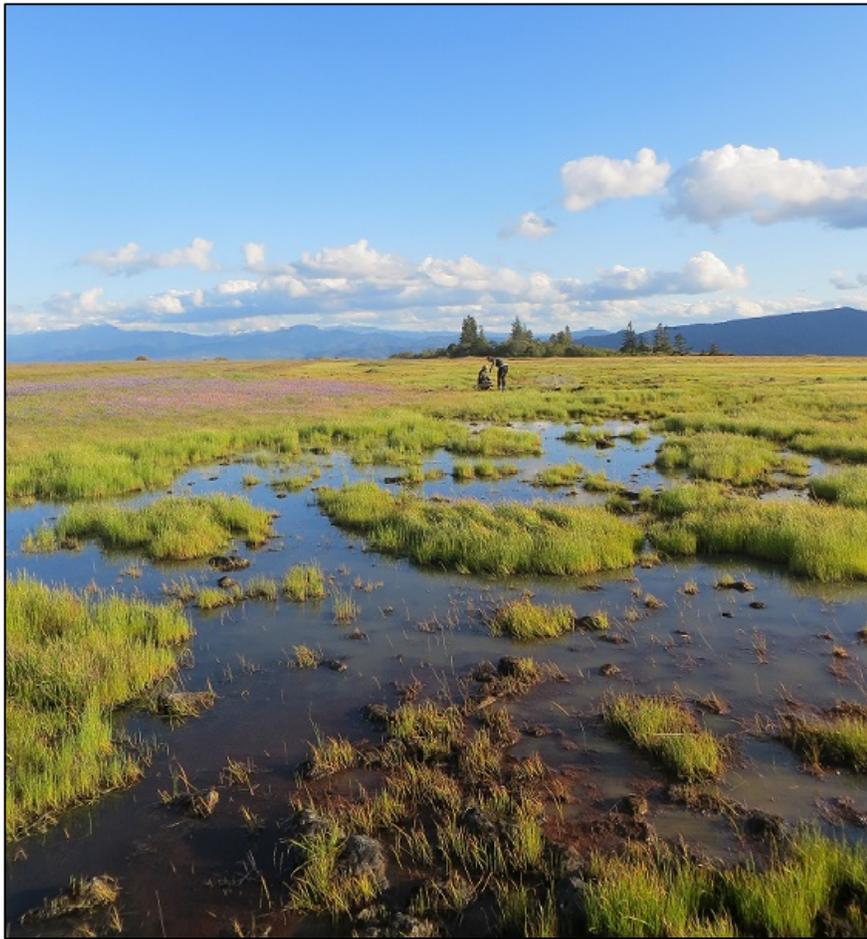


Threat assessment for *Limnanthes pumila* ssp. *pumila* (dwarf woolly meadowfoam) on Table Rocks ACEC



2018

Report to the USDI Bureau of Land Management,
Medford District

Report prepared by A. Lisa Schomaker and Matt A. Bahm
Institute for Applied Ecology



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.



Questions regarding this report or IAE should be directed to:

Matt A. Bahm

Conservation Research Program Director

Institute for Applied Ecology

563 SW Jefferson Avenue

Corvallis, Oregon 97333

phone: 541-753-3099

email: mattab@appliedeco.org

ACKNOWLEDGMENTS

The authors gratefully acknowledge the contributions to this project in 2018 by Sasha Joachims, Bryan Wender, and Marta Lefevre-Levy of the BLM, and IAE staff and interns: Meaghan Petix, Erin Gray, Denise Giles, Mary McKean, and Samantha Hooper.

Cover photograph: Pool habitat on Lower Table Rock.

Suggested Citation

Schomaker, A. L. and M. A. Bahm. 2018. Threat assessment for *Limnanthes pumila* ssp. *pumila* (dwarf woolly meadowfoam) on Table Rocks ACEC. Institute for Applied Ecology, Corvallis, Oregon and USDI Bureau of Land Management, Medford District. vii + 60.

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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.

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 2018, we monitored *L. pumila* ssp. *pumila* populations and focus discussion on population trends of *L. pumila* ssp. *pumila* on Upper and Lower Table Rocks.

Limnanthes pumila* ssp. *pumila

- Following a steady decline from 2010 to 2012, the number of *L. pumila* ssp. *pumila* in long-term monitoring plots on Lower Table Rock have fluctuated. While 2015 had the lowest number of *L. pumila* ssp. *pumila* observed over the course of this study, we recorded increases in the number of plants in 2016 and 2017, and no significant change in 2018.
- At Upper Table Rock, our lowest numbers of plants were also observed in 2015, but after a rebound in 2016 have remained relatively stable over the last two years.
- In 2018, we observed significantly fewer *L. pumila* ssp. *pumila* in high traffic areas than in moderate traffic areas at Lower Table Rock, but no significant difference was observed in the mean number of plants at Upper Table Rock, or in the mean number of flowers per plant at either site.

Long-term monitoring plots were also used to assess impacts of a prescribed fire that occurred in the area of the fire retardant drop in October, 2015. The mean number of flowers per plant was lower in burned plots than in unburned plots in 2018, contrary to findings from 2016. Litter cover remained similar in burned and unburned plots. These results should be interpreted cautiously as plots were not designed to monitor fire effects.

Community monitoring of the fire retardant drop

- Monitoring was not conducted on the transects in the area of the fire retardant drop in 2018.
- From 2013 to 2017 we observed a decline in non-native grasses both within and outside of the fire retardant drop; over the final two years of sampling (2016-2017), non-native grass cover remained stable.

Threat assessment for *Limnanthes pumila* ssp. *pumila* (dwarf woolly meadowfoam) on Table Rocks ACEC

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 an overstory of shrub and tree species, 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 austini*, *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 non-native species (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 consistently observe 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, potentially posing a great threat to native species in these habitats (Figure 2). The growing human 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.

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;
4. Assess population trends of *L. pumila* ssp. *pumila* on Upper and Lower Table Rocks over time, documenting potential threats.



FIGURE 2. DENSE THATCH FROM INTRODUCED ANNUAL GRASSES IN *L. PUMILA* SSP. *PUMILA* HABITAT IN 2012.

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 2012; Oregon Biodiversity Information Center 2016). Closely related subspecies that occur in Jackson County include *L. floccosa* ssp. *floccosa*, *L. floccosa* ssp. *grandiflora* (Federally Endangered), and *L. floccosa* ssp. *bellingermaniana* (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*

austiniiae 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 annual 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 vernal wet areas of BLM-administered land contained *L. pumila* ssp. *pumila*.

Project History

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*. To test for effects of human impact on *L. pumila* ssp. *pumila* and monitor long-term population trends, additional caged and uncaged plot pairs were added in high and low traffic areas in 2012 (a total of 10 caged and uncaged plot pairs, 5 pairs in each traffic level= 20 plots; Gray et al. 2012). These plots have been monitored from 2012-2018 to yield long-term population trends of this rare species.

Grazing exclosures and long-term monitoring plots were established on the northern end of Upper Table Rock in 2007. Twenty plots have been resampled annually through 2018. Although there is no longer cattle grazing on Upper Table Rock, these plots allow us to study changes in population dynamics over time in the northern portion of Upper Table Rock.

Five new transects were added to Lower Table Rock in spring 2013 to describe the area impacted by a 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 were collected and habitat type was mapped to describe potential impacts of the fire retardant drop. A spatial analysis of the area impacted by the fire retardant drop was conducted in 2014 and transects were monitored through 2017.

Given a recently observed increase in recreation traffic on the southern end of Upper Table Rock, we added six new plots in 2015 to observe population trends in high traffic areas and six in moderate traffic areas in 2016. The increased visitor use has resulted in little to no *L. pumila* ssp. *pumila* habitats able to be defined as “low” traffic areas, and we have changed all formerly “low” traffic plots to “moderate” or “high” traffic as appropriate. These plots were monitored through 2018 to assess the impacts of recreation traffic on *L. pumila* ssp. *pumila* on the southern end of Upper Table Rock.

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 (*Draft Report Jettisoned Retardant, BLM Medford District. 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 comparable substance (Larson and Duncan 1982).



FIGURE 4. EMERGENCY FIRE RETARDANT DROP (IN RED) THAT OCCURRED ON LOWER TABLE ROCK ON JULY 7, 2010.

From 2013-2017, assessing the impacts of the fire retardant drop became an objective of the overall habitat quality monitoring. In the fall of 2015, the BLM conducted a prescribed fire in the area impacted by the fire retardant drop as an effort to control invasive grasses and thatch buildup.

METHODS

Limnanthes pumila ssp. *pumila* monitoring

Population trends on Lower Table Rock

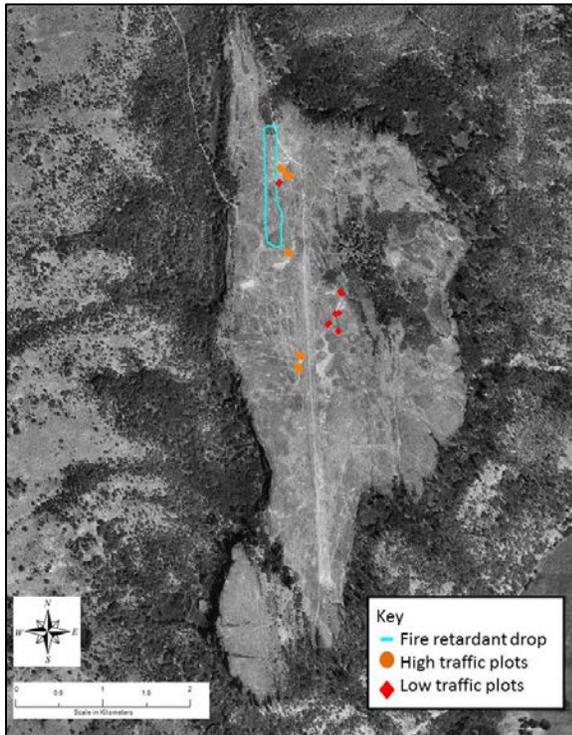


FIGURE 5. LIMNANTHES PUMILA SSP. PUMILA POPULATION MONITORING PLOTS ON LOWER TABLE ROCK.

To assess long-term population trends of *L. pumila* ssp. *pumila* on Lower Table Rock, we converted the experimental trampling plots that had been established in 2007 and 2009, only including plots that were not trampled [0 passes]), into long-term monitoring plots in 2012 (Gray et al. 2012). These trampling plots had measured 0.5m x 1.5m, and their locations were randomly placed along transects testing the effects of trampling; when they were changed to long-term monitoring plots, they were converted to 1m² plots. In 2012, the majority of the long-term monitoring plots could not be located (six were located, three of which had no *L. pumila* ssp. *pumila* present). Therefore, in 2012, 17 new 1m² plots were established. To investigate the potential effects of human trampling these plots were established in both high and low traffic areas and were either surrounded by cages (caged) or not (uncaged) (Appendix A). Some plots were established adjacent to the remaining long-term monitoring plots that had been re-located from 2007 and 2009, while others were established in new locations. In total there were 20 plots – five pairs (caged and uncaged) in each traffic level (Figure 5). Caged plots enabled us to compare

population dynamics to uncaged plots in order to describe the effects of trampling, and to determine if the frequency differs in relation to their proximity to recreation traffic. High and low traffic areas were designated by noting the proximity to major trails and any notable human impact. Increased visitor use over the last few years has resulted in little to no *L. pumila* ssp. *pumila* habitat occurring in “low” traffic areas, so plots that were initially designated as “low” traffic are now considered to be “moderate” traffic plots.

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 four-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 C, Appendix D). Data collected in these plots include mean number of plants, mean flowers per plant (collected from ten random plants/plot), and percent cover for *L. pumila* ssp. *pumila*, native and non-native species by functional group (graminoids and forbs), litter, and rocks. To enable comparisons between years, data were scaled by plot size (number of plants/m²). These data 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 human impacts on population trends at Upper Table Rock

Twenty 1m² 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. Haphazardly selected individuals were identified by being closest to one of ten randomly dropped pin flags. 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). Cattle were excluded from Upper Table Rock in 2009, but plots have continued to be monitored to study effects of native ungulates.

In the years following 2007, additional information recorded in plots 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 animal activity. In 2013, 2015, 2016, and 2017, 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 including litter, bare ground, and rocks.

To determine the impact of human recreation activity on *L. pumila* ssp. *pumila*, six plots were added to the southern end of Upper Table Rock in 2015 in areas of high recreation traffic, with another six added in moderate recreation areas in 2016. Plots were 1m² and were established in areas with a density of at least three *L. pumila* ssp. *pumila* plants per m². Plots were monitored similar to long-term monitoring plots on Upper and Lower Table Rocks.

Community monitoring of the fire retardant drop

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 2m west of the trail and were marked with nails and blue whiskers, and unique tag numbers. The transect bearing was recorded and each transect was marked with a nail at both the 50 and 100m mark. Transects ranged from 100-200m 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 1m² plots every 20m (with a random starting place between 1 and 10m), where percent cover was recorded for bare ground, litter, rock, moss, *L. pumila* ssp. *pumila*, graminoids, and forbs (native and non-native). Each 1m² 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). Plots were not monitored in 2018.

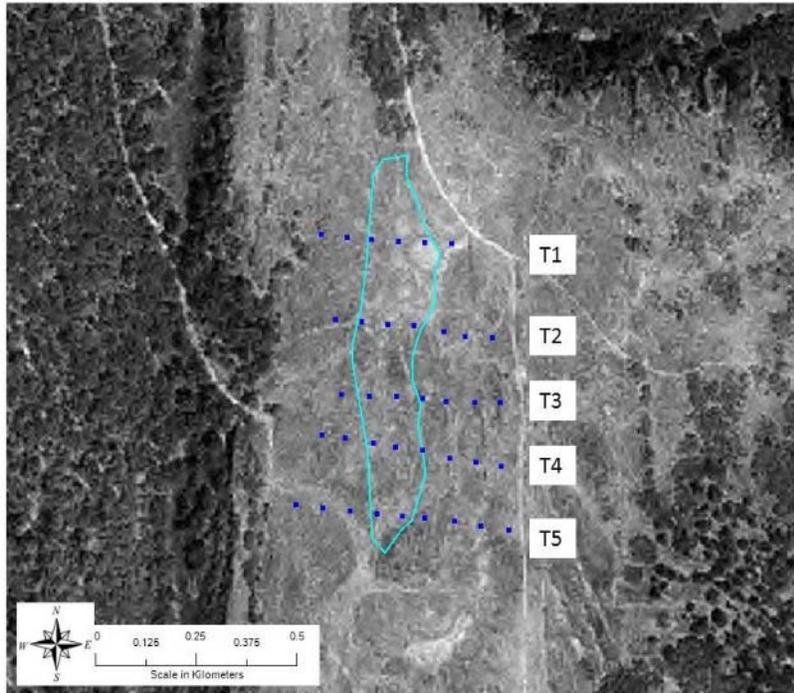


FIGURE 6. 2013 TRANSECTS (DELINEATED BY DARK BLUE MARKINGS, EACH POINT IS A PLOT SAMPLED, "T1" REPRESENTS "TRANSECT 1", ETC.) DISSECTING THE AREA IMPACTED BY THE 2010 FIRE RETARDANT DROP (LIGHT BLUE) ON LOWER TABLE ROCK.

A prescribed fire occurred on October 22, 2015, burning just over 20 acres in the area of the fire retardant drop to control the increase of non-native grasses and thatch buildup on Lower Table Rock. After the burn, a suite of native forbs and grasses were seeded in the burned area including *Achnatherum lemmonii* (32 lb.), *Koeleria macrantha* (32 lb.), *Poa secunda* (32 lb.), *Elymus elymoides* (21 lb.), *Danthonia californica* (21 lb.), *Pseudoroegneria spicata* (21 lb.), *Achyrachaena mollis* (0.5 lb.), *Grindelia nana* (0.5 lb.), *Collinsia grandiflora* (0.5 lb.), and *Clarkia purpurea* (0.5 lb.).

Data Analyses

We utilized one-way ANOVA (F-statistic) and/or Wilcoxon rank-sum test (W-statistic; R v. 3.4.2) where appropriate to examine the effects of recreation on number of *L. pumila* ssp. *pumila*, number of flowers per plant, *L. pumila* ssp. *pumila* cover, native and non-native graminoid cover, native and non-native forb cover, and litter cover. Using one-way ANOVA and/or Wilcoxon signed-rank test (V-statistic; R v. 3.4.2) we examined whether there were differences in caged versus uncaged plots. Kruskal-Wallis rank-sum test with multiple comparisons by Dunn's test (Kruskal-Wallis χ^2 -statistic; R v. 3.4.2) was utilized to analyze population trends across the years on Lower Table Rock. All data presented are means \pm 95% confidence intervals.

RESULTS AND DISCUSSION

Limnanthes pumila ssp. *pumila* monitoring

Population trends on Lower Table Rock

Numbers of *L. pumila* ssp. *pumila* have varied over the first decade of monitoring, ranging from an average of 199 plants per plot in 2010, to only eight plants per plot in 2015. The plot average decreased significantly from 2010 to 2012 (Kruskal-Wallis $\chi^2=68.6$, $p<0.001$), and after a period of little change from 2012 to 2014, fell to the 10-year low in 2015. Since then, a significant but small increase has led to relatively stable plot averages from 2016 to present; in 2018, the mean number of *L. pumila* ssp. *pumila* per plot ($n = 20$) was 39 (Figure 7, top). Despite the increase, averages in 2016, 2017, and 2018 were still significantly lower than those observed over the first two years of long-term monitoring, 2009-2010 (Kruskal-Wallis $\chi^2=68.6$, $p<0.001$). This is an annual species and such variability is expected, but whether or not numbers of plants will rebound to pre-2012 levels remains to be seen. Continued monitoring will help to discern any significant long-term changes in subsampled population size.

Though the mean number of plants was highest early in the study, reproductive effort during those years was relatively low (less than four flowers per plant). Throughout the study, our population has averaged roughly four flowers per plant for every year except 2016 (Figure 7, bottom). There was a statistically significant decrease from four to an average of two flowers per plant in 2015 (coincident with the drop in number of plants per plot) followed by a statistically significant increase in 2016 to an average of nine (Kruskal-Wallis $\chi^2=48.62$, $p<0.001$), more than double the long-term average observed over 10 years of monitoring (Figure 7, bottom). In 2017 and 2018, number of flowers per plant fell back to an average of three and four, respectively (Figure 7, bottom). There is no consistent correlation between number of plants and number of flowers per plant over our decade of monitoring, but it may be interesting to look at these patterns within the context of climatic variability.

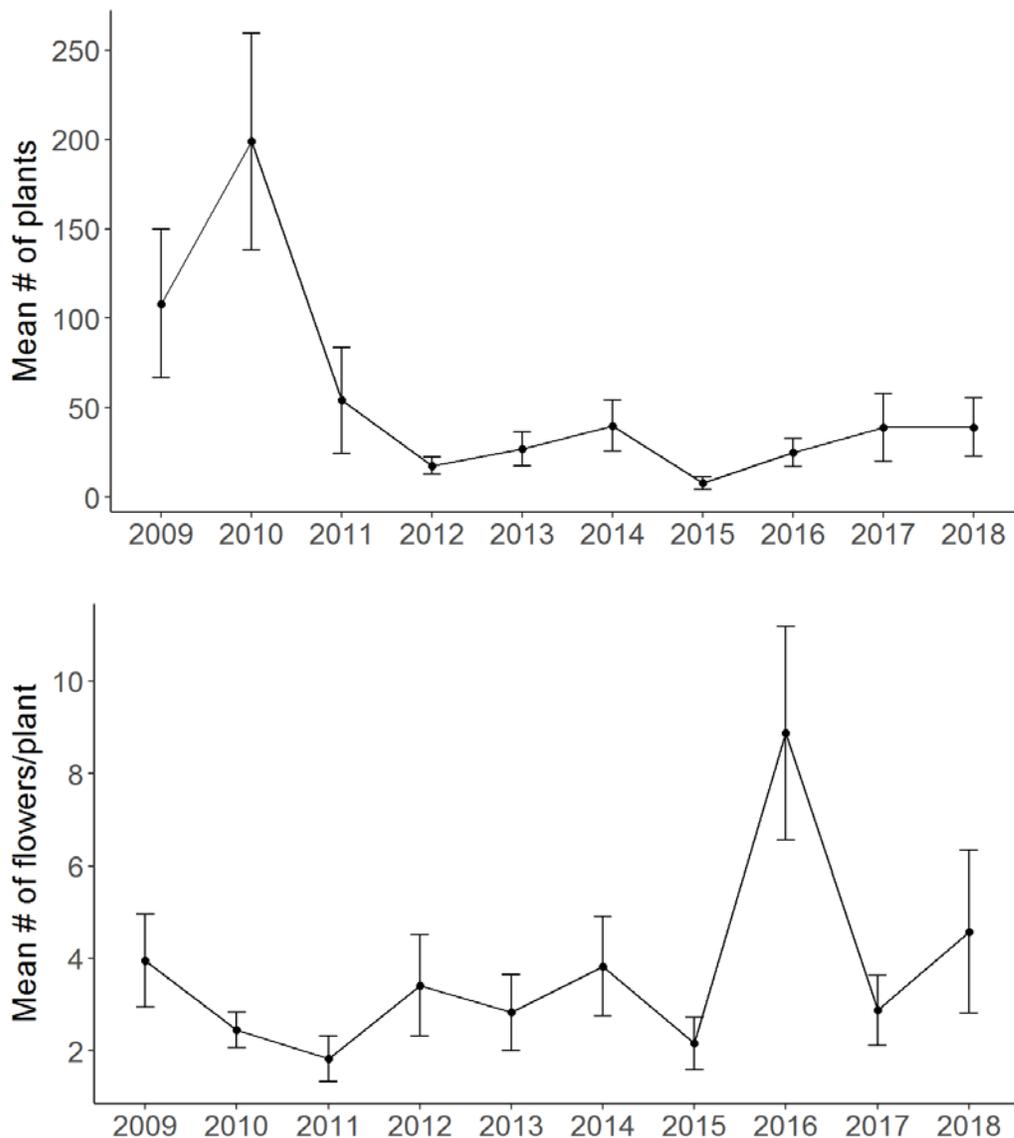


FIGURE 7. MEAN NUMBER OF PLANTS (TOP) AND MEAN FLOWERS PER PLANT (BOTTOM) IN *L. PUMILA* SPP. *PUMILA* POPULATION MONITORING PLOTS ON LOWER TABLE ROCK IN 2009-2018. VALUES FROM 2009-2011 (N=10) WERE SCALED TO REFLECT DIFFERENCES IN PLOT AREA. IN 2012, NEW POPULATION MONITORING PLOTS WERE ESTABLISHED FOR LONG-TERM MONITORING (2012-2018, N=20). ERROR BARS REPRESENT 95% CONFIDENCE INTERVALS.

Average grass and litter cover in monitoring plots has also varied over time with no clear long-term trends. After the fire retardant drop in 2010 we did note an initial increase in grass cover, potentially overcrowding other forb species found in the vernal pool habitat. This initial flush after the fertilizer effect from the fire retardant seems to

have stabilized, though total grass cover has remained high, despite some regions being subjected to a prescribed burn in the fall of 2015.

In 2012, total grass and litter cover were observed at their lowest averages of 11% and 3%, respectively, but both increased steeply in 2013. Since 2013, total grass cover has declined steadily, while litter cover has been more variable. In 2014 we began to distinguish between types of grasses and since then, exotic grasses have made up the majority of total grass cover. No significant trends in exotic or native grass cover from year to year are yet discernable (Figure 8). While litter cover increased significantly in the last two years of monitoring (Kruskal Wallis $\chi^2=76.18$, $p=0.017$), the 2018 average of 25.7% still lies well below the seven-year high of 60% cover reached in 2013. Litter cover, often in the form of thatch from dead exotic grasses, may negatively impact germination of native vegetation. Plot photos taken annually can also help us to qualitatively assess plot attributes such as litter and grass cover over time, but the differences are often subtle and inconsistencies in methodology complicate such assessments (Figure 9).

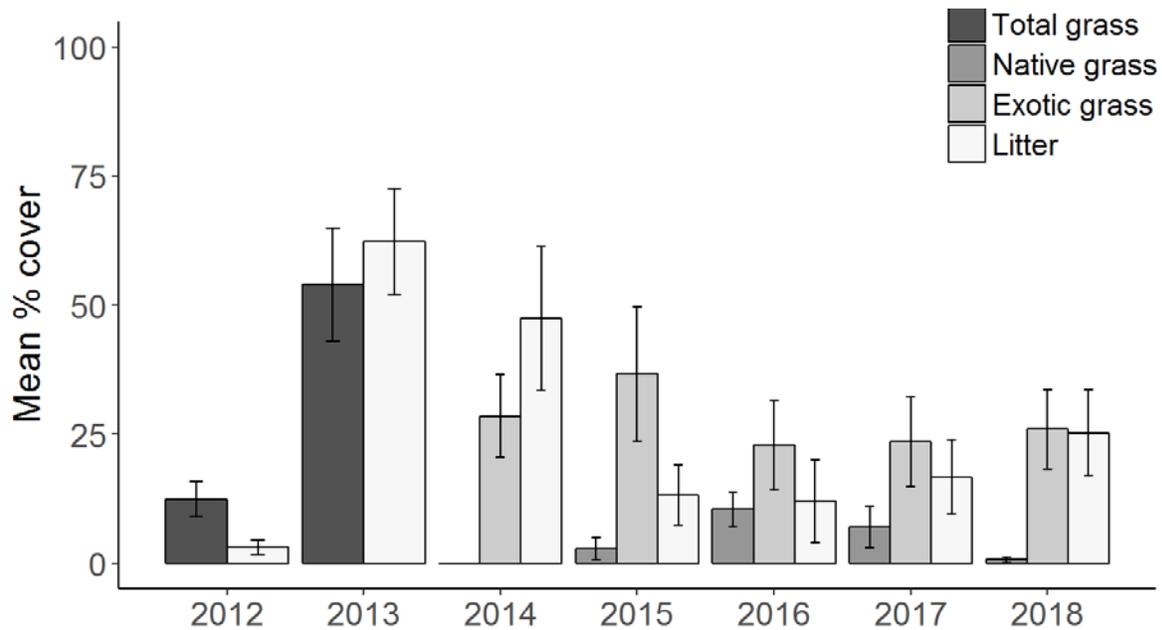


FIGURE 8. MEAN GRASS AND LITTER COVER IN LONG-TERM MONITORING PLOTS FROM 2012 - 2018. IN 2012 AND 2013 (*) ONLY TOTAL GRASS COVER WAS COLLECTED. SEPARATE COVER VALUES FOR EXOTIC AND NATIVE GRASSES WERE RECORDED IN 2014-2018. ERROR BARS REPRESENT 95% CONFIDENCE INTERVALS.

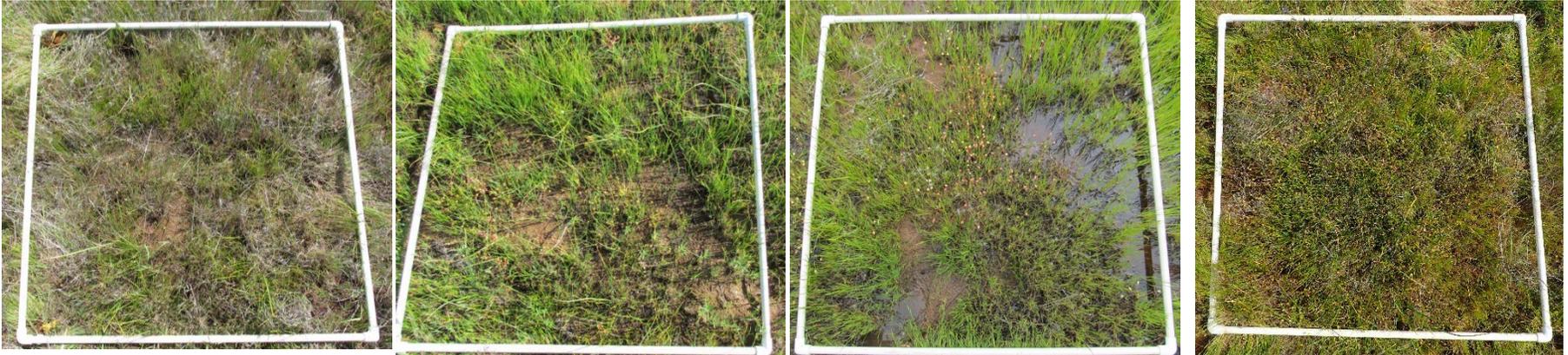
Plot 311 -- uncaged

2015

2016

2017

2018



Plot 312 -- caged

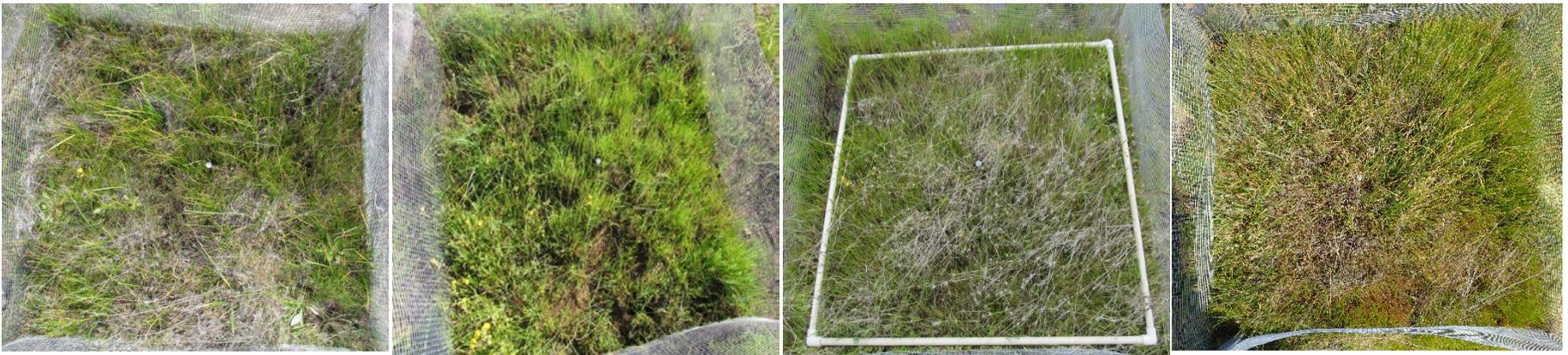


FIGURE 9. PHOTOPOINTS FROM CAGED AND UNCAGED PLOTS ON LOWER TABLE ROCK FROM 2015-2018. NOTE THE CHANGES IN LITTER OBSERVED IN PLOTS OVER TIME.

Effects of Recreation Traffic on Lower Table Rock

In 2013, 2015, and 2016 there were significantly higher mean numbers of plants in moderate traffic areas versus high traffic areas (2013: $F=10.52$, $p=0.004$; 2015: $W=14$, $p=0.006$; 2016: $F=5.38$, $p=0.032$; Figure 10). In 2018 we again observed a moderate but significant difference suggesting a higher number of plants in moderate traffic plots ($W=82.5$, $p=0.016$), but we continued to see no significant difference in number of flowers per plant (Figure 11, top). Exotic grass cover was significantly lower in moderate traffic plots in 2018 ($F=6.7$, $p=0.019$), while cover of *L. pumila* ssp. *pumila*, native grasses, native and exotic forbs, and litter did not differ between high and moderate traffic areas (Figure 12, top). There were also no significant differences between caged and uncaged plots in mean number of plants per plot or number of flowers per plant (Figure 11, bottom), nor were there significant differences in the cover of *L. pumila* ssp. *pumila*, native and exotic forbs, native and exotic grasses, or litter (Figure 12, bottom).

Differences in high and moderate traffic areas, particularly for exotic grass cover and the number of *L. pumila* ssp. *pumila* individuals suggest that high recreation traffic can adversely affect these vernal pool communities. Limiting access to areas of high population density during flowering times could potentially reduce negative impacts.

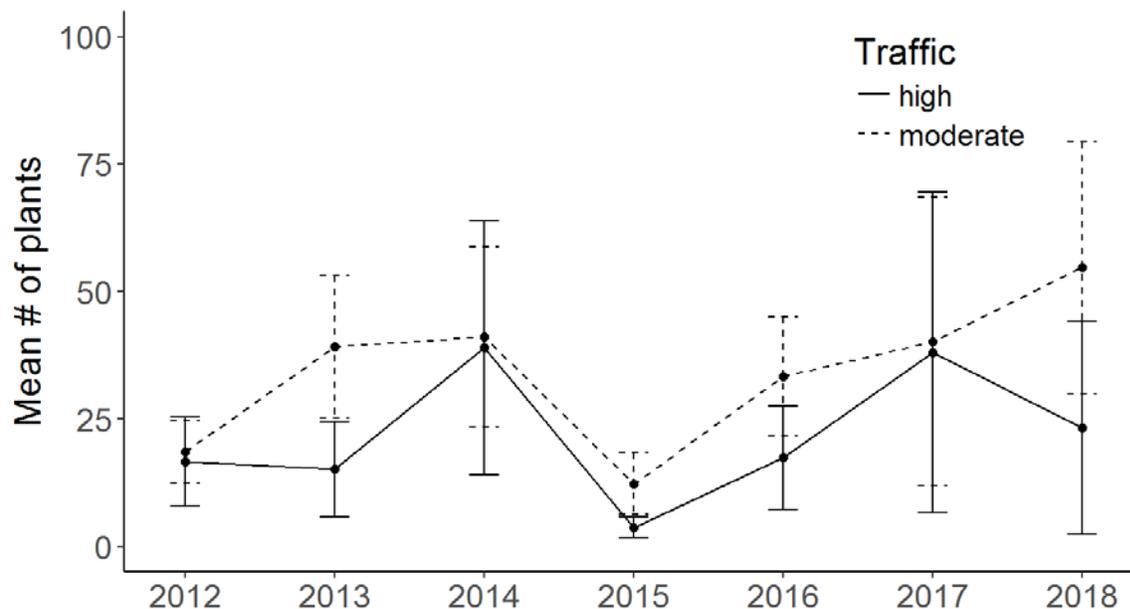


FIGURE 10. MEAN NUMBER OF PLANTS IN HIGH AND MODERATE TRAFFIC PLOTS ON LOWER TABLE ROCK FROM 2012-2018. PLOTS THAT WERE INITIALLY DESIGNATED AS “LOW” TRAFFIC IN EARLY YEARS OF THIS STUDY ARE NOW CONSIDERED TO BE “MODERATE” TRAFFIC PLOTS DUE TO INCREASED VISITOR USE. FOR SCALE REFERENCE, THE HIGHEST MEAN # OF PLANTS OBSERVED OVER THE ENTIRE STUDY WAS 199 (2010). ERROR BARS REPRESENT 95% CONFIDENCE INTERVALS.

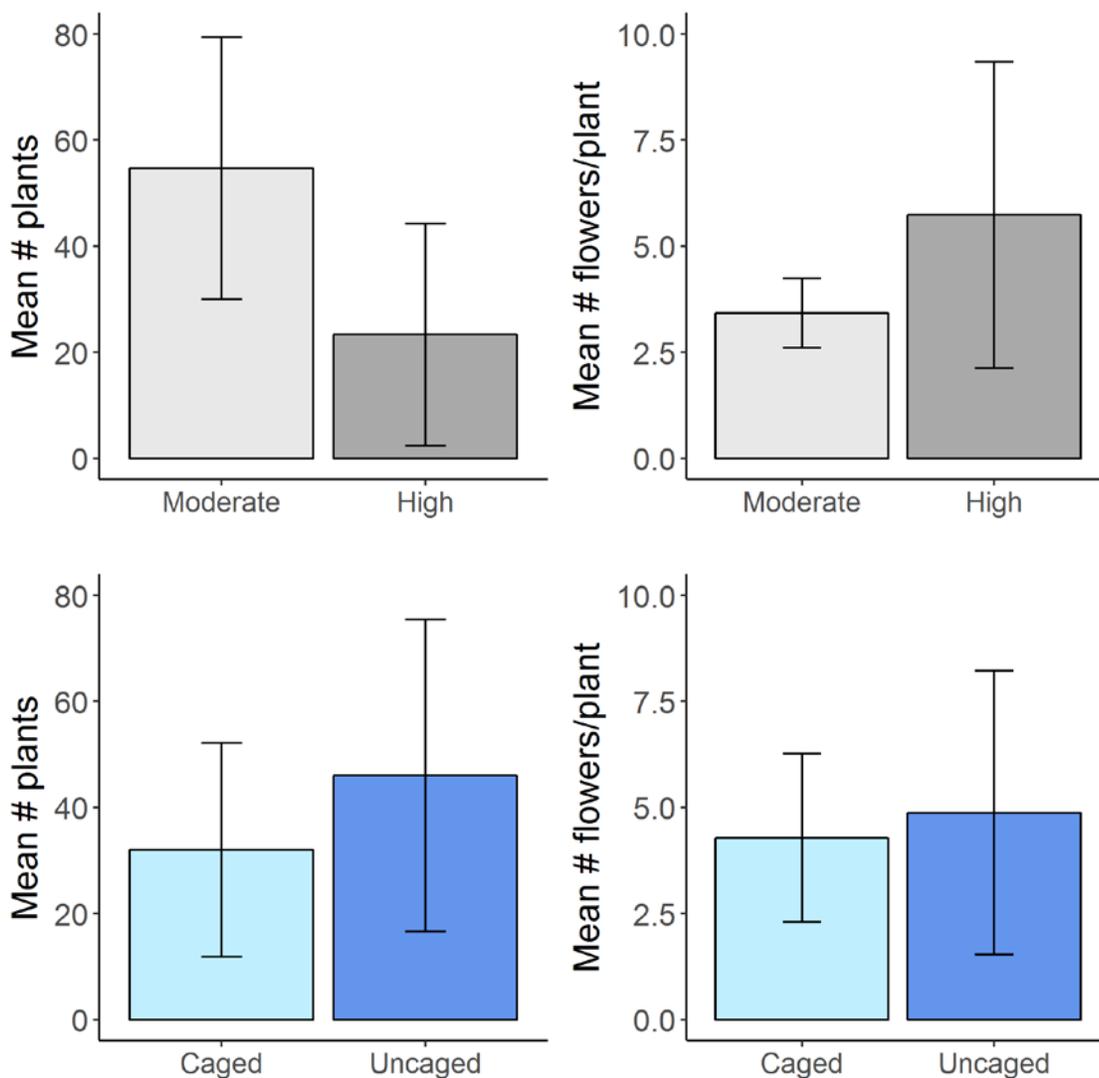


FIGURE 11. MEAN NUMBER OF PLANTS AND MEAN NUMBER OF FLOWERS PER PLANT IN 2018, SORTED BY HIGH AND MODERATE RECREATION TRAFFIC (ABOVE) AND CAGED AND UNCAGED PLOTS (BELOW). PLOTS THAT WERE INITIALLY DESIGNATED AS “LOW” TRAFFIC IN EARLY YEARS OF THIS STUDY ARE NOW CONSIDERED TO BE “MODERATE” TRAFFIC PLOTS DUE TO INCREASED VISITOR USE. ERROR BARS REPRESENT 95% CONFIDENCE INTERVALS.

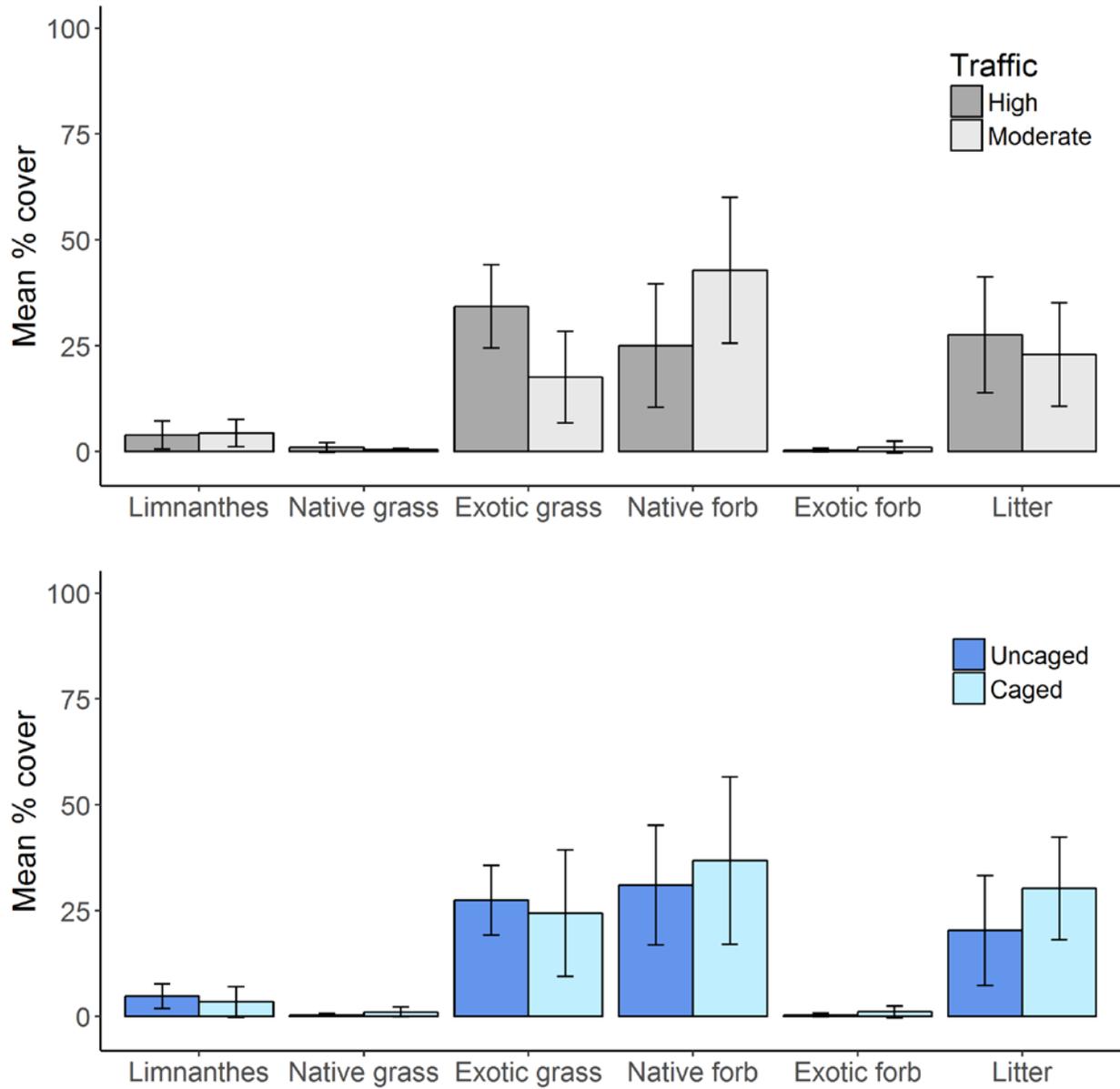


FIGURE 12. MEAN PERCENT COVER IN PLOTS ON LOWER TABLE ROCK IN 2018, BY RECREATION TRAFFIC (TOP), AND CAGE TREATMENT (BOTTOM). 'NATIVE FORB' INCLUDES *LIMNANTHES* COVER. PLOTS THAT WERE INITIALLY DESIGNATED AS "LOW" TRAFFIC IN THE BEGINNING OF THE STUDY ARE NOW CONSIDERED TO BE "MODERATE" TRAFFIC PLOTS DUE TO INCREASED VISITOR USE. ERROR BARS REPRESENT 95% CONFIDENCE INTERVALS.

Effects of grazing and human impacts on population trends at Upper Table Rock

Previous results indicate that large ungulates may have a negative effect on the density of *L. pumila* ssp. *pumila* (Thorpe and Massatti 2009). Cattle were last grazed in 2008, and analysis of data from 2010 to 2017 showed no significant difference between the enclosure and open plots for number of plants or flowers per plant. Similarly, in 2018 we found no difference between enclosure and open plots with respect to number of *L. pumila* ssp. *pumila* ($W=29$, $p=0.23$) or number of flowers per plant ($W=44$, $p=\sim 1$, Figure 13). The continued similarity between enclosed and open plots since the removal of cattle suggests that subsequent native ungulate activity has had little to no effect on population dynamics.

While 2015 was the lowest recorded year for both plants and number of flowers per plant in both enclosed and open plots, mean number of plants in 2016 was similar to the higher values seen in 2013 (and earlier) and number of flowers per plant reached its highest average since 2008. Patterns such as these suggest that the previous year's performance cannot always be a prediction for how the species will do in subsequent seasons, as many other ecosystem-level factors are involved. Mean number of plants and number of flowers per plant declined again in 2017, though not as low as 2015 averages, and no significant change was observed in 2018 (Figure 13). Across all plots on Upper Table Rock, number of plants per plot ranged from three to 49, and mean number of flowers per plant ranged from one to five, similar to values observed in 2016 and 2017.

Grass cover in both enclosed and open plots has varied over time with high levels in 2010 and 2013, and low levels in 2012. Grass cover dropped again in 2018, reaching levels similar to those observed in 2012 (Figure 14). Though total grass cover has varied over time, the percentage of grass cover dominated by non-native grasses including *B. hordeaceus* and *T. caput-medusae* has remained high. Management focused on decreasing non-native grasses in these areas should be a high priority.

Finally, litter cover in both open and enclosed plots has dropped steadily from 2013 (mean = 75%) to 2018 (mean = 6%) (no data for 2014). This could be due to a larger-scale decrease in grass/thatch cover (not detected in our monitoring plots), significant increases in exotic forb cover, and/or a change in phenology associated with regional climate shifts that may impact how litter is assigned in the field.

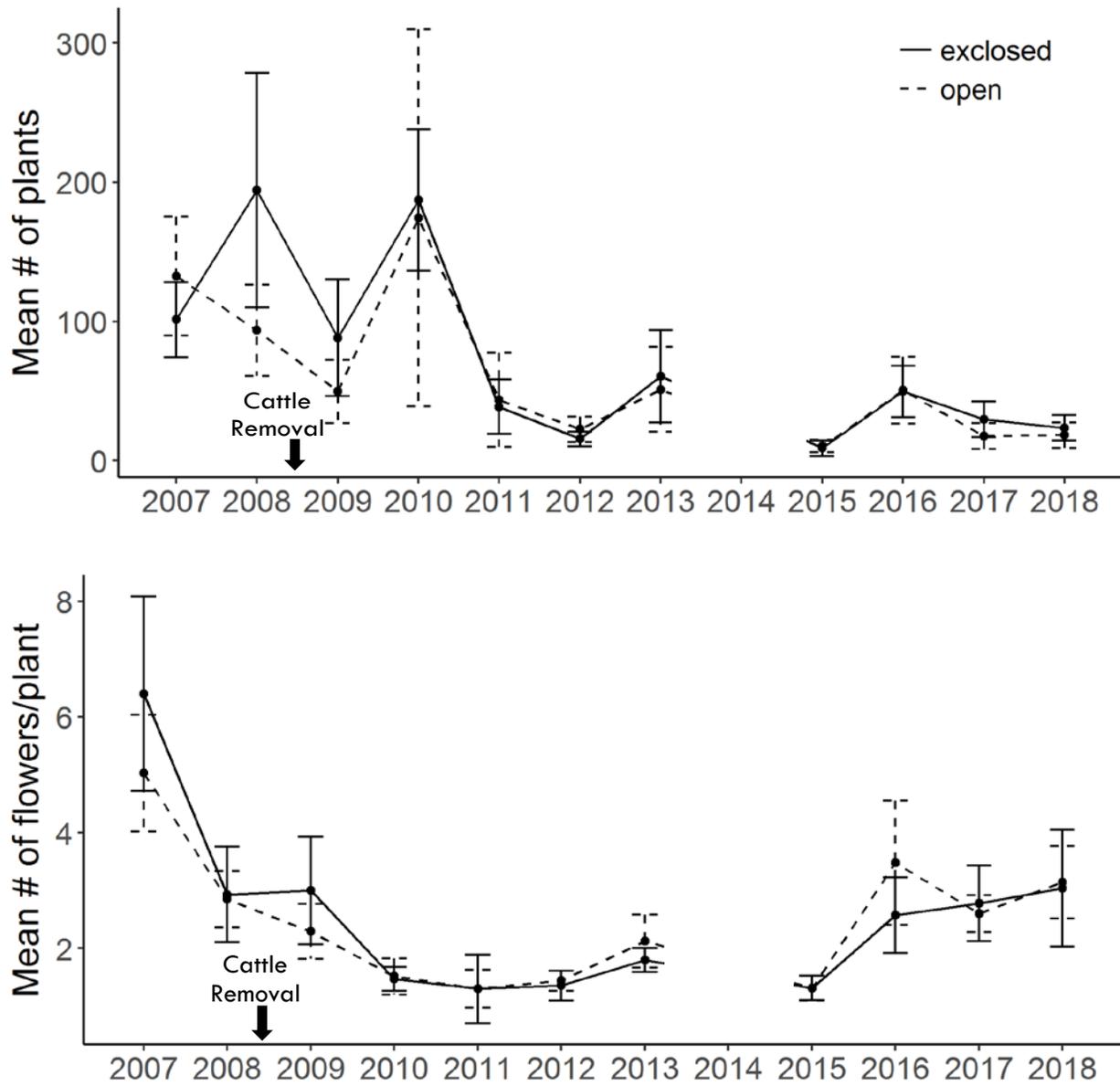


FIGURE 13. MEAN NUMBER OF PLANTS (TOP) AND FLOWERS PER PLANT (BOTTOM) IN EXCLOSED AND OPEN PLOTS ON UPPER TABLE ROCK IN 2007 - 2018. ERROR BARS REPRESENT 95% CONFIDENCE INTERVALS. CATTLE WERE REMOVED AFTER THE 2008 SEASON, AS INDICATED. PLOTS WERE NOT MONITORED IN 2014.

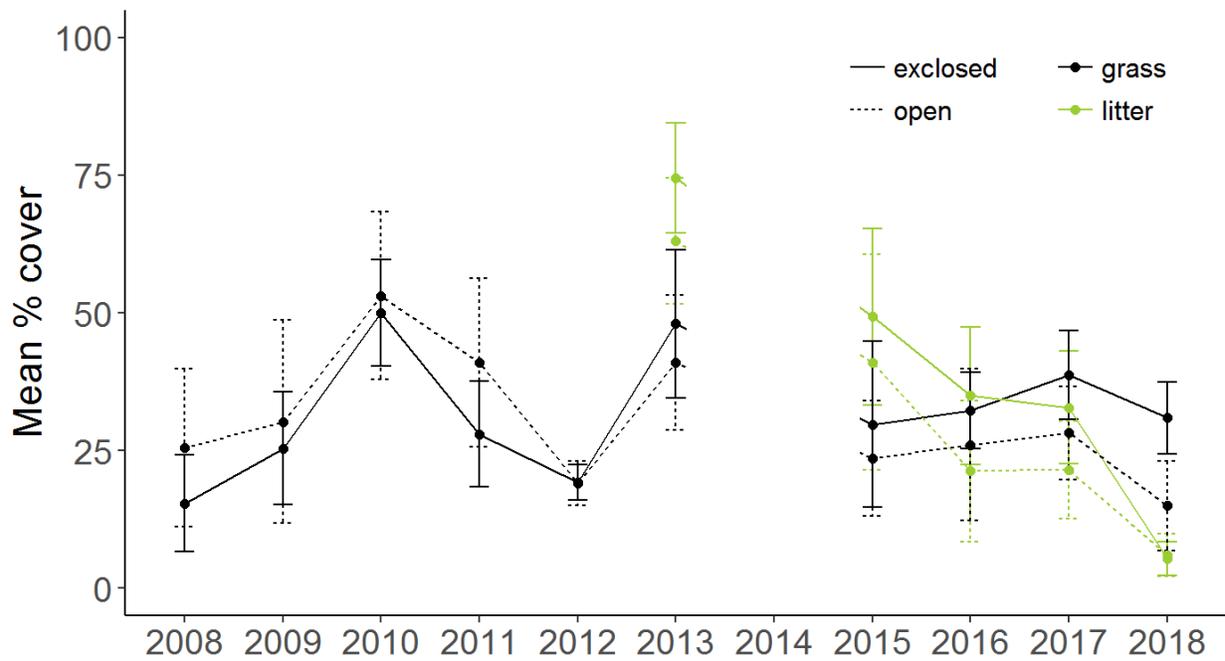


FIGURE 14. MEAN PERCENT COVER OF GRAMINOIDS AND LITTER IN *L. PUMILA* SSP. *PUMILA* MONITORING PLOTS ESTABLISHED ON UPPER TABLE ROCK. ERROR BARS REPRESENT 95% CONFIDENCE INTERVALS. GRAMINOID COVER WAS RECORDED IN 2008-2018, LITTER COVER WAS NOT RECORDED FROM 2008-2012. PLOTS WERE NOT MONITORED IN 2014.

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. In 2016, six more plots were added in areas of moderate recreation traffic (i.e. further away from established trails). This entire area has experienced increased visitation in recent years with off-trail use in and around vernal pools that support *L. pumila* ssp. *pumila*. In 2016, similar to other plots across this study, mean number of plants and mean number of flowers per plant increased from the low values observed in 2015 (high traffic plots only, Table 1). In 2017, mean number of plants and mean number of flowers per plant decreased in high traffic plots, while mean number of plants increased in moderate traffic plots. Apart from a slight increase in mean number of plants in high traffic plots, plants per plot and flowers per plant decreased from 2017 to 2018. No significant differences were observed between high and moderate traffic plots in number of plants or number of flowers per plant. Results from Lower Table Rock exhibit significant differences between high and moderate traffic areas, with greater numbers of *L. pumila* ssp. *pumila* and greater native forb cover observed in moderate traffic areas, suggesting that recreation traffic can negatively impact these communities (Gray and Bahm 2016). Continued monitoring on the southern end of Upper Table Rock will be necessary to see if there are also significant human impacts in this area.

TABLE 1. MEAN NUMBER OF PLANTS AND MEAN NUMBER OF FLOWERS PER PLANT OF *L. PUMILA* SSP. *PUMILA* IN LONG-TERM MONITORING PLOTS ON THE SOUTHERN END OF UPPER TABLE ROCK. "N/A" INDICATES THAT PLOTS WERE NOT ESTABLISHED DURING THAT YEAR. VALUES ARE MEANS \pm 95% CONFIDENCE INTERVALS.

Plot	# plants \pm 95% C.I.			
	2015	2016	2017	2018
High Traffic (Est. 2015)	10.0 \pm 5.9	41.0 \pm 24.6	15.2 \pm 12.7	19.2 \pm 25.5
Moderate Traffic (Est. 2016)	N/A	26.2 \pm 8.8	38.2 \pm 21.1	9.0 \pm 6.8
Plot	# flowers per plant \pm 95% C.I.			
	2015	2016	2017	2018
High Traffic (Est. 2015)	3.1 \pm 1.4	7.3 \pm 2.3	5.8 \pm 3.2	2.4 \pm 0.8
Moderate Traffic (Est. 2016)	N/A	9.5 \pm 3.5	8.5 \pm 2.1	5.4 \pm 6.3

Community monitoring of the fire retardant drop

Transects were not monitored in 2018 but results from 2017 are included here.

Across all transects dissecting the area impacted by the fire retardant drop, flat habitats were the most abundant composing roughly 46%, followed by pool habitats (33%), with mound habitats composing the remainder (21%, Table 2). Mound habitats had decreased from 23% in 2015 to 16% in 2016, but increased to 21% in 2017. Pool habitats had decreased between 2014 and 2015, but increased in 2016 to 28% and then up to 33% in 2017 (Table 2).

Limnanthes pumila ssp. *pumila* and other native species were associated with pool habitats, while mound habitats have been associated with exotic grasses. These changes in community type should be interpreted cautiously because there is a chance that plots were not placed in the exact location each year as they were roughly marked using a transect. The prescribed fire in the fall of 2015 could have greatly impacted these changes and the increase of pool habitats noted.

TABLE 2. PERCENTAGE OF TRANSECTS OCCUPIED BY FLAT, MOUND, AND POOL HABITATS ON LOWER TABLE ROCK IN 2017.

Transect	Proportion of Transect		
	Flat	Mound	Pool
1	44	32	24
2	21	30	49
3	58	18	24
4	38	14	48
5	66	15	19
Average	46	21	33

To assess plant community composition within and outside of the area impacted by the fire retardant drop, we monitored a total of 37 1-m² plots along the transects, ranging from 6 to 9 plots per transect (dark blue, Figure 6). Mean *L. pumila* ssp. *pumila* cover was 0.18%, which was less than cover in 2016 (0.74%), but an increase from 2015 (0.03%). Across all plots, non-native grasses composed cover ranging from 3-70%, with an average of 28%, which was a slight increase from 2016 (24%) but a decrease from the 37% average seen in 2015. Flat habitats were the most common comprising 62% of all plots, followed by pool habitats (24%) and mound habitats (14%). Native grasses were most abundant in pool habitats, with lower cover in flat and mound habitats (Figure 15). Non-native grasses tended to dominate flat and mound habitats, with fewer in pool habitats. Native forbs were the most abundant in mound habitats, which was observed in 2016 as well. Non-native forbs were less abundant, particularly in flat and pool habitats. *Limnanthes pumila* ssp. *pumila* cover was the most abundant in pool habitats. Litter cover was highest in mound habitats; flat and pool habitats had similar litter cover, but was slightly less in pools (Figure 15).

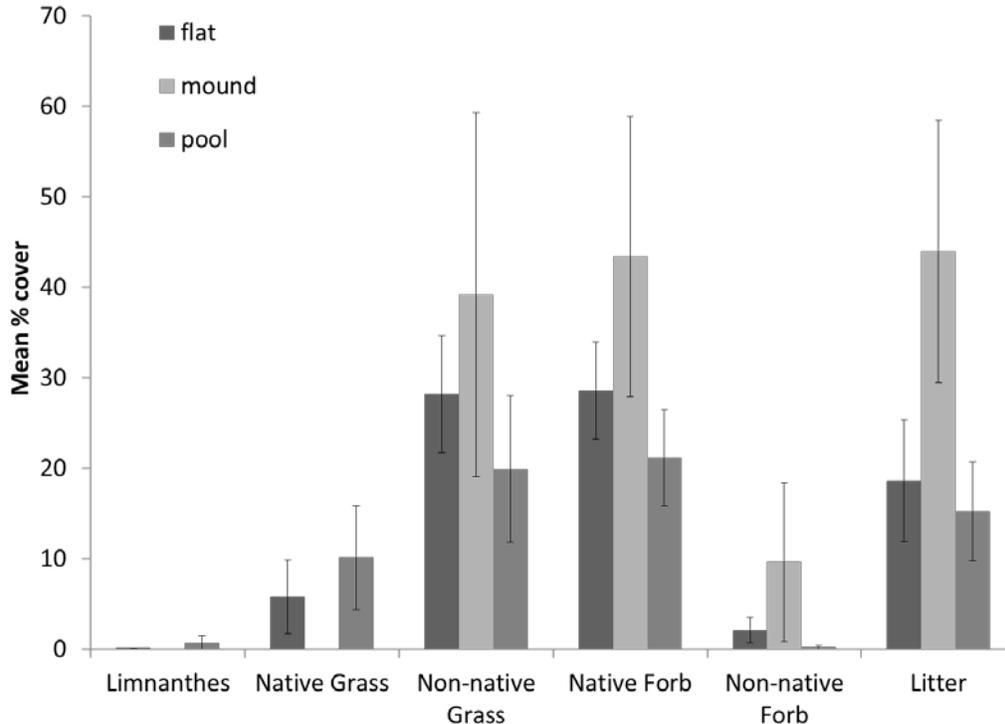


FIGURE 15. PERCENT COVER IN ALL PLOTS ALONG FIRE RETARDANT TRANSECTS ON LOWER TABLE ROCK, BY HABITAT TYPE (N, FLAT =25, MOUND = 7, POOL = 7) IN 2017. ERROR BARS REPRESENT 95% CONFIDENCE INTERVALS. 'NATIVE FORB' INCLUDES *LIMNANTHES* COVER.

From 2013 to 2016 we observed a decline in non-native grasses both within and outside of the fire retardant drop (Table 3, Figure 16). In 2016, there was a decrease in non-native grass cover outside of the retardant drop area while levels remained similar inside of the drop. In 2017, there was a slight increase in non-native grass cover outside of the retardant drop area while levels remained similar inside of the drop. Litter cover declined from 2013 to 2017 both within and outside of the fire retardant drop (Table 3, Figure 16), resulting in 2017 having the lowest litter cover across all years. In 2016 we saw the highest cover of *L. pumila* ssp. *pumila* since 2013, both inside and outside of the drop, which seemed to be similar to increases observed in other plots that year, but could have also been a response to the prescribed fire that occurred across this entire area in the fall of 2015 (Figure 15). Following this increase, in 2017 there was a decrease in *L. pumila* ssp. *pumila* cover both outside and inside the drop area (Figure 16).

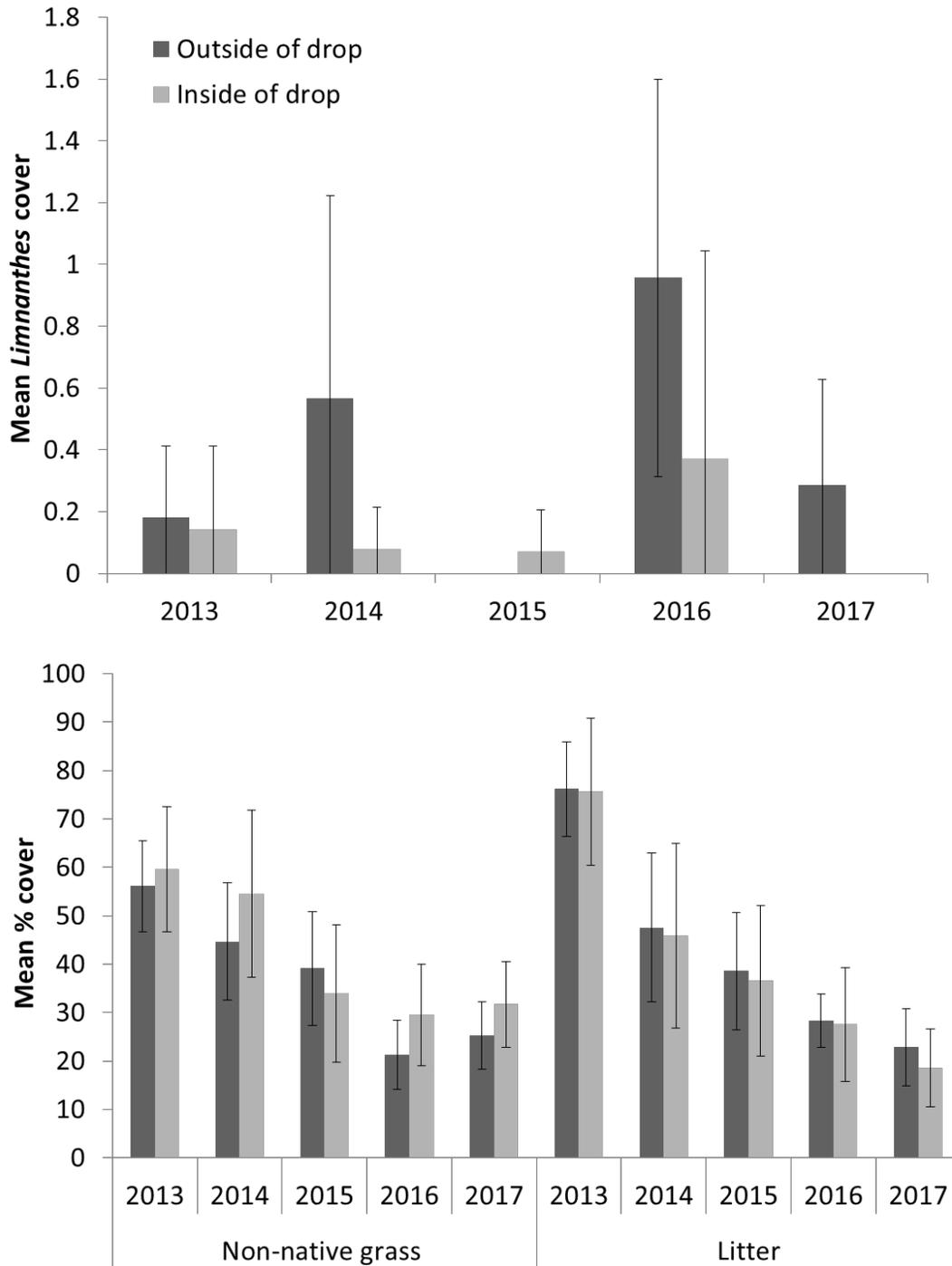


FIGURE 16. MEAN *L. PUMILA* SSP. *PUMILA* COVER COLLECTED FROM PLOTS ALONG TRANSECTS INSIDE AND OUTSIDE THE AREA OF THE FIRE RETARDANT DROP IN 2013 TO 2017. MEAN COVER OF NON-NATIVE GRASSES AND LITTER COLLECTED FROM PLOTS ALONG TRANSECTS INSIDE AND OUTSIDE OF THE AREA OF THE FIRE RETARDANT DROP FROM 2013 TO 2017 (BELOW). ERROR BARS REPRESENT 95% CONFIDENCE INTERVALS.

TABLE 3. MEAN PERCENT COVER BY HABITAT TYPE (FLAT, MOUND, POOL) IN MONITORING PLOTS WITHIN AND OUTSIDE OF THE AREA IMPACTED BY THE FIRE RETARDANT DROP, 2013-2017.

	Mean <i>Limnanthes</i> cover					Mean non-native grass cover					Mean litter cover				
	<u>2013</u>	<u>2014</u>	<u>2015</u>	<u>2016</u>	<u>2017</u>	<u>2013</u>	<u>2014</u>	<u>2015</u>	<u>2016</u>	<u>2017</u>	<u>2013</u>	<u>2014</u>	<u>2015</u>	<u>2016</u>	<u>2017</u>
Outside of drop	0.2	0.6	0.0	1.0	0.3	56.1	44.7	39.1	21.3	25.2	76.2	47.5	38.6	28.3	22.8
flat	0.0	0.0	0.0	0.3	0.0	40.5	30.2	24.9	24.6	25.0	61.0	36.6	32.9	28.0	21.6
mound	0.2	0.0	0.0	0.3	0.0	65.9	80.0	65.0	13.3	37.7	87.0	92.5	53.2	40.0	45.0
pool	1.1	2.6	0.0	3.4	1.0	80.0	52.0	67.5	16.0	19.5	92.5	43.0	37.5	22.0	14.5
Inside of drop	0.1	0.1	0.1	0.4	0.0	59.6	54.5	33.9	29.5	31.7	75.6	45.9	36.6	27.6	18.6
flat	0.0	0.0	0.0	0.0	0.0	41.7	49.8	23.0	31.8	33.2	56.2	46.0	34.2	30.5	13.9
mound	0.7	0.0	0.0	0.1	0.0	73.3	90.0	57.5	40.0	41.5	96.0	97.5	60.0	20.5	42.5
pool	0.0	0.4	0.5	2.5	0.0	73.0	48.3	65.0	7.5	20.7	86.8	21.3	25.0	20.0	16.7

In 2017 we observed an increase in non-native grass cover in pool habitats, both outside and inside of the drop, from 2016 values, however, cover still remained lower than 2013-2015 values (Table 3). Contrary to 2016, we saw a decrease in *L. pumila* ssp. *pumila* cover in pool habitats both outside and inside of the drop in 2017. Although mean *L. pumila* ssp. *pumila* cover in pool habitats was lower in 2017 than 2016, it was higher than in 2015, when *L. pumila* ssp. *pumila* only occurred in one plot (inside of the drop) (Table 3). Overall, litter cover decreased in both areas in 2017. In pool habitats, litter cover decreased outside and inside the drop area, while in mound habitats, litter cover increased outside and inside the drop area. In 2016 we had noted the lowest levels of non-native grasses and litter and the highest cover of *L. pumila* ssp. *pumila*. In 2017, litter was at the lowest levels across all years, but non-native grass cover had increased and *L. pumila* ssp. *pumila* cover had decreased both outside and inside the drop. 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 2017, mean cover of natives in pool habitats was 31%, which was lower than in 2016 (38%), but an increase from recent years since the fire retardant drop. 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; Gray et al. 2012). While 2016 and 2017 had higher numbers than most recent years, the decline in cover from a native dominated pool community to one now dominated by non-natives is troubling.

In October 2015, the BLM conducted a prescribed fire in the area affected by the fire retardant drop in an effort to target non-native grasses and buildup of litter. The area burned covered the area originally impacted by the fire retardant drop and extended beyond, using the main trail as the eastern fire boundary (Figure 17). This area was greater than the footprint we used previously to define impacts of the fire retardant drop in our transect monitoring, and encompassed what we defined as “inside of the drop” and “outside of the drop” (Figure 17). In 2016, 2017, and 2018 we used the long-term monitoring plots on Lower Table Rock to assess impacts of the prescribed fire on *L. pumila* ssp. *pumila* and the plant community; there were nine long term monitoring plots within the burned portion and twelve outside of the burn. In 2016, mean number of flowers per plant was greater in burned plots than unburned plots ($F=18.81$, $p<0.001$; Figure 18). However, number of plants did not differ significantly between burned and unburned plots in 2017 ($W=25$, $p=0.067$) or 2018 ($W=57.5$, $p=0.49$; Figure 18). Contrary to the trend in 2016, we observed slightly fewer flowers per plant in burned plots in 2018 ($W=75$, $p=0.04$; Figure 18). These results should be interpreted cautiously as the plots were not established to test specifically for the effects of fire.

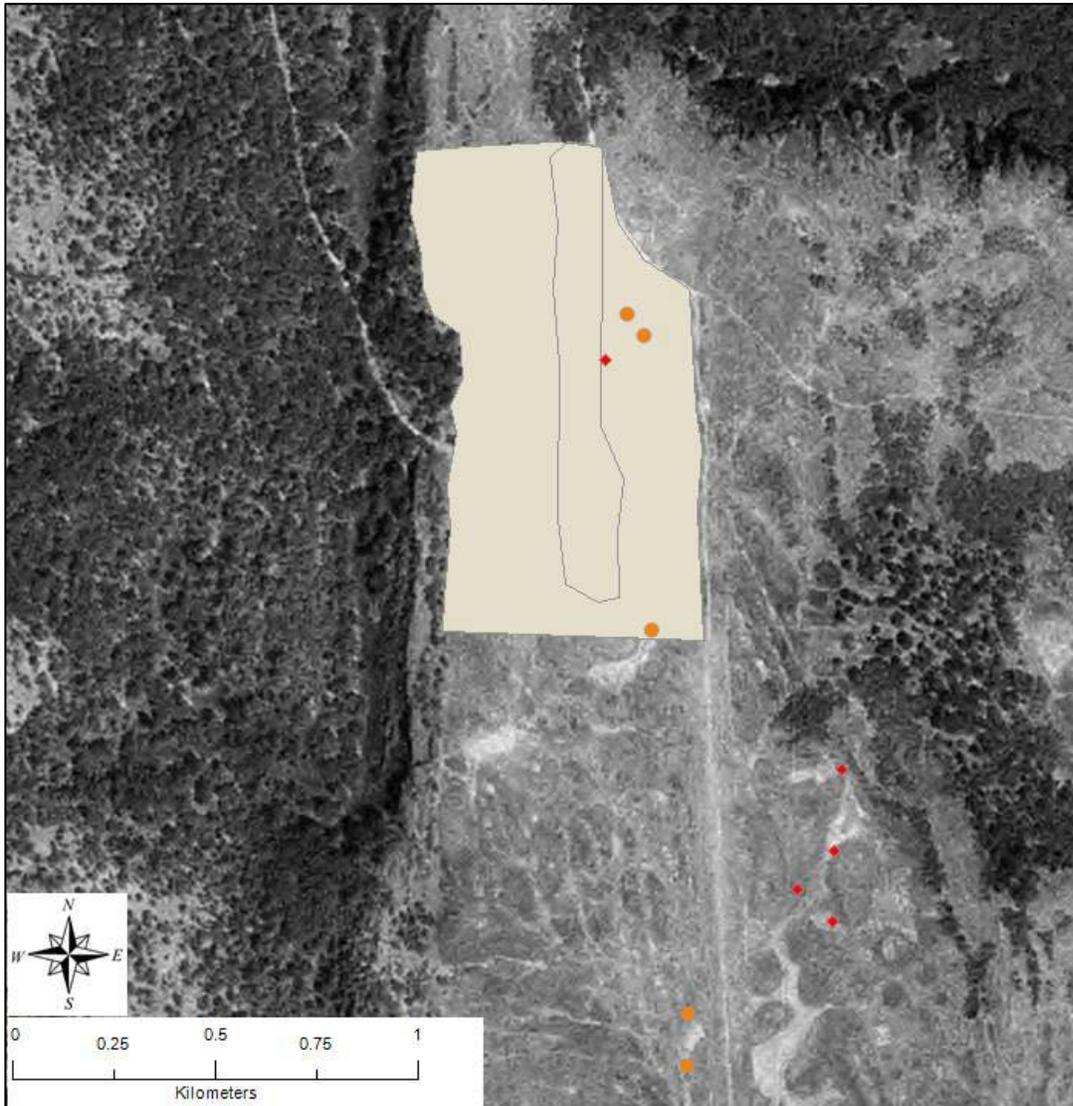


FIGURE 17. LOCATION OF THE PRECIBED FIRE ON LOWER TABLE ROCK THAT OCCURRED IN OCTOBER 2015 (TAN AREA). THE ORIGINAL AREA IMPACTED BY THE FIRE RETARDANT DROP IS OUTLINED WITHIN. HIGH AND MODERATE TRAFFIC PAIRED PLOTS ARE INDICATED BY RED DOTS (MODERATE TRAFFIC) AND ORANGE DOTS (HIGH TRAFFIC). SEE APPENDIX B FOR MORE PLOT DETAIL.

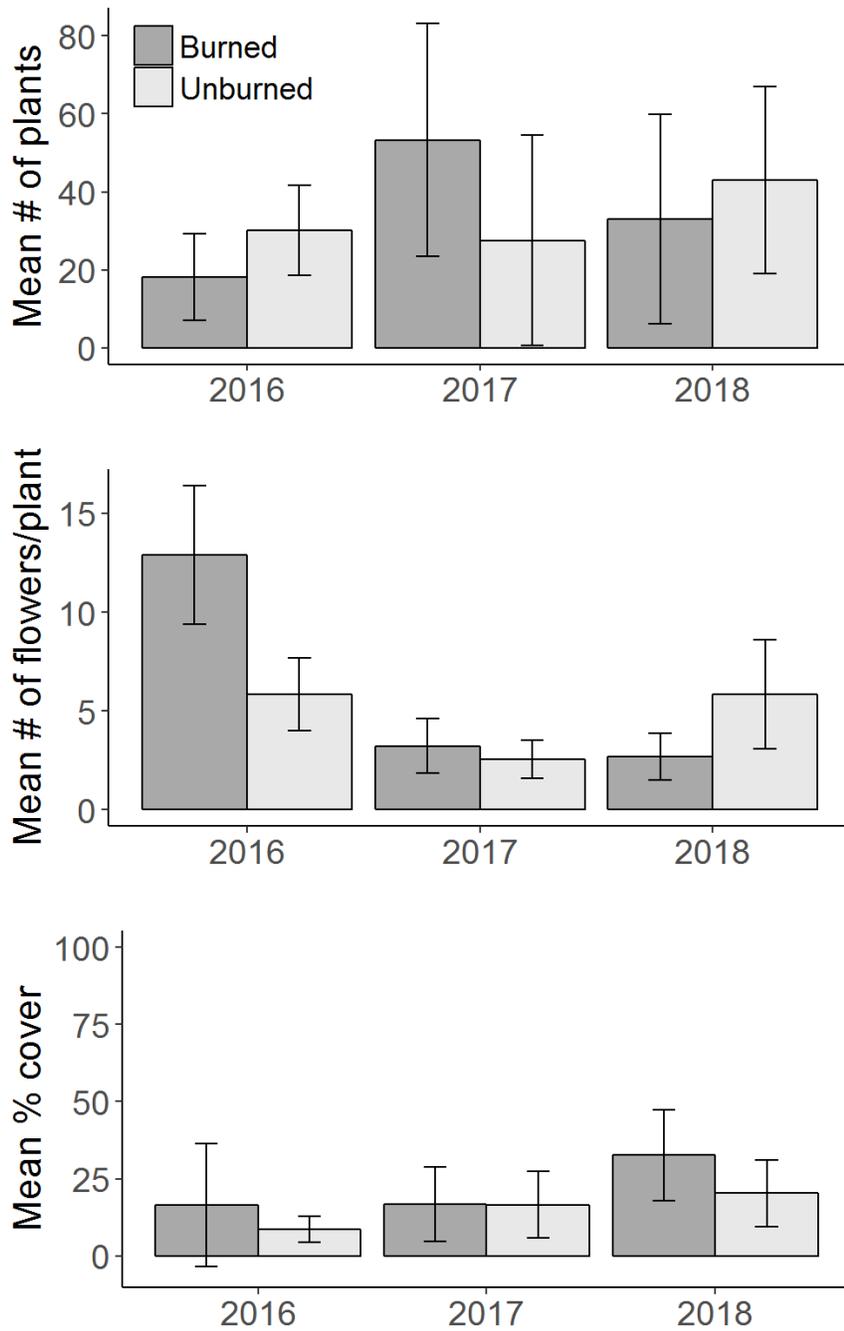


FIGURE 18. MEAN NUMBER OF *L. PUMILA* SSP. *PUMILA* PLANTS, MEAN NUMBER OF FLOWERS PER PLANT, AND MEAN PERCENT LITTER COVER IN 2016, 2017, AND 2018 IN PLOTS THAT WERE BURNED (N=9) AND UNBURNED (N=12) DURING THE PRESCRIBED FIRE IN FALL 2015. ERROR BARS REPRESENT 95% CONFIDENCE INTERVALS.



FIGURE 19. 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 increase in exotic grasses in 2010 and the years shortly after could be a 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 shifts in plant community in the area of the fire retardant drop. When the drop occurred in July 2010, many of the native species were past their main 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 (Figure 19). These species can 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 enabled exotic winter annuals to gain a competitive advantage over native forbs and grasses. Though the fertilizing compounds diminished with time, increased abundance of exotic annual grasses could have added substantially to the existing seed-bank. After the retardant drop we also observed an increase of silica-rich litter which decomposes at a slow rate (Johnson and Davies 2012) and potentially diminishes germination success in other species. Results from 2013 suggest that invasion of exotic species was ubiquitous on Lower Table Rock, had spread both within and outside of the area of the fire retardant drop, and was associated with a severe decline in the *L. pumila* ssp. *pumila* population. Changes in plant community composition were easily observable in aerial imagery (Gray et al. 2015).

CONCLUSIONS

From 2010-2013, we observed a severe decline (nearly 88%) in *L. pumila* ssp. *pumila* on both Upper and Lower Table Rock, coupled with a decrease in reproductive effort. During this same time, we recorded significant increases in cover of non-native grasses and litter. This abrupt shift was most likely associated with a fire retardant drop that occurred in 2010, leading to a fertilizer effect and very high litter cover in 2013. Despite a slight increase in 2014, our sampled *L. pumila* ssp. *pumila* population declined to its lowest numbers over the course of the study on both Upper and Lower Table Rock in



FIGURE 20. POOL HABITAT ON LOWER TABLE ROCK.

2015, paralleling a decline in critical pool habitat on Lower Table Rock (Figure 20). In 2016, we observed a rebound in number, cover, and reproductive effort of *L. pumila* ssp. *pumila* on both Upper and Lower Table Rocks. This increase was promising, particularly given that 2015 was the lowest year over the course of the study. However, the increased reproductive effort in 2016 did not translate to increases in *L. pumila* ssp. *pumila* in 2017 or 2018. There has been a slight increase in number of plants in long-term monitoring plots on Lower Table Rock, but also a decrease in cover along community transects and a decrease in number of plants and reproductive effort on the northern end of Upper Table Rock. In 2017, we did observe an increase in crucial pool habitat, which may be beneficial for future population health. Since the initial decline observed after the fire retardant drop on Lower Table Rock, the *L. pumila* ssp. *pumila* population has rebounded, but not to numbers as high as were observed at the study's outset. Continued population monitoring is essential to recognize the long-term trends that may be obscured by the expected fluctuations of this annual species.

The noted decline in *L. pumila* ssp. *pumila* 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. Following the prescribed fire in fall 2015, we observed more flowers in plots that had been burned, and variable litter cover across all plots (Gray and Bahm 2016). It is likely that timing of the fire played a key role in the outcome of the burn. Research suggests that burning when *T. caput-medusae*, the most widespread exotic grass at the Table Rocks, is at the "soft dough" stage can decrease its cover up to 90% (McKell et al. 1962; Zimmerman et al. 2002). At the Jepson Prairie in California, the Nature Conservancy conducted burn trials in vernal pool habitat and found that late fall burns decreased exotic species cover, but also tended to decrease some native species cover. Late spring burns (after native seed set) were found to be the most effective at thatch reduction and killing seeds pre-dispersal (primarily those of exotic

grasses; Pollak and Kan 1998). While a fall burn may have impacted the plant community, a spring burn may yield more long-term effects on non-native grass cover.

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. 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 moderate recreation traffic in recent years 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 from 2015 to 2018. The multitude of secondary trails suggests that more action could be taken, particularly during the growing season, to protect these sensitive habitats. Though the Table Rocks offer a fantastic educational opportunity for studying the ecology of rare ecosystems and connecting local human populations to their natural surroundings, limiting impact in high-traffic areas might be necessary to enable *L. pumila* ssp. *pumila* to recover. *Limnanthes pumila* ssp. *pumila* is the most fragile prior to setting fruit, so timing centered on the phenology of this species would be imperative.

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. In 2016 and 2017, many of the large pools observed in the past were present (Figure 20), but in 2018 were dry. This variability in climate and its impact on habitat could greatly affect the populations of rare annual endemics occurring on the Table Rocks and continued monitoring coupled with active management remains necessary.

LITERATURE CITED

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APPENDIX A. SITE DIRECTIONS TO UPPER AND LOWER TABLE ROCKS.

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. 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 ESTABLISHED 2012.

Plot ID	Tag #	Waypoint	Year established	Use	Caged	Latitude ¹	Longitude
303	261	162	2012	high	no	42.456425	122.952693
304	304	163	2012	high	yes	52.456471	122.952802
307	262	164	2012	low	no	42.456099	122.952875
308	308	165	2012	low	yes	42.456127	122.95284
309	309	166	2012	high	yes	42.45628	122.95253
310	898 (old tag 291)	167	2012	high	no	42.456286	122.952446
311	266	168	2012	high	no	42.454287	122.952381
312	593 (old tag 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	69 (old tag 363)	174	2012	low	no	42.452556	122.950978
317	317	175	2012	low	yes	42.452517	122.951027
318	63 (old tag 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	62 (old tag 323)	181	2012	high	yes	42.451665	122.951867

¹NAD83, UTM 10N

*Indicates plot sampled in previous year(s)

Extra plots monitored on Lower Table Rock*

Plot	Tag #	Year established	Use	Caged	Latitude ¹	Longitude
736	443	2009	high	no	42.4542667	122.9524000
941	64 (old tag 941)	2007	high	no	42.4564833	122.9527333
942	238 (old tag 942)	2007	low	no	42.4568333	122.950333

¹NAD83, UTM 10N

*Not monitored in 2018

APPENDIX C. UPPER TABLE ROCK PLOT LOCATIONS.

Upper Table Rock Northern Plot Locations

Plot ID	Tag #	Year established	Caged	Latitude ¹	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	693	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 700/967)	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	692 (old tag 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
962	89 (old tag 962)	2013	no	42.47940137	122.9141945
151	275	2013	no	42.47928587	122.9117733

¹NAD83, UTM 10N

Upper Table Rock Southern Plot Locations

Plot ID	Tag #	Year established	Recreation traffic	Latitude ¹	Longitude
540	554	2015	high	42.466240	-122.895551
541**	551	2015	high	42.466266	-122.895519
542	68 (old tag 542)	2015	high	42.466192	-122.895159
543	798 (old tags 67 and 552)	2015	high	42.465479	-122.895901
544	553	2015	high	42.465875	-122.895530
545	545	2015	high	42.467729	-122.894719
555**	555	2016	low	42.468291	-122.896868
556	556	2016	low	42.468609	-122.897550
557	557	2016	low	42.468643	-122.897487
558	558	2016	low	42.469768	-122.898049
559*	559	2016	low	42.470128	-122.897707
560	65 (old tag 560)	2016	low	42.470158	-122.898084
66*	66	2017	low	42.469976	-122.897513

¹NAD83, UTM 10N

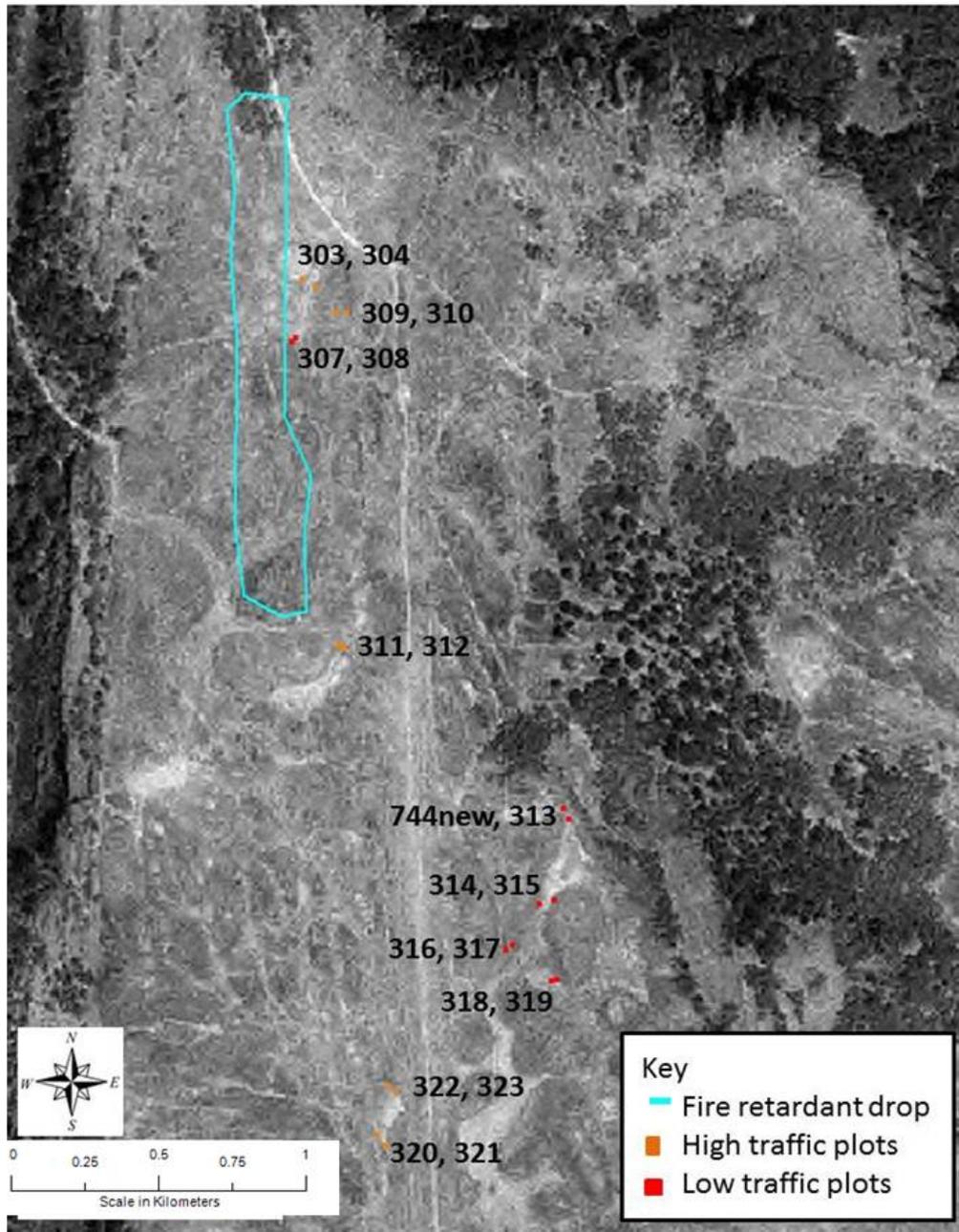
*NOTE: Could not locate Plot #559 in 2017, thus a new plot, #66, was established in the approximate vicinity.

**NOTE: Did not locate plots 541 or 555 in 2018

APPENDIX D. PLOT MAPS

Lower Table Rock

Long-term *L. pumila* ssp. *pumila* population monitoring plots established in 2012 with plot identification numbers (monitored from 2012-2018).



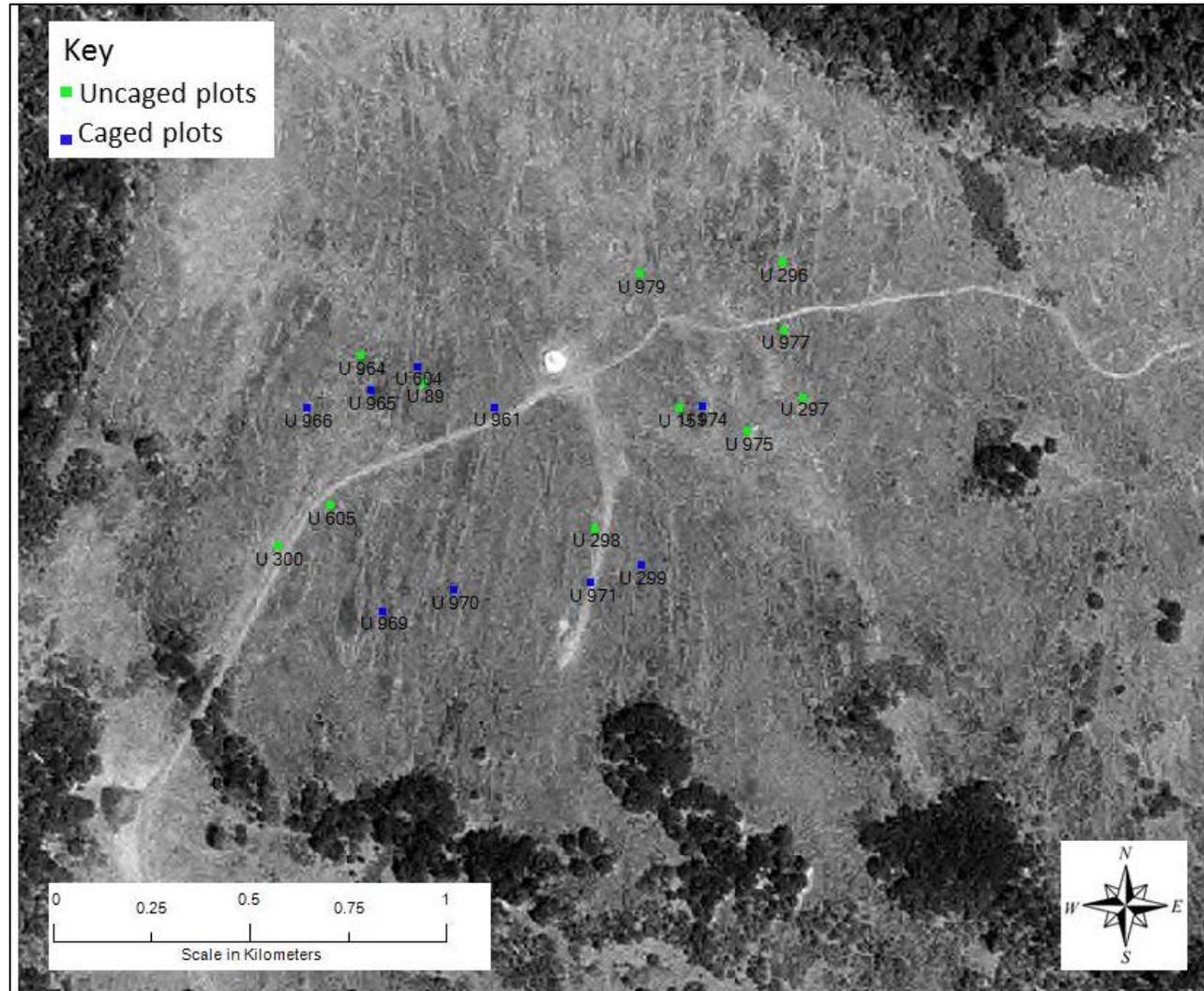
2009 trampling plot start points on Lower Table Rock. See Appendix B for plot azimuths and side of the tape to sample. End point GPS coordinates are also available in IAE files. Points are approximations only; plots could be ± 25 feet from points.



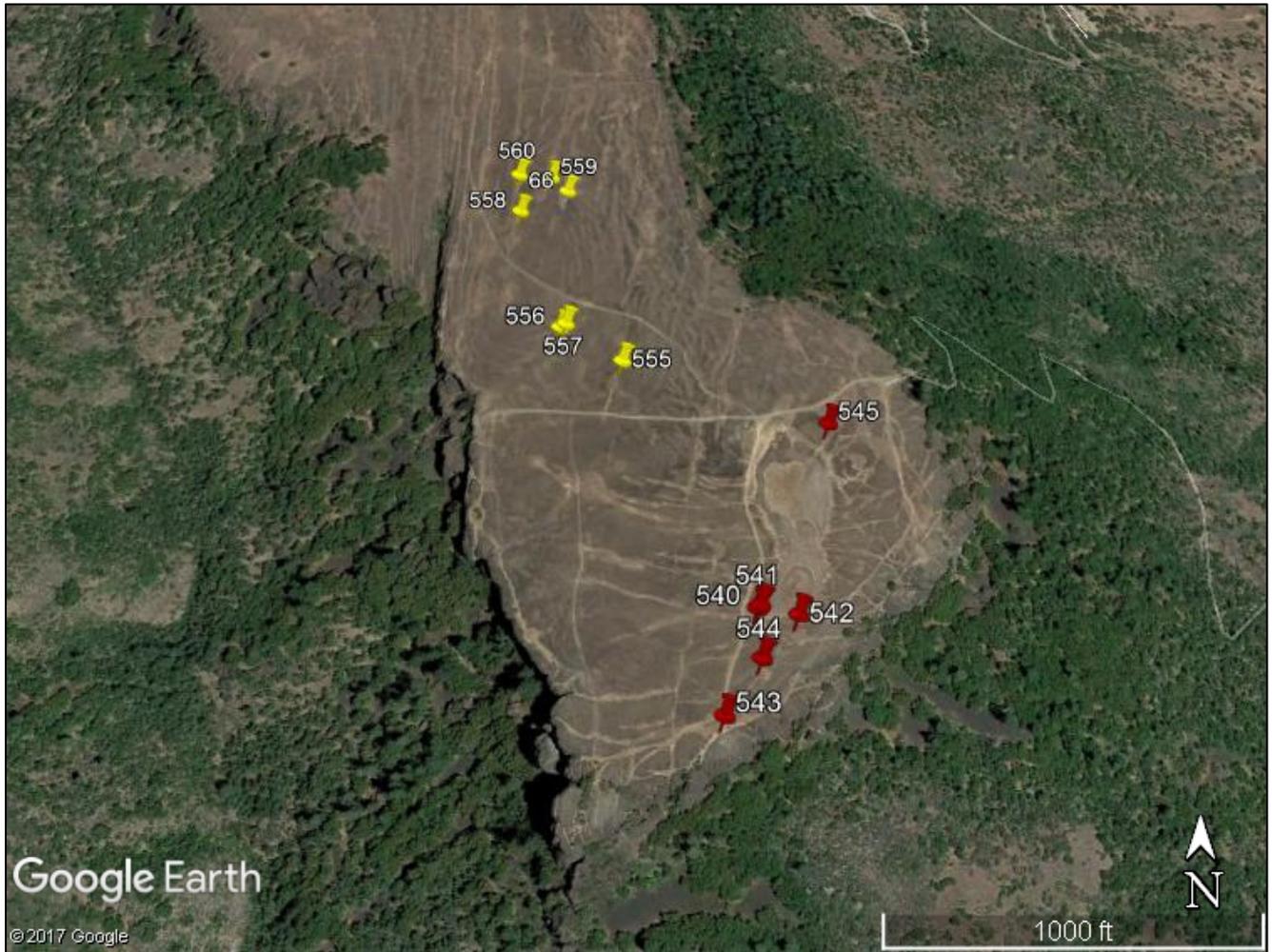
2007 trampling plot start points on Lower Table Rock. See Appendix B for plot azimuths and side of the tape to sample. Points are approximations only; plots could be ± 25 feet from points.



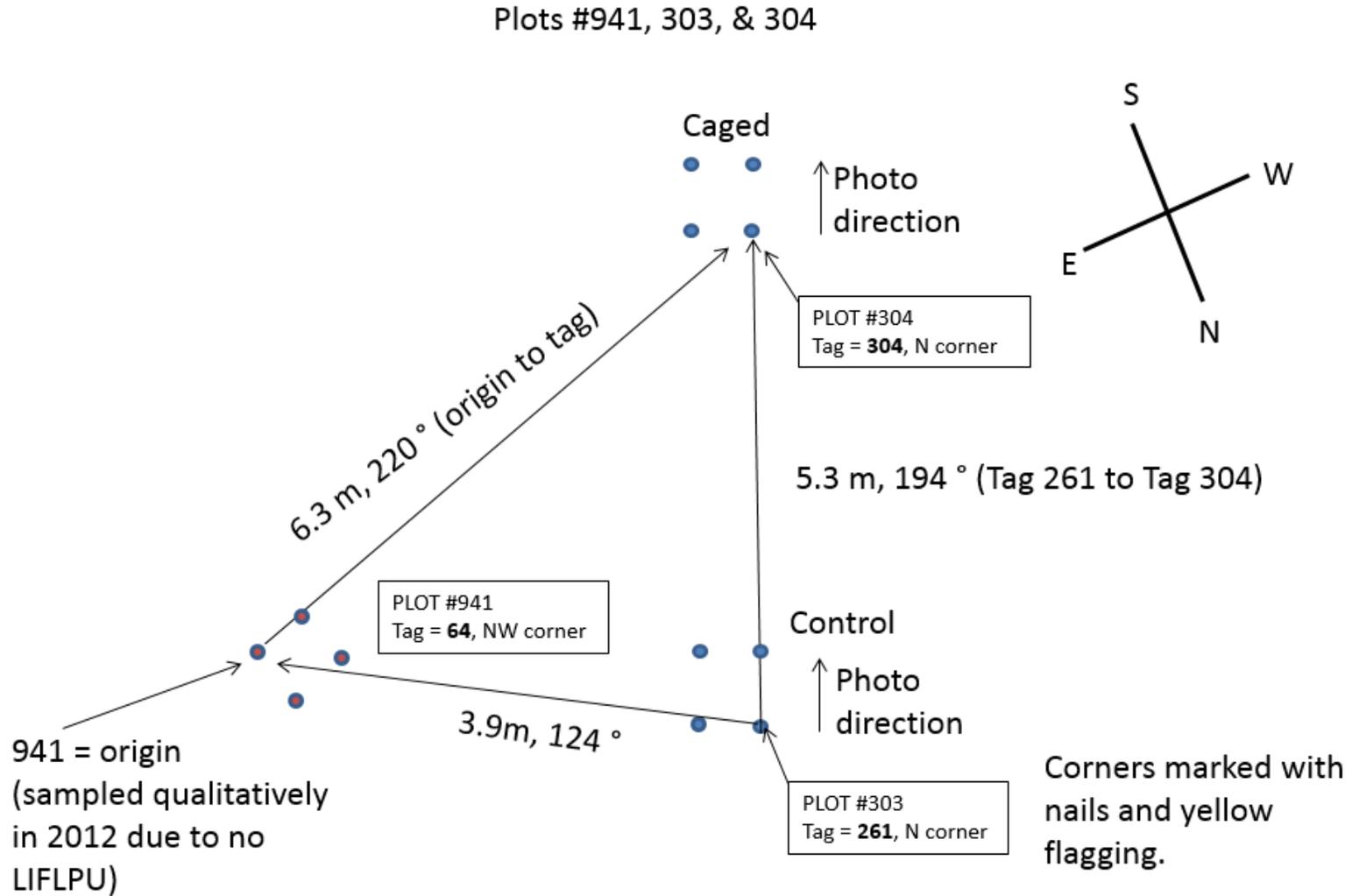
Long-term monitoring plot locations (were grazing plots) on Upper Table Rock North.



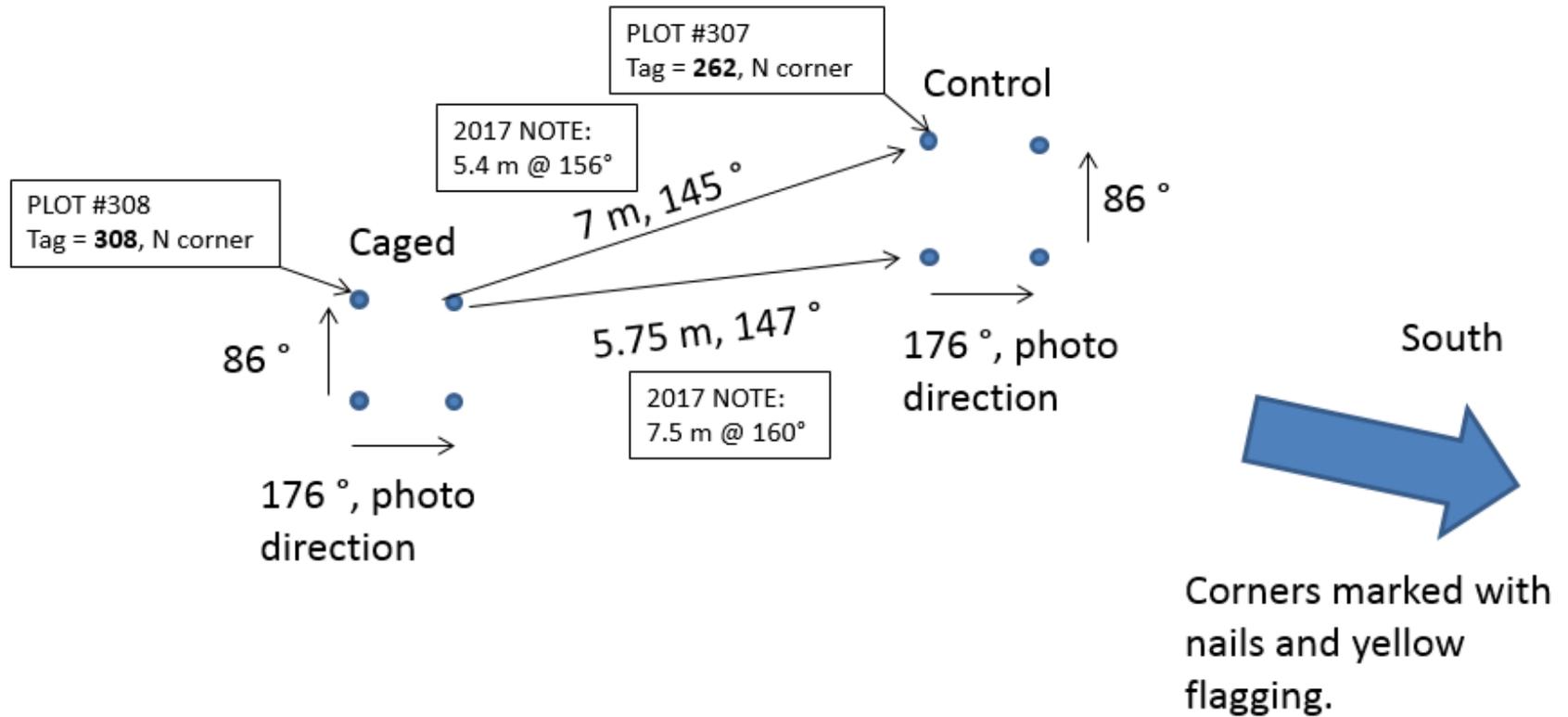
Limnanthes pumila ssp. *pumila* monitoring plots on Upper Table Rocks South established in 2015 and 2016. Yellow plots represent those in moderate recreation traffic areas, and red plots represent those in high recreation traffic.



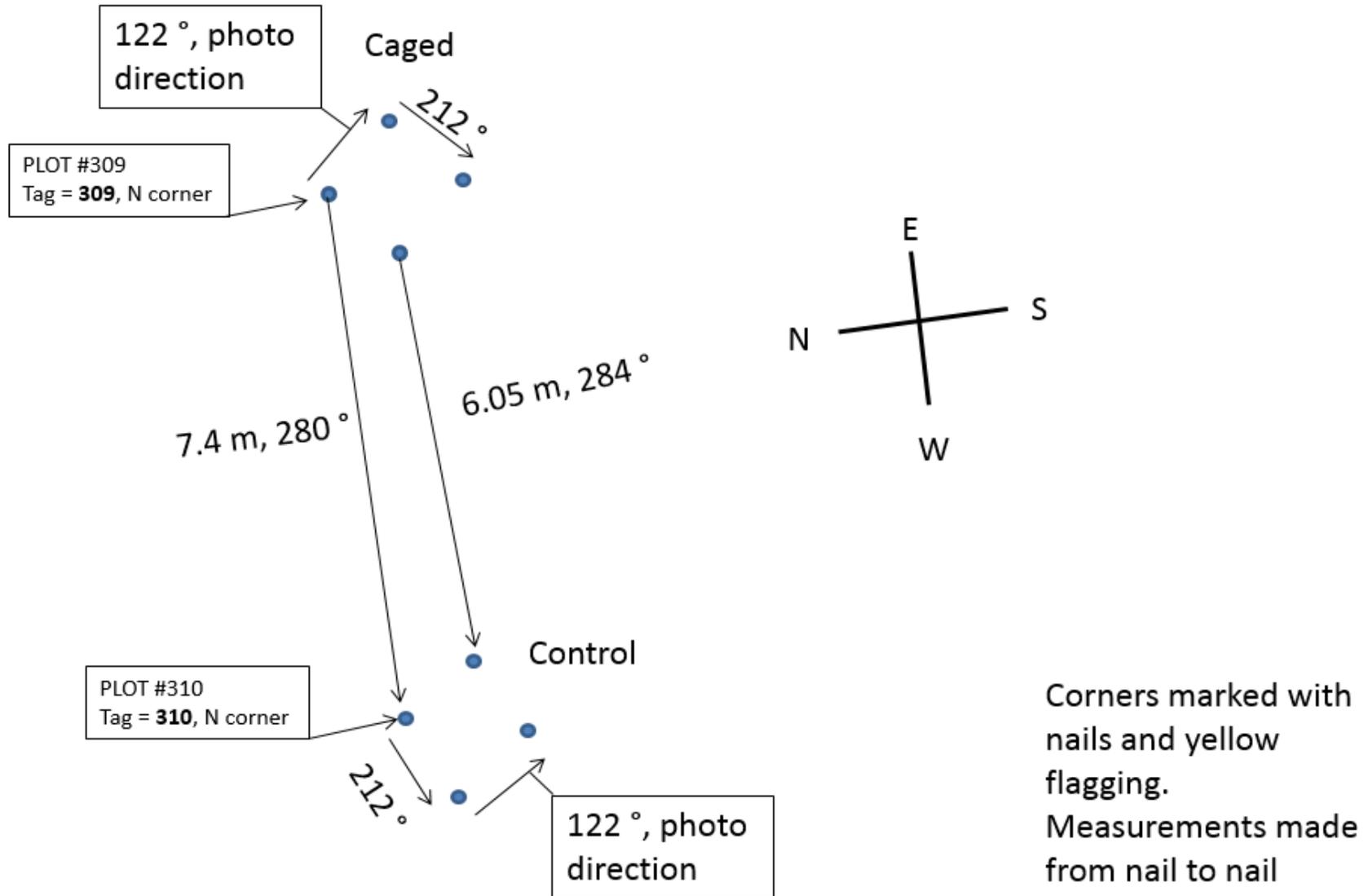
Maps of *L. pumila* ssp. *pumila* population monitoring plots established on Lower Table Rock in 2012.

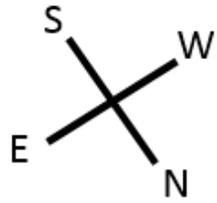


Plots #307 (control) & 308 (caged)

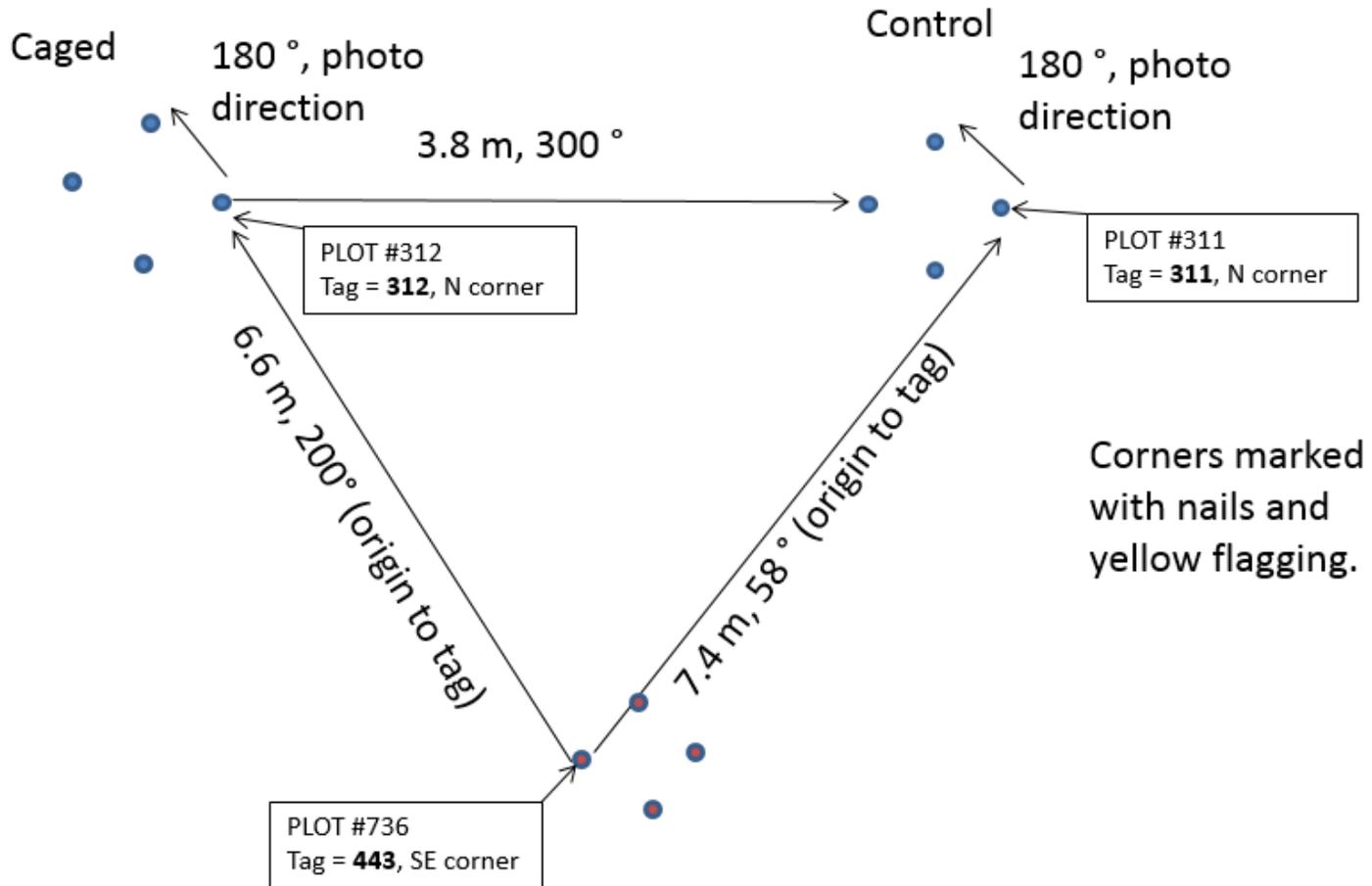


Plots #309 (caged) & 310 (control) → near 944 [944 could not be located in 2012]



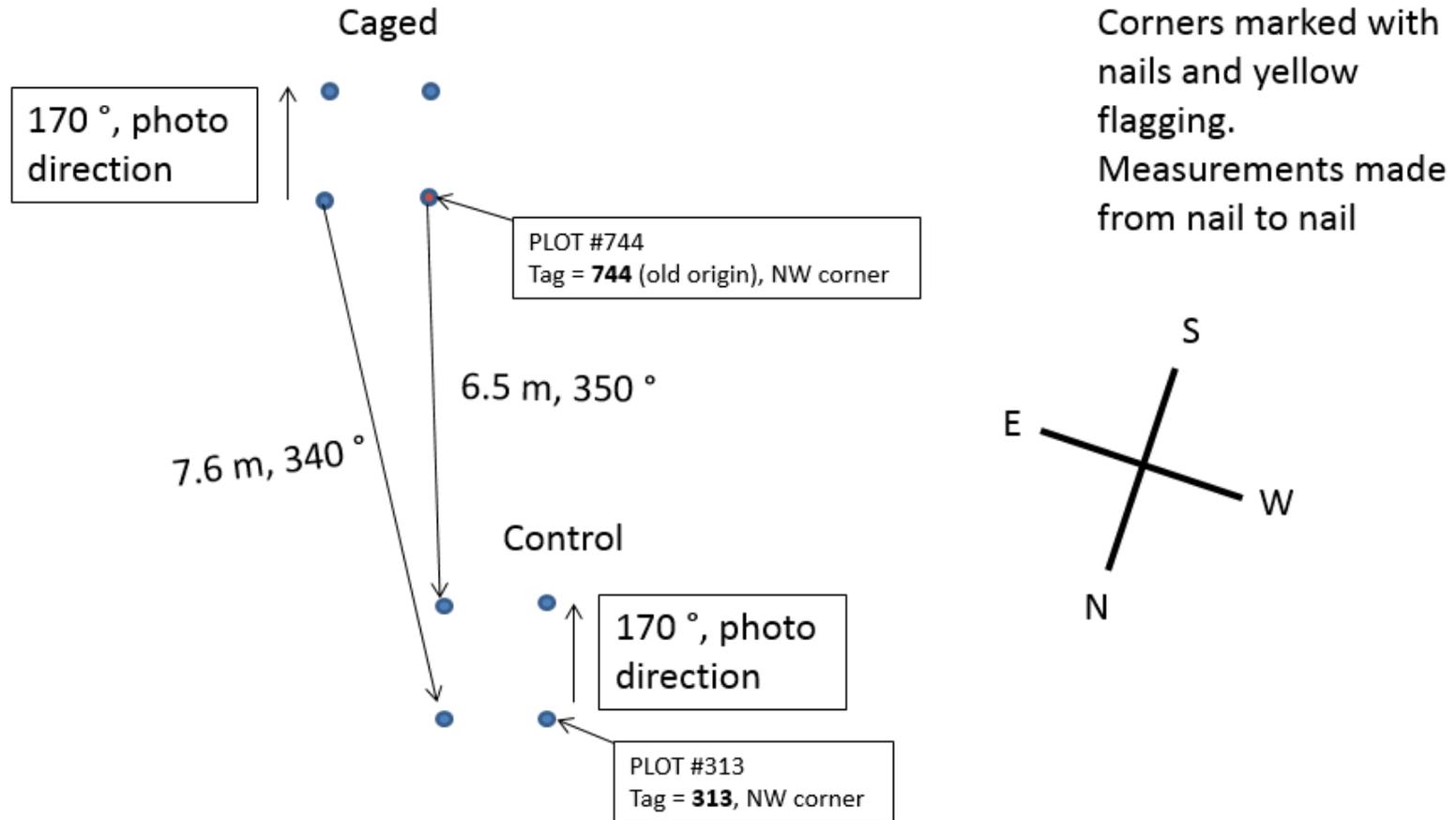


Plots #736 (Tag = 443), 311 (control), & 312 (caged)



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

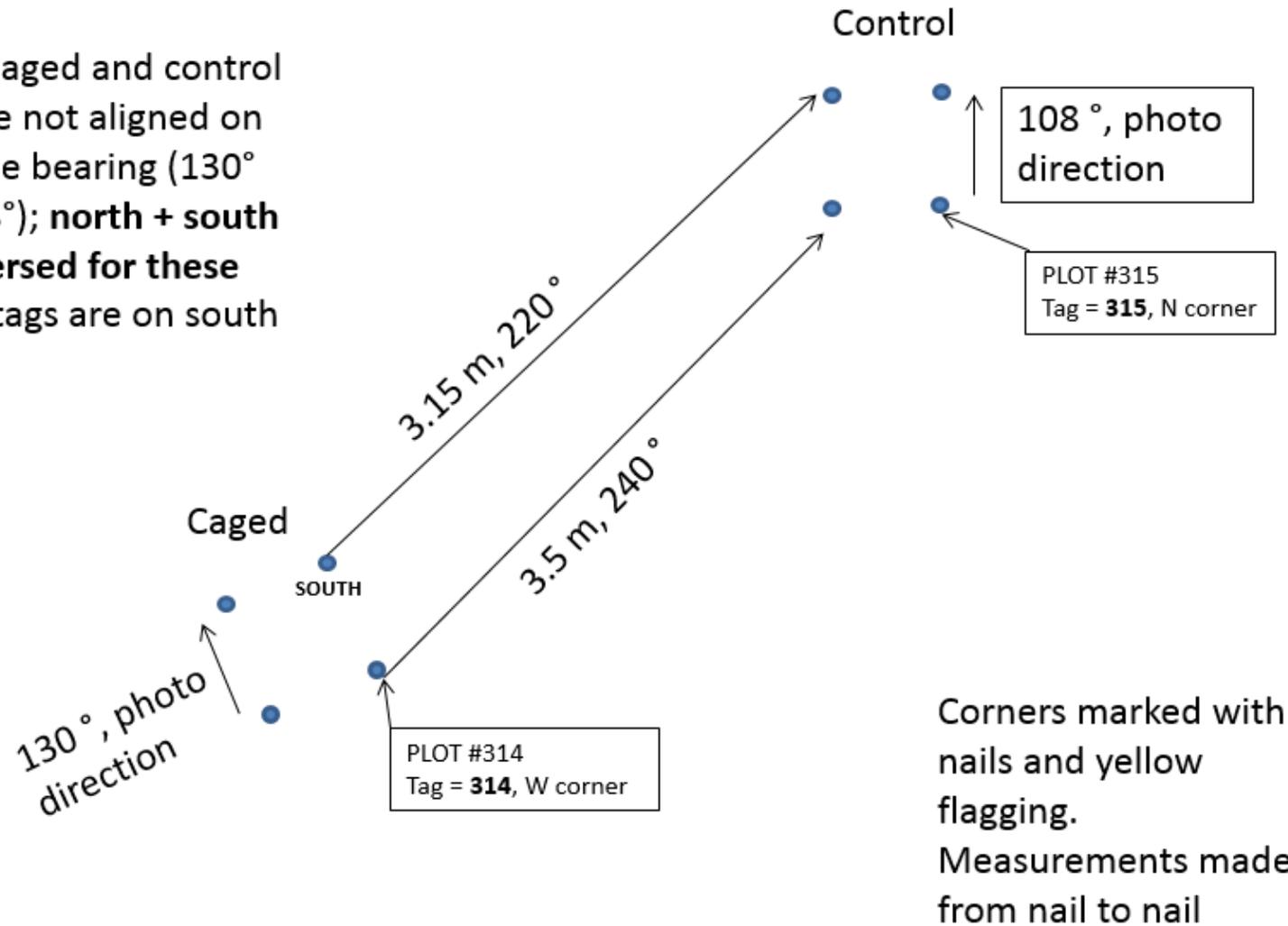
Plots #744 (caged plot & old origin) & 313 (control)



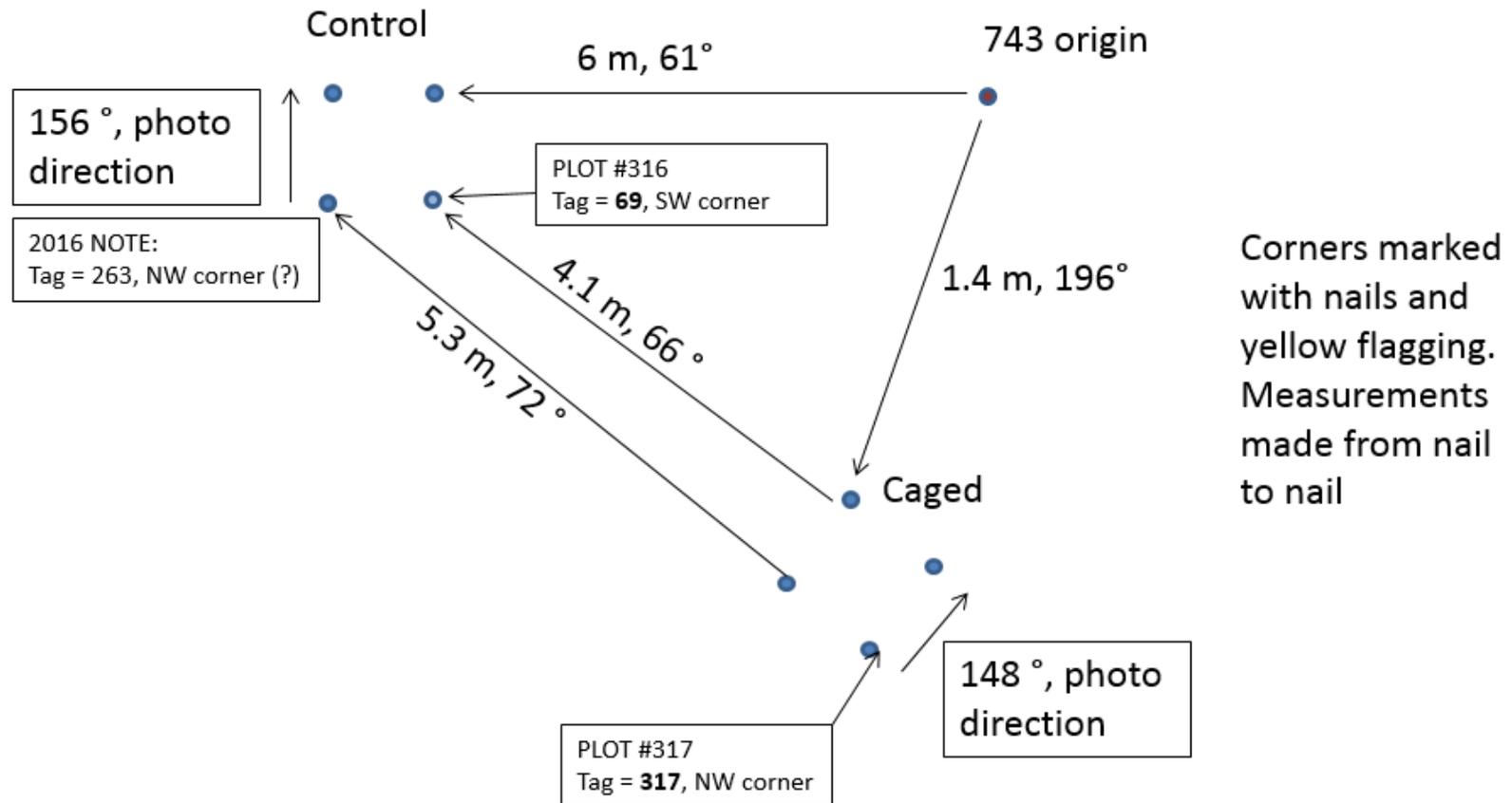
Tag 744 found, control sampled as in previous years (except its 1m²). Compare data to previous years for the control.

Plots #314 (caged) & 315 (control)

Note: Caged and control plots are not aligned on the same bearing (130° and 108°); **north + south are reversed for these plots** – tags are on south corners

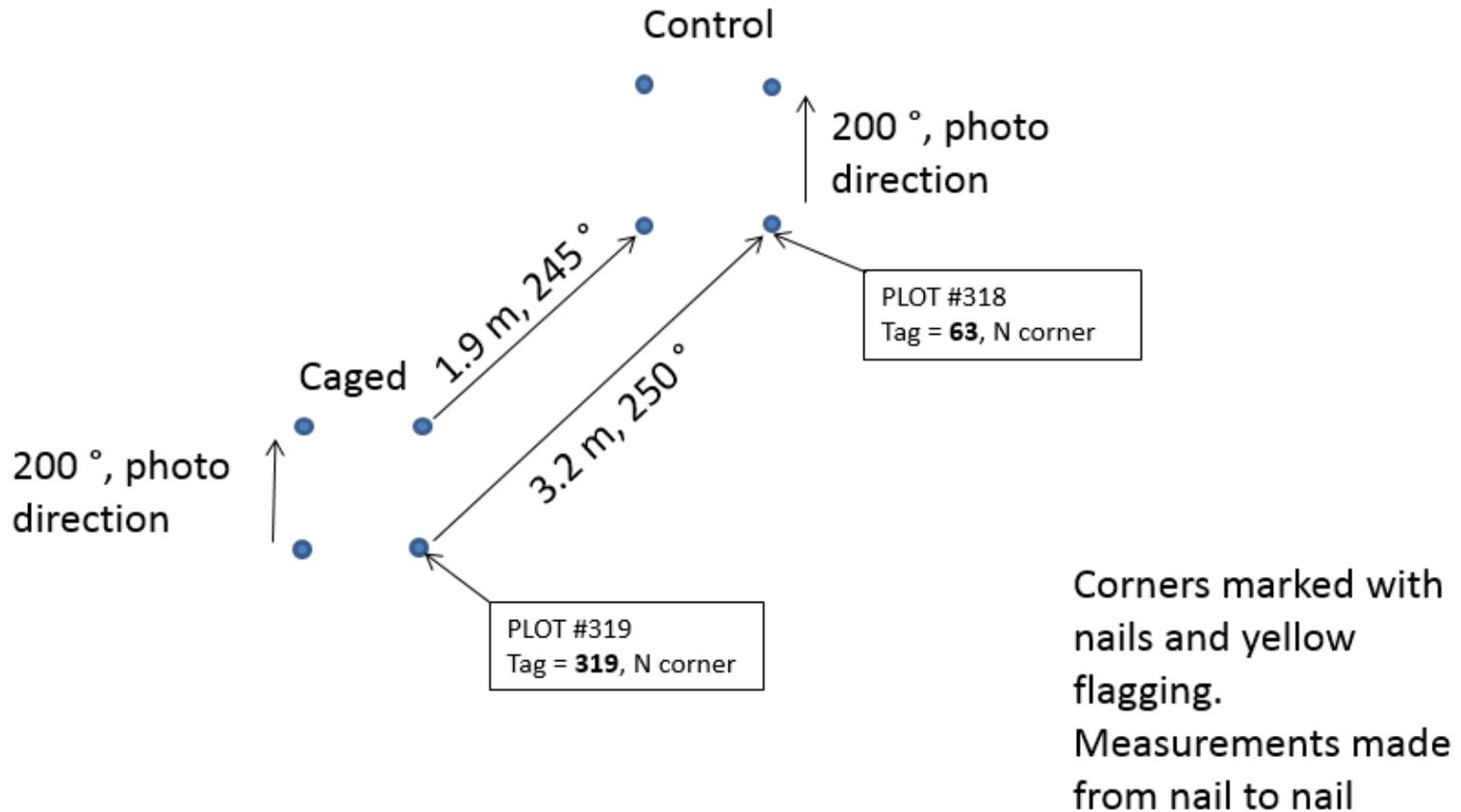


Plots #743 (origin), 316 (control) & 317 (caged)

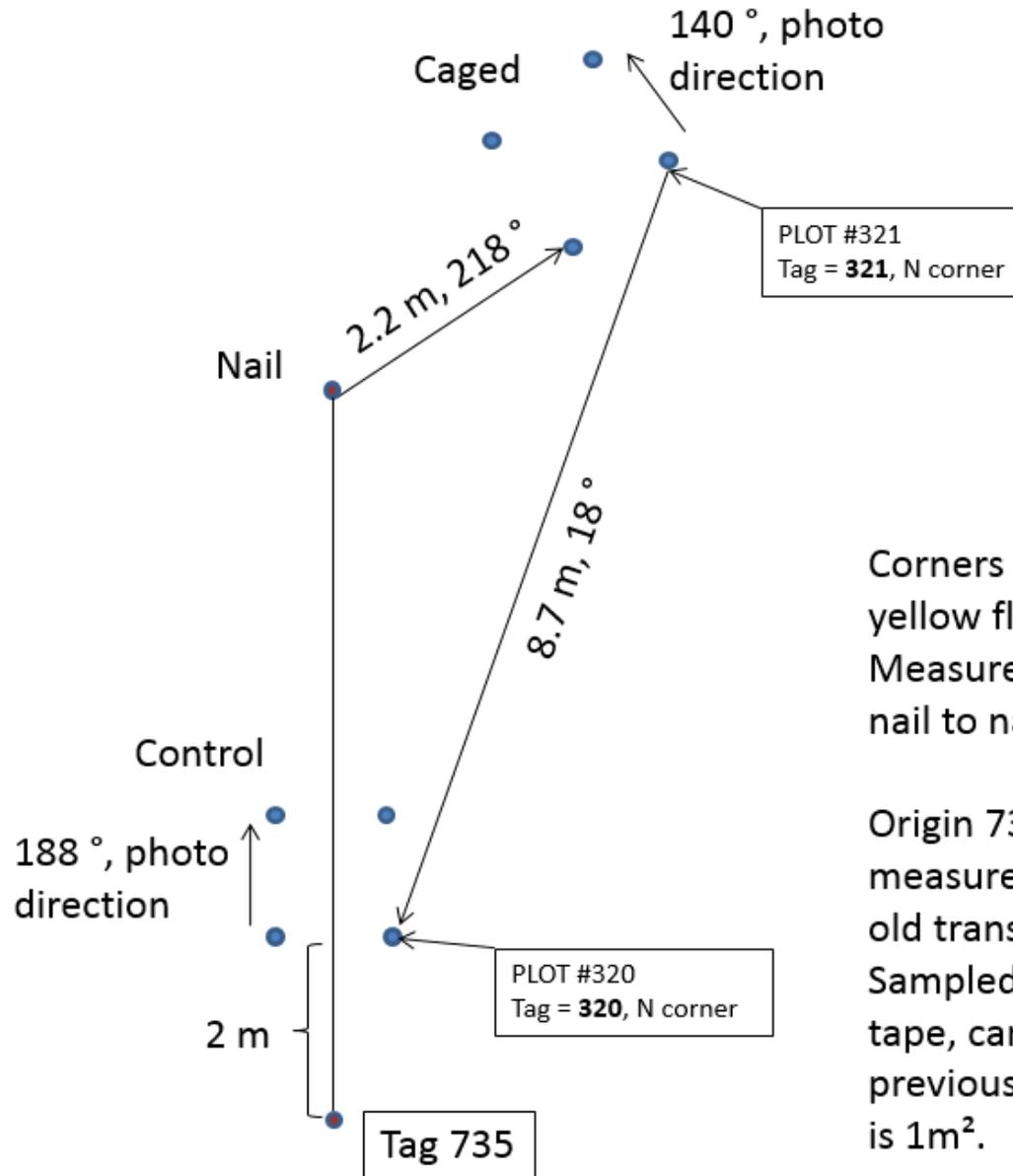


Tag #743 found, control placed 6m from origin, not in the same place as previous years. Do not compare data to previous years for the control.

Plots #319 (caged) & 318 (control)



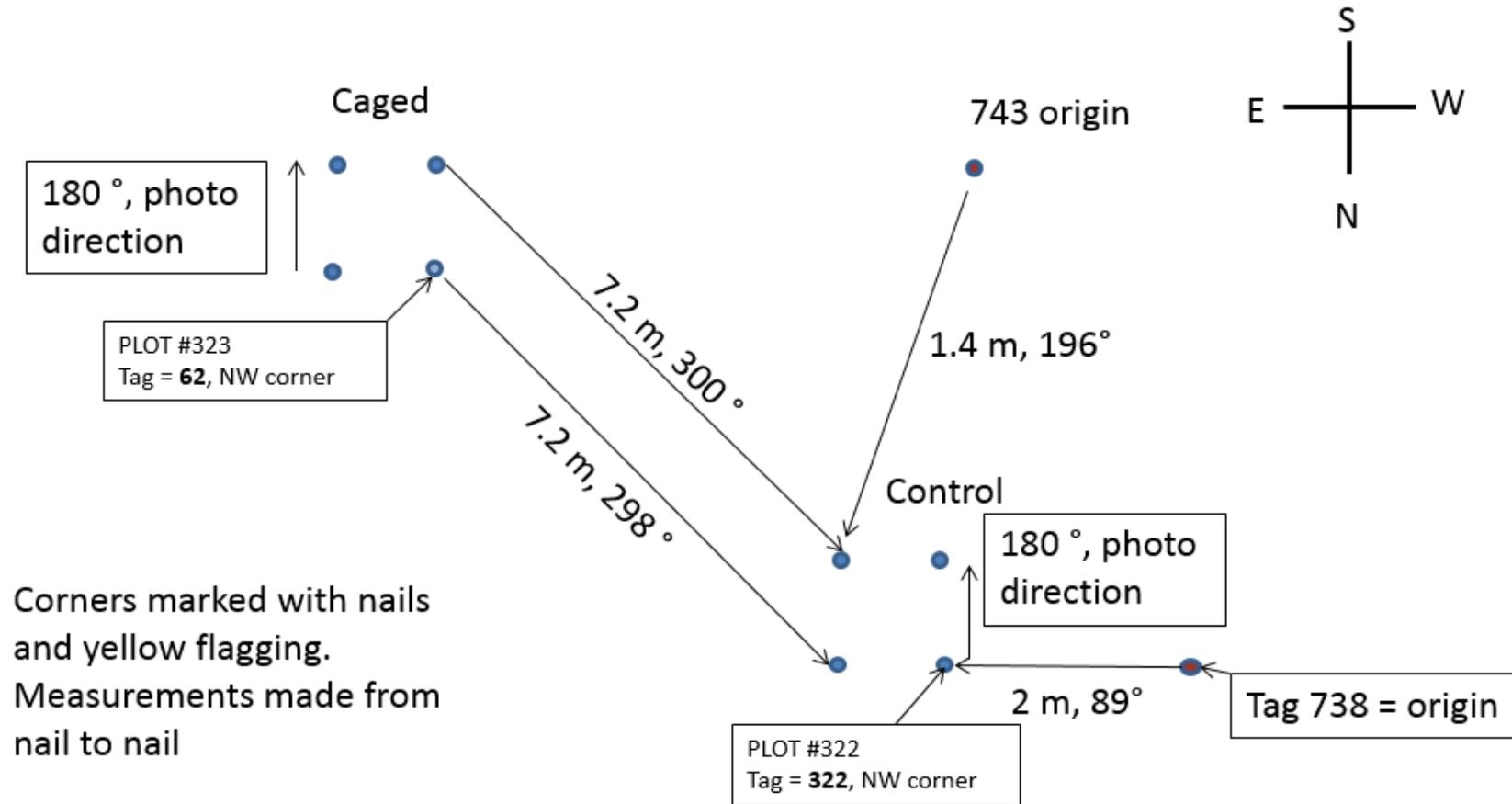
Plots #735, 320 (control) & 321 (caged)



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 8m). Sampled on both sides of the tape, can be compared to previous years, except that it is 1m².

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



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

APPENDIX E. PHOTO-POINTS TAKEN IN 2015, 2016, AND 2017 OF CAGED AND UNCAGED LONG-TERM MONITORING PLOTS.

Plot 303 Uncaged- 2016



2017



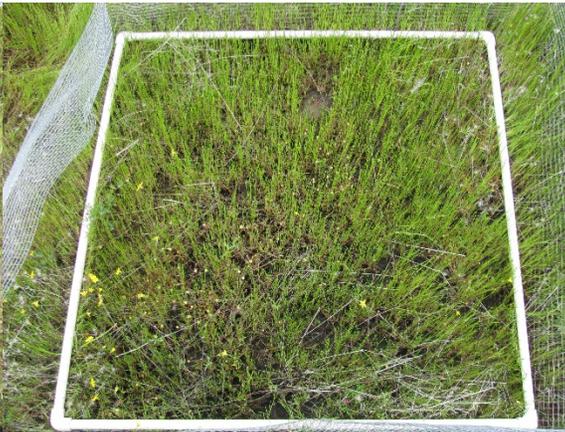
2018



Plot 304 Caged- 2016



2017



2018



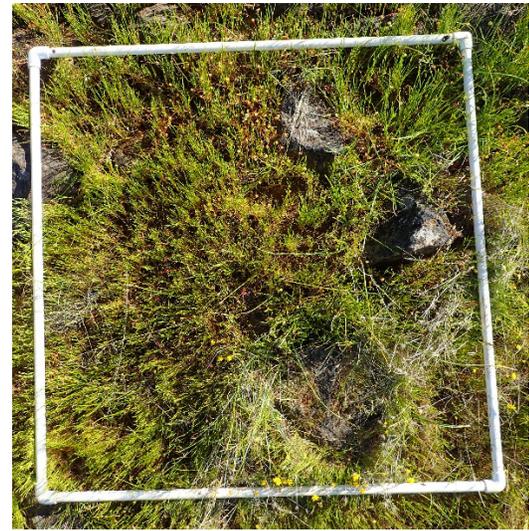
Plot 307- Uncaged 2016



2017



2018



Plot 308- Caged 2016



2017



2018



Plot 309- Caged 2016



2017



2018



Plot 310- Uncaged 2016



2017



2018



Plot 311- Uncaged 2016



2017



2018



Plot 312- Caged 2016



2017



2018



Plot 313- Uncaged 2016



2017



2018



Plot 314- Caged 2016



2017



2018



Plot 315- Uncaged 2016



2017



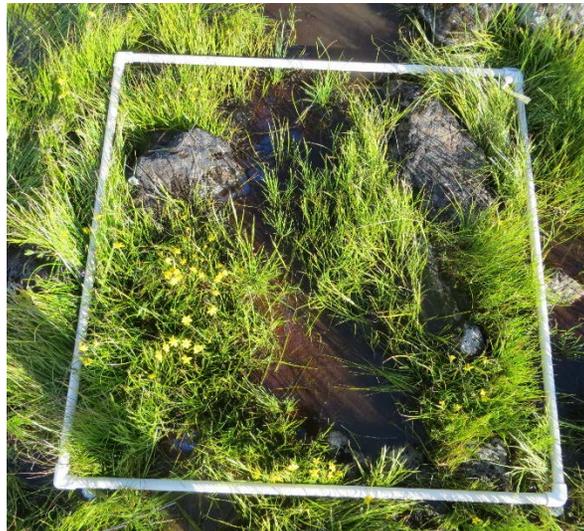
2018



Plot 316- Uncaged 2016



2017



2018



Plot 317- Caged 2016



2017



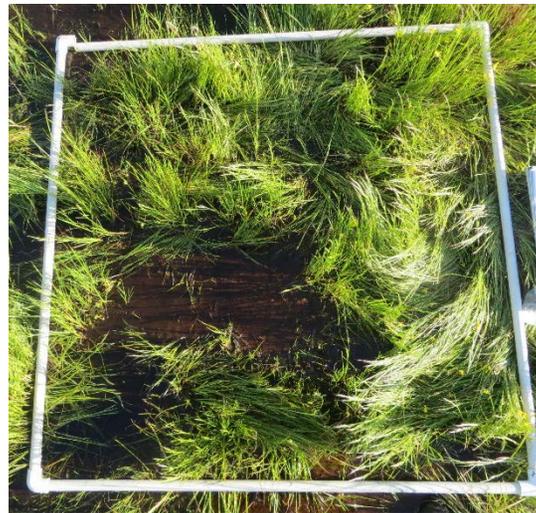
2018



Plot 318- Uncaged 2016



2017



2018



Plot 319- Caged 2016



2017



2018



Plot 320- Uncaged 2015



2016



2018 [*could not locate in 2017]



Plot 321- Caged 2016



2017



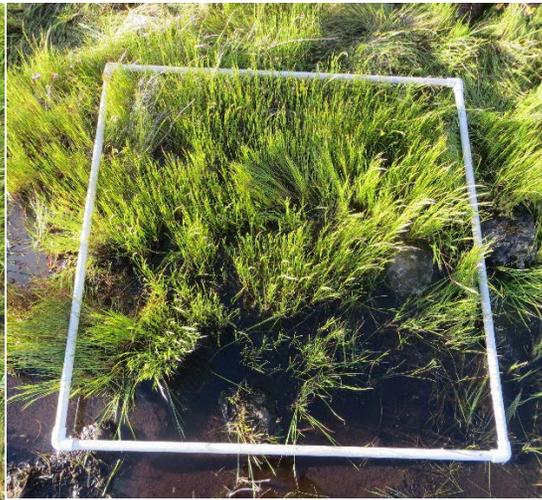
2018



Plot 322- Uncaged 2016



2017



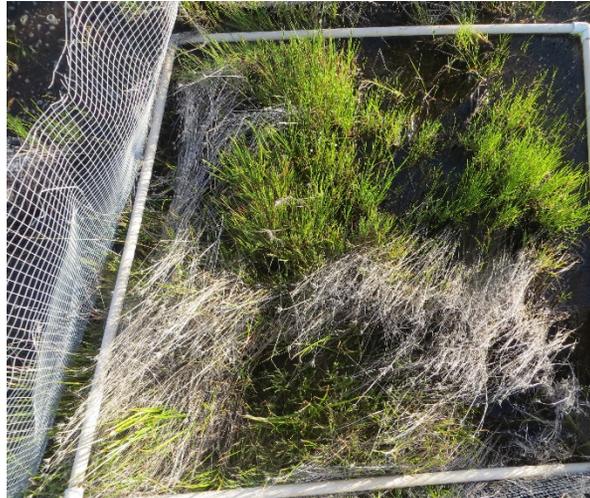
2018



Plot 323- Caged 2016



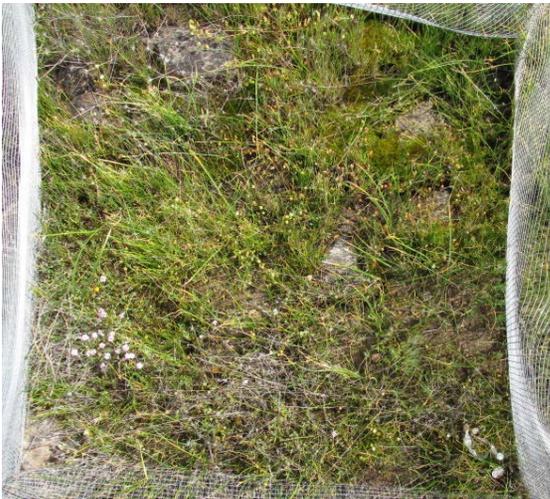
2017



2018



Plot 744- Caged 2016



2017



2018

