Threat assessment for *Limnanthes pumila* ssp. *pumila* on Table Rocks ACEC

2015

Report to the USDI Bureau of Land Management, Medford District

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PREFACE

This report is the result of a collaboration 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 photograph: Pools on Lower Table Rock

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EXECUTIVE SUMMARY

Upper and Lower Table Rocks, located northeast of Medford, Oregon, are collectively designated as an Area of Critical Environmental Concern (ACEC) by the Bureau of Land Management (BLM). The Table Rocks are characterized primarily by vernal pool and mound habitats that support several rare species, including *Limnanthes pumila* ssp. *pumila* (née *Limnanthes floccosa* ssp. *pumila),* which is a state threatened and federal Species of Concern, and C*allitriche marginata,* a BLM Sensitive species. The Oregon Biodiversity Information Center (ORBIC) has identified *L. pumila* ssp. *pumila* as a List 1 taxon, considered threatened with extinction or presumed extinct throughout its range (ORBIC 2013). *Limnanthes pumila* ssp. *pumila* is a narrow endemic known only from the Table Rocks (U.S. Fish and Wildlife Service 2006). Threats to the species and habitats at Table Rocks include invasive species, grazing, impacts associated with recreational use (e.g., trampling), and climate change.

Since 2006, the Institute for Applied Ecology (IAE) has monitored experimental plots to determine population trends and the effects of grazing, trampling, and invasive species on *L. pumila* ssp. *pumila* and used transects to document plant community types, disturbances (including trails and animals activity), and distribution of habitat types. In 2015, we monitored *L. pumila* ssp. *pumila* population plots on both Upper and Lower Table Rocks, and in high and low traffic areas to monitor for effects of recreation on Lower Table Rock. In 2011-2013 we noticed a substantial increase in abundance and spread of annual invasive grasses, including *Taeniatherum caput-medusae* (medusahead) and *Poa bulbosa* (bulbous bluegrass), particularly on Lower Table Rock.

In light of a recent dumping of fire retardant that occurred on a portion of Lower Table Rock in July 2010, we added plant community monitoring transects in the affected area in 2013 and have monitored them since. In this report, we focus discussion on population trends of *L. pumila ssp. pumila* and more recent analyses, including the new community transects added in the fire retardant drop area. In-depth discussion of past studies, including *L. pumila* ssp. *pumila* grass removal plots, trampling plots, and monitoring of C*allitriche marginata,* and habitat quality surveys can be found in Appendices F-I.

Limnanthes pumila* ssp. *pumila

- The number of *L. pumila* ssp. *pumila* has fluctuated greatly between years with a steep decline from 2010-2013 in both number of plants and number of flowers per plant within monitoring plots on Lower Table Rock (2009-2012). In 2014 we observed slight increase in number of plants and number of flowers per plant within these plots to levels similar to in 2011. In 2015 we observed the lowest number of *L. pumila* ssp. *pumila* over the course of this study. Mean number of plants in plots declined from 44 to 6 from 2014 to 2015. In addition, number of flowers per plant also declined. This severe decline, coupled with the relatively low number seen in recent years is cause for concern.
- Similar to in 2013, in 2015 we observed markedly different cover of *L. pumila* ssp. *pumila* in high and low traffic areas, where high traffic areas had fewer plants than low traffic areas. This indicates that recreation can influence this annual species, particularly in times where the population numbers are low.

- Similar to trends seen on Lower Table Rock, in plots established on Upper Table Rock in 2007, we observed the lowest number of plants over the course of this study in 2015. Number of flowers per plant was also at one of the lowest levels over the course of this study.

Community monitoring of the fire retardant drop

- In 2015 we observed a decrease in cover of non-native grasses and litter both within and outside of the area impacted by the fire retardant drop. Similarly, we observed a decline in the number of *L. pumila* ssp. *pumila* that occurred within plots. Pool habitats declined from 2014 to 2015, and in 2015, mound and pool habitats remain dominated by non-native grass cover. While it is promising that we have seen a decrease in non-native grass cover and litter cover both within and outside of the fire retardant drop in recent years, habitats continue to be impacted, particularly in mound and pool habitats.

2015 exhibited the lowest numbers of *L. pumila* ssp. *pumila* in plots on both Lower and Upper Table Rock. Given the recent decline observed in population size and the number of flowers per plant, we recommend continued monitoring of population dynamics on both Upper and Lower Table Rocks. Data suggest that the population on Lower Table Rock has experienced extreme annual variability, however the low numbers observed in recent years, particularly from 2010-2015, suggest that this species is struggling. In 2014 we observed a relatively high number of reproductive plants on Lower Table Rock, however this did not translate into a successful year in 2015. While pools were dominated by native species just a few years ago, in 2015 we found these habitats to be dominated by exotic grass cover, which can outcompete many native species endemic to these sensitive habitats. The impact of recreation, combined with the recent invasion of non-native grass species suggests that careful monitoring will be necessary to understand population trends and assess what management actions might be needed in the future. Likewise, high temperatures experienced in recent years combined with variable precipitation is likely greatly affecting population dynamics for rare species on both table rocks. Direct management targeted at combatting non-native species may be necessary for the perpetuation of rare species on the Table Rocks. Though both Upper and Lower Table Rock provide a valued recreation opportunity, limiting some access at sensitive times may decrease negative effects associated with trampling. Adding more signage, particularly on the southern end of Upper Table Rock would hopefully encourage hikers to stop trampling sensitive areas and the remaining *L. pumila* ssp. *pumila* habitat.

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REPORT TO THE USDI BUREAU OF LAND MANAGEMENT, MEDFORD DISTRICT

INTRODUCTION

Upper and Lower Table Rocks were designated in 1984 as an Area of Critical Environmental Concern (ACEC) to protect special plants and animal species, unique geologic and scenic values, and education opportunities. The Medford District BLM manages significant portions of both Table Rocks. In 1977, The Nature Conservancy (TNC) established a preserve on a portion of the top and flanks of Lower Table Rock (Figure 1). In 2009, TNC purchased the remaining private lands on Upper and Lower Table Rocks, permanently protecting the areas and their rare plants and wildlife.

The habitat on top of the Table Rocks includes vernal pools, mounds, and flat, rocky scablands. The impermeable volcanic substrate retains water during winter and spring months in vernal pools. The mounded prairie/vernal pool complex lacks shrub and tree species forming an overstory, leaving it hot and dry during the summer months; during July and August, temperatures periodically top 100° F. Numerous rare species occur at Upper and Lower Table Rocks, including the BLM sensitive species *Limnanthes pumila* ssp. *pumila*, *Plagiobothrys austiniae, P. greenei*, and *Callitriche marginata*.

Figure 1. IAE staff monitoring plant community on Lower Table Rock.

The potential threats to vernal pool species on the Table Rocks include grazing by native ungulates, recreational use, and invasion by exotic weeds (Figure 2). Cattle grazing historically occurred on both Upper and Lower Table Rocks. Grazing continued at Upper Table Rock through 2008, but ceased after TNC's purchase of the remaining private lands in 2009. Thousands of people visit Upper and Lower Table Rocks each year, with the highest traffic in the spring, when most plant species, including *L. pumila* ssp. *pumila,* are flowering. Foot traffic and occasionally horse traffic (though not permitted) negatively impact *L. pumila* ssp. *pumila* populations intersected by trails. Recreation traffic has increased notably over the years, especially on the southern end of Upper Table Rock. While there are primary trails for use by visitors, we observed many people wandering off-trail directly through sensitive pool habitat. The abundance and thatch of non-native grasses (e.g. *Taeniatherum caput-medusae*) on Lower Table Rock has increased notably over the years, posing a great threat to native species in these habitats (Figure 2). The growing population of the Rogue Valley, improvements to the trails, and increased environmental education about the ACEC will undoubtedly lead to more use of the Table Rocks.

Figure 2. Invasive annual grasses in *L. pumila* ssp. *pumila* habitat in 2013

The initial goals of this project were to develop a quantitative monitoring strategy for assessing population trends and vernal pool habitat quality, and collect baseline data on *L. pumila* ssp. *pumila* to evaluate population trends and the effects of human activities and management practices. Specifically, these goals include:

1. Assess the effects of trampling on *L. pumila* ssp. *pumila* growth, reproduction, and recruitment,
2. Assess the effects of grazing on *L. pumila* ssp. *pumila* growth, reproduction, and recruitment,
3. Assess habitat quality (including cover of invasive vs. native plant species) on Upper and Lower Table Rocks, and
4. Assess population trends of *L. pumila* ssp. *pumila* on Upper and Lower Table Rocks over time, documenting potential threats

Limnanthes pumila* ssp. *pumila

Figure 3. *Limnanthes pumila* ssp. *pumila* (dwarf woolly meadowfoam)

Limnanthes pumila ssp. *pumila* (née *Limnanthes floccosa* ssp. *pumila,* dwarf woolly meadowfoam, Limnanthaceae; Figure 3) is a State Threatened and Federal Species of Concern, endemic from only two populations, Upper and Lower Table Rocks in Jackson County, Oregon (U.S. Fish and Wildlife Service 2006). Closely related subspecies that occur in Jackson County include *L. floccosa* ssp. *floccosa*, *L. floccosa* ssp. *grandiflora* (Federally Endangered), and *L. floccosa* ssp. *bellingeriana* (Bureau Sensitive). All subspecies are associated with vernal pools or seasonally wet areas. Other sensitive plant species that co-occur with *L. pumila ssp. pumila* include *Plagiobothrys austiniae* and *P. greenei.*

Limnanthes pumila ssp. *pumila* is a partially autogamous annual that flowers from March to May. Population numbers fluctuate from year to year depending on the amount and timing of rainfall and average temperature. Although plants are concentrated within vernal pools, they also occur in slight depressions where water collects and/or drains or on the edges of pool habitat. Mapping populations is impractical because of yearly fluctuations in the number of plants and their scattered distribution. A survey conducted in 2002 on Upper Table Rock found that approximately 70% of the vernally wet areas of BLM-administered land contained *L. pumila* ssp. *pumila*.

Fire retardant drop July, 2010

In July 2010, an emergency load of fire retardant was jettisoned on top of Lower Table Rock due to problems with a tanker aircraft. Three-thousand gallons of fire retardant were dumped on BLM lands on Lower Table Rock in critical habitat for both the vernal pool fairy shrimp (*Branchinecta lynchi*) and *L. pumila* ssp. *pumila* (Figure 4). The substance jettisoned, Phos-Chek fire retardant, was composed of 80% water, 14% fertilizer salts, and 6% coloring agents. The active ingredients are primarily ammonium sulfates and phosphates, which could produce a significant fertilizer effect within plant communities of the affected area on Lower Table Rock (USDI BLM 2010). In a study of the effects of Phos-Chek on vegetation in Australia, the application of fire retardant increased weed invasion (Bell et al. 2005); similar results were found on annual grasslands in California where annual grasses dominated treatments using DAP (diammonium phosphate), a similar substance (Larson and Duncan 1982). More information is needed regarding the effects of the fire retardant drop on the impacted areas. In 2013, assessing the impacts of the fire retardant drop became an objective of the overall habitat quality monitoring.

Figure 4. Emergency fire retardant drop (in red) that occurred on Lower Table Rock on July 7, 2010.

Project overview

On Lower Table Rock, experimental trampling plots and grass removal plots were initially established in 2006 to determine their effects on *L. pumila* ssp. *pumila* (discussed in detail in Appendices G & H). The markers for most of these plots were removed between sampling in 2006 and 2007 and we were not able to obtain post-treatment data. New trampling plots were established in 2007 and were sampled in 2008. In 2009, an additional set of trampling plots was established. These and three of the 2007 trampling plots were monitored 2010. In 2011, we were able to locate and monitor only two of the remaining 2007 trampling plots (only those that had not been trampled [0 passes]) and all of those established in 2009. In 2012 only six trampling plots from were found, two established in 2007 and four established in 2009; of those, only three (established in 2009) had *L. pumila* ssp. *pumila* present. To test for effects of human impact on *L. pumila* ssp. *pumila* and monitor long-term population trends, additional caged and uncaged plots pairs were added in high and low traffic areas (a total of 10 caged and uncaged plot pairs, 5 pairs in each traffic level= 20 plots). These plots were monitored in 2013, 2014, and 2015 and will be monitored in the future to yield long-term population trends of this rare species. In addition, in 2013-2015 we monitored three additional plots that had no *L. pumila* ssp. *pumila* present in 2012 (established in 2009).

In order to determine potential competitive effects of invasive grasses and the feasibility of manual removal, we established grass removal plots in 2007 (discussed in detail in Appendix H). These plots were monitored in May 2008, but due to loss of plot markers, were not monitored in succeeding years.

In 2008, we tested a technique for measuring habitat quality using transects. This sampling technique was expanded in 2009, when we established transects on Upper and Lower Table Rock to characterize disturbances and the plant communities in representative pool, mound, and flat habitats. Additional transects were monitored in 2010 and 2011, but were not monitored since.

Grazing exclosures and long-term monitoring plots were established on Upper Table Rock in 2007. Twenty plots were resampled annually through 2013. In 2012, five plots were not located and were replaced in the general vicinity of the old plots. In 2013, 2 plots were replaced. Although there is no longer grazing on Upper Table Rock, these plots allow us to study changes in population dynamics over time.

Five new transects were added to Lower Table Rock in spring 2013 to describe the area impacted by the fire retardant drop that occurred in 2010. Transects ran east to west across the impacted area, along which plant community data to the functional group level was collected and habitat type was mapped to describe potential impacts of the fire retardant drop.

Given a recently observed increase in recreation traffic on the southern end of Upper Table Rock, we added 5 new plots in 2015 to observe population trends in high traffic areas. We were hoping to establish plots in areas of high and low recreation traffic, but all of the areas with *L. pumila* ssp. *pumila* present were in close proximity to obviously used primary and secondary trails, thus were qualified as high traffic. In future years, we will evaluate the area to see if we can find *L. pumila* ssp. *pumila* in areas that represent both high and low recreation traffic.

Results from trampling plots, grass removal plots, *Callitriche marginata* monitoring, habitat quality surveys and disturbance analysis are discussed in detail in Appendices F-I.

METHODS

Limnanthes pumila ssp. *pumila* monitoring

Population trends on Lower Table Rock

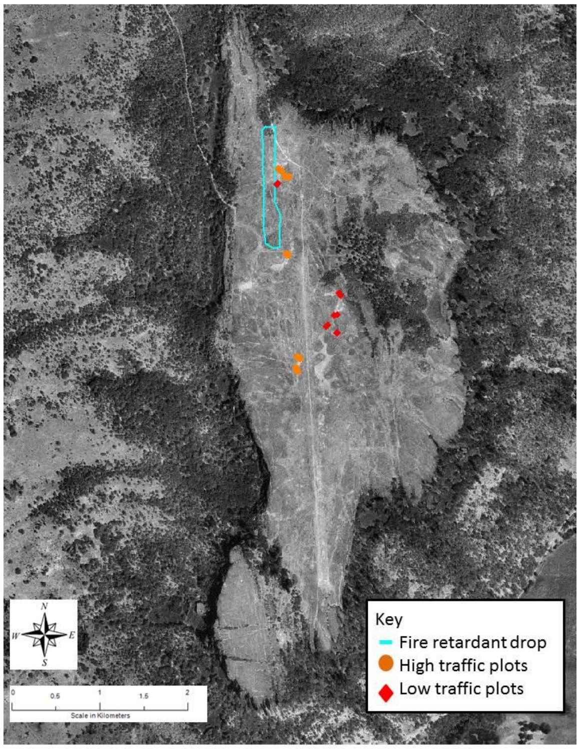

Figure 5. *L. pumila ssp. pumila* population monitoring plots on Lower Table Rock

To assess long-term population trends of *L. pumila* ssp. *pumila* on Lower Table Rock, we converted the trampling plots (portions not trampled [0 passes], described in Appendix G) into long-term monitoring plots in 2011. Originally, ten plots were established in 2007 and ten more were established in 2009, though they have not been sampled each year due to difficulty in plot markings remaining. Plots established prior to 2011 were 0.5m x 1.5m, and their locations were randomly placed along the transect testing the effects of trampling (Appendix B and Appendix G). We were unable to find the majority of the monitoring plots in 2012, and of the six found, only three had presence of *L. pumila* ssp. *pumila*.

To investigate the potential effects of human trampling in high and low traffic areas, we established 1m^2 plots surrounded by cages adjacent to old Lower Table Rock sampling plots (Appendix B). Caged plots enable us to compare population dynamics to uncaged plots to describe the effects of trampling, and if the frequency differs in relation to their proximity to recreation traffic. Additional 1 m^2 plots were established to equal 5 pairs (caged and uncaged), in each traffic level (20 plots total; Figure 5). High and low traffic areas were designated by noting the proximity to major trails and any notable human impact. Cages were constructed from 0.5 inch hardware cloth, and were secured to the ground using a combination of nails, garden staples, and rocks. Plot corners were marked with 4 inch nails and washers, yellow flagging, and a unique tag number for each plot. Photo-points and GPS waypoints were taken at each plot and plot pairs were mapped (Appendix D, Appendix E). Data collected in these plots include mean number of plants, mean flowers per plant (collected from 10 random plants/plot), percent cover for *L. pumila* ssp. *pumila,* native and non-native species by functional group (graminoids and forbs), litter, and noting any presence of exotic species. To enable comparisons between years, data were scaled by plot size (number of plants/m^2). Data will enable comparisons of population trends on Lower Table Rock over time, documenting threats to the species and increasing understanding of effects of recreation on *L. pumila* ssp. *pumila*.

Effects of grazing and population trends on Upper Table Rock

Twenty 1 m^2 plots were established on Upper Table Rock in May 2007 to study the effects of cattle grazing on *L. pumila* ssp. *pumila*. Two corners of each plot were marked with rebar that extended slightly above the soil surface and a large nail with a metal washer sunk into the soil. The location of each plot was recorded with a GPS unit and a compass bearing and distance from an origin spike (Appendix C). We counted the number of individual plants per plot and the number of flowers on ten haphazardly selected individuals per plot. In September 2007, we covered ten randomly selected plots with hogwire. The hogwire overlapped the plots' edges. While this design minimized impacts by large mammals (e.g. deer, elk, and cattle), it allowed access by small mammals (e.g. voles).

All plots were relocated in May 2008 and surveyed as in May 2007. Additional information recorded included total percent cover by *L. pumila* ssp. *pumila* and graminoid species. In 2012, 15 plots were relocated and monitored, and 5 new plots were established in close proximity to old-plot locations to equal 10 open and 10 plots with exclosures. Some of the exclosures appeared battered from either human or cattle activity. While cattle are now excluded from Upper Table Rock, surveys will continue in the future to track *L. pumila* ssp. *pumila* population changes over time. In 2010, grazing data were analyzed to assess the impact of native ungulate grazing, as a year had passed since cattle were last on the Table Rocks. A general linear model with Poisson errors was used for the number of plants in each plot, and an ANOVA with log transformation was used for the number of flowers per plant in each plot (R 2.12, R Core Development Team, www.cran-r.org). In 2013 and 2015, plots were monitored similar to those on Lower Table Rock collecting data on number of *L. pumila* ssp. *pumila,* number of flowers per plant, and percent cover of the plant community to the functional group level.

Five plots were added to the southern end of Upper Table Rock in 2015 to follow population trends in areas of high recreation traffic. Plots were 1m^2 and were established in areas with a density of at least three *L. pumila* ssp. *pumila* plants per m^2. Plots were monitored similar to long-term monitoring plots on Upper and Lower Table Rocks. In future years, we will evaluate the area to find areas of low recreation traffic to add long-term monitoring plots to for comparison.

Community monitoring of the fire retardant drop

We have documented a severe decline in *L. pumila* ssp. *pumila* on Lower Table Rock along with a dramatic increase in invasive annual grasses in the area impacted by the fire retardant drop of 2010. To document potential long-term effects of this drop, we established five permanently marked transects running east to west from the main trail to the western side of Lower Table Rock, dissecting the area of the fire retardant drop (Figure 6). Transects all started approximately 2 m west of the trail and were marked with nails and blue whiskers, and unique tag numbers. The transect bearing was recorded and the transect was marked with a nail at both the 50 and 100 m mark. Transects ranged from 100-200 m long. Habitat class (pool, flat, mound) was mapped along the entire transect to determine the proportion of each transect that is composed of these habitat classes. We monitored 1m^2 plots every 20 m (with a random starting place between 1 and 10 m), where percent cover was recorded for bare ground, litter, rock, moss, *L. pumila* ssp. *pumila*, grasses, and forbs (native and non-native). Each 1m^2 plot was marked with a GPS point in the SE corner along the tape. All plots were monitored on the right side of the tape (N).

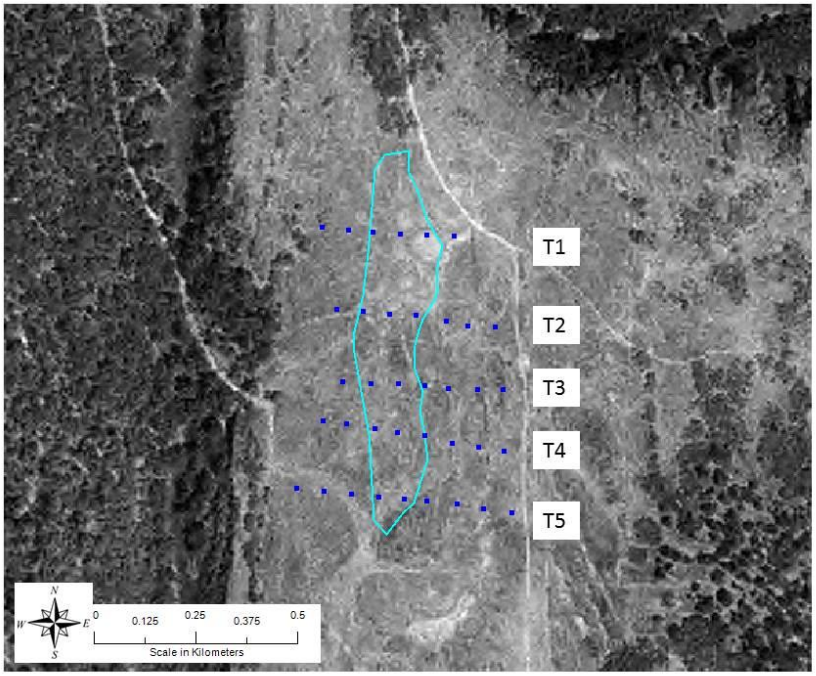

Figure 6. 2013 Transects (delineated by dark blue markings, each point is a plot sampled, “T1” represents “Transect 1”, etc.) dissecting the area impacted by the 2010 fire retardant drop (light blue) on Lower Table Rock.

Spatial analysis of vegetation change in the area impacted by the fire retardant drop

In 2013 we used images collected at peak growing season in 2009 and 2011 provided by the National Agriculture Imagery Program (NAIP) to detect changes in vegetation following the fire retardant drop on Lower Table Rock in the summer of 2010. These images were recorded using digital sensors and record four color bands at a resolution of 1m (Oregon State University 2013). The extent and location of the fire retardant drop was determined using Google Earth Imagery taken in July, 2010, where the stain from the fire retardant was clearly visible (Figure 4).

Gross changes in vegetation cover and composition can be detected using GIS software including MapWindow (open source) and ArcGIS 10 (Alqurashi and Kumar 2013, Singh 1989). To detect changes in vegetation before and after the fire retardant drop, standard Normalized Difference Vegetation Index (NDVI) methods were used (Chavez and MacKinnan 1994, Alqurashi and Kumar 2013). In this process the average value of the three color bands for each pixel in 2009 (pre-drop) was subtracted from the average value in 2011 (post-drop). In this study, the absolute value of the change was reported.

RESULTS AND DISCUSSION

Limnanthes pumila ssp. *pumila* monitoring

Population trends on Lower Table Rock

Following a severe decline from 2010 to 2012, the *L. pumila* ssp. *pumila* the population increased slightly in 2013 and 2014, but has dropped down to its lowest levels in 2015 (Figure 7, Table 1). While the slight increase in plants in 2014 seemed promising, this marks the fifth consecutive year of having fewer than 100 plants per plot. While this species is an annual and some variability would be expected, the continued decline exhibited is concerning. In 2015, the mean number of *L. pumila* ssp. *pumila* per plot from plots established in 2009 (n = 4) was 6, which was a decrease from 44 plants in 2014 (Figure 7, Table 3). In plots established in 2009, the number of flowers per plant has steadily decreased over time (Figure 7), with a 75% decrease between 2009 and 2012 (means = 4 and 1 flower, respectively). In 2014 there was an increase in number of flowers per plant in these plots to 5 flowers per plant, which was the greatest number recorded for these plots. In 2015, number of flowers per plant declined again to values similar to previous years (Figure 7).

Similar to plots established in 2009, those established in 2012 (n=17) had increases in number of plants/plot from 2012 to 2014 and a decline in 2015 to its lowest numbers (mean of 8 plants/plot; Figure 7, Table 1). Plots were established in 2012 in areas of high *L. pumila* ssp. *pumila* abundance, which at the time were difficult to find. Number of plants per plot followed similar trends to those established in 2009, even with the targeted approach of establishing in areas with high abundance (Figure 7). While there was an observed increase in number of plants in 2014 to values similar to what were observed in 2011, these values still remained minimal when compared to values found in population monitoring plots in 2009 and 2010 (Figure 7).

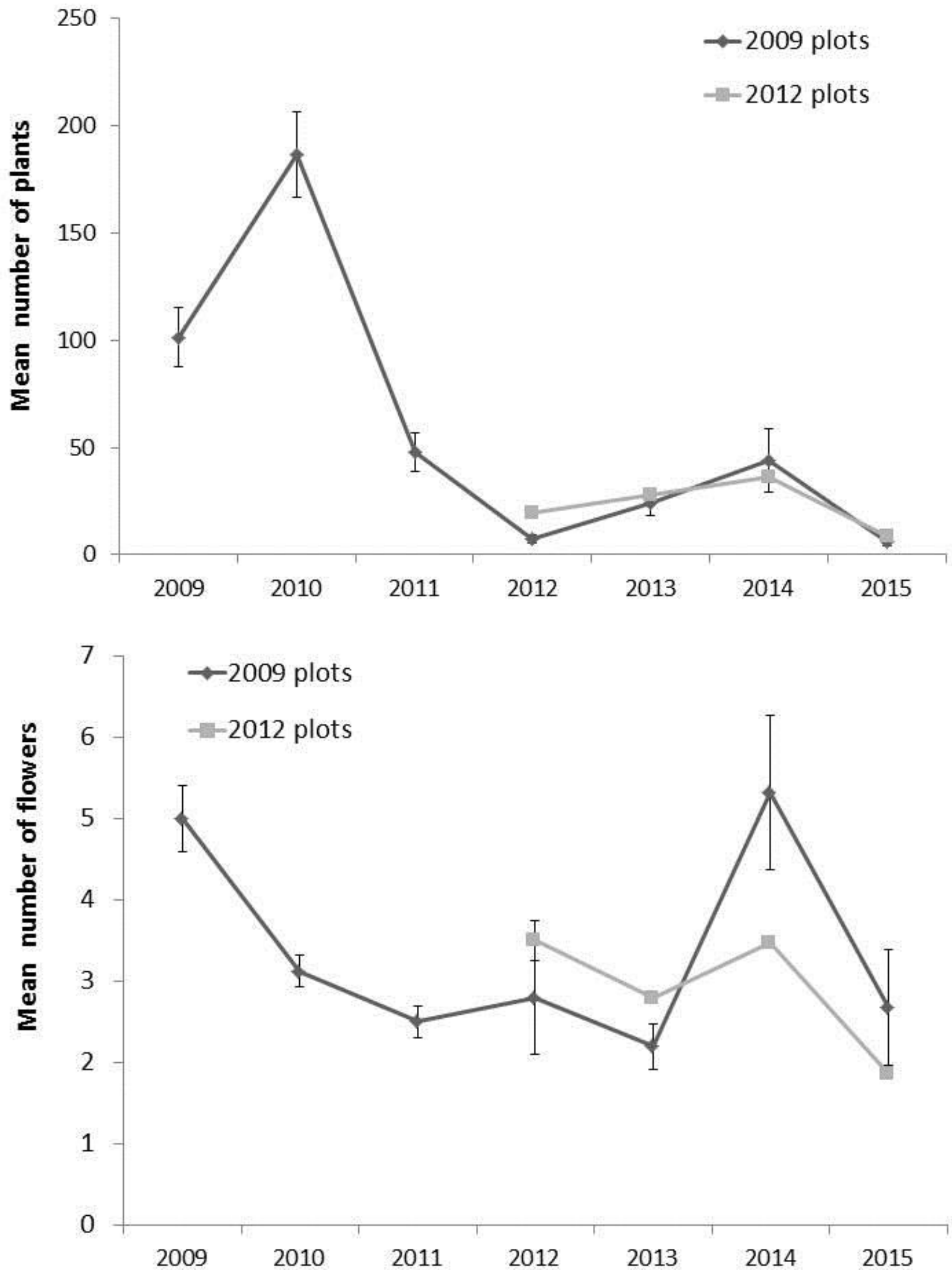

Figure 7. Mean number of plants (top) and mean flowers per plant (bottom) in *L. pumila* ssp. *pumila* population monitoring plots on Lower Table Rock in 2009-2014. Values from 2009-2011 were scaled to reflect differences in plot area. In 2015, 4 plots from 2009 were re-sampled. '2012 plots' indicates new population monitoring plots established in 2012 for long-term monitoring (n = 20) in areas of high *Limnanthes* abundance. Error bars are ± 1 S.E.

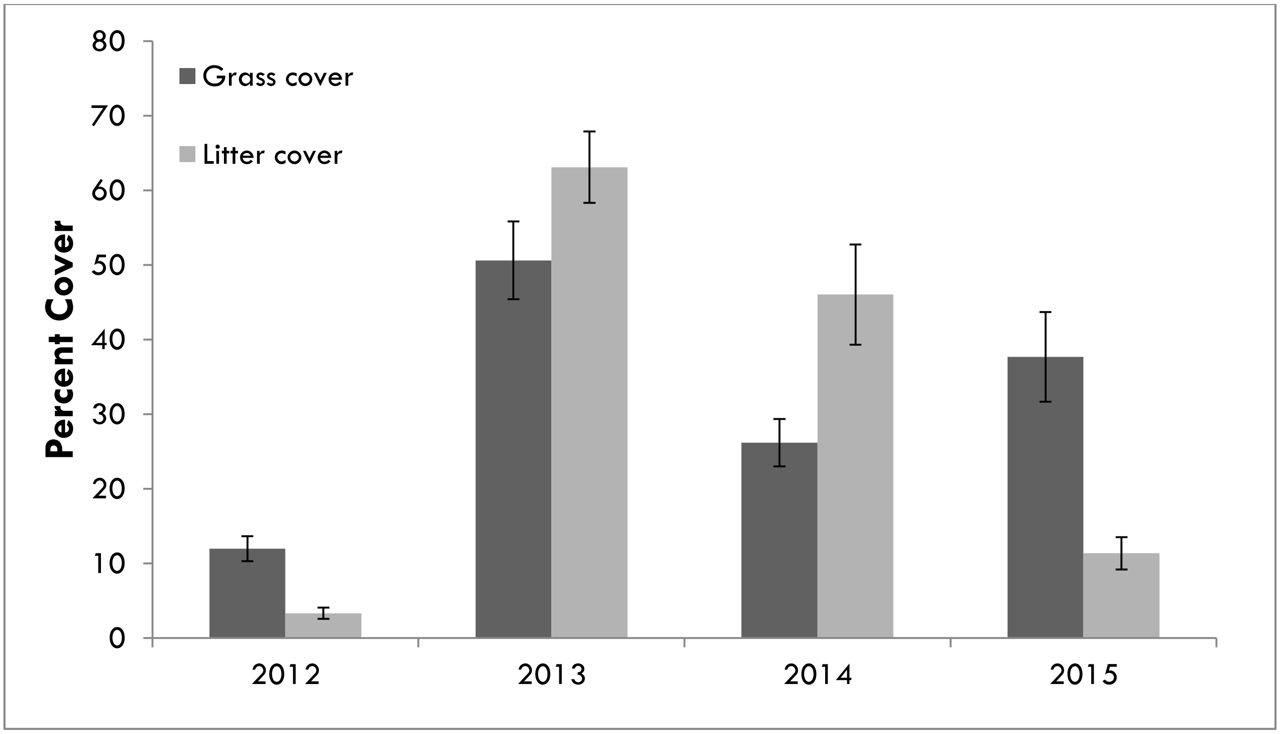

Figure 8. Mean grass and litter cover in long-term monitoring plots, 2012-2015.

Grass and litter cover have been variable in long-term plots over time (Figure 8, Figure 9). In 2012, grass cover was relatively low in plots exhibited a steep increase in 2013, litter also increased during that time. In 2014 we observed a decline in grass cover and a slight decline in litter cover in these plots. In 2015, grass cover increased again but not to 2013 levels, however litter cover declined to its second lowest abundance. These data represent total grass cover, which has been dominated by exotic grasses with relatively low cover of native grasses (Figure 11). While litter has declined in recent years, it is still present in plots and able to impact germination of native vegetation (Figure 9).

Table 1. . Average number of plants and flowers per plant of *Limnanthes pumila* ssp. *pumila* in two types of plots monitored on Lower Table Rock 2009-2015. 'Established in 2012' indicates new population monitoring plots for long term monitoring in areas of high abundance. For plots established in 2009, values from 2009-2011 were scaled to reflect differences in monitoring plots size. Values are ± 1 S.E. "N/A" denotes data that are not available because plots were not sampled.

Plot	# plants ± 1 S.E.							# flowers ± 1 S.E.						
	2009	2010	2011	2012	2013	2014	2015	2009	2010	2011	2012	2013	2014	2015
Established in 2009	101.4 ± 13.8	186.5 ± 20.1	47.8 ± 9.0	7.3 ± 1.8	23.8 ± 5.6	43.8 ± 14.6	5.8 ± 1.8	5.0 ± 0.4	3.1 ± 0.2	2.5 ± 0.2	2.8 ± 0.7	2.2 ± 0.3	5.3 ± 0.9	2.7 ± 0.7
Established in 2012	N/A	N/A	N/A	19.4 ± 1.9	27.9 ± 4.0	36.4 ± 7.4	8.3 ± 1.9	N/A	N/A	N/A	3.5 ± 0.5	2.8 ± 0.3	3.5 ± 0.5	1.9 ± 0.2

Table 2. Mean values (2014-2015) for long-term *Limnanthes pumila* ssp. *pumila* monitoring plots established in 2012 in areas of high and low pedestrian traffic.

	High Traffic						Low Traffic					
	Uncaged		Caged		Mean		Uncaged		Caged		Mean	
Mean Values	2014	2015	2014	2015	2014	2015	2014	2015	2014	2015	2014	2015
Number of Plants	35	4	42	4	38	4	45	10	28	14	38	12
Flowers/plant	5	3	2	1	4	2	3	2	5	3	4	2
Limnanthes Cover	6	1	7	0	6	1	6	2	6	2	6	2
Grass Cover	30	48	33	38	31	43	28	17	30	36	29	27
Litter Cover	53	6	67	12	59	9	28	9	49	19	37	14

Plot 311- Uncaged 2013

2014

2015

Plot 312- Caged 2013

2014

2015

Figure 9. Photo-points of selected plots (plots 311 & 312) in high traffic areas 2013-2015. Photo-points for all plots are in Appendix E.

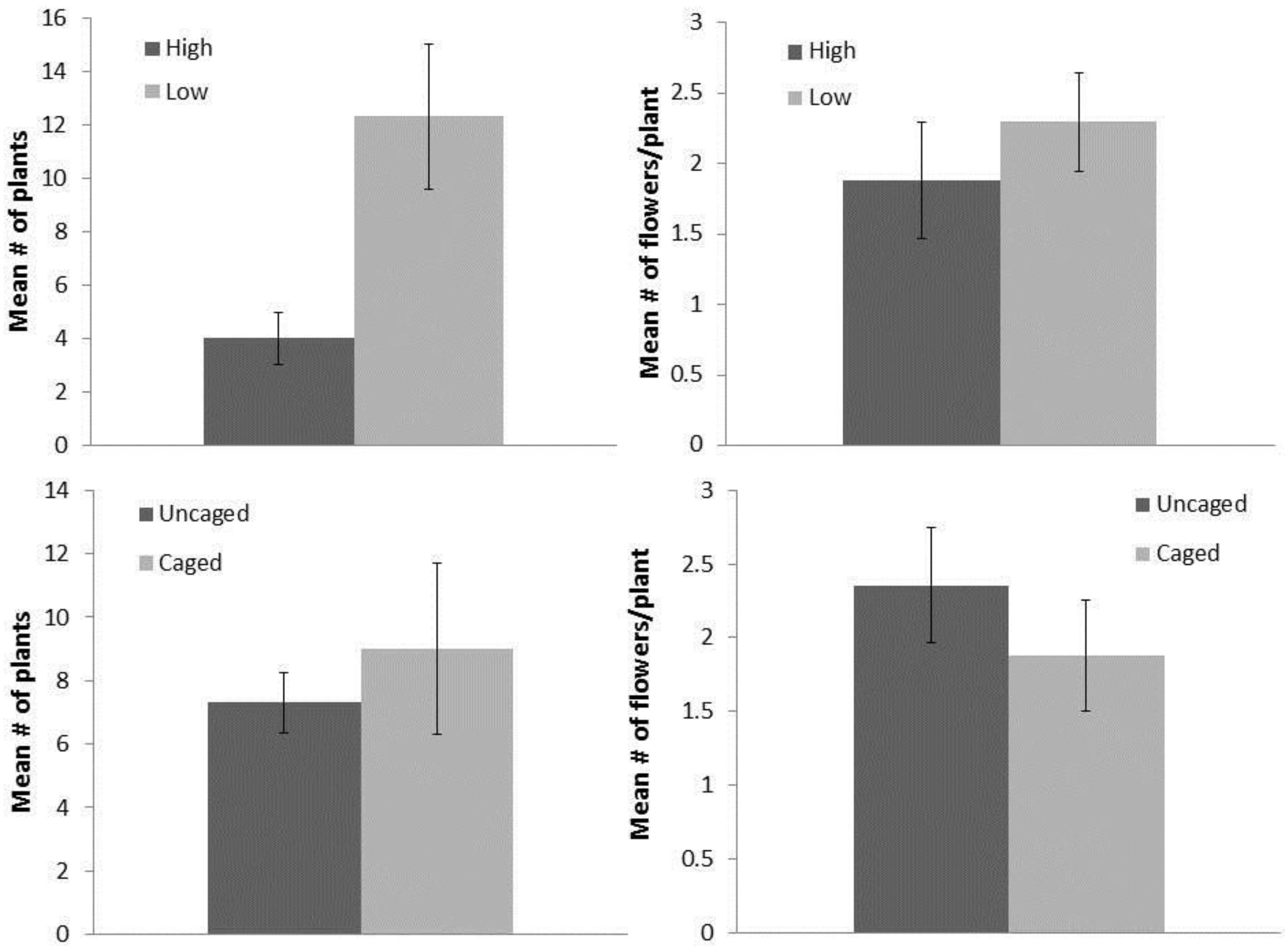

Figure 10. Mean number of plants and mean number of flowers per plant (2015), sorted by high and low recreation traffic (above) and caged and uncaged plots (below). Error bars are ± 1 S.E.

To test for effects of recreational traffic on *L. pumila* ssp. *pumila,* we monitored 20 plots on Lower Table Rocks (10 caged, 10 uncaged, paired in areas of high and low recreation traffic), these plots were established in 2012. In 2015, we observed fewer plants in high traffic areas than in low traffic areas (Figure 10, Table 2), this was similar to trends seen in 2013. We did not observe a difference in mean number of flowers per plant in 2015 between high and low traffic plots (Figure 11, top). Similar to trends in all plots, 2015 had far fewer plants than in previous years (Table 2). Interestingly, litter cover tended to be greater in low traffic areas than high traffic areas (Figure 10, top); in previous years we've seen a direct relationship between grass cover and litter. Cover of *L. pumila* ssp. *pumila,* native forbs, and litter tended to be greater in low traffic plots relative to high traffic plots (Figure 11). Cover of native and exotic grasses tended to be greater in high traffic plots than in low traffic ones. Similar to 2013 and 2014, there was no notable difference between caged and uncaged plots (Figure 10, bottom). Cover of *L. pumila* ssp. *pumila* was equal between the two types of treatments, while litter cover tended to be greater in caged plots (Figure 10, bottom).

We observed the lowest numbers recorded for *L. pumila* ssp. *pumila* in 2015. This was following a slight increase in 2014 for both number of plants and number of flowers per plant. The observed decline and the documented lowest amount of *L. pumila* ssp. *pumila* is consistent across all of our monitoring plots, both on Upper and Lower Table Rocks. While litter has declined over recent years, grass cover increased from 2014 to 2015 (Figure 8); of grass cover, native grasses compose a relatively small amount of the total (Figure 11). Since the fire retardant drop in 2010 we had been noting a great increase in non-native grasses, which show potential to compete with native vernal pool species endemic to Table Rocks. Litter and grass cover remain much higher than they were when the plots were established in 2012 (Figure 11). Photo-points from the plots illustrate this clearly; there was a significant increase in both non-native grasses and litter in 2013, and while it declined slightly in 2014 and 2015, more litter and grass cover than there was previously (Figure 9, Appendix E). While 2014 was a successful year for reproductive effort, this did not translate into a successful year for *L. pumila* ssp. *pumila* numbers. It is very likely that the population changes observed recently, including the decline in 2015, is likely the result of effects of the fire retardant drop coupled with climate variability. The previous results of stark differences between high and low traffic areas indicate that trampling prior to fruiting of *L. pumila* ssp. *pumila* can be detrimental (Appendix G), suggesting that recreation poses one of the greatest threats to this rare species. Limiting access to areas of high population density during flowering times could allow for the population to rebound.

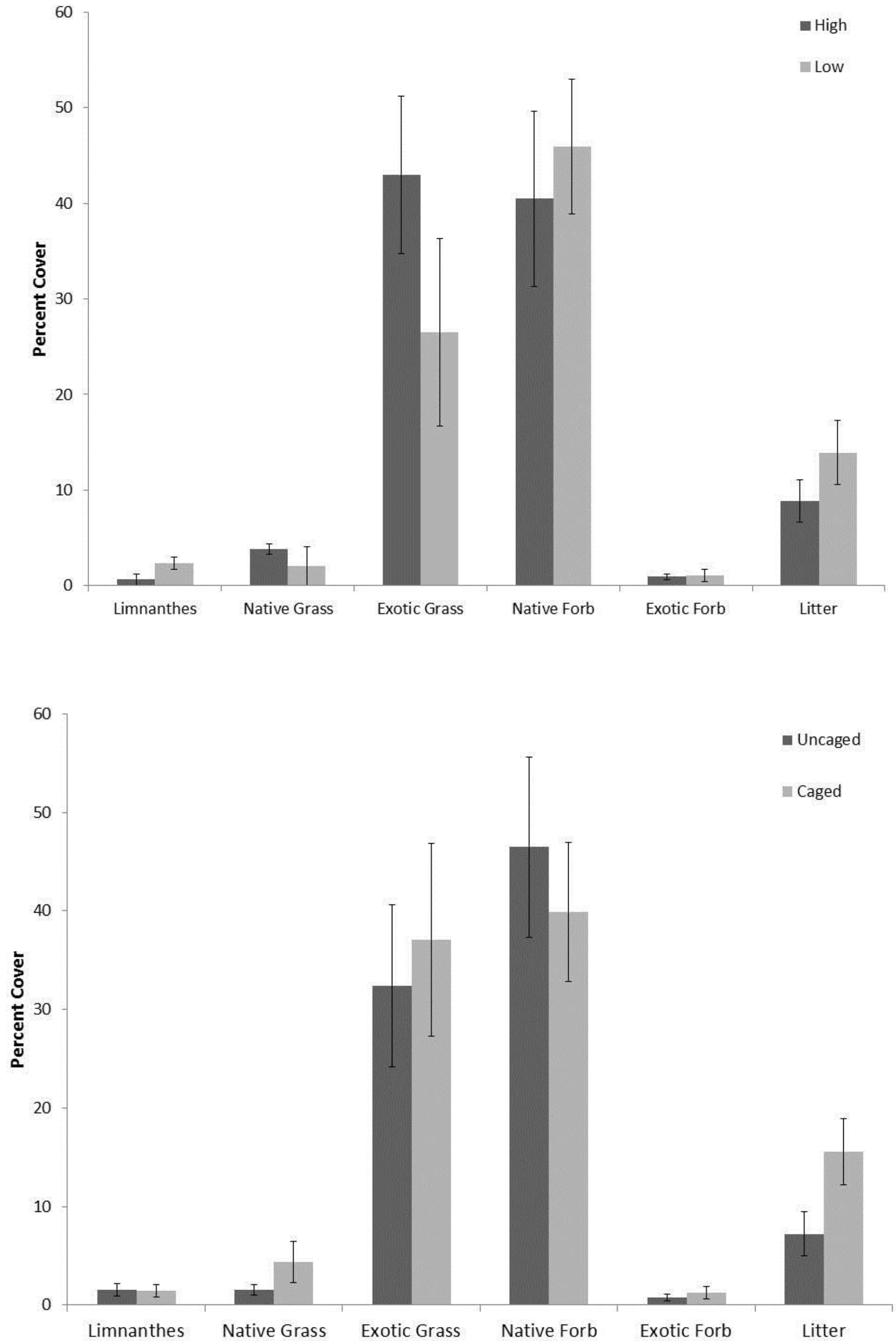

Figure 11. Percent cover in plots on Lower Table Rock, by recreation traffic (high, low), and treatment (caged, uncaged). Error bars = ± 1SE. 'Native forb' includes *Limnanthes* cover.

Effects of grazing and population trends on Upper Table Rock

Our results indicate that large ungulates have a negative effect on the density of *L. pumila* ssp. *pumila* (Figure 12, Table 3). While the number of plants in open and fenced plots differed between years (2007-2008, $p = 0.04$), the overall effect of fencing was significant ($p = 0.03$). Between 2007 and 2008, the number of plants in fenced plots increased while the number of plants in open plots decreased. This pattern was not observed from 2008 to 2009, when the number of plants in both types of plots decreased. The last period of cattle grazing was in May 2008; thus the lack of exclosure effect from 2008 to 2009 could reflect the lack of ungulate impacts as the plants germinated and grew in 2009. Exclosures did not have an effect on the number of flowers per plant ($p = 0.67$), which decreased in all plots from 2007 to 2008. Flowers per plant remained relatively stable from 2008 to 2009 in both types of plots.

Analysis of 2010 data showed no significant difference between the caged and uncaged plots for number of plants ($p = 0.86$) or flowers per plant ($p = 0.92$). In 2015, similar to previous years, we found no difference between caged and uncaged plots with respect to number of *L. pumila* spp. *pumila* and number of flowers (Figure 12). These results suggest that these populations are highly variable, even without disturbance caused from cattle. The continued similarity between caged and uncaged plots since the removal of cattle suggests that grazing significantly affected population dynamics for this species until livestock were removed and that native ungulates have little effect on plant population dynamics. In 2015 we saw lots of elk tracks in and around several of our plots.

By April 2015, Upper Table Rock had been closed to cattle grazing for seven years. The only grazing taking place was presumed to be by native ungulates. While the number of plants in the caged and uncaged plots increased dramatically between 2009 and 2010, there has been a consistent decline in both number of plants and number of flowers per plant, with 2015 being the lowest year for both values over the course of this study (Table 3, Figure 12). In 2015, mean number of plants per plot decreased from 2013, from 60 to 9 plants. Also in 2015, there was a decrease in mean number of flowers per plant, which has remained relatively stable since 2010 and increased slightly in 2013 (Figure 12). Across all plots on Upper Table Rock, number of plants per plot ranged from 0 to 29, and mean number of flowers/plant ranged from 1 to 2, which was extremely low compared to previous years. Grass cover has been variable over the years of this study, with very high values in 2010, a drop in cover in 2011 and 2012, and an increase again in 2013 (Figure 13). Grass cover decreased from 2013 to 2015, however values were still higher than those in 2012. Though these values have been variable, graminoid cover is composed mostly of non-native grasses including *B. hordeaceous* and *T. caput-medusae*. These values indicate that management related to decreasing non-native grasses in these areas should be a high priority. Variability in population dynamics indicates that long-term studies of this species are important for increased understanding of fluctuations in these populations over time. The decline exhibited in both number of plants and number of flowers per plant seed over recent years is alarming, particularly given that this area of Upper Table Rock is not as highly used by hikers as the southern end. This suggests that climate in recent years, in combination with changes in the plant community, could be the cause for such declines and continued monitoring will be essential.

In 2015, six plots were established on the southern end of Upper Table Rock in areas of high recreation traffic to monitor *L. pumila* ssp. *pumila* population dynamics. Results from these plots will be presented in future years once they have been monitored more than once.

Table 3. Mean number of plants and flowers per plant of *Limnanthes pumila ssp. pumila* in exclosed and open plots monitored on Upper Table Rock 2007-2015. Values are ± 1 S.E. Plots were not monitored in 2014.

Plot	# plants ± 1 S.E.								# flowers ± 1 S.E.							
	2007	2008	2009	2010	2011	2012	2013	2015	2007	2008	2009	2010	2011	2012	2013	2015
Exclosed	101.3 ± 13.8	194.2 ± 42.9	88.3 ± 21.4	187.1 ± 26.0	38.7 ± 9.9	15.5 ± 2.7	60.5 ± 16.9	8.9 ± 2.8	6.3 ± 0.9	2.9 ± 0.4	3.0 ± 0.5	1.5 ± 0.1	1.3 ± 0.3	1.4 ± 0.1	1.8 ± 0.1	1.3 ± 0.1
Open	154.1 ± 21.8	93.5 ± 16.7	49.6 ± 11.6	174.4 ± 69.1	43.6 ± 17.2	22.6 ± 4.6	51.0 ± 15.6	10.4 ± 2.3	4.8 ± 0.5	2.9 ± 0.2	2.3 ± 0.2	1.5 ± 0.2	1.3 ± 0.2	1.5 ± 0.1	2.1 ± 0.2	1.3 ± 0.1

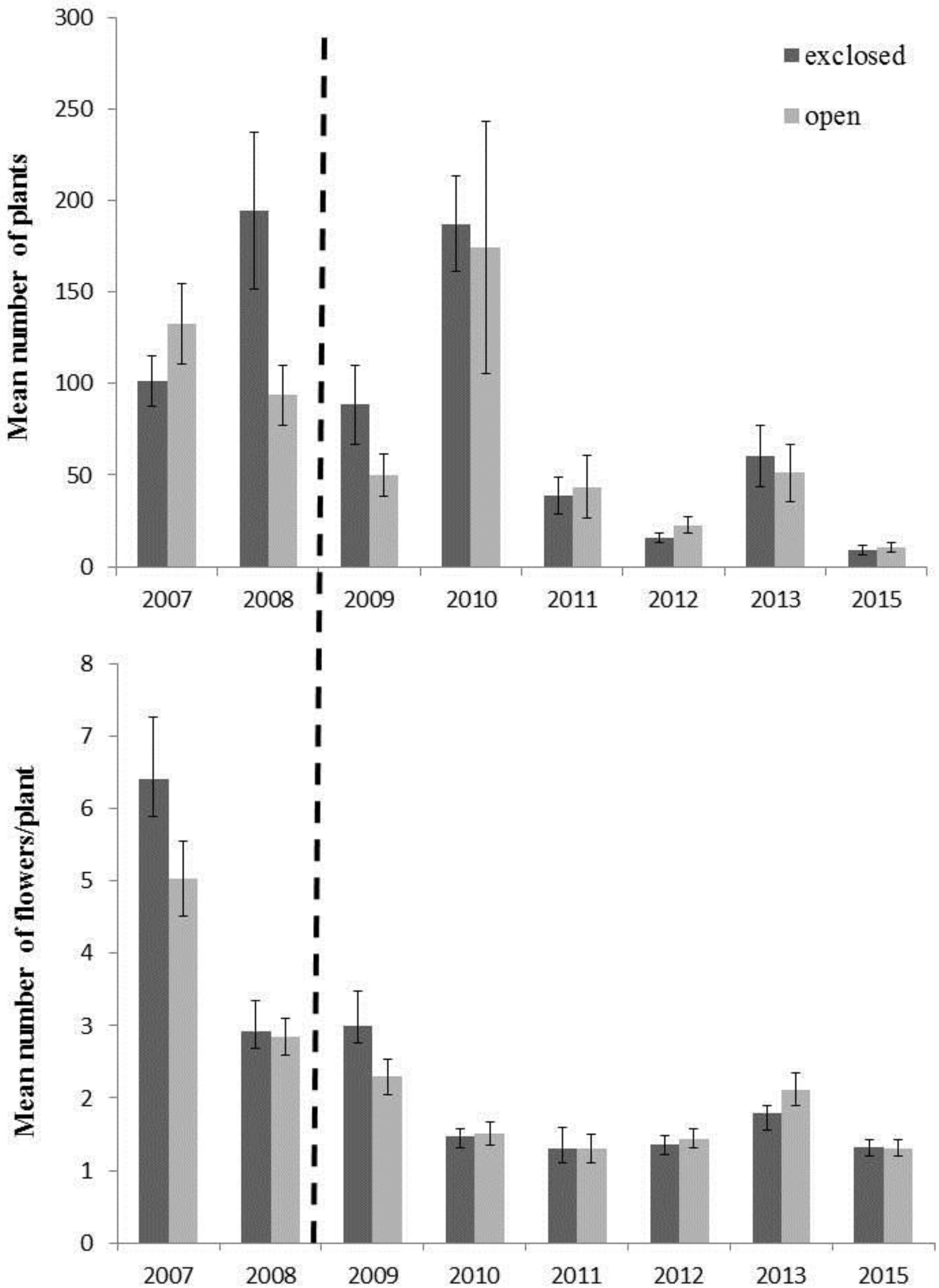

Figure 12. Mean number of plants (top) and flowers per plant (bottom) in exclosed and open plots on Upper Table Rock in 2007 - 2015. Error bars are ± 1 S.E. The dashed line indicates when cattle were removed. Plots were not monitored in 2014.

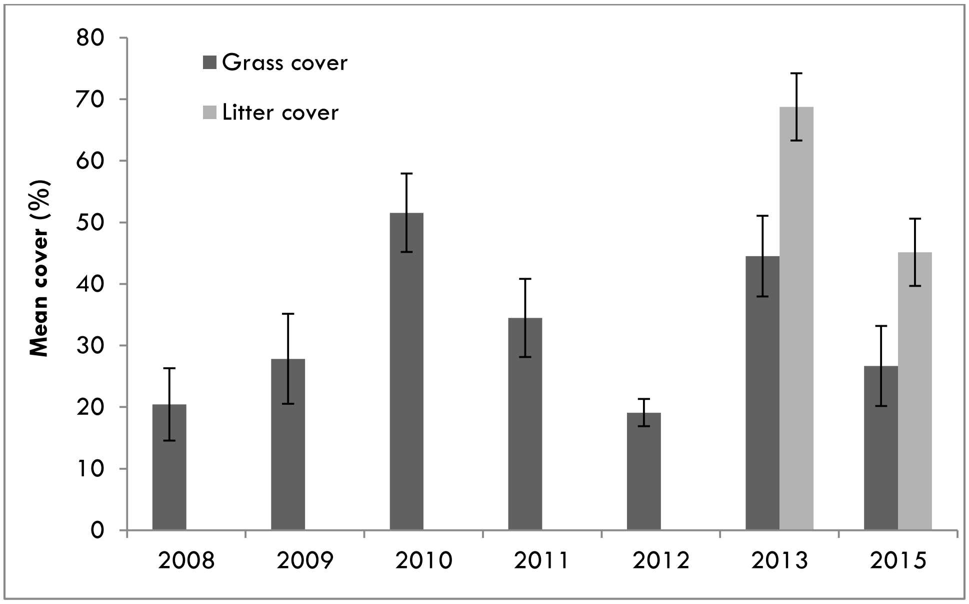

Figure 13. Mean percent cover of graminoids and litter in *L. pumila* ssp. *pumila* monitoring plots established on Upper Table Rock. Error bars represent ± 1SE. Graminoid cover was recorded in 2008-2015, litter cover was not recorded from 2008-2012. Plots were not monitored in 2014.

Community monitoring of the fire retardant drop

We established five transects in 2013 dissecting the fire retardant drop to provide more information regarding the long-term changes associated with this event (Figure 6). Along each transect, we mapped the change in habitat type (flat, mound, pool) and calculated the proportion of each transect composed of each habitat type. Across all of the transects, flat habitats were the most abundant composing roughly 65%, followed by mound habitats (24%), with pool habitats composing the remainder (11%, Table 4). From 2014 to 2015 there was an increase in proportion of flat habitats and a decrease in mound and pool habitats. Mound habitats decreased slightly from 26% in 2014 to 23% in 2015. Pool habitats had the greatest decrease between 2014 and 2015, from 20% to 11%; this decline is concerning as *L. pumila* ssp. *pumila* and other native species are associated with pool habitats. These changes could be attributed to the edges of pool habitats being more invaded by exotic species or flat habitats increasing due to trampling. Mound habitats were not present inside of the fire retardant drop in 2015, while there were some plots on mounds in 2014.

Table 4. Percentage of transects occupied by flat, mound, and pool habitats on Lower Table Rock, 2015.

	Proportion of Transect		
Transect	Flat	Mound	Pool
1	41	48	11
2	37	39	25
3	80	10	10
4	85	12	3
5	71	19	10
Total	65	24	11

To assess plant community composition within and outside of the area impacted by the fire retardant drop, we monitored a total of 37 1 m^2 monitoring plots along the transects, ranging from 6 to 9 plots per transect (dark blue, Figure 6). Within these, *L. pumila* ssp. *pumila* was only present in one of the plots, with a percent cover of 1%, which was a decrease from that in 2014 (7% maximum in 5 plots), this plot occurred outside of the fire retardant drop. Across all plots, non-native grasses composed cover ranging from 2-90%, with an average of 37% and a mode of 50%. Native grasses were most abundant in flat and pool habitats, with lower cover in mound habitats (Figure 14). Non-native grasses tended to dominate mound and pool habitats. Native forbs were the most abundant in pool habitats. Non-native forbs were less abundant, particularly in pool habitats. Within plots, we noticed a decline in pool habitats, with an increase in flat and mound habitats.

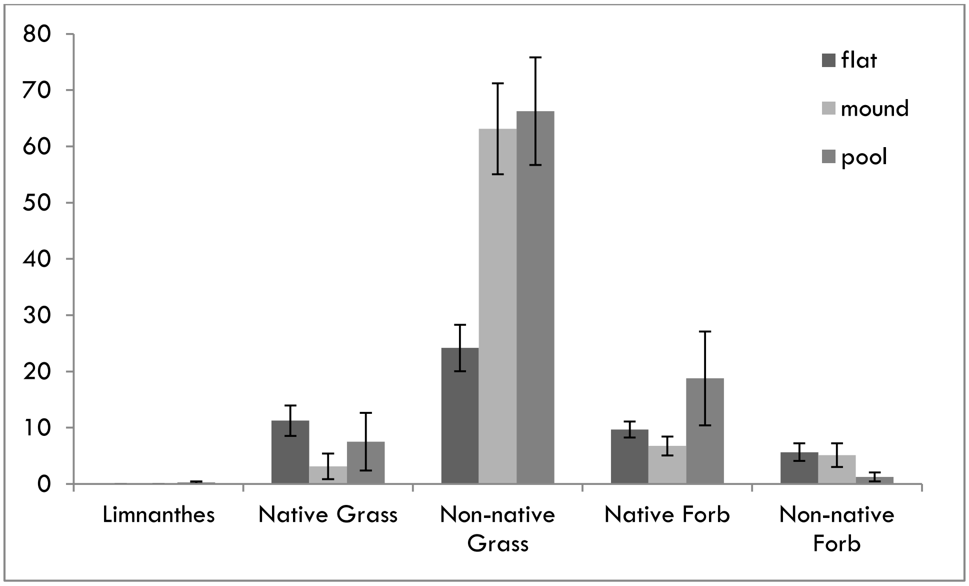

Figure 14. Percent cover in all plots along fire retardant transects on Lower Table Rock, by habitat type (N, flat =25, mound = 8, pool = 2). Error bars = ± 1SE. 'Native forb' includes *Limnanthes* cover.

From 2013 to 2015 we have observed a decline in non-native grasses both within and outside of the fire retardant drop (Figure 14), with little differentiation between the two areas. Litter cover also declined from 2013 to 2015 both within and outside of the fire retardant drop (Table 5), with more decline occurring in plots outside of the drop. Similar to in 2013, non-native grasses dominated pool habitats outside of the drop (85%) but not within (48%, Table 5). Non-native grasses were also high in mound habitats outside of the drop. Outside of the drop, litter cover was highest in mound habitats (55%), however inside of the drop it was high in pool habitats (48%). Interestingly, in pool habitats outside of the drop, non-native grasses had high cover (85%) however litter cover was quite low (15%), this is not similar to many other plots where litter cover and non-native grass cover were associated. *Limnanthes pumila* ssp. *pumila* only occurred in 1 plot in 2015 as opposed to 5 in 2014, of those cover of *L. pumila* ssp. *pumila* decreased completely inside of the drop from 2014 to 2015, but increased in areas outside of the drop (Table 5, Figure 15). These changes were only present in a very small number of plots and do not necessarily represent overall trends.

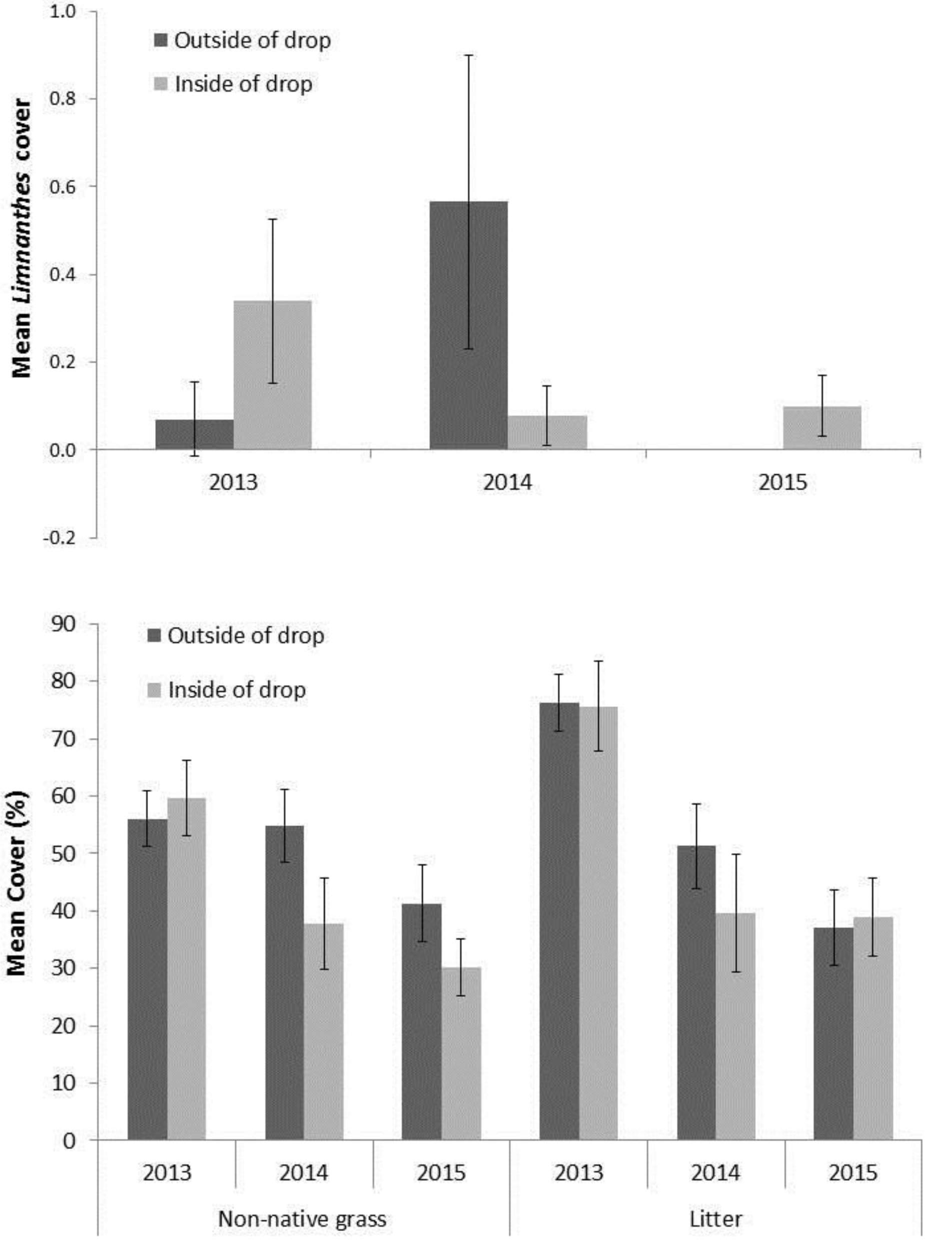

Figure 15. Mean *L. pumila* ssp. *pumila* cover collected from plots along transects inside and outside the area of the fire retardant drop in 2013 to 2015. Mean cover of non-native grasses and litter collected from plots along transects inside and outside of the area of the fire retardant drop from 2013 to 2015 (below).

Table 5. Mean percent cover by habitat type (flat, mound, pool) in monitoring plots within and outside of the area impacted by the fire retardant drop, 2013, 2014, and 2015.

	Mean *Limnanthes* cover			Mean non-native grass cover			Average of Litter		
	2013	2014	2015	2013	2014	2015	2013	2014	2015
Outside of drop	0.1	0.6	0.0	56.1	54.9	41.3	76.2	51.3	37.1
flat	0.2	0.0	0.0	40.5	48.4	21.2	61.0	49.8	29.6
mound	0.0	0.0	0.0	65.9	80.0	63.1	87.0	93.8	54.9
pool	0.0	2.6	0.0	80.0	59.0	85.0	92.5	30.2	15.0
Inside of drop	0.3	0.1	0.1	59.6	37.7	30.2	75.6	39.7	38.9
flat	0.4	0.0	0.0	41.7	24.8	27.3	56.2	27.9	37.5
mound	0.7	0.0	NA	73.3	90.0	NA	96.0	95.0	NA
pool	0.0	0.4	0.5	73.0	36.7	47.5	86.8	42.7	47.5

Between 2013 and 2015, we have seen a decrease in mean non-native grass cover inside the drop, and a subsequent decline in litter cover in the same area. This might suggest that the initial increase was due to a fertilizer effect from the fire retardant drop, and that over time it might decline and normalize. Continued monitoring will be essential to see if this was just a better year or is a long-term trend. While *L. pumila* ssp. *pumila* occurred exclusively in pool habitats, mound habitats host a wide range of native forbs. These mound and pool habitats are now composed of high cover by exotic annual grasses, creating dense thatch which can be detrimental to native species (Figure 16). Without intervention, these grasses could continue to increase at the expense of native species on Lower Table Rocks. The lack of *L. pumila* ssp. *pumila* in the majority of the plots suggests that this species continues to occupy a small percentage of the habitat on Lower Table Rock.

Pool habitats, which have historically been occupied with unique narrow endemics such as *L. pumila* ssp. *pumila* and others, have had high cover of non-native species and relatively low cover of natives. In previous years (2009-2011), plant community composition across Lower Table Rock was quantified and pool habitats were composed of the highest proportions of native species (90% native cover; Appendix I). This decline in cover from a native dominated pool community to one now dominated by non-natives is troubling. Continued monitoring will be necessary to see if these changes represent a long-term trend.

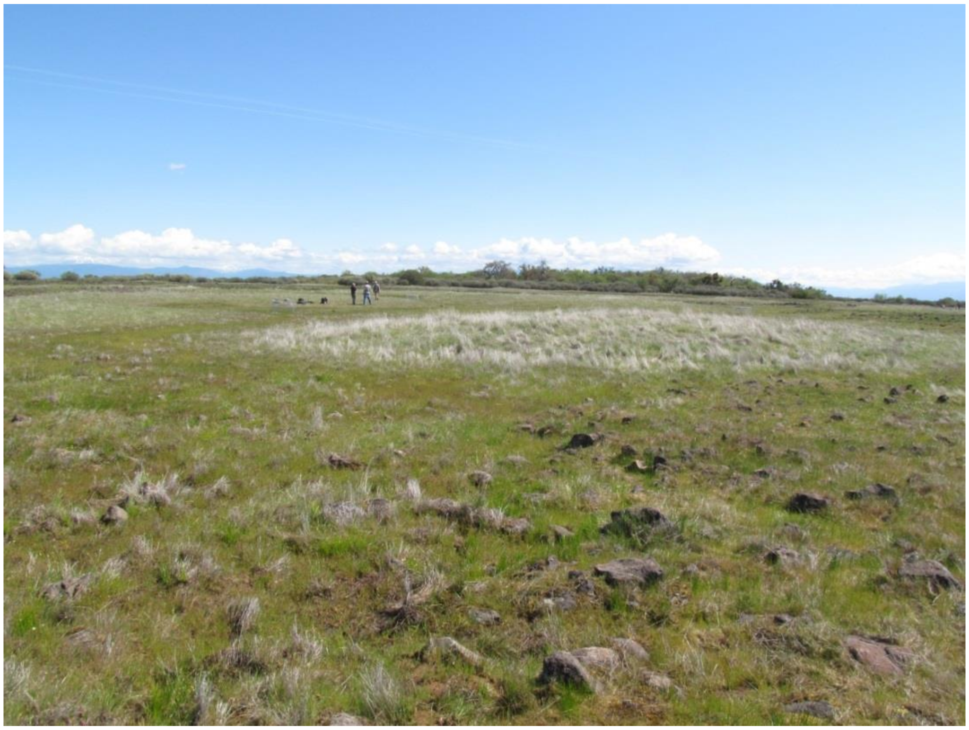

Figure 16. Mound habitat on Lower Table Rock, made visible by the dominance of non-native graminoids including *T. caput-medusae* and the litter it leaves behind.

The dramatic increase in exotic grasses since 2010 at Lower Table Rock seems to be a major factor in the decline of *L. pumila* ssp. *pumila* in areas where it was once abundant. Differences in life-history characteristics between native forbs and exotic grasses could explain observed differences in the effects on a variety of native plants on Lower Table Rock, particularly in the area of the fire retardant drop. When the drop occurred in July 2010, many of the native species were past their period of growth. The fertilizer effect most likely enhanced exotic annual grass species, in particular winter annuals such as *T. caput-medusae*, which germinate in the fall. These species experience rapid root growth over winter, and produce copious amounts of seed in the spring, at a time when native species are just beginning to germinate. This difference in life-history traits enables exotic winter annuals to have a competitive advantage over native forbs and grasses, and this advantage may have been enhanced by the fire retardant drop. Though the fertilizer likely washed away with time due to precipitation and weather, increased abundance of exotic annual grasses will add to the existing seed-bank and we have observed an increase of silica-rich litter, which decomposes at a slow rate (Johnson and Davies 2012). Results from 2013 suggest that invasion of exotic species had become ubiquitous on Lower Table Rock and has spread both within and outside of the area of the fire retardant drop, and this was associated with a severe decline in the *L. pumila* ssp. *pumila* population. While in 2014 and 2015 we observed a decline in non-native grasses and litter in these plots, continued monitoring will be essential to track these changes and see if these trends continue.

Spatial analysis of vegetation change in the area impacted by the fire retardant drop

Changes that occurred in the area of the fire retardant drop on Lower Table Rock are visible with the naked eye in composite imagery from 2009 and 2011 (Figure 17), where the area impacted by the fire retardant drop is notably lighter in color than the remainder of the rest of Lower Table Rock.

We were able to quantify these changes using the absolute Normalized Difference Vegetation Index (NDVI) from pre- and post-fire retardant drop. The greatest changes in vegetation were found in the area of the fire retardant drop as well as in the pool complex on the east side of the abandoned airstrip in the center of the table (Figure 18). These areas, indicated by the dark color, support our data which suggest that changes are not only occurring in the area of the fire retardant drop but have extended beyond, into the other large pool complexes and areas associated with high recreation traffic.

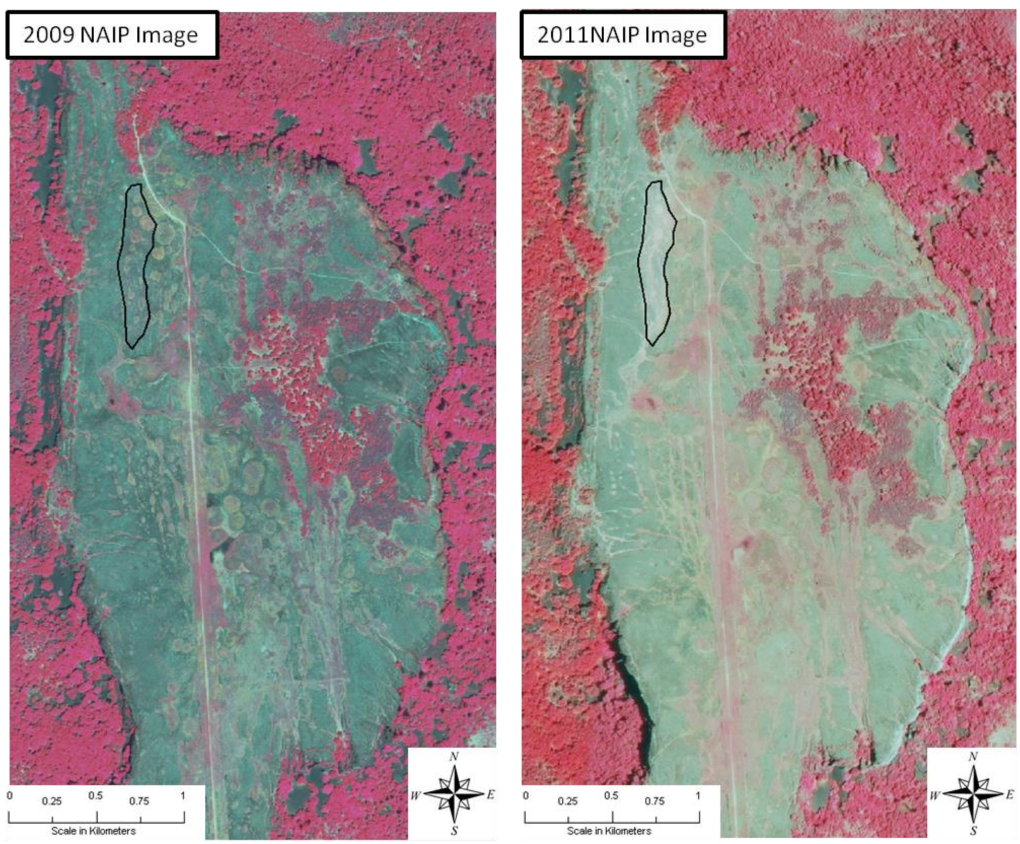

Figure 17. Imagery from the NAIP pre- (2009) and post- (2011) fire retardant drop. Area outlined in black indicates the extent of the fire retardant visible on 7/20/2010 in Google Earth.

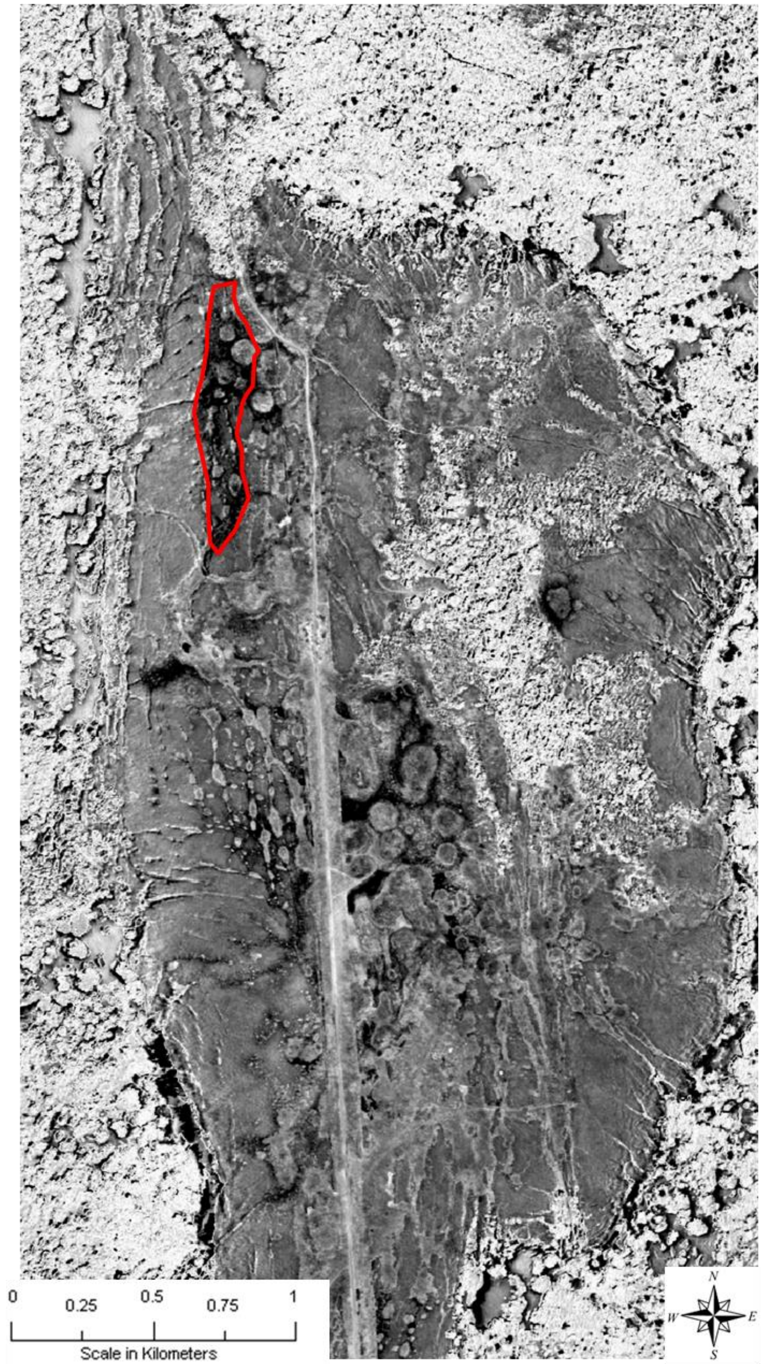

Figure 18. Absolute change in vegetation cover from 2009 to 2011. Dark areas indicate areas of greatest change, white areas indicate areas with little or no change in vegetation cover. The area of the fire retardant drop is outlined in red.

While the results from this spatial analysis do not indicate the type of vegetation change which occurred on Lower Table Rock, these data combined with our vegetation transect data indicate that the changes observed reflect a dramatic increase in the cover of exotic species, particularly in the area of the fire retardant drop and across high traffic areas on Lower Table Rock. The pool habitats found to be most heavily impacted by this invasion are those that house the unique, rare species assemblages on the Table Rocks. Without intervention, the future species such as *L. pumila* ssp. *pumila* remain unknown.

CONCLUSIONS

Figure 19. Pool habitat on Lower Table Rock

From 2010-2013, we observed a severe decline in *L. pumila* ssp. *pumila* across both Table Rocks, coupled with a decrease in reproductive effort for plants. During this time, we also noted an increase in cover of non-native grasses. This cover of non-native grasses seemed to be associated with the fire retardant drop that occurred in 2010, promoting a fertilizer effect that resulted in extremely high cover of litter in 2013. Following a slight increase in 2014, *L. pumila* ssp. *pumila* declined to its lowest numbers over the course of the study on both Upper and Lower Table Rock in 2015, along with a documented decline in pool habitat on Lower Table Rock (Figure 19). While we have seen variability in the amount of non-native grasses and litter cover, these two categories far outnumber native grasses or forbs in monitoring plots. The severe decline observed in 2015 suggests that other factors may be greatly affecting population dynamics on both Table Rocks. Future monitoring will be essential to track the population and gain understanding of its potential threats. The noted decline in *Limnanthes* in 2012 and 2013 coupled with the high cover of invasive annual grasses suggests that the fire retardant drop was a legitimate threat to the species.

Along with invasion by exotic species, trampling associated with recreation poses a significant threat to native plant communities on both Table Rocks (Prior to 2009, cattle grazing also had a significant impact on the plant communities at Upper Table Rock). Trampling during the active growing season of *L. pumila* ssp. *pumila* has the potential to decrease seed production and future recruitment (Appendix G). Human recreation also has the potential to facilitate invasion by exotic species (Pickering and Mount 2010). The demonstrated differences in number of *L. pumila* ssp. *pumila* between areas of high and low recreation traffic in 2013 and 2015 suggest that recreation on the Table Rocks does pose a significant threat to the rare species endemic to these unique habitats, especially during times of high cover of non-native grasses. We observed many people walking off-trail through extremely sensitive habitats on the southern end of Upper Table Rock in 2015. The multitude of secondary trails on this area of high recreation traffic suggests that more steps need to be taken, particularly during the growing season, to protect these sensitive habitats that *L. pumila* ssp. *pumila* inhabits.

Climate change poses another threat to this species. There are many unknowns associated with predicted warming temperatures and their effects on these ephemeral systems. The decline we observed in 2015 was noted across both Upper and Lower Table Rocks, suggesting that climate variability has impacted the populations in recent years. The amount of standing water we have seen in pools has varied; in 2014 many of the pools were wet but not as saturated as we have observed in previous years however even the very large pools in Lower Table Rock were dry in 2015 (Figure 19). This variability in climate and its impact on habitat could greatly affect the populations of rare annual endemics occurring on the Table Rocks. The decline exhibited since 2010 could be attributed to hot and dry conditions experienced in recent years on the Table Rocks (Figure 20). Maximum temperatures from 2013-2015 have been well above the long-term normals with 2014 being the warmest year with a relatively warm fall (Figure 20, top, PRISM 2015). Minimum temperatures have remained above the long-term normals from 2012-2015, with 2014 being the warmest year. Mean precipitation has been variable over the years, with previous years experiencing more dry conditions than in the past, however winter 2015 (Dec 2014-Feb 2015) was an extremely wet year in comparison (Figure 20). 2013 was a drier year, however 2012 and 2015 tended to have wetter springs and falls than long-term normals. These unique climate trends observed over recent years have likely impacted populations of *L. pumila* ssp. *pumila* over time, especially in combination with human recreation traffic and invasion by exotic species. Continued monitoring will be essential to see how populations of annual species perpetuate into the future.

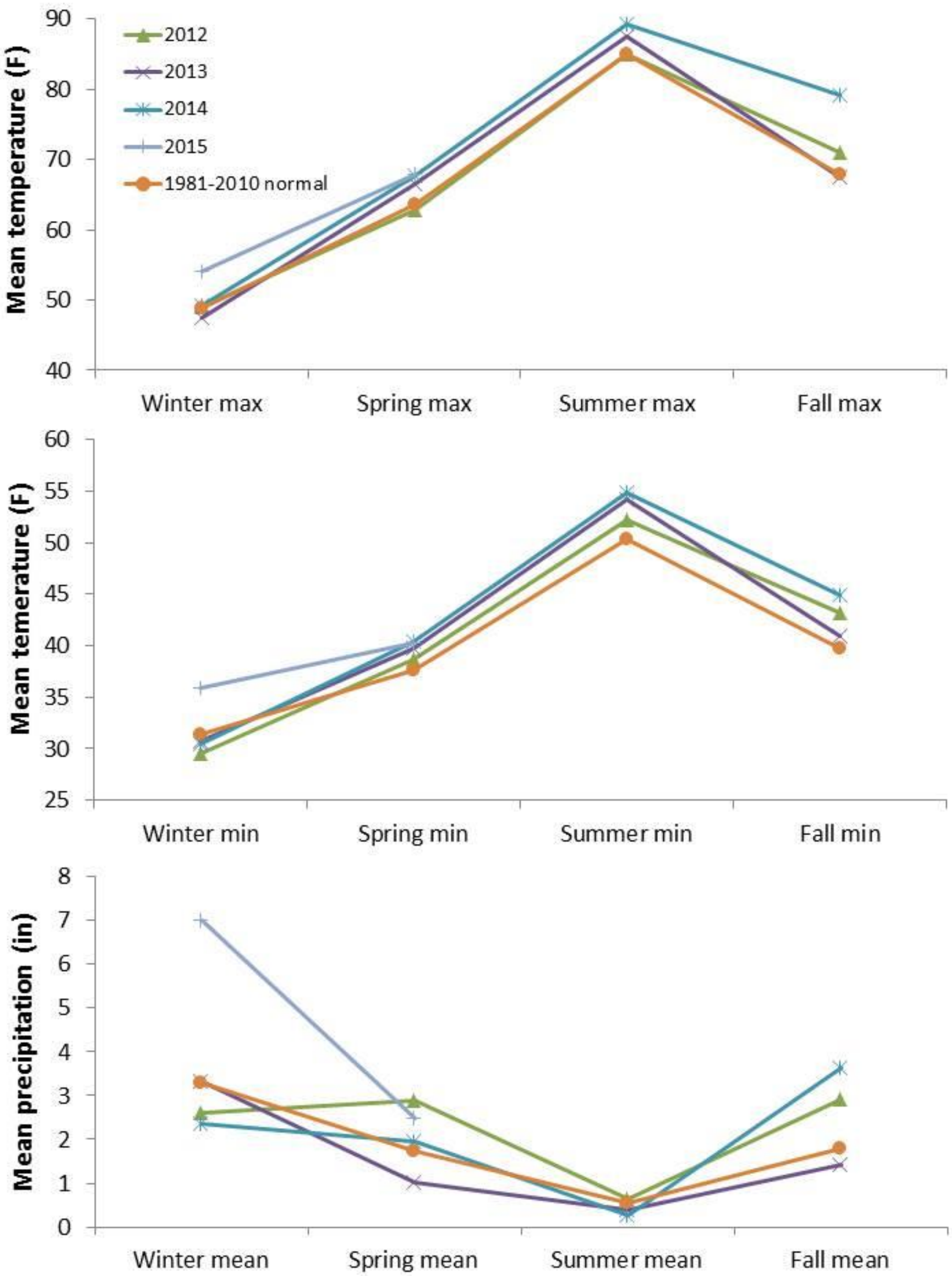

Figure 20. Mean maximum temperature (top), mean minimum temperature (middle), and mean precipitation (bottom) at Table Rocks from 2012-2015, with long-term climate normals (1981-2010).

We observed the lowest numbers for *L. pumila* ssp. *pumila* in 2015, in plots on both Upper and Lower Table Rocks. This decline is worrisome, particularly following a slight increase in plants and reproductive effort in 2014. We recommend continued monitoring in order to determine long-term population trends and to describe areas where the species seems particularly vulnerable or changes are occurring rapidly. One such area could be the southern end of Upper Table Rock where it was difficult to find locations to establish new plots (with more than 4 plants/plot) in 2015. Continued monitoring will enable us to see if direct intervention is necessary to treat the non-native grasses observed or to keep recreation traffic out of sensitive areas. To address invasion by exotic grasses, treatment options for vernal pools have included prescribed fire in California (Witham et al. 1998). Research suggests burning when medusahead is at the "soft dough" stage can be effective in decreasing the species up to 90% (McKell et al. 1962, University of Nevada Cooperative Extension). At the Jepson Prairie in California, the Nature Conservancy conducted burn trials in vernal pool habitat; they found that late fall burns decreased exotic species but also tended to decrease some native species. Late spring burns (after native seed set) were found to be the most favorable with regards to thatch reduction and killing seeds that have not yet been dispersed (primarily exotic grasses; Witham et al. 1998).

We demonstrated that areas of high recreation traffic had much less *L. pumila* ssp. *pumila* than low traffic areas in 2015. Though the Table Rocks offers a fantastic educational opportunity for connection to nature, limiting impact in high-traffic areas might be necessary to enable *L. pumila* ssp. *pumila* to recover. We have demonstrated that *L. pumila* ssp. *pumila* is the most fragile prior to setting fruit, so timing centered around the phenology of this species would be imperative.

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APPENDICES

Appendix A. Site Directions

Directions

There are several ways to approach the Table Rocks once you are in the Medford vicinity. You should be able to easily navigate to them using just a Gazetteer.

From Corvallis: Take I-5 South to exit 33 (Central Point). Turn left at the end of the off-ramp (onto E Pine St). E Pine turns into Biddle, from off-ramp travel ~1 mile and turn left onto Table Rock Road. Drive ~5.2 miles. To get to Upper Table Rock, turn right onto Modoc Rd. and drive ~1.5 miles. The trailhead parking lot will be on your left after ~1.5 miles. Starting in 2010, we should be able to drive to the top of Upper. Contact BLM Botanist Marcia Wineteer to get permission and directions. To get to Lower, from junction of Table Rock Road and Modoc, slight left (stay on Table Rock Road) and drive an additional 2.5 miles. Turn left onto Wheeler Road and drive ~0.8 miles, trailhead parking lot will be on left.

Appendix B. Lower Table Rock plot locations

- Plots set up in May 2007, 2009, and 2012.
- 2009 trampling plot azimuths include a 15° east declination
- Nails with washers placed just to inside of rebar or conduit
- 2'nd Origin stake: on east side of trail in tuft of lupine and grass, ~9m E of trial toward large rock in post (12m to W). 42°27.161'N, 122°57.098'W

Plot #	WGS 84	Notes
2007 Trampling plots Unless noted, plots are sampled and trampled to the west		
941	42°217.389'N 122°57.164'W	340° from origin to end, sampled to W, not located 2009. 1 m^2 plot monitored qualitatively in 2012.
942	42.27.410'N 122°57.182'W	264° from rebar to tag (NW corner), not located 2009. 1 m^2 plot monitored qualitatively in 2012.
943	42°27.402' 122°57.181'W	220° end to end, sample on right side with back to trail, not located 2009. Not found in 2012.
944	42°27.374'N 122°57.169'W	234° end to end, sampled on right side; not located since 2007
945	42°27.368'N 122°57.172'W	172°, sampled on right side, not located since 2008
946	42°27.364'N 122°57.140'W	164 ° end to end; sampled to west (right) side, not located 2008
947	42°27.167'N 122°57.048'W	124° end to end, sampled on right, not located since 2008
948	42°27.153'N 122°57.058'W	192° end to end. Not located in 2012.
949	42°27.147' N 122°57.064' W	233° end to end; monitored and trampled to NW, unreliably reestablished 2009, not located in 2012.
950	42°27.141' N 122°57.066' W	204° end to end; not located since 2008.
2009 Trampling plots		
735	42°27.088' N 122°57.118' W	188° from origin to end. Control from 2 – 3.5 m. 2012: New tag 320, 1m^2 plot.
736	42°27.256' N 122°57.144' W	156° origin to end, sampled on W side of tape. Control from 0 – 1.5 m. 1 m^2 plot monitored qualitatively in 2012.
737	42°27.117' N 122°57.140' W	99° from origin to end, sampled on S side of tape. Control from 2 – 3.5 m. Not located in 2012.
738	42°27.100' N 122°57.117' W	89° from origin to end, sampled on S side of tape. Control from 2 – 3.5 m. 2012: New tag 322, 1m^2 plot.
739	42°26.978' N 122°57.058' W	32° origin to end, sampled on W side of tape. Control from 4 – 5.5 m. Not located in 2012.
740	42°27.033' N 122°57.054' W	338° from origin to end, sampled on W side of tape. Control from 6 – 7.5 m. Not located in 2012.

741	42°27.042' N 122°57.061' W	New 1 m² plot established using origin in 2011. 5° from origin to end, sampled on W side of tape. Control from 6 – 7.5 m. Not located in 2012.
742	42°27.145' N 122°57.057	236° from origin to end, sampled on NW side of tape. Control from 4 – 5.5 m. Not located in 2012.
743	42°27.150' N 122°57.061' W	61° from origin to end, sampled on SE side of tape. Control from 4 – 5.5 m. Not located in 2012.
744	42°27.197'N 122°57.034' W	342° from origin to end, sampled on W side of tape. Control from 6 – 7.5 m. 2012: New tag 313, 1m² plot.
Weeded plots, not sampled in 2009, status of plots unknown		
951 (changed to **561** in 2008)	42°27.389'N 122°57.166W	tag in upper left west is weeded
952	42°27.413'N 122°57.179'W	#942 169°, 3.2m east side is weeded; not sampled 2008
953	42°27.403'N 122 ° 57.183'N	1m W from #943 west side is weeded
954	42°27.377'N 122°57.166'W	1m from #944 west is weeded; not located 2008
955 (changed to **560** in 2008)	42°27.368'N 122°57.171'W	1m west of #943 west is weeded
956	42°27.360'N 122°57.144'W	1m to east of #946 east is weeded; not sampled 2008
957	42°27.171'N 122°57.053'W	orientation: 140° weeded in west; not sampled 2008
958	42°27.157'N 122°57.060'N	rebar in NE and SW weeded in east
959	42°27.145'N 122°57.064'W	orientation: 158° weeded in east
960	42°27.136'N 122°57.045'W	orientation: 158° weeded in west

Lower Table Rock long term monitoring plot locations (NAD83, UTM 10N, established 2012)

Plot ID	Tag	Waypoint	Year established	Use	Caged	Latitude	Longitude
303	261	162	2012	high	no	42.456425	122.952693
304	304	163	2012	high	yes	52.456471	122.952802
307	307	164	2012	low	no	42.456099	122.952875
308	262	165	2012	low	yes	42.456127	122.95284
309	309	166	2012	high	yes	42.45628	122.95253
310	291	167	2012	high	no	42.456286	122.952446
311	266	168	2012	high	no	42.454287	122.952381
312	312	169	2012	high	yes	42.454302	122.95243
744-new	744	170	2012	low	yes	42.453376	122.950605
313*	313 (old tag 744)	171	2009	low	no	42.45331	122.950559
314	314	172	2012	low	yes	42.452829	122.950656
315	315	173	2012	low	no	42.452804	122.950765
316	363	174	2012	low	no	42.452556	122.950978
317	317	175	2012	low	yes	42.452517	122.951027
318	264	176	2012	low	no	42.452347	122.950655
319	319	177	2012	low	yes	42.452359	122.940618
320*	320 (old tag 738)	178	2009	high	no	42.45134	122.951939
321	321	179	2012	high	yes	42.451403	122.951998
322* (old tag 735)	265	180	2009	high	no	42.451692	122.951942
323	323	181	2012	high	yes	42.451665	122.951867

*Indicates plots re-sampled from previous years

Extra plots monitored on Lower Table Rock (NAD83), no *L. pumila ssp. pumila* present in 2012

Plot	Year established	Use	Caged	Latitude	Longitude
736	2009	high	no	42.4542667	122.9524000
941	2007	high	no	42.4564833	122.9527333
942 (new tag 238)	2007	low	no	42.4568333	122.950333

Appendix C. Upper Table Rock plot locations

Upper Table Rock plot locations (NAD83, UTM 10N)

Plot ID	Tag #	Year established	Caged	Latitude	Longitude
961	961	2007	yes	42.47924999	122.9135208
604	604 (old tag 963)	2007	yes	42.47951914	122.9142633
965	965	2007	yes	42.4793427	122.9146848
966	966	2007	yes	42.47920934	122.9152950
969	274	2007	yes	42.47780713	122.9145120
970	970	2007	yes	42.47796807	122.9138504
971	971	2007	yes	42.47804862	122.9125602
974	974	2007	yes	42.47929643	122.9115566
299	299 (old tag 980)	2012	yes	42.47818046	122.9120915
964	964	2007	no	42.47958192	122.9147995
300	271 (old tag 967)	2012	no	42.47823402	122.9155309
605	605 (old tag 968)	2007	no	42.4785299	122.9150365
975	975	2007	no	42.47913617	122.9111286
977	977	2007	no	42.4798472	122.9108062
979	979	2007	no	42.48020771	122.9121783
298	298 (old tag 972)	2012	no	42.47842991	122.9125406
297	297 (old tag 976)	2012	no	42.47938486	122.9106126
296	272 (old tag 978)	2012	no	42.48031768	122.9108470
89	89	2013	no	42.47940137	122.9141945
151	275	2013	no	42.47928587	122.9117733

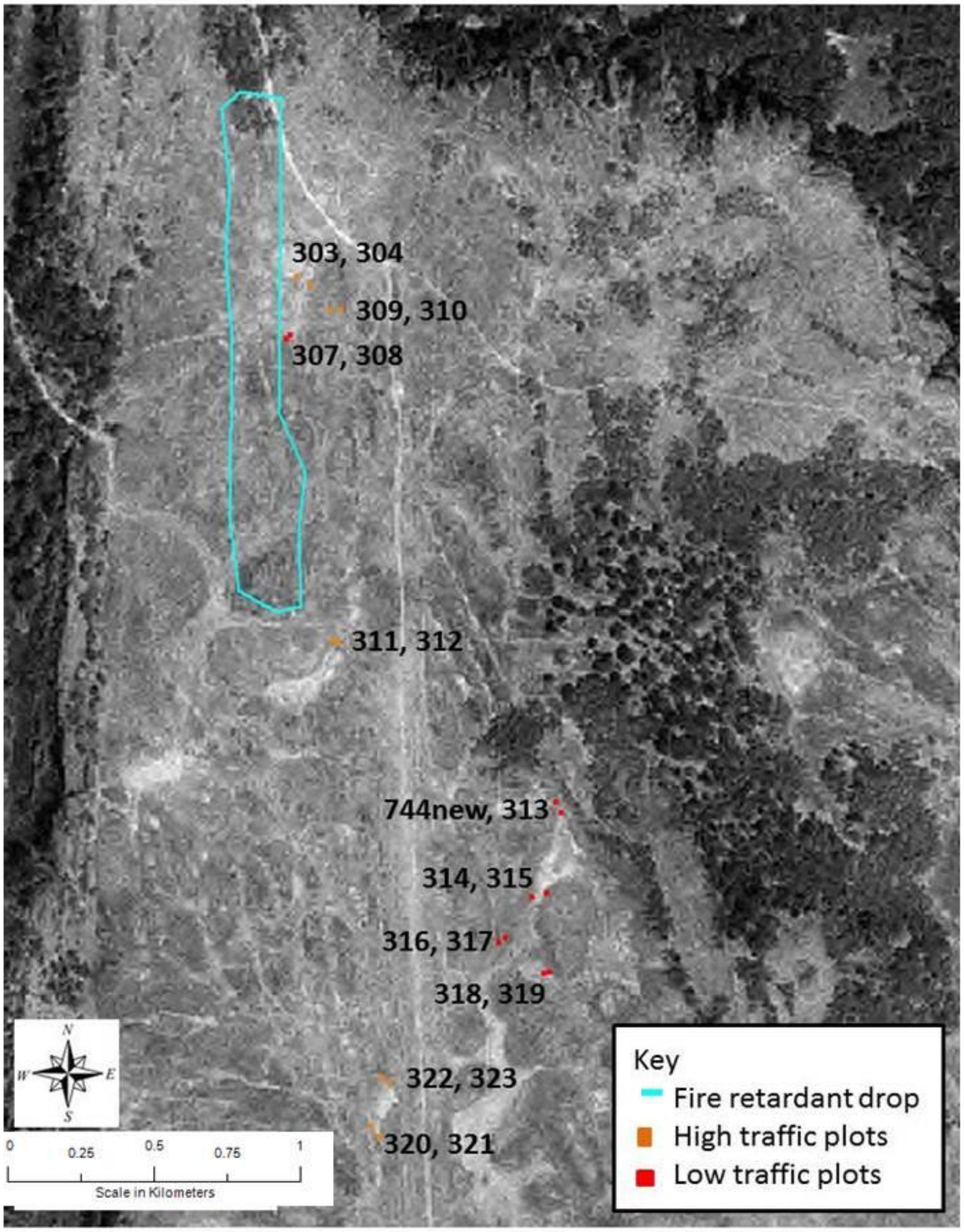
Upper Table Rock southern plot locations (NAD83, UTM 10N)

Plot ID	Tag #	Year established	Recreation traffic	Latitude	Longitude
540	540	2015	high	42.466240	-122.895551
541	541	2015	high	42.466266	-122.895519
542	542	2015	high	42.466192	-122.895159
543	543	2015	high	42.465479	-122.895901
544	544	2015	high	42.465875	-122.895530
545	545	2015	high	42.467729	-122.894719

Appendix D. Plot maps

Lower Table Rock

2012 long-term *L. pumila ssp. pumila* population monitoring plots with plot identification numbers (monitored in 2012 and 2013).

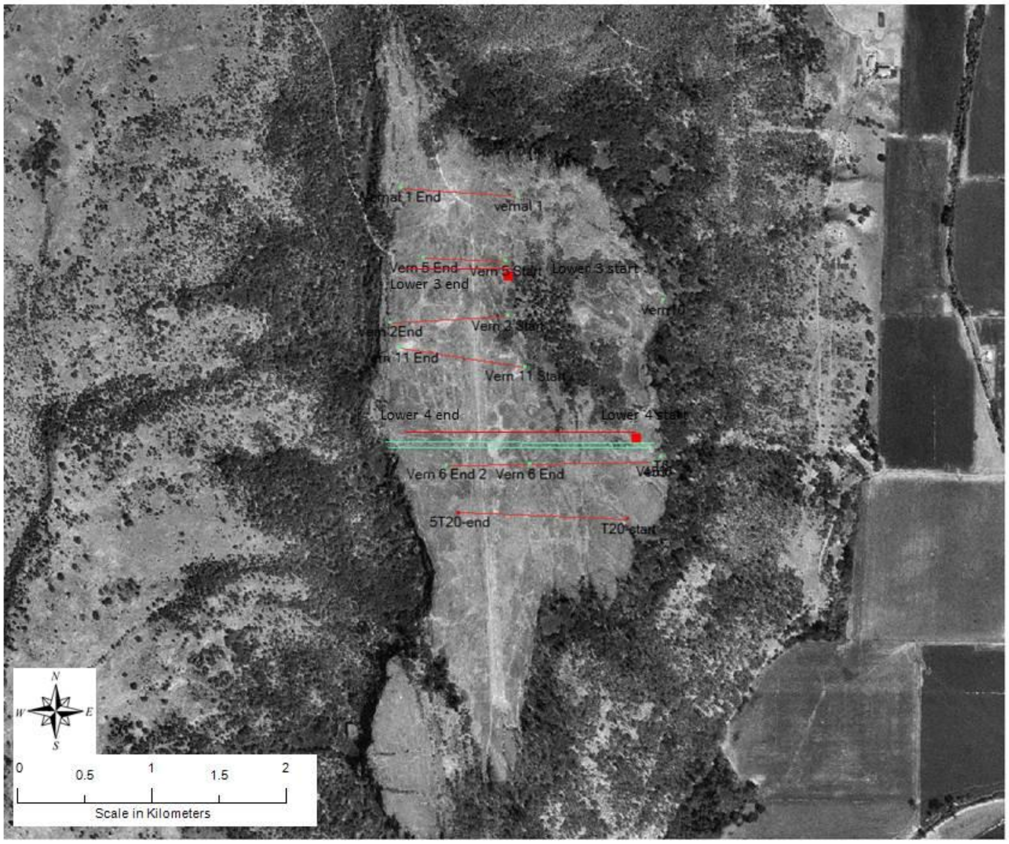


2009 trampling plot start points on Lower Table Rock. See Appendix B for plot azimuths and side of the tape to sample. End point GPS coordinates are also available in IAE files. Points are approximations only; plots could be ±25 feet from points.

2007 trampling plot start points on Lower Table Rock. See Appendix B for plot azimuths and side of the tape to sample. Points are approximations only; plots could be ±25 feet from points.

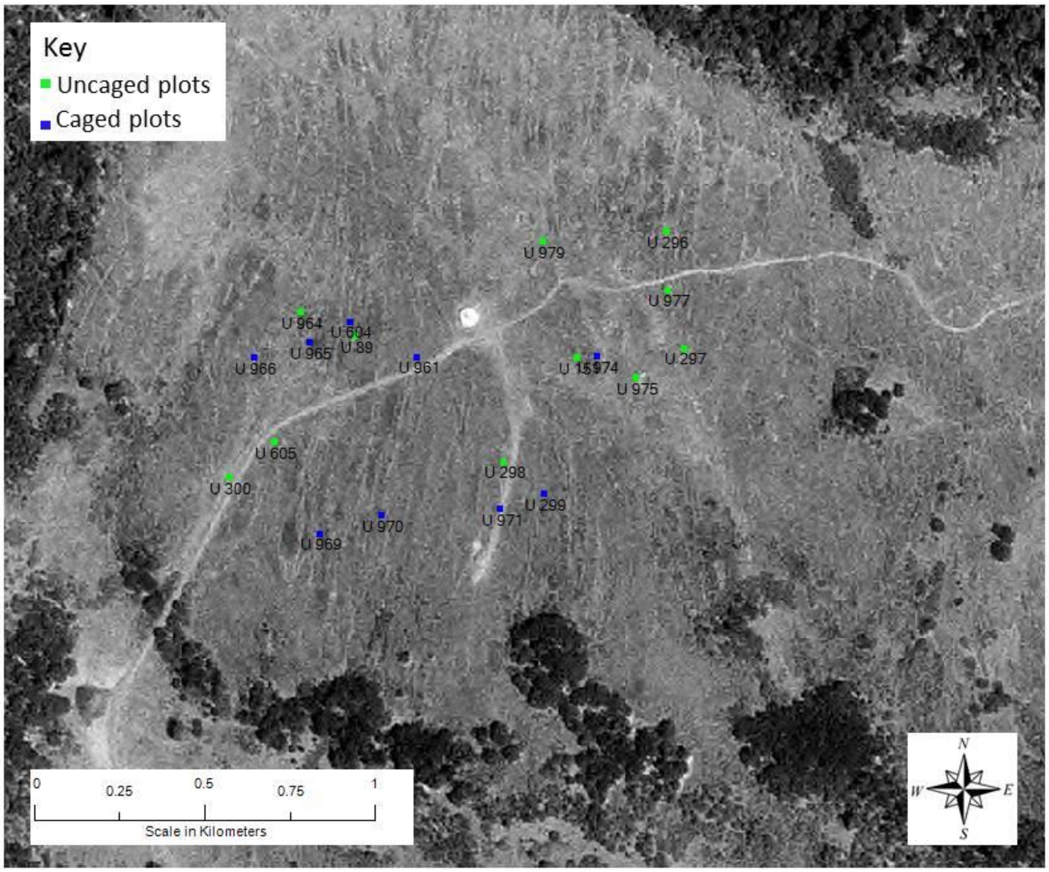
2007 grass removal plots on Lower Table Rock. Points are approximations only; plots could be ±25 feet from points. Plots were not sampled in 2009.

2009 Habitat transect start and end points at Lower Table Rock. Transects were run at 270°.

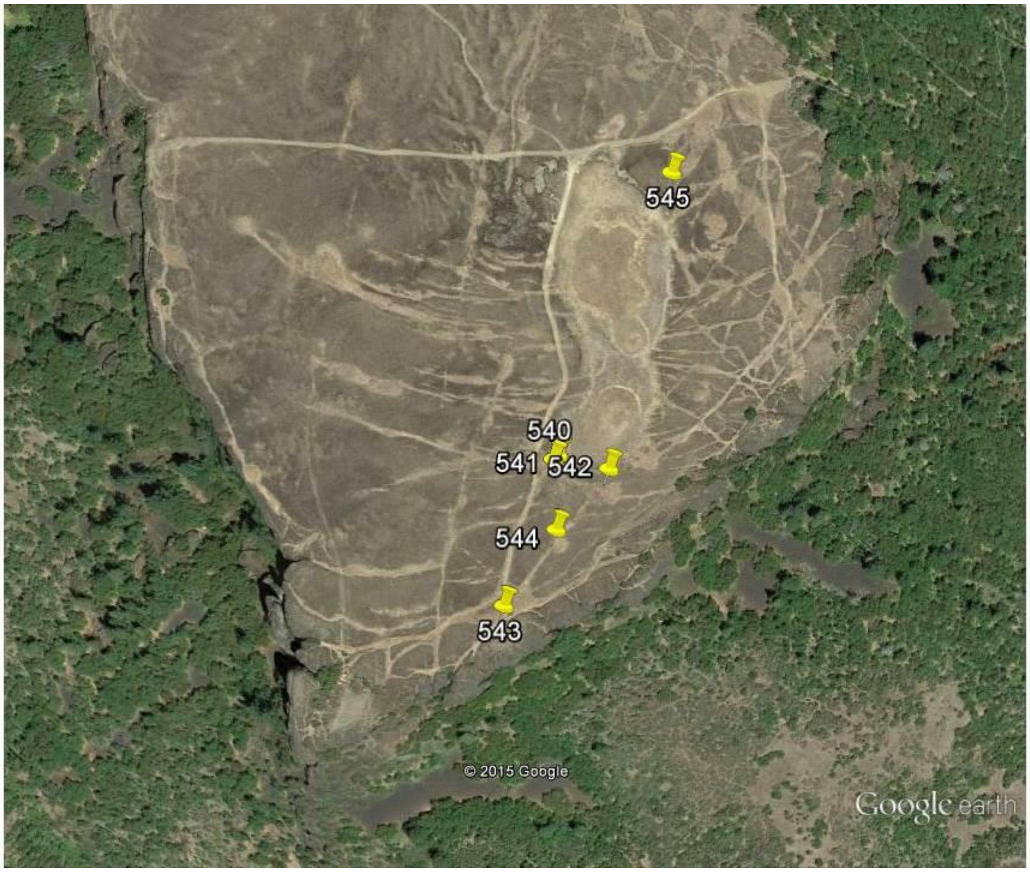


Upper Table Rock

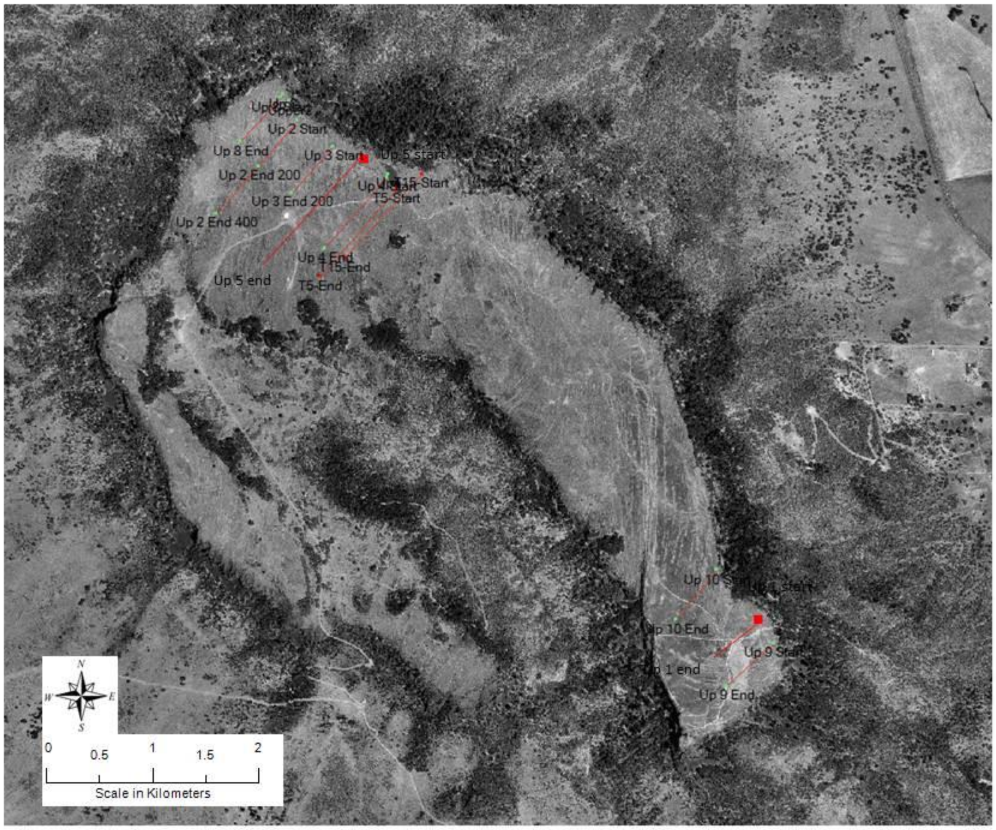
Long-term monitoring plot locations (were grazing plots) on Upper Table Rock North.



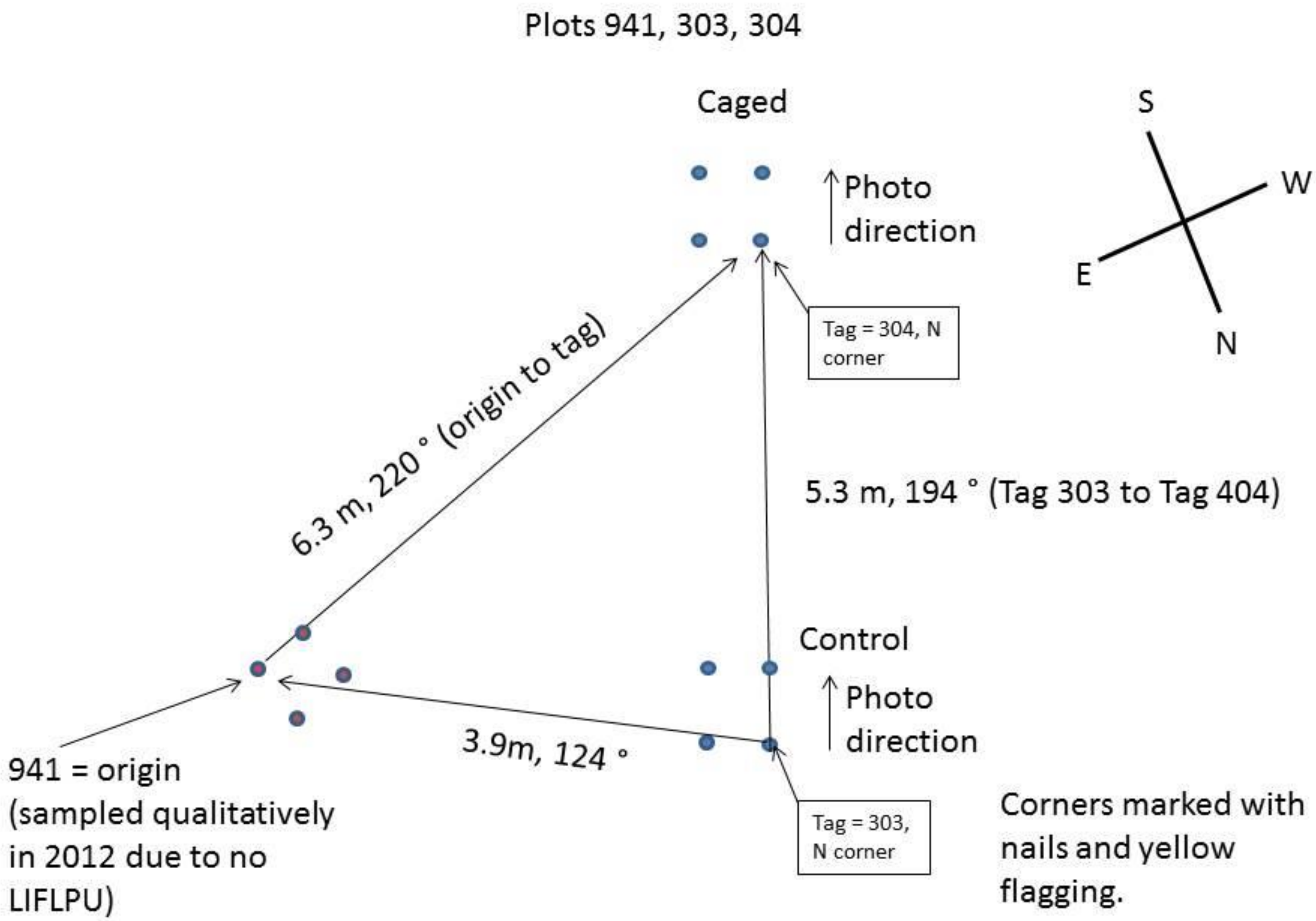
2015 *Limnanthes pumila* ssp. *pumila* monitoring plots on Upper Table Rocks South



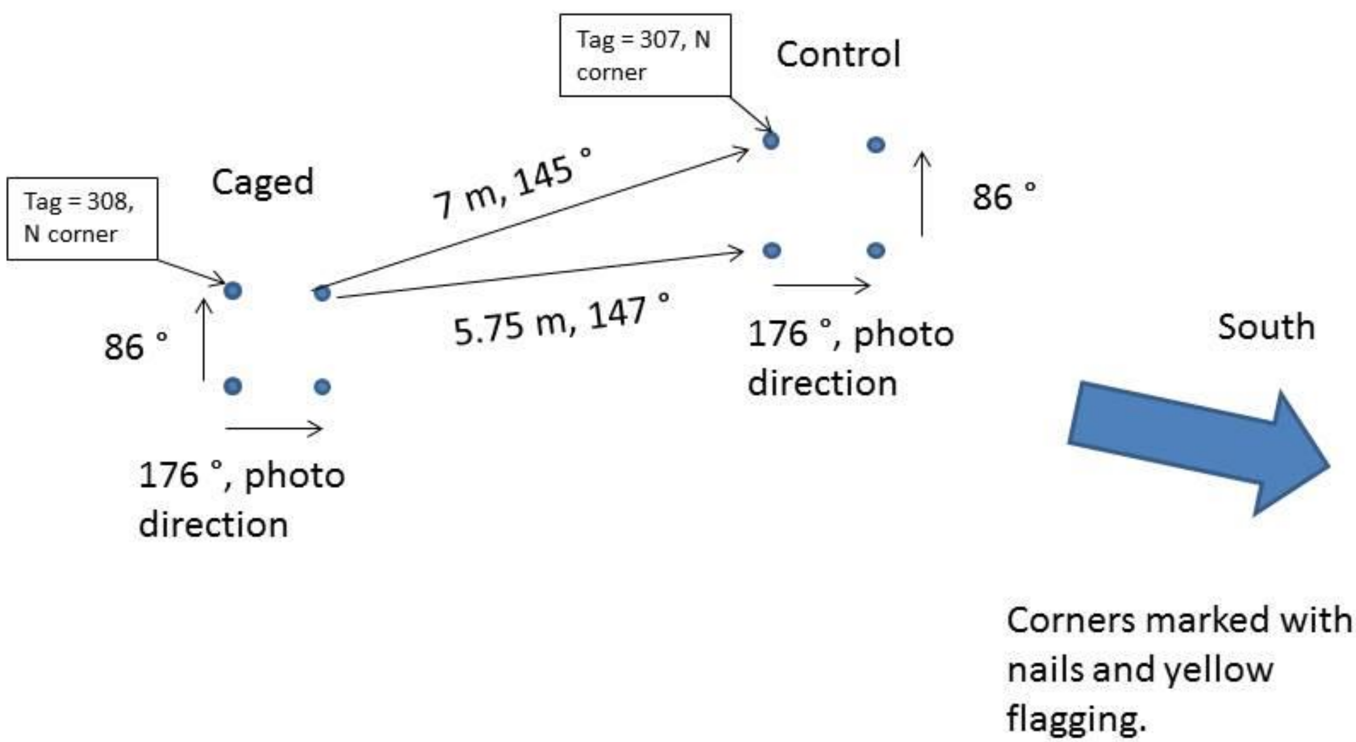
2009 Habitat transect start and end points at Upper Table Rock. Transects were run at 220°.



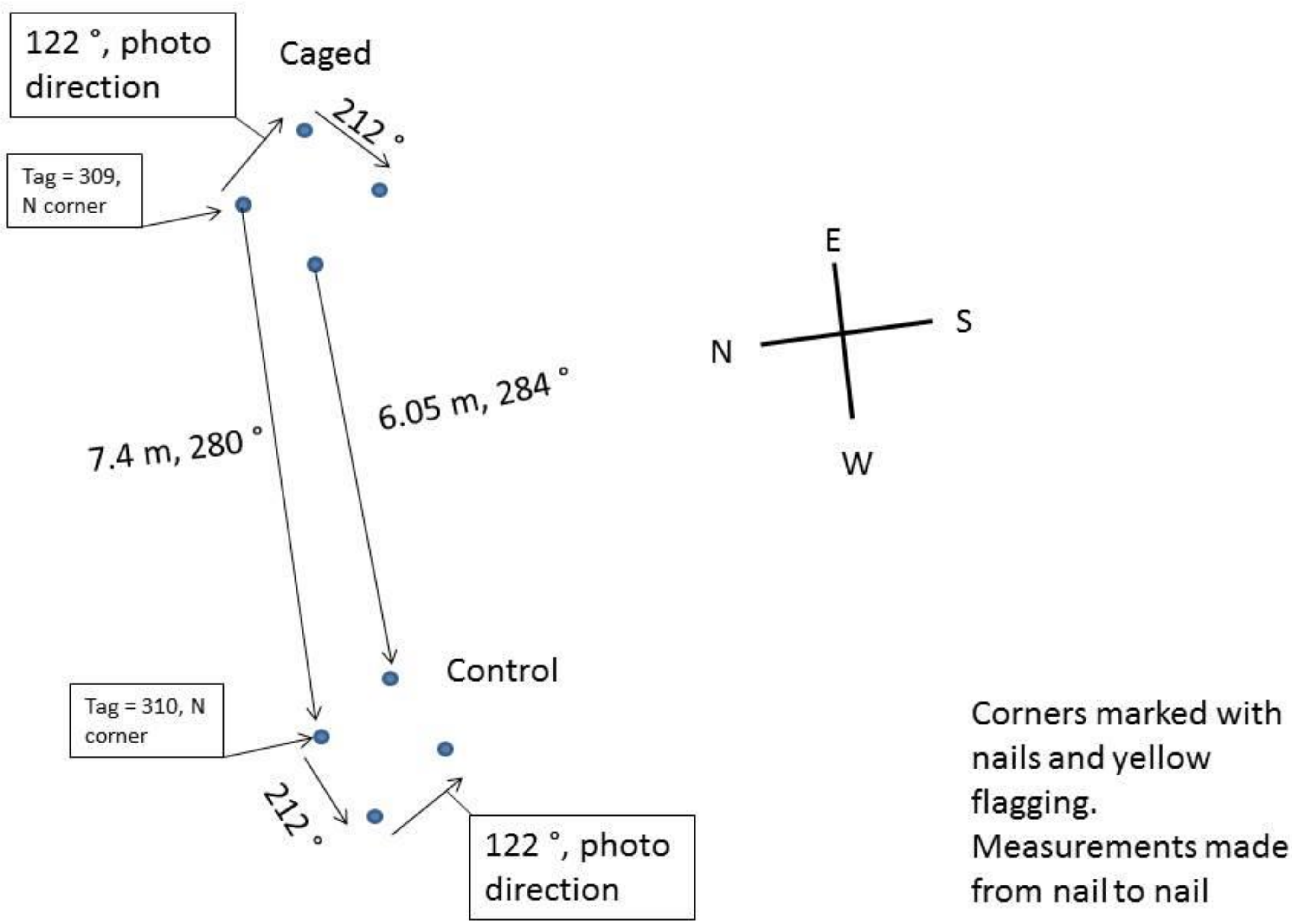
Maps of *L. pumila ssp. pumila* population monitoring plots established on Lower Table Rock in 2012

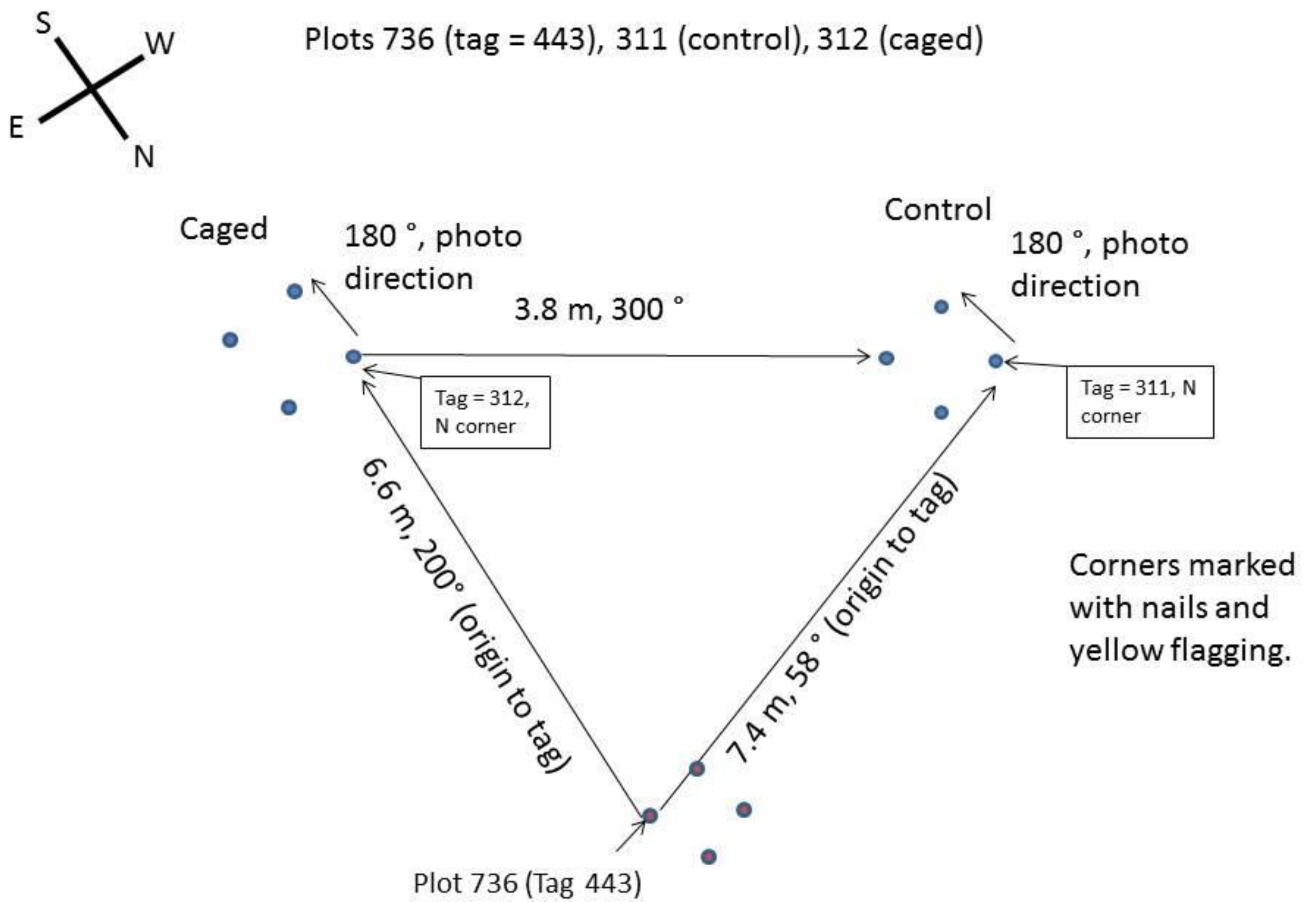


Plots 307 (control) & 308 (caged)



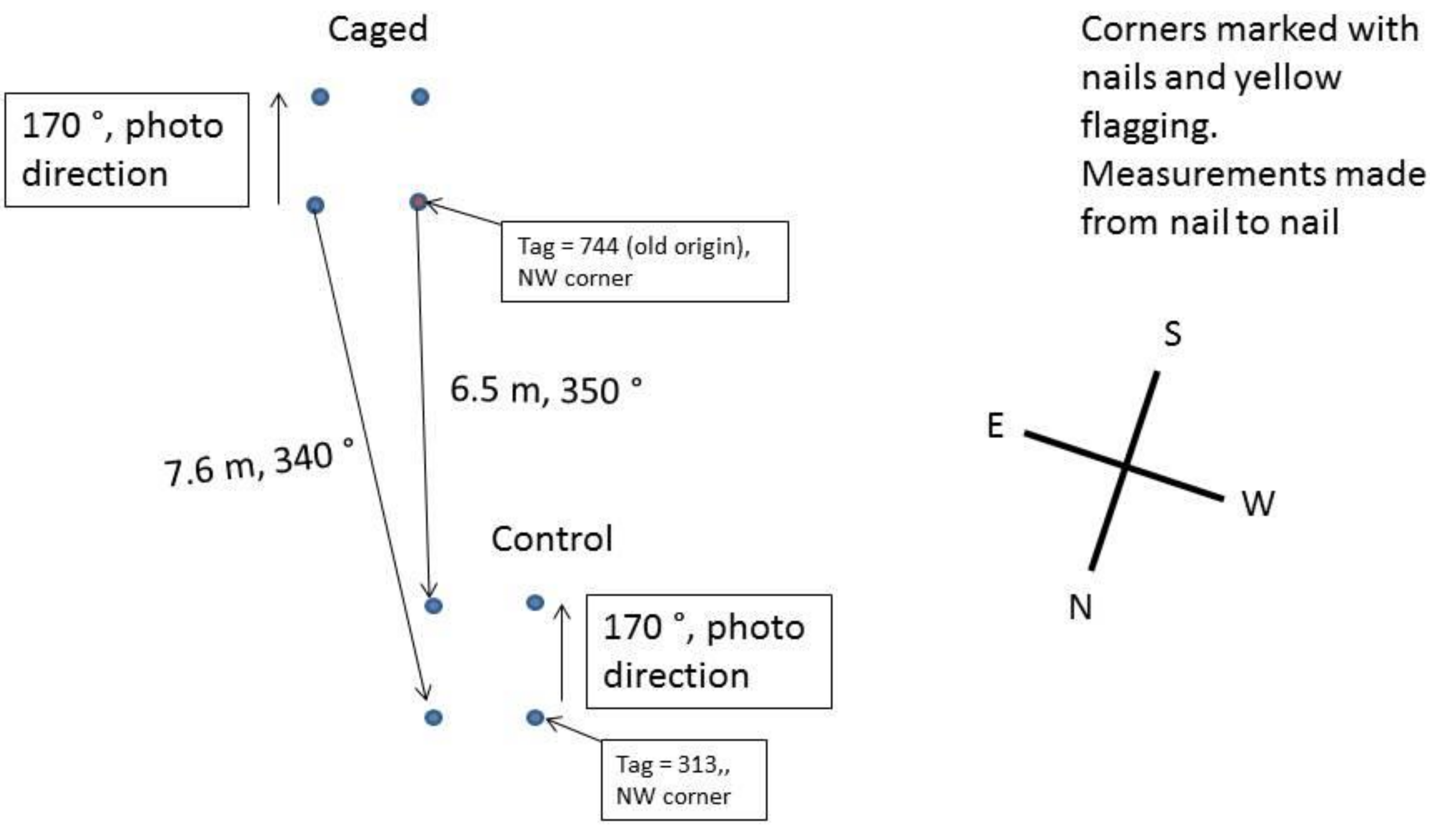
Plots 309 (caged) & 310 (control), near 944. 944 could not be located in 2012





736 (marker 443- conduit with pink/white tape = origin) sampled qualitatively in 2012 due to no LIFLPU.

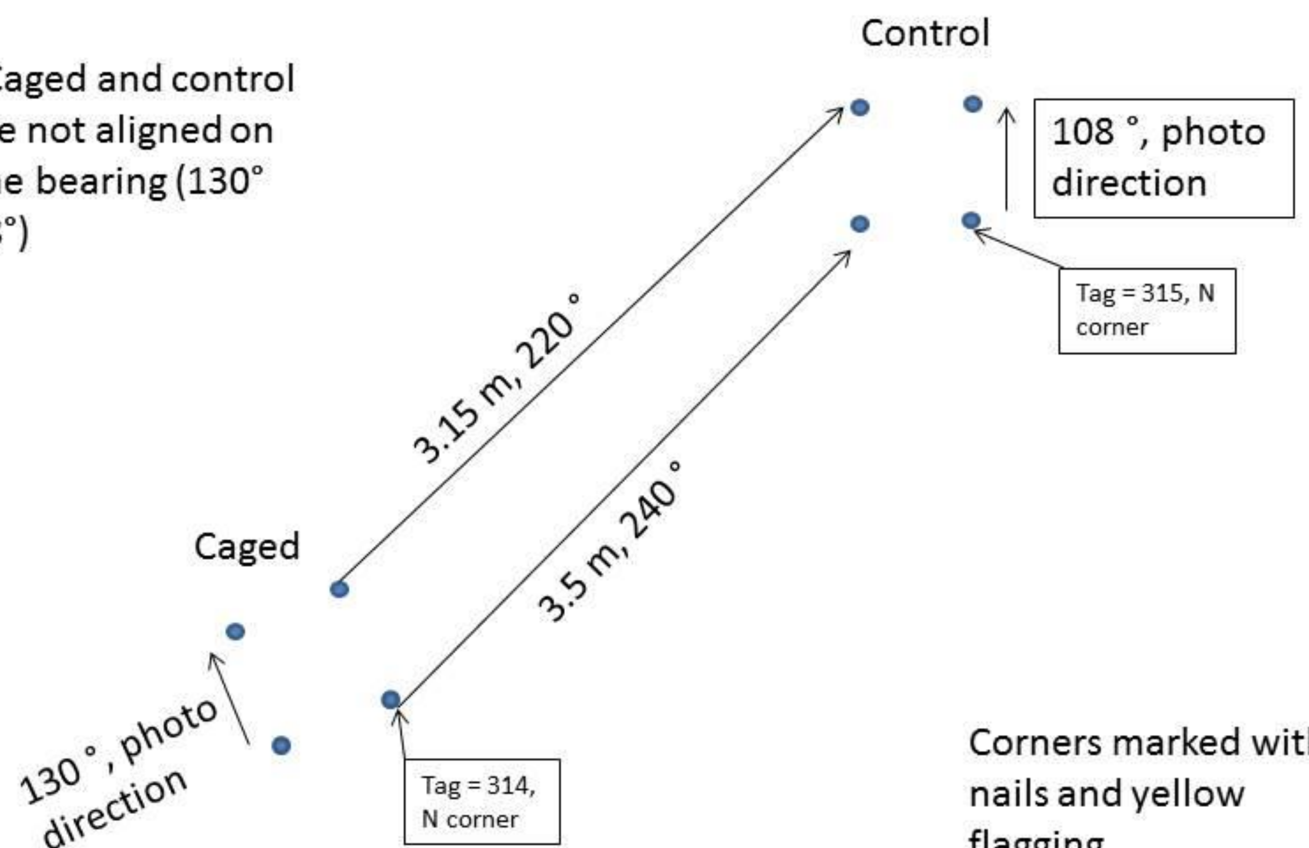
Plots 744 (caged plot & old origin) & 313 (control).



Tag 744 found, control sampled as in previous years (except its $1m^2$). Compare data to previous years for the control.

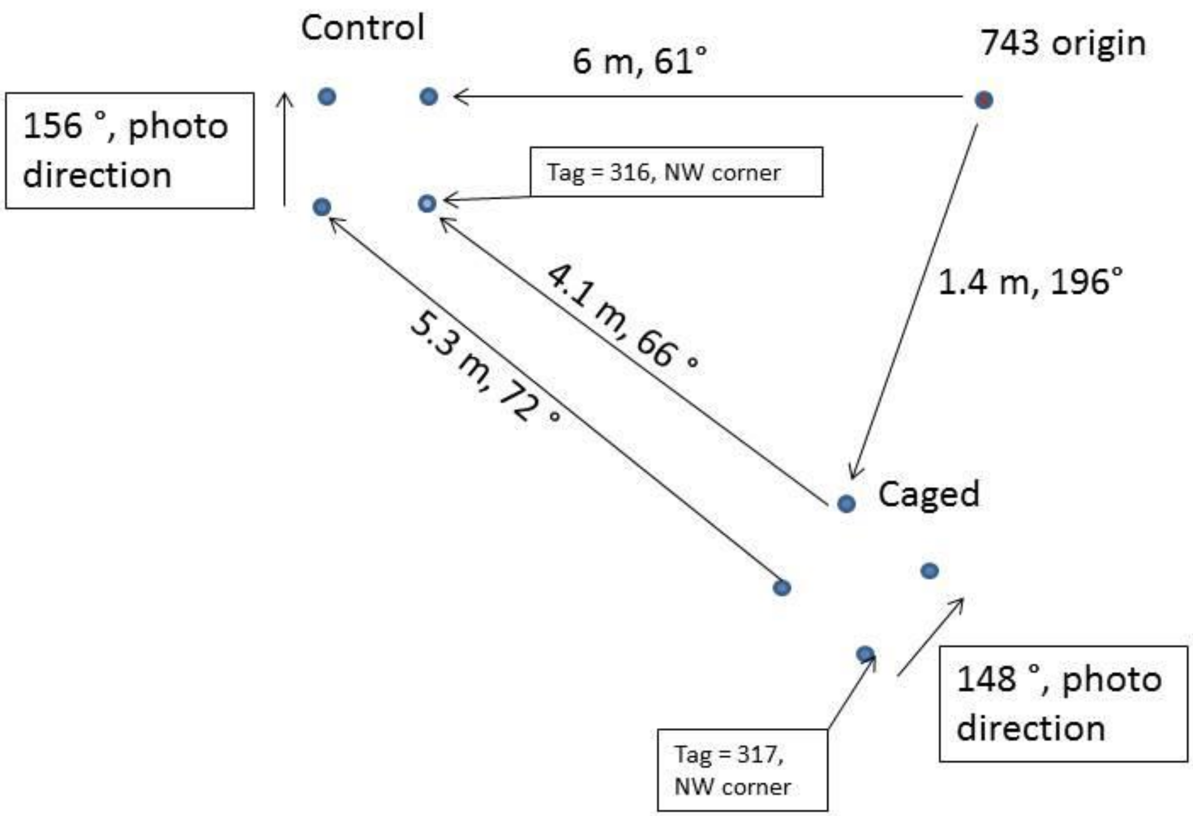
Plots 314 (caged) & 315 (control)

Note: Caged and control plots are not aligned on the same bearing (130° and 108°)



Corners marked with nails and yellow flagging. Measurements made from nail to nail

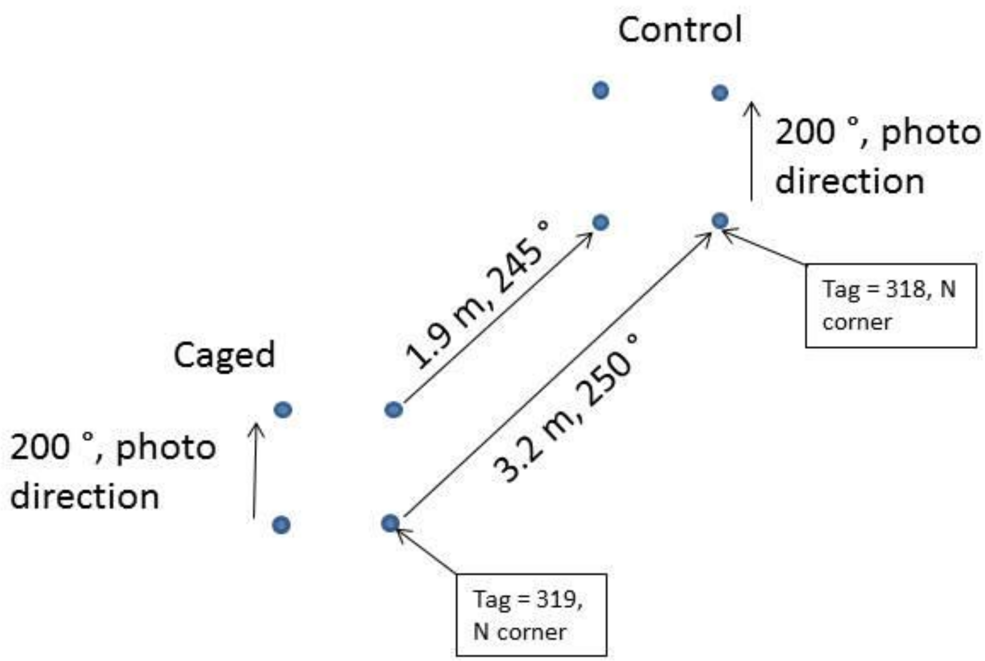
Plots 743 (origin), 316 (control) & 317 (caged).



Corners marked with nails and yellow flagging. Measurements made from nail to nail

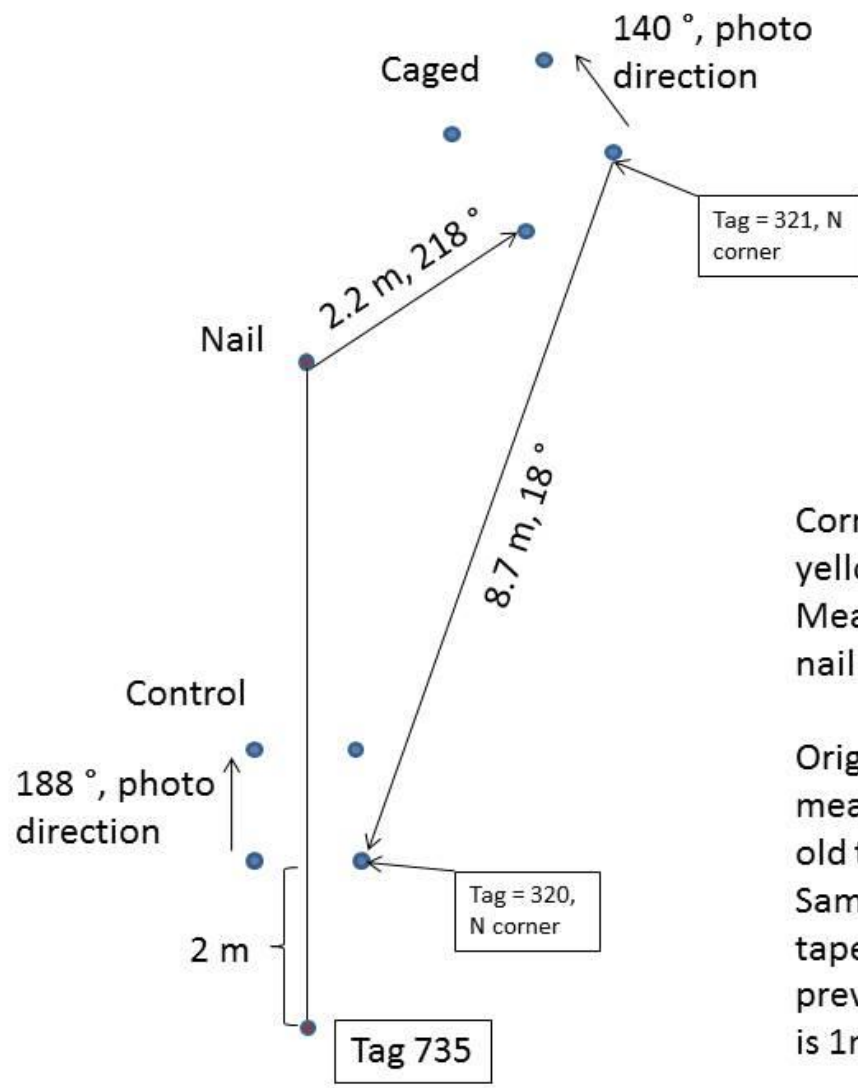
Tag 743 found, control placed 6 m from origin, not in the same place as previous years. Do not compare data to previous years for the control.

Plots 319 (caged) & 318 (control)



Corners marked with nails and yellow flagging. Measurements made from nail to nail

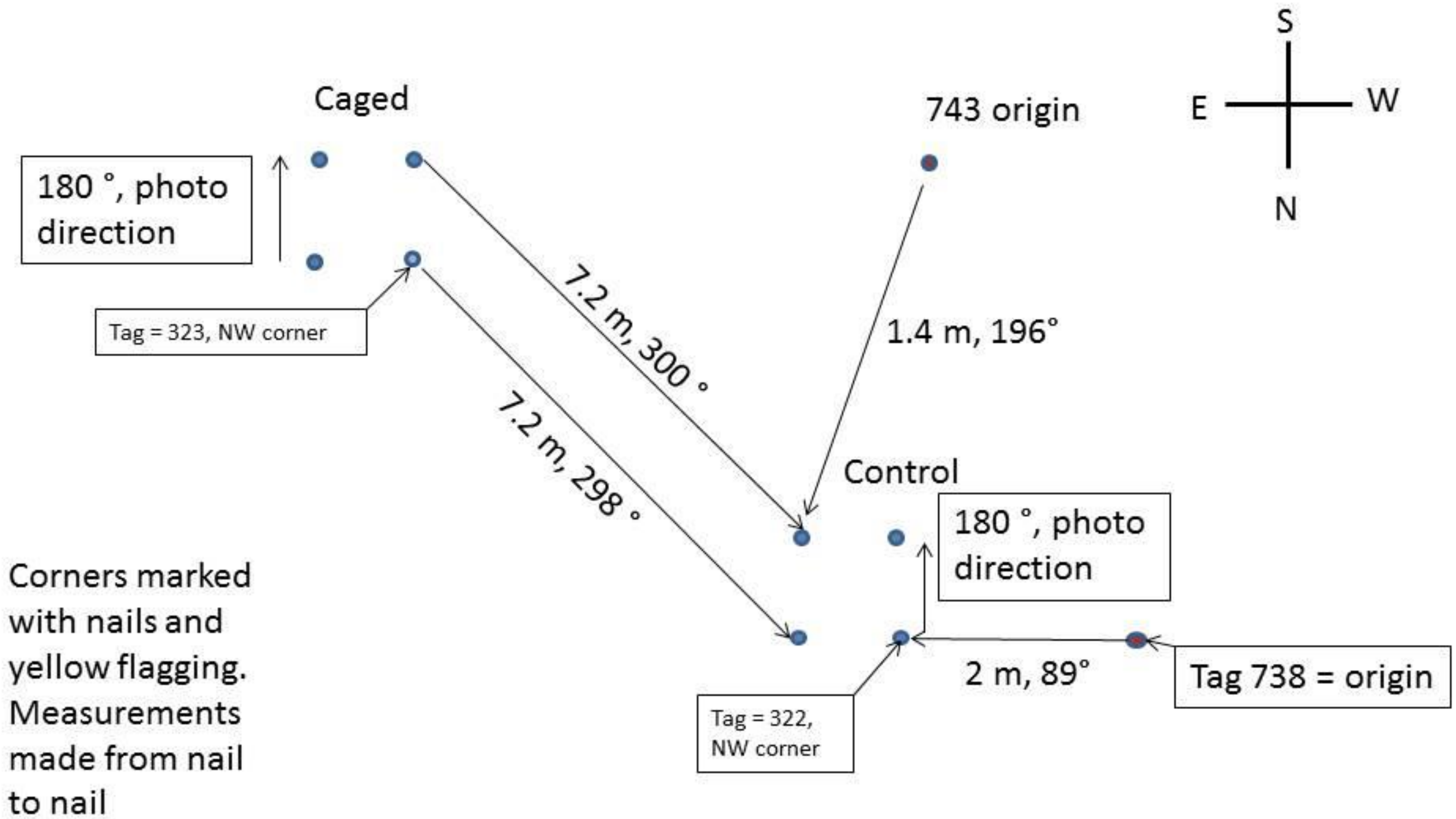
735, Plots 320 (control) & 321 (caged)



Corners marked with nails and yellow flagging. Measurements made from nail to nail.

Origin 735 found. Plot 320 measured from 2-3 m on the old transect (origin to 8 m. Sampled on both sides of the tape, can be compared to previous years, except that it is $1m^2$.

Plots 738 (origin), 322 (control) & 323 (caged).



Tag 738 found, control placed 2 m from origin, sampled as in previous years (except that it's 1m²). Can compare to previous years.

Appendix E. Photo-points taken in 2013 2014, and 2015 of caged and uncaged long-term monitoring plots.

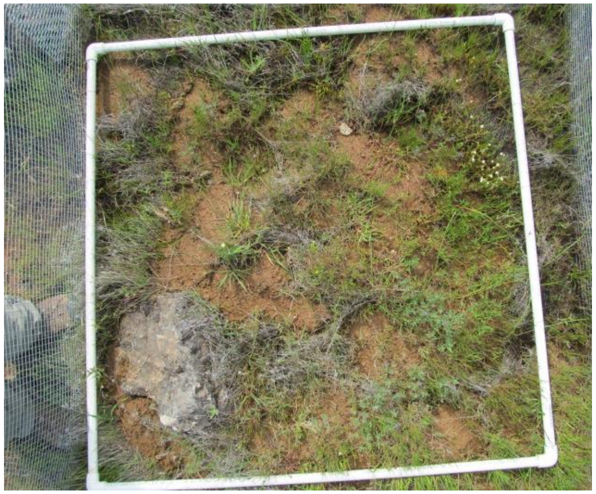
Plot 303 Uncaged- 2013 2014 2015

Plot 304 Caged- 2013 2014 2015

Plot 307- Uncaged 2013 2014 2015

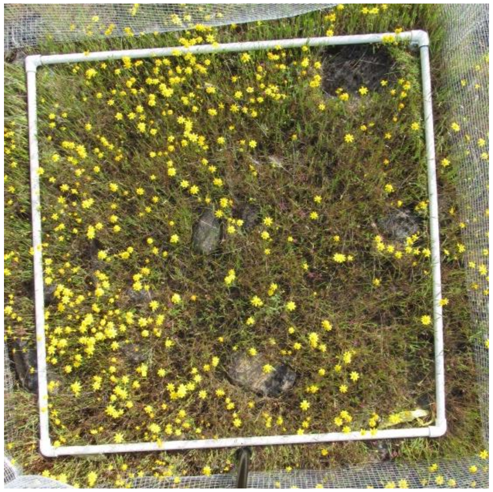


Plot 308- Caged 2013 2014 2015


Plot 309- Caged 2013 2014 2015

Plot not found in 2013



Plot 310- Uncaged 2013 2014 2015

Plot 311- Uncaged 2013 2014 2015



Plot 312- Caged 2013 | 2014 | 2015



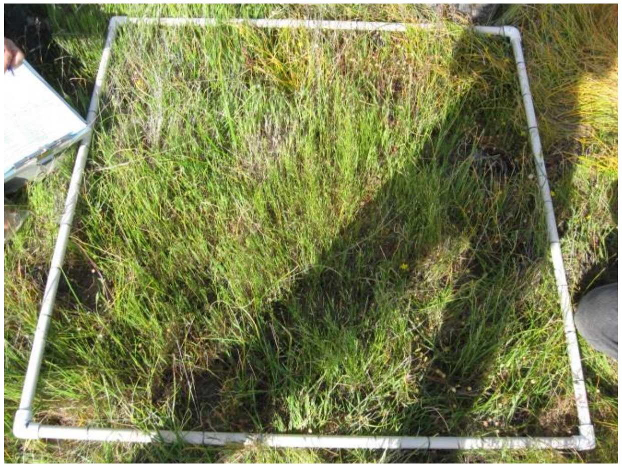
Plot 313- Uncaged 2013 | 2014 | 2015



Plot 314- Caged 2013 | 2014 | 2015



Plot 315- Uncaged 2013 | 2014 | 2015



Plot 316- Uncaged 2013 2014 2015



Plot 317- Caged 2013 2014 2015

Plot 318- Uncaged 2013 | 2014 | 2015

Plot 319- Caged 2013 | 2014 | 2015



Plot 320- Uncaged 2013 2014 2015


Plot 321- Caged 2013 2014 2015



Plot 322- Uncaged 2013 2014 2015



Plot 323- Caged 2013 2014 2015

Plot 744- Caged 2013 2014 2015

Appendix F. *Callitriche marginata* monitoring on Lower Table Rock (2008)

Callitriche marginata (winged water-starwort, Callitrichaceae, Figure 21) is a BLM Sensitive species in Oregon. This taxon is widely distributed along the west coast of North America from Baja California to British Columbia, with one disjunct population occurring in Portage County, Wisconsin. In Oregon this taxon is restricted to vernal pools in Jackson and Josephine counties and near The Dalles in Wasco County.

Figure 21. *Callitriche marginata* (winged water-starwort).

Callitriche marginata can be found floating on the surface or submerged up to 60 cm in wet areas, especially vernal pools, and often becomes stranded as its habitat dries out. This plant is easily recognizable in fruit because its pedicel ranges from 1 to 25 mm, significantly longer than any other *Callitriche* species on the west coast.

Methods

In May 2008 we estimated the cover of C. *marginata* at two vernal pools on Lower Table Rock. These were dubbed the North pool (N 42° 27.194' W 122° 57.037', WGS 84) and the South pool (N 42° 27.094' W 122° 57.055', WGS 84). The North pool was almost dried out; the water level was below the height of the standing vegetation. The South pool was long and many-channeled and had standing water in three smaller subsections (Figure 22). We monitored plant community composition in the largest water-filled pool at the South site by running a 5 m transect from the high water mark to the center of the pool; this layout captured the moisture gradient of the drying pool. Cover of every vascular plant and totals for nonvascular plants, duff, bare ground, dry mound, algae, footprints, and standing water were estimated in five 1 m^2 plots along the east side of the transect.

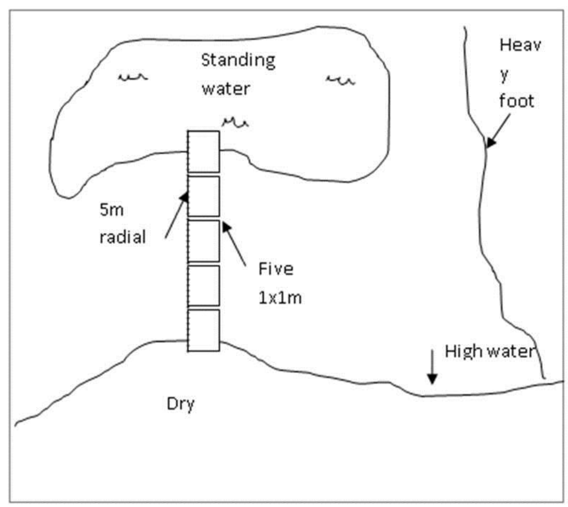


Figure 22. Five meter transect and layout of 1 m^2 cover plots at the South pool. The drawing is not to scale.

Results

Preliminary surveys found that approximately half of filled pools contained populations of *Callitriche marginata*. In one *Callitriche*-containing pool ('South pool'), *Callitriche* covered approximately 75% of the total water surface with relatively uniform density. The plants were post-anthesis and the fruits were maturing. The substrate of the pool was mineral soil with a few scattered rocks (Table 6). The sampled pool lies about 20 m from the main trail and appeared to receive quite a bit of foot traffic right up to the water's edge (Figure 9); during our visit a school group of about 50 students walked up to the edge of the pool.

Cover of vascular plants ranged from 29% to 50% and increased from the wet pool interior to the dry outer margin (Table 6). *Callitriche marginata* was dominant in the three interior plots whereas a mix of graminoids and forbs including *Plagiobothrys* spp. and *Deschampsia danthonioides* dominated the outer (drier) plots. Nonvascular and abiotic cover ranged from 48% to 85% and increased from the pool margins to the pool interior. Disturbance by people (footprints) was most evident in the pool interior (Figure 23).

Figure 23. Heavy foot traffic through the South pool (left) with a close-up of boot prints in the mud (right).

Table 6. Percent cover of biotic and abiotic variables in each plot at the South pool. Plot 1 was at the dry margin of the pool whereas Plot 5 was in the pool's interior.

	Percent Cover				
Species List	**Plot 1**	**Plot 2**	**Plot 3**	**Plot 4**	**Plot 5**
Alopecurus saccatus	0	2	1	1	1
Poaceae sp.	0	2	0	0	0
Lasthenia californica	1	2	1	0	0
Black tip	0	0	0	0	0
Callitriche marginata (dry) (a subset of 'duff')	5	0	19	20	10
Callitriche marginata (wet)	0	0	0	0	10
cf. *Navarretia leucocephala* (corolla tube small)	5	4	1	3	2
Caryophyllaceae sp.	0	4	1	1	1
Claytonia sp.	0	0	0	0	0
Deschampsia danthonioides	12	0	0	0	0
Eleocharis acicularis	3	4	2	3	2
Plagiobothrys sp. (long lvs)	0	2	2	1	0
Plagiobothrys sp. (short lvs)	15	20	5	1	1
Eremocarpus setigerus	9	8	4	2	2
nonvascular	6	6	0	0	0
bare ground	7	40	40	40	30
footprint	0	0	0.5	0	5
dry/mound	20	0	0	0	0
standing water	0	0	0	0	20
duff	25	2	30	20	10
algae	0	0	0	20	20
Total Cover:	**108**	**96**	**106.5**	**113**	**114**

Appendix G. Effects of trampling on *Limnanthes pumila* ssp. *pumila* on Lower Table Rock (2007-2011)

Experimental trampling plots are an effective method to test the effects of different levels of physical impact on plant populations (Hylgaard and Liddle 1981, Ikeda and Okutomi 1992, Cole 1995, Cole and Monz 2002). We established ten 8 m x 0.5 m trampling plots on Lower Table Rock in both 2007 and 2009; each plot consisted of 4 - 1.5 m x 0.5 m subplots with a 0.5 m buffer separating each subplot (Figure 24). Two corners of each plot were marked with rebar that extended slightly above the soil surface and a large nail with a metal washer sunk into the soil. The location of each plot was recorded with a GPS unit. In 2007, we noted the distance and direction to each plot from 'reference' spikes located near the main trail (Appendix B, Appendix D). However, as these spikes were also removed prior to our next sampling period, we did not use this method in 2009.

We counted the total number of *L. pumila ssp. pumila* individuals and the number of flowers on ten plants within each subplot prior to treatment in 2007 and 2009. Haphazardly selected individuals were identified by being closest to one of ten randomly dropped pin flags. If ten or less plants were present in a subplot, each one was measured. One of four treatments (0, 10, 50, and 100 passes) was randomly applied to each subplot. Passes were accomplished by walking normally through the length of the subplot area (from buffer to buffer); passes were evenly distributed throughout the subplot. Plots were trampled and monitored to the side of the tape recorded in Appendix B; if no side was noted, plots were sampled west of the tape.

The percent cover of *L. pumila ssp. pumila* and graminoids as determined by ocular estimation was also recorded before trampling in the 2009 plots. These measurements were repeated in May 2008 when we relocated eight of the ten trampling plots. Due to time constraints and difficulty locating the plots (the majority of the plot markers had again been removed), these plots were not monitored in 2009. In 2010, we monitored the three remaining 2007 trampling plots and all 2009 plots. We monitored two of the remaining 2007 plots [only the portions that had not been trampled (0 passes)] and all of the 2009 trampling plots in 2011. 2012 monitoring results are discussed on page 6.

Results

Trampling caused a decline in the number of *L. pumila ssp. pumila* individuals ($p = 0.09$) in plots established in 2007 and monitored in 2008. This was driven by a difference in the number of plants per plot when the control treatment (0 passes) was compared to trampling with 50 or 100 passes ($p = 0.01$ and 0.03 respectively, Bonferroni adjusted $\alpha = 0.01$; Figure 25). There was no effect of trampling on flowers per plant (Figure 25). Two of the 2007 trampling plots were relocated and monitored in 2011. Changes in number of plants and flowers per plant varied among the treatments, but were not significant.

One year after the 2009 trampling, there was a tendency for a lower number of plants as trampling intensity increased, but this was not significant ($p = 0.40$; Figure 25). In 2011, plots that were trampled in 2009 decreased in both number of plants and number of flowers per plant with increased trampling, though number of plants were much less than the previous year across all treatments, including the control (Figure 25). The number of flowers per plant steadily decreased across years for all treatments, and decreased with increasing trampling in 2011.

Differences in results between treatment years may at least partially be influenced by the timing of trampling relative to plant phenology. In 2007, plants were in peak flower and had not yet produced fruit. Thus, it is likely that the lower number of plants in the heavy trampling treatments were caused by the lower number of seeds produced in the plots that year. In contrast, in 2009, the majority of plants had already set seed. In these plots, trampling was unlikely to significantly reduce the number of seeds entering the seed bank that year. Damage to these populations may be minimized by limiting access to the pool edges that support populations of *L. pumila ssp. pumila* while the plants are actively growing and reproducing.

Although the plots that were heavily trampled in 2007 appeared to have recovered in 2010, it is important to note that our treatments only occurred once. High volume traffic (both within a day and over several days) may cause greater ecosystem impacts (e.g. soil compaction) than observed in these plots. One large group may have the same impact as our concentrated trampling treatments of 50 and 100 passes, only over larger areas of the landscape. We recommend continued monitoring to assess any long-term impacts of trampling.

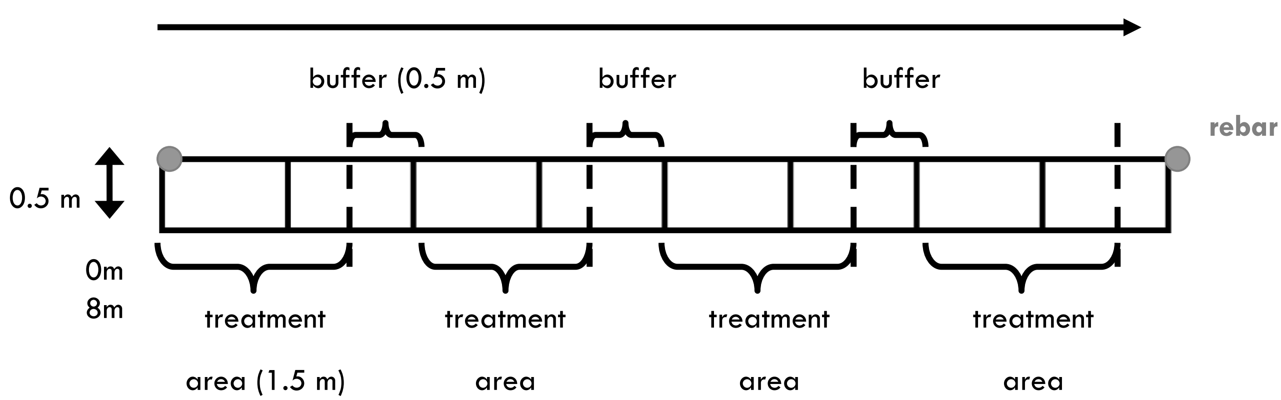


Figure 24. Trampling plot layout on Lower Table Rock. A 0.5 m buffer separated each 1.5m treatment area.

Table 7. Average number of plants and flowers per plant of *Limnanthes pumila ssp. pumila* in Trampling plots on Lower Table Rock in 2007-2011. Values are ± 1 S.E. "N/A" denotes data that are not available because plots were not sampled.

Plot	# plants ± 1 S.E.					# flowers ± 1 S.E.				
	2007	2008	2009	2010	2011	2007	2008	2009	2010	2011
2007 Trampling plots										
0 passes	62.5 ± 11.4	75.5 ± 11.5	N/A	75.3 ± 36.6	N/A	3.7 ± 0.4	2.1 ± 0.3	N/A	2.2 ± 0.3	N/A
10 passes	92.7 ± 10.8	68.1 ± 21.4	N/A	47.0 ± 10.1	N/A	3.7 ± 0.6	1.5 ± 0.3	N/A	2.2 ± 0.1	N/A
50 passes	77.5 ± 10.7	35.5 ± 6.0	N/A	18.6 ± 19.1	N/A	3.2 ± 0.4	3.1 ± 1.1	N/A	7.8 ± 0.1	N/A
100 passes	70.2 ± 9.7	40.9 ± 9.4	N/A	55.7 ± 23.2	N/A	3.1 ± 0.3	2.3 ± 0.5	N/A	2.2 ± 0.7	N/A
2009 Trampling plots										
0 passes	N/A	N/A	81.1 ± 13.8	149.2 ± 20.1	38.2 ± 9	N/A	N/A	4.0 ± 0.4	2.5 ± 0.2	2.0 ± 0.2
10 passes	N/A	N/A	58.7 ± 9.8	143.9 ± 20.5	41.1 ± 16.7	N/A	N/A	4.3 ± 0.5	2.8 ± 0.3	1.6 ± 0.3
50 passes	N/A	N/A	87.8 ± 24.1	128.8 ± 33.2	13.6 ± 5.1	N/A	N/A	3.5 ± 0.3	2.8 ± 0.2	1.3 ± 0.4
100 passes	N/A	N/A	74.5 ± 14.9	118.6 ± 36.7	14.3 ± 5.4	N/A	N/A	4.7 ± 0.8	3.4 ± 0.5	1.3 ± 0.3

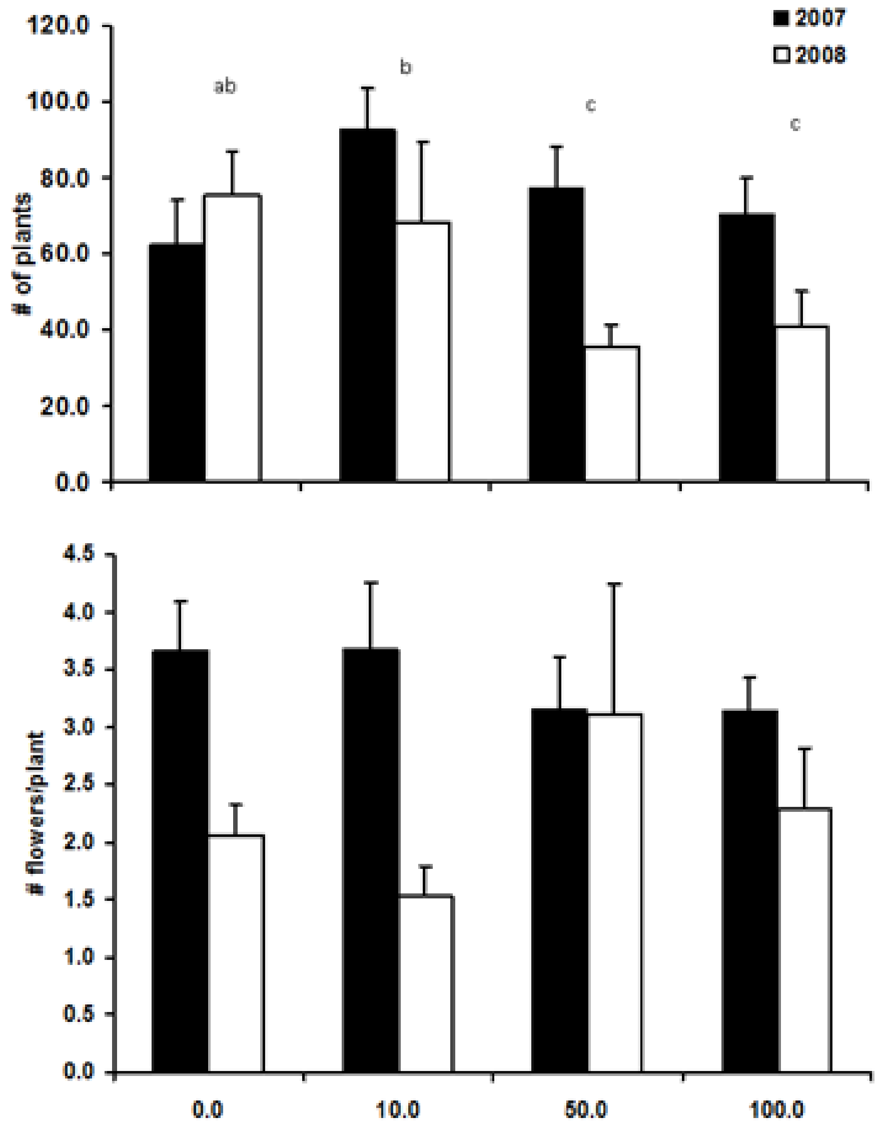


Figure 25. Number of plants (top) and flowers per plant (bottom) in trampling plots on Lower Table Rock in 2007 and 2008. Error bars are + 1 S.E. There was a difference between treatments on the number of plants ($p = 0.0897$). Different letters indicate significant differences between treatments in 2008 ($p < 0.05$). There was no treatment effect on the number of flowers per plant.

Appendix H. Effects of grass removal on *Limnanthes pumila ssp. pumila* on Lower Table Rock (2007-2008)

Ten 1 m^2 grass removal plots were established on Lower Table Rock in 2007 to compare the growth of *L. pumila ssp. pumila* in plots with and without competition by graminoids. Plots with at least 50% cover of graminoids were selected for treatment. Two corners of each plot were marked with rebar that extended slightly above the soil surface and a large nail with a metal washer sunk into the soil. The location of each plot was recorded with a GPS unit and a compass bearing and distance from an origin spike (Appendix B). Each plot was divided into two subplots (1 m x 0.5 m), which were randomly assigned as either control or treatment. All graminoids and thatch were removed by hand-pulling in treatment plots. Prior to treatment, we determined the total number of *L. pumila ssp. pumila* individuals in each subplot and the number of flowers on ten haphazardly selected individuals.

Six of the ten plots were relocated in May 2008 and surveyed as in May 2007. Additional information recorded included total percent cover by *L. pumila ssp. pumila* and graminoid species. Several plots were partially reestablished because corner markers were either disrupted or missing. Plots that could not be accurately reestablished were considered lost. Data collection for these plots was suspended in 2009.

Data analysis

An ANCOVA was used to determine the effects of trampling and grass removal in 2008 (NCSS v. 07.1.12). Pairwise comparisons were used to test for differences between treatments using a Bonferroni correction for multiple comparisons. In all ANCOVAs, the response variable was the number of plants or flowers per plant in the respective treatment's plots in 2008 and the covariate was the number of plants or flowers per plant in 2007. Plots not located and sampled in 2008 were deleted from the analyzed datasets (4 grass removal and 2 trampling plots). The same tests were run for trampling plots established in 2009 using 2010 data, and for the three trampling plots from 2007 that were relocated in 2010 (SPSS v. 17.0, 2009). A Repeated Measures General Linear Model (GLM) was used to determine the effects of grazing exclosure plots (SPSS 17.0, 2009) using either the number of plants or the number of flowers per plant in 2008 and 2009 as the response variable and the 2007 data as the covariate.

Results

When plots originally weeded in May 2007 were revisited in fall 2007, we observed that grass had not reinvaded the weeded half of the plots, suggesting that this treatment was effective for the first season. However, the effects of a one-time grass removal appeared to be transitory, and grass cover was similar in treated and untreated plots in 2008. In 2008, the number of *L. pumila ssp. pumila* did not differ with grass removal (Figure 26; Table 8, $p = 0.55$). The number of flowers per plant also did not change significantly with grass removal ($p = 0.35$; Table 8).

Because many exotic grasses are annuals, enough seed may persist in the seedbank to overwhelm the effects of a single removal treatment. It is likely that any treatments expected to have a beneficial impact would need to be repeated over several years.

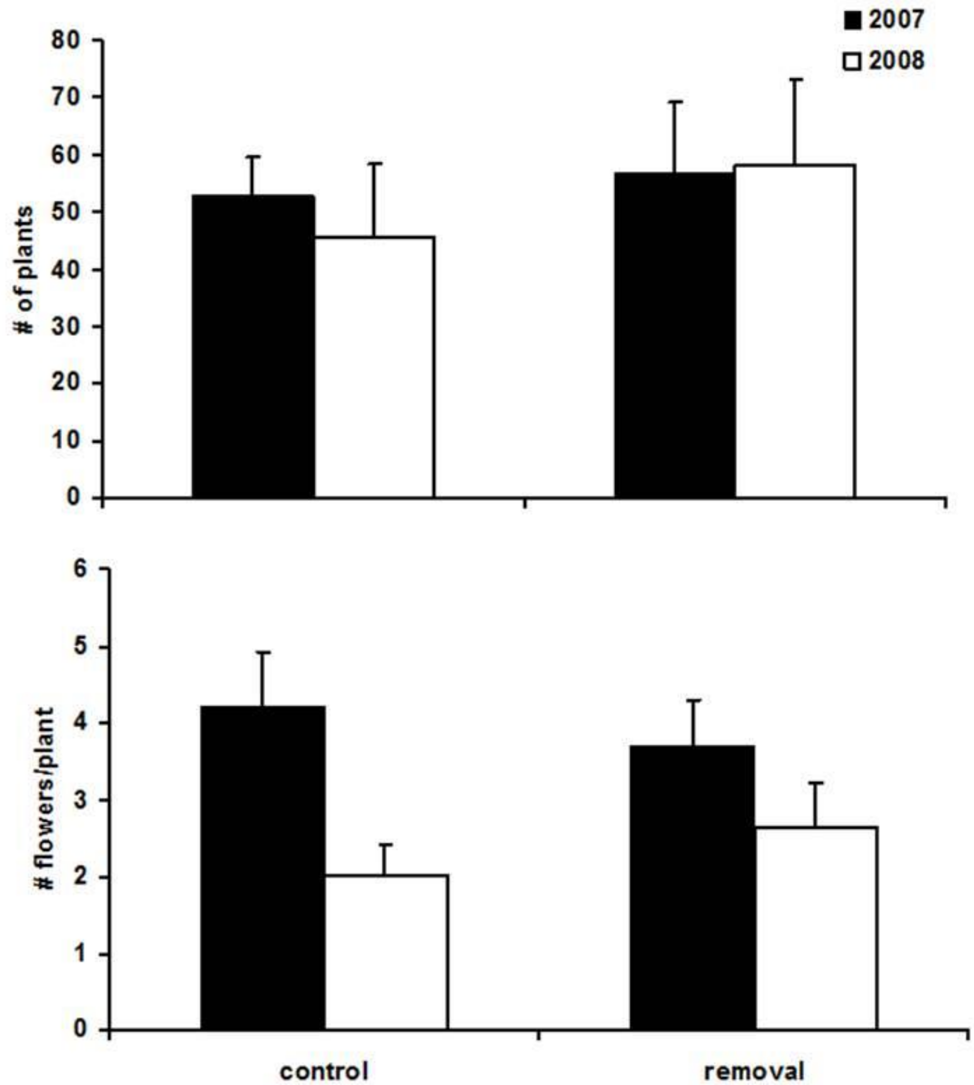


Figure 26. Number of plants (top) and flowers per plant (bottom) in grass removal plots on Lower Table Rock in 2007 and 2008. Error bars are + 1 S.E.

Table 8. Average number of plants and flowers per plant of *Limnanthes pumila ssp. pumila* in Grass Removal plots on Lower Table Rock in 2007-2008. Values are ± 1 S.E. "N/A" denotes data that are not available because plots were not sampled.

Plot	# plants ± 1 S.E.		# flowers ± 1 S.E.	
	2007	2008	2007	2008
Grass removal plots				
Control	52.7 ± 7.0	45.8 ± 12.5	4.2 ± 0.7	2.0 ± 0.4
Removal	56.9 ± 12.4	58 ± 15.1	3.7 ± 0.6	2.6 ± 0.6

Appendix I. Habitat quality surveys 2009-2011

Methods

In May 2009 transects ranging in length from 200 to 487 meters (depending on terrain) were sampled on Upper Table Rock (6 transects) and Lower Table Rock (5 transects). To increase sample sizes and monitoring accuracy three additional transects were established and sampled in 2010: two on Upper Table Rock and one on Lower Table Rock. Four more transects were installed and sampled in 2011, two each on Upper and Lower Table Rocks, with the longest measuring 600 m. Transect origins were located on the east sides of Upper and Lower Table Rocks (see Appendix D for maps of plots and their orientations). Origins were selected using a stratified random design in order to sample from an unbiased, but representative area on each Table Rock. BLM-managed habitat was divided into smaller sections and origin points randomly selected within each section. Transects were run at parallel azimuths (270° at Lower, 220° at Upper) and were extended to capture the variety of habitat types across the landscape (e.g. mounds, pools, and flats). Transect origins and ends were recorded with a GPS unit; transects were otherwise un-monumented.

1 m^2 plots were used to monitor plant community composition along each transect. The first plot on each transect was randomly placed on the south side of the transect tape between 0 m and 30 m. Sampling continued at 25 meter intervals thereafter. Within each plot, we recorded the percent cover of all vascular plant species and ground surface (bare ground, litter, rock, moss, and water). Cover in each plot was at least 100% and often exceeded 100% when there were overlapping vegetation layers. We also recorded the habitat type (pool, mound, or flat) of each plot. Disturbance and rare species data were also recorded at every point where they occurred along transects (presence value). Disturbance categories included: cattle feces <1 year, cattle feces >1 year, cattle prints, other animal prints, other animal feces, new rodent hole, old rodent hole, primary trail, secondary trail, human footprints (non-IAE), human footprints (IAE), and other impacts. Species composition data from the quadrats were summarized by Table Rock (Upper vs. Lower) and habitat type (flat, mound, or pool). Summary data included frequency (the percent of quadrats of a given category occupied by a species) and the average cover of the species (across all representative plots, not just the ones occupied). We also summarized the native and exotic cover of major functional groups (annual vs. perennial, forbs vs. grasses) for each Table Rock.

We used a common ordination method, non-metric multidimensional scaling (NMS, Kruskal 1964), to compare the species composition by habitat type. NMS is an ordination method that is best used for community variables with non-normal data and non-linear relationships (McCune and Grace 2002). Due to heterogeneity in the data set, rare species that occurred in 10% or less of the plots were deleted. We fit descriptive abiotic and biotic explanatory variables (litter, moss, rock, water, total native cover, total exotic cover, and total cover of functional group categories: annual, perennial, forb, grass and shrub) onto the ordination to understand the correlation between these factors and species composition. NMS ordinations were performed using PC-ORD version 6.0 (McCune and Mefford 2011) with the autopilot setting "slow and thorough" mode, Sørensen distance measure, and no penalty for ties.

To explore the relationship between disturbance types and habitat on each Table Rock, data collected for disturbance types were converted to proportions of disturbance type along each transect. Mean proportions of each disturbance type were calculated for all transects on either the Upper or Lower Table Rock to enable comparisons between Table Rock and disturbance type. To explore the relationship between habitat type (flat, pool, or mound) and disturbances on Upper and Lower Table rocks, frequency of disturbance was calculated within habitat types along each transect. Mean proportions of these disturbances were then calculated.

Results and Discussion

One hundred forty-four vascular plant species were found along habitat transects at Upper and Lower Table Rocks in 2009 and 2011 (Table 11). About 65% (94) of these species were native while 20% (29) were exotic; an additional 21 species could not be identified and thus their nativity is undetermined. Common native species within plots (regardless of habitat type) included: *Castilleja attenuata, Lupinus bicolor, Lasthenia californica, Linanthus bicolor, Collinsia grandiflora, Deschampsia danthonioides,* and *Trifolium depauperatum*. Common exotic species included *Poa bulbosa, Taeniatherum caput-medusae, Bromus hordeaceus* ssp. *hordeaceus, Draba verna* and *Aira caryophyllea*. Other species were specific to a certain habitat type, or on a specific Table Rock.

Bare ground and litter were present in all plots on both Table Rocks (Table 9), although the average cover of bare ground was low. Litter cover was generally higher on mounds where the plant community was dominated by graminoids. Rocks were found most frequently on flats. Although the transects crossed many pool habitats, water was encountered only on Lower Table Rock. Moss was also frequently found within plots and reached its highest average cover in flats.

Table 9. Ground surface characteristics on Upper and Lower Table Rock within mound, flat, and pool habitat types from all transects monitored through 2011.

Table Rock	**Habitat Type**	**Cover category (% quadrats occupied / mean % cover)**				
		Bare ground	**Litter**	**Rock**	**Water**	**Moss**
Upper	**Mound**	100/10.5	100/82.3	33/4.2	0/0	79/4.0
	Flat	96/8.9	99/43.4	100/27.5	0/0	94/26.8
	Pool	92/7.9	92/62.6	100/21.3	0/0	85/3.0
Lower	**Mound**	95/6.0	97/86.1	24/1.1	0/0	70/4.6
	Flat	97/2.9	98/62.0	92/19.2	0/0	97/22.1
	Pool	82/11.2	82/61.3	64/4.7	27/21.8	45/1.1

Plant community composition

The plant community composition of Lower and Upper Table Rocks was clearly differentiated between habitat types (Figure 27, Figure 28). On both Lower and Upper Table Rocks, quadrats located in flats were associated with moss and rock groundcover, including cover by perennial exotic grasses (Figure 29). Mound habitats had higher cover of annual species and litter. Pool habitats tended to have higher native cover (90%).

On Lower Table Rock (Figure 27), the exotic grass species *Poa bulbosa* and *Aira caryophyllea* were common in flat habitats. Also common were native annual forbs including *Montia dichotoma*, *Selaginella wallacei, Minuartia californica* and *Allium amplectens*. Invasive annual grasses *Taeniatherum caput-medusae* and *Bromus hordeaceus* were strongly associated with mound habitats, along with native species *Lithophragma* sp., *Plectritis congesta,* and *Nemophila pedunculata*.

On Upper Table Rock (Figure 28), the exotic annual grass *Aira caryophyllea* and the exotic perennial grass *Poa bulbosa* were associated with flat habitats, as well as many native annual forbs, such as *Trifolium willdenovii, Lupinus microcarpus,* and *Selaginella wallacei*. On mound habitats we typically found *Taeniatherum caput-medusae* and *Bromus hordeaceus* as well as native annual and perennial forbs similar to those on Lower Table Rocks.

Examining major functional groups (Figure 29), flat habitats had a high cover of exotic perennial grasses, particularly at Lower Table Rock. This was due exclusively to *Poa bulbosa*, the only exotic perennial grass we found in the flat habitats. *Poa bulbosa* was also very abundant in the mound habitat at Lower Table Rock, but not Upper. At both Lower and Upper Table Rocks, exotic annual grasses were very abundant in mound habitats, particularly *Taeniatherum caput-medusae* and *Bromus hordeaceus*. This high abundance is likely influencing the strong association between mound habitats, litter cover, and annual species cover. Combined abundance of native plant species was highest in the pool habitats, including native perennial grasses which were uncommon in other habitat types. Annual forbs were the most abundant group of native species in the flat and mound habitats, while perennial forbs were more abundant in the pool habitats. Native annual grasses had low cover in all habitats.

The high abundance of annual and perennial exotic grasses was negatively associated with native species in mound habitats. Flat habitats, though dominated by *Poa bulbosa*, also had a fairly high proportion of native cover, particularly on Upper Table Rock.

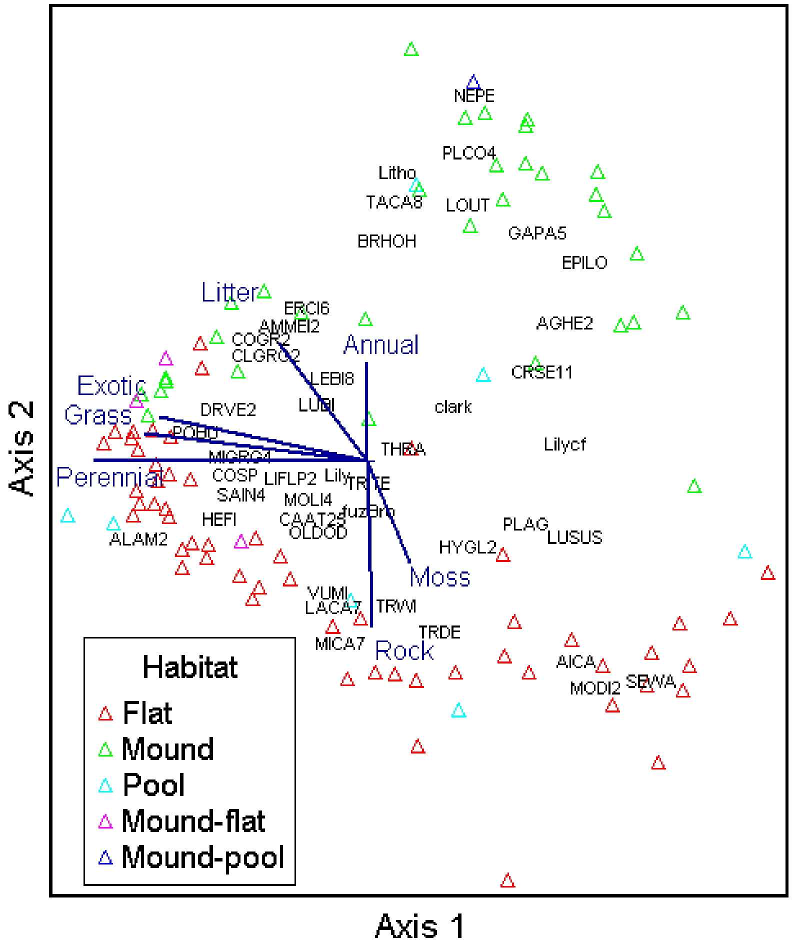


Figure 27. NMS ordination of community composition in Lower Table Rock 2009-2011. Triangles represent sample units (quadrats) in species space, and distance between points indicates similarity of community composition by quadrat. Color of each plot indicates its habitat type. Species abbreviations (in black) indicate their locations in species space. Environmental variables with notable relationships with the ordination axes ($r^2 > 0.2$) are indicated by vector lines (dark blue), with the length of the line representing the strength of the correlation with parallel axes. Variance explained by Axis 1 was 37%, while Axis 2 explained 24% of the variance.

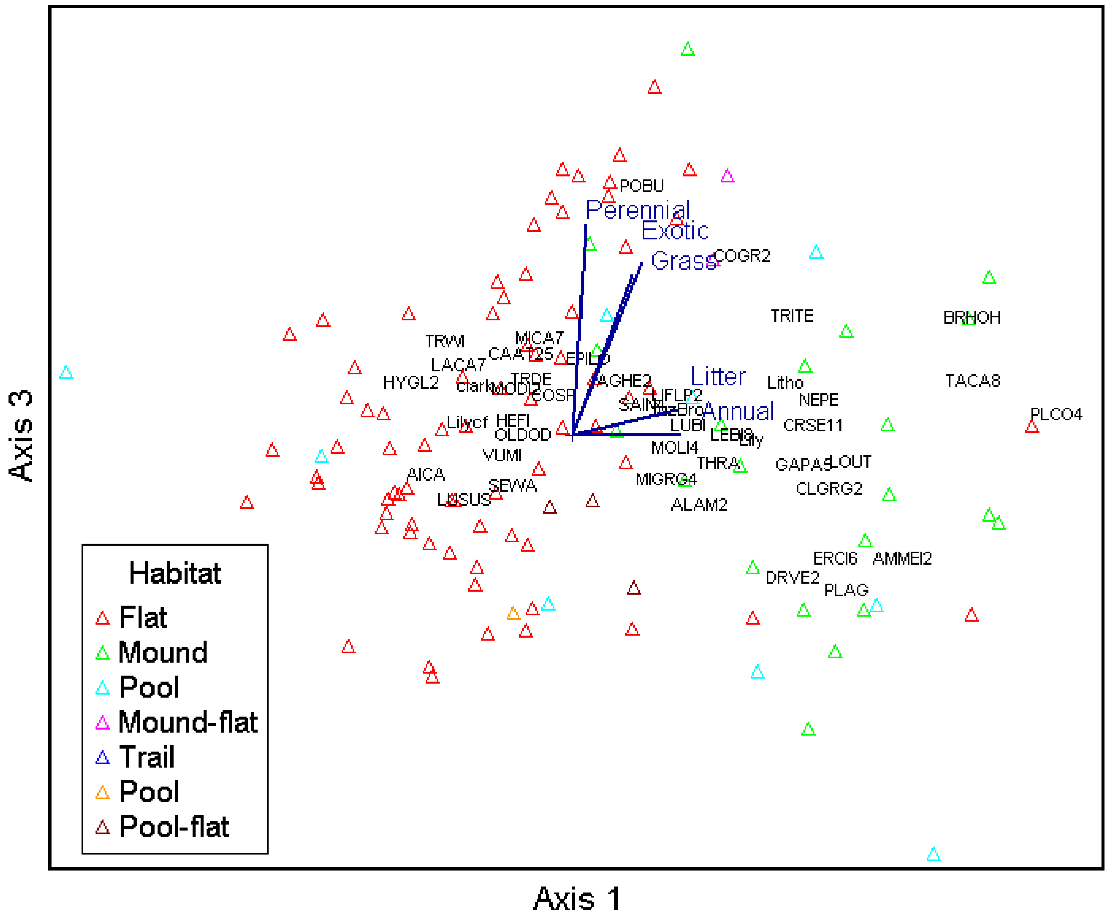


Figure 28. NMS ordination of community composition in Upper Table Rock 2009-2011. Triangles represent sample units (quadrats) in species space, and distance between points indicates similarity of community composition by quadrat. Color of each plot indicates its habitat type. Species abbreviations (in black) indicate their locations in species space. Environmental variables with notable relationships with the ordination axes ($r^2 > 0.2$) are indicated by vector lines (dark blue), with the length of the line representing the strength of the correlation with parallel axes. Variance explained by Axis 1 was 28%, while Axis 3 explained 15% of the variance.

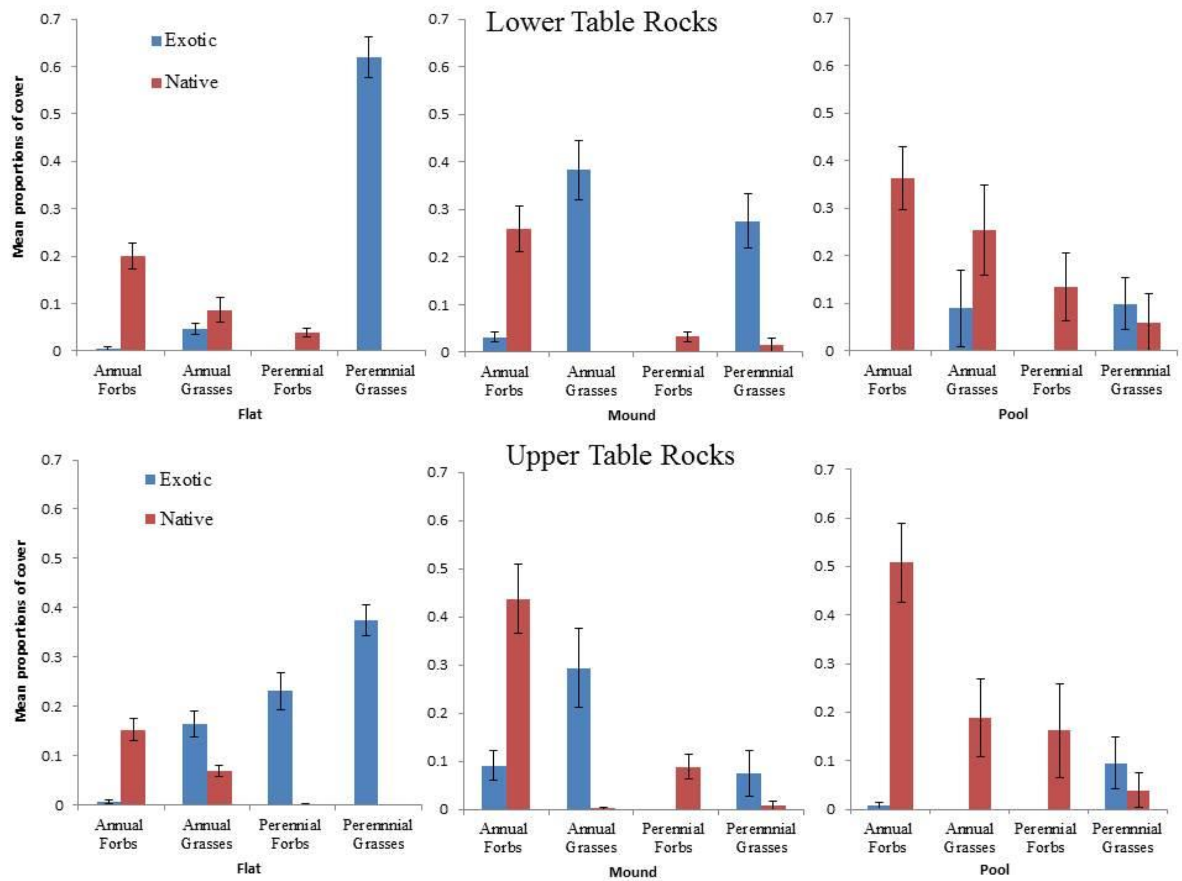


Figure 29. Mean proportions of cover of native and exotic plant cover, by functional group and habitat type, in community sampling quadrats surveyed 2009-2011. Exotic perennial forbs and native perennial shrubs were uncommon and are not shown. Bars represent means ± 1 SE.

Disturbance Analysis

Disturbance data collected along the eighteen transects between 2009 and 2011 provide a summary of common sources of ground disturbance. Portions of transects effected by disturbance ranged from 0 to 17% across both Lower and Upper Table Rocks. Total portions of each transect affected by disturbance were greater on the Upper than on Lower Table Rock. Mean portions of disturbance types varied between Lower and Upper Table Rocks (Figure 30). While no cattle disturbances were observed on Lower Table Rock, these disturbances made up 42% of all disturbances on Upper Table Rock (Table 10). Disturbances caused by animals other than cattle were greater on Lower Table Rock than on Upper Table Rock (84% and 52%, respectively), with the greatest portions caused by rodent holes (new and old). Portions of disturbance caused by humans were greater on Lower Table Rock than on Upper Table Rock (16% and 6%, respectively), and were much less than the other disturbance types.

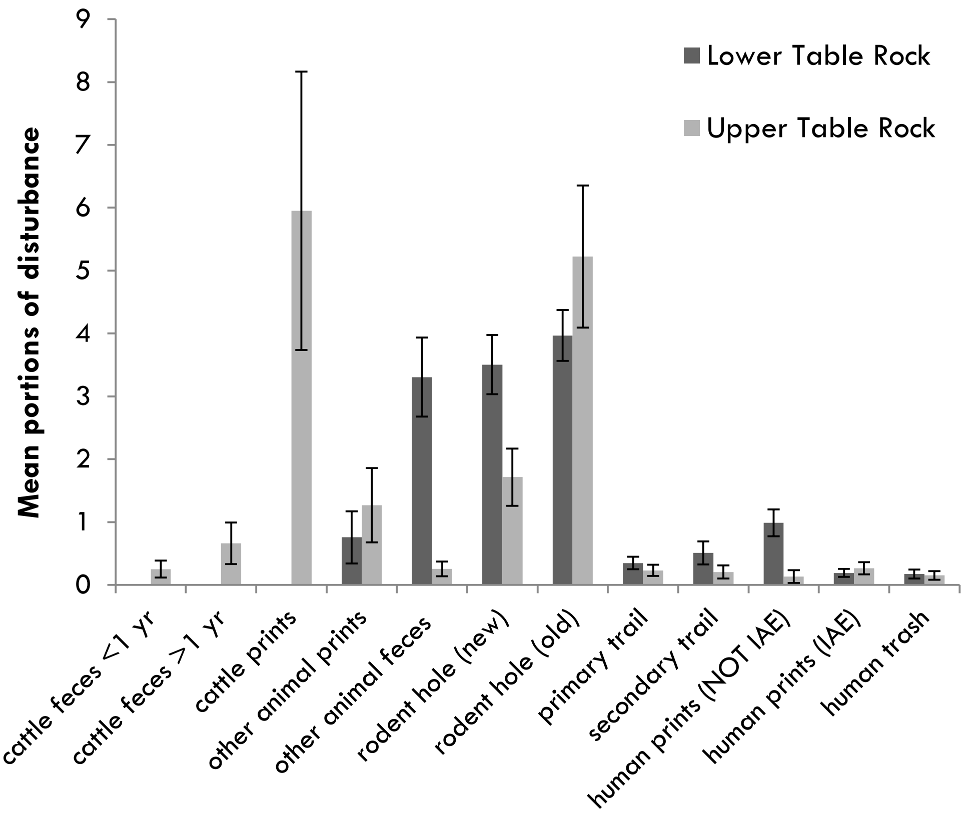


Figure 30. Mean portions of disturbance type on both Lower and Upper Table Rocks. Bars indicate ± 1 SE. Note that data from 2009-2011 were pooled, thus "cattle feces <1" does not necessarily indicate that there is evidence of cattle use after 2009.

Table 10. Percentage of disturbance type for Lower and Upper Table Rocks.

Table Rock	Cattle disturbances	Other animal disturbances	Human disturbances
Lower	0	84	16
Upper	42	52	6

Disturbances varied by habitat type (Figure 31). Greater portions of disturbance were noted in flat habitats than those on mounds or in pools. Disturbances caused by cattle on Upper Table Rock, and were present in all three habitat types. Other animal disturbances (prints, feces, and rodent holes) made up the greatest portions of disturbance on both Table Rocks and across the three habitat types, with the greatest portions occurring in flat or mound habitats. Human caused disturbances (trails, trash, and footprints) comprised very small portions of disturbance on both Upper and Lower Table Rocks, with little variability depending on habitat type. Pool habitats had the least disturbance on both Upper and Lower Table Rocks.

Portions of disturbance recorded depend greatly on the locations of transects and the habitat types they pass through. Flat habitat types occurred most often, with fewer mound and even fewer pool habitat types along transects (Figure 31). We have observed that human disturbances, primarily footprints, occur most often near pool habitats, which are the least-common. Potential magnitude of each disturbance type should be taken into account when considering our results. Non-cattle animal disturbances, primarily rodent holes and feces, were the most abundant disturbance type on both Upper and Lower Table Rocks (Figure 31), however their effects on sensitive species may not be as dramatic as other disturbances, such as heavy trampling. Though our results suggest that human-caused disturbances are small in proportion to other disturbance types, their effects, primarily around areas of sensitive plant species, could be much greater than other disturbances. We have observed human disturbances primarily on trails or near pool margins, which are hard to capture with randomly placed transects. Trends noted in our trampling plots indicate number of plants decrease with increasing trampling, which should be considered when managing access to Upper and Lower Table Rocks for recreation. Humans may also act as a vector for invasion by noxious plant species. Though we did not see any state-listed noxious weeds along these transects, state-listed weeds have been observed on the Table Rocks. Likewise, we observed numerous invasive species present that are not yet on Oregon's noxious weed list.

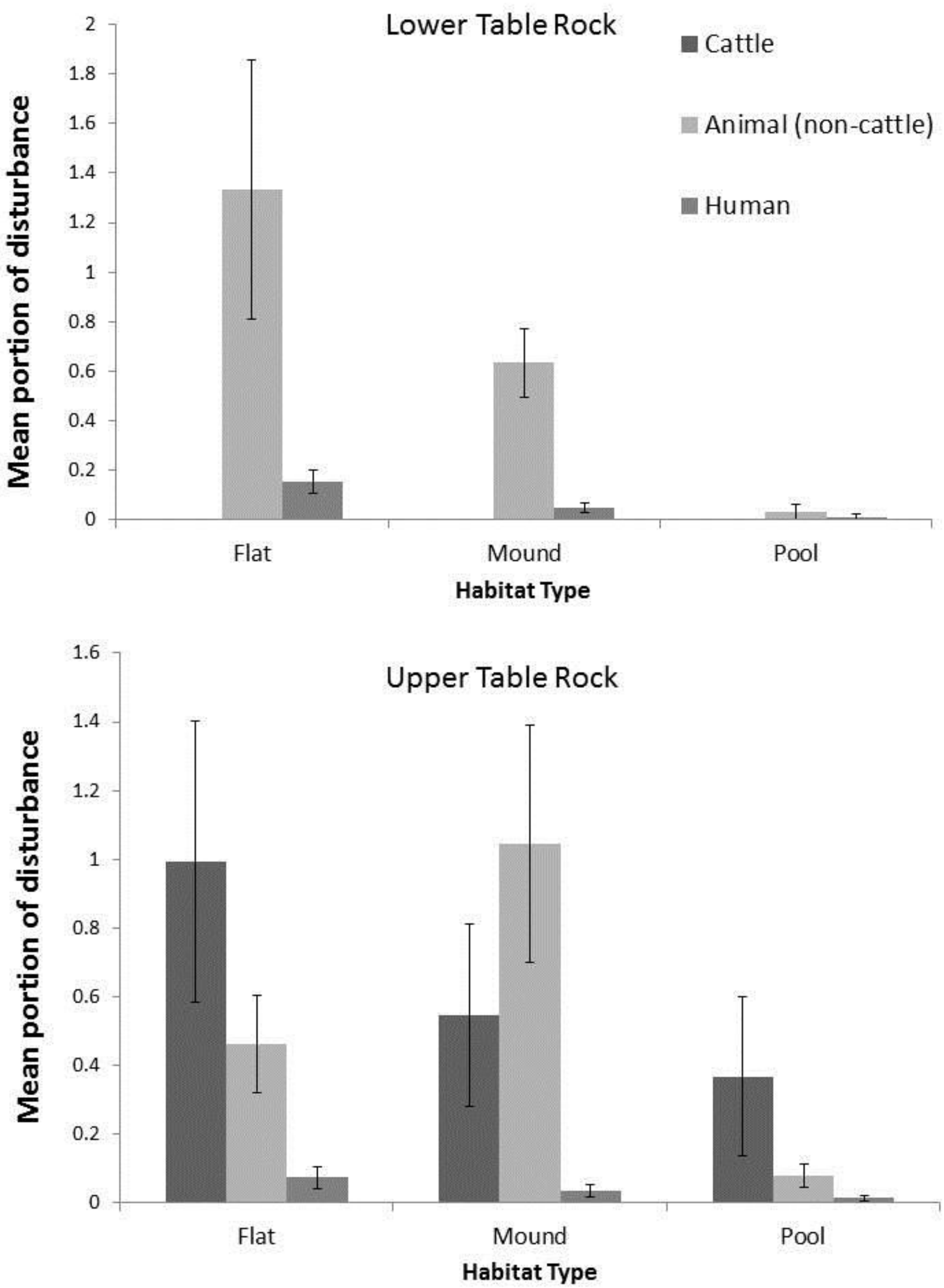


Figure 31. Mean portion of disturbance type (cattle, animal, and human caused) by habitat type on Lower (above) and Upper Table Rock (below). Bars indicate ± 1 SE.

Table 11. All species found in quadrats along habitat transects at Upper and Lower Table Rocks 2009-2011. The percent of quadrats occupied and mean percent cover are listed by species for each Table Rock by habitat type (mound, pool, and flat). "N" = the total number of quadrats of a given habitat type. Mean percent cover is for all quadrats across the entire habitat type.

	Upper Table Rock						Lower Table Rock					
	Mound (n=24)		Flat (n=81)		Pool (n=13)		Mound (n=37)		Flat (n=59)		Pool (n=11)	
Species	% quadrats occupied	mean % cover	% quadrats occupied	mean % cover	% quadrats occupied	mean % cover	% quadrats occupied	mean % cover	% quadrats occupied	mean % cover	% quadrats occupied	mean % cover
Achillea millefolium							8	0.01				
Achyrachaena mollis	17	0.02	1	0.001								
Agoseris grandiflora	4	0.004	7	0.01			14	0.08	12	0.03		
Agoseris heterophylla	13	0.05	30	0.04			8	0.06	15	0.02		
Aira caryophyllea	4	0.004	79	1.09	15	0.02	3	0.003	37	0.23		
Allium acuminatum			1	0.04								
Allium amplectens			21	0.26	54	4.39			12	0.07	27	7.64
Allium parvum			12	0.01					5	0.01		
Allium sp.									2	0.002		
Alopecurus saccatus			1	0.001	31	0.13					73	2.85
Alopecurus saccatus litter											18	11.36
Amsinckia menziesii var. *intermedia*							35	0.42	31	0.35	18	0.02
cf. *Amsinckia menziesii* var. *intermedia*	38	3.05	10	0.18			14	0.19	15	0.06		
Aphanes arvensis			2	0.002								
Apiaceae sp.			1	0.001								
Fuzzy Asteraceae sp.											9	0.01
Ligulate Asteraceae sp.							8	0.02				
Ligulate Asteraceae 2 sp.							3	0.003				

	Upper Table Rock						Lower Table Rock					
	Mound (n=24)		Flat (n=81)		Pool (n=13)		Mound (n=37)		Flat (n=59)		Pool (n=11)	
Species	% quadrats occupied	mean % cover	% quadrats occupied	mean % cover	% quadrats occupied	mean % cover	% quadrats occupied	mean % cover	% quadrats occupied	mean % cover	% quadrats occupied	mean % cover
Bromus hordeaceus ssp. *hordeaceus*	38	3.94	21	0.08			57	0.52	32	0.09	45	
Fuzzy *Bromus* sp.	21	0.59	4	0.004			30	0.39	10	0.01	9	
Callitriche marginata			5	0.02	77	1.38					36	
Calystegia occidentalis						5	0.01					
Camassia leichtlinii		1	0.001									
Camassia quamash		1	0.001	8	0.08							
Cardamine oligosperma	8	0.01	1	0.001			5	0.01			9	0.01
Castilleja attenuata	21	0.02	47	0.05	15	0.02	19	0.02	61	0.16	9	0.01
Castilleja sp.						5	0.01					
Ceanothus cuneatus	4	0.004										
Centaurea solstitialis						5	0.06					
Cerastium fontanum ssp. *vulgare*	4	0.004										
Cerastium glomeratum	8	0.01					16	0.04				
Clarkia gracilis ssp. *gracilis*	46	0.69	23	0.05	8	0.01	3	0.03	2	0.002		
Clarkia sp.	17	0.10	7	0.03			38	0.22	19	0.02		
Collinsia grandiflora	8	0.01	1	0.001			51	1.85	41	0.55	36	0.56
Collinsia sparsiflora	13	0.01	28	0.16	23	0.39	14	0.01	37	0.16		
Collinsia sp.								2	0.002			
Crassula tillaea		11	0.06					5	0.02			
Cynosurus echinatus	4	0.04					3	0.003				

Species	Upper Table Rock: Mound (n=24) % quadrats occupied	Upper Table Rock: Mound (n=24) mean % cover	Upper Table Rock: Flat (n=81) % quadrats occupied	Upper Table Rock: Flat (n=81) mean % cover	Upper Table Rock: Pool (n=13) % quadrats occupied	Upper Table Rock: Pool (n=13) mean % cover	Lower Table Rock: Mound (n=37) % quadrats occupied	Lower Table Rock: Mound (n=37) mean % cover	Lower Table Rock: Flat (n=59) % quadrats occupied	Lower Table Rock: Flat (n=59) mean % cover	Lower Table Rock: Pool (n=11) % quadrats occupied	Lower Table Rock: Pool (n=11) mean % cover
Danthonia californica						3	0.003					
Daucus pusillus	4	0.21										
Deschampsia danthonioides	5	0.02	54	0.53			2	0.03	18	0.37		
Draba verna	46	0.17	6	0.01	8	0.01	27	0.08	12	0.11	18	
Elymus elymoides						5	0.27	2	0.002			0.01
Epilobium minutum		1	0.001			3	0.003	8	0.01			0.01
Epilobium sp.	21	0.65	4	0.04			30	0.67	10	0.01		
Eremocarpus setigerus	33	0.03	6	0.01			30	0.03	5	0.01	9	
Erodium cicutarium	54	0.17	2	0.002			38	0.22	2	0.002		
Galium aparine	4	0.004					3	0.003				
Galium parisiense	42	0.04	1	0.001			43	0.11	3	0.003		
Geranium dissectum	4	0.004										
Gnaphalium sp.								2	0.002			
Hemizonia fitchii	4	0.004	27	0.06	8	0.01	3	0.003	32	0.08	9	0.01
Heterocodon rariflorum	2	0.002			5	0.01						
Holcus lanatus												
cf. *Holcus lanatus*						5	0.05					
cf. *Hordeum* sp.				8	0.01							
Hypochaeris glabra		7	0.01			14	0.15	31	2.40			
Hypochaeris radicata		1	0.001			3	0.003	10	0.06			
Idahoa scapigera	13	0.01	9	0.04	15	0.02	5	0.01	3	0.003	9	0.01
Isoetes nuttallii	4	0.04			8	0.23					9	2.73

	Upper Table Rock						Lower Table Rock					
	Mound (n=24)		Flat (n=81)		Pool (n=13)		Mound (n=37)		Flat (n=59)		Pool (n=11)	
Species	**% quadrats occupied**	**mean % cover**	**% quadrats occupied**	**mean % cover**	**% quadrats occupied**	**mean % cover**	**% quadrats occupied**	**mean % cover**	**% quadrats occupied**	**mean % cover**	**% quadrats occupied**	**mean % cover**
Juncus sp.			10	0.01	8	0.01	3	0.003	2	0.002		
Lactuca serriola						14	0.04	3	0.003			
Lasthenia californica	17	0.02	90	2.42	62	0.52	5	0.01	83	1.90	45	1.12
Lemna sp.											9	0.01
Lepidium nitidum	4	0.004	16	0.04	23	0.40			2	0.002		
Liliaceae channel leaf sp.	21	0.02	21	0.02	15	0.16	30	0.03	15	0.02	9	0.01
Liliaceae sp.	21	0.02	6	0.01	15	0.16	27	0.03	29	0.09	36	0.29
Liliaceae sp. (wide, wet)			15	0.08					9	0.45		
Limnanthes pumila ssp. pumila	4	0.004	9	0.07	46	0.63	5	0.01	7	0.01	55	1.05
Linanthus bicolor	67	0.19	19	0.03			35	0.08	12	0.01		
Lithophragma glabrum	8	0.05	1	0.001					14	0.03		
Lithophragma sp. (not flowering)	33	0.03	14	0.02	8	0.01	35	0.06	7	0.01	9	0.01
Lomatium piperi		5	0.005					2	0.002			
Lomatium triternatum		1	0.001									
Lomatium utriculatum	63	1.26	2	0.002			54	0.47	5	0.04		
Lotus micranthus								2	0.002			
Lotus sp.			2	0.03								
Lupinus bicolor	58	0.65	49	0.14	8	0.01	65	0.35	69	0.30	27	0.20
Lupinus microcarpus		26	0.17			3	0.003	5	0.01			

	Upper Table Rock						Lower Table Rock					
	Mound (n=24)		**Flat (n=81)**		**Pool (n=13)**		**Mound (n=37)**		**Flat (n=59)**		**Pool (n=11)**	
Species	**% quadrats occupied**	**mean % cover**	**% quadrats occupied**	**mean % cover**	**% quadrats occupied**	**mean % cover**	**% quadrats occupied**	**mean % cover**	**% quadrats occupied**	**mean % cover**	**% quadrats occupied**	**mean % cover**
Micropus californicus								3	0.01			
Minuartia californica	4	0.004	36	0.16	38	0.55	3	0.003	15	0.08		
Minuartia douglasii		4	0.01			5	0.01	2	0.002			
Moenchia erecta	4	0.004	4	0.17	8	0.15	3	0.003	2	0.002		
Montia dichotoma	8	0.01	20	0.04	38	0.04			2	0.002	9	0.01
Montia fontana		2	0.03	54	0.56			2	0.002	45	1.74	
Montia howellii		4	0.004	8	0.01			5	0.01	9	0.27	
Montia linearis	13	0.01	16	0.17	69	0.50	3	0.003	12	0.04	18	0.18
Myosotis discolor	4	0.004					3	0.003				
Myosurus minimus		5	0.03	8	0.04					9	0.01	
Navarretia sp.		1	0.001									
Nemophila pedunculata	46	0.52	7	0.10			14	0.12	3	0.003	9	0.36
Nemophila sp.	8	0.01					5	0.02				
Olsynium douglasii		31	0.08					24	0.04			
Orobanche uniflora		1	0.001									
Pectocarya pusilla	8	0.13	4	0.04	8	0.01						
Phlox gracilis		27	0.07	92	0.30	11	0.01	25	0.03	64	0.15	
Plagiobothrys nothofulvus	4	0.08	1	0.001			8	0.08				
Plagiobothrys shastensis							2	0.002				
Plagiobothrys sp.		6	0.05					2	0.002			
Plagiobothrys sp. (mound sp.)	63	0.79	6	0.03			16	0.02	3	0.02		

	Upper Table Rock						Lower Table Rock					
	Mound (n=24)		Flat (n=81)		Pool (n=13)		Mound (n=37)		Flat (n=59)		Pool (n=11)	
Species	% quadrats occupied	mean % cover	% quadrats occupied	mean % cover	% quadrats occupied	mean % cover	% quadrats occupied	mean % cover	% quadrats occupied	mean % cover	% quadrats occupied	mean % cover
Plagiobothrys sp. (pool sp.)	8	0.05	7	0.03	77	2.83					27	0.11
Plectritis congesta		1	0.001			62	3.97	12	0.11	18	2.82	
Poa bulbosa	54	5.23	70	6.77	46	0.79	73	21.03	95	27.27	36	5.45
Poa secunda		4	0.01	8	0.01							
Polygonum californicum	2	0.002							9	0.01		
Psilocarphus sp.				8	0.01							
Rumex acetosella						3	0.03					
Saxifraga integrifolia	13	0.09	31	0.21	31	0.17	8	0.01	25	0.23	9	0.09
Scleranthus annuus		2	0.002					2	0.02			
Scribneria bolanderi		6	0.01	8	0.01			5	0.02			
Selaginella wallacei		33	0.29					10	0.05			
Sonchus sp.	13	0.13					8	0.01	2	0.002		
Taeniatherum caput-medusae	71	6.85	9	0.59			89	13.81	31	0.61	36	3.74
Thysanocarpus curvipes	17	0.02					14	0.01	3	0.003	9	0.01
Thysanocarpus radians	67	0.98	37	0.43			27	0.03	22	0.04		
Tonella tenella		1	0.001									
Tragopogon sp.						3	0.01					
Trifolium albopurpureum	13	0.05					14	0.02	2	0.002		
Trifolium depauperatum	21	0.02	53	0.50	69	0.72	22	0.02	68	0.23	18	0.02
Trifolium dubium	25	0.90					14	0.07	3	0.04		

	Upper Table Rock						Lower Table Rock					
	Mound (n=24)		Flat (n=81)		Pool (n=13)		Mound (n=37)		Flat (n=59)		Pool (n=11)	
Species	% quadrats occupied	mean % cover	% quadrats occupied	mean % cover	% quadrats occupied	mean % cover	% quadrats occupied	mean % cover	% quadrats occupied	mean % cover	% quadrats occupied	mean % cover
Trifolium subterraneum	2	0.002			11	0.02	2	0.01				
Trifolium variegatum				8	0.01	3	0.003					
Trifolium willdenovii	17	0.02	14	0.09	23	0.02			15	0.24	36	0.38
Trifolium sp.	13	0.09	27	0.06			3	0.03	12	0.04	27	0.46
Triteleia sp.						16	0.04	25	0.54	9	0.01	
cf. *Triteleia* sp. (single terete leaf)	13	0.04	77	0.17	46	5.33	35	0.06	63	1.01	27	5.01
Veronica arvensis	8	0.01										
Veronica peregrina				15	0.02			2	0.002			
Veronica persica	21	0.02					5	0.01	2	0.002	9	0.01
Veronica sp.		1	0.001									
Vicia sativa	8	0.17										
Vicia sp.	4	0.004					3	0.03				
Vulpia bromoides		7	0.53					12	0.02			
Vulpia microstachys	8	0.09	84	2.05	69	1.41			51	2.43	18	0.18
Wyethia angustifolia						3	0.08					
Zigadenus venenosus						3	0.003	3	0.003			
Unk: Fuzzy dicot		4	0.004			3	0.003					
Unk.: grass							3	0.003				
Unk: linear lf, coarse sparse hairs							2	0.002				
Unk: little blue borage						3	0.14					
Unk: perennial grass	29	1.30	2	0.04	8	0.01						

	Upper Table Rock						Lower Table Rock					
	Mound (n=24)		Flat (n=81)		Pool (n=13)		Mound (n=37)		Flat (n=59)		Pool (n=11)	
Species	**% quadrats occupied**	**mean % cover**	**% quadrats occupied**	**mean % cover**	**% quadrats occupied**	**mean % cover**	**% quadrats occupied**	**mean % cover**	**% quadrats occupied**	**mean % cover**	**% quadrats occupied**	**mean % cover**
Unk: small round basal lvs	4	0.004	2	0.002					14	0.03		
Unk. Wide monocot (basal lvs)							2	0.002				