochiron occidentalis*, *Horkelia daucifolia*, *Isoetes nuttallii*, *Calochortus uniflorus*, and *Viola hallii*. Trees and shrubs, such as *Pinus ponderosa*, *Pinus jeffreyi*, *Arctostaphylos* spp., and *Ceanothus cuneatus* border these grassy meadows (Mousseax 1993). Populations of *L. cookii* are also found in the Illinois Valley in grass-dominated gaps within oak woodland, especially in the Reeves Creek area. These habitats have upland soils and are on hillsides which are substantially different in character than the wet sites in the Illinois Valley lowlands. The soils at French Flat are moderately serpentine, which restricts the growth of many plant species. In contrast, the soils in Reeves Creek and Agate Desert populations of *L. cookii* are non-serpentine in origin. In addition to French Flat and Reeves Creek, population monitoring of *L. cookii* by IAE is also conducted at the Rough and Ready ACEC and at Indian Hill, also managed by the Medford District BLM. For more information about these populations see Pfingsten et al. 2016.

Mining activities continue to threaten *L. cookii*. Placer gold mining has restricted the population at French Flat and permanently altered much of the natural hydrologic patterns through the meadows. Some of the French Flat subpopulations monitored and discussed in this report are located on BLM managed lands adjacent to the Hillside Placer No. 1 and No. 3 mines owned and operated by a local resident. A proposed mining plan filed in 1993 would involve destruction of a significant portion of this subpopulation. Recently, mining plans have been filed with BLM that will alter habitat immediately adjacent to *L. cookii* at French Flat ACEC.

L. cookii habitat in the Illinois Valley is threatened not only by invasion of non-native species, and mining, but also by rural development and abuse by recreational users in the area. At Illinois Forks State Park, an unofficial trail cuts through one of the populations of *L. cookii* at the site. Unoccupied plots close to the river, which were placed adjacent to an existing *L. cookii* population were disturbed by recreational users between 2014 and 2015 when a bulldozer (or other heavy equipment) was used to create a path to the river from the adjacent private property. Because unoccupied plots were purposefully established in areas without *L. cookii,* we do not know the effects of these activities on the *L. cookii* in this portion of the habitat. French Flat has been repeatedly damaged by ORV use, where we observed fresh vehicle tracks from 2002-2007.

The 2012 USFWS Recovery Plan for the Rogue and Illinois Valley Vernal Pool and Wet Ecosystems states the following regarding the recovery priority and necessary habitat requirements for the species:

> **"Recovery priority.** *Lomatium cookii* has a recovery priority number of 2C, based upon a high degree of threat, a high potential for recovery, and a taxonomic classification as a species. The "C" indicates the potential for conflict between the species and construction, development, or other economic activities."
>
> "The primary constituent elements for *L. cookii* critical habitat include vernal pools, seasonally wet meadows within oak and pine forests, sloped mixed conifer openings, and shrubby plant habitats, the dominant native plant association of these habitats, and intact hydrology and soils that provides for adequate soil moisture. Enhancement and protection of these elements is critical to recovering the species."

Goal and Objectives

The goal of this project was to develop management techniques for *L. cookii* to support recovery of the species. The specific objectives were to:

1. Study the effects of herbicide at sites occupied and unoccupied by *L. cookii,* and the surrounding plant community. (Illinois Forks State Park)
2. Study the effects of fire on *L. cookii* and surrounding the plant community. (French Flat Middle and French Flat South)

METHODS

Effects of Herbicide

To assess herbicide as a potential tool to control annual grasses and other noxious weeds in the presence of *L. cookii*, IAE worked with Oregon State Parks and the Medford BLM to conduct herbicide trials at Illinois River Forks State Park. Management treatments included glyphosate, imazapic and fluazifop, as well as an untreated control. Plots were sprayed with glyphosate on 7 November 2014 and imazapic on 10 November 2014, fluazifop was sprayed on 9 March 2015. All herbicide applications included a non-ionic surfactant (Table 1).

Treatment plots were monitored by IAE staff prior to treatment application in May 2014, and post-treatment in May 2015-2017. Treated plots in the areas without *L. cookii* are 2m x 2m, and 0.5m x 0.5m in the occupied areas. Plant species were identified to species level in all plots, and percent cover estimated. In the occupied plots, demographic information was recorded for each *L. cookii* individual.

Table 1. Herbicide application rates and dates of application at Illinois Forks State Park.

Chemical	Trade Name	Target species	Rate (oz/gal)	Surfactant (Activator 90)	Spray Volume	Time
Fluazifop	Fusilade DX	Grass specific, post-emergence	0.75	0.64 oz/gal	30 gal/acre	3/9/2015, 2:30 pm
Glyphosate	Roundup Custom	Broad spectrum, post-emergence	1.28	0.64 oz/gal	30 gal/acre	11/7/14, 3:00 pm
Imazapic	Plateau	Broad spectrum, pre-emergence	0.16	0.64 oz/gal	30 gal/acre	11/10/14, 1:30 pm

Unoccupied

In May 2014, 12 plots were established by IAE in areas not occupied by *L. cookii*. Plots are 2 x 8 meters (divided into four 2m x 2m treatment squares) marked at the corners with 8 yellow

capped PVC pipes (Figure 3). The northwest corner is marked with the first plot tag in the series and the opposite corner (southeast) is marked with the next consecutively numbered plot tag. Four 1-m^2 plots are marked in the middle of each 2m x 2m plot with nails and hot pink washers in the northwest (has plot ID tag) and southeast corners (Figure 3). For plot coordinates and schematics, see Appendix A and Appendix B.

Figure 2. Photo of an unoccupied plot at Illinois Forks State Park. In this photo, the 1m x 1m frames are in the center of each 2m x 2m treatment plot.

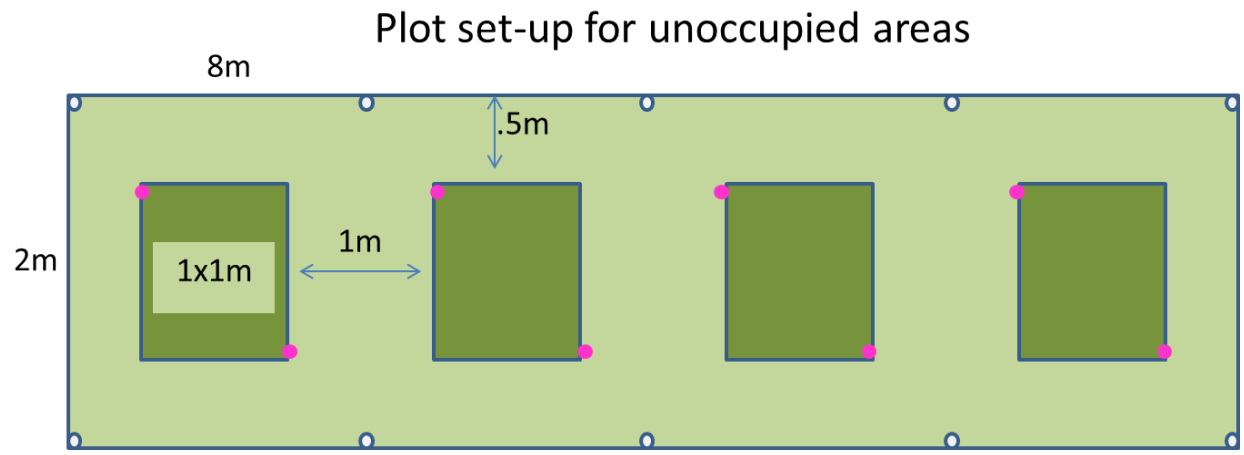

Figure 3. Plot setup for areas not occupied by *Lomatium cookii*. Plots are 2m x 8m, and each treatment block is 2m x 2m. Only the central 1m^2 of each treatment plot was monitored for community composition.

Occupied

In May of 2014, 40 0.5m x 0.5m plots occupied by *L. cookii* at Illinois River Forks State Park were established in a patch of *L. cookii* approximately 20m x 15m wide. A 25 meter baseline was established running roughly N/S along the eastern edge of the *L. cookii* population and is marked with concrete markers placed flush with the ground at both ends. The head of the transect is at the N end, and is marked with tag #801 (end tag #802). See Appendix B for maps of the occupied plots at Illinois Forks State Park.

The 40 plots monitored for both demography and plant community were established on transects that run perpendicular to this baseline (the longest of these transects is 15m). Within each demographic plot, all *L. cookii* plants were mapped, given unique numbers (beginning with #1), assigned to the life history categories discussed in the density section below, the length of the longest leaf was measured, and the presence or absence of grazing was recorded.

Effects of Fire

Plant Community and Demography

To study the effects of fire on *L. cookii* and the plant community, French Flat South and French Flat Middle were chosen for an experimental burn treatment. In the fall of 2015, portions of French Flat South and French Flat Middle were burned under the supervision of BLM Medford staff (Appendix C). In addition to fire, some trees were removed or girdled and shrubbery encroaching along the edges of the meadow was thinned. Existing plots established by IAE were chosen in both burned areas and unburned areas to collect plant community data, as well as demographic information. Plant species were identified to species level in all plots, and percent cover estimated.

At French Flat Middle and French Flat South, 20-30 existing 0.5m x 0.5m demographic plots were monitored to assess effects of burning on these plots. Approximately half of the plots in each

meadow were burned (Appendix C). Similar to the demographic plots at Illinois Forks, within each demographic plot, all *L. cookii* plants were mapped, given unique numbers (beginning with #1), assigned to the life history categories discussed earlier, and the presence or absence of grazing was recorded. For details regarding the longer term history of these plots see Pfingsten et al. 2016.

Lomatium cookii Density plots

Thirty to forty density plots have been established at both French Flat Middle and French Flat South. In the 40m x 0.10m density plots, all *L. cookii* were counted and assigned to a specific life-history category, as follows:

S seedling

V1/2 vegetative with 1 or 2 leaves

V3 vegetative with 3 or more leaves

R1 reproductive with 1 umbel

R2 reproductive with 2 umbels

R3 reproductive with 3 or more umbels

Life-history categories were originally developed for *Lomatium bradshawii* monitoring in the Willamette Valley (Kaye et al. 2001). The similarities of the life-history characteristics of these species cause the categories to be applicable to *L. cookii* as well. Reproductive plants were segregated by umbel number because studies of *L. bradshawii* have shown that one-umbel plants rarely produce seed, while two-umbel plants produce seed on the second umbel, and three umbel plants may produce many seeds (Kaye and Kirkland 1994).

Data Analysis

We used analysis of variance (ANOVA; R Development Core Team 2009) to test for the response of mean plant size of *L. cookii* (2017 only), using herbicide treatment (control, fluazifop, glyphosate, and imazapic) as predictors. Due to differences found between treatments, pairwise comparisons were made using the Tukey HSD. To test for differences in survival by herbicide treatment, we used a General Linear Model (GLM) to look at differences in proportions of survival from plants that were originally present in 2014 when plots were established. Due to the high variability seen within the plots, all other comparisons were based off of use of 95% confidence intervals.

RESULTS

Effects of Herbicide

Lomatium cookii

In order to evaluate the treatment effects on *L. cookii*, the percent survivorship of original plants and average size were compared by treatment type (Table 2 and Figure 4). Two plots (plots #831-fluazifop and #812-glyphosate) were not included in analysis due to their proximity to a heavily used trail (use increased over the course of the study). See Appendix E for more detailed plot information.

There were no effects of treatment on survivorship of *L. cookii* in the herbicide plots. In the first year post-treatment, survivorship in the treatment plots ranged from 78%-92%, and in 2017 survivorship of original plants ranged from 25-55%, which was a sharp decline from previous years, particularly in the glyphosate and fluazifop plots (Table 2). While in previous years survivorship was highest in plots treated with fluazifop, in 2017 only 25% of original plants remained. In each year, new plants were noted in all treatment plots, with the most occurring in plots treated with glyphosate and imazapic (Table 2).

In 2017, mean plant size (cm) differed significantly between treatment types; plants in the control treatment were larger than plants in the herbicide treatments (Figure 4, $P<0.001$). In previous years (2015 and 2016), there were no differences in plant size between treatment plots (Figure 4). From 2014 to 2016, plant size declined steadily, however this decline was independent of treatment (Figure 4). In 2017, plant size tended to increase in all treatment types, with the greatest increase occurring in plants present in the control plots. While plant size also increased in the herbicide treatment plots, their size did not differ significantly, but did differ from the larger size in the control plots.

Table 2. Total number of plants in each treatment plot, number and percent of original plants present, and the number of new recruits from 2014-2017 at Illinois Forks State Park.

Total # of plants present in treatment plots				
Treatment	**2014**	**2015**	**2016**	**2017**
Control	49	47	45	31
Fluazifop	25	29	31	25
Glyphosate	56	59	64	68
Imazapic	55	51	50	46

Number and % of original plants present							
	2014	**2015**		**2016**		**2017**	
Control	49	39	80%	31	63%	27	55%
Fluazifop	25	23	92%	19	76%	6	24%
Glyphosate	56	44	79%	38	68%	17	30%
Imazapic	55	43	78%	38	69%	29	52%

Number of new plants in each year				
	2014	**2015**	**2016**	**2017**
Control	-	8	8	6
Fluazifop	-	6	7	6
Glyphosate	-	15	12	12
Imazapic	-	8	5	13

Table 3. Average number of plants in demographic plots by treatment with 95% confidence intervals.

Treatment	**Average Number of Plants**							
	2014	95%C.I.	2015	95%C.I.	2016	95%C.I.	2017	95%C.I.
Control	4.9	*±3.2*	4.7	*±2.5*	4.5	*±1.9*	3.1	*±1.3*
Fluazifop	2.7	*±1.4*	3.2	*±1.8*	3.4	*±2.3*	2.8	*±1.7*
Glyphosate	6.2	*±2.4*	6.5	*±2.9*	7.1	*±3.3*	7.6	*±3.5*
Imazapic	5.5	*±3.1*	5.1	*±2.8*	5.0	*±2.5*	4.6	*±3.6*

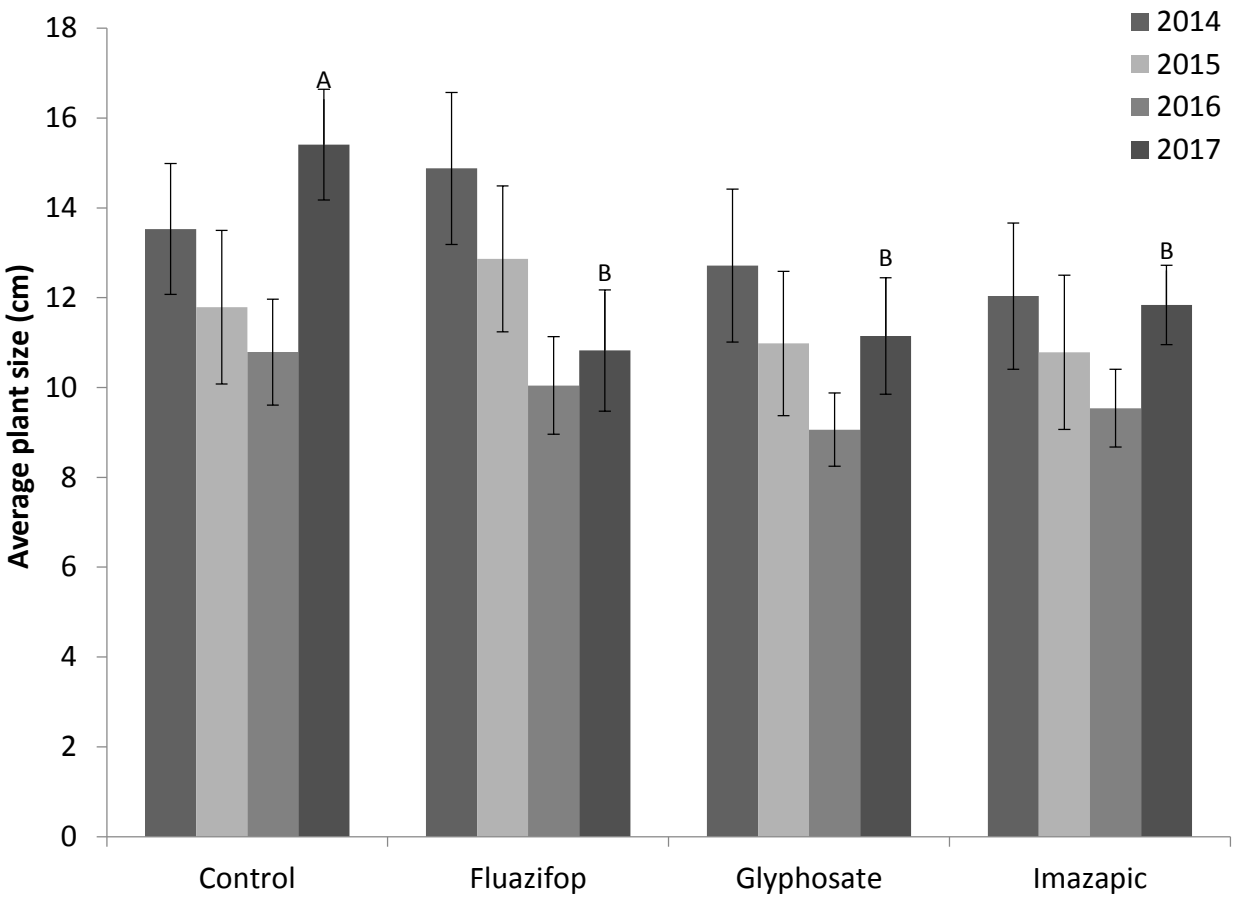

Figure 4. Average size (cm) of *L. cookii* in demographic plots at Illinois Forks State Park, 2014-2017. Error bars represent 95% confidence intervals. Letters above 2017 values represent significant differences between treatments using Tukey's HSD test ($P<0.001$).

Plant Community

Results are reported separately for the two groups, occupied and unoccupied plots, as the initial plant community differed between the two areas. The initial composition of areas occupied with *L. cookii* generally had less forbs (both native and invasive) and more graminoids, with a large proportion of the graminoids present classified as native perennials (often *Danthonia californica*).

Occupied Habitat

Forbs

Mean forb cover across all treatments increased from 12% in 2014 to 28% in 2017. All treatments increased in native forbs from 2014 to 2017 (from 5% to 17%), however there was a lot of variability between plots (Figure 5). Average cover of introduced forbs remained similar from 2014 to 2017 (7% and 11%, respectively). Imazapic treatment showed a large (but not significant) increase from 7%-19% cover; however, forb cover in all of these plots was extremely variable. Dominant non-native forbs include *Hypochaeris radicata* and *Trifolium dubium*. The dominant native forb species observed was *Chloropogon pomeridianum*, with most forbs having average cover <1%. Of the 23 forb species noted in 2014, only 3 had average cover higher than 1%; 6 of the 29 species noted in 2017 had cover >1% (Appendix F).

Graminoids

Graminoid cover decreased in all occupied plots from 2014-2017, from 55% to 17% (Figure 6). Native and introduced graminoid cover decreased across all treatment types from 2014 to 2017 (natives: 25% to 10%; introduced: 30% to 7%), including the control (Figure 6). From 2014 to 2017, changes in cover of the perennial *Agrostis* sp. (from 27% to 1%) and *Danthonia californica* (from 28% to 10%) were the largest contributors to these decreases (Figure 7).

Native perennial graminoids decreased in cover in all treatments from 2014 to 2017 (24% to 10%). The only native graminoid to have more than 1% average cover was *Danthonia californica*. Invasive annual graminoids with >1% cover include *Cynosurus echinatus*, *Taeniatherum caput-medusae*, and *Bromus hordeaceus* (Appendix G). Introduced perennial graminoids (dominantly *Agrostis* sp.) decreased across all treatments (19% to 0.5%) from 2014 to 2017, including the control (Figure 7).

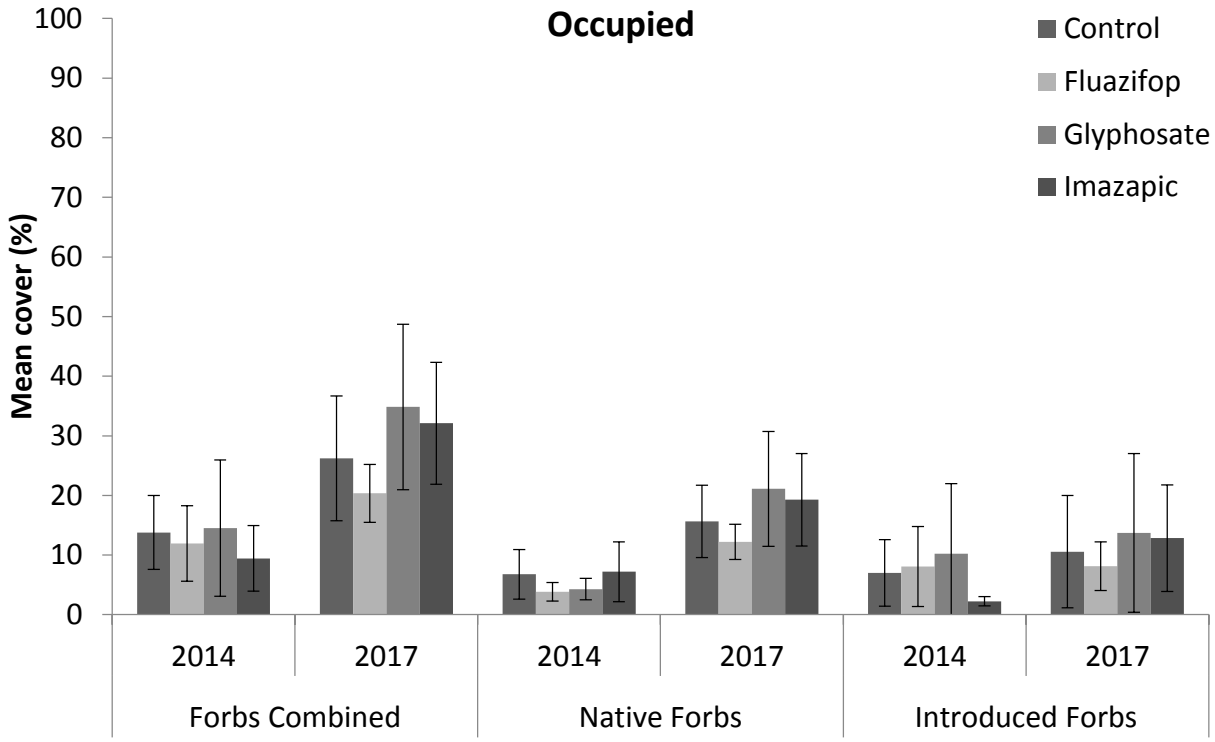

Figure 5. Average percent cover of forbs by treatment in the occupied habitat. Error bars represent 95% confidence intervals.

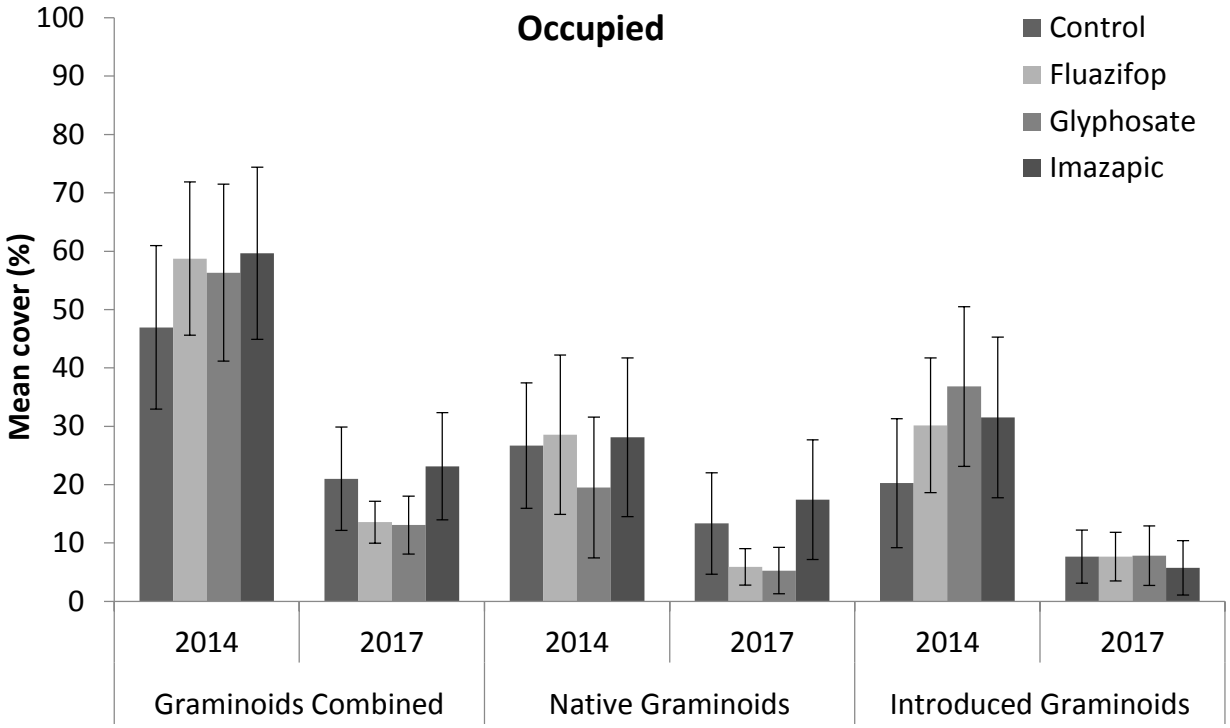

Figure 6. Average percent cover of graminoids by treatment in the occupied habitat. Error bars represent 95% confidence intervals.

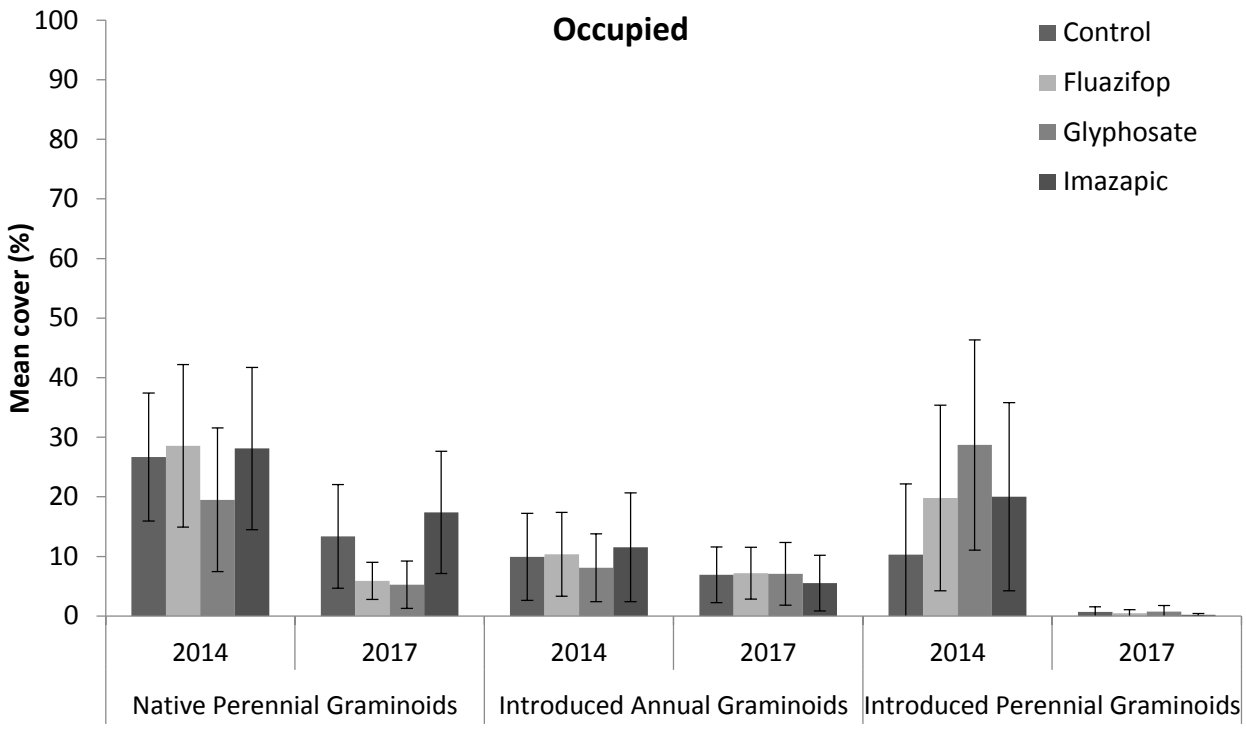

Figure 7. Average percent cover of annual and perennial graminoids. Error bars represent 95% confidence intervals.

Unoccupied Habitat

Forbs

Forb cover increased across all plots from 2014 to 2017, from 26% to 44%. This was following a decrease from 2014 to 2016 (Appendix F.). This increase was due to an increase in non-native forbs across all treatment plots, including the control (Figure 8). The largest increases from 2014 to 2017 occurred in plots treated with fluazifop and glyphosate (from 29% to 51%, and 23%-51% respectively). Native forbs remained similar in cover from 2014 to 2017 with no clear treatment effects. Similar to the occupied plots, a total of 47 forb species were noted in 2017, 30 native and 17 introduced. In 2017, four native forb species had cover higher than 1% including *Madia* spp., *Trifolium variegatum*, *Chlorogalum pomeridianum*, and *Camassia quamash* (Appendix F). Dominant introduced forbs include *Hypochaeris radicata* and *Torilis arvensis*.

Graminoids

Total graminoid cover decreased from 26% to 16% from 2014 to 2017, with decreases occurring in all treatment plots (Figure 10). The largest decreases occurred in plots treated with fluazifop (from 27% to 14%) and glyphosate (from 27% to 10%); this decrease was due to decreases seen in introduced graminoids in those treatment plots. On average, native graminoid cover remained low (<5%) and similar between 2014 and 2017, with high variability between plots (Figure 10). The dominant native graminoid in the unoccupied plots was *Achnatherum*

lemmonii. Introduced graminoids in the unoccupied habitat with cover >1% in 2014 (listed in order of decreasing abundance) include *Bromus hordeaceus*, *Cynosurus echinatus*, *Bromus rigidus*, *Taeniatherum caput-medusae*, and *Bromus tectorum*. In 2017, in addition to the previously listed annual graminoids, *Vulpia myuros*, and *Aira caryophyllea* had cover >1% (Appendix G).

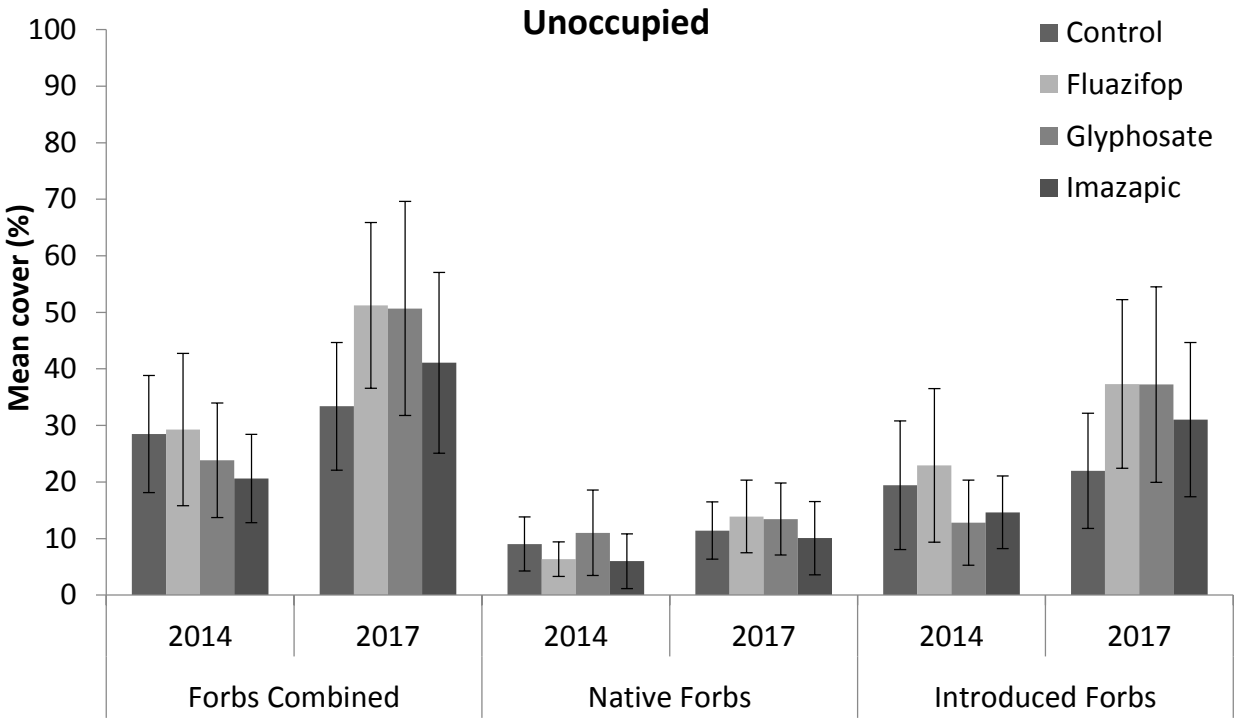

Figure 8. Average percent cover of forbs in unoccupied habitat. Error bars represent 95% confidence intervals.

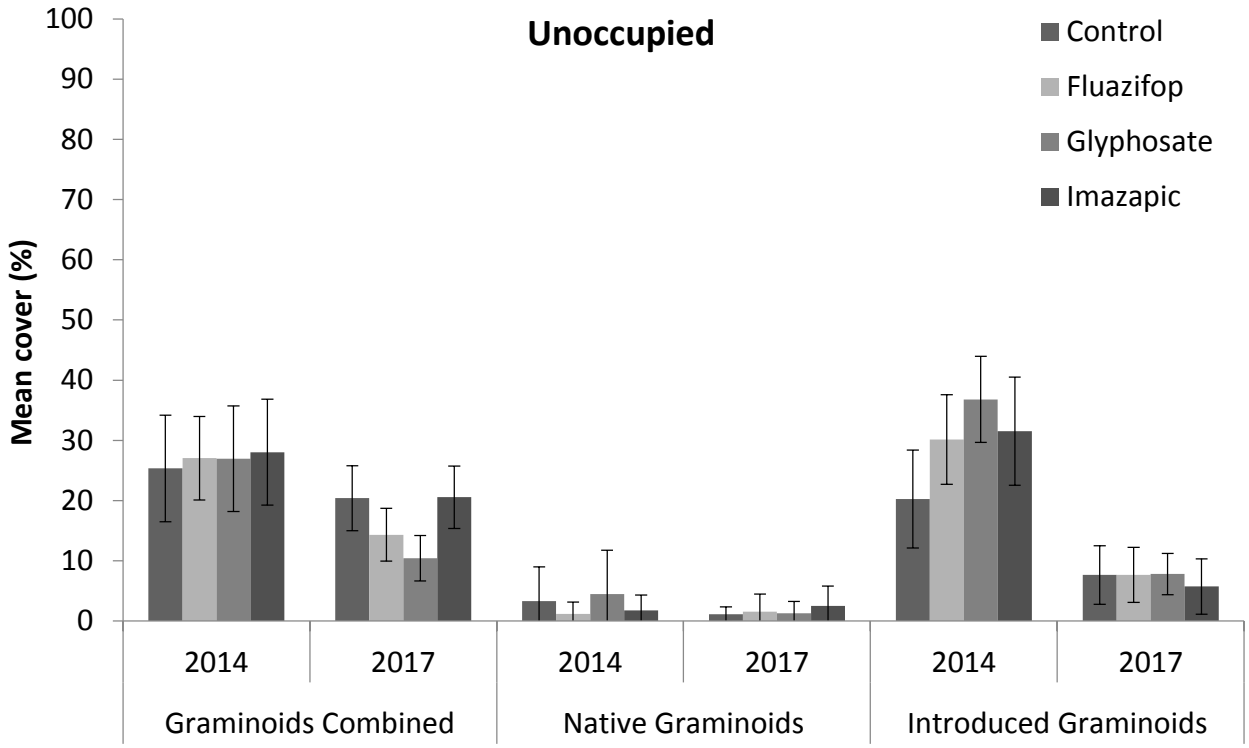

Figure 9. Average percent cover of graminoid species in unoccupied habitat. Error bars represent 95% confidence intervals.

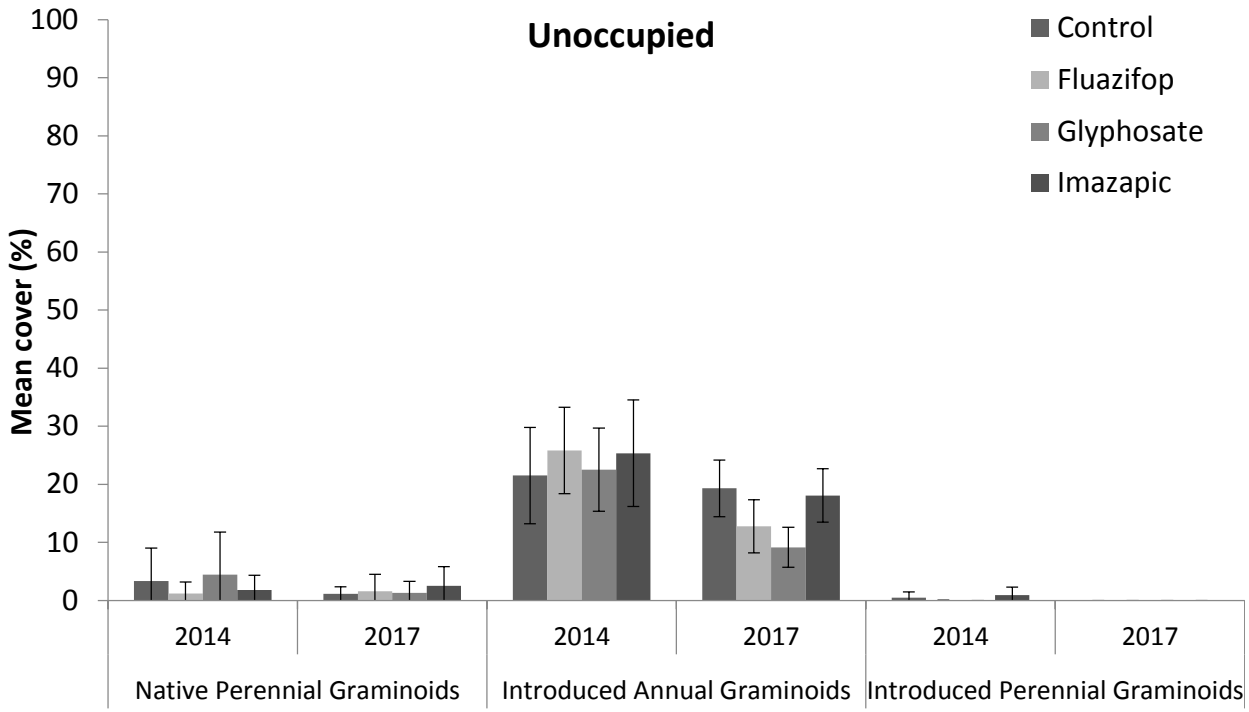

Figure 10. Average percent cover of annual and perennial graminoids in unoccupied habitat. Error bars represent 95% confidence intervals.

Effects of Fire

Lomatium cookii Density

In 2017, density of *L. cookii* did not differ between burned and unburned plots at French Flat Middle and South (Figure 11). Mean density in burned and unburned plots at French Flat South was 6.6 vs. 7.9 m^{-2}, respectively. At French Flat Middle, mean density in burned vs. unburned plots was 5.2 vs. 7.0 m^{-2}. Similarly, number of plants in each size/reproductive class did not differ between burned and unburned plots, at both sites (Figure 12). At French Flat South, there tended to be more vegetative plants in unburned plots, but the variability was so high within these plots that differences were not significant. Similar to in 2016, size class "V3" (vegetative plants with 3 or more leaves) were the most abundant representing roughly half of the plants in the population. At both sites, seedlings were very rare (Figure 12). Proportion of reproductive plants did not differ significantly between burned and unburned plots at either site (French Flat South: 0.34 vs. 0.23 respectively, French Flat Middle: 0.25 vs. 0.18 respectively; Figure 13). Across all plots, grazing impacted 20% of all plants at French Flat South and 40% of all plants at French Flat Middle. At both sites, grazing did not differ in burned vs. unburned plots (Figure 14).

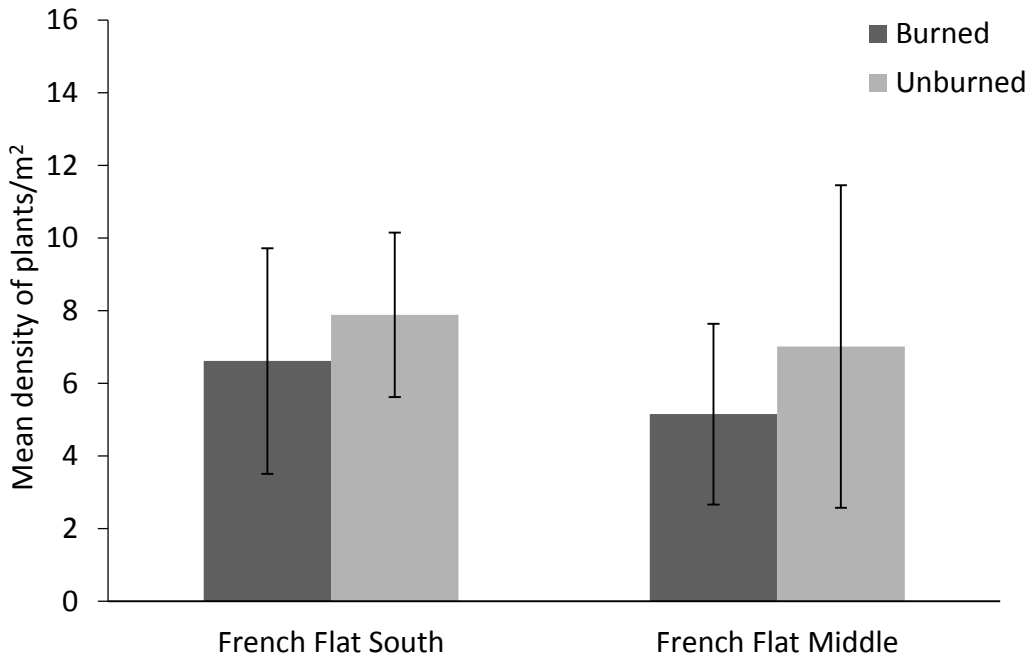

Figure 11. Density of *L. cookii* in 2017 in the burned and unburned portions of French Flat Middle and French Flat South. Error bars represent 95% confidence intervals.

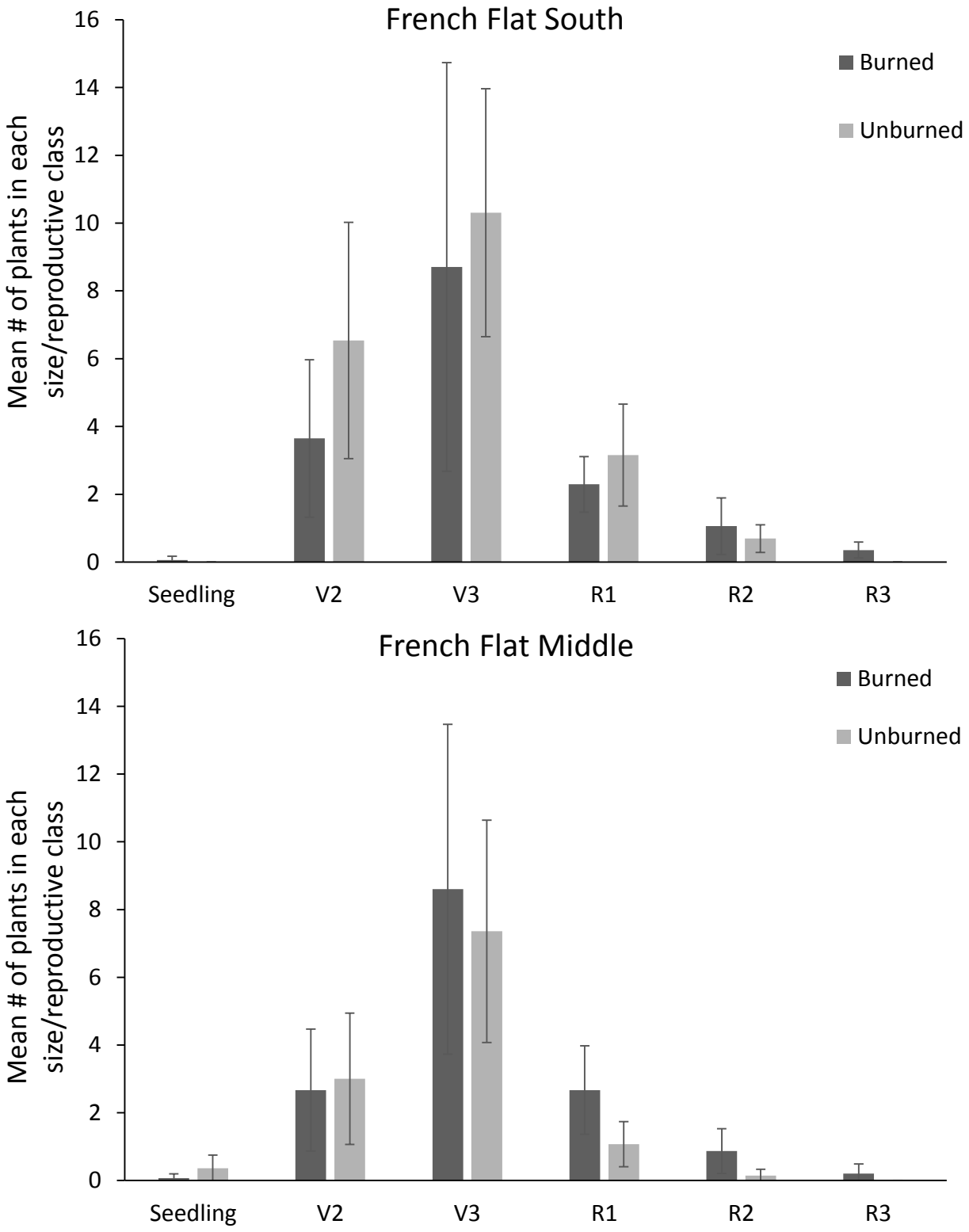

Figure 12. Mean number of plants in each size class at French Flat South and French Flat Middle, 2017. "V" indicates "vegetative" with the number following representing the number of leaves. "R" indicates "reproductive" with the number following representing the number of umbels. Error bars represent 95% confidence intervals.

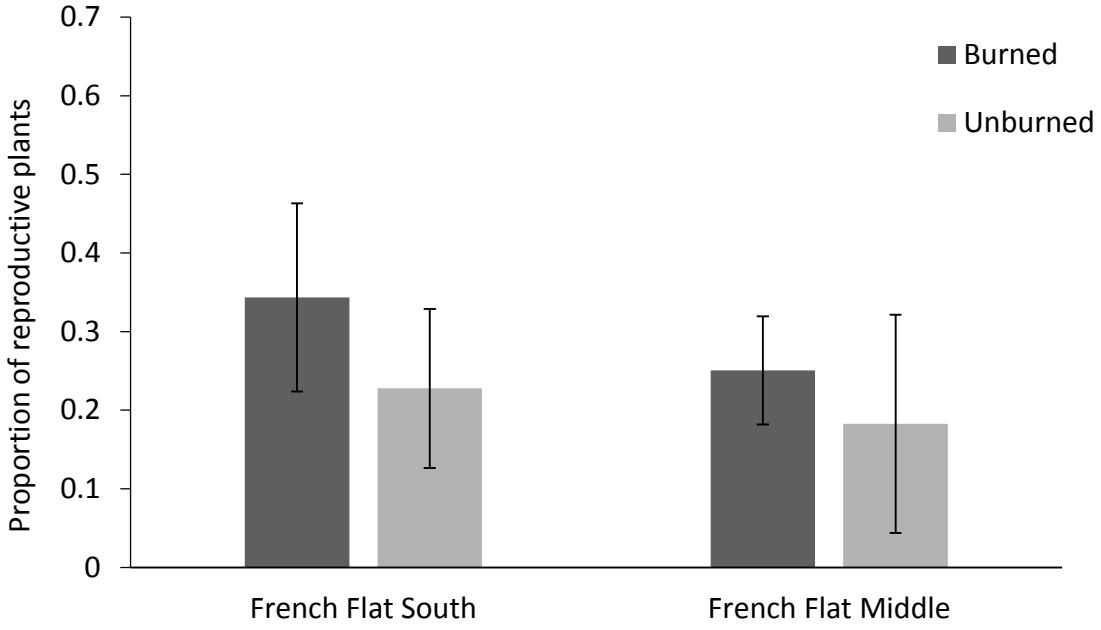

Figure 13. Mean proportion of reproductive *L. cookii* in burned and unburned plots at French Flat Middle and French Flat South in 2017. Error bars represent 95% confidence intervals.

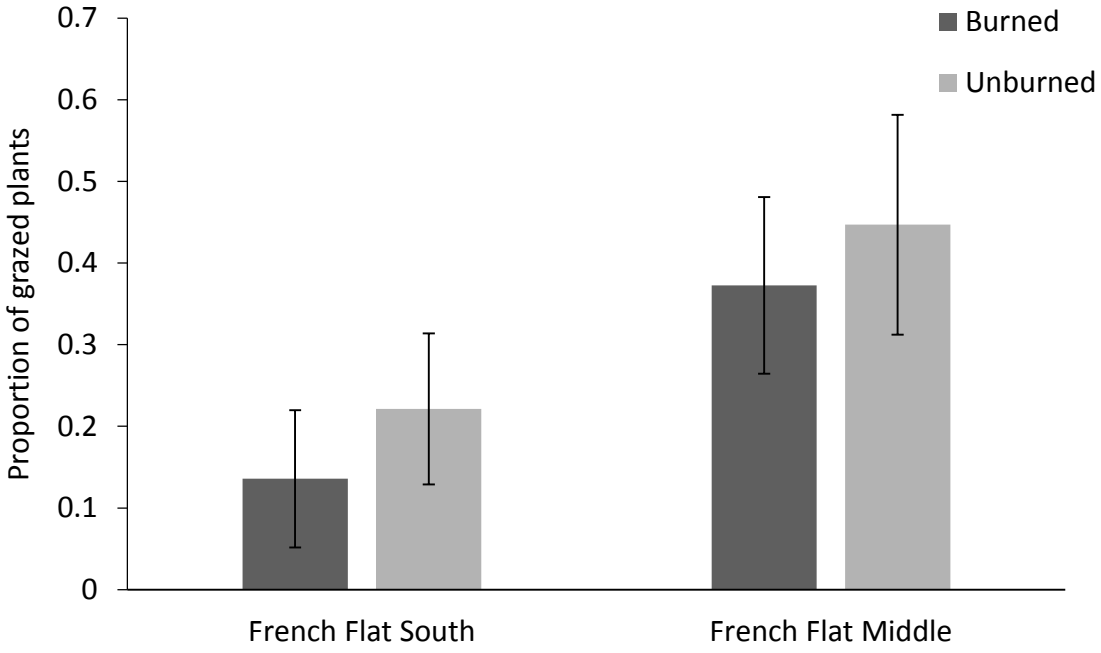

Figure 14. Proportion of plants grazed in the burned and unburned portions of French Flat Middle and French Flat South in 2017. Error bars represent 95% confidence intervals.

Plant Community

In the second year of monitoring post-burn, the burned plots tended to have less litter cover than unburned plots at both French Flat South (22% vs. 53%) and French Flat Middle (49% vs. 66%; Figure 15). The difference observed in 2017 was not as apparent as in 2016 at French Flat South (14% vs. 51%), and at French Flat Middle (6% vs. 45%). Similar to in 2016, bare ground cover was higher in the burned plots at French Flat South (40% vs. 18%), whereas at French Flat Middle, there was no difference in bare ground cover in the burned vs unburned plots, instead Rock/Gravel cover tended to be greater in burned plots (Figure 15).

The plant community responded similarly to the burn treatment at both sites. There was no difference between burned and unburned plots on the cover of native forb species in either meadow (Figure 16). Native graminoid cover tended to be less in the burned plots at both sites with cover of 31% vs. 19% at French Flat South, and 26% vs. 17% at French Flat Middle (Figure 16). Cover of invasive grasses in both areas was low (<2%), thus differences between burned and unburned plots are negligible with respect to total cover. Similarly, introduced forbs were only present in the burned plots at French Flat Middle and covered less than 1% in total.

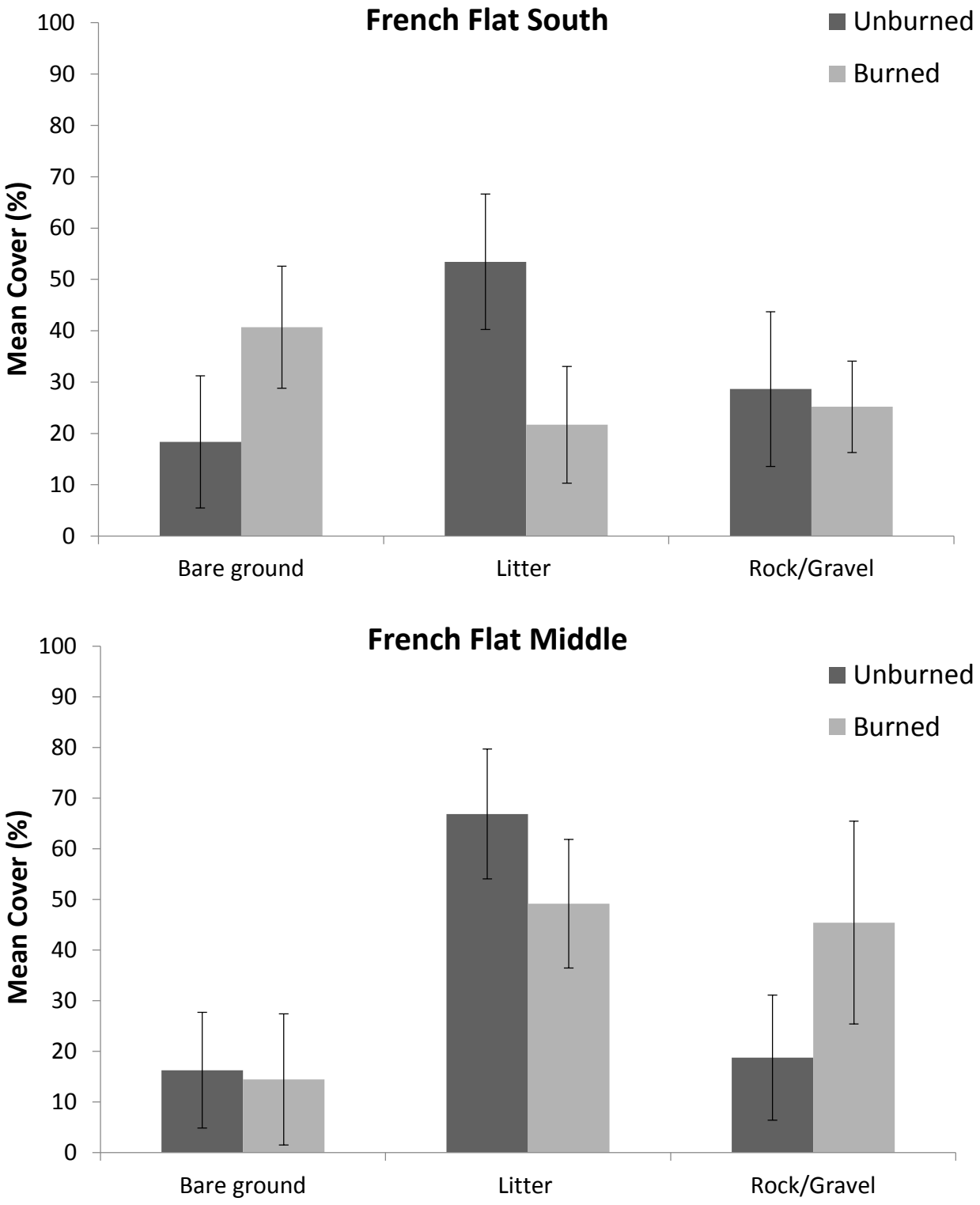

Figure 15. Ground cover in burned and unburned plots at French Flat South and French Flat Middle in 2017. Error bars represent 95% confidence intervals.

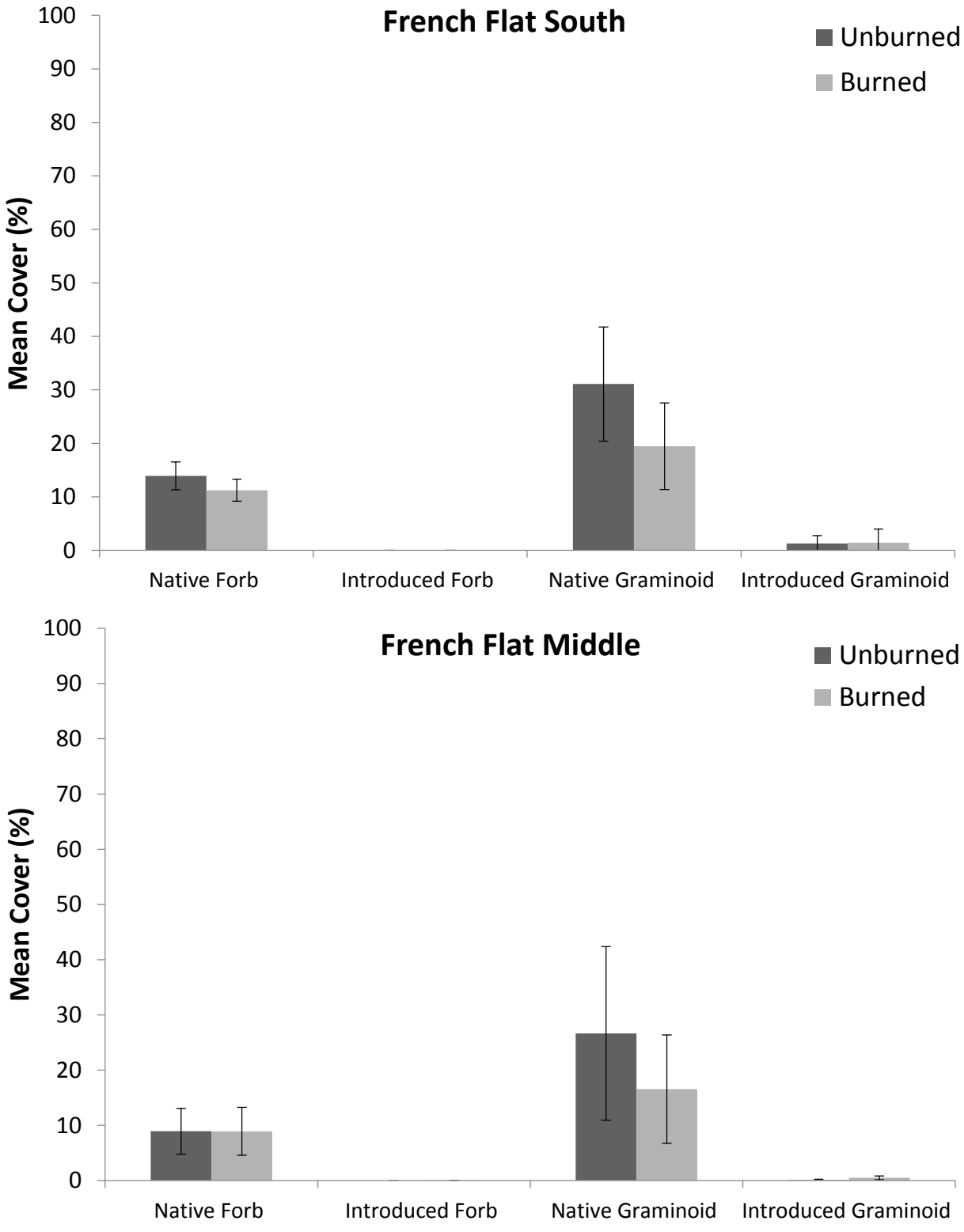

Figure 16. Forb and graminoid cover, by nativity, in burned and unburned plots at French Flat South and French Flat Middle in 2017. Error bars represent 95% confidence intervals.

DISCUSSION

Lomatium cookii Response to Habitat Management Treatments

Prescribed Fire

Since 2014, densities at both French Flat Middle and French Flat South have been among some of the lowest recorded at these sites since monitoring began in 1993. Competition from other (introduced) species, changes in soil pH and composition from needle and litter cast, encroachment by shrubby and woody species, as well as climatic and other factors at French Flat may be contributing to these declines. While burned plots had slightly lower densities of *L. cookii* than unburned plots in the first season, this difference was not statistically significant. In the second year post-burn, differences between burned and unburned plots were not significant at either site. This suggests that burning could be a valuable management tool in occupied habitat, and while it may not positively impact the density of *L. cookii,* it isn't detrimental to this rare species either. It was predicted that there would be increases in seedling recruitment and potentially an increase in reproductive effort into the future in the burned plots. In 2017 we saw that while burned plants had slightly higher proportions of reproductive plants, these differences were not significant. Likewise, seedling recruitment did not differ between treatments, though the number of recruits was relatively small in both treatments. Continued monitoring will be essential to see if there is a lag-time in effects of the fire treatment on *L. cookii* density, reproductive effort, and recruitment.

Additionally, expansion of the population into the newly cleared meadow edges is anticipated, though it is possible that seed addition (or transplanting) as well as litter removal of *Pinus* (and less so *Quercus*, *Ceanothus* and *Arctostaphylos*) may be recommended to accelerate the colonization of the newly created meadow edges at both French Flat South and Middle, and to increase connectivity between the two populated areas.

Invasive forb cover was low in all plots at French Flat (<1%), however, the presence of non-native forb species only in burned plots highlights that management in this ACEC should consider early detection and control of weedy species.

During monitoring of the *L. cookii* populations at French Flat in the recent past, an increase in the presence of *T. caput-medusae* into the occupied habitat at French Flat Middle and French Flat South has been noted. The presence of this weed species is particularly alarming, as the meadows of the French Flat ACEC are otherwise dominated by native species. Aggressive control of this invasive species is recommended.

Herbicide Treatments

At Illinois Forks State Park, no significant differences were observed between survivorship or recruitment between treated and control plots. Additionally, recruitment was noted in all plots. Although none of the treatments resulted in satisfactory changes in the targeted non-native species, the recruitment of new *L. cookii* individuals at least shows that the treatments did not appear to do harm. Height was found to be statistically greater in control plots than in all plots treated with herbicide, and future monitoring will enable us to see if these herbicide impacts continue and what they mean for fitness of this species. These results are encouraging from a

land management perspective, as it indicates that careful, appropriate, and well-timed habitat management can be performed in *L. cookii* occupied populations for the control of some troublesome species.

Plant Community Response to Habitat Management Treatments

Illinois Forks State Park:

At Illinois Forks State Park in the unoccupied (and weedy) habitat, there were visual differences between the herbicide-treated plots even in the second year post-treatment, and in 2017 these differences were detected in a portion of the plant community composition. While there was a decline in graminoids across all treatments (including the control), the decline in introduced graminoids in the fluazifop and glyphosate treated plots was greater than that in the control. This decline was largely represented by declines in cover of introduced annual grasses. Previous studies have shown that fall application of imazapic (pre-emergent herbicide) and spring application of fluazifop (grass-specific herbicide), alone and in combination, reduced exotic annual grasses for two years after treatment (Menke and Kaye 2016). Most changes in plant community composition observed in 2017 in both occupied and unoccupied habitat occurred across all treatments, including the controls. Because these vegetation changes were observed even in the controls, these changes could be in part due to annual (and seasonal) differences between water levels, or other climatic factors in this ephemeral vernal pool environment. For example, the decrease in *Agrostis* sp. in the occupied plots is likely due to the retreat of the species from the vernal pool edge; *Agrostis* sp. had encroached into the pool area during the exceptionally dry season of 2013. Additionally, our monitoring occurred in the spring (May) of each year, thus we may not have detected changes to the annual grass community in other parts of the year. For example, *T. caput-medusae* germinates in the early fall, and it is possible that due to the timing of our monitoring we did not fully detect changes in this species.

Recreational use at the Illinois Forks State Park has increased, and two of our plots were eliminated from analysis due to increased traffic over the course of this study. In 2013, a disc-golf course was established at the site, and while the course does not pass through *L. cookii* habitat, an unofficial trail has been established leading through the population towards the northeast. In recent years, a new picnic structure was constructed and bathroom facilities were upgraded. Development on private property adjacent to the park may also have unknown effects on the plant community and local hydrology.

French Flat:

At French Flat, in the area occupied with *L. cookii*, cover of introduced grasses were so low that we were not able to distinguish any effects of the fire on these problematic species in our community data. However, invasive annual grasses (in particular *T. caput-medusae)* are becoming more common, and encroaching from the edges of the meadow (and along the road) into the portions of the meadow occupied by *L. cookii*. Currently, these patches are small and uncommon enough that the species is only rarely detected in our monitoring, which focuses on the occupied habitat. While native graminoid cover was lower in the first year post-fire at both French Middle and French Flat South, this was mostly related to decreases in the size of bunches of *Danthonia*

spp. which continued to rebound in 2017. The longer-term effects of burning on *T. caput-medusae* and other invasive species at this otherwise relatively pristine location can inform future management actions.

At Illinois Forks State Park, in occupied habitat, plots have had a general shift (independent of treatment) away from perennial graminoids towards more annual grasses (both native and invasive). Continued habitat monitoring at French Flat will allow us to see if these changes are also occurring at French Flat, and to detect longer-term responses to burning treatments.

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APPENDIX A. COORDINATES FOR UNOCCUPIED AND OCCUPIED HABITAT PLOTS AT ILLINOIS FORKS STATE PARK.

Unoccupied Habitat

River/ Road	Block tag #s NW/SE corners	Meter sq. Plot tag#				Coordinates of NW corner tag (NAD 83)
Road	901/902	903	904	905	906	42.15844011 -123.65429099
Road	907/908	909	910	911	912	42.1582578 -123.65404523
Road	913/914	915	916	917	918	42.15818086 -123.65393442
Road	919/920	21	22	23	24	42.15805706 -123.65332036
Road	925/926	927	928	929	930	42.15771742 -123.65269465
Road	931/932	933	934	935	936	42.15699775 -123.65173870
Road	937/938	939	940	941	942	42.15760075 -123.65262156
River	943/944	945	946	947	948	42.15576972 -123.65672392
River	949/950	951	952	953	954	42.15575723 -123.65665460
River	955/956	963	964	965	966	42.15552061 -123.65664622
River	961/962	963	964	965	966	42.15518818 -123.65698258
River	967/968	969	970	971	972	42.15531668 -123.65685635

[1] The occupied plots can be found near Plots 901/902. The 25m baseline runs roughly North-South from #801 to #802 and is marked with concrete markers on both ends.

Occupied Habitat

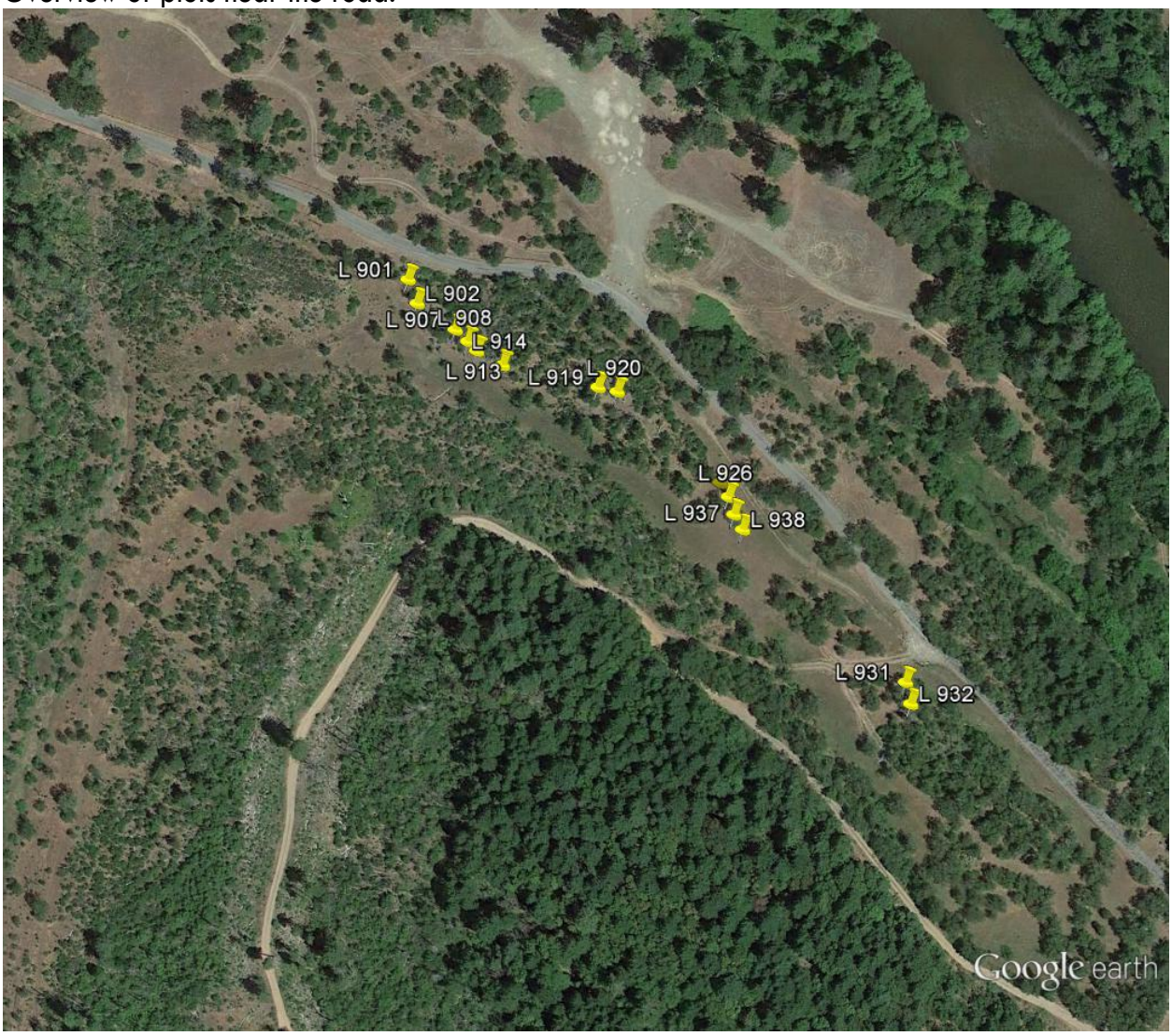
Plot#	Treatment	Transect #/Baseline Meter	Location of Demography Plot (m)
803	Control	843/21.5m	5.45
804	Fluazifop	843/21.5m	6.5
806	Imazapic	844/20.5m	4.6
807	Glyphosate	844/20.5m	5.6
808	Fluazifop	844/20.5m	7.5
809	Imazapic	845/19.5m	5.3
810	Control	845/19.5m	7.1
811	Imazapic	846/ 18.5m	6.15
812	Glyphosate	846/ 18.5m	7.4
813	Control	846/ 18.5m	6
814	Fluazifop	847/17.5m	15.15
815	Glyphosate	847/17.5m	7
816	Imazapic	847/17.5m	8.5
817	Control	848/16.5m	5.9
818	Glyphosate	848/16.5m	6.7
819	Fluazifop	848/16.5m	7.7
820	Glyphosate	849/ 15.5m	9.7
821	Control	849/ 15.5m	6.6
822	Imazapic	849/ 15.5m	7.8
823	Glyphosate	849/ 15.5m	9
824	Fluazifop	850/14.5	10.1
825	Control	850/14.6	7.8
826	Glyphosate	850/14.7	9.8
827	Fluazifop	850/14.8	10.85
828	Imazapic	850/14.9	13
829	Imazapic	851/13.5m	1.4
830	Fluazifop	851/13.5m	7.3
831	Fluazifop	851/13.5m	10.8
832	Control	852/13m	3.9
833	Glyphosate	852/13m	8.3
834	Imazapic	853/12.5m	4.4
835	Fluazifop	854/12m	3.5
836	Glyphosate	854/12m	5
837	Control	854/12m	7.3
838	Imazapic	855/11.5m	5.6
839	Control	856/11m	3.25
840	Fluazifop	856/11m	13.1
841	Glyphosate	858/9.5m	5.8
842	Imazapic	859/8.5m	3.7
401	Control	859/8.5m	5.9

APPENDIX B. AERIAL PHOTOS AND SCHEMATICS OF PLOTS IN THE UNOCCUPIED AND OCCUPIED HABITATS AT ILLINOIS FORKS STATE PARK.

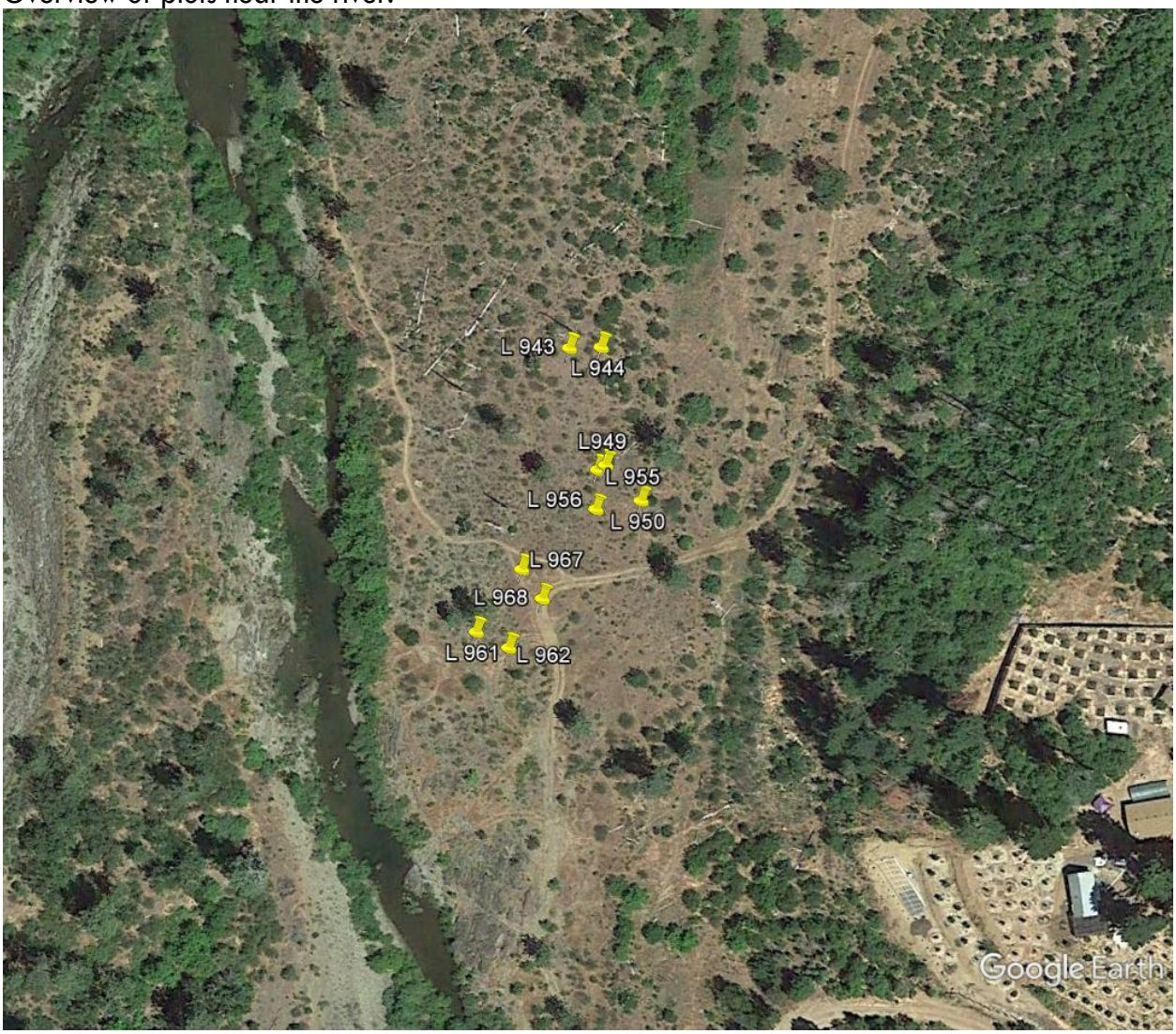
Unoccupied Habitat

There are a total of 12 macroplots, 7 near the entrance road to the park and 5 to the west closer to the Illinois River. The baseline marking the occupied plots can be found near Plot 901/902. GPS points are marked at opposite corners for each plot.

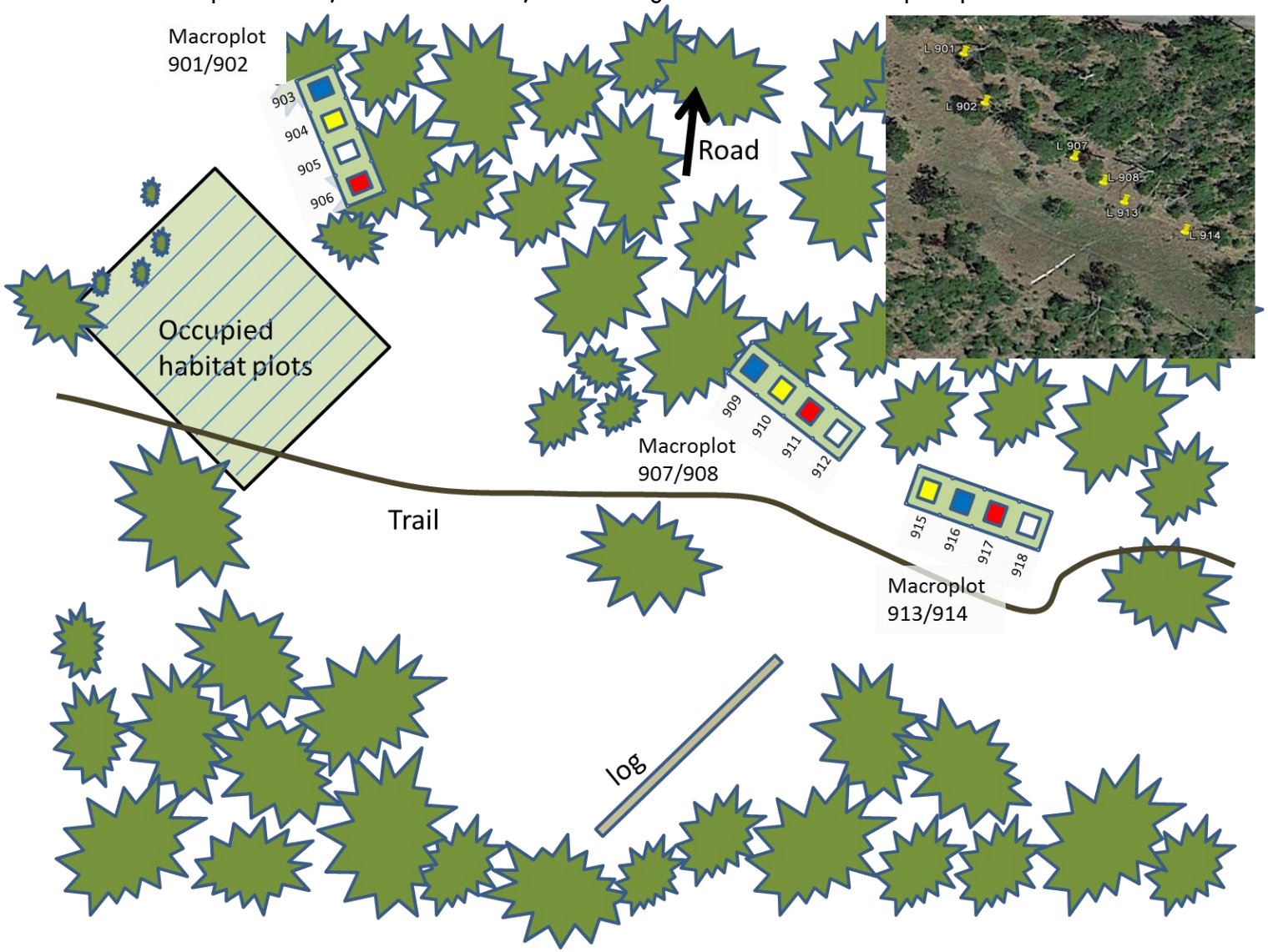
Overview of plots near the road.



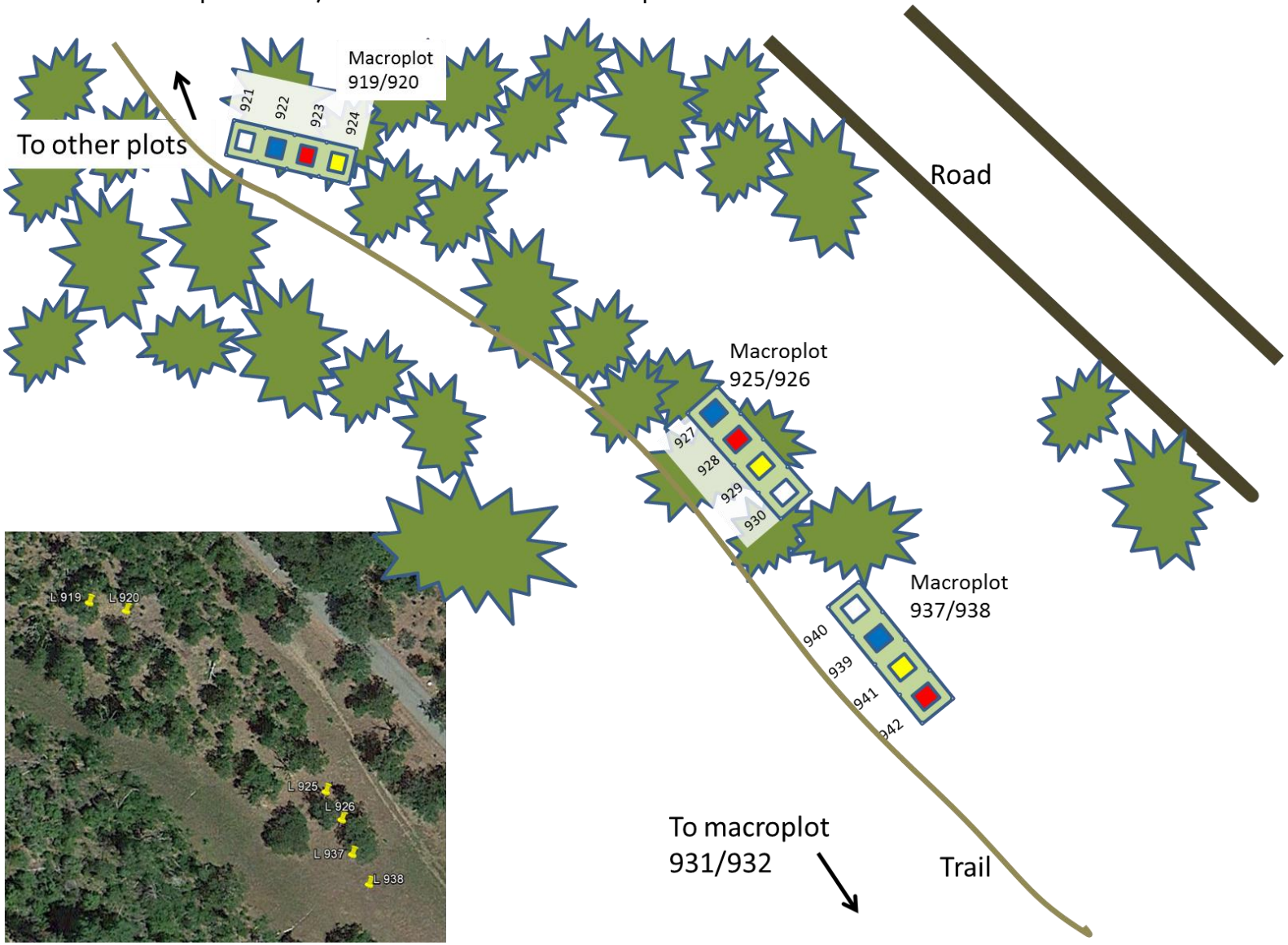
Overview of plots near the river.



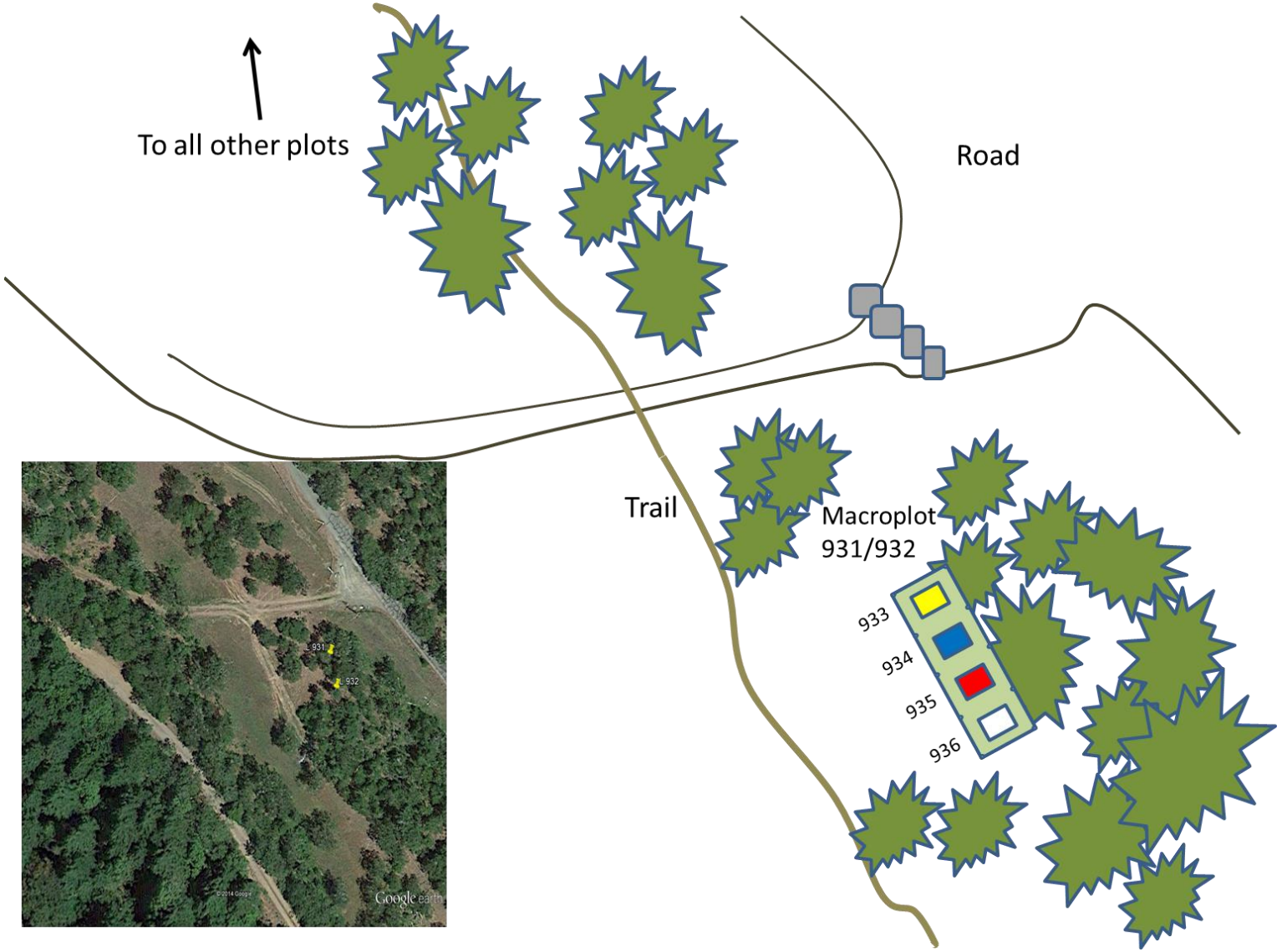
Schematic of macroplots #901, #907 and #913, as well as general location of occupied plots.



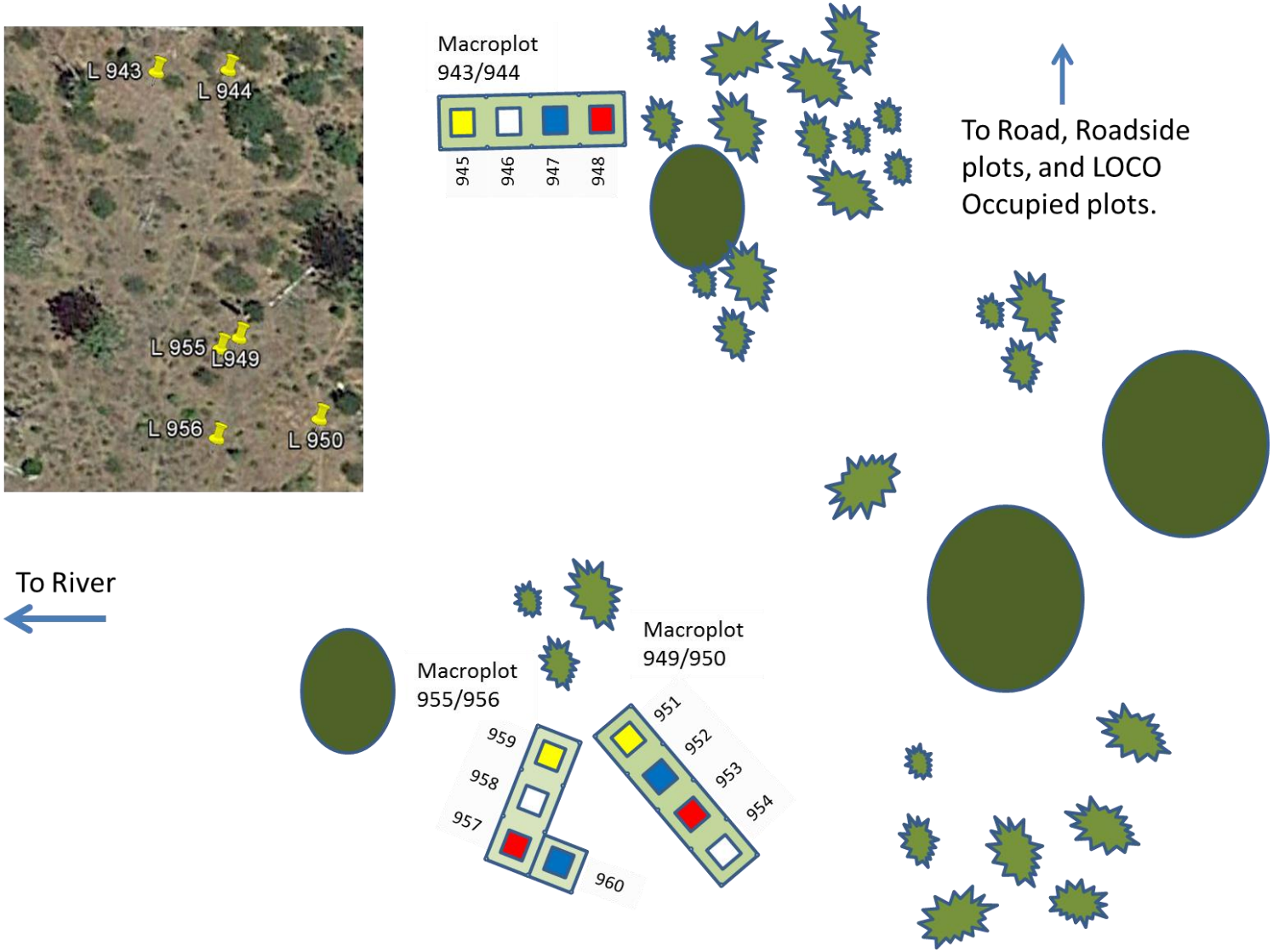
Schematic of macroplots #919, #925 and #937 in the unoccupied area.



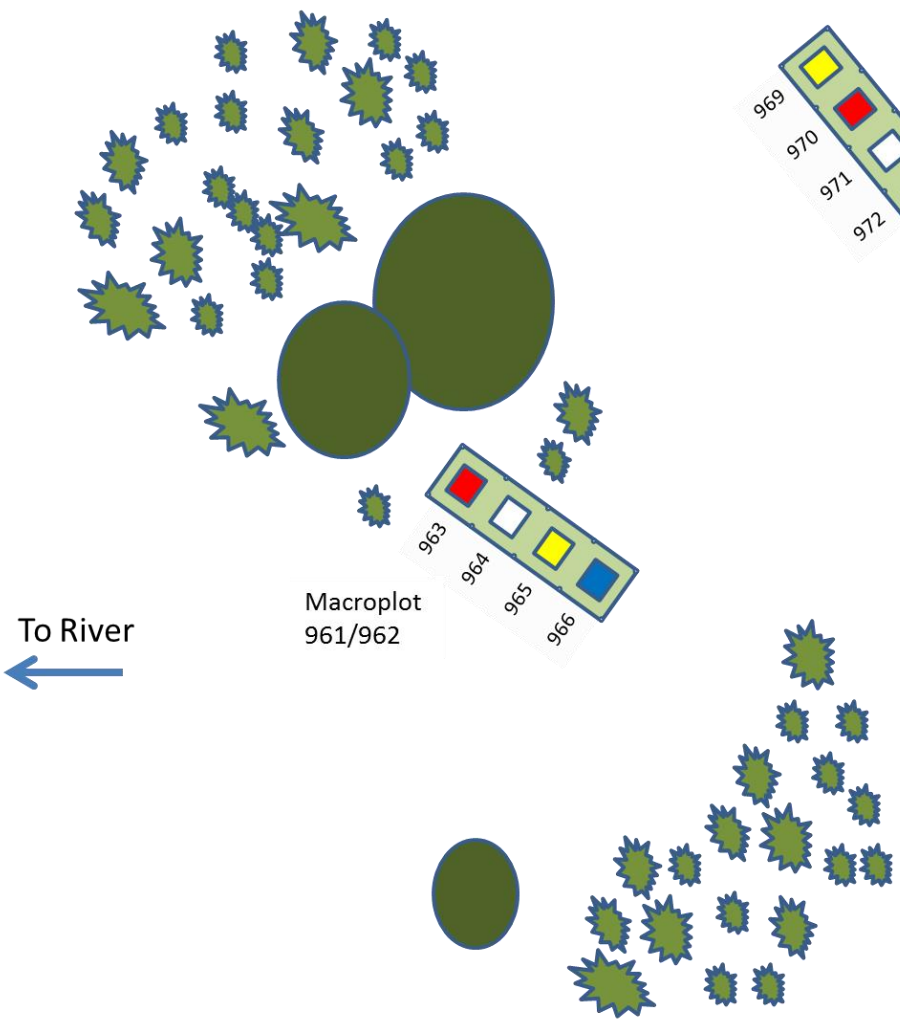
Schematic of macroplot #931.



Schematic of macroplots #943, #949 and #955.

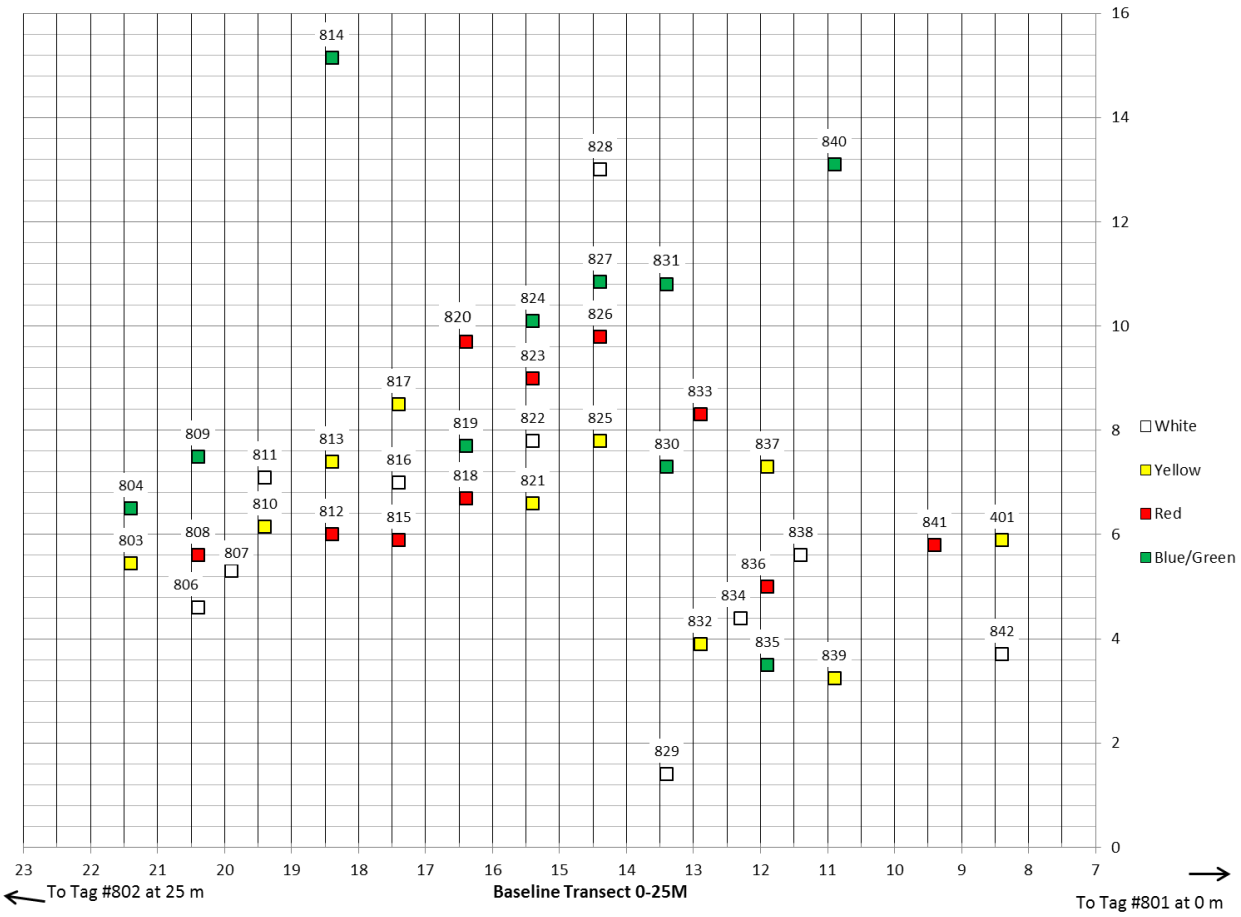


Schematic of macroplots #961 and #967.



Occupied Habitat

There are 40 0.5mx0.5m plots established along 15m transects that run perpendicular to the 25m baseline (#801-802). Location along the baseline, and location of the demography plot(s) along the transects are recorded in the following table. The perpendicular transects are marked at both ends with tagged 18" PVC, capped with IAE labels, and pounded into the ground with ~3-6" exposed. The placement of the perpendicular transects and the location of the demographic plot (s) along these transects were selected using a random number generator. If the randomly selected target location did not have at least three *L.* cookii, the next closest suitable area along the transect (with at least three *L. cookii*) was selected[1]. Demographic plots are marked with nails and (hot pink) washers on opposite corners (NE – with tag and SW).



Schematic of plots established in the occupied habitat. In this diagram, white = imazapic, yellow = control , red =glyphosate and blue/green = fluazifop .

[1] Due to the limited size of the population, one to three plots in each treatment have only one or two plants instead of the targeted minimum of three plants.

APPENDIX C. LOCATIONS OF DENSITY AND DEMOGRAPHY PLOTS AT FRENCH FLAT MIDDLE AND FRENCH FLAT SOUTH.

French Flat Middle

Established in 2013.

2013 New Plot #	Side of Tape	Location on Baseline (m)	End Rebar at (m)	End Rebar Tag	2013 Last Plant Found at (m)	Demog. Tag	Demog. Plot Location (NE Corner)	Demog. Plot Location (End)
165	W	2.8	30	166	25.95	33	11.43	10.9
154	W	6.5	37	153	34	1	11.2	10.75
155	E	6.5	37	156	26.5	3	18.05	18.55
161	E	9.1	40	162	35.2	8	23.25	23.75
163	E	9.7	40	164	39.55	7	15.5	16
163	E	9.7	40	164	38.05	10	33.25	33.75
28	W	15	37	29	35.7	876	18.55	19.05
167	E	17.5	40	166	38.05	-	-	-
30	E	19	39.3	31	35.1	-	-	-
33	W	22	40	34	28.1	877	23.45	23.95
169	W	25	40	170	38.7	37	22.24	21.71
171	E	27.1	33.5	172	33	38	2.4	2.9
199	W	31	30	200	29.3	-	-	-
35	E	35	40	36	38.6	-	-	-
173	E	36.6	40	174	36.6	874	20.5	30
173	E	36.6	40	174	36.6	875	11.2	11.7
175	W	40.2	35	176	31.85	167	23.45	23.95
158	W	43.1	30	157	20.6	18	13.2	12.7
159	E	43.5	30	160	28.25	28	5.2	5.7
177	E	46.6	35.5	178	33.9	29	5.1	5.6
179	E	55.1	15.4	180	13.7	31	4.75	5.25
181	W	56	20.4	182	19	-	-	-
183	E	60	11.3	184	11.05	-	-	-
185	E	62	10.8	186	9.7	-	-	-
187	W	67	9.9	188	6.7	-	-	-
189	E	72	15	190	14.9	168	6.5	7
37	W	74	16	38	6.9	-	-	-
191	W	82	15.5	192	11.4	169	2.5	2
193	W	86	10.5	194	3.5	-	-	-
195	E	89	21.4	196	19.5	170	-	-
197	W	95	15	198	10.5	-	-	-
39	W	98	15	40	8.7	-	-	-

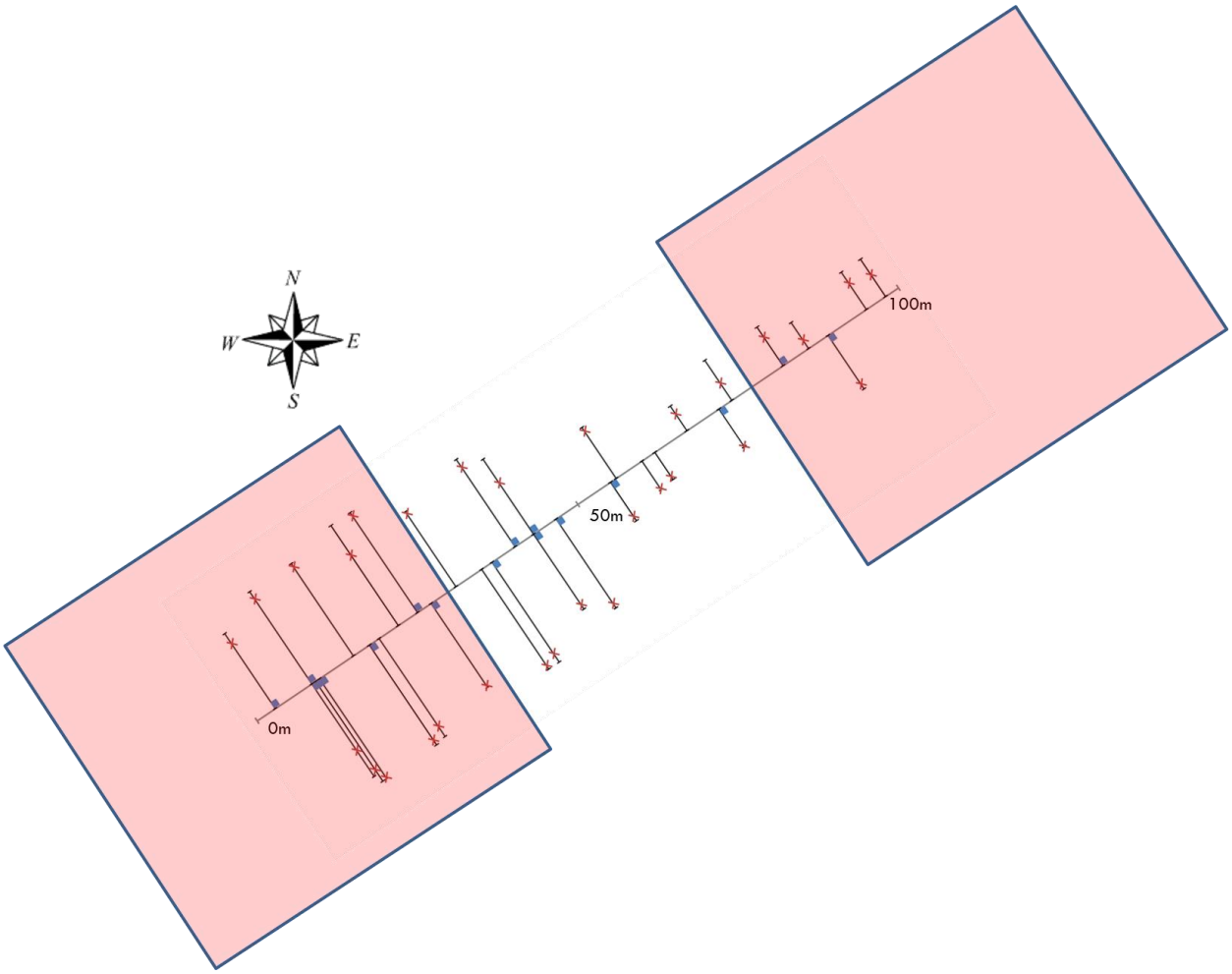
French Flat South

Established in 2012.

2012 New Plot #	Side of Tape	Location on Baseline (m)	End Rebar at (m)	End Rebar Tag	2012 Last Plant Found at (m)	Demog. Tag	Demog. Plot Location (NE Corner)	Demog. Plot Location (End)
362	E	13	23	363	9.3	-	-	-
364	W	27	30	365	10.4	-	-	-
366	W	30	33	367	6.9	-	-	-
707	W	36	21	708	15.9	329	10.5	11
709	W	38	21	710	15.8	330	6.5	7
711	W	42	21	712	12.7	331	4	4.5
749	E	45	40	750	23.6	353	15.5	15
713	E	52	37	714	25.8	332	17.5	17
741	E	57	35	742	27.1	352	20.5	20
743	E	59	40	744	30.1	354	21.5	21
753	E	61	36	754	31.8	357	23	22.5
745	W	65	39	746	23.9	361	13.5	14
747	E	70	40	748	32.1	360	8.5	8
751	E	72	40	752	22.8	355	5.5	5
725	W	79	40	726	11.8	338	3	3.5
715	E	81	40	716	30.4	333	11.5	11
717	W	94	40	718	28.7	334	13.5	14
719	E	95	40	720	30.9	335	19	18.5
721	E	97	40	722	30.6	336	15.5	15
723	W	99	32	724	31.0	337	16	16.5
727	W	107	28	728	24.6	339	13	13.5
701	E	109	40	702	27.2	326	24.5	24
703	E	111	40	704	28.3	327	23	22.5
705	W	116	32	706	23.0	328	19	19.5
729	W	119	33	730	22.8	340	24	24.5
755	E	125	40	756	27	356	16.5	16
731	E	126	40	732	19.1	341	5.5	5
733	W	128	35.5	734	29.2	342	20	20.5
735	E	129	40	736	23.6	343	9	8.5
737	W	136	40	738	31.5	344	15	15.5
757	W	142	33	758	32.8	358	5	5.5
759	W	144	34	760	32.6	359	9.5	10
739	W	154	40	740	32.8	345	18	18.5

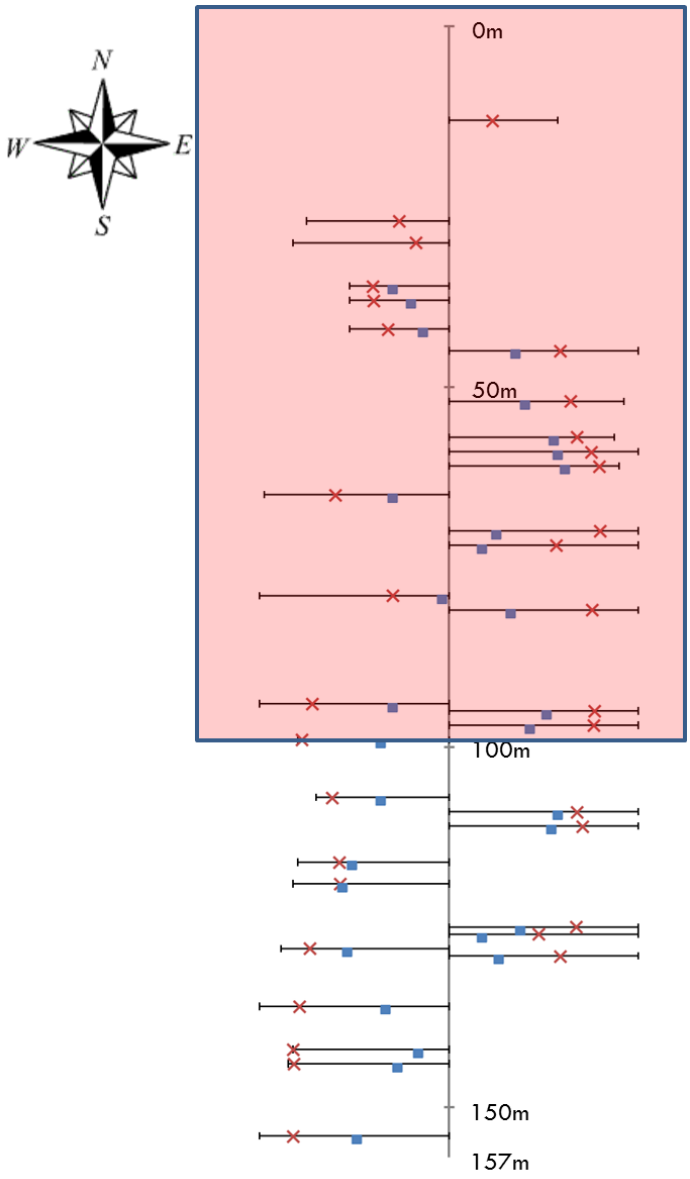
APPENDIX D. SCHEMATIC OF DENSITY AND DEMOGRAPHY PLOTS AT FRENCH FLAT MIDDLE AND FRENCH FLAT SOUTH.

French Flat Middle



Demography and density plots were established in 2013. Baseline transect is 100m with a bearing of 034° (northeast). Last plants located on density plots are indicated by red crosses. Demography plots are indicated by blue squares and are not located along the baseline transect as shown here. The shaded areas were burned in the fall of 2015.

French Flat South



Demography and density plots were established in 2012. Baseline transect is 157m with a bearing due south. Last plants located on density plots are indicated by red crosses. Demography plots are indicated by blue squares. The shaded areas were burned in the fall of 2015.

APPENDIX E. NUMBER OF L. COOKII IN EACH DEMOGRAPHIC PLOT AT ILLINOIS FORKS STATE PARK, 2014-2017.

Treatment[1]	Plot #	2014	2015	2016	2017
CONTROL TOTAL		49	47	45	31
Control	401	3	3	3	3
Control	803	3	4	5	5
Control	810	17	15	12	1
Control	813	1	1	1	1
Control	817	3	3	3	3
Control	821	12	7	6	7
Control	825	3	3	4	5
Control	832	3	3	3	3
Control	837	2	2	2	2
Control	839	2	6	6	1
FLUAZIFOP TOTAL		25	29	31	50
Fluazifop	804	3	6	10	9
Fluazifop	808	1	1	1	1
Fluazifop	814	2	3	2	2
Fluazifop	819	1	1	1	1
Fluazifop	824	1	1	1	1
Fluazifop	827	4	4	3	4
Fluazifop	830	3	3	3	4
(Fluazifop)	831	17	27	27	25
Fluazifop	835	8	9	9	1
Fluazifop	840	2	1	1	2
GLYPHOSATE TOTAL		56	59	64	68
Glyphosate	807	4	3	3	3
(Glyphosate)	812	17	20	14	0
Glyphosate	815	8	10	16	13
Glyphosate	818	5	8	8	8
Glyphosate	820	5	4	5	6
Glyphosate	823	12	14	14	14
Glyphosate	826	11	9	7	14
Glyphosate	833	8	9	8	8
Glyphosate	836	2	1	2	2
Glyphosate	841	1	1	1	0

Treatment[1]	Plot #	2014	2015	2016	2017
IMAZAPIC TOTAL		55	51	50	46
Imazapic	806	1	1	2	1
Imazapic	809	12	10	8	0
Imazapic	811	3	3	4	3
Imazapic	816	9	11	10	9
Imazapic	822	7	5	5	6
Imazapic	828	1	1	1	1
Imazapic	829	3	3	3	2
Imazapic	834	15	13	13	19
Imazapic	838	1	1	1	1
Imazapic	842	3	3	3	4

[1]Plots in parentheses were not included in analysis in 2017.

APPENDIX F. PLANT COMMUNITY DATA (FORBS AND SHRUBS) FROM FORKS STATE PARK IN OCCUPIED AND UNOCCUPIED PLOTS, 2014-2017.

	Total Forbs		Native Forbs		Introduced Forbs		Tree/Shrub	
2014	Avg.	*95%C.I.*	Avg.	*95%C.I.*	Avg.	*95%C.I.*	Avg.	*95%C.I.*
Unoccupied								
control	28.5	*5.2*	9.0	*2.6*	19.4	*5.0*	0.1	*0.2*
fluazifop	29.3	*10.4*	6.3	*4.8*	22.9	*11.4*	0.4	*0.1*
glyphosate	23.8	*13.5*	11.0	*3.1*	12.8	*13.6*	0.1	*0.8*
imazapic	20.6	*10.1*	6.0	*7.5*	14.6	*7.5*	0.0	*0.1*
Occupied								
control	13.8	*4.1*	6.8	*1.9*	7.0	*4.0*	5.5	*2.7*
fluazifop	11.9	*6.8*	3.9	*4.6*	8.1	*6.1*	0.1	*10.8*
glyphosate	14.5	*6.9*	4.3	*1.7*	10.2	*7.3*	0.0	*0.2*
imazapic	9.4	*12.5*	7.2	*2.0*	2.3	*12.8*	0.0	*0.0*
2015								
Unoccupied								
control	28.0	*6.4*	7.7	*2.3*	20.4	*6.4*	0.0	*0.2*
fluazifop	42.2	*11.7*	5.1	*4.3*	37.1	*10.9*	0.4	*0.0*
glyphosate	14.1	*15.8*	11.1	*1.6*	3.0	*15.9*	0.1	*0.8*
imazapic	23.4	*7.6*	2.0	*7.5*	21.4	*1.3*	0.0	*0.2*
Occupied		*11.0*		*1.1*		*11.0*		*0.0*
control	12.0	*3.2*	6.3	*1.6*	5.7	*2.7*	7.5	*3.7*
fluazifop	23.4	*3.8*	7.1	*2.8*	16.4	*3.4*	0.2	*14.7*
glyphosate	8.6	*8.7*	7.2	*2.4*	1.4	*7.5*	0.0	*0.4*
imazapic	13.9	*2.2*	8.0	*2.2*	5.9	*0.8*	0.0	*0.0*
2016								
Unoccupied								
control	26.7	*5.5*	8.3	*2.6*	18.5	*5.2*	0.0	*0.3*
fluazifop	42.5	*7.0*	9.7	*4.3*	32.8	*6.9*	0.6	*0.0*
glyphosate	26.0	*10.7*	14.1	*4.4*	11.9	*11.8*	0.3	*1.1*
imazapic	32.9	*9.1*	6.1	*7.9*	26.8	*4.9*	0.0	*0.5*
Occupied								
control	13.4	*2.7*	6.3	*1.3*	7.0	*2.2*	7.5	*3.7*
fluazifop	11.0	*4.0*	4.2	*2.4*	6.8	*4.2*	0.1	*14.7*
glyphosate	11.2	*5.7*	5.6	*1.1*	5.6	*5.9*	0.1	*0.2*
imazapic	13.3	*5.9*	7.2	*2.0*	6.1	*4.5*	0.0	*0.1*
2017								
Unoccupied								
control	33.4	*7.8*	11.4	*3.0*	22.0	*7.1*	0.0	*0.5*
fluazifop	51.2	*11.3*	13.9	*5.1*	37.3	*10.2*	1.1	*0.0*
glyphosate	50.7	*14.6*	13.4	*6.4*	37.2	*14.9*	0.0	*2.1*
imazapic	41.1	*18.9*	10.1	*6.4*	31.0	*17.3*	0.0	*0.0*
Occupied								
control	26.2	*5.7*	15.7	*3.9*	10.6	*5.1*	6.0	*2.9*
fluazifop	20.3	*11.5*	12.2	*6.6*	8.1	*10.3*	0.0	*11.8*
glyphosate	34.8	*5.3*	21.1	*3.2*	13.7	*4.5*	0.0	*0.0*
imazapic	32.1	*15.2*	19.3	*10.5*	12.8	*14.6*	0.0	*0.0*

APPENDIX G. PLANT COMMUNITY DATA (GRAMINOIDS) FROM FORKS STATE PARK IN OCCUPIED AND UNOCCUPIED PLOTS, 2014-2017.

	Graminoids Combined		Native Graminoids		Introduced Graminoids		Native Perennial Graminoids		Introduced Annual Graminoids		Introduced Perennial Graminoids	
	Mean Cover	*95% C.I.*	Mean Cover	*95% C.I.*	Mean Cover	*95% C.I.*	Mean Cover	*95% C.I.*	Mean Cover	*95% C.I.*	Mean Cover	*95% C.I.*
2014												
Unoccupied												
Control	25.3	*4.1*	3.3	*2.4*	22.0	*3.9*	3.3	*2.4*	21.5	*3.9*	0.5	*0.4*
Fluazifop	27.0	*8.8*	1.2	*5.7*	25.8	*8.1*	1.2	*5.7*	25.8	*8.3*	0.0	*1.0*
Glyphosate	27.0	*6.9*	4.5	*2.0*	22.5	*7.4*	4.5	*2.0*	22.5	*7.4*	0.0	*0.0*
Imazapic	28.0	*8.8*	1.8	*7.3*	26.3	*7.2*	1.8	*7.3*	25.3	*7.2*	0.9	*0.0*
Occupied												
Control	47.0	*7.0*	26.7	*6.1*	20.3	*6.3*	26.7	*6.1*	9.9	*3.6*	10.3	*7.7*
Fluazifop	58.7	*14.0*	28.6	*10.7*	30.2	*11.0*	28.6	*10.7*	10.4	*7.3*	19.8	*11.9*
Glyphosate	56.3	*13.1*	19.5	*13.6*	36.8	*11.6*	19.5	*13.6*	8.1	*7.0*	28.7	*15.6*
Imazapic	59.7	*15.2*	28.1	*12.1*	31.5	*13.7*	28.1	*12.1*	11.5	*5.7*	20.0	*17.6*
2015												
Unoccupied												
Control	32.4	*5.1*	2.1	*1.1*	30.3	*5.0*	2.1	*1.1*	30.0	*5.0*	0.3	*0.2*
Fluazifop	7.9	*8.8*	0.8	*3.3*	7.1	*9.4*	0.8	*3.3*	7.1	*9.5*	0.0	*0.7*
Glyphosate	2.0	*6.9*	1.0	*1.1*	1.0	*7.1*	1.0	*1.1*	1.0	*7.1*	0.0	*0.0*
Imazapic	22.0	*1.6*	2.0	*1.6*	20.0	*0.6*	2.0	*1.6*	19.8	*0.6*	0.3	*0.0*
Occupied												*0.5*
Control	32.1	*6.3*	11.7	*4.3*	20.4	*3.9*	11.7	*4.3*	17.5	*3.8*	2.9	*1.6*
Fluazifop	13.9	*14.1*	10.4	*7.8*	3.5	*12.1*	10.4	*7.8*	1.7	*12.8*	1.8	*4.9*
Glyphosate	1.1	*7.8*	0.7	*7.8*	0.4	*1.7*	0.7	*7.8*	0.4	*1.3*	0.1	*1.6*
Imazapic	24.6	*1.0*	18.3	*0.6*	6.4	*0.4*	18.3	*0.6*	1.7	*0.4*	4.7	*0.0*

	Graminoids Combined		Native Graminoids		Introduced Graminoids		Native Perennial Graminoids		Introduced Annual Graminoids		Introduced Perennial Graminoids	
	Mean Cover	*95% C.I.*	Mean Cover	*95% C.I.*	Mean Cover	*95% C.I.*	Mean Cover	*95% C.I.*	Mean Cover	*95% C.I.*	Mean Cover	*95% C.I.*
2016												
Unoccupied												
Control	23.4	*4.6*	1.9	*1.0*	21.4	*4.6*	1.9	*1.0*	21.4	*4.6*	0.0	*0.0*
Fluazifop	8.3	*7.6*	0.8	*3.2*	7.5	*7.7*	0.8	*3.2*	7.5	*7.7*	0.0	*0.0*
Glyphosate	4.1	*6.0*	0.3	*1.2*	3.8	*6.2*	0.3	*1.2*	3.8	*6.2*	0.0	*0.0*
Imazapic	24.0	*1.5*	1.9	*0.5*	22.1	*1.6*	1.9	*0.5*	22.1	*1.6*	0.0	*0.0*
Occupied												
Control	26.9	*4.0*	8.3	*2.4*	18.6	*3.2*	8.3	*2.4*	17.1	*3.2*	1.5	*0.8*
Fluazifop	8.1	*10.0*	3.3	*5.2*	4.8	*9.9*	3.3	*5.2*	4.0	*9.9*	0.8	*2.9*
Glyphosate	3.5	*2.9*	0.8	*2.1*	2.7	*2.5*	0.8	*2.1*	2.4	*2.8*	0.3	*0.6*
Imazapic	13.4	*1.3*	9.4	*0.8*	4.0	*1.4*	9.4	*0.8*	3.2	*1.5*	0.8	*0.4*
2017												
Unoccupied												
Control	20.4	*2.6*	1.1	*1.2*	19.3	*2.4*	1.1	*1.2*	19.3	*2.4*	0.0	*0.0*
Fluazifop	14.3	*5.4*	1.6	*1.2*	12.8	*4.9*	1.6	*1.2*	12.8	*4.9*	0.0	*0.0*
Glyphosate	10.5	*4.4*	1.3	*2.9*	9.1	*4.6*	1.3	*2.9*	9.1	*4.6*	0.0	*0.0*
Imazapic	20.6	*3.8*	2.5	*2.0*	18.1	*3.4*	2.5	*2.0*	18.1	*3.4*	0.0	*0.0*
Occupied												
Control	21.0	*3.7*	13.4	*3.8*	7.7	*2.2*	13.4	*3.8*	6.9	*2.3*	0.7	*0.4*
Fluazifop	13.6	*8.9*	5.9	*8.7*	7.7	*4.6*	5.9	*8.7*	7.2	*4.7*	0.5	*0.8*
Glyphosate	13.1	*3.6*	5.3	*3.1*	7.8	*4.1*	5.3	*3.1*	7.1	*4.3*	0.7	*0.6*
Imazapic	23.1	*5.0*	17.4	*4.0*	5.7	*5.1*	17.4	*4.0*	5.5	*5.3*	0.2	*1.0*

APPENDIX H. MEAN COVER OF THE PLANT COMMUNITY BY SPECIES IN OCCUPIED AND UNOCCUPIED PLOTS AT FORKS STATE PARK (2014-2017)

Species with *0.0* in italics indicates that the species was present with an average values <0.1% cover.

			2014		2015		2016		2017	
		OCCUPIED:	Y	N	Y	N	Y	N	Y	N
Duration	**Native/Invasive**	**Species**								
GROUND COVER:										
		Litter grass	-	-	70.3	77.8	61.0	73.4	50.1	76.0
		Litter oak	-	-	29.4	22.2	39.1	26.6	49.6	24.0
		Bare ground	1.1	4.3	2.8	7.1	1.6	9.7	2.3	3.2
		Litter	95.8	95.9	87.8	92.0	75.3	78.1	90.3	92.1
		Moss	2.2	3.1	7.7	2.8	15.9	8.5	7.4	3.4
		Rock	3.8	2.4	6.5	3.7	9.6	8.0	18.2	5.3
GRAMINOIDS:										
Perennial	Native	*Achnatherum lemmonii*	0.6	2.4	0.4	1.4	0.3	1.2	0.5	1.5
Perennial	Invasive	*Agrostis* sp.	19.7	0.3	2.3	0.1	0.8	*0.0*	0.5	0.0
Annual	Invasive	*Aira caryophyllea*	0.4	0.9	0.3	1.4	1.3	3.4	1.5	2.4
Annual	Invasive	*Avena fatua*	*0.0*	*0.0*	0.0	*0.0*	0.0	0.0	0.0	0.0
Annual	Invasive	*Briza minor*	0.1	*0.0*	0.4	0.3	0.1	*0.0*	0.7	*0.0*
Annual	Invasive	*Bromus hordeaceus*	1.0	13.0	0.4	6.8	0.5	4.6	0.6	4.6
Annual	Invasive	*Bromus rigidus*	0.5	4.5	1.1	1.8	0.7	1.7	1.0	2.1
Perennial	Native	*Bromus* sp.	0.0	0.0	0.0	0.0	*0.0*	0.0	0.0	*0.0*
Annual	Invasive	*Bromus tectorum*	*0.0*	1.2	*0.0*	0.7	*0.0*	0.8	*0.0*	1.1
Perennial	Native	*Carex* sp.	0.2	0.0	0.0	0.0	*0.0*	0.0	0.0	0.0
Perennial	Invasive	*Cynosurus cristatus*	0.0	0.0	0.0	0.0	0.0	0.0	*0.0*	0.0
Annual	Invasive	*Cynosurus echinatus*	1.7	1.6	0.4	*0.0*	0.7	0.3	0.1	0.1

			2014		2015		2016		2017	
		OCCUPIED:	Y	N	Y	N	Y	N	Y	N
Duration	**Native/Invasive**	**Species**								
Perennial	Native	*Danthonia californica*	24.4	0.1	9.8	*0.0*	5.0	0.0	7.3	0.1
Perennial	Native	*Danthonia unispicata*	0.0	*0.0*	0.0	0.0	0.0	0.0	0.0	0.0
Perennial	Invasive	*Festuca roemeri*	0.0	0.1	0.1	0.1	0.0	0.0	0.0	0.0
Perennial	Native	*Festuca* sp.	0.3	0.1	0.0	0.0	0.0	0.0	0.0	0.0
Perennial	Native	*Isoetes nuttallii*	0.0	0.0	*0.0*	0.0	0.1	*0.0*	0.9	*0.0*
Perennial	Native	*Juncus* sp.	0.2	0.0	0.0	0.0	*0.0*	*0.0*	0.5	*0.0*
Perennial	Native	*Luzula* sp.	0.0	0.0	*0.0*	0.0	*0.0*	0.0	*0.0*	0.0
Annual	Invasive	*Poa bulbosa*	0.0	*0.0*	0.0	*0.0*	0.0	*0.0*	0.2	0.7
Perennial	Native	*Poa secunda*	0.0	*0.0*	0.0	0.0	*0.0*	0.0	0.1	*0.0*
Annual	Invasive	*Taeniatherum caput-medusae*	6.3	1.9	2.8	1.2	3.2	0.8	2.6	0.5
Annual	Invasive	*Vulpia myuros*	*0.0*	0.7	0.1	2.3	0.1	2.1	0.4	3.4
TREE/SHRUB:										
Perennial	Native	*Ceanothus cuneatus*	0.0	0.1	0.0	0.1	0.0	0.1	0.0	0.3
Perennial	Native	*Cercocarpus* sp.	0.0	*0.0*	0.0	0.0	0.0	0.0	0.0	*0.0*
Perennial	Native	*Quercus garryana*	*0.0*	*0.0*	0.1	0.0	*0.0*	*0.0*	0.0	0.0
Perennial	Native	*Toxicodendron diversilobum*	1.4	*0.0*	1.9	*0.0*	1.9	0.1	1.5	*0.0*
FORBS:										
Perennial	Native	*Allium* sp.	0.1	0.1	0.8	0.5	1.0	0.6	2.5	0.4
Perennial	Native	*Brodiaea* sp.	*0.0*	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Annual	Native	*Calandrinia ciliata*	0.0	0.0	0.0	0.0	0.0	*0.0*	0.0	0.1
Perennial	Native	*Calochortus uniflorus*	*0.0*	*0.0*	0.2	0.0	0.2	*0.0*	0.1	0.0
Perennial	Native	*Camassia quamash*	1.1	0.1	0.9	0.2	0.8	0.1	1.8	*0.0*
Annual	Native	*Cardamine oligosperma*	0.0	0.0	0.0	0.0	0.0	*0.0*	0.0	0.0
Annual	Native	*Castilleja tenuis*	*0.0*	0.1	*0.0*	0.1	*0.0*	0.1	*0.0*	0.1

			2014		2015		2016		2017	
		OCCUPIED:	Y	N	Y	N	Y	N	Y	N
Duration	**Native/Invasive**	**Species**								
Annual	Invasive	*Centaurea cyanus*	0.0	0.0	0.0	0.1	0.0	0.1	0.0	0.1
Annual	Invasive	*Centaurium erythraea*	0.0	0.0	0.0	*0.0*	0.0	0.0	0.0	0.0
Perennial	Native	*Cerastium arvense*	*0.0*	0.0	0.1	0.1	0.1	0.8	0.1	0.3
Perennial	Invasive	*Cerastium glomeratum*	0.0	0.2	0.0	0.2	*0.0*	*0.0*	*0.0*	*0.0*
Perennial	Native	*Chlorogalum pomeridianum*	1.5	2.0	1.4	2.3	1.0	2.4	2.1	2.4
Annual	Native	*Clarkia* spp.	0.1	0.3	0.5	0.8	0.2	0.7	0.3	0.4
Perennial	Invasive	*Crepis* sp.	0.0	0.0	0.0	0.1	0.0	*0.0*	0.0	*0.0*
Annual	Invasive	*Daucus pusillus*	0.6	1.3	0.5	0.3	0.3	1.0	0.3	0.9
Perennial	Native	*Dichelostemma* sp.	0.0	*0.0*	0.0	*0.0*	*0.0*	0.1	*0.0*	0.1
Perennial	Invasive	*Dipsacus fullonum*	0.0	0.0	0.0	*0.0*	0.0	0.0	0.0	0.0
Perennial	Native	*Dodecatheon* sp.	0.0	0.0	0.0	0.0	0.0	0.0	*0.0*	0.0
Annual	Native	*Epilobium* spp.	0.0	0.0	0.0	*0.0*	0.0	0.0	0.0	0.0
Perennial	Native	*Eriogonum* sp.	0.0	*0.0*	0.0	0.0	0.0	*0.0*	0.0	*0.0*
Perennial	Native	*Eriophyllum lanatum*	0.0	*0.0*	0.0	0.0	0.0	0.0	0.0	*0.0*
Annual	Invasive	*Erodium cicutarium*	0.0	0.0	0.0	0.1	0.0	0.2	0.0	*0.0*
Annual	Native	*Eschscholzia californica*	0.0	0.3	0.0	0.2	0.0	0.3	0.0	0.3
Annual	Invasive	*Galium parisiense*	0.3	0.3	0.7	0.3	0.5	0.3	0.4	0.3
Annual	Invasive	*Geranium dissectum*	0.4	0.2	0.5	0.1	0.3	0.2	0.6	0.3
Perennial	Invasive	*Geranium molle*	*0.0*	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Annual	Native	*Githopsis specularioides*	0.0	*0.0*	*0.0*	0.1	*0.0*	*0.0*	0.0	*0.0*
Annual	Invasive	*Gnaphalium* sp.	0.0	0.0	0.0	*0.0*	*0.0*	*0.0*	*0.0*	0.0
Perennial	Invasive	*Hypericum perforatum*	*0.0*	*0.0*	0.0	*0.0*	*0.0*	*0.0*	*0.0*	*0.0*
Perennial	Invasive	*Hypochaeris radicata*	0.5	7.0	3.4	14.9	3.3	15.1	5.7	21.8
Annual	Invasive	*Lactuca* sp.	*0.0*	0.0	*0.0*	0.1	0.0	0.1	0.0	0.0

			2014		2015		2016		2017	
		OCCUPIED:	Y	N	Y	N	Y	N	Y	N
Duration	**Native/Invasive**	**Species**								
Annual	Invasive	*Lamium purpureum*	0.0	0.0	0.0	0.0	*0.0*	0.0	0.0	0.0
Annual	Native	*Lathyrus nevadensis*	0.1	*0.0*	0.2	*0.0*	*0.0*	0.0	0.3	*0.0*
Annual	Native	*Limnanthes gracilis*	0.2	*0.0*	0.2	0.0	0.9	0.1	3.5	0.2
Annual	Native	*Linanthus bicolor*	*0.0*	0.1	0.1	0.2	0.2	0.9	0.7	1.6
Annual	Native	*Lithophragma parviflorum*	0.0	0.0	0.0	*0.0*	0.0	*0.0*	0.0	*0.0*
Perennial	Native	*Lomatium cookii*	1.4	0.0	1.8	0.0	0.7	0.0	1.1	0.0
Annual	Native	*Lotus micranthus*	*0.0*	0.4	*0.0*	0.2	*0.0*	0.3	0.2	0.5
Annual	Native	*Lotus unifoliolatus*	*0.0*	0.3	*0.0*	0.3	*0.0*	0.3	*0.0*	0.6
Annual	Native	*Lupinus bicolor*	0.1	1.3	*0.0*	0.2	0.0	1.1	0.2	2.0
Annual	Native	*Madia* spp.	0.1	2.2	0.0	1.3	0.0	1.1	0.0	2.2
Annual	Invasive	*Micropus californicus*	0.1	0.2	0.1	0.2	0.1	0.3	0.2	0.5
Annual	Native	*Mimulus* sp.	0.0	0.0	0.0	0.0	*0.0*	0.0	0.2	0.0
Annual	Invasive	*Moenchia recta*	0.0	*0.0*	*0.0*	0.0	0.0	0.0	*0.0*	0.0
Perennial	Native	*Moehringia* sp.	0.0	0.0	0.0	0.0	0.0	0.0	*0.0*	0.0
Annual	Invasive	*Myosotis discolor*	0.1	0.1	0.4	0.3	0.3	0.1	0.1	*0.0*
Annual	Native	*Navarretia* sp.	*0.0*	*0.0*	0.1	*0.0*	0.1	*0.0*	*0.0*	0.1
Annual	Native	*Nemophila* sp.	0.0	0.0	0.0	*0.0*	0.0	*0.0*	0.0	0.0
Annual	Native	*Orobanche uniflora*	0.0	0.0	0.0	0.0	0.0	0.0	0.0	*0.0*
Annual	Native	*Pectocarya pusilla*	0.0	0.0	0.0	0.0	0.0	*0.0*	*0.0*	*0.0*
Annual	Invasive	*Peplis portula*	0.0	0.0	0.0	*0.0*	0.0	*0.0*	0.0	0.0
Annual	Native	*Plagiobothrys* sp.	0.0	*0.0*	0.0	*0.0*	0.0	0.1	0.0	*0.0*
Perennial	Invasive	*Plantago lanceolata*	0.0	0.2	0.0	0.1	0.0	0.1	0.0	0.1
Annual	Native	*Plectritis congesta*	0.0	0.0	0.0	0.0	*0.0*	*0.0*	0.0	0.0
Annual	Native	*Ranunculus occidentalis*	0.2	0.0	0.3	0.0	0.1	0.0	0.2	0.0
Perennial	Invasive	*Rumex acetosella*	0.0	0.4	0.0	0.2	0.0	*0.0*	0.0	0.0

			2014		2015		2016		2017	
		OCCUPIED:	Y	N	Y	N	Y	N	Y	N
Duration	**Native/Invasive**	**Species**								
Annual	Invasive	*Scleranthus annuus*	0.2	0.4	0.3	0.2	0.1	*0.0*	0.2	0.0
Perennial	Native	*Spiranthes* sp.	*0.0*	0.0	0.1	*0.0*	*0.0*	0.0	*0.0*	0.0
Annual	Native	*Thysanocarpus curvipes*	0.0	0.1	0.0	*0.0*	0.0	0.1	0.0	0.1
Annual	Native	*Tonella tenella*	0.0	0.0	0.0	0.0	0.0	*0.0*	0.0	0.0
Annual	Invasive	*Torilis arvensis*	0.9	2.1	0.1	0.2	0.1	0.8	0.1	0.1
Annual	Native	*Trifolium albopurpureum*	0.0	0.0	0.1	0.0	0.2	*0.0*	*0.0*	0.1
Annual	Native	*Trifolium bifidum*	0.0	0.0	0.0	0.0	0.0	0.0	0.1	0.0
Annual	Invasive	*Trifolium dubium*	3.6	5.0	1.2	3.0	1.4	3.8	5.2	7.5
Annual	Native	*Trifolium microcephalum*	0.3	0.7	0.1	0.1	0.1	0.2	0.7	0.4
Annual	Invasive	*Trifolium subterraneum*	0.0	0.0	0.0	*0.0*	0.0	*0.0*	0.0	*0.0*
Annual	Native	*Trifolium variegatum*	0.0	0.0	0.0	0.0	*0.0*	0.0	1.8	*0.0*
Annual	Native	*Trifolium willdenovii*	0.1	*0.0*	0.1	*0.0*	*0.0*	0.0	0.4	*0.0*
Annual	Native	*Trifolium wormskioldii*	0.0	*0.0*	0.0	0.0	0.0	0.0	0.0	0.0
Annual	Invasive	*Valerianella locusta*	0.0	*0.0*	*0.0*	*0.0*	0.1	*0.0*	*0.0*	0.1
Perennial	Native	*Veronica americana*	*0.0*	*0.0*	*0.0*	*0.0*	*0.0*	*0.0*	*0.0*	*0.0*
Annual	Invasive	*Vicia sativa*	0.2	*0.0*	0.1	0.2	*0.0*	0.1	*0.0*	0.1
Perennial	Native	*Viola hallii*	0.1	0.0	0.2	0.0	0.1	0.0	0.3	0.0
		Count of Species:								
		Introduced Graminoid Species	10	12	10	12	9	10	11	9
		Native Graminoid Species	5	5	4	2	8	3	6	6
		Total Graminoid Species	15	17	14	14	17	13	17	15
		Introduced Forb	13	16	13	24	15	22	15	17
		Native Forb Species	23	25	23	25	26	30	29	30

			2014		2015		2016		2017	
		OCCUPIED:	Y	N	Y	N	Y	N	Y	N
Duration	**Native/Invasive**	**Species**								
		Total Forb	36	41	36	49	41	52	44	47
		Count of species with values >1%								
		Invasive Graminoid Species	4	5	3	5	2	4	3	5
		Native Graminoid species	1	1	1	1	1	1	1	1
		Native Forb Species	3	3	2	2	1	3	6	4
		Invasive Forb	1	4	2	2	2	3	2	2
		Total Forb	4	7	4	4	3	6	8	6

APPENDIX I. PLANT COMMUNITY DATA BY FUNCTIONAL GROUP FOR BURNED AND UNBURNED PLOTS AT FRENCH FLAT MIDDLE AND FRENCH FLAT SOUTH (2017)

	Native Forb Cover		Invasive Forb Cover		Native Graminoid Cover		Introduced Graminoid Cover		Annual Introduced Graminoid Cover		Perennial Introduced Graminoid Cover	
	Mean	95% CI	Mean	95% CI	Mean	95% CI	Mean	95% CI	Mean	95% CI	Mean	95% CI
French Flat Middle	8.92	3.01	0.01	0.01	20.59	8.65	0.34	0.23	0.29	0.22	0.05	0.10
Unburned	8.93	4.15	0.00	0.00	26.65	15.71	0.10	0.14	0.10	0.14	0.00	0.00
Burned	8.92	4.32	0.02	0.02	16.55	9.82	0.50	0.34	0.42	0.34	0.08	0.16
French Flat South	12.49	1.68	0.00	0.00	24.89	6.81	1.36	1.51	0.14	0.14	1.22	1.44
Unburned	13.91	2.62	0.00	0.00	31.09	10.69	1.26	1.50	0.16	0.28	1.10	1.41
Burned	11.24	2.04	0.00	0.00	19.48	8.10	1.44	2.56	0.12	0.12	1.32	2.44

APPENDIX J. MEAN COVER OF THE PLANT COMMUNITY BY SPECIES IN BURNED AND UNBURNED PLOTS AT FRENCH FLAT MIDDLE AND FRENCH FLAT SOUTH (2016-2017)

Year	Duration	Nativity	Growth Form	2016				2017			
SITE				FF MIDDLE		FF SOUTH		FF MIDDLE		FF SOUTH	
BURNED (Y/N)				N	Y	N	Y	N	Y	N	Y
Bare ground				24.5	28.4	23.9	57.2	16.3	14.5	18.4	40.7
Litter				49.4	12.7	51.6	13.8	66.9	49.2	53.4	21.7
Rock/Gravel				25.9	44.8	14.3	26.3	18.8	45.4	28.6	25.2
Moss				2.1	12.5	4.3	4.3	3.9	6.4	4.3	4.6
Big rock				0.6	0.3	0.0	0.6	0.0	0.5	0.0	0.5
Agoseris heterophylla	Annual	Native	Forb	0.0	0.0	0.0	0.1	0.0	0.0	0.0	0.0
Agrostis sp.	Unknown	Introduced	Graminoid	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Aira caryophyllea	Annual	Introduced	Graminoid	0.0	0.1	0.0	0.0	0.1	0.1	0.0	0.1
Allium sp.	Perennial	Native	Forb	3.5	2.5	3.6	5.2	1.9	1.0	2.6	3.2
Apocynum sp.	Perennial	Native	Forb	0.0	0.1	0.0	0.5	0.0	0.0	0.0	0.0
Arctostaphylos sp.	Perennial	Native	Tree/Shrub	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Bromus hordeaceus	Annual	Introduced	Graminoid	0.0	0.0	0.0	0.0	0.0	0.2	0.2	0.0
Bromus rigidus	Perennial	Introduced	Graminoid	0.0	0.0	0.2	0.5	0.0	0.0	1.0	1.3
Bromus tectorum	Annual	Introduced	Graminoid	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Calochortus uniflorus	Perennial	Native	Forb	1.6	0.4	1.7	0.6	2.1	0.6	2.1	0.8
Camassia sp.	Perennial	Native	Forb	0.2	0.2	0.1	0.2	0.0	0.0	0.1	0.4
Carex tumulicola	Perennial	Native	Graminoid	0.5	0.3	0.1	0.2	0.1	0.3	1.0	0.9
Castilleja attenuata	Annual	Native	Forb	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Castilleja rubicundula	Annual	Native	Forb	0.0	0.1	0.0	0.0	0.0	0.0	0.0	0.0
Ceanothus cuneatus	Perennial	Native	Tree/Shrub	0.0	0.3	0.0	0.0	0.0	0.0	0.0	0.0
Cerastium glomeratum	Perennial	Native	Forb	0.0	0.8	0.0	0.0	0.0	0.2	0.0	0.0
Cercocarpus ledifolius	Perennial	Native	Tree/Shrub	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Chlorogalum sp.	Perennial	Native	Forb	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Clarkia gracilis	Annual	Native	Forb	0.0	0.1	0.0	0.3	0.5	1.1	0.9	0.1
Claytonia sp.	Annual	Native	Forb	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Collomia heterophylla	Annual	Native	Forb	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Cynosurus echinatus	Annual	Introduced	Graminoid	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Danthonia californica/unispicata	Perennial	Native	Graminoid	30.6	10.4	30.6	13.3	23.6	14.1	28.1	17.1
Daucus pusillus	Perennial	Native	Forb	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0

Year	Duration	Nativity	Growth Form	2016				2017			
SITE				FF MIDDLE		FF SOUTH		FF MIDDLE		FF SOUTH	
Deschampsia cespitosa	Perennial	Native	Graminoid	1.9	1.2	0.1	0.0	1.0	1.1	0.0	0.0
Elymus glaucus	Perennial	Native	Graminoid	0.1	0.1	0.0	0.0	0.0	0.0	0.0	0.0
Epilobium brachycarpum	Annual	Native	Forb	0.1	0.2	0.2	0.1	0.3	0.1	0.6	0.3
Epilobium rigidum	Perennial	Native	Forb	0.4	0.1	0.2	0.0	0.0	0.0	0.0	0.0
Festuca roemeri	Perennial	Native	Graminoid	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Galium aparine	Annual	Native	Forb	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Galium parisiense	Annual	Introduced	Forb	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Geranium dissectum	Annual	Introduced	Forb	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Gnaphalium sp.	Annual	Introduced	Forb	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Gratiola sp.	Unknown	Unknown	Forb	0.0	0.0	0.0	0.0	0.0	0.0	0.3	0.0
Hesperochiron californicus	Perennial	Native	Forb	1.2	0.1	0.1	0.1	0.9	0.5	0.4	0.5
Horkelia daucifolia	Perennial	Native	Forb	0.0	0.5	1.3	0.5	0.1	0.2	0.6	0.3
Hypericum perforatum	Perennial	Introduced	Forb	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Hypochaeris radicata	Perennial	Introduced	Forb	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Isoetes sp.	Perennial	Native	Graminoid	0.5	0.2	0.1	0.1	1.2	0.9	0.8	0.7
Juncus sp.	Perennial	Native	Graminoid	0.0	0.0	0.5	0.0	0.5	0.1	0.6	0.0
Lathyrus nevadensis	Perennial	Native	Forb	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Limnanthes gracilis	Annual	Native	Forb	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Linanthus bicolor	Annual	Native	Forb	0.0	0.1	0.0	0.2	0.3	0.4	0.0	0.1
Lomatium cookii	Perennial	Native	Forb	0.7	0.5	0.8	0.9	1.4	0.9	1.1	1.0
Lotus micranthus	Annual	Native	Forb	0.0	0.0	0.0	0.0	0.0	0.0	0.1	0.0
Lotus unifoliolatus	Annual	Native	Forb	0.2	0.1	0.1	0.1	0.4	0.1	0.3	0.1
Lupinus bicolor	Annual	Native	Forb	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Luzula comosa	Perennial	Native	Graminoid	0.1	0.0	0.1	0.0	0.1	0.0	0.1	0.0
Madia sp.	Annual	Native	Forb	1.1	0.6	2.1	1.9	0.4	0.6	2.0	2.6
Micropus californicum	Annual	Native	Forb	0.0	0.0	0.0	0.0	0.0	0.1	0.0	0.3
Mimulus sp.	Annual	Native	Forb	0.0	0.4	0.1	0.0	0.0	1.5	0.5	0.0
Montia linearis	Annual	Native	Forb	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Myosotis discolor	Annual	Introduced	Forb	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
native fescue perennial	Perennial	Native	G	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Navarretia intertexta	Annual	Native	Forb	0.0	0.0	0.4	0.4	0.1	0.2	0.2	0.3
Nemophila sp.	Annual	Native	Forb	0.0	0.0	0.0	0.0	0.0	0.1	0.0	0.0
Panicum sp.	Perennial	Introduced	Graminoid	0.0	0.1	0.0	0.0	0.0	0.1	0.0	0.0

Year	Duration	Nativity	Growth Form	2016				2017			
SITE				FF MIDDLE		FF SOUTH		FF MIDDLE		FF SOUTH	
Pectocarya pusilla	Annual	Native	Forb	0.0	0.2	0.1	0.0	0.0	0.6	0.1	0.1
Lythrum portula	Annual	Introduced	Forb	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Perennial Brome	Perennial	Unknown	Graminoid	0.0	0.1	0.0	0.3	0.1	0.3	0.0	0.1
Perideridia sp.	Annual	Native	Forb	0.0	0.0	0.0	0.0	0.0	0.0	0.1	0.0
Plagiobothrys sp.	Annual	Native	Forb	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Poa bulbosa	Annual	Introduced	Graminoid	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Poa compressa	Perennial	Introduced	Graminoid	0.0	0.0	0.0	0.0	0.0	0.0	0.1	0.0
Poa secunda	Perennial	Native	Graminoid	0.0	0.0	0.5	1.0	0.1	0.2	0.5	0.8
Quercus garryana	Perennial	Native	Tree/Shrub	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Ranunculus occidentalis	Annual	Native	Forb	0.3	0.3	1.0	1.3	0.0	0.2	2.0	1.2
Saxifrage sp.	Perennial	Native	Forb	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Scleranthus annuus	Annual	Introduced	Forb	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Stipa lemmonii	Perennial	Native	Graminoid	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Taeniatherum caput-medusae	Annual	Introduced	Graminoid	0.0	0.0	0.0	0.0	0.0	0.1	0.0	0.0
Thysanocarpus curvipes	Annual	Native	Forb	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Torilis arvensis	Annual	Introduced	Forb	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Trifolium dubium	Annual	Introduced	Forb	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Trifolium microcephalum	Annual	Native	Forb	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Trifolium variegatum	Annual	Native	Forb	0.0	0.0	0.1	0.1	0.0	0.0	0.3	0.0
Trifolium willdenovii	Annual	Native	Forb	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Valerianella locusta	Annual	Introduced	Forb	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Vicia sativa	Annual	Introduced	Forb	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Viola hallii	Perennial	Native	Forb	0.3	0.1	0.0	0.0	0.5	0.8	0.0	0.0
Vulpia bromoides	Annual	Introduced	Graminoid	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Zigadenus venenosus	Annual	Native	Forb	0.0	0.0	0.1	0.0	0.1	0.0	0.0	0.0