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

2017

Report to the USDI Bureau of Land Management, Medford District

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Institute for Applied Ecology

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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: Pool habitat 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.

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 2017, 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, number of *L. pumila* ssp. *pumila* in long-term monitoring plots on Lower Table Rock have fluctuated over the years. 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 over the last two years.
- In 2017, we again observed fewer plants in high traffic areas than in moderate traffic areas, but there was not a significant difference as there was in 2016.
- Upper Table Rock had trends similar to those observed on Lower Table Rock – 2015 had the lowest numbers over the course of this study, but there have been increases in number of plants and number of flowers per plant over the last two years.
- In 2017, mean number of plants and number of flowers per plant did not differ significantly between moderate traffic and high traffic plots in 2017. Continued monitoring of these plots over time will allow us to compare impacts of recreation traffic on the heavily used portion of Upper Table Rock.

Community monitoring of the fire retardant drop

- From 2013 to 2016 we observed a decline in non-native grasses both within and outside of the fire retardant drop; over the past two years of sampling, non-native grass cover has remained stable. After low numbers in 2015, we observed an increase in *L. pumila* ssp. *pumila* in 2016, followed by a decrease in 2017. Pool habitats declined from 2014 to 2015, but increased in 2016 and 2017.
- Long-term monitoring plots were used to assess impacts of the prescribed fire that occurred in the area of the fire retardant drop in fall 2015. Mean number of plants and number of flowers per plant did not differ between burned and unburned plots in 2017. Litter cover was similar in burned plots and unburned plots. These results should be interpreted cautiously as plots were not set up to monitor fire effects.

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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 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*.

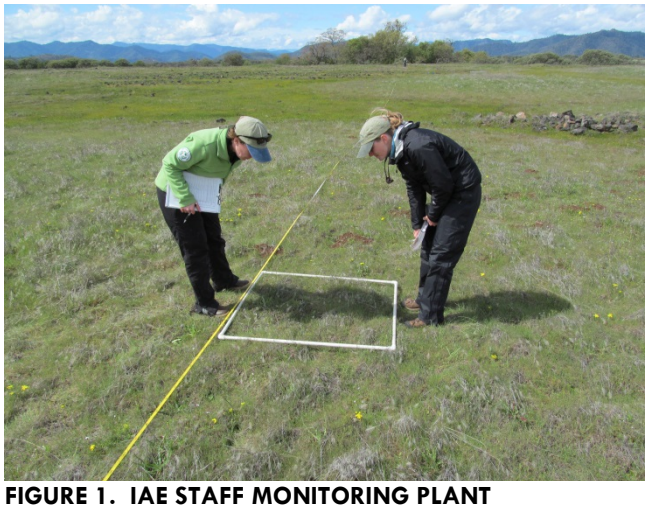

FIGURE 1. IAE STAFF MONITORING PLANT COMMUNITY ON LOWER TABLE ROCK.

The potential threats to vernal pool species on the Table Rocks include grazing by native ungulates, recreational use, and invasion by 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 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, potentially 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. DENSE THATCH FROM INTRODUCED ANNUAL GRASSES IN L. PUMILA SSP. PUMILA HABITAT IN 2012.

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.

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 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 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

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

(Larson and Duncan 1982). More information was 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. 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.

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 plots 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 2012-2017 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 2017. 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 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. A spatial analysis of the area impacted by the fire retardant drop was conducted in 2014 and transects have been monitored through 2017.

Given a recently observed increase in recreation traffic on the southern end of Upper Table Rock, we added 6 new plots in 2015 to observe population trends in high traffic areas and 6 in moderate traffic areas in 2016. The increased visitor use has resulted in little to no *L. pumila* ssp. *pumila* habitats occurring in "low" traffic areas. These plots were monitored through 2017 to assess the impacts of recreation traffic on *L. pumila* ssp. *pumila* on the southern end of Upper Table Rock.

METHODS

Limnanthes pumila ssp. *pumila* monitoring

Population trends on Lower Table Rock

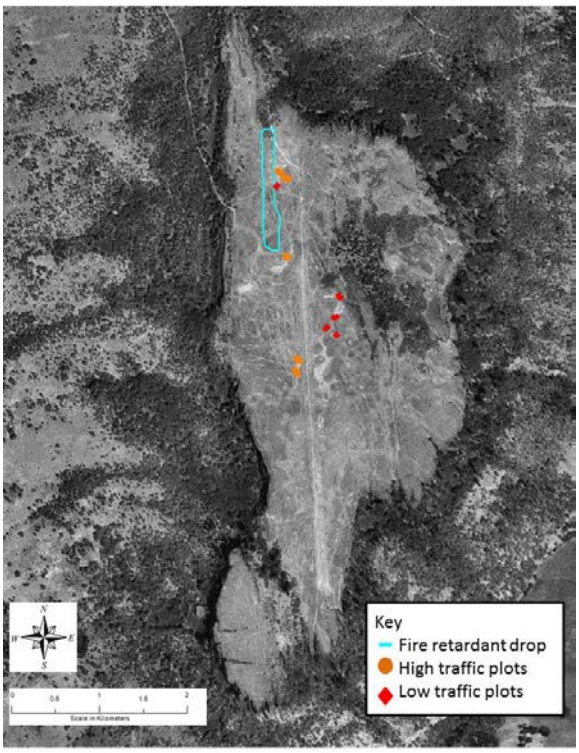

FIGURE 5. *L. PUMILA SSP. PUMILA* POPULATION MONITORING PLOTS ON LOWER TABLE ROCK.

To assess long-term population trends of *L. pumila* ssp. *pumila* on Lower Table Rock, we converted the experimental trampling plots that had been established in 2007 and 2009 (portions not trampled [0 passes]; Gray et al. 2012) into long-term monitoring plots in 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 converted into long-term monitoring plots, they thereafter became 1m^2 plots. In 2012, the majority of the long-term monitoring plots could not be located (6 were located, 3 of which had no *L. pumila* ssp. *pumila* present). Therefore, in 2012, 17 new 1m^2 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 B). 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 – 5 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* habitats 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 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), 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/m^2). 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*.

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 ± 95% confidence intervals.

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

Twenty $1m^2$ 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. 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 6 added in moderate recreation areas in 2016. 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.

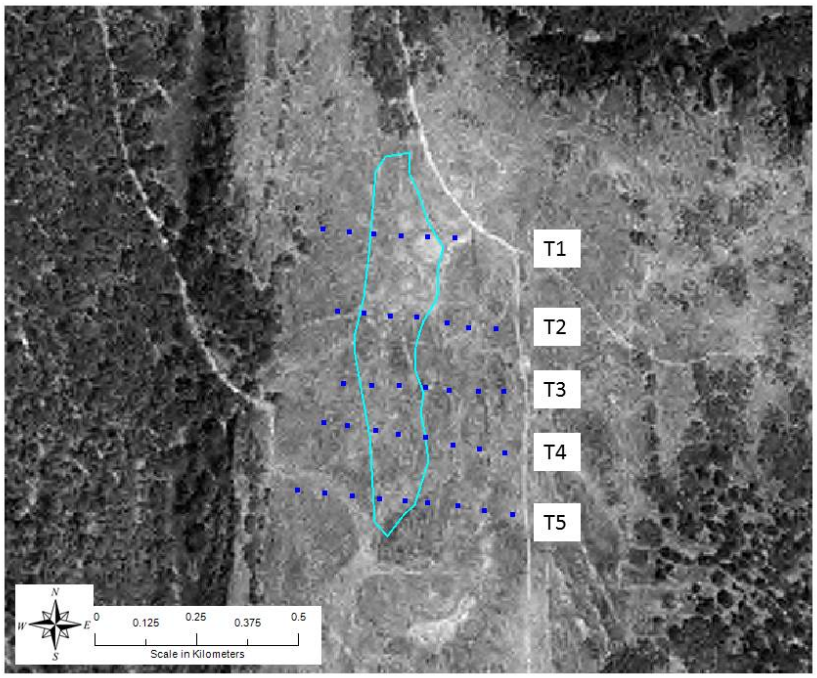

FIGURE 6. 2013 TRANSECTS (DELINEATED BY DARK BLUE MARKINGS, EACH POINT IS A PLOT SAMPLED, "T1" REPRESENTS "TRANSECT 1", ETC.) DISSECTING THE AREA IMPACTED BY THE 2010 FIRE RETARDANT DROP (LIGHT BLUE) ON LOWER TABLE ROCK.

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 2 m 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 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 1m² 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*, 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).

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.).

RESULTS AND DISCUSSION

Limnanthes pumila ssp. *pumila* monitoring

Population trends on Lower Table Rock

Following a statistically significant decrease from 2010 to 2012 (Kruskal-Wallis $\chi^2=67.15$, $p<0.001$), number of *L. pumila* ssp. *pumila* in long-term monitoring plots have varied in recent years but increased in both 2016 and 2017 from the low numbers observed in 2015 (Figure 7). In 2017, the mean number of *L. pumila* ssp. *pumila* per plot (n = 20) was 39, which was an increase from 8 plants in 2015 and 25 plants in 2016 (Figure 7). However, values in 2017 were still significantly lower than the first two years of long-term monitoring, 2009-2010 (Kruskal-Wallis $\chi^2=67.15$, $p<0.001$). This species is an annual and variability would be expected; future years of monitoring will enable us to see if we have been witnessing a continued decline or if numbers in the early years of this study happened to be high in comparison.

Though mean number of plants was higher earlier in the study, reproductive effort during those years was relatively low (less than 4 flowers per plant). Across sampling years, plants have averaged less than 4 flowers per plant every year except for 2016 (Figure 7). From 2009 to 2011, the number of flowers per plant steadily declined, then increased over the next few years back up to values similar to those observed in 2009. There was a statistically significant decrease in 2015, followed by a statistically significant increase in 2016 (Kruskal-Wallis $\chi^2=48.62$, $p<0.001$), where number of flowers per plant increased to an average of 9 flowers per plant, which was the greatest noted over the course of this study (Figure 7). In 2017, number of flowers per plant decreased to an average of 3 flowers per plant, similar to 2015 values (Figure 7).

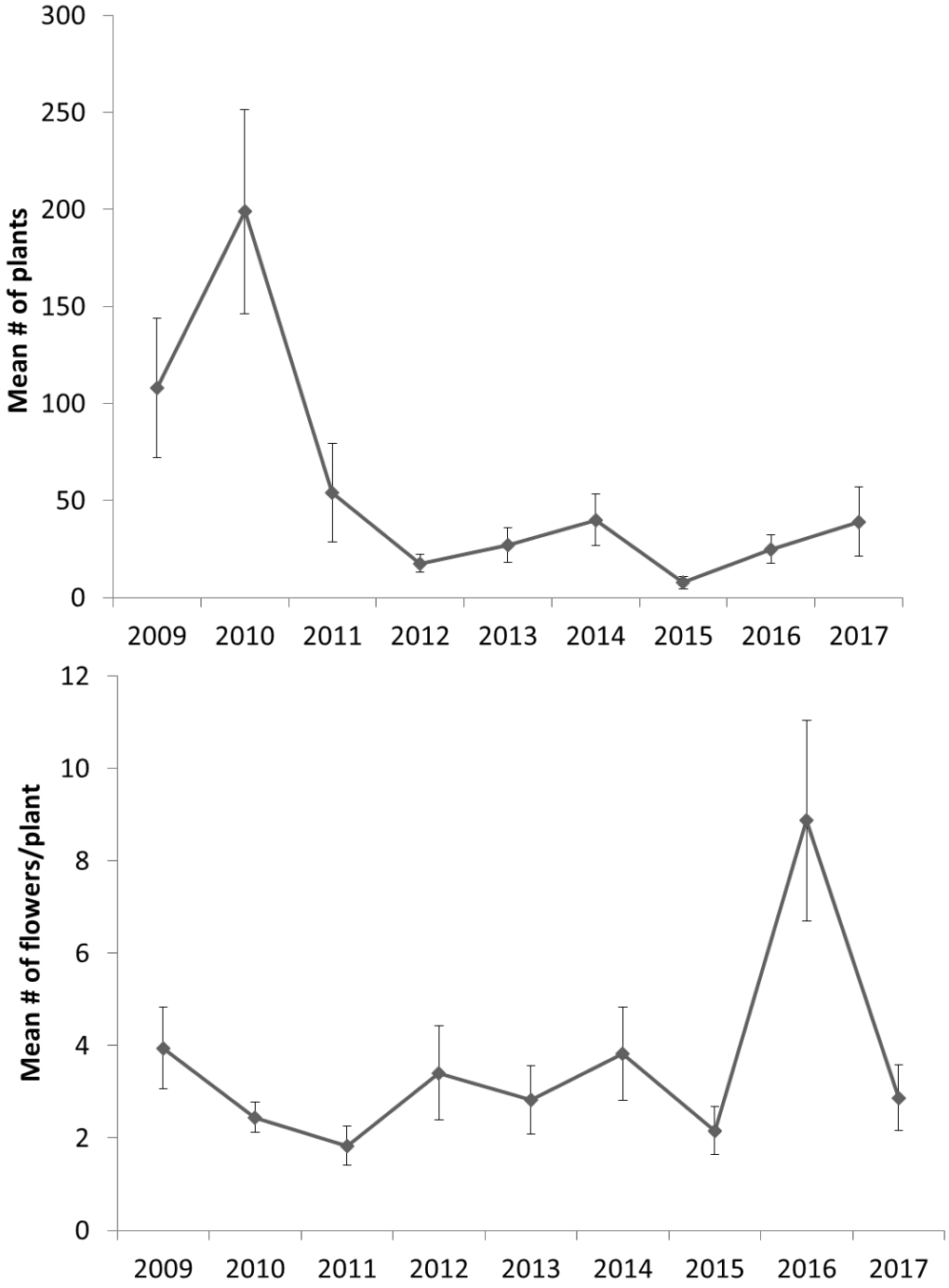

FIGURE 7. MEAN NUMBER OF PLANTS (TOP) AND MEAN FLOWERS PER PLANT (BOTTOM) IN *L. PUMILA* SSP. *PUMILA* POPULATION MONITORING PLOTS ON LOWER TABLE ROCK IN 2009-2017. VALUES FROM 2009-2011 (N=10) WERE SCALED TO REFLECT DIFFERENCES IN PLOT AREA. IN 2012, NEW POPULATION MONITORING PLOTS WERE ESTABLISHED FOR LONG-TERM MONITORING (2012-2017, N=20). ERROR BARS REPRESENT 95% CONFIDENCE INTERVALS.

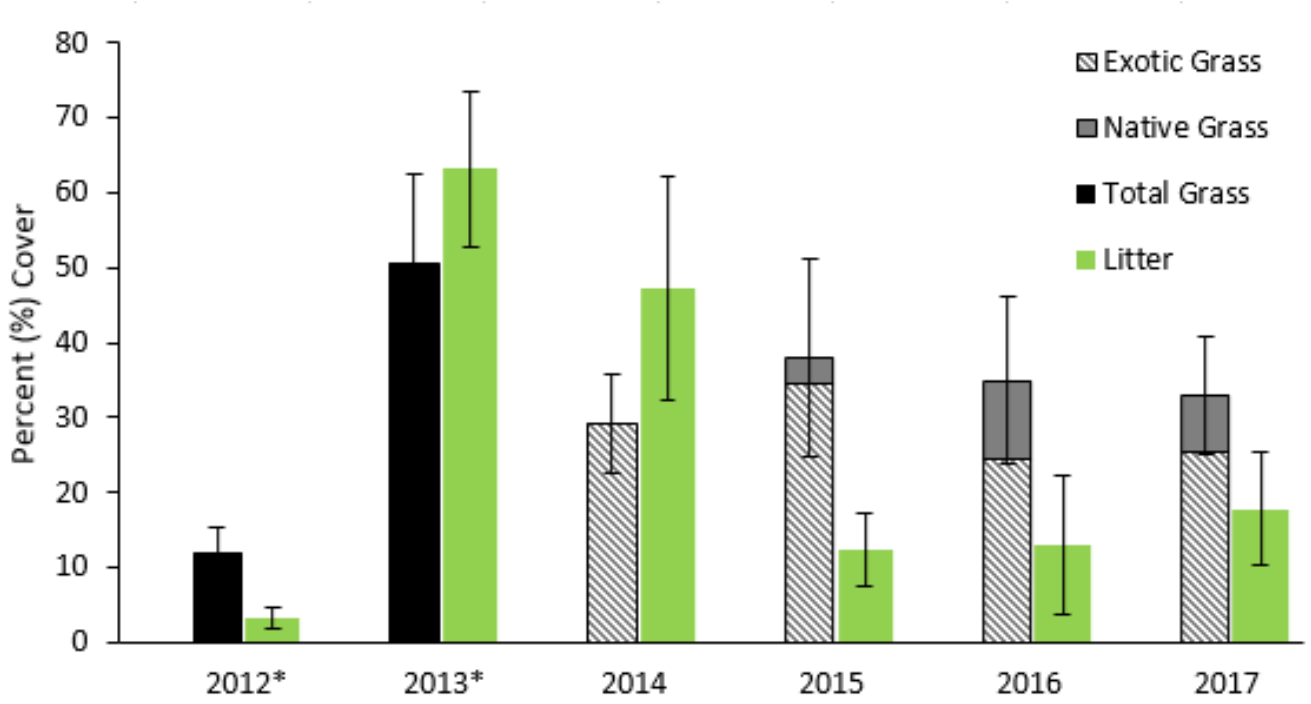

FIGURE 8. MEAN GRASS AND LITTER COVER IN LONG-TERM MONITORING PLOTS FROM 2012 - 2017. IN 2012 AND 2013 (*) ONLY TOTAL GRASS COVER WAS COLLECTED. SEPARATE COVER VALUES FOR EXOTIC AND NATIVE GRASSES WERE RECORDED IN 2014-2017. ERROR BARS REPRESENT 95% CONFIDENCE INTERVALS.

Grass and litter cover have been variable in long-term monitoring plots over time (Figure 8, Figure 9). In 2012, grass cover was relatively low in plots, but exhibited a steep increase in 2013; litter cover increased nearly twenty-fold during that time as well. 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, while litter cover declined to its second lowest abundance. Grass and litter cover have remained stable over the past three years of sampling. Total grass cover has largely been composed of exotic grasses over the years, but the native grass component has increased in the last three years (Figure 8). While litter has declined in recent years, it is still present in plots and able to impact germination of native vegetation (Figure 8, Figure 9).

Plot 311 -- uncaged

2014 **2015** **2016** **2017**

Plot 312 -- caged

FIGURE 9. PHOTOPOINTS FROM CAGED AND UNCAGED PLOTS ON LOWER TABLE ROCK FROM 2014-2017. NOTE THE CHANGES IN LITTER OBSERVED IN PLOTS OVER TIME.

Effects of Recreation Traffic

In previous years (2013, 2015, and 2016) there have been significant differences in the number of plants between high traffic and moderate 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 2017, similar to trends seen in previous years, we observed fewer plants in high traffic areas than in moderate traffic areas (Figure 10; Figure 11); however, there was not a significant difference as there was in 2016 (2017: W=44, *p*=0.677; 2016: F=5.38, *p*=0.032). We did not observe a significant difference in mean number of flowers per plant in 2017 between high and moderate traffic plots (F=1.68, *p*=0.211; Figure 10). Native forb cover was not significantly different in moderate traffic plots than high traffic plots in 2017 (Figure 11), as it was in 2016 (2017: W=35.5, *p*=0.285; 2016: F=7.28, *p*=0.014). Cover of *L. pumila* ssp. *pumila*, native grasses, exotic forbs, exotic grasses, and litter did not differ between high and moderate traffic areas (Figure 11, top). Similar to 2013-2016, there was not a significant difference between caged and uncaged plots in mean number of plants per plot or number of flowers per plant (W=54, *p*=0.791; F=0.791, *p*=0.386; Figure 10). Cover of *L. pumila* ssp. *pumila*, native forbs, native grasses, exotic forbs, and exotic grasses did not differ between the treatments, but litter cover was significantly greater in caged plots (V=2, *p*=0.01; Figure 10, bottom). This could be due to the cages working as a barrier and building up litter.

In 2017 we observed some of the highest numbers of *L. pumila* ssp. *pumila* in recent years, which was a stark contrast to the low numbers observed in 2015. This was following a slight increase in 2014 for both number of plants and number of flowers per plant. After the fire retardant drop in 2010 we had noted an initial increase in exotic grasses, which have the potential to compete with native vernal pool species endemic to Table Rocks. This initial flush after the fertilizer effect from the fire retardant drop seems to have declined. Litter and grass cover also increased after the initial nutrient pulse from the drop but have declined, potentially aided by the prescribed fire that occurred October 22, 2015. Differences in high and moderate traffic areas, particularly for number of *L. pumila* ssp. *pumila* observed in 2013, 2015, and 2016, suggest that recreation traffic can affect these communities and the rare species within them. Limiting access to areas of high population density during flowering times could potentially limit these negative impacts.

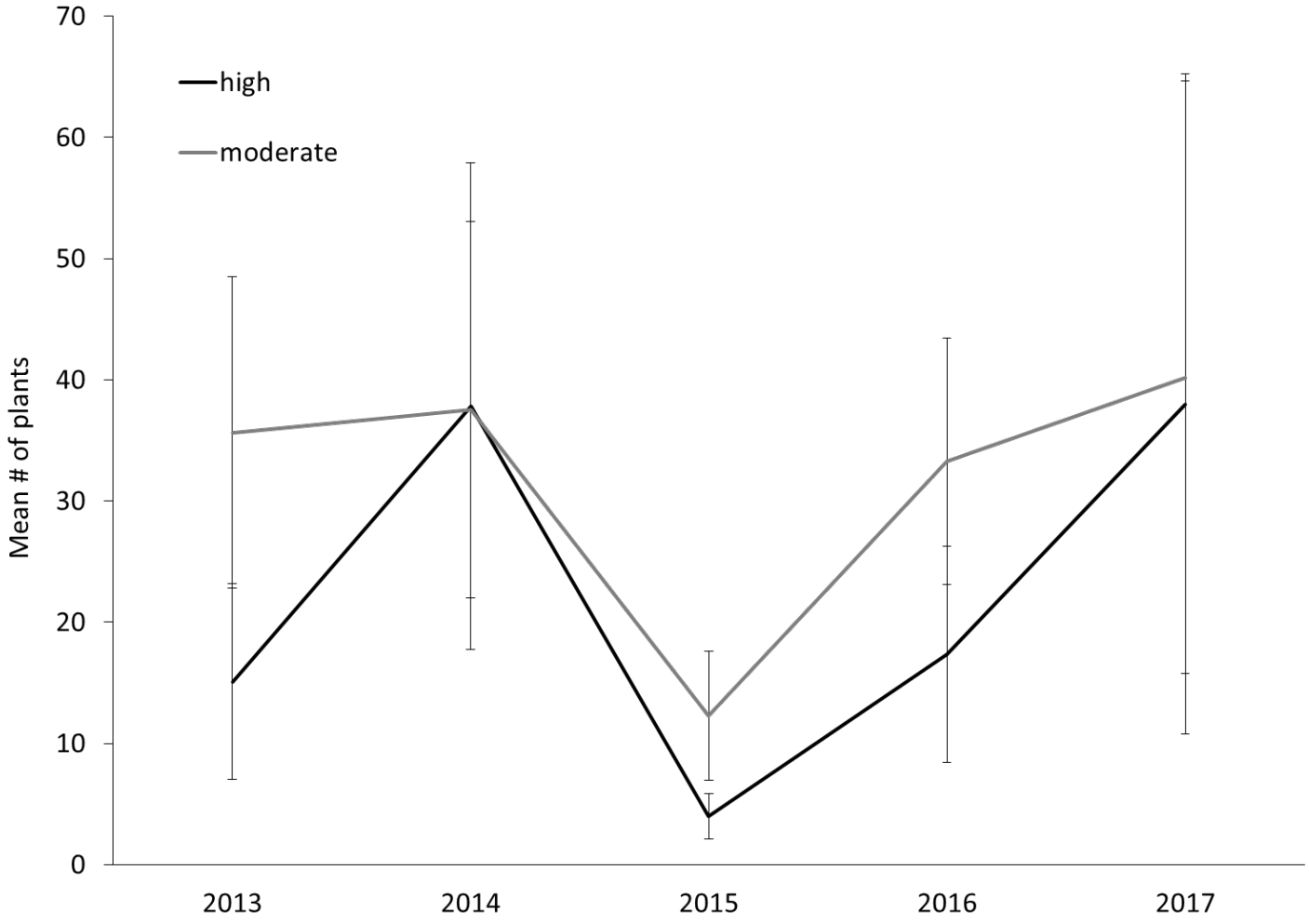

FIGURE 10. MEAN NUMBER OF PLANTS IN HIGH AND MODERATE TRAFFIC PLOTS ON LOWER TABLE ROCK FROM 2013-2017. PLOTS THAT WERE INITIALLY DESIGNATED AS "LOW" TRAFFIC IN EARLY YEARS OF THIS STUDY ARE NOW CONSIDERED TO BE "MODERATE" TRAFFIC PLOTS DUE TO INCREASED VISITOR USE. ERROR BARS REPRESENT 95% CONFIDENCE INTERVALS.

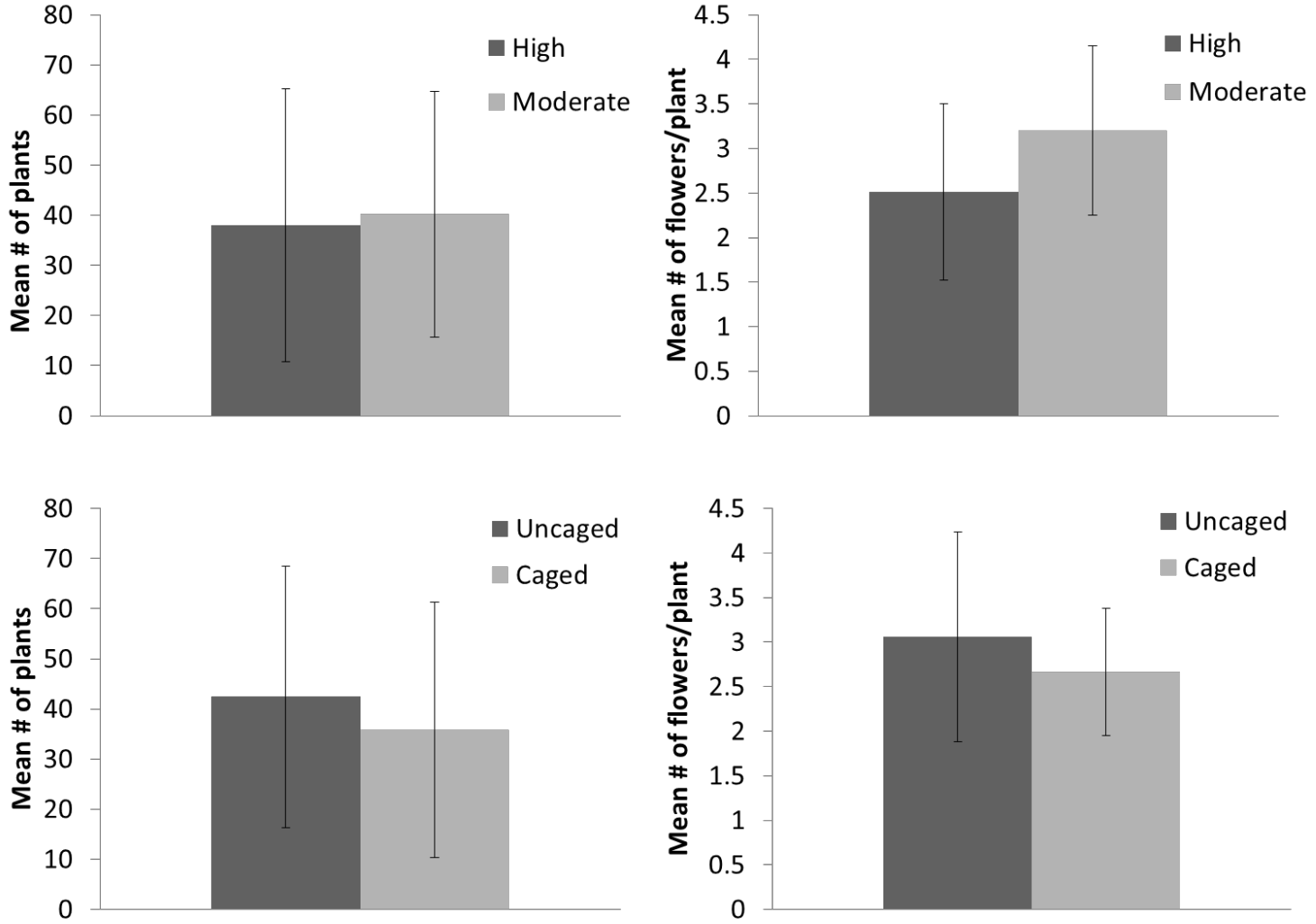

FIGURE 11. MEAN NUMBER OF PLANTS AND MEAN NUMBER OF FLOWERS PER PLANT IN 2017, SORTED BY HIGH AND MODERATE RECREATION TRAFFIC (ABOVE) AND CAGED AND UNCAGED PLOTS (BELOW). PLOTS THAT WERE INITIALLY DESIGNATED AS "LOW" TRAFFIC IN EARLY YEARS OF THIS STUDY ARE NOW CONSIDERED TO BE "MODERATE" TRAFFIC PLOTS DUE TO INCREASED VISITOR USE. ERROR BARS REPRESENT 95% CONFIDENCE INTERVALS.

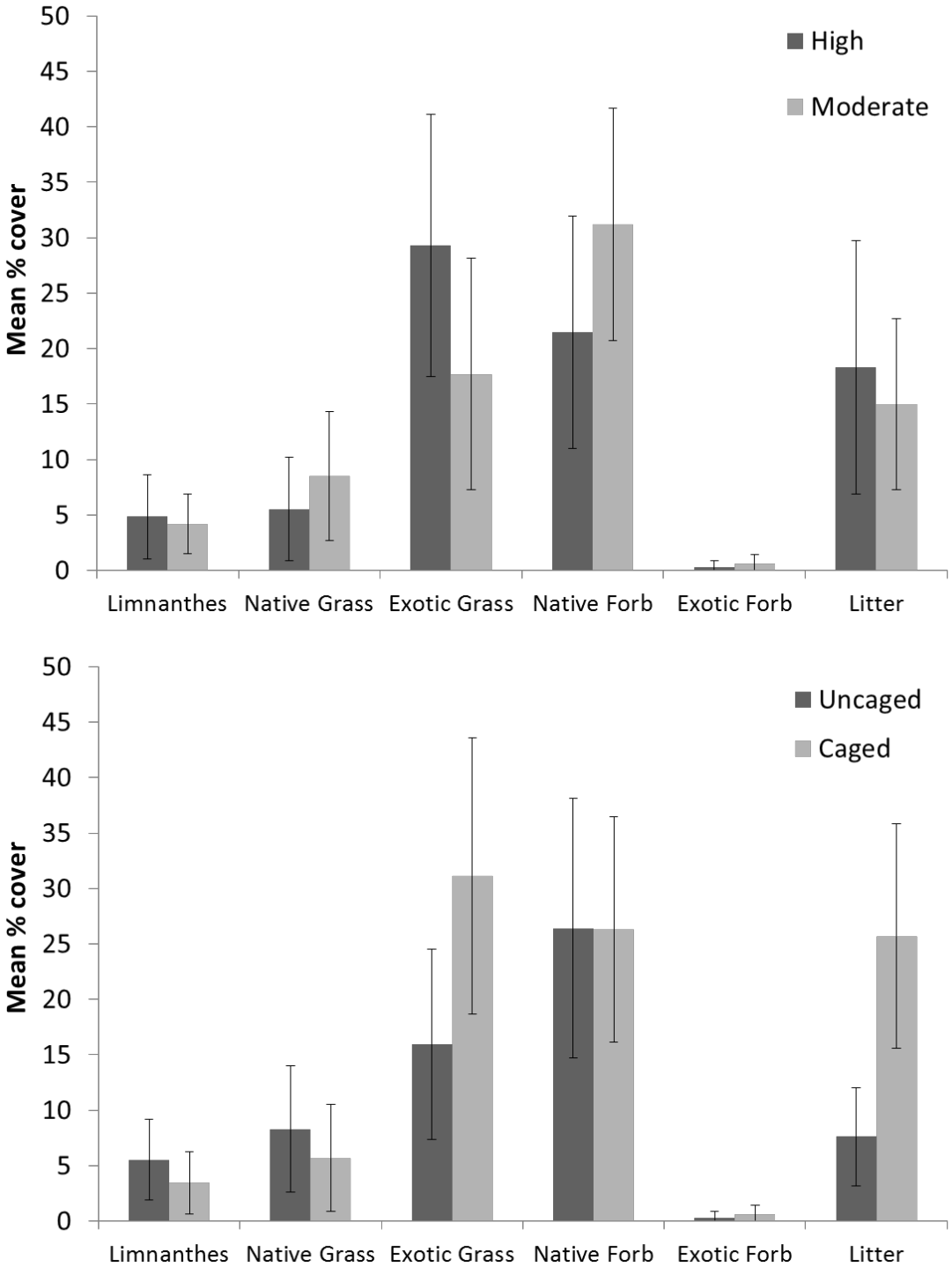

FIGURE 12. PERCENT COVER IN PLOTS ON LOWER TABLE ROCK IN 2017, BY RECREATION TRAFFIC (HIGH, MODERATE), AND TREATMENT (CAGED, UNCAGED). 'NATIVE FORB' INCLUDES *LIMNANTHES* COVER. PLOTS THAT WERE INITIALLY DESIGNATED AS "LOW" TRAFFIC IN EARLY YEARS OF THIS STUDY ARE NOW CONSIDERED TO BE "MODERATE" TRAFFIC PLOTS DUE TO INCREASED VISITOR USE. ERROR BARS REPRESENT 95% CONFIDENCE INTERVALS.

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

Our previous results indicate that large ungulates have a negative effect on the density of *L. pumila* ssp. *pumila* (Thorpe 2009). 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. 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 2017, similar to recent years, we found no difference between caged and uncaged plots with respect to number of *L. pumila* spp. *pumila* (V=13, p=0.160; Figure 13). The continued similarity between caged and uncaged plots since the removal of cattle suggests that cattle grazing significantly affected population dynamics for this species until livestock were removed and that native ungulates have little effect on plant population dynamics. In 2016 we saw lots of elk tracks in and around several of our plots and many of the cages had been pushed into the ground suggesting they may have been trampled and are likely no longer excluding trampling or grazing by native ungulates.

While 2015 was the lowest recorded year for both plants and number of flowers per plant in exclosed and open plots, mean number of plants in 2016 was similar to values seen in 2013 and number of flowers per plant was at the second highest number since 2007 (Figure 13). Mean number of plants and number of flowers per plant declined again in 2017, but were not as low as 2015 values (Figure 12). Across all plots on Upper Table Rock, number of plants per plot ranged from 0 to 63, and mean number of flowers/plant ranged from 1 to 5, which was lower than 2016 values. Grass cover has varied 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 14). Grass cover decreased from 2013 to 2015, however, values have increased each year from 2015-2017 and remain higher than 2012 values (Figure 14). Though these values have been variable, grass cover has been composed mostly of non-native grasses including *B. hordeaceus* and *T. caput-medusae*. These values indicate that management related to decreasing non-native grasses in these areas should be a high priority. While 2015 was a very low year, 2016 had high numbers of plants, many with lots of flowers, suggesting that the previous year cannot present a prediction for how the species will do. While 2017 had lower numbers than 2016, both number of plants and number of flowers per plant were still higher than 2015. Long-term studies are essential to understand just how variable these fluctuations can be and if the population is being impacted over time.

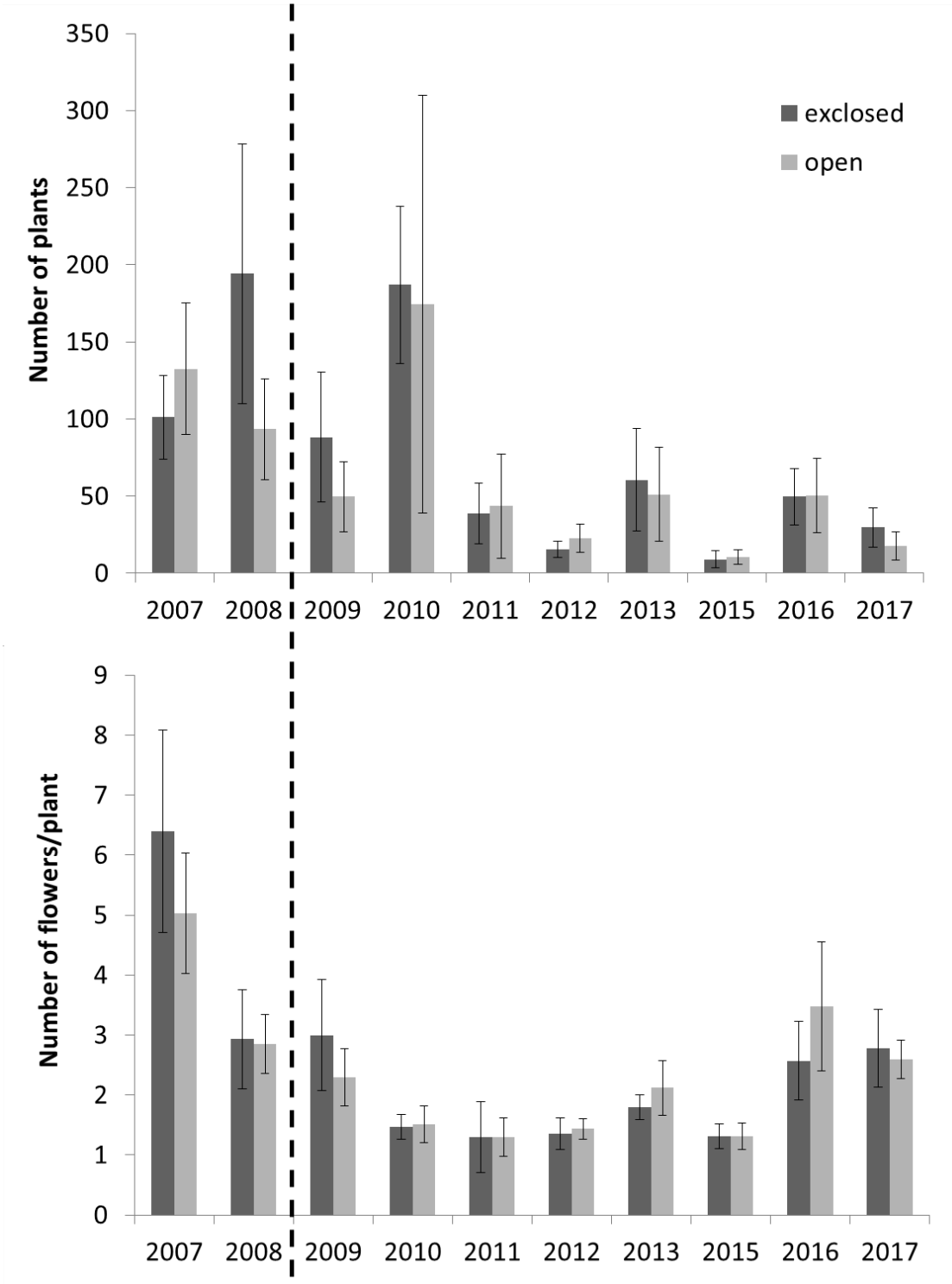

FIGURE 13. MEAN NUMBER OF PLANTS (TOP) AND FLOWERS PER PLANT (BOTTOM) IN EXCLOSED AND OPEN PLOTS ON UPPER TABLE ROCK IN 2007 - 2017. ERROR BARS REPRESENT 95% CONFIDENCE INTERVALS. THE DASHED LINE INDICATES WHEN CATTLE WERE REMOVED. PLOTS WERE NOT MONITORED IN 2014.

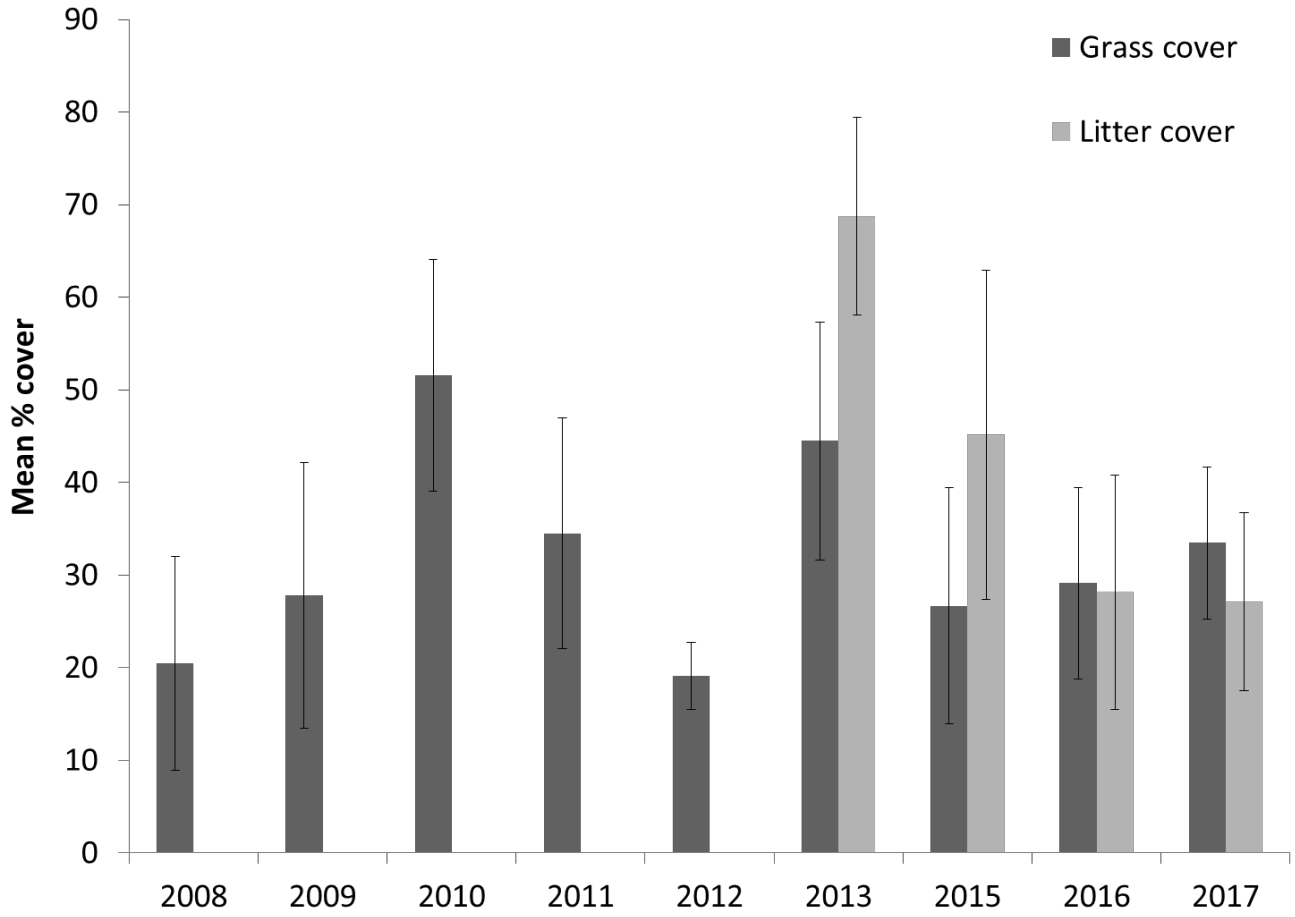

FIGURE 14. MEAN PERCENT COVER OF GRAMINOIDS AND LITTER IN *L. PUMILA* SSP. *PUMILA* MONITORING PLOTS ESTABLISHED ON UPPER TABLE ROCK. ERROR BARS REPRESENT 95% CONFIDENCE INTERVALS. GRAMINOID COVER WAS RECORDED IN 2008-2017, LITTER COVER WAS NOT RECORDED FROM 2008-2012. PLOTS WERE NOT MONITORED IN 2014.

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 had increased visitors in recent years with lots of off-trail use through many 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 values seen 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 (Table 1). Mean number of plants and number of flowers per plant were higher in moderate traffic plots than high traffic plots in 2017, though not significantly ($F=3.81$, $p=0.79$; $F=1.30$, $p=0.281$; Table 1). Results from Lower Table Rock have revealed differences in 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 et al. 2016). Continued monitoring on the southern end of Upper Table Rock will be necessary to see if there are negative human impacts in this area of the Table Rocks as well.

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 ± 95% CONFIDENCE INTERVALS.

Plot	**# plants ± 95% C.I.**		
	2015	2016	2017
High Traffic (Est. 2015)	10.0 ± 5.9	41.0 ± 24.6	15.2 ± 12.7
Moderate Traffic (Est. 2016)	N/A	26.2 ± 8.8	38.2 ± 21.1
	# flowers per plant ± 95% C.I.		
	2015	2016	2017
High Traffic (Est. 2015)	3.1 ± 1.4	7.3 ± 2.3	5.8 ± 3.2
Moderate Traffic (Est. 2016)	N/A	9.5 ± 3.5	8.5 ± 2.1

Community monitoring of the fire retardant drop

Across all of the 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 3). 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 3). *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.

	Proportion of Transect		
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 m^2 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).

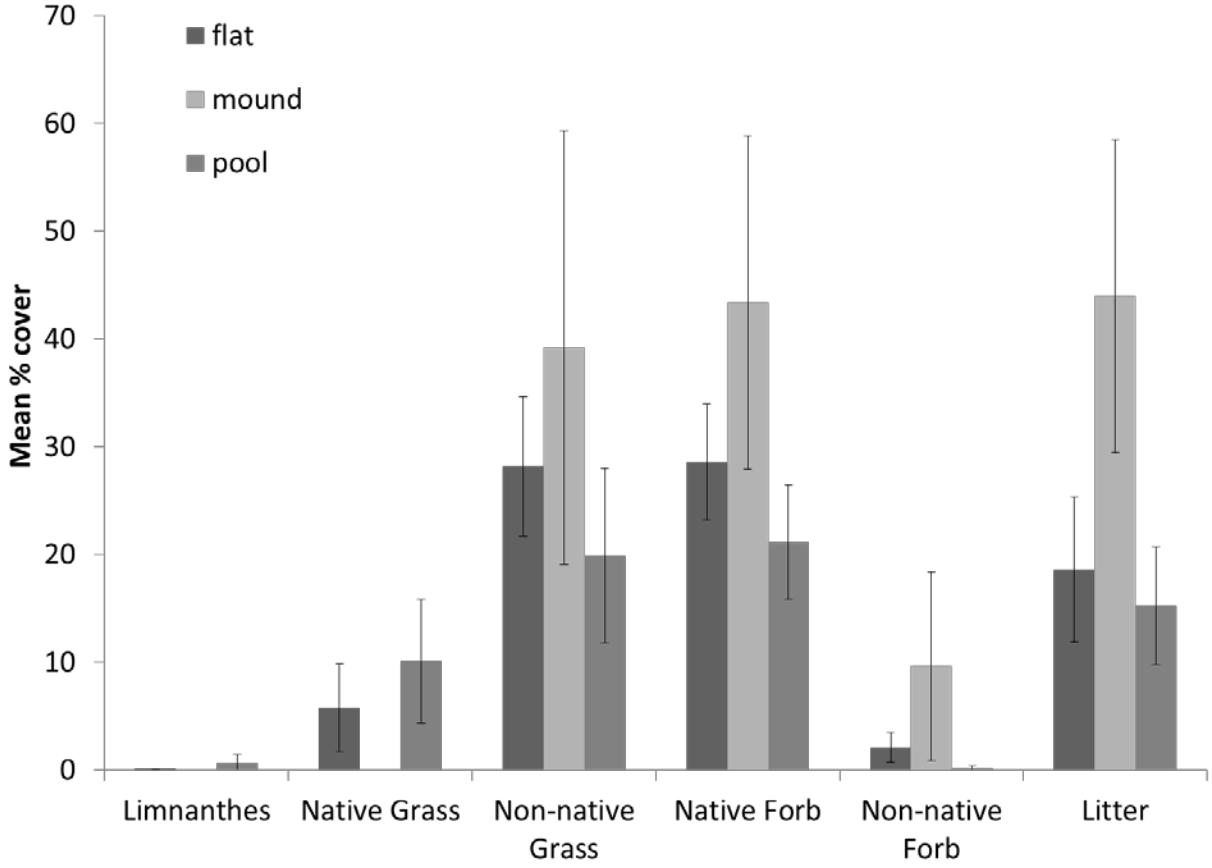

FIGURE 15. PERCENT COVER IN ALL PLOTS ALONG FIRE RETARDANT TRANSECTS ON LOWER TABLE ROCK, BY HABITAT TYPE (N, FLAT =25, MOUND = 7, POOL = 7) IN 2017. ERROR BARS REPRESENT 95% CONFIDENCE INTERVALS. 'NATIVE FORB' INCLUDES *LIMNANTHES* COVER.

From 2013 to 2016 we observed a decline in non-native grasses both within and outside of the fire retardant drop (Table 4, 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 4, 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).

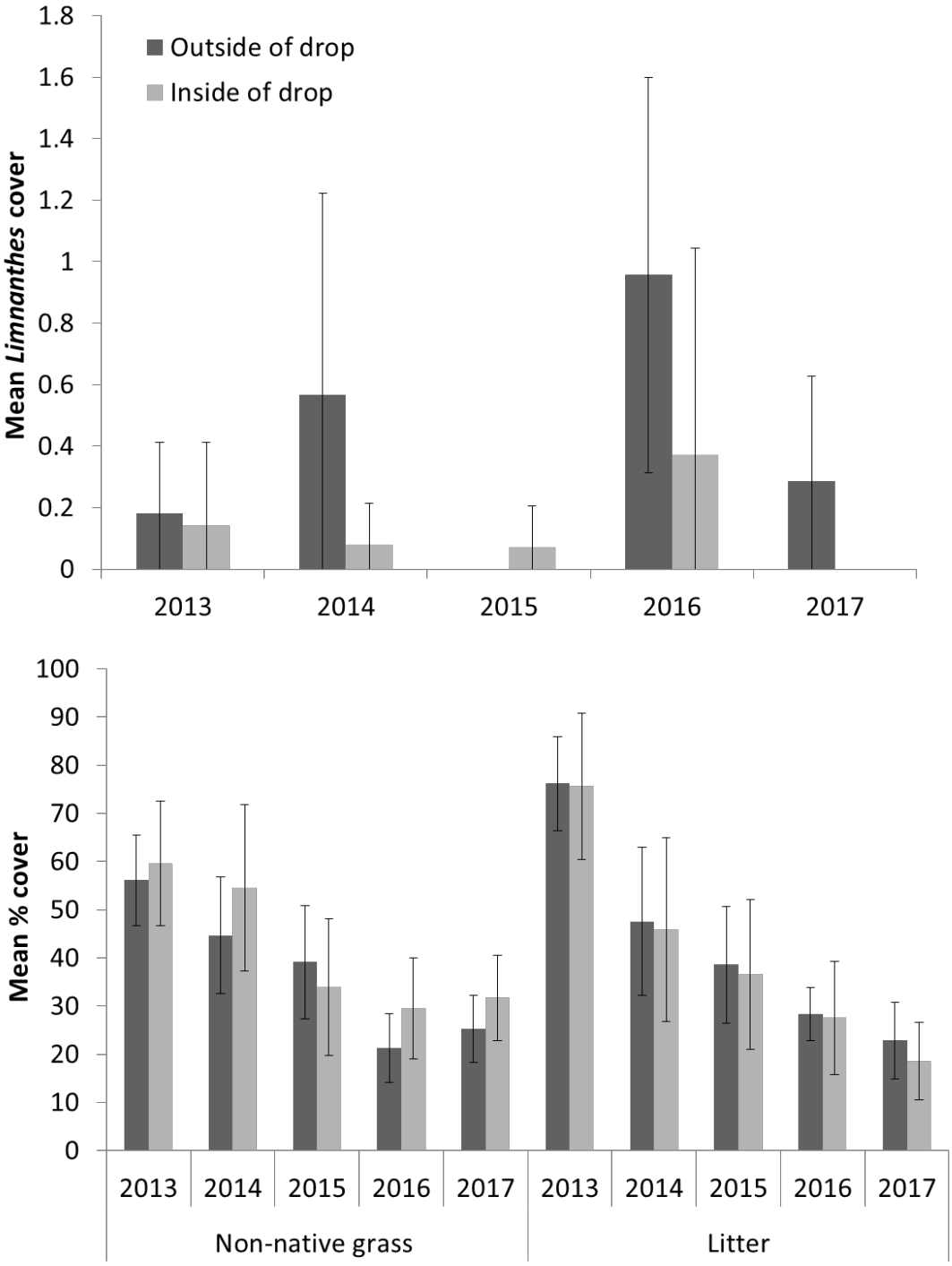

FIGURE 16. MEAN *L. PUMILA* SSP. *PUMILA* COVER COLLECTED FROM PLOTS ALONG TRANSECTS INSIDE AND OUTSIDE THE AREA OF THE FIRE RETARDANT DROP IN 2013 TO 2017. MEAN COVER OF NON-NATIVE GRASSES AND LITTER COLLECTED FROM PLOTS ALONG TRANSECTS INSIDE AND OUTSIDE OF THE AREA OF THE FIRE RETARDANT DROP FROM 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 *Limnanthes* cover					Mean non-native grass cover					Mean litter cover				
	2013	2014	2015	2016	2017	2013	2014	2015	2016	2017	2013	2014	2015	2016	2017
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 4). 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 1 plot (inside of the drop) (Table 4). 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 year, 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. Continued monitoring will be necessary to see if these changes represent a long-term trend.

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 and 2017 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 and number of flowers per plant did not differ significantly between burned and unburned plots in 2017 ($W=25$, $p=0.067$; $F=1.57$, $p=0.227$; Figure 18). Litter cover was also similar between burned plots and unburned plots in 2017 (16.8 and 16.5%, respectively) (Figure 18). While these results are interesting they should be interpreted cautiously as these plots were not set up to test the effects of fire and also

had other factors contributing to results observed such as caging treatments and the amount of recreation traffic they experienced.

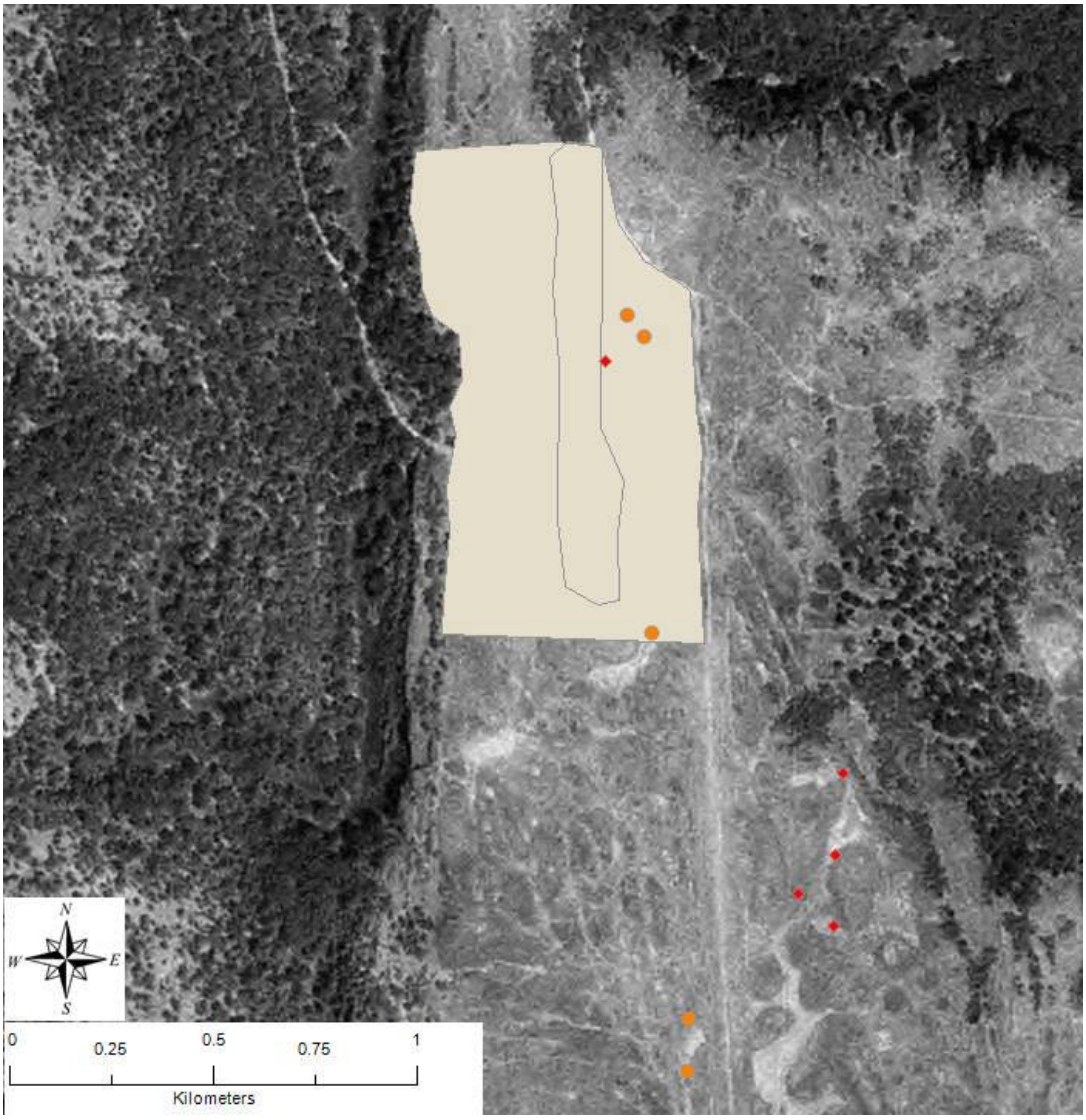

FIGURE 17. LOCATION OF THE PRECRIBED FIRE ON LOWER TABLE ROCK THAT OCCURRED IN OCTOBER 2015 (TAN AREA). THE ORIGINAL AREA IMPACTED BY THE FIRE RETARDANT DROP IS OUTLINED WITHIN. HIGH AND MODERATE TRAFFIC PAIRED PLOTS ARE INDICATED BY RED DOTS (MODERATE TRAFFIC) AND ORANGE DOTS (HIGH TRAFFIC). SEE APPENDIX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

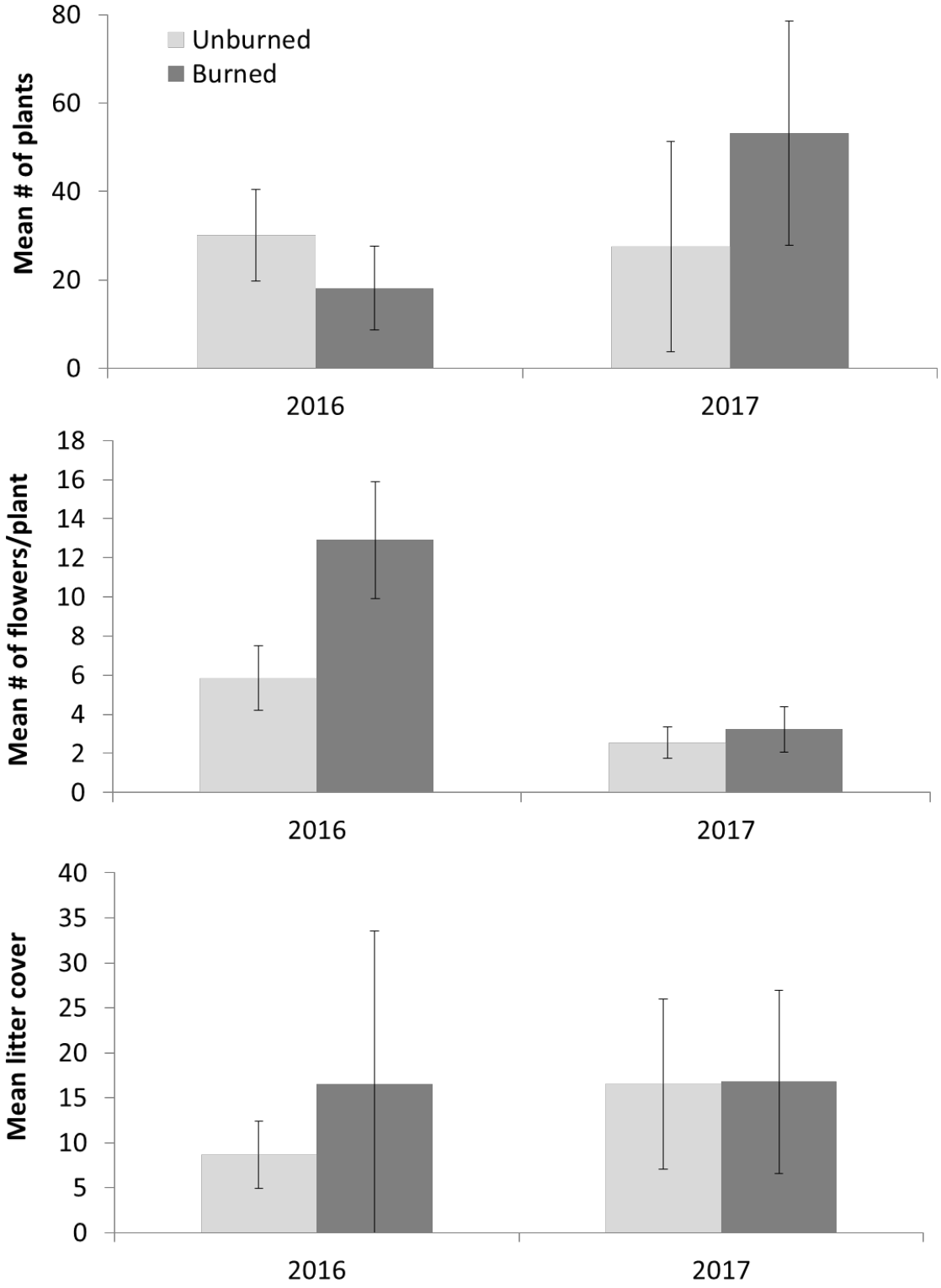

FIGURE 18. MEAN NUMBER OF *L. PUMILA* SSP. *PUMILA* PLANTS, MEAN NUMBER OF FLOWERS, AND MEAN LITTER COVER IN 2016 AND 2017 IN PLOTS THAT WERE BURNED (N=9) AND UNBURNED (N=12) DURING THE PRESCRIBED FIRE IN FALL 2015. ERROR BARS REPRESENT 95% CONFIDENCE INTERVALS.

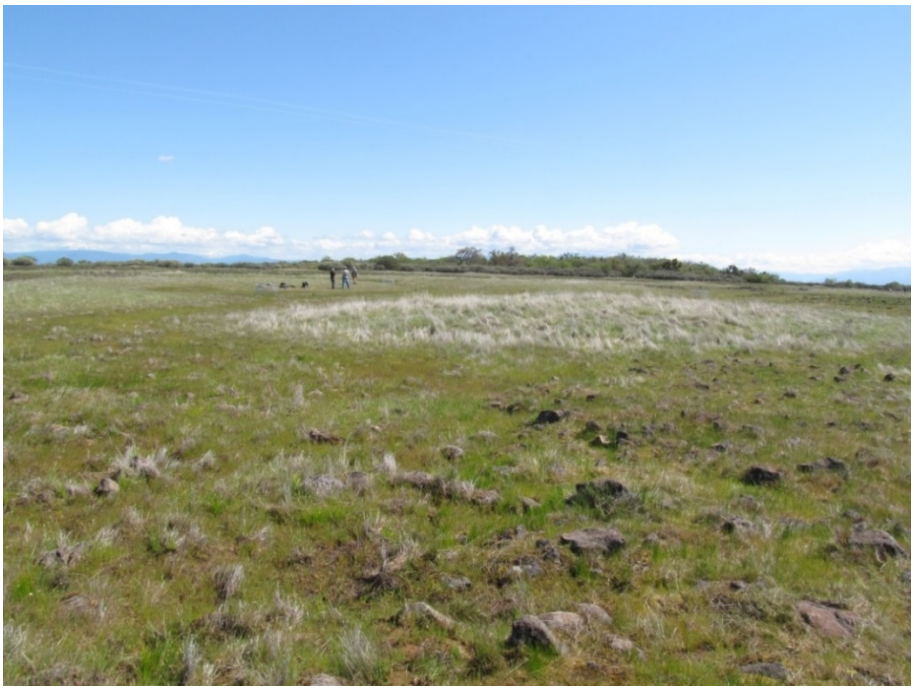

FIGURE 19. MOUND HABITAT ON LOWER TABLE ROCK, MADE VISIBLE BY THE DOMINANCE OF NON-NATIVE GRAMINOIDS INCLUDING *T. CAPUT-MEDUSAE* AND THE LITTER IT LEAVES BEHIND.

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 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 (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 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 could have added to the existing seed-bank and we 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 had spread both within and outside of the area of the fire retardant drop, which was associated with a severe decline in the *L. pumila* ssp. *pumila* population. Changes in plant community composition were observable in aerial imagery (Gray et al. 2015). Since 2014, we have observed a steady decline in non-native grasses and litter in these plots. In 2016 there was an increase in cover of *L. pumila* ssp. *pumila*, but this did not carry over into 2017. Continued monitoring will be essential to track these changes and see if positive trends continue.

CONCLUSIONS

FIGURE 20. POOL HABITAT ON LOWER TABLE ROCK.

From 2010-2013, we observed a severe decline (nearly 88%) 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 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 in numbers was promising, particularly given that 2015 was the lowest year over the course of this study. However, the increased reproductive effort in 2016 did not translate to increases in *L. pumila* ssp. *pumila* across both Table Rocks in 2017. There was a slight increase in number of plants in long-term monitoring plots on Lower Table Rock, but there was a decrease in cover observed along the transects and a decrease in number of plants and reproductive effort on the northern end of Upper Table Rock. We did observe a continued decline in litter and cover of non-native grasses, particularly on Lower Table Rock, as well as an increase in pool habitat, which are positive trends. Since the initial decline observed after the fire retardant drop on Lower Table Rock, the *L. pumila* ssp. *pumila* population has appeared to have rebounded, but not to numbers as high as we have observed earlier in this study. Continued monitoring will be essential to see if we are now seeing typical fluctuations for this annual species or if there is an overlying negative trend.

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 et al. 2016). It is likely that timing of the fire played a great role in the effects of the burn. 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 2002). 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). While a fall burn may have impacted the plant community, consideration of a spring burn might 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 in 2015, 2016, and 2017. The multitude of secondary trails suggests that more steps need to be taken, particularly during the growing season, to protect these sensitive habitats that *L. pumila* ssp. *pumila* inhabits. 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. *Limnanthes pumila* ssp. *pumila* is the most fragile prior to setting fruit, so timing centered around 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 we have seen in the past were present (Figure 20). This variability in climate and its impact on habitat could greatly affect the populations of rare annual endemics occurring on the Table Rocks. Continued monitoring will be essential to see how populations of annual species perpetuate into the future.

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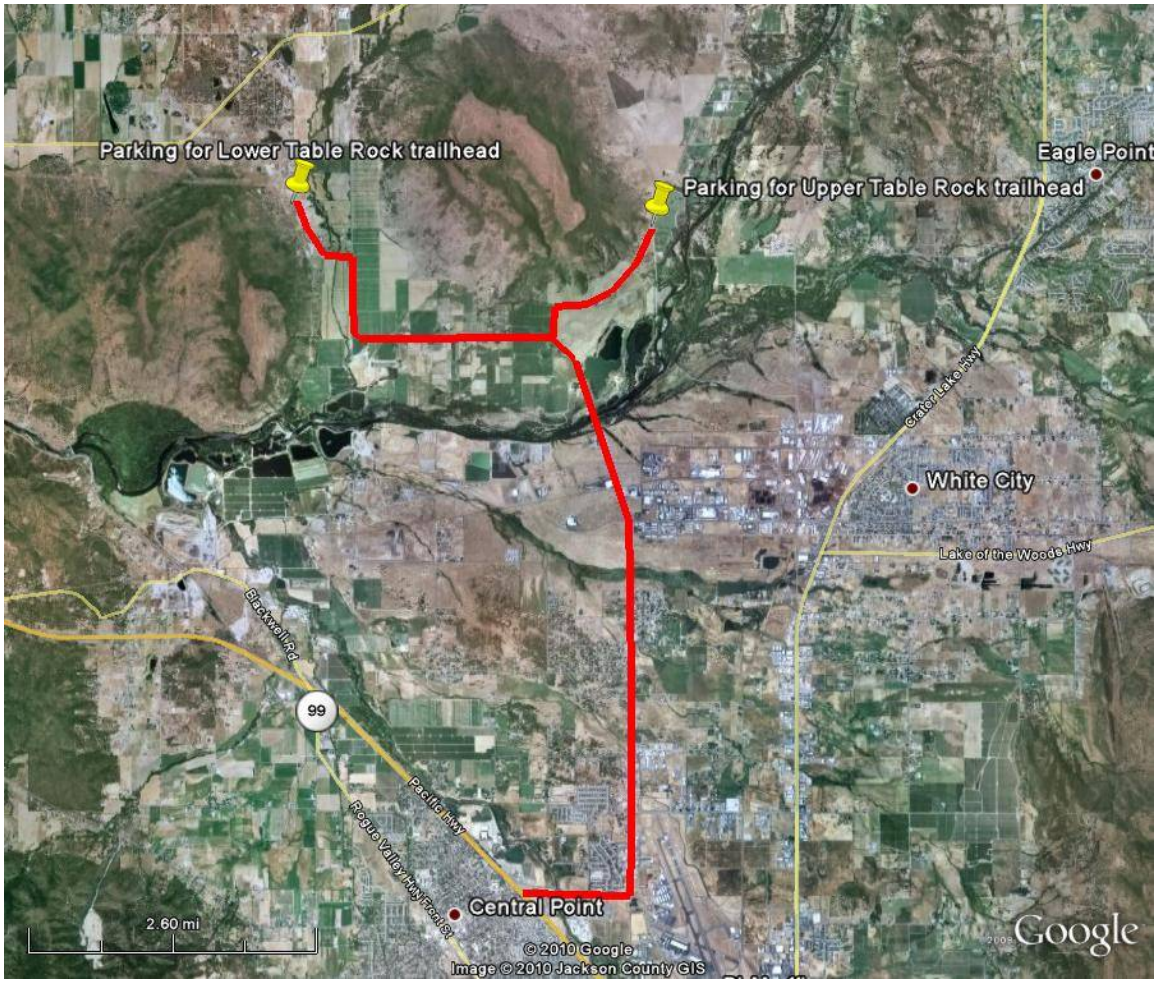
APPENDIX A. SITE DIRECTIONS TO UPPER AND LOWER TABLE ROCKS.

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. 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 A. 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	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	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

[1]NAD83, 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

[1]NAD83, UTM 10N

APPENDIX B. 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

[1]NAD83, UTM 10N

Upper Table Rock Southern Plot Locations

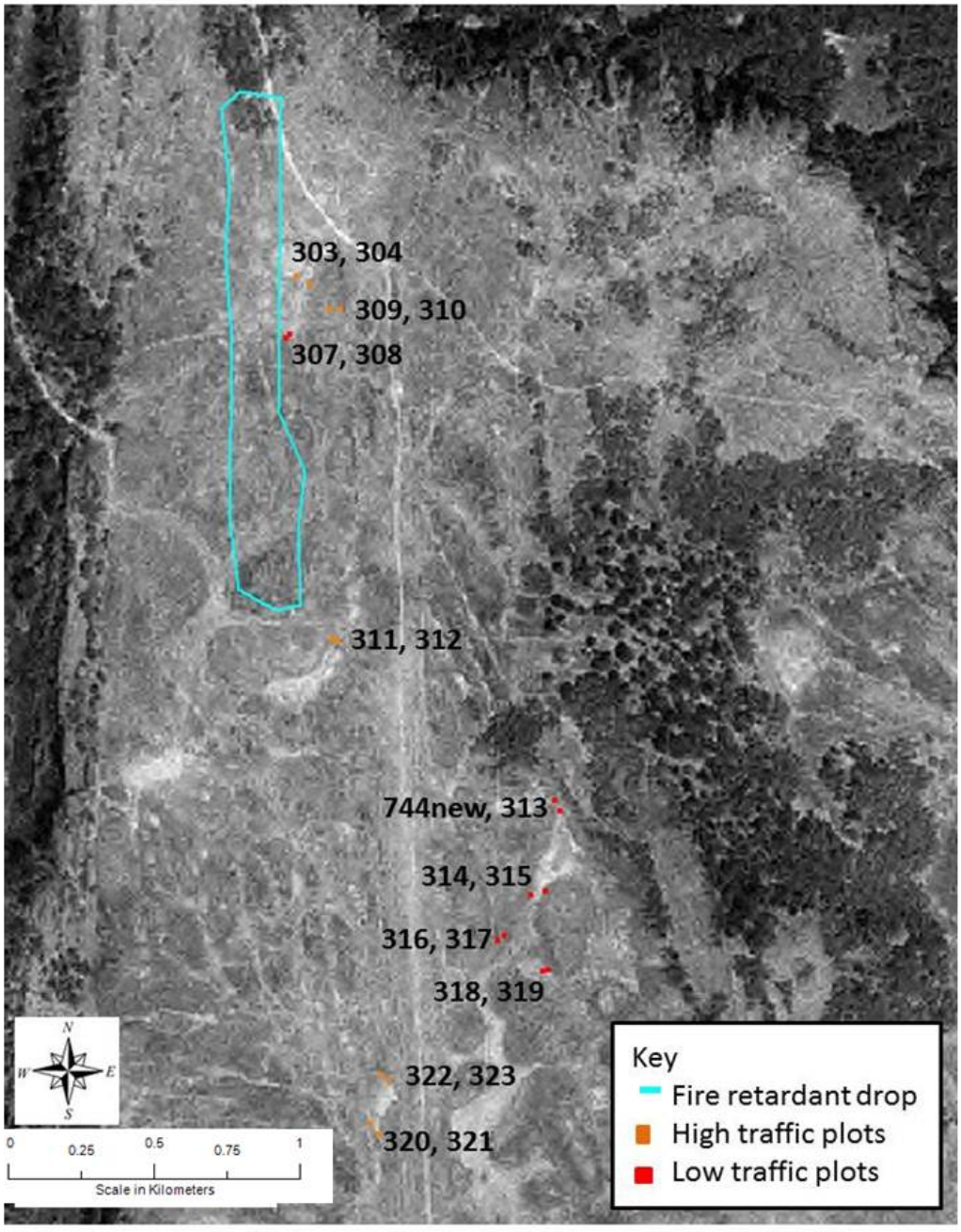
Plot ID	Tag #	Year established	Recreation traffic	Latitude[1]	Longitude
540	554	2015	high	42.466240	-122.895551
541	551	2015	high	42.466266	-122.895519
542	68 (old tag 542)	2015	high	42.466192	-122.895159
543	67 (old tag 552)	2015	high	42.465479	-122.895901
544	553	2015	high	42.465875	-122.895530
545	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

[1]NAD83, UTM 10N
*NOTE: Could not locate Plot #559 in 2017, thus a new plot, #66, was established in the approximate vicinity.

APPENDIX C. PLOT MAPS.

Lower Table Rock

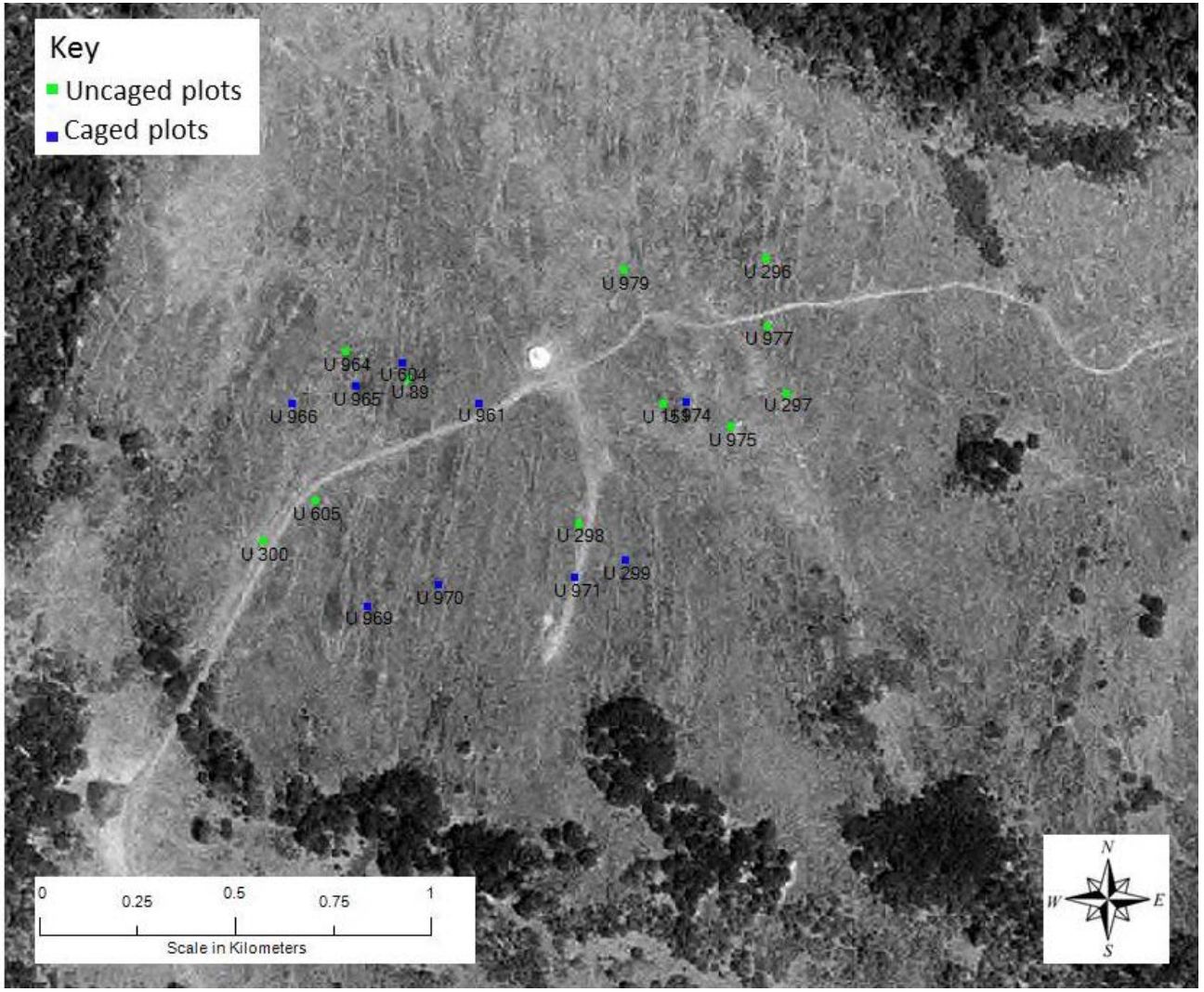
Long-term *L. pumila* ssp. *pumila* population monitoring plots established in 2012 with plot identification numbers (monitored from 2012-2017).



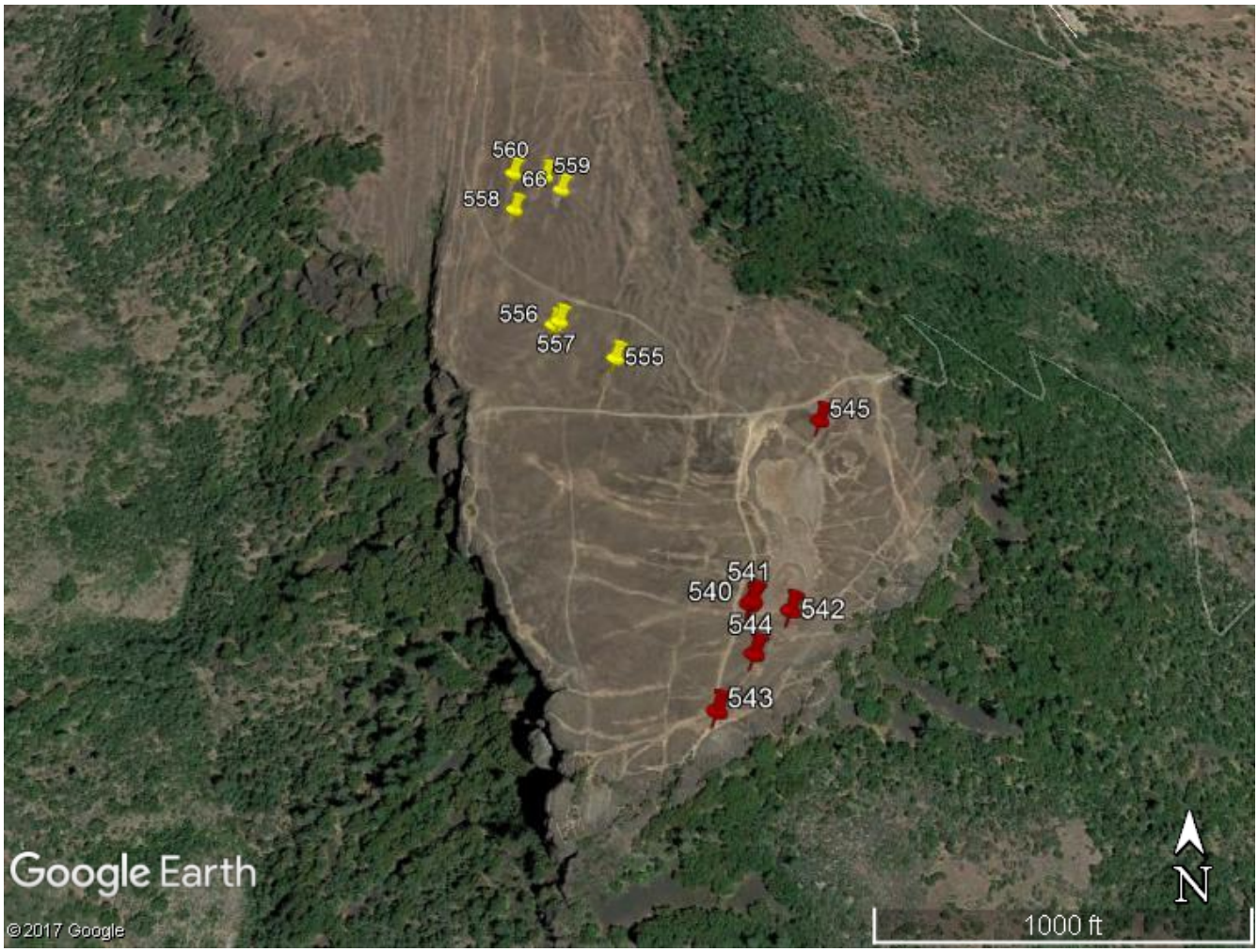
2009 trampling plot start points on Lower Table Rock. See Appendix B for plot azimuths and side of the tape to sample. End point GPS coordinates are also available in IAE files. Points are approximations only; plots could be ±25 feet from points.

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.

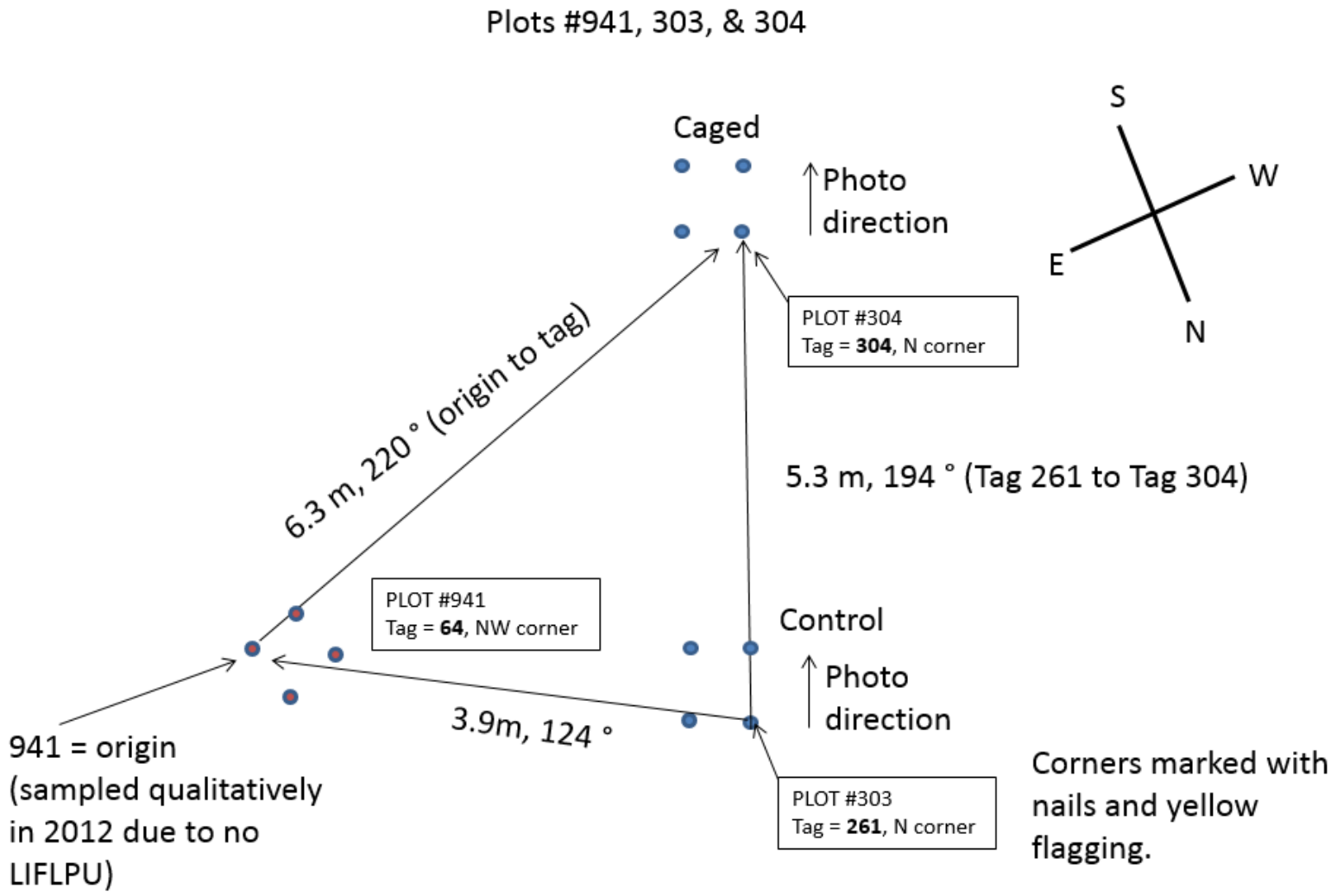
Long-term monitoring plot locations (were grazing plots) on Upper Table Rock North.



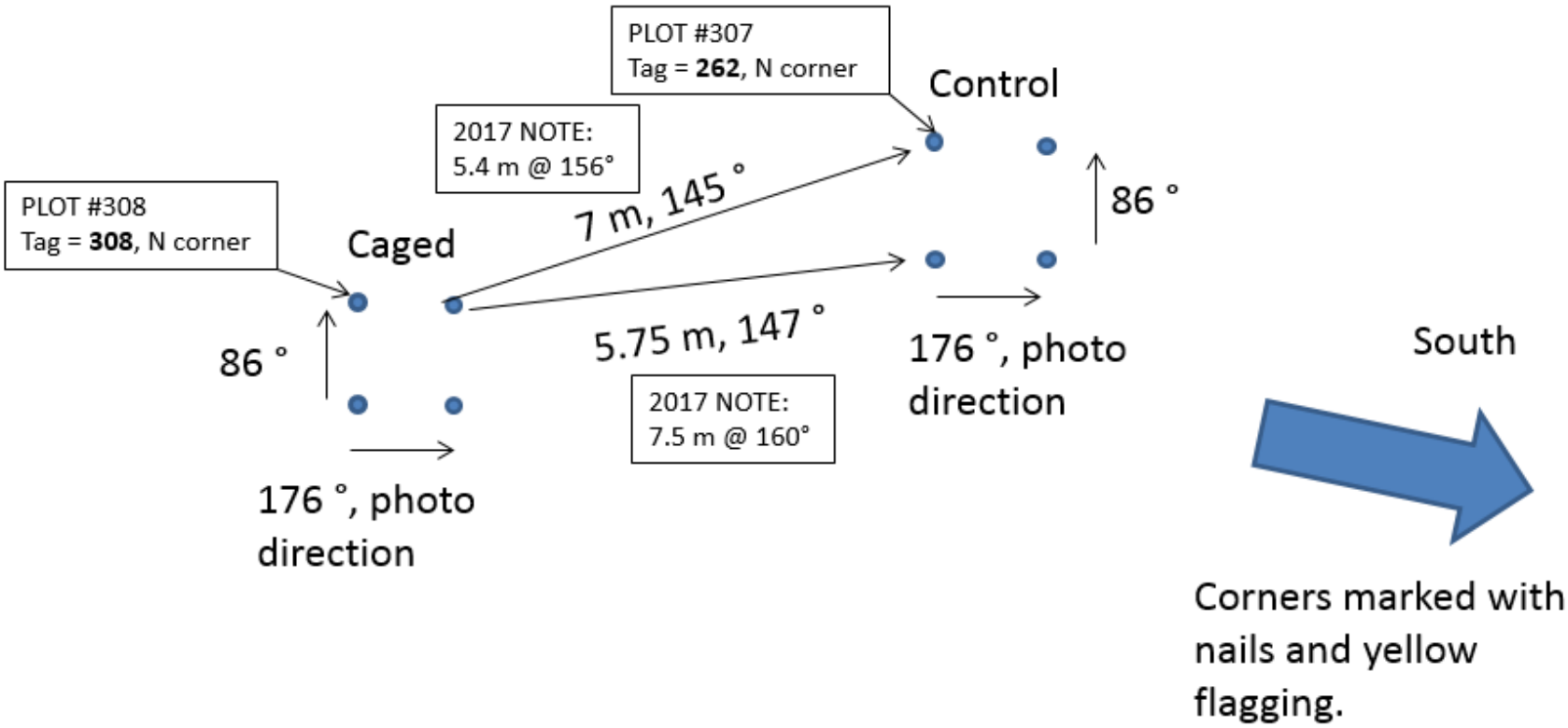
Limnanthes pumila ssp. *pumila* monitoring plots on Upper Table Rocks South established in 2015 and 2016. Yellow plots represent those in moderate recreation traffic areas, and red plots represent those in high recreation traffic.



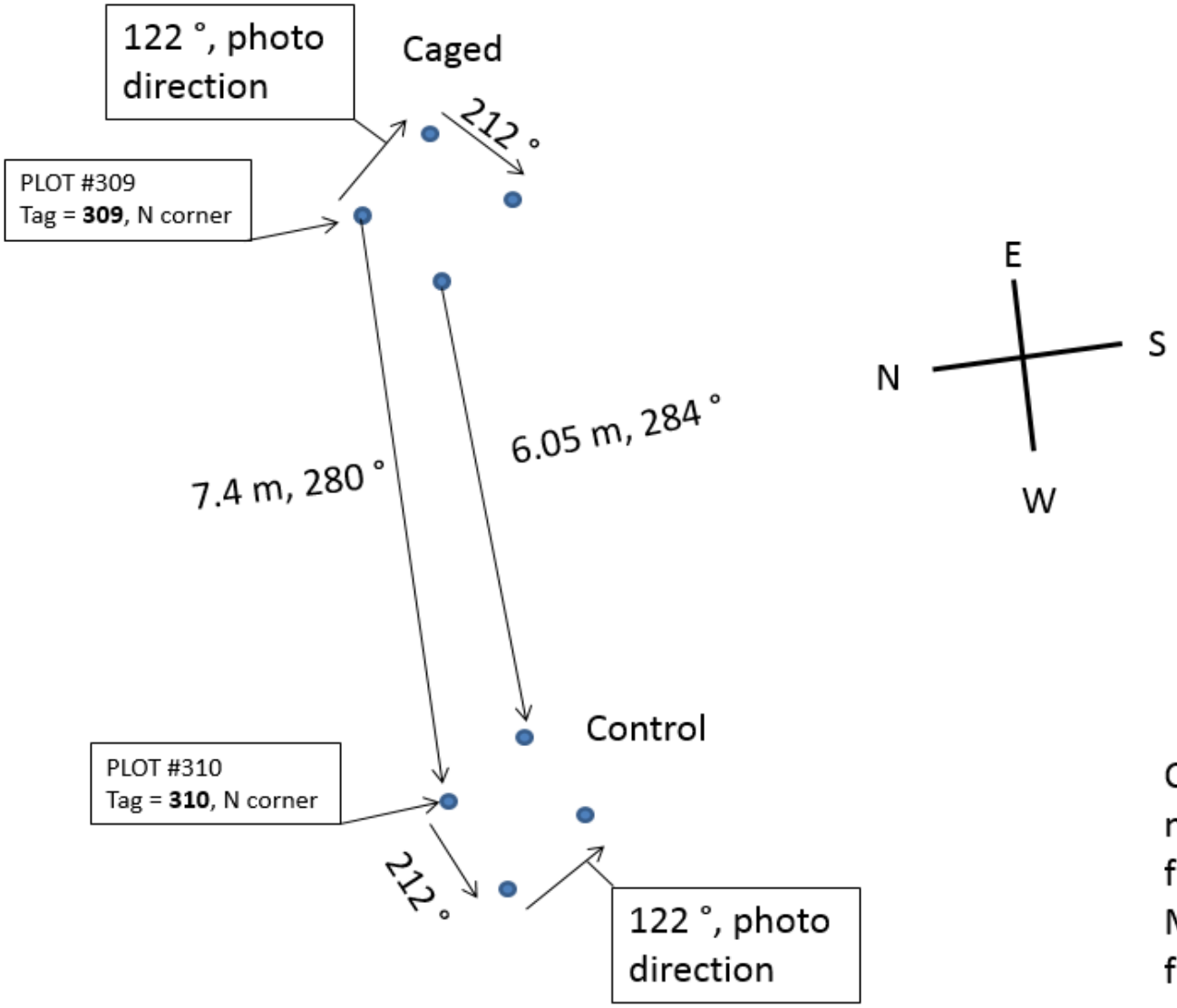
Maps of *L. pumila* ssp. *pumila* population monitoring plots established on Lower Table Rock in 2012.



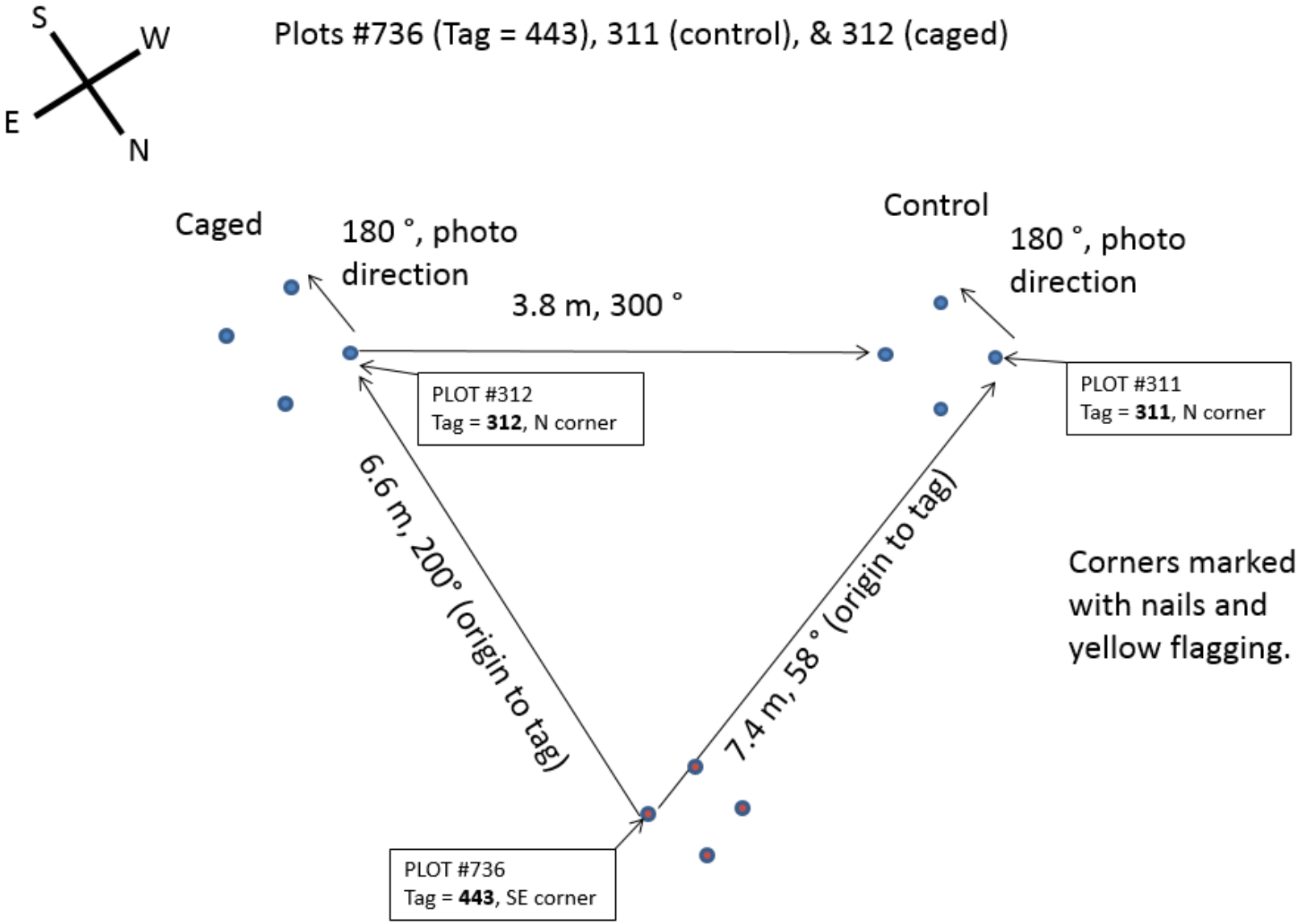
Plots #307 (control) & 308 (caged)



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

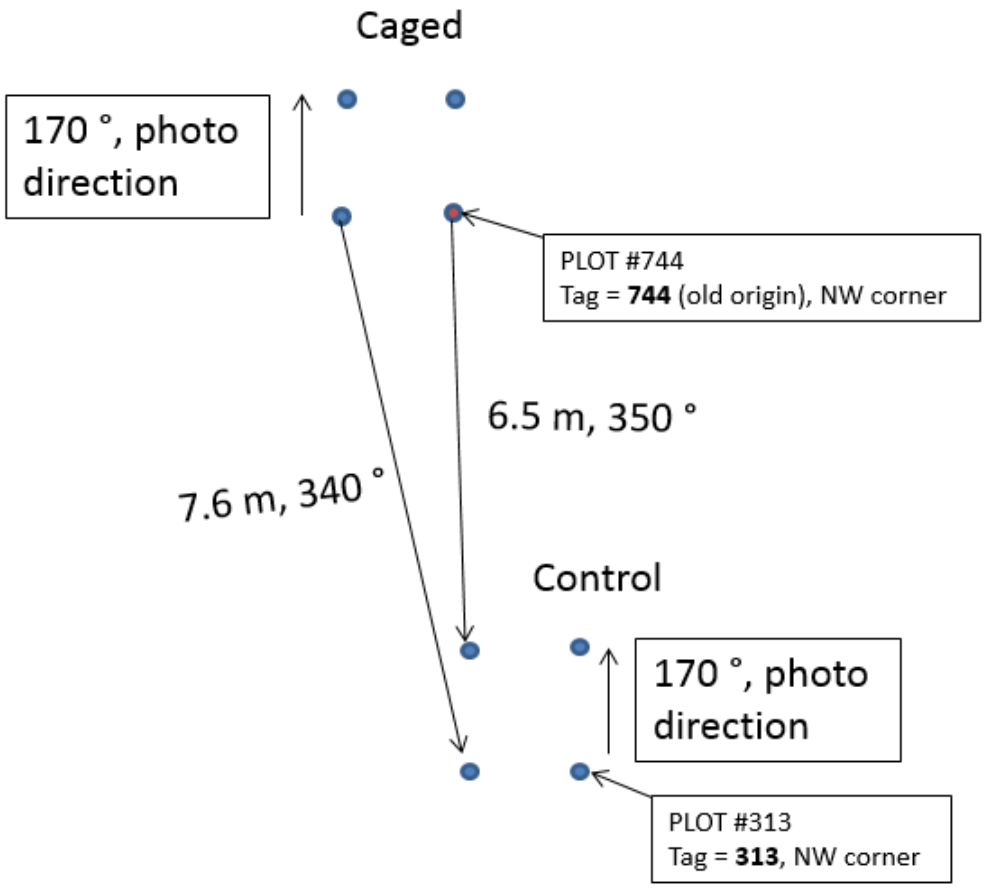


Corners marked with nails and yellow flagging.
Measurements made from nail to nail

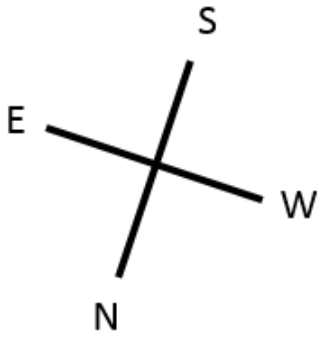


736 (marker 443- conduit with pink/white tape = origin) sampled qualitatively in 2012 due to no LIFLPU.

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



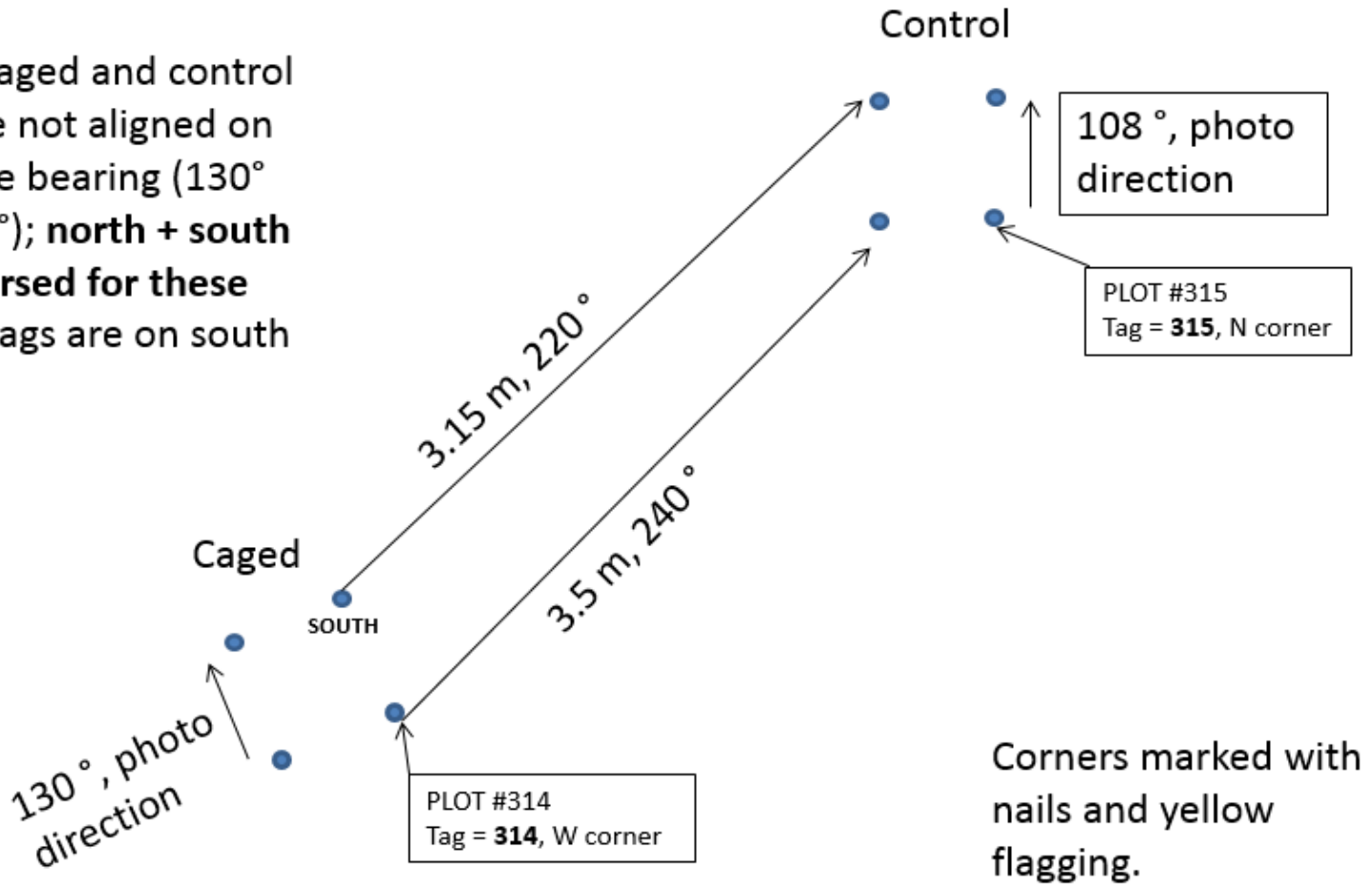
Corners marked with nails and yellow flagging.
Measurements made from nail to nail



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

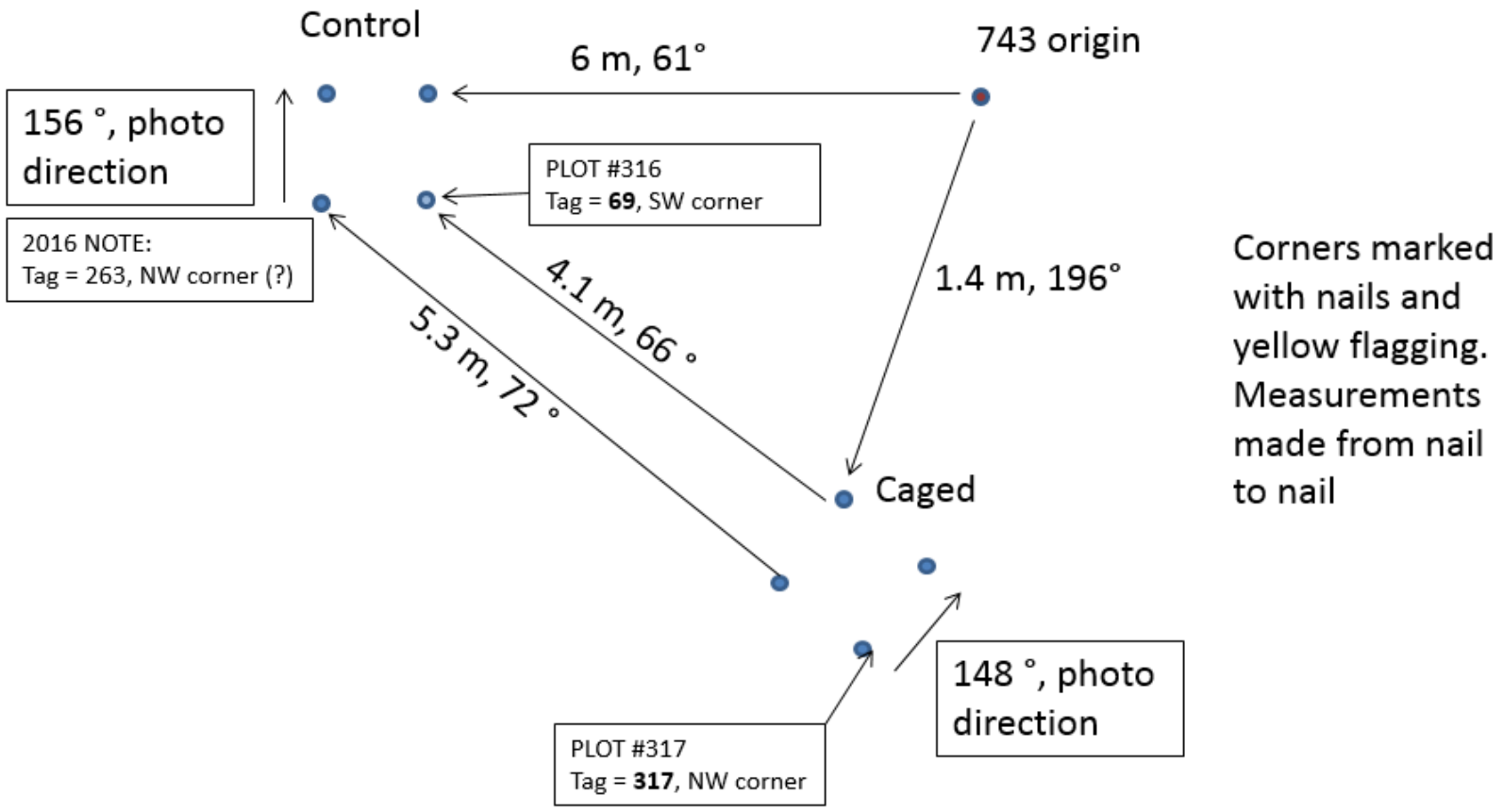
Plots #314 (caged) & 315 (control)

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



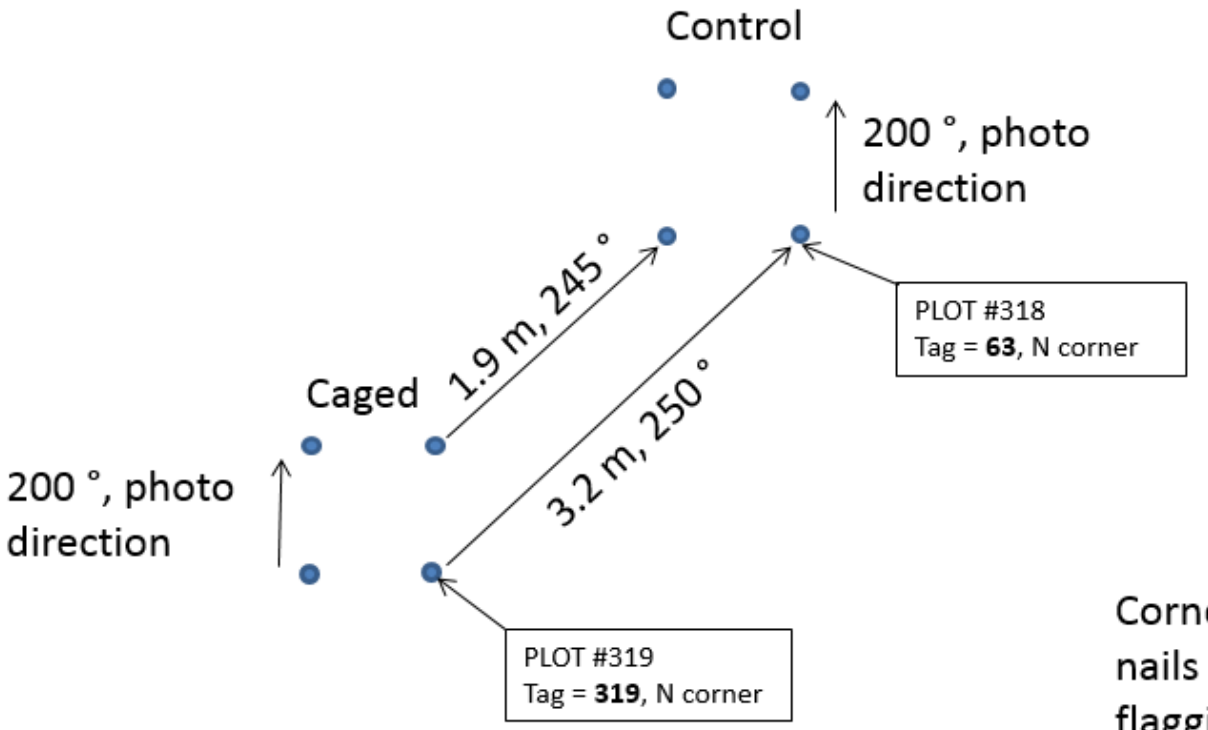
Corners marked with nails and yellow flagging.
Measurements made from nail to nail

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



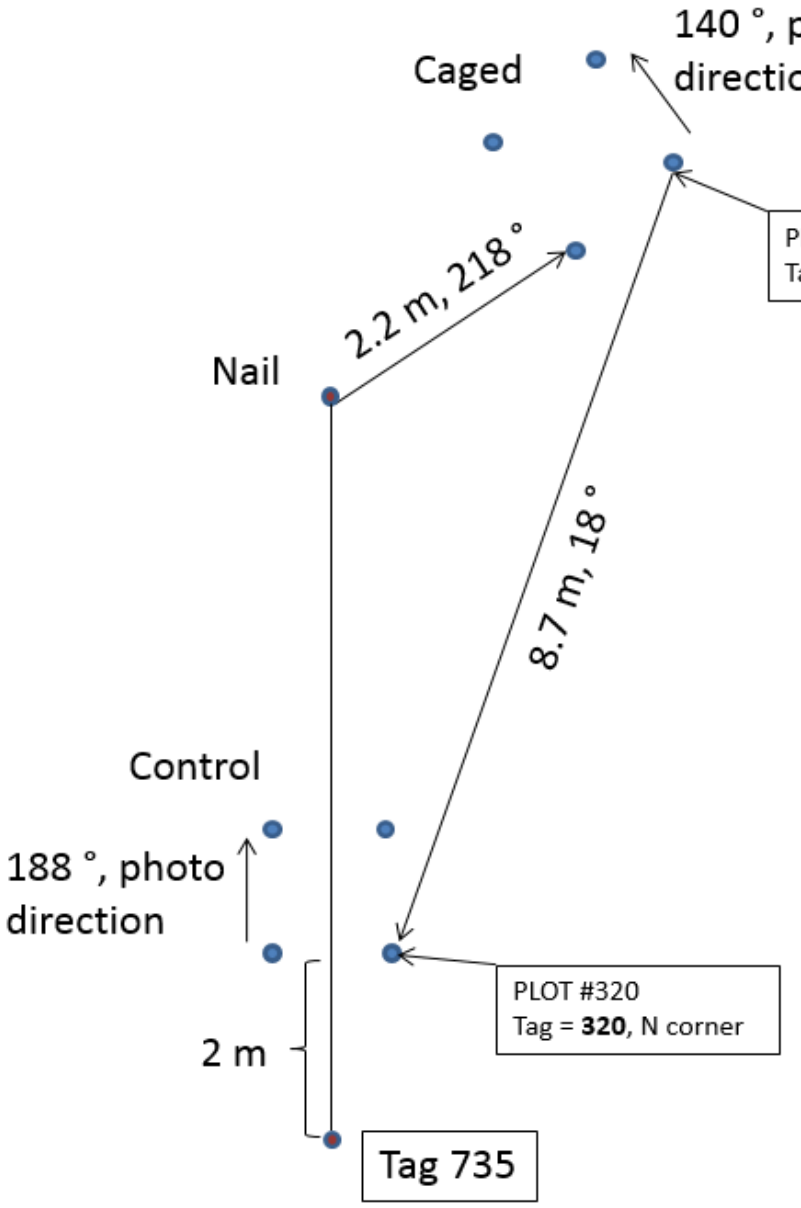
Tag #743 found, control placed 6m from origin, not in the same place as previous years. Do not compare data to previous years for the control.

Plots #319 (caged) & 318 (control)



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

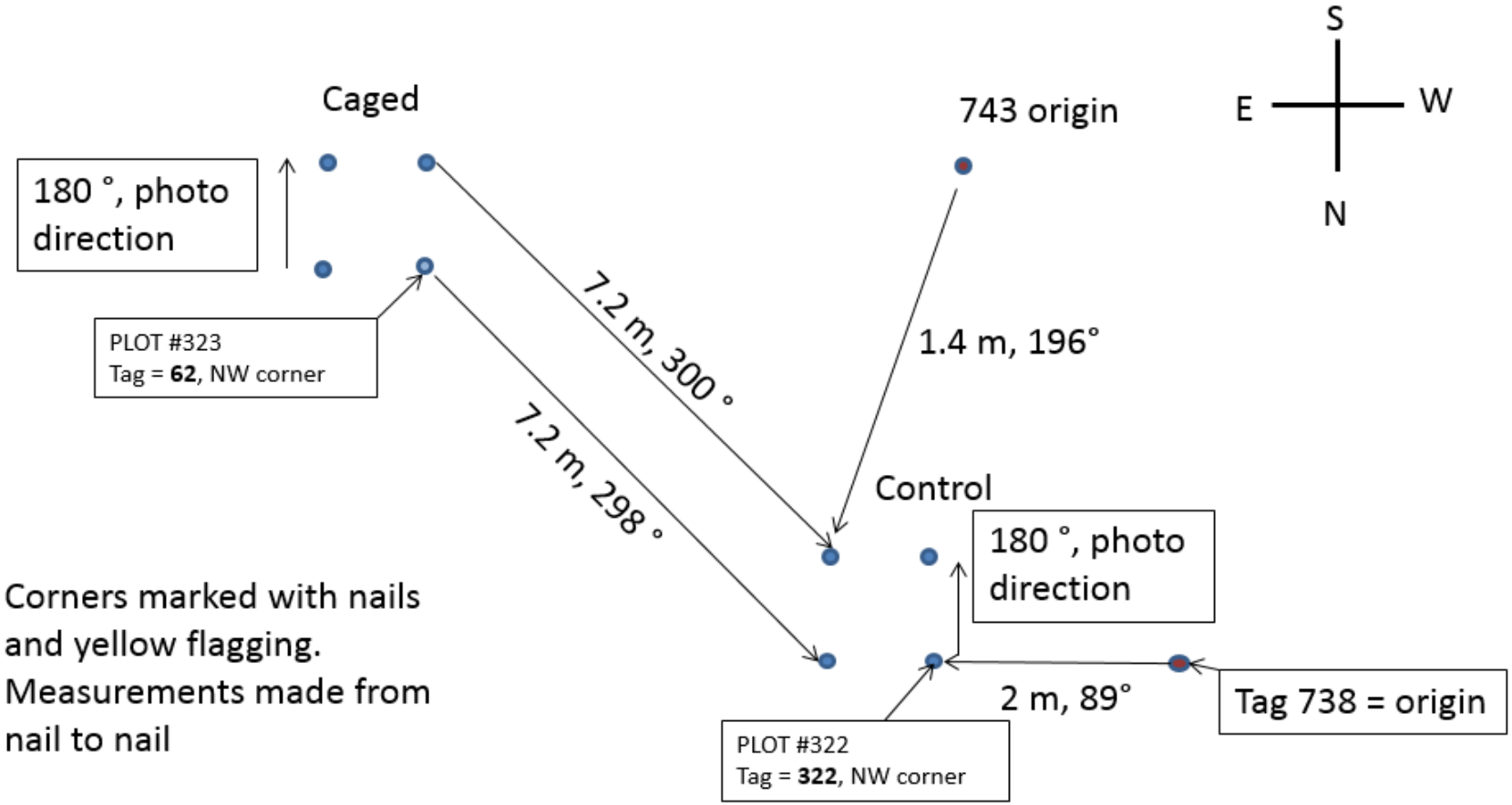
Plots #735, 320 (control) & 321 (caged)



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

Plot 303 Uncaged- 2015

2016

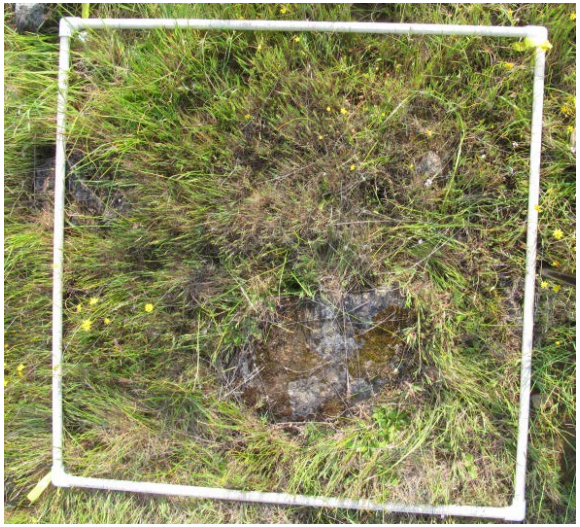
2017

Plot 304 Caged- 2015

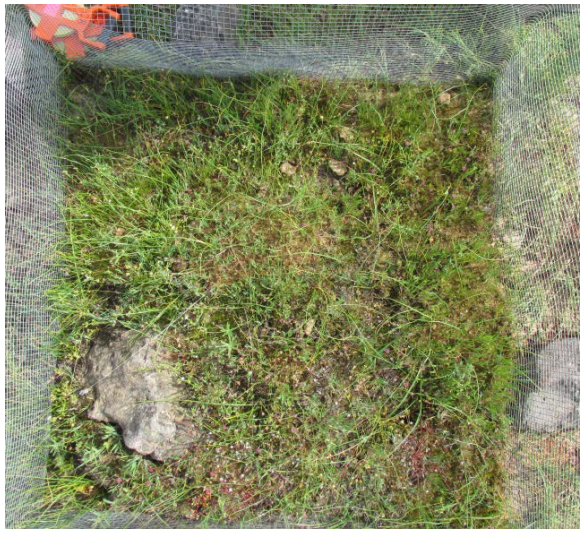
2016

2017

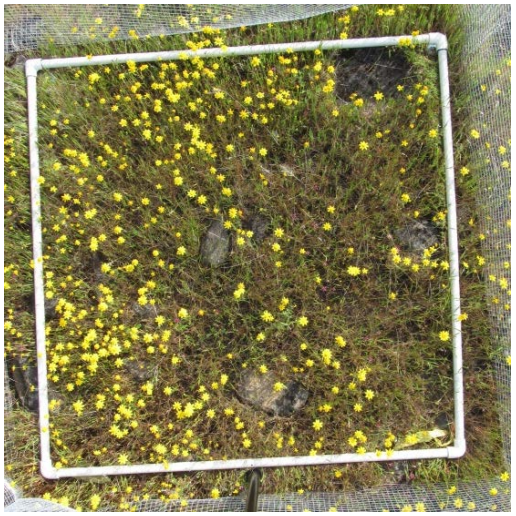
Plot 307- Uncaged 2015 2016 2017



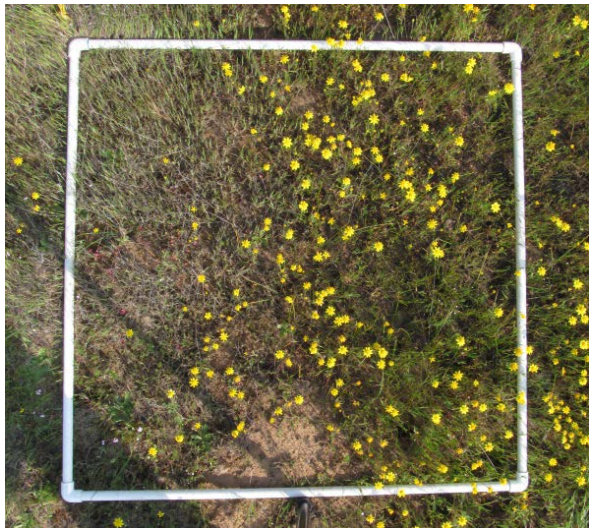
Plot 308- Caged 2015 2016 2017


Plot 309- Caged 2015 2016 2017



Plot 310- Uncaged 2015 2016 2017



Plot 311- Uncaged 2015 2016 2017

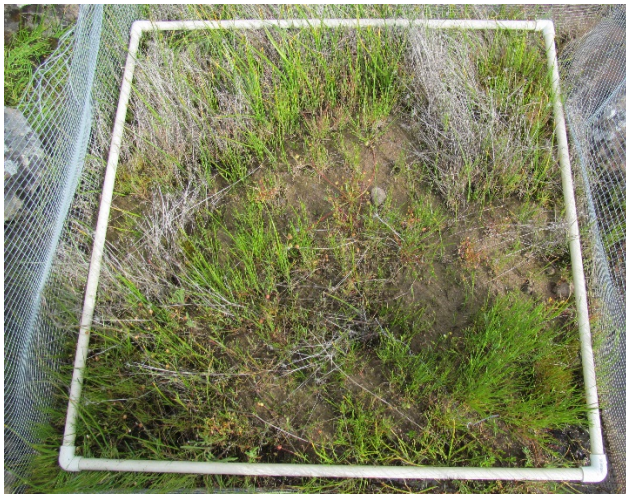
Plot 312- Caged 2015 2016 2017

Plot 313- Uncaged 2015 2016 2017



Plot 314- Caged 2015 2016 2017



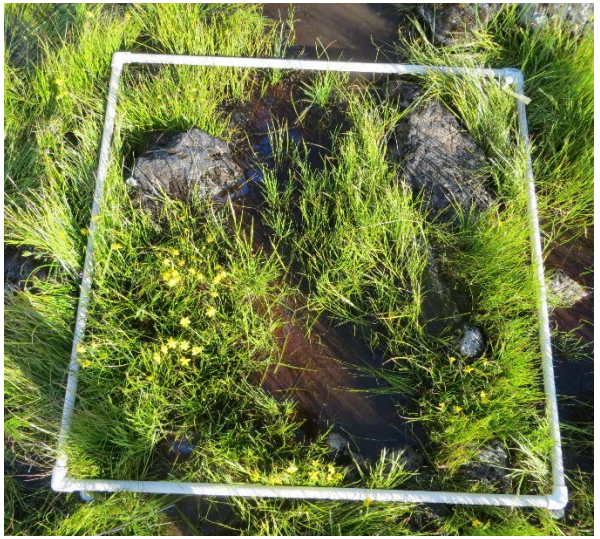


Plot 315- Uncaged 2015 2016 2017



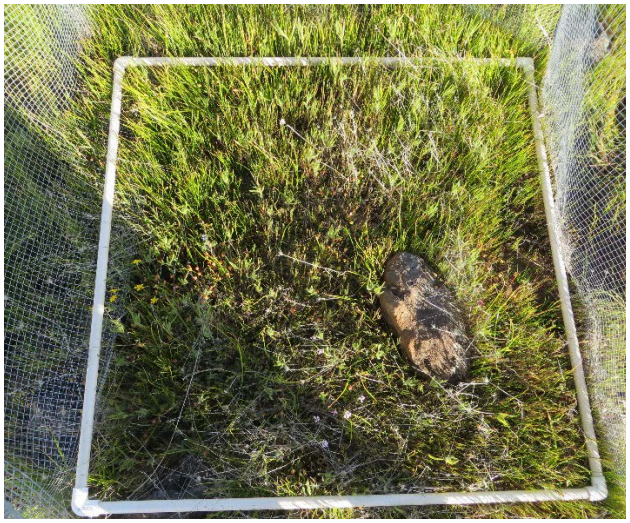
Plot 316- Uncaged 2015 2016 2017



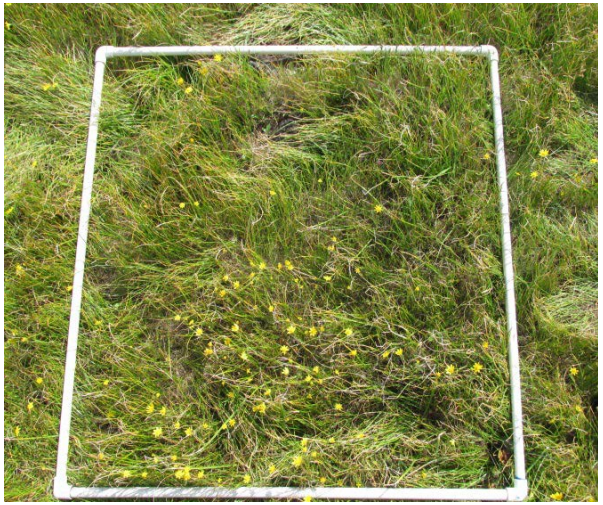


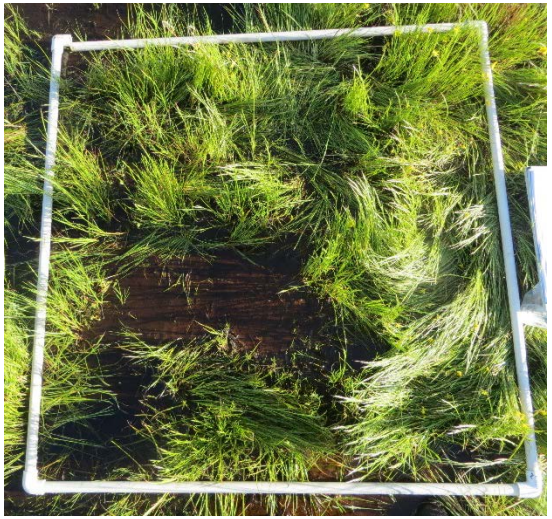
Plot 317- Caged 2015 2016 2017





Plot 318- Uncaged 2015 2016 2017





Plot 319- Caged 2015 2016 2017



Plot 320- Uncaged 2014 2015 2016 [*could not locate in 2017*]

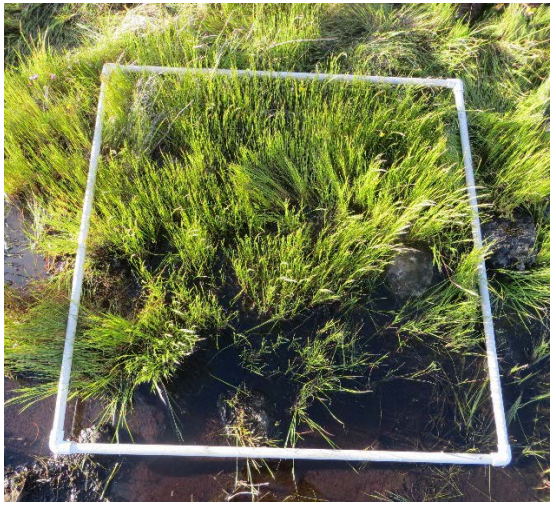


Plot 321- Caged 2015 2016 2017



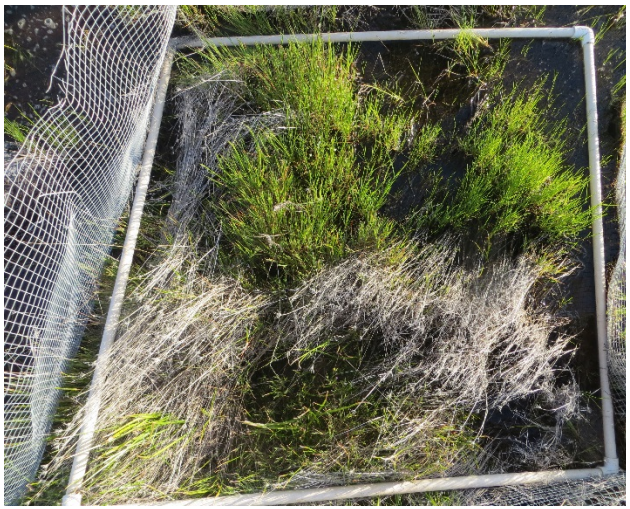
Plot 322- Uncaged 2015 2016 2017





Plot 323- Caged 2015 2016 2017





Plot 744- Caged 2015 2016 2017