Lupinus oreganus in the BLM Roseburg District: Population monitoring and restoration

2016

Report to the Bureau of Land Management, Roseburg District

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PREFACE

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

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Cover photograph: Kincaid's *L. oreganus* (*Lupinus oreganus*) and large subpopulation at Callahan Meadows.

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EXECUTIVE SUMMARY

This document reports preliminary findings and summarizes methods used in monitoring the threatened species *Lupinus oreganus* in the BLM Roseburg District. In 2016, we monitored *L. oreganus* populations by assessing foliar (leaf) cover (a measure of abundance), raceme count, and fruit production at six different sites in the Roseburg District.

Seed set and raceme count was up from 2015 values at all sites monitored in the Roseburg BLM District. This is most likely due to a reduction in extremely hot days experienced in the Pacific Northwest in 2016 compared to 2015. Foliar cover remained relatively stable at most sites compared to 2015 values.

In 2012-2016, meadow knapweed (*Centaurea pratensis)* was found along the roadside at China Ditch near the end of the Patch C roadside transect. Flowering individuals were removed by IAE staff in 2014 and 2015, where feasible; however, it is recommended that the area continue to be monitored for the noxious weed which could quickly invade the surrounding *L. oreganus* population.

Callahan Meadows

Over the course of this study, the foliar cover of *L. oreganus* at the site has remained stable in the main portion of the population. However, the handful of plants representing subpopulation 2 has decreased over time- and is in peril of being crowded out by invasive perennial grasses. Raceme counts rebounded from the 2015 low to 321 in 2016, however due to the polyploid nature of this population, reproductive effort does not lend towards the longevity of this population, as no viable fruits are produced.

China Ditch

This site responded positively to thinning treatments that occurred in the fall of 2009, with increases in foliar cover and seed set, however in 2015, there was a dramatic decrease in cover, seed set and raceme count. In 2016, foliar cover continued to decrease. Brush clearing treatments are recommended to maintain suitable habitat for *L. oreganus*. The population of *L.* oreganus at China Ditch is the largest population on protected land in Douglas County.

Dickerson Heights

Although a relatively small patch (~20 x 30 m), the *L. oreganus* at Dickerson Heights occupies nearly all suitable habitat in a tongue of land at a junction of two logging roads. *L. oreganus* responded positively to thinning treatments in 2009 with increased seed set and raceme count (and seedlings were often noted in the first years post treatment). In 2012, the foliar cover of the population has apparently stabilized, however raceme count and seed set have shown generally declining trends. As at other sites, raceme counts at Dickerson Heights were alarmingly low in 2015. In 2016, *L. oreganus* cover decreased by 19% from 2015 values.

Letitia Creek

At Letitia Creek, both foliar cover and raceme count have plummeted since monitoring began in 2003. Since 2006, cover has steadily declined from more than 28 m^2 of foliar cover to only 2.8 m^2 in 2014 and reached an all-time low in 2011 at 1.2 m^2. Raceme count has fluctuated drastically since monitoring began starting at the record high of 199: No racemes were counted in 2014 or 2015. In 2016, foliar cover dropped slightly below 2% and only three racemes were observed.

Loose Laces

Over the course of this study, three of the four subpopulations (1, 2 and 4) have shown general trends towards increasing foliar cover (particularly following clearing treatments in the fall of 2009. Subpopulation 3, which is found along the active roadside (as compared to above the cut-bank or on an old ski-road), has experienced decreases in cover as well as reproductive effort over the course of this study. In 2016, cover remained stable at subpopulations 2, 3 and 4, however, subpopulation 1 decreased in cover by 38% from 2015 values.

Fruiting effort has also generally improved since the beginning of the study starting with 3.6 fruits per raceme in 2004 to 6.8 fruits per raceme recorded in 2014. Seed set in 2015 was lower at 4.9 fruits per raceme, the highest for any site in 2015. In 2016, subpopulations 2, 3 and 4 increased the number of racemes produced compared to 2015 values, but subpopulation 1 decreased in raceme production from 2015. When evaluating fruits per raceme for all populations at Loose Laces, the 2016 average was the highest recorded at 8.13 fruits per raceme.

Stout's Creek

In 2016, *L. oreganus* cover (7.08%) and number of racemes (87) was relatively low compared to previous years. This is most likely a direct result from the 2015 Stouts Creek Fire. Although raceme count was low in 2016, the number of fruits per raceme increased to 8.5, the highest recorded number thus far in the study.

Lupinus oreganus on the BLM Roseburg District: Population monitoring and restoration

REPORT TO THE BUREAU OF LAND MANAGEMENT, ROSEBURG DISTRICT

INTRODUCTION

This report documents work conducted on *Lupinus oreganus (*nee *sulphureus* ssp. *kincaidii*, Kincaid's *L. oreganus*; Figure 1), in the Roseburg District of Bureau of Land Management.

Species Status

L. oreganus, a member of the legume family (Fabaceae), is listed by the Oregon Department of Agriculture and the U.S. Fish and Wildlife Service as a threatened species. This species serves as an obligate host plant for larvae of Fender's blue butterfly (*Icaricia icarioides fenderi*), which is listed as an endangered species.

Background Information

L. oreganus is found in native prairie remnants in the Willamette Valley, southwestern Washington, and forest openings in Douglas County, Oregon. Only 161 sites are known to support this species and 94 of these cover less than one acre (USFWS 2010). The majority of the sites are on privately held land, which is exempt from protection(s) provided by state and federal listing, increasing the importance of management by state and federal agencies on public land. Only a limited number of remnant populations of *L. oreganus* exist in Douglas County. Of the extant populations in Douglas County, eight are located on BLM land, four are found on private land and one population is managed by the US Forest Service. The 2006 Management and Recovery Plan proposes a goal of 5,000 m^2 of occupied habitat consisting of at least two meta-populations in Douglas County. Work by IAE in 2016/2017 will include augmentation efforts using plant materials collected from the BLM populations. A separate report regarding these efforts is forthcoming.

Figure 1. Kincaid's *lupine* (*Lupinus oreganus*).

Within the Willamette Valley, *L. oreganus* is a larval host plant for the endangered Fender's blue butterfly, making conservation of the *L. oreganus* important for the *L. oreganus* itself as well as the insect (Schultz et al. 2003). There are no known sightings of Fender's blue in Douglas County and it is not known whether the two species co-occurred historically in that area.

Reproduction and Population Biology

L. oreganus is an herbaceous, perennial that reproduces by seed. Plants form clumps of basal leaves and eventually produce one or more flowering stems. This species also spreads vegetatively, though it is unknown to what extent vegetative growth might result in the formation of physiologically distinct clones. *L. oreganus* requires insects for successful fertilization and seed formation (Kaye, 1999).

Objectives

- Summarize population monitoring and available trend data for *L. oreganus* at Loose Laces, Letitia Creek, Callahan Meadows, China Ditch, Dickerson Heights, and Stout's Creek sites (ongoing).
- Identify potential threats to populations including the presence of weedy species, shrub encroachment and anthropogenic factors (ongoing).
- Assess reproductive vigor at Callahan Meadows, Loose Laces, China Ditch, Dickerson Heights and Stout's Creek, report data, and compare it to past data when possible (ongoing).
- Study the effects of pollen transfer on seed production at Callahan Meadows (2008-2009).
- Survey for the presence of Fender's blue butterfly (intensive surveys 2007-2009).

METHODS

Study Areas

Monitoring of *L. oreganus* occurred at six locations in the South River Resource Area of the Bureau of Land Management Roseburg District, which encompasses all *L. oreganus* on BLM land in Douglas County: Loose Laces, Letitia Creek, Callahan Meadows (near Tiller), China Ditch (near the China Ditch Historic Site northeast of Myrtle Creek), Dickerson Heights (southwest of Winston), and Stout's Creek (south of Milo). There are two other known sites with *L. oreganus* in Douglas County, the first is near Callahan Meadows and is managed by the US Forest Service, and the second is a continuation of the population at Letitia Creek that extends onto private land.

Figure 2. Monitoring *L. oreganus* at Dickerson Heights.

For complete site descriptions see Appendix 3.

Monitoring Plots

At four sites, Loose Laces, Letitia Creek, Callahan Meadows and Dickerson Heights, we performed a census of all foliar cover and racemes in each population. At two sites, China Ditch and Stout's Creek, the populations were sub-sampled. At China Ditch, representative transects were established in the three major subpopulations labeled A, C and D. Since each site, population or subpopulation varies in shape, size and density, different plot layouts were used for each population.

Monitoring plots in units or transect segments were used for detection of future changes in population density.

Racemes were counted as either mature or aborted. The mature inflorescence count included racemes in early stages of development not showing signs of abortion at the time of monitoring. It should be noted these early-stage racemes had the potential to abort.

Since 2007, cover has been the only measure of abundance of *L. oreganus* at these sites, as is standard throughout the species' range (USFWS 2010). Cover of *L. oreganus* was initially determined by counting the number of leaves, in part because leaves are the portion of the plant utilized by *I. icaroides fenderi*. In 2005 and 2006, we monitored both the number of leaves and measured cover of the plants in order to determine the relationship between these variables. Foliar cover was determined by measuring the length and width of each patch and using these values to determine the rectangular area.

Loose Laces

FOUR SUBPOPULATIONS, MONITORING ESTABLISHED IN 2003, CENSUS OF POPULATION

Subpopulation 1: At this most northern subpopulation, one 110 m transect was established along a curving old skid road (Figure 3). Each end of the transect was marked with a metal fencepost, and each 20 m segment of the transect was marked with a piece of metal rebar pounded into the ground. Each marker was labeled with a numbered metal tag. We recorded the bearing (in degrees) of each segment marker to the next marker and positioned the start-point of the transect via GPS. We monitored *L. oreganus* cover and racemes on the west and east side of the transect in 5 m long segments.

Subpopulation 2: At this site, one 15 m transect was established along an old skid road (Figure 4). We marked the start of the transect with a metal fencepost and the end of the transect with a piece of metal rebar. These markers were labeled with metal tags and we recorded the bearing from the start to the end of the transect. The transect start-point was positioned via GPS. We monitored *L. oreganus* cover and racemes on the north and south sides of the transect in 1 m long segments.

Subpopulation 3 (Main road population): At this site, we established one 150 m transect along BLM road 31-6-10 (Figure 4). Each transect end was marked with a tagged metal fencepost. An additional tagged metal fencepost was placed after the first 100 m of the transect. We monitored *L. oreganus* cover and racemes on the west and east sides of the transect in 5 m segments.

Subpopulation 4 (Above road cut bank on east side of road): At this site in 2003, we established two parallel 15 m reference transects, set apart by 4 m (Figure 5). The ends of each transect were marked with tagged metal fence posts. The first transect (tag 515 and 514) was positioned closest to the road, and the second transect (tag 517 and 516) was positioned 4 m uphill. All *L. oreganus* leaves were sampled in a grid of 12, 2 m x 5 m plots positioned along the transects (see sketch map, Figure 6). All plants were monitored in 5 m segments above and below both transects.

Letitia Creek

TWO SUBPOPULATIONS, MONITORING ESTABLISHED IN 2003, CENSUS OF POPULATION ON BLM PROPERTY

Public-Private border subpopulation: At this site in 2003, we established one, 10 m transect marked by tagged metal rebar. This transect runs approximately along the border between BLM and private land, with BLM to the north and private to the south (Figure 6). We counted all *L. oreganus* leaves and racemes along the transect on public land.

Main subpopulation: At this site we counted all *L. oreganus* leaves and racemes in each "plot" as laid out for *Eucephalus vialis*, including additional "road" plots #0-10 between *E. vialis* plots (Figure 7, Appendix 2).

Callahan Meadows

TWO SUBPOPULATIONS, MONITORING ESTABLISHED IN 2003 AND 2004, CENSUS OF POPULATION

Subpopulation 1 (Large, southern subpopulation): At this site in 2003, we established a 12 m x 12 m plot surrounding the entire subpopulation with corners marked by tagged pieces of rebar (Figure 8). The plot is divided into a grid of 2 m x 2 m cells, and all *L. oreganus* leaves and racemes were counted in each cell. Cells were numbered according to an x-y coordinate system with the origin in the lower left (southwest) corner.

Subpopulation 2 (Small, northern subpopulation): In 2004, we established a new transect through the smaller, more northern subpopulation at Callahan Meadows (Figure 9). The new transect is 6 m long and marked with conduit posts at both ends. We surveyed for leaves and racemes in a 2 m wide belt on both sides of the meter tape. Leaves and racemes were counted in 2 m segments along the west and east sides of the transect.

China Ditch

THREE SUBPOPULATIONS LABELED AS A, C AND D ESTABLISHED IN 2004; 5 ADDITIONAL TRANSECTS ESTABLISHED IN 2010. THIS IS A SUBSAMPLE OF THE POPULATION

This site was first located in 2003. We established easily accessible monitoring transects along the roadside in each of the three subpopulations in 2004. To monitor a more representative area of the population, not along the roadside, we also established a short transect above the road in subpopulation 2. Extensive thinning in 2009 revealed the full extent of the population and greatly improved access to the non-roadside patches. In 2010, we established five additional transects in non-roadside patches (Figure 10). These representative transects are intended to capture the variability in *L. oreganus* cover at the site. Unlike the monitoring transects at other sites, these transects do not encompass the entire population at China Ditch and should not be interpreted as a census.

Patch A Roadside (previously "Subpopulation 2"): In this subpopulation, we established a 42 m long transect on the east side of the road, adjacent to the cut bank (Figure 11). The ends of the transect are marked with tagged pieces of rebar and there is one additional piece at 26 m. Only leaves and racemes on the east side of the road were sampled. All plants were sampled that were within a 3 m

wide "belt" parallel to the tape; plants extending 3 m up the cut bank (with the tape stretched tight) were included in the data for the transect above and sampled for leaves and racemes.

Patch A Transect 1 (previously "Representative Transect above subpopulation 2"): We established a short transect on the hillside above subpopulation 2 (between ~30-35 m; Figure 12). This transect is 5 m long, and encompasses most of a "patch" of plants in a more natural environment than the roadside. The majority of plants appeared to be on the east side of the meter tape, extending 3.5 m from the transect. In 2010, it was no longer clear what the previously measured boundaries of this patch were, due to extensive thinning. Thus, only the west side of this transect was monitored, extending out to the edge of the cut-bank.

Patch A Transect 2: This transect was established in 2010 after extensive thinning in 2009. This transect is 25 m long at a bearing of 204° (Figure 13). A short and tall conduit mark the beginning (N) and end (S) of the transect, respectively. This transect is on top of small ridge, just south of Patch A Transect 1. All *L. oreganus* within 1.5 m to the east and west of the transect were monitored.

Patch A Transect 3: This transect was established in 2010 after extensive thinning in 2009. This transect is 25 m long at a bearing of 204° (Figure 13). A short and tall conduit mark the beginning (N) and end (S) of the transect, respectively. This transect is on a south-facing slope and all *L. oreganus* within 1.5 m to the east and west of the transect were monitored.

Patch C Roadside (previously "subpopulation 1"): At this site, we established a 75 m long transect along the north side of the road (adjacent to the cut bank; Figure 14). The transect starts and ends with pieces of tagged metal conduit pounded into the ground. Tagged pieces of rebar were used to mark 15 m, 30 m, 60 m, and 75 m points along the transect. *L. oreganus* leaves and racemes were counted in 5 m segments, including only the plants on the north side of the road and excluding the 3-4 clumps of plants on the south side of the road.

Patch C Transect 1: This transect was established in 2010, after extensive thinning in 2009. This transect is 25 m long and is marked by a short and tall conduit at the beginning (E) and end (W) of the transect, respectively (Figure 14). This transect is about midway down a steep slope towards the top of Patch C and is easily accessed from the skid road at the top. All *L. oreganus* within 1.5 m to the north and south of the transect were monitored.

Patch C Transect 2: This transect was established in 2010 after extensive thinning in 2009. Located near Transect 1, this transect is 25 m long and captures more of the steep slope population (Figure 14). The beginning (E) and end (W) of the transect are marked by a short and tall conduit, respectively. All *L. oreganus* within 1.5 m to the north and south of the transect were monitored.

Patch D Roadside (previously "subpopulation 3"): At this site, we established a 70 m long transect on the inside curve/cut bank of the road (Figure 15). The first 40 m of the transect are on the north side of the road, and as the road curves, the remaining 40 m continue along the west side of the road. The transect is marked with six tagged rebar posts (at 0 m, 30 m, 40 m, 45 m, 50 m and 70 m). Leaves and racemes were counted in 5 m segments on the north (or west, for the 40 m-70 m portion of the transect) side of the road. Plants on the hillside above the road cut were not sampled.

Patch D Transect 1: This transect was established in 2010, after extensive thinning in 2009. This transect is 25 m long (Figure 15). Short and tall conduit mark the beginning and end of the transect, respectively. All *L. oreganus* within 1.5 m to the east and west of the transect were monitored. This transect is located above Patch D Roadside, approximately midway through the upslope subpopulation. The transect was placed to capture the variability in slope aspect and *L. oreganus* cover in the subpopulation.

Dickerson Heights

ONE POPULATION, MONITORING ESTABLISHED IN 2005, CENSUS

At this site, a 15 m x 23 m plot contains most of the population at the site (Figure 16). The plot is divided into a grid of 33, 2 m x 5 m and 3, 3 m x 5 m segments. We measured foliar cover and racemes. In 2014, we added 3, 2 m x 5 m segments and a triangle extending 3 m west of A23 continuing down to the southwestern rebar of A2 due to population expansion. We conducted a complete census of the area, including all the *L. oreganus* inside and outside of the grid.

Stout's Creek

TWO SUBPOPULATIONS, MONITORING ESTABLISHED IN 2005, SUBSAMPLE OF POPULATION

Subpopulation 1: Four transects encompass all *L. oreganus* plants in this area (Figure 17). Transect A (14 m long) and B (26 m long) are adjacent to each other and run up the slope, about 6 m apart. Plants within 3 m on either side of each transect were sampled. Transect A was sampled in 1 m segments, and Transect B was sampled in 1 m segments. Transect C is a 20 m long by 11 m wide belt transect, and Transect D is a 12 m long x 7 m wide belt transect.

Subpopulation 2: The end of the transect is visible soon after taking the left fork of the road split. Continue down the road until the end of a curve turning right, and the beginning of the transect will be visible above road 30-3-34 (north of road). We established a transect along the natural curve of the road, with rebar placed at set points to assure the transect could be laid out consistently each year (Figure 18). The transect begins near the public/private property border and totals 130 m (running east for 25 meters then straight north for the remaining 115 m).

Below (south) road 30-3-34, we established three monitoring plots (Figure 19) marked clearly with tall conduit poles. Plot 1 is 10 m x 10 m, divided into 4, 5 m x 5 m segments; Plot 2 is 5 m x 7 m, divided into 7, 1 m x 5 m segments, and Plot 3 is 10 m x 5 m, divided into 10, 1 m x 5 m segments.

Site Maintenance

Between 2009 and 2010, all sites except Callahan Meadows and Letitia Creek were thinned to open up the canopy. In general, slash from thinning was not placed within existing plots and negative impacts to monitoring plots were likely minimized. At sites where the populations are sub-sampled (China Ditch and Stout's Creek), slash was placed outside of the existing *L. oreganus* plots. *Lupinus oreganus* seedlings were commonly seen germinating in areas where slash had been burned and bare ground was exposed during monitoring in 2011 and 2012.

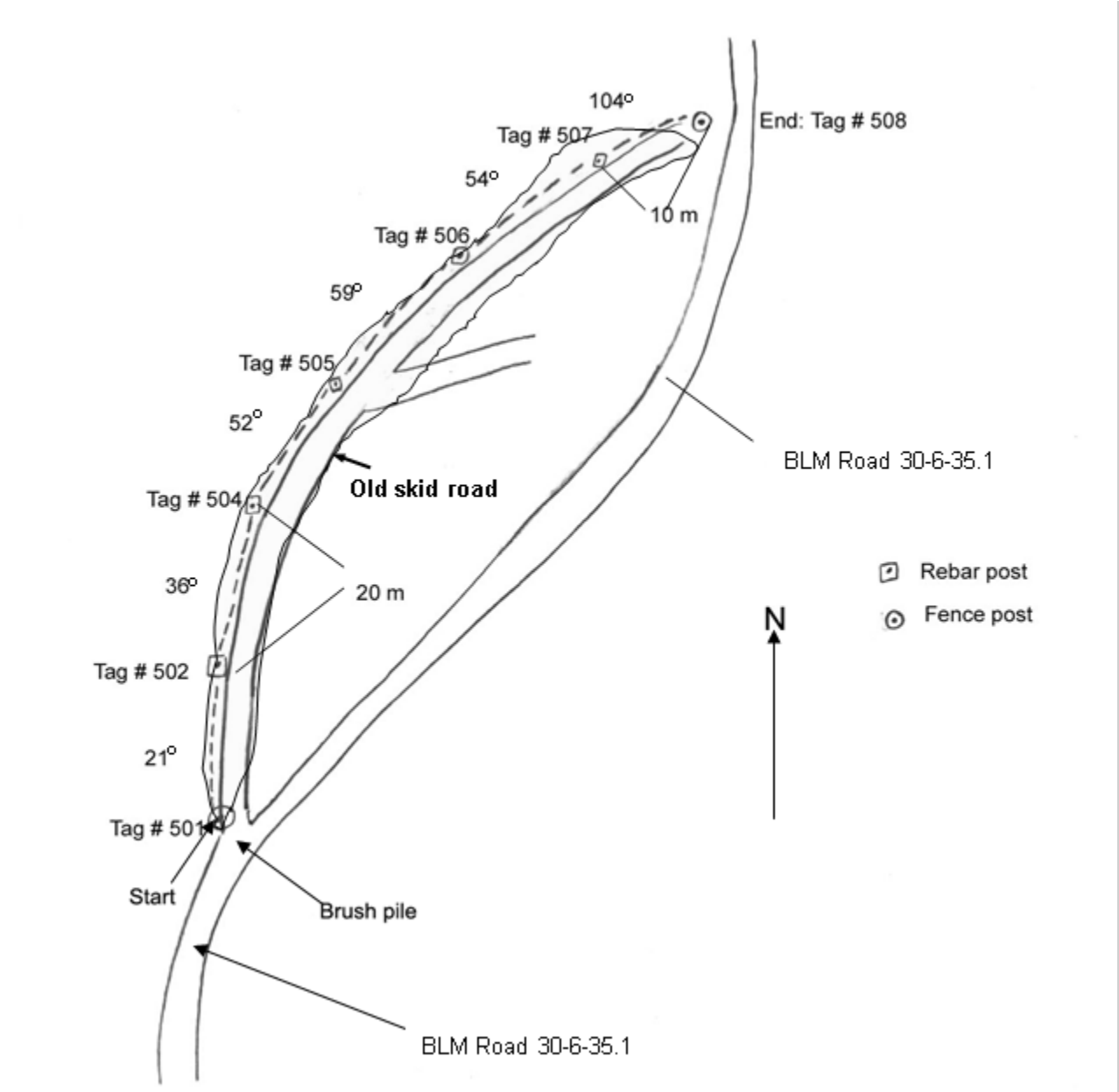

Figure 3. Diagram of Loose Laces *L. oreganus* subpopulation 1. The general outline of the population is shown in the shaded area. Start and end points of the reference transect are marked with tagged fence posts. Each 20 m segment of the transect is marked with tagged rebar posts. The final segment of the transect is 10 m long.

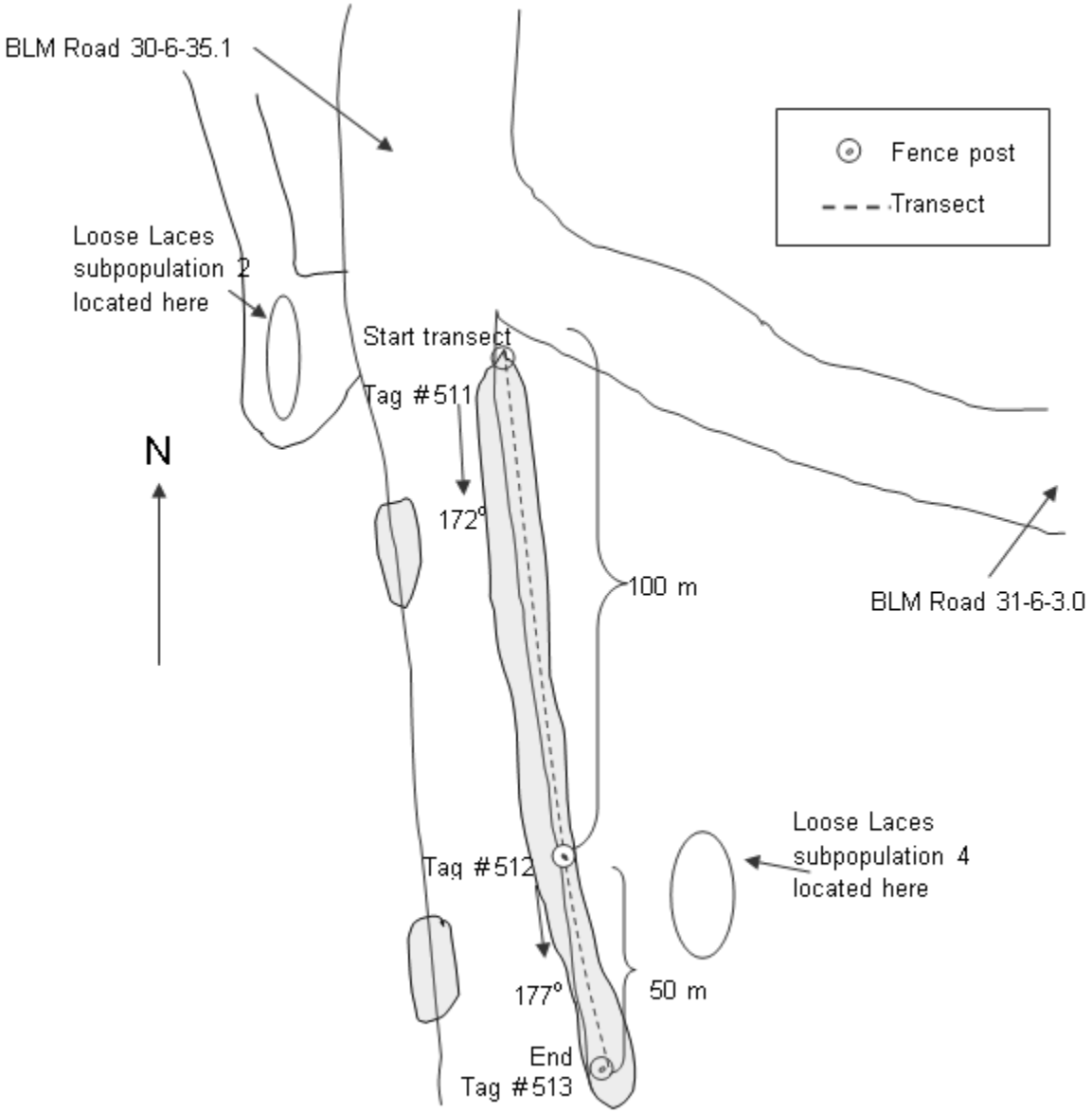

Figure 4. Diagram of loose laces *L. oreganus* subpopulation 3 monitoring transect layout. Approximate subpopulation border is shaded. Total transect length is 150 m. All leaves and racemes were counted on both sides of the transect (including those on the west side of the road). See figure 6 for detail of Loose Laces *L. oreganus* subpopulation 4 monitoring transect layout.

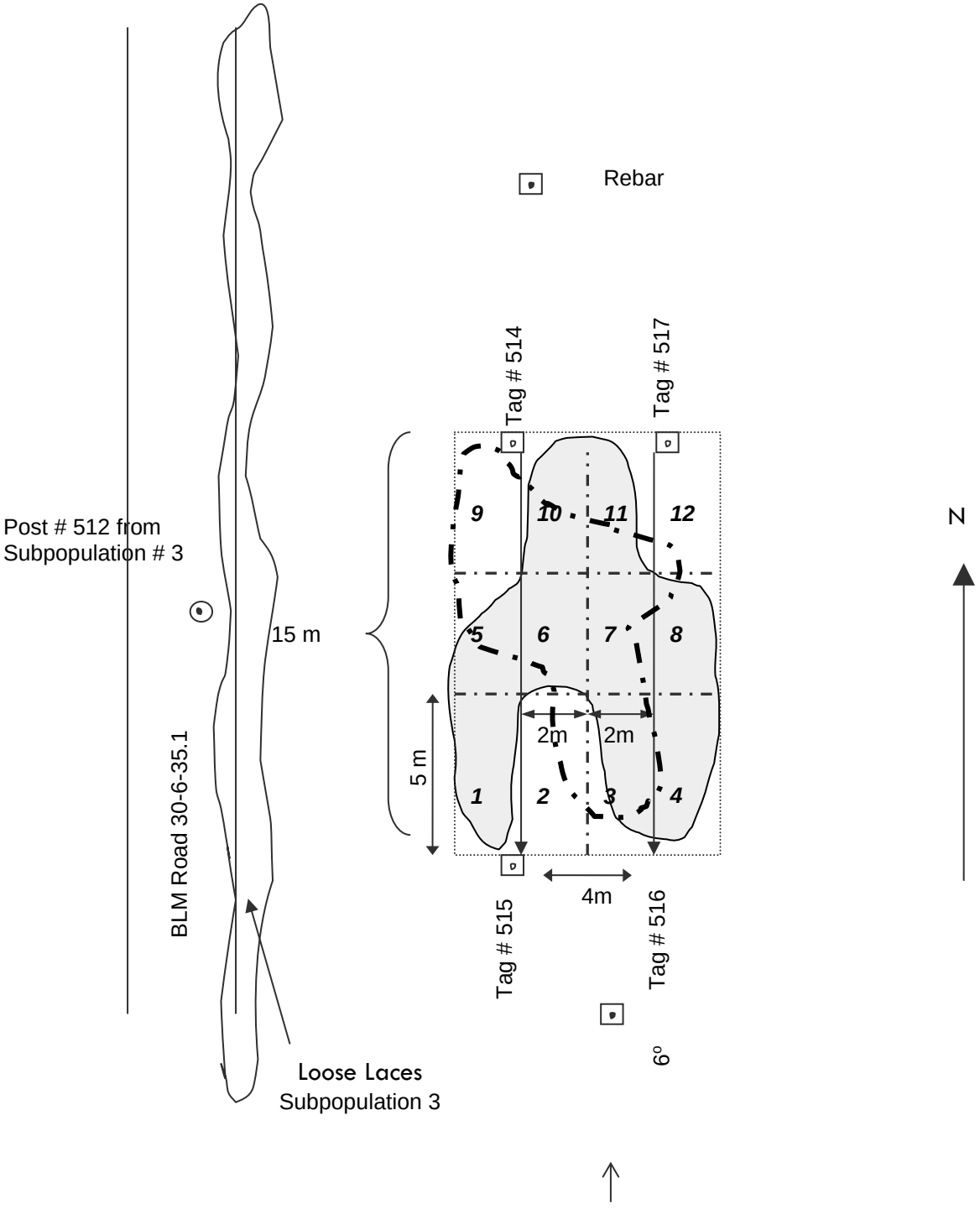

Figure 5. Diagram of loose laces *L. oreganus* subpopulation 4 monitoring transect layout. Previous subpopulation border is shaded and subpopulation border from 2014 is dashed. There are two 15 m reference transects that are 4 m apart. All leaves and racemes were counted on both sides of both transects in 5 m segments, numbered as shown above.

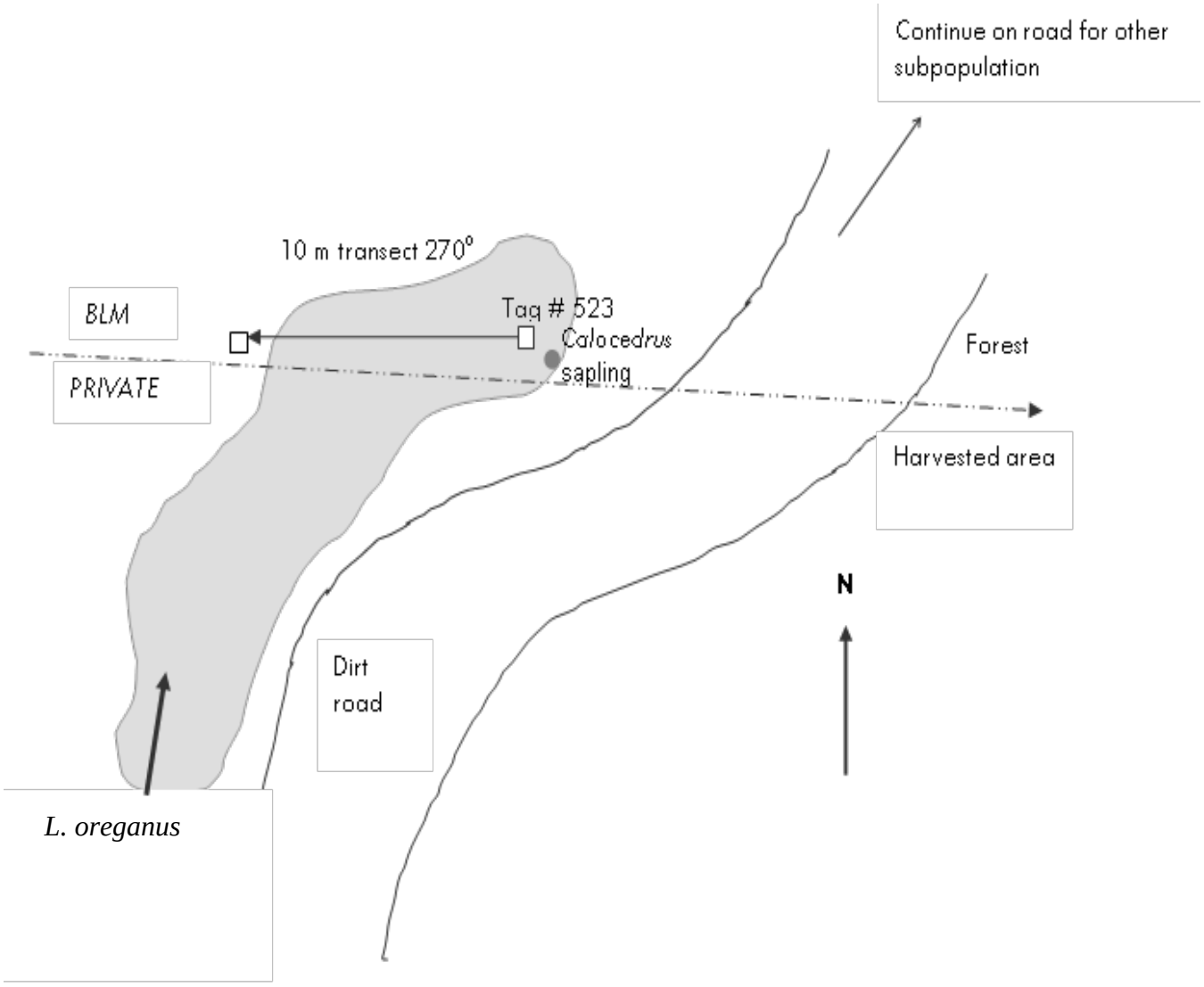

Figure 6. Diagram of the smaller Letitia Creek subpopulation located on the border between public and private land, south of the main, larger subpopulation. We established a 10 m transect heading due west. *Lupinus oreganus* plants are located in two main areas on BLM land: 4 m north and 1 m west of rebar post and at 4 m west of the rebar post by the path. There are many more plants on the adjacent private land.

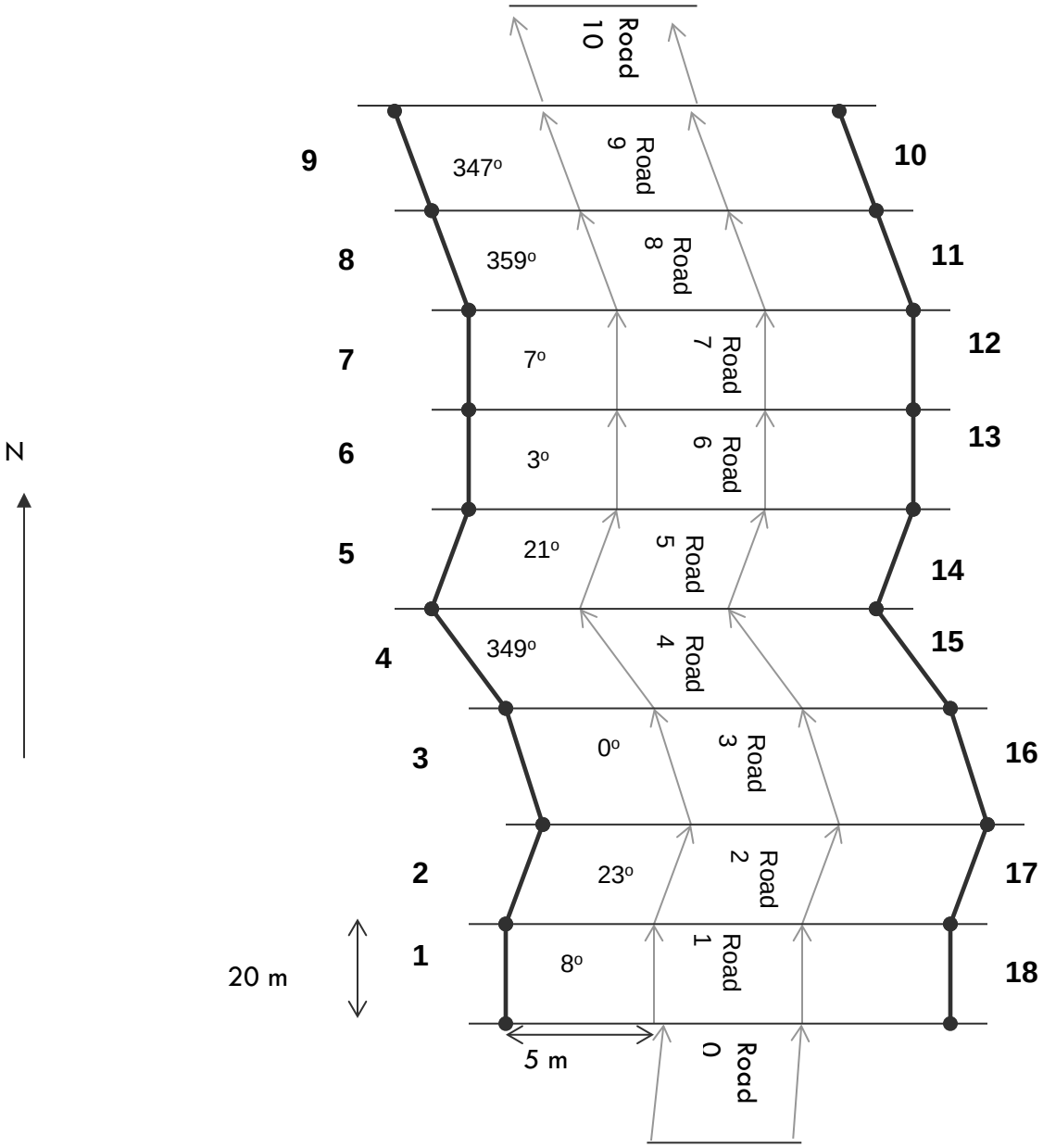

Figure 7. Placement of reference transects and plots along the ridge road at the larger, main Letitia Creek *L. oreganus* population. Plots are 5 m x 20 m in size, with corners marked by various types of posts. Plots #1-9 are read south to north on the west side of the road and plots #10-18 are read north to south on the east side of the road. Each 20 m segment of road between plots was considered a separate plot. These plots were numbered from south to north as road #0-10. Road 0 and 10 plots were added in 2003 and are not part of the *E. vialis* monitoring layout.

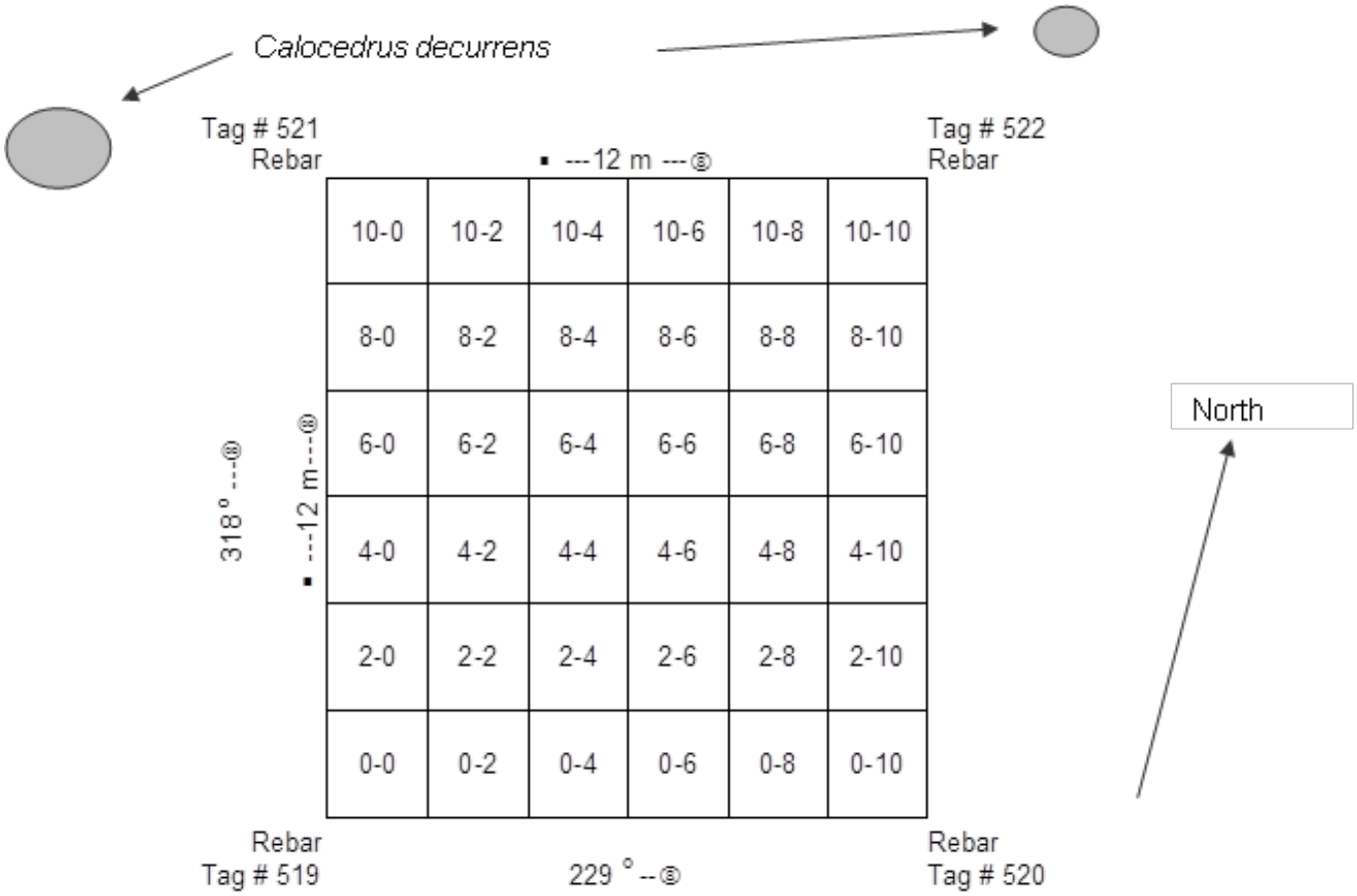

Figure 8. Map of the southern, larger Callahan Meadows *L. oreganus* monitoring plot layout (subpopulation 1). A 12 m x 12 m plot was marked with tagged rebar posts. Within the plot, there are 36, 2 m x 2 m sub-plots, each numbered by an x-y coordinate system. In each sub-plot, foliar cover and racemes were measured.

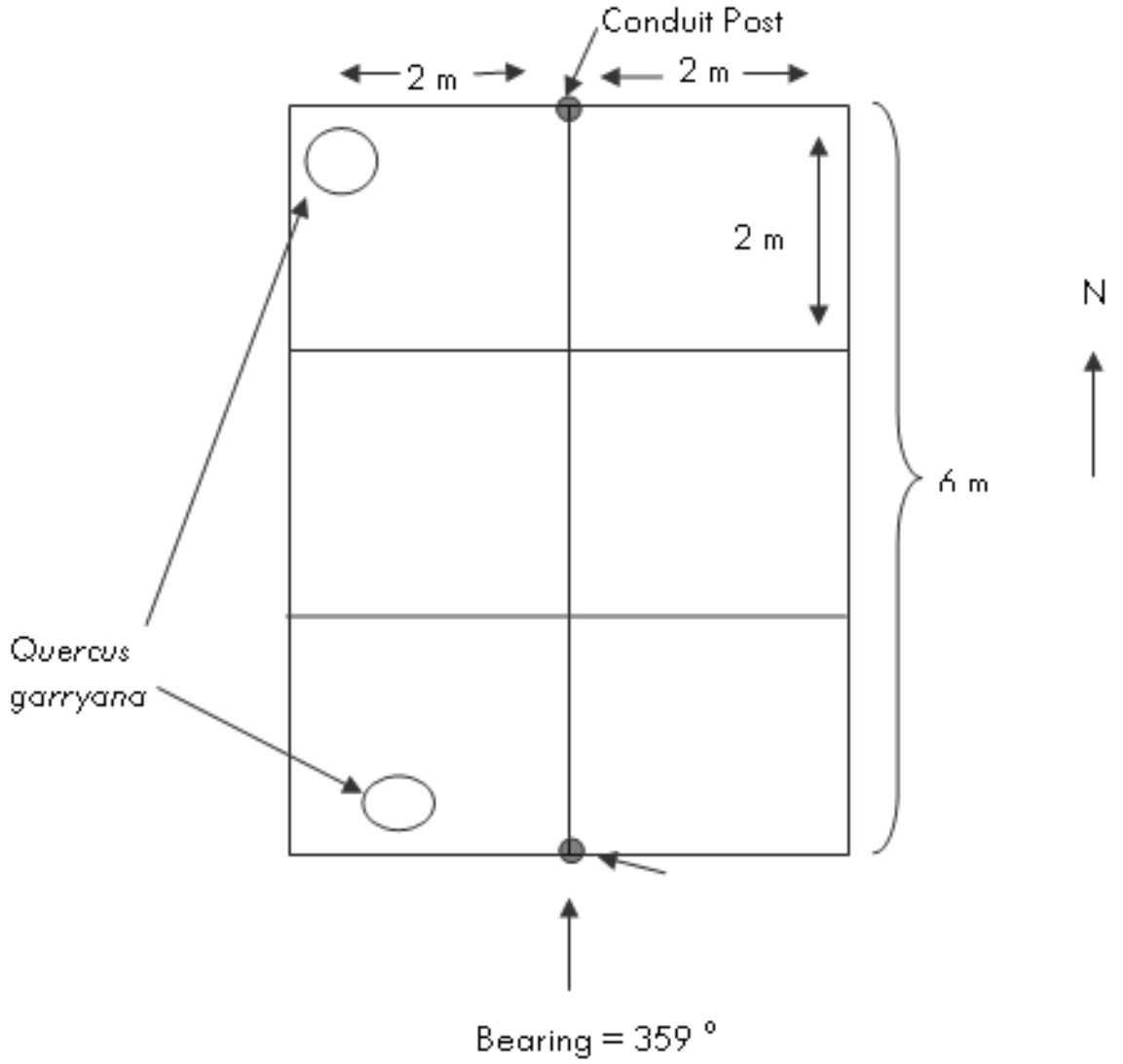

Figure 9. Map of the northern, smaller Callahan Meadows *L. oreganus* monitoring plot layout (subpopulation 2). A 6 m transect was established through the subpopulation with each end marked by conduit posts. Leaves and racemes were counted and cover calculated within 2 m of the transect, forming a 4 m x 6 m monitoring area.

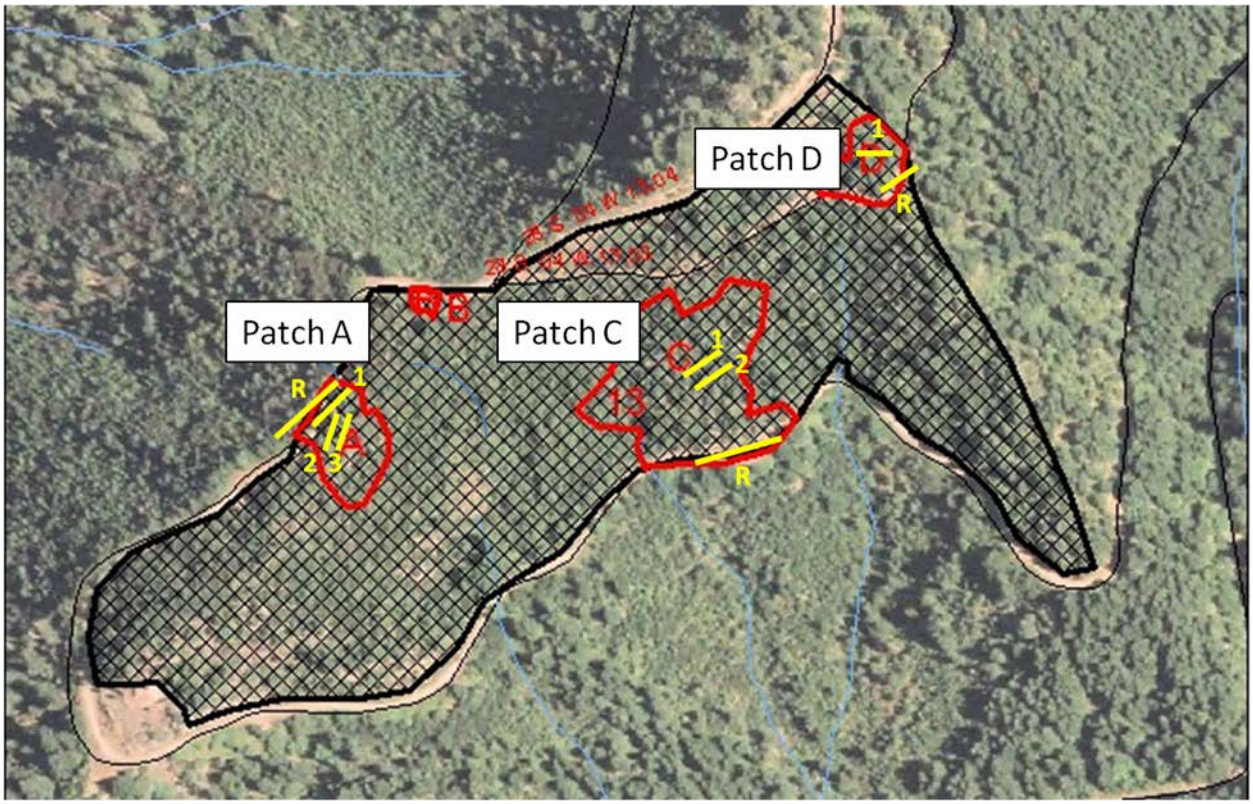

Figure 10. Aerial photo of China Ditch area showing approximate locations of transects for patches A, C and D. R = ROADSIDE, 1 = TRANSECT 1, 2 = TRANSECT 2, 3 = TRANSECT 3.

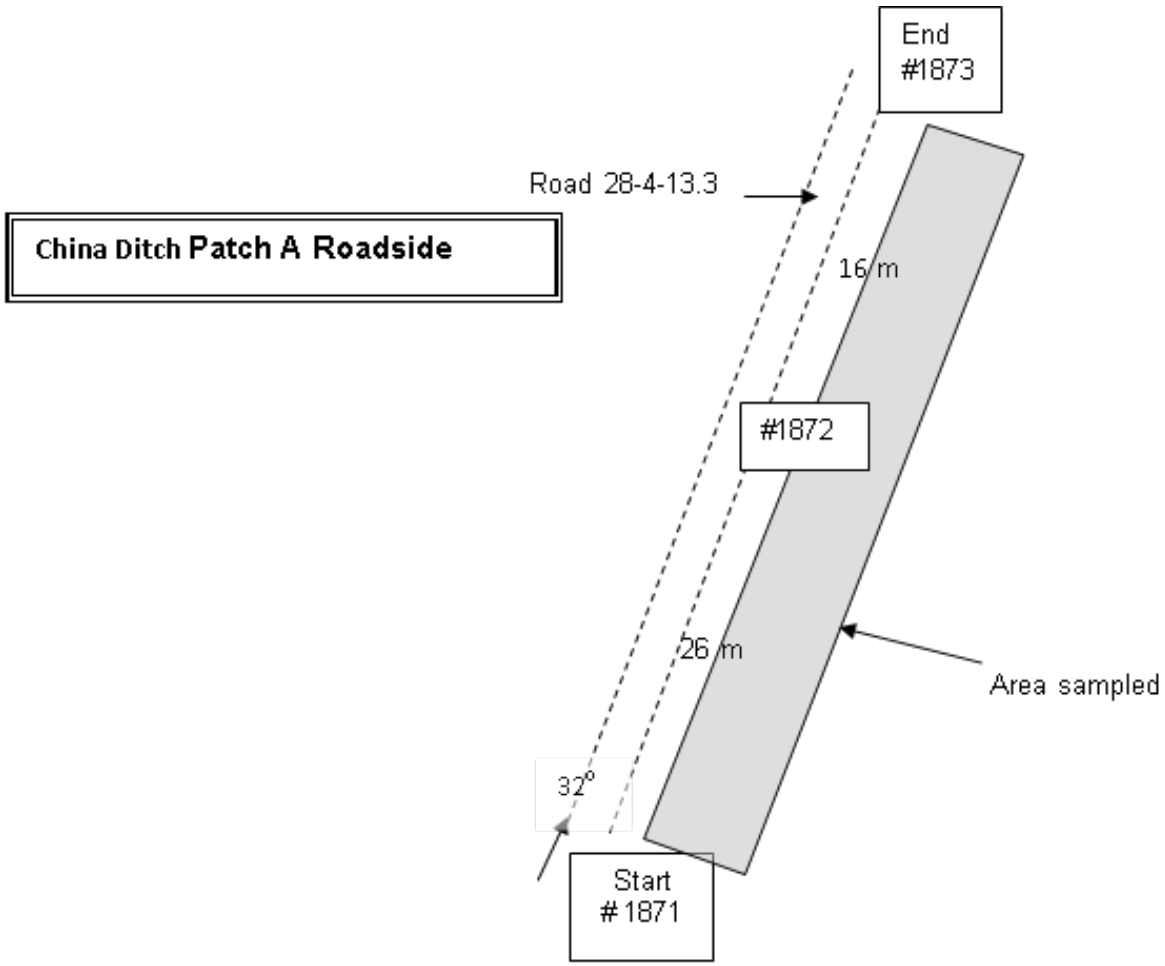

Figure 11. Monitoring transect established in China Ditch Patch A. The transect for Patch A Roadside (subpopulation 2) is 42 m long and is sampled on the east side of the road, to 3 m up the cut bank.

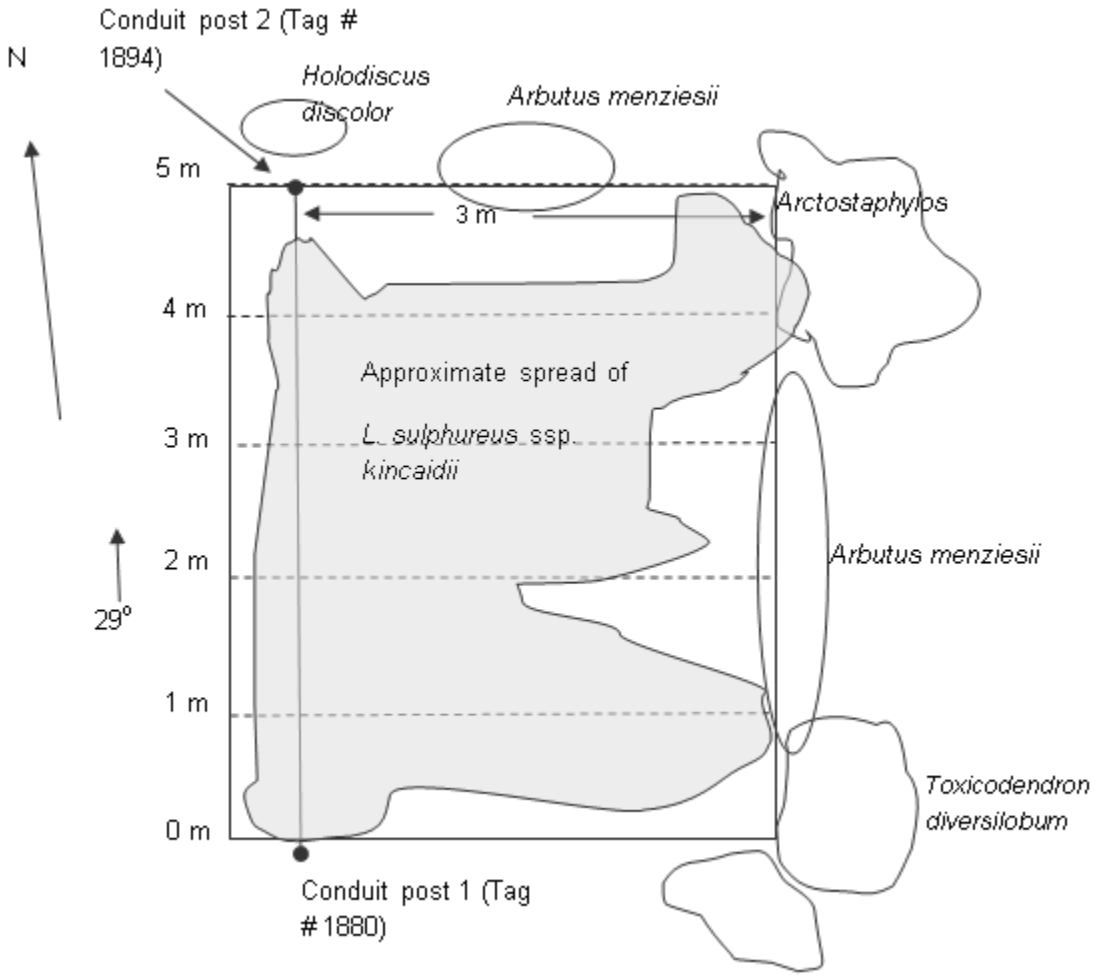

Figure 12. Transect established in "representative area" of China Ditch Patch A Transect 1 (previously representative transect above subpopulation 2). This transect is above the road cut and the roadside transect established in this subpopulation (beginning at about 30 m along the roadside transect). Beginning in 2010, it was no longer clear what the previously measured boundaries of this patch were, due to extensive thinning. Thus, only the west side of this transect was monitored, extending out to the edge of the cut-bank.

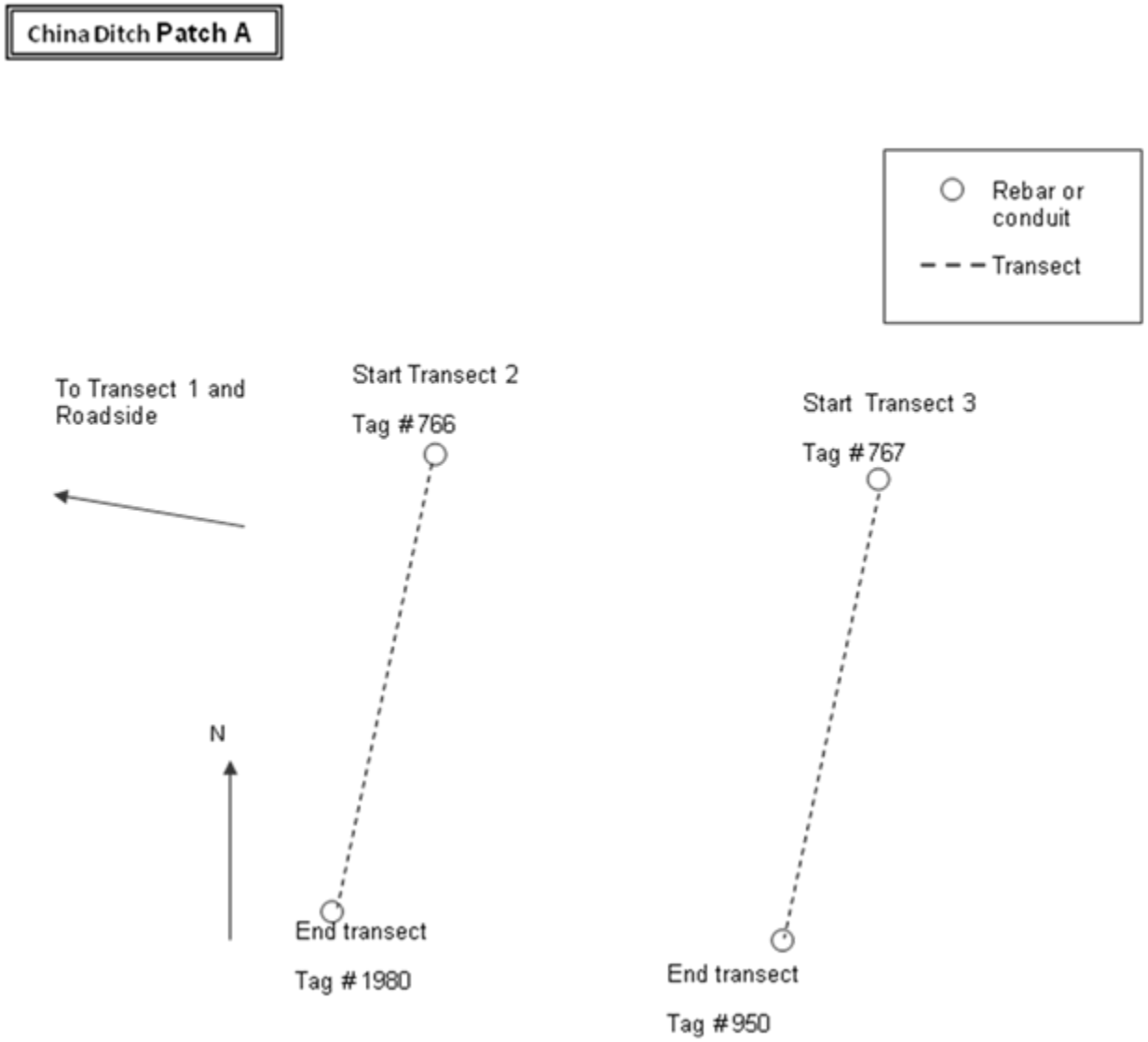

Figure 13. Schematic of Patch A Transects 2 and 3. The transects are located east of transect 1 and patch a roadside, and are measured on both sides of the transect within 1.5 meters of the tape.

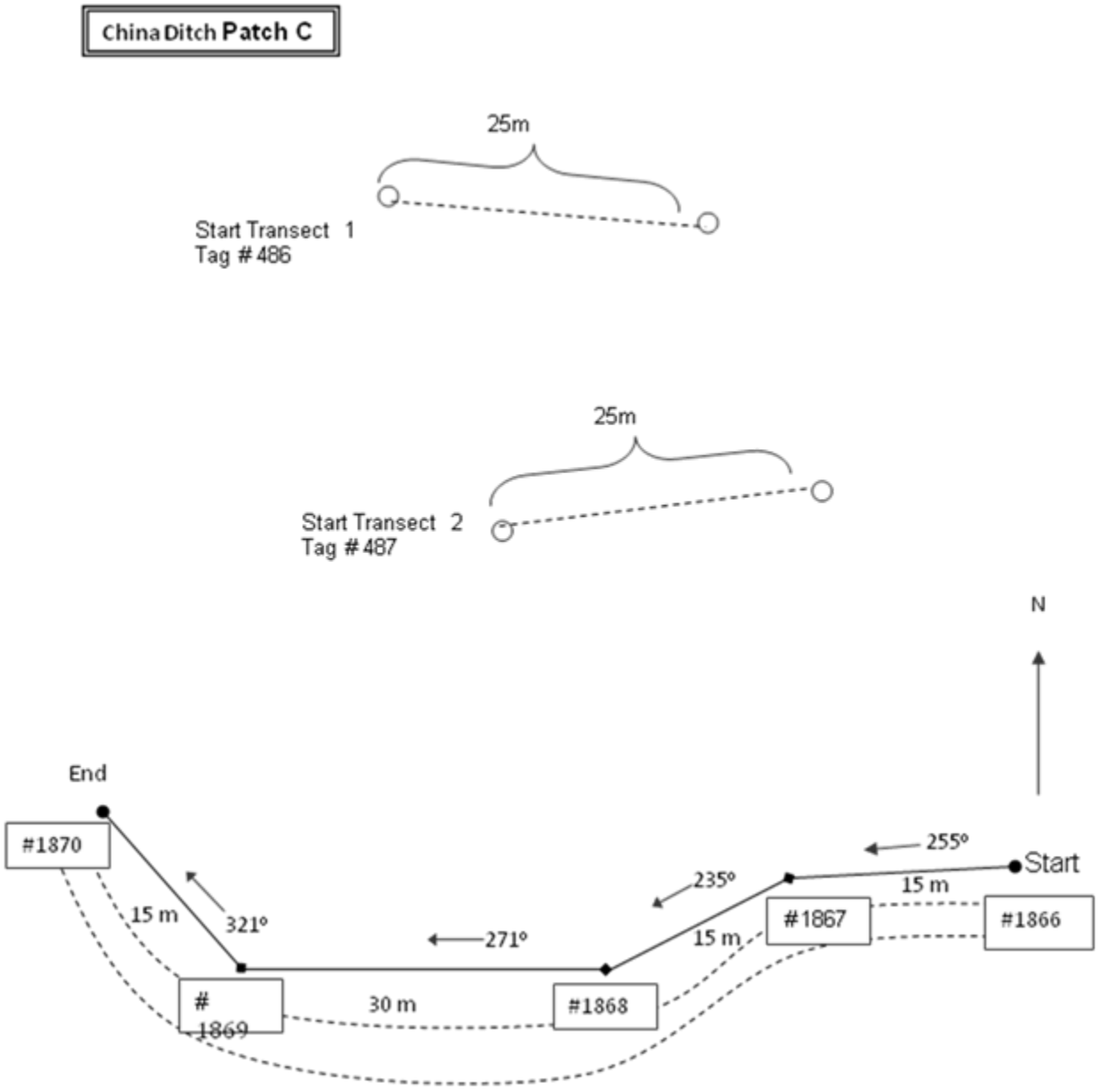

Figure 14. Schematic of monitoring transects in Patch C. The transect in Patch C Roadside (subpopulation 1) is 75 m long and is sampled on the north side of the road. Transects 1 and 2 are 25 m long, *L. oreganus* is measured within 1.5 m on both sides of the tape.

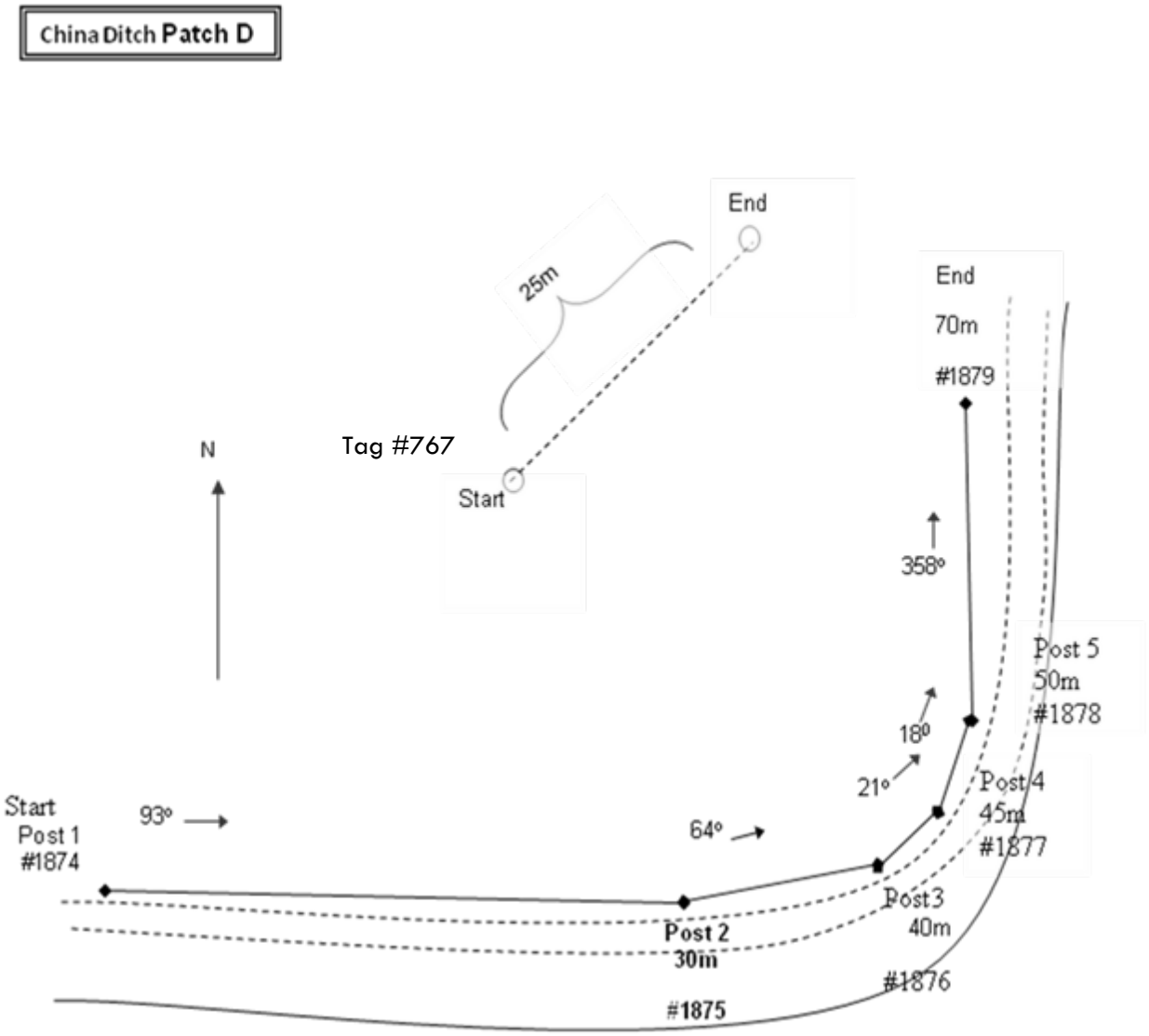

Figure 15. China Ditch Patch D, monitoring transects. 70 meter long transect established in China Ditch Patch D Roadside (previously subpopulation 3) and Patch D Transect 1. Plants were sampled on the inside curve of the road only (the north and west sides). Only plants on the roadside and cut bank were sampled. Plants on the hillside above the cut bank were not sampled. In transect 1, plants were measured within 1.5 meters of the transect.

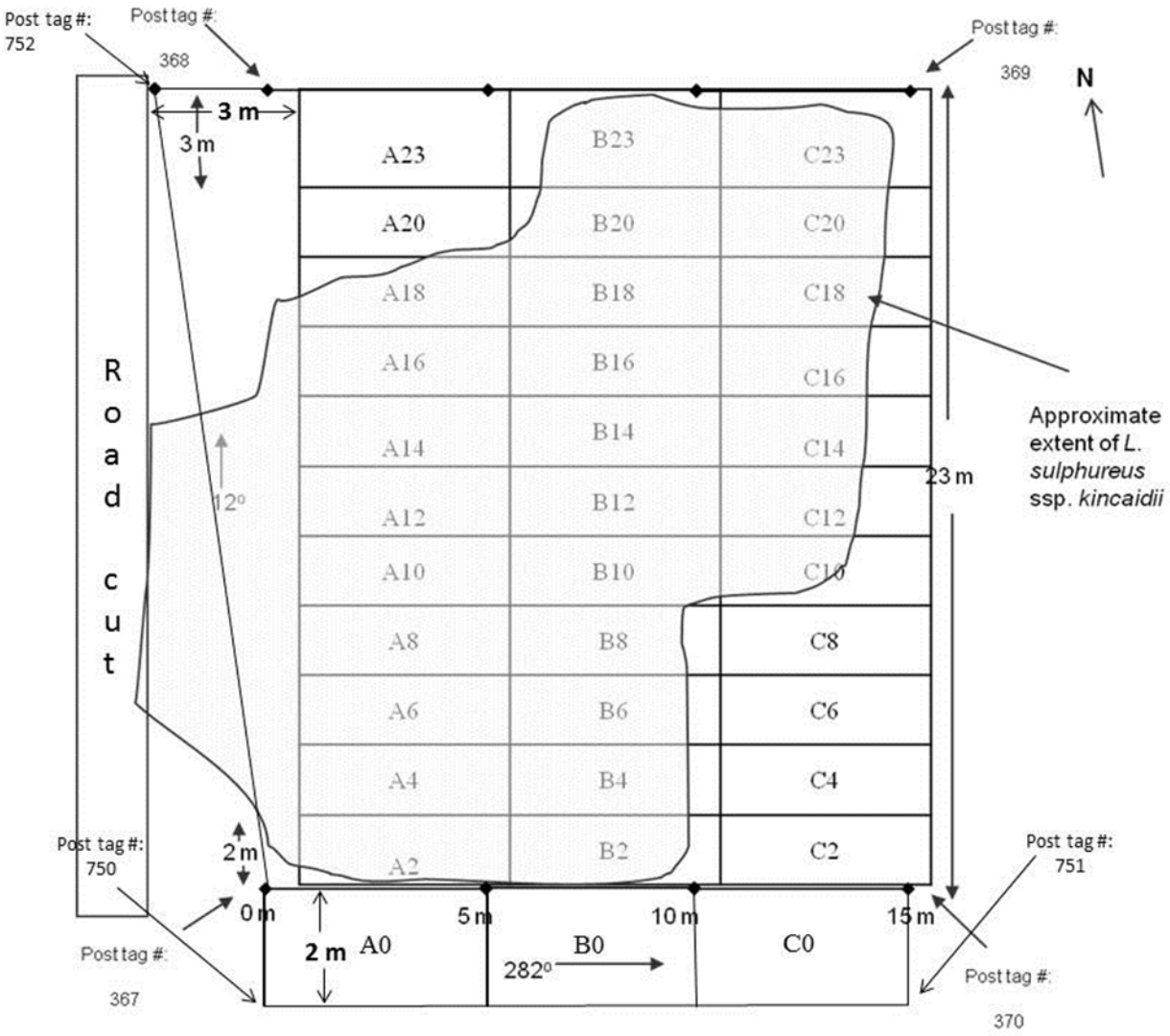

Figure 16. Plot (15 m x 23 m) established in 2005 to census Dickerson Heights population. Leaves and racemes on plants in each 2 m x 5 m cell of the grid were counted. Additional plants occur between west side of plot and road; leaves and racemes on these plants were also counted.

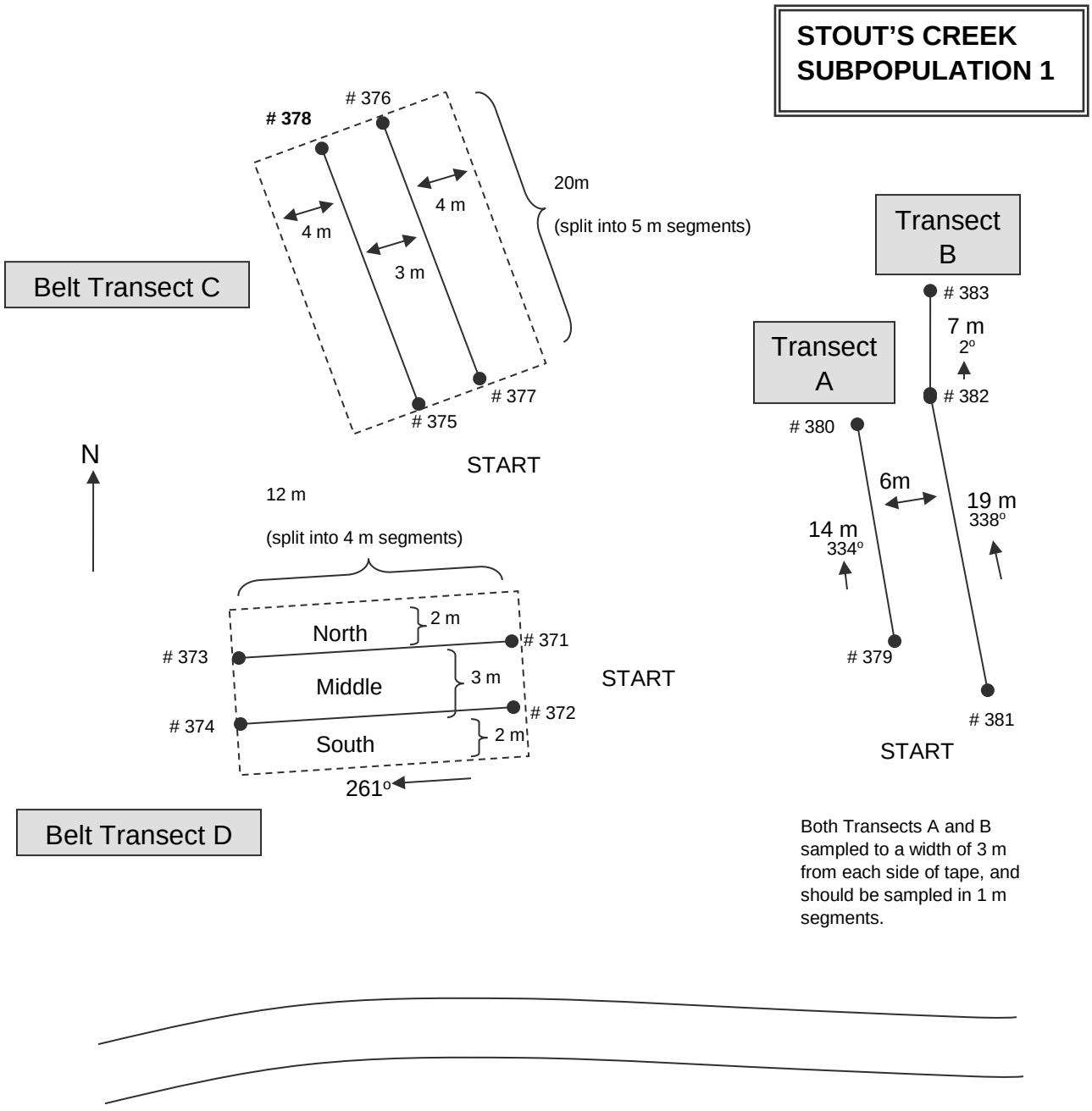

Figure 17. Diagram of the Stout's Creek subpopulation 1 monitoring transect layout.

This area suffered decline, and was impacted by road/fire activity in 2015.

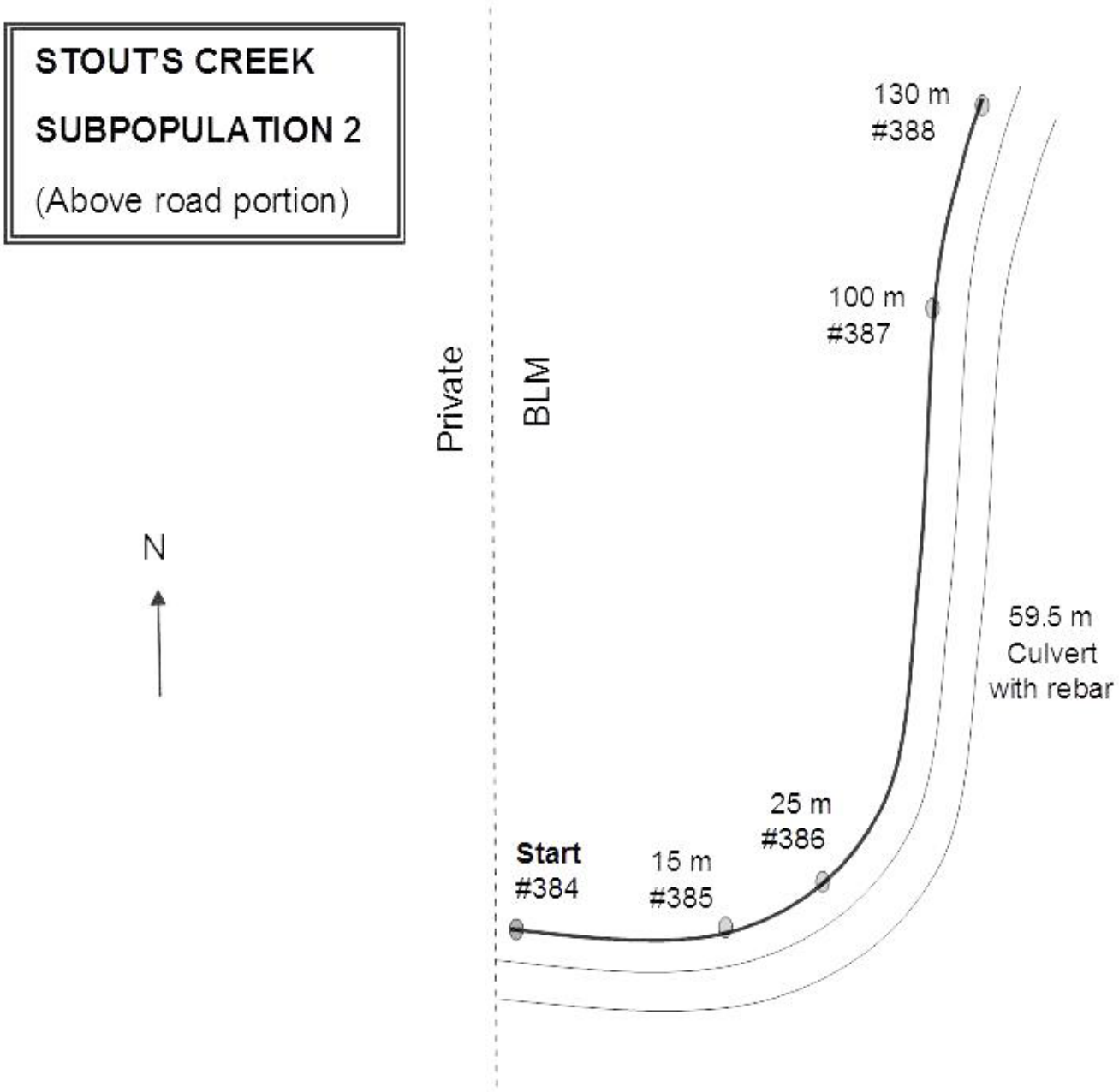

Figure 18. Diagram of Stout's Creek subpopulation 2, above road transect. Meter tape should be run along road side ditch, in natural arc, but rebar should match up with distances on map. Plants extend about 20 m above transect. In 2015 this plot was disturbed during road maintenance and will need to be re-established for future monitoring efforts.

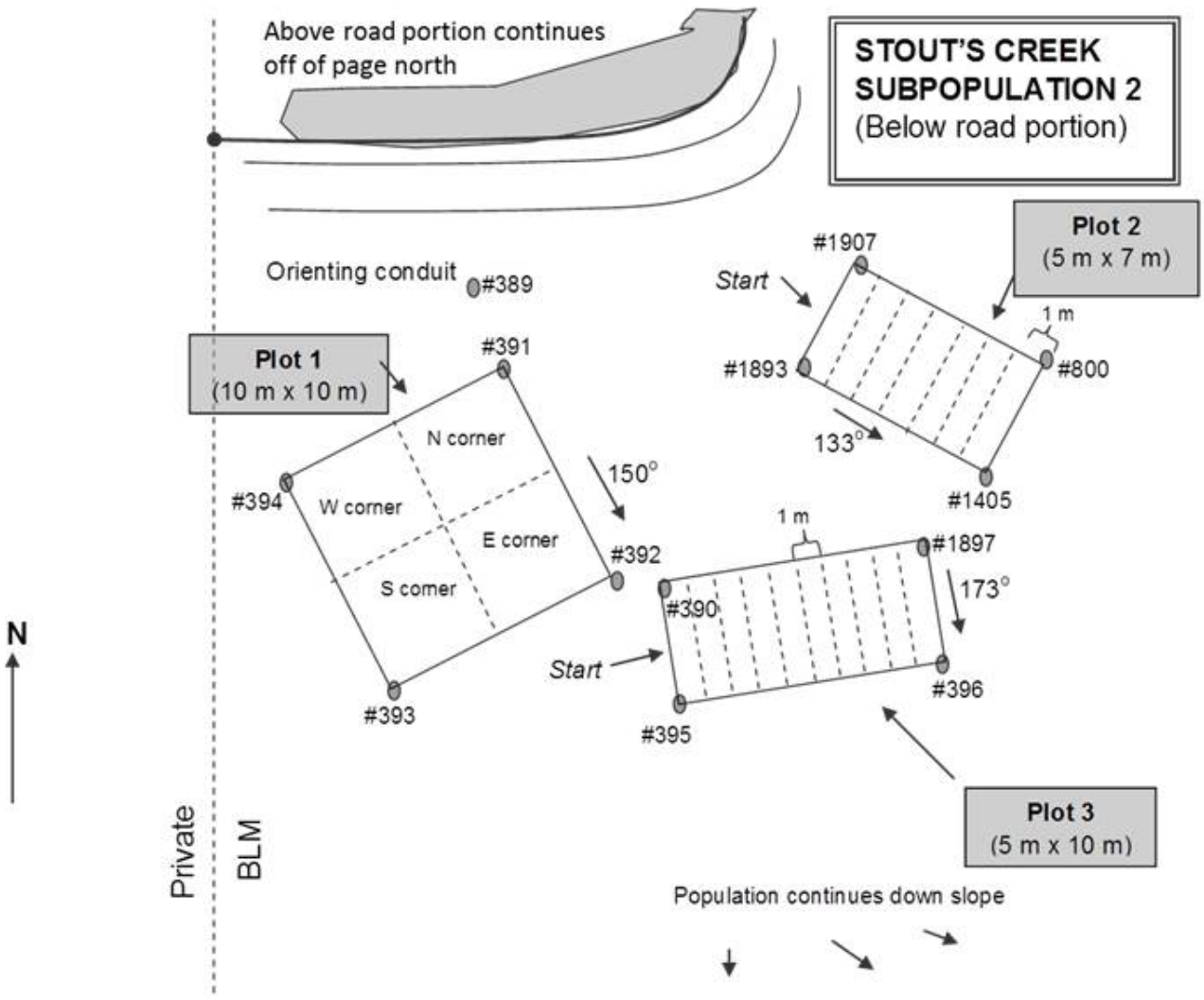

Figure 19. Diagram of Stout's Creek subpopulation 2 focused on the portion of the subpopulation below the road. Three sub-sample plots were established. Bearings and tag numbers are indicated in diagram. Plot 2 was re-created in 2011, as 3 of the posts had been dislodged during thinning and brush-clearing.

Reproductive Assessment

To assess reproductive effort in the *L. oreganus* populations on the Roseburg District, we conducted additional sampling of reproductive plants in the Loose Laces, Callahan Meadows, China Ditch, Dickerson Heights and Stout's Creek sites. In July 2007-2014, 30 racemes were randomly selected per site to sample for the number of fruits on mature racemes. We selected racemes rather than plants, since it is frequently impossible to distinguish an individual plant from neighboring plants. We counted total fruit number on each raceme. Fruits (Figure 20) and seeds were not removed from plants so that that year's seed production could contribute to the natural population at each site.

Fender's blue butterfly surveys

In 2007, we searched all monitored *L. oreganus* patches for evidence of use by Fender's blue butterfly. Specifically, we inspected the underside of each *L. oreganus* leaf for butterfly eggs. Eggs of Fender's blue butterfly are identifiable as small (0.5–1.0 mm) white spheres on the underside of *L. oreganus* leaves (Figure 21). Hatched eggs resemble unhatched eggs except they are burst in the center making them look like little white "donuts." Hatched and unhatched eggs would be counted together (although none were located). Surveys were suspended in 2010.

Figure 20. *Lupinus oreganus* fruits. Photo: T.N. Kaye

Figure 21. Eggs of Fender's blue butterfly are identifiable as white dots on the undersides of *Lupinus oreganus* leaves.

RESULTS

In 2016, foliar cover of *L. oreganus* was reduced at all sites compared to 2015 cover (Table 2). Conversely, the number of racemes (Table 2) and fruits per raceme in 2016 increased at all sites compared to 2015 values (Table 3). 2015 was an exceptionally bad year for seedset of *L. oreganus* across its range, and at all sites monitored by IAE in the Willamette Valley, reproductive effort was exceptionally low (Giles et al. 2015).

Callahan Meadows

L. oreganus foliar cover at Callahan Meadows has varied between years, but overall has increased or remained stable (Table 1 and Figure 25). *L. oreganus* cover slightly decreased in 2016 to 13.4 m^2 which is the third highest cover for this site since monitoring began. The highest recorded cover occurred in 2012 with 15.7 m^2. Reproductive effort for this site has fluctuated since 2007, with a range of 57-566 racemes. In 2016, 321 racemes were counted, with none observed in the second subpopulation.

China Ditch

Five new representative monitoring transects were established at China Ditch in 2010, which brings the total number of transects monitored to nine. *L. oreganus* cover values are reported here separately as original transects totals and also as a total of all transects (which includes all original transects and new transects added in 2010).

In 2016, foliar cover of *L. oreganus* for the original five transects and for all transects was 21.28m^2 and 39.97m^2, respectively (Table 2, Figure 26). Overall, foliar cover slightly decreased from 2015 cover estimates. However, there was variation between transects in respect to net cover change between years (Table 2, Figure 26). For example, in patch A, the roadside transect, Transect 1and 3 decreased in foliar cover, while transect 2 increased in foliar cover. In patch C, the roadside and Transect 1 increased in foliar cover while Transect 2 decreased in foliar cover. In patch D, both transects saw reductions in *L. oreganus* foliar cover in 2016.

Raceme production remains high but fluctuates annually; 314 and 398 racemes were produced in 2016 in the five original transects and all transects, respectively (Table 2). Raceme count for all transects increased by 310% between 2015 and 2016. In addition, the average number of fruits per raceme was 9.47, which was the highest recorded number since the study began (Table 3, Figure 26).

Dickerson Heights

In 2016, *L.* oreganus foliar cover was 39.26m^2, which was slightly lower than 2015 foliar cover (Table 2). However, foliar cover remains relatively high at Dickerson Heights and has seen an upward trend since thinning in 2009. The number of racemes has fluctuated greatly at this site but generally has increased since monitoring began in 2005 (Figure 27). In 2010, the number of racemes increased 99% to 641 and reached the apex in 2012 with 854 racemes; in 2014, the average fruits per raceme at the site was 5.5 (Table 3). Plot boundaries for the census monitoring at Dickerson Heights were expanded in 2014 as the population has grown and changed. A total of 131 seedlings were noted while taking foliar cover measurements in 2011, 62 in 2012 and 198 in 2014 (seedlings were not included in our monitoring efforts in 2013).

Letitia Creek

Foliar cover of *L. oreganus* at Letitia Creek has decreased steadily since 2006 (Table 1, Figure 26). In 2006, foliar cover was 8.12m^2 and has dropped to 1.73m^2 in 2016, with the majority of *L. oreganus* found in subpopulation 1 (Table 1, Figure 24). Not surprisingly, the number of racemes has plummeted from a high of 199 in 2004 to 3 in 2016 (Figure 24). Management of the *L. oreganus* population at this site should be of the highest priority, as it has crashed in only 11 years from a healthy population to an un-reproductive population (Figure 24).

Loose Laces

In 2016, total foliar cover of *L. oreganus* was reduced from 2015 cover estimates (Table 1, Figure 22, Figure 23). Foliar cover in subpopulations 2, 3, and 4 were slightly reduced, with the majority of foliar cover loss observed at subpopulation 1. Although it decreased by 38% between 2015 and 2016, subpopulation 1 still has the highest foliar cover (15.24m^2) among sub-pupations at Loose Laces (Figure 23).

Overall, reproductive efforts have remained positive through the course of the study. In 2016, there were 523 racemes which had an average of 8.1 fruits per raceme, the highest value since monitoring began (Table 3). However, raceme production varied among sites. Raceme count at subpopulation 1 was reduced by 23% in 2016 from 2015 values (32.19m^2 from a high of 44.57m^2), while all other subpopulations increased (Table 1, Table 2, Figure 23).

Stout's Creek

In 2016, only plots 1, 2 and 3 from subpopulation 2 were monitored at Stout's Creek. Total cover of the surveyed plots was 7.08m^2, approximately 15% less than 2014 cover estimates. Reproductive efforts remained stable in 2016, with raceme production (87) similar to 2014 levels and fruits per raceme (8.5) slightly above the average (8.1) of all populations monitored in the Roseburg District in 2016 (Table 3, Figure 28).

Because of road maintenance related to the 2015 Stouts Creek Fire which destroyed plot markers, and subsequent time and access constraints related to active post-fire logging operations in 2016, the 'above road' portion of subpopulation 2, which includes the 'roadside' populations, and all of subpopulation 1were not able to be monitored using the same methodology as in previous years. Instead a rough estimate of cover was made for each area.

Fender's blue butterfly surveys

We have found no evidence of Fender's blue butterflies at any of the sites that we monitored in the Roseburg District.

Table 1. Leaf and raceme totals for *Lupinus oreganus* populations at Loose Laces, Letitia Creek, Callahan Meadows, and Stout's Creek monitored between 2009 and 2016 at the Roseburg District. Values for Stouts Creek Roadside in 2016 are approximate.

Population	2009	2009	2010	2010	2011	2011	2012	2012	2013	2013	2014	2014	2015	2015	2016	2016
	Racemes	Cover (m2)	Racemes	Cover (m^2)	Racemes	Cover (m^2)	Racemes	Cover (m^2)	Racemes	Cover (m^2)	Racemes	Cover (m^2)	Racemes	Cover (m^2)	Racemes	Cover (m^2)
LOOSE LACES TOTAL	**473**	**19.11**	**578**	**17.55**	**714**	**19.27**	**563**	**26.29**	**879**	**40.13**	**808**	**34.83**	**473**	**44.57**	**523**	**32.19**
Subpopulation 1	*75*	*3.22*	92	3.64	147	4.94	170	7.34	341	10.71	463	17.06	260	24.60	200	15.25
Subpopulation 2	*9*	*1.17*	3	0.82	13	0.79	47	2.14	52	3.51	97	3.85	32	4.38	66	3.7
Subpopulation 3	*374*	*12.39*	437	10.31	470	10.57	297	13.48	382	20.43	81	9.62	106	9.06	153	8.01
Subpopulation 4	*15*	*2.33*	46	2.75	84	2.96	49	3.34	104	5.47	167	4.30	*75*	6.50	104	5.23
LETITIA CREEK TOTAL	**157**	**5.2499**	**24**	**2.98**	**5**	**1.17**	**2**	**1.54**	**Not monitored in 2013 due to squatter camp**		**0**	**2.80**	**0**	**2.92**	**3**	**1.73**
Subpopulation 1	*3*	*0.54*	22	2.64	*5*	1	0	0.38			0	0.34	0	0.29	2	1.60
Subpopulation 2	*154*	*4.71*	2	0.33	0	0.162	2	1.16			0	2.47	0	2.63	1	0.14
CALLAHAN MEADOWS TOTAL	**338**	**9.433**	**510**	**13.12**	**475**	**9.07**	**425**	**15.74**	**239**	**13.23**	**376**	**13.38**	**107**	**14.27**	**321**	**13.43**
Subpopulation 1	*334*	*9.23*	509	12.83	473	8.91	425	15.49	239	12.97	376	13.12	107	14.12	321	13.4
Subpopulation 2	*4*	*0.2*	1	0.3	2	0.16	0	0.24	0	0.26	0	0.26	0	0.15	0	0.03
STOUT'S CREEK TOTAL[1,2]	**141**	**11**	**329**	**17.72**	**179**	**7.58**	**312**	**19.32**	**369**	**27.81**	**490**	**23.93**			**87**	**7.08**
Subpopulation 1																
Transect A	-	*0*	0	0	1	0.01	0	0	0	0	0	0.00				
Transect B	-	*0.12*	0	0.15	0	0	0	0.08	0	0.02	0	0.02			**Not monitored in 2016**	
Transect C	-	*0.13*	0	0.05	0	0	0	0.01	0	0	0	0.00				
Transect D	*3*	*0.18*	0	0.26	0	0.11	0	0.09	0	0.05	0	0.00				
Subpopulation 2													**Not monitored in 2015 due to site access issues**			
Above the road	*84*	*6.48*	288	12.5	114	2.88	257	12.39	313	19.73	399	15.54			**(50-100)**	**(<5.0)**
(Below the road) Plot 1	*30*	*1.51*	*7*	1.42	16	1.26	23	1.65	32	2.66	54	3.13			56	3.75
(Below the road) Plot 2	*5*	*0.71*	*5*	0.57	32	1.75	12	2.7	*5*	2.58	10	2.60			13	1.82
(Below the road) Plot 3	*19*	*1.99*	29	2.77	16	7.58	20	2.39	19	2.76	27	2.64			18	1.51

Table 2. Leaf and raceme totals for *Lupinus oreganus* populations at China Ditch and Dickerson Heights, and Grand Totals for all sites, monitored between 2009 and 2016 at the Roseburg District.

Population	2009 Racemes	2009 Cover (m^2)	2010 Racemes	2010 Cover (m^2)	2011 Racemes	2011 Cover (m^2)	2012 Racemes	2012 Cover (m^2)	2013 Racemes	2013 Cover (m^2)	2014 Racemes	2014 Cover (m^2)	2015 Racemes	2015 Cover (m^2)	2016 Racemes	2016 Cover (m^2)
CHINA DITCH TOTAL[2]	**620**	**19.18**	**827**	**40.63 (27.24)[4]**	**794 (420)[4]**	**25.02 (13.4)[4]**	**1007 (713)[4]**	**53.03 (32.48)[4]**	**840 (522)[4]**	**64.17 (34.68)[4]**	**942 (684)[4]**	**77.75 (40.74)[4]**	**97 (84)[4]**	**44.19 (25.7)[4]**	**398 (314)[4]**	**39.97 (21.28)[4]**
Patch A																
Roadside (prev. subpop. 2)	108	3.83	124	6.08	87	2.37	73	3.82	61	5.17	70	4.5	2	2.11	0	1.01
Transect 1 (prev. rep. transect 1)	-	0.52	5	0.36	33	0.68	54	4.18	83	5.55	151	6.47	49	4.87	23	1.8
Transect 2[3]	-	-	42	2.31	113	3.57	105	6.14	104	7.48	82	4.16	9	2.5	28	3.39
Transect 3[3]	-	-	10	0.48	84	3.01	23	1.37	50	1.76	66	5.92	0	2.87	6	2.33
Patch C																
Roadside (prev. subpop. 1)	312	8.9	327	12	201	5.89	377	14.48	222	11.01	277	14.46	3	8.15	182	10.98
Transect 1[3]	-	-	8	2.58	21	0.73	55	5.24	64	7.77	35	14.22	0	4.29	44	5.51
Transect 2[3]	-	-	84	5.77	155	3.27	67	5.38	91	8.6	61	7.91	0	4.58	5	4.35
Patch D																
Roadside (prev. subpop. 3)	308	10.28	217	8.79	99	4.46	209	10	156	12.94	186	15.32	30	10.4	109	7.5
Transect 1[3]	-	-	10	2.24	11	1.03	44	2.39	9	3.88	14	4.79	4	4.3	1	3.1
DICKERSON HEIGHTS TOTAL[1]	**322**	**20.65**	**641**	**24.32**	**704**	**31.38**	**844**	**47.42**	**684**	**45.6**	**770**	**49.89**	**151**	**48.49**	**(not counted)**	**39.26**
GRAND TOTALS *	**2,051**	**84.74**	**2909**	**116.31**	**2,871**	**93.49**	**3,705**	**163.07**	**3,011**	**190.96**	**3,386**	**202.6**	**828**	**154.44**	**1,332**	**133.66**

[1]New monitoring transect(s) established in 2005.
[2]Leaf and inflorescence totals are not a census.
[3]New monitoring transects established in 2010.
[4]Numbers in parentheses do not include values for new transects installed in 2010 at China Ditch.

Table 3.Fruits per raceme for Lupinus oreganus populations monitored between 2003 and 2016 at the Roseburg District.

	Fruits/raceme (Average)													
Site	**2003**	**2004**	**2005**	**2006**	**2007**	**2008**	**2009**	**2010**	**2011**	**2012**	**2013**	**2014**	**2015**	**2016**
Loose Laces	0	3.6	2.6	3.1	4	2.6	2	4.3	4.6	6.4	6	6.8	4.9	8.1
China Ditch		8.5	5.7	5.8	6.0	4.6	5.7	6.0	7.4	3.8	4.3	5.6	0.7	9.5
Callahan Meadows		0	0	0	0.0	0	0	0	0	0	0	N/A	N/A	N/A
Stout's Creek			3.4	3.3	2.5	0.1	1.9	3.1	5.6	4.5	2.9	6.2	N/A	8.5
Dickerson Heights			7.1	2.4	6.1	4.2	4.1	6.0	6.3	6.7	5.1	6.5	4.3	6.5
Letitia Creek						6.8				0	N/A	N/A	N/A	N/A

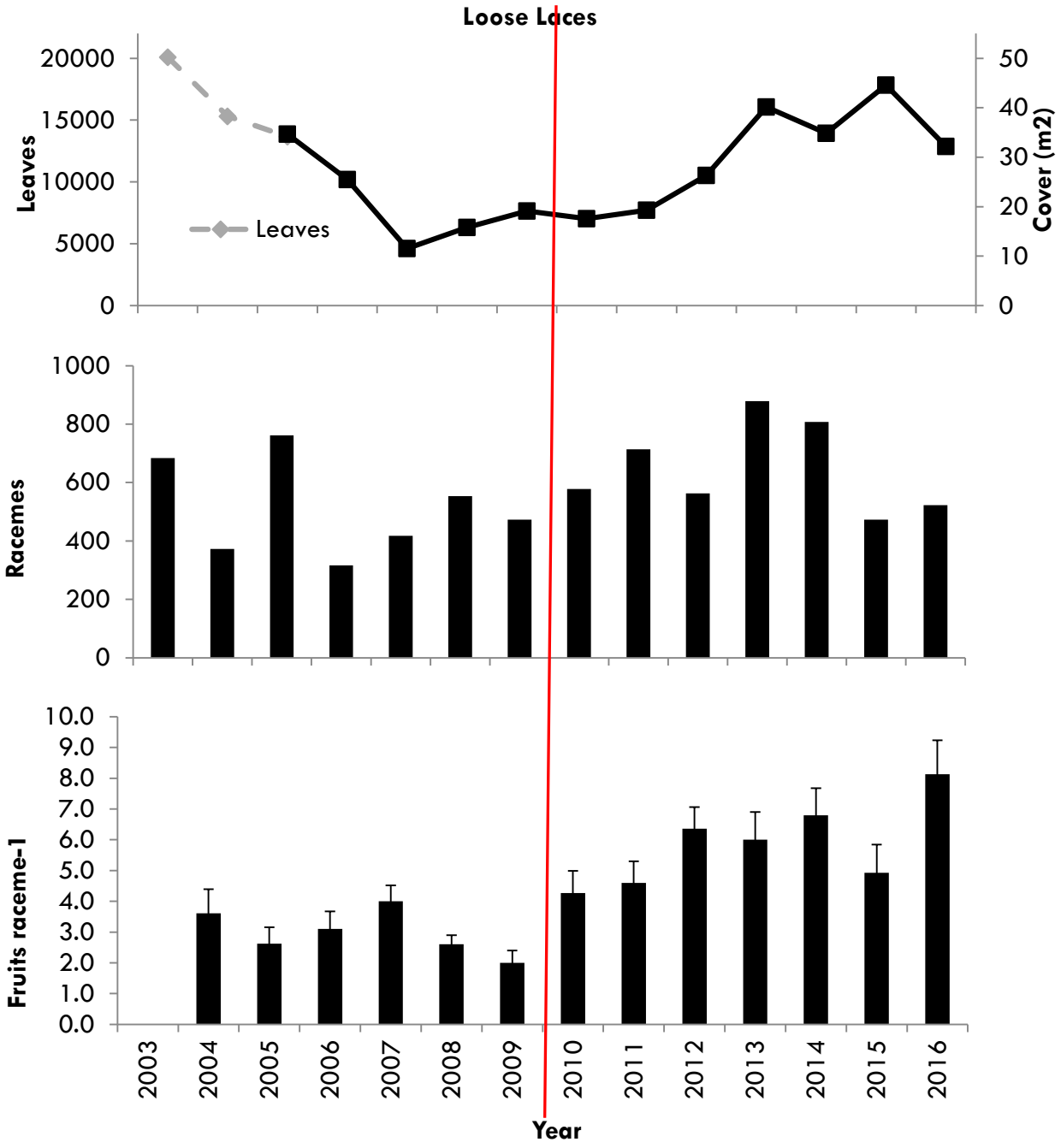

Figure 22. The number of leaves (2003 – 2005), foliar cover (2005 – 2016), number of racemes, and number of fruits per raceme of *L. oreganus* at Loose Laces. The red line represents timing of thinning treatments. Error bars where present represent one standard error.

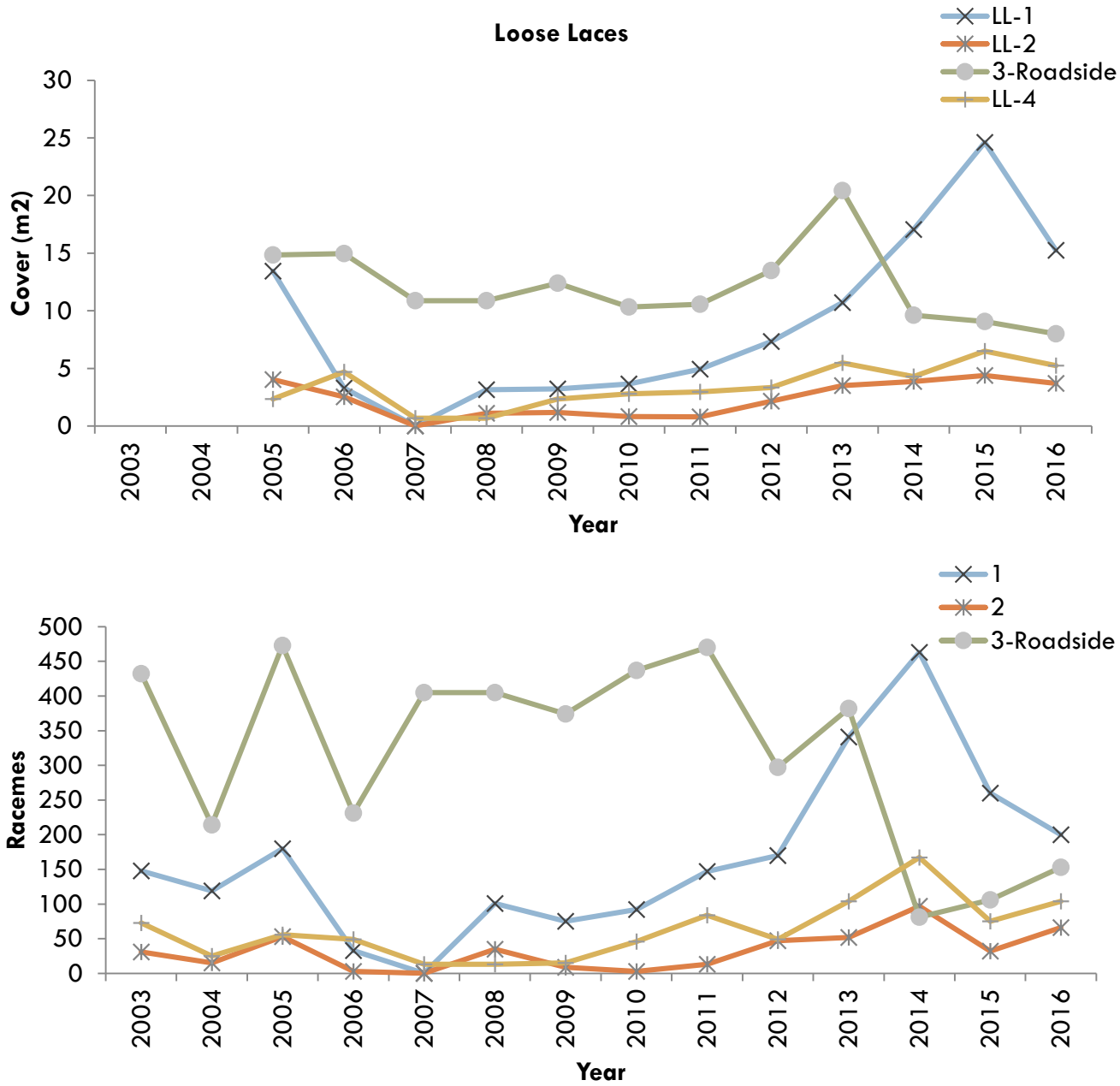

Figure 23. Cover and number of racemes by subpopulation at Loose Laces. Note that the roadside population has experienced a generally downward trend over the course of monitoring.

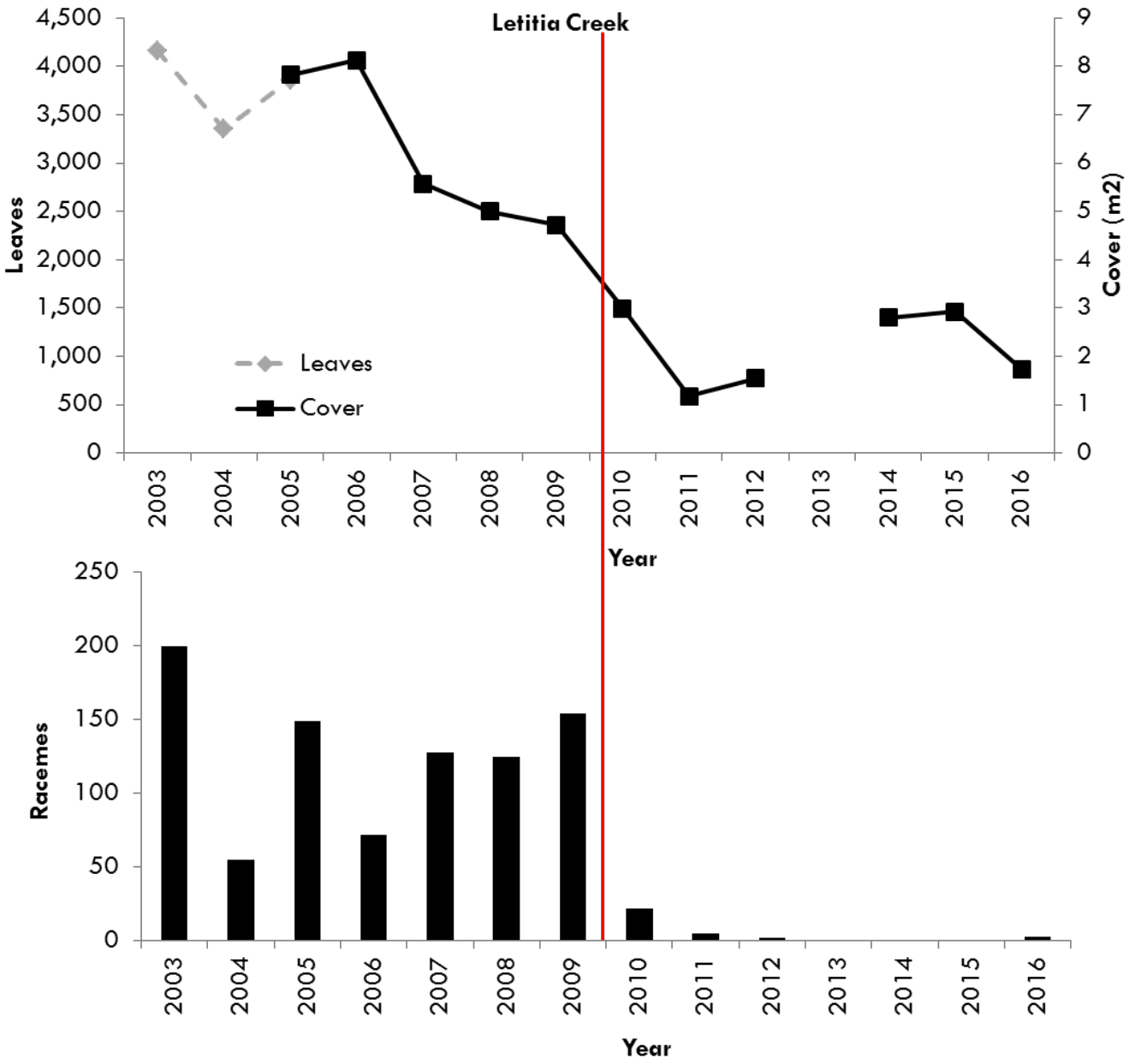

Figure 24. The number of leaves (2003 – 2005), foliar cover (2005 – 2016), and number of racemes of *L. oreganus* at Letitia Creek. Fruit data was only recorded in 2008 and 2012, see table 2). The red line represents timing of thinning treatments. Letitia Creek was not monitored in 2013 due to the presence of a squatter camp in the vicinity.

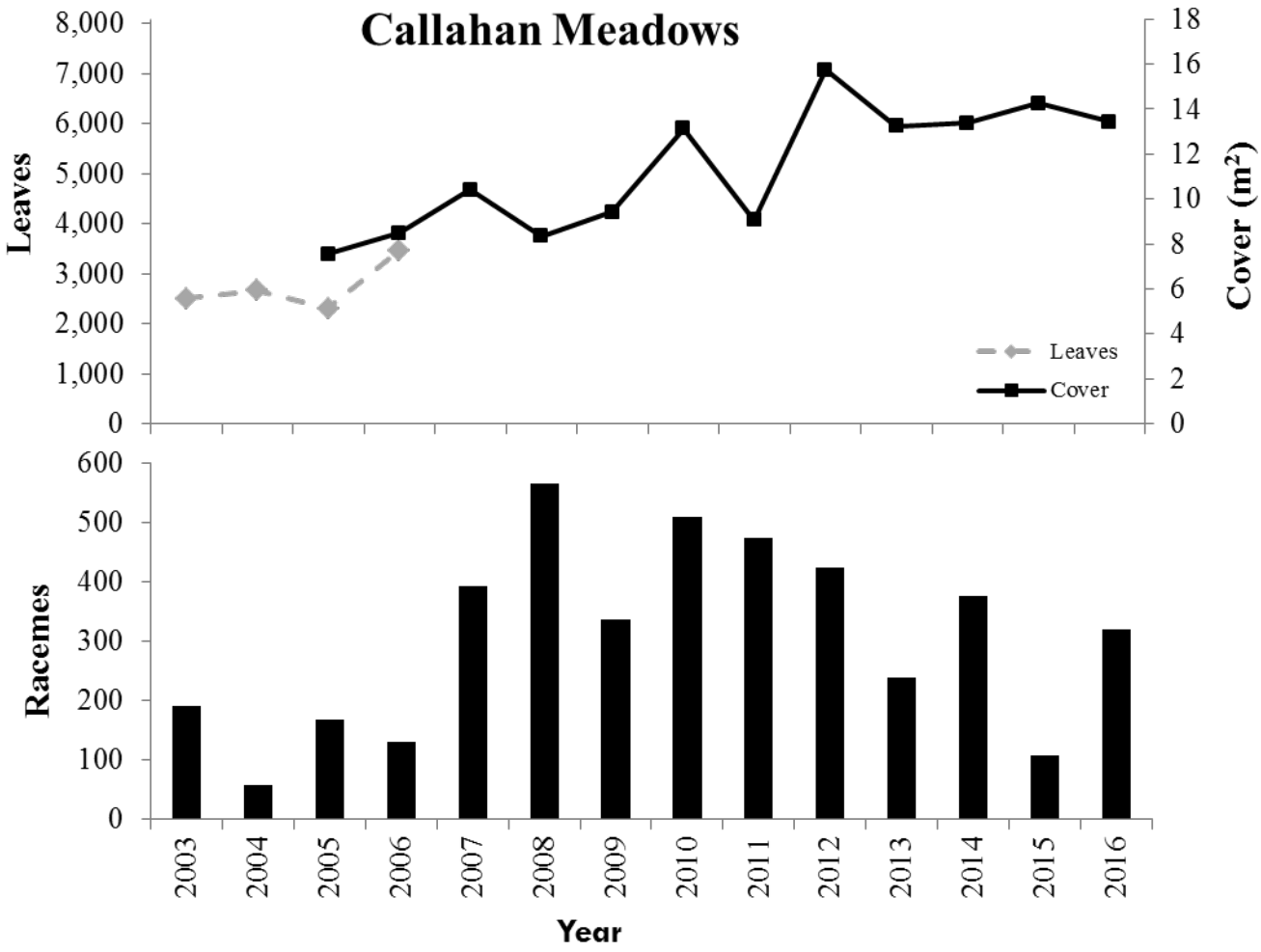

Figure 25. The number of leaves (2004 – 2005), foliar cover (2005 – 2016), and number of racemes of *L. oreganus* at Callahan Meadows. No fruits have been recorded at the site.

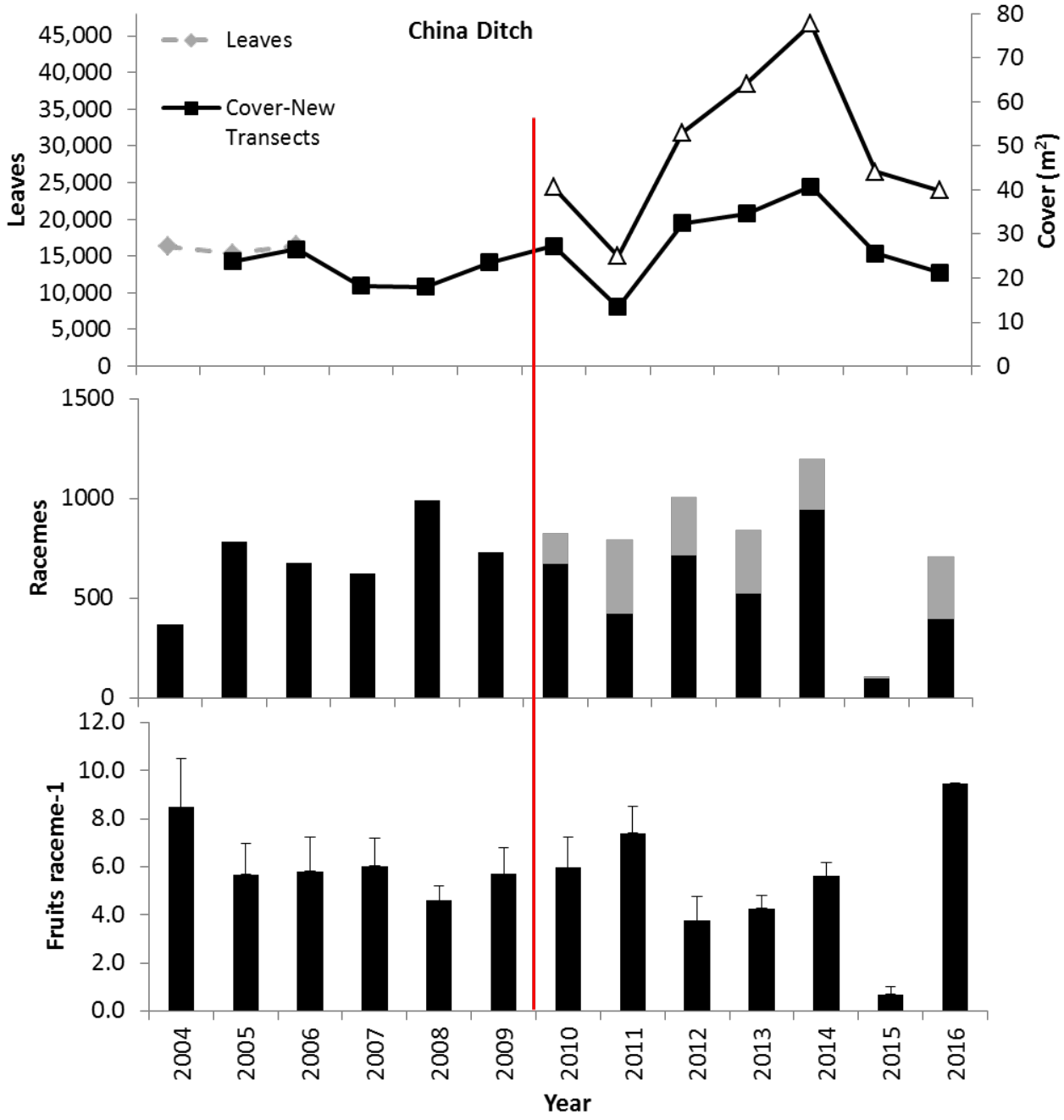

Figure 26. The number of leaves (2004 – 2006), foliar cover (2005 – 2016), number of racemes, and number of fruits per raceme of *L. oreganus* at China Ditch. In 2010, 5 new transects were added and one plot was modified, thus the reason for a dramatic increase in cover. Grey bars represent the number of racemes from new transects. Red line indicates timing of thinning treatments. Error bars where present represent one standard error.

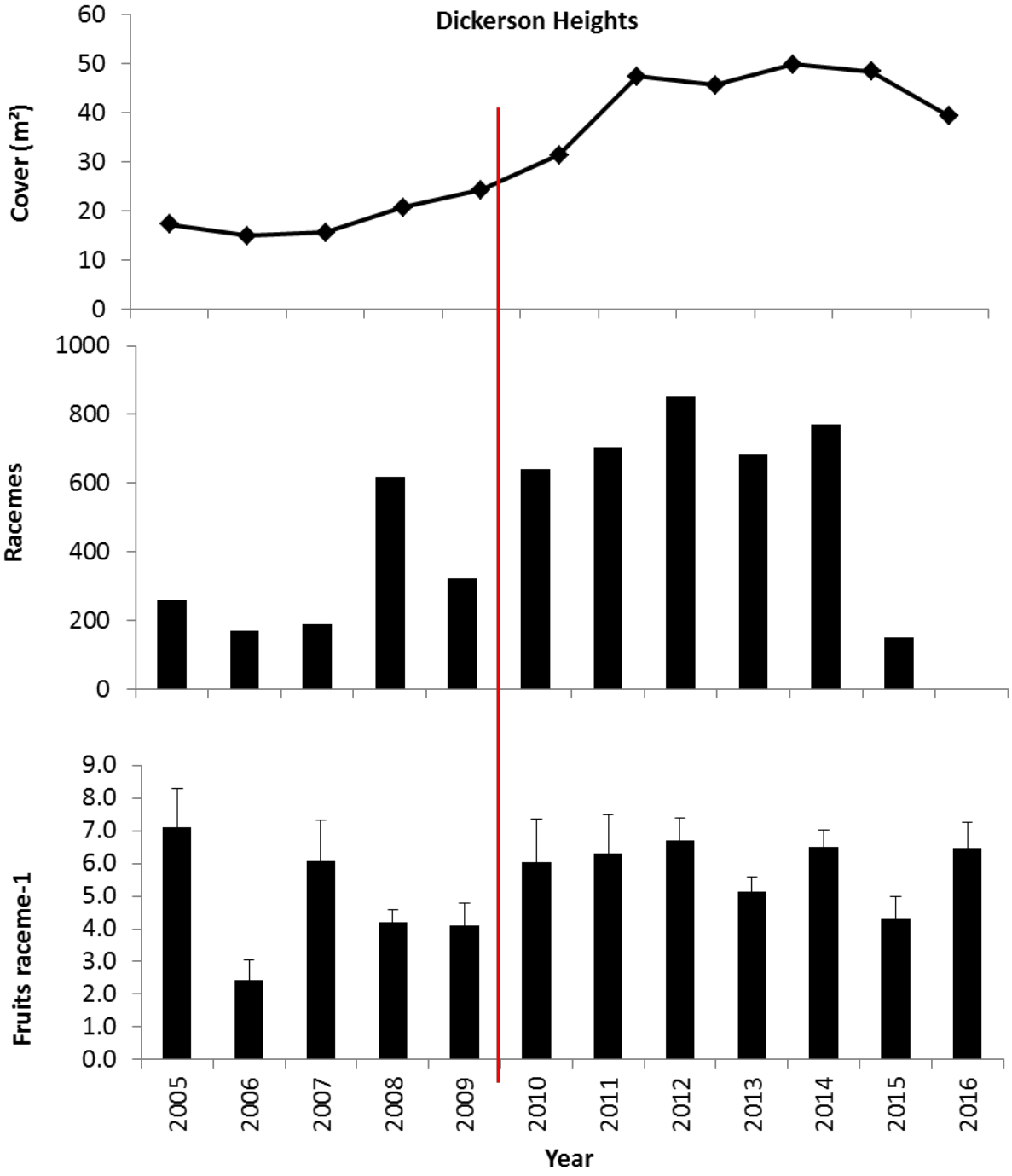

Figure 27. Foliar cover, number of racemes, and number of fruits per raceme of *L. oreganus* at Dickerson Heights from 2005-2016. Red line indicates timing of thinning treatment. Error bars where present represent one standard error. Racemes were not counted in 2016.

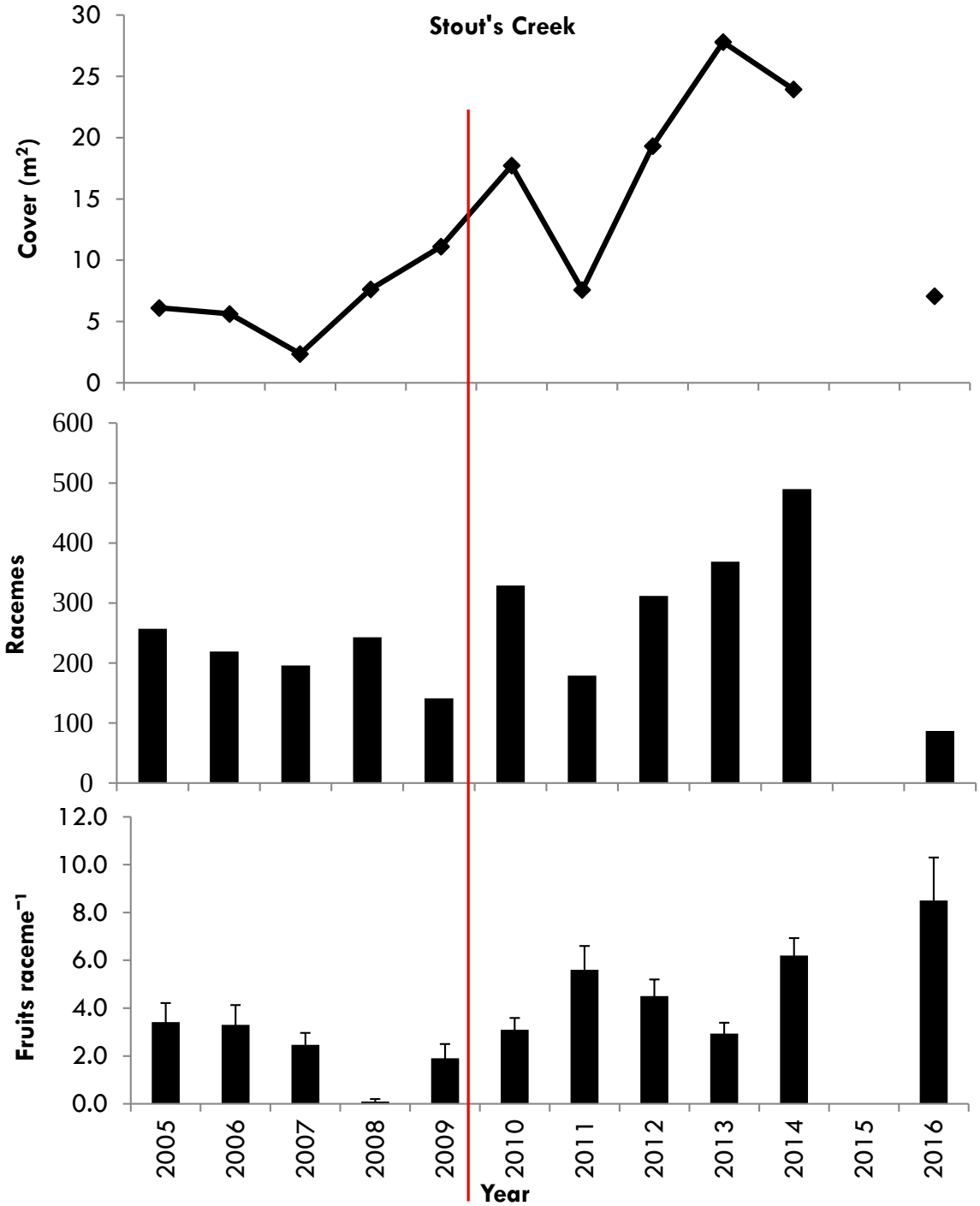

Figure 28. Foliar cover, number of racemes, and number of fruits per raceme of *L. oreganus* at Stout's Creek from 2005-2016. This site was not monitored in 2015 due to site access issues. The red line indicates timing of thinning treatment. Error bars, where present, are one standard error. Not all plots were monitored in 2016, see discussion.

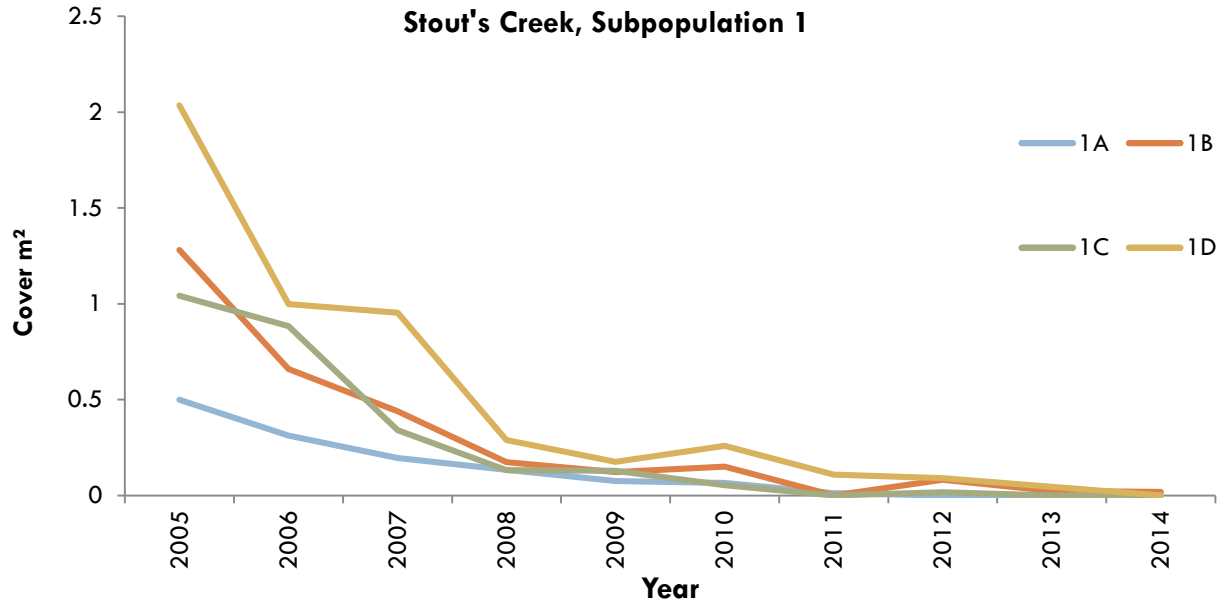

Figure 29. Cover of *L. oreganus* at Stout's Creek subpopulation1. Subpopulation 1 has declined to just one plant in 2014. This site was not monitored in 2015 and 2016 due to site access issues.

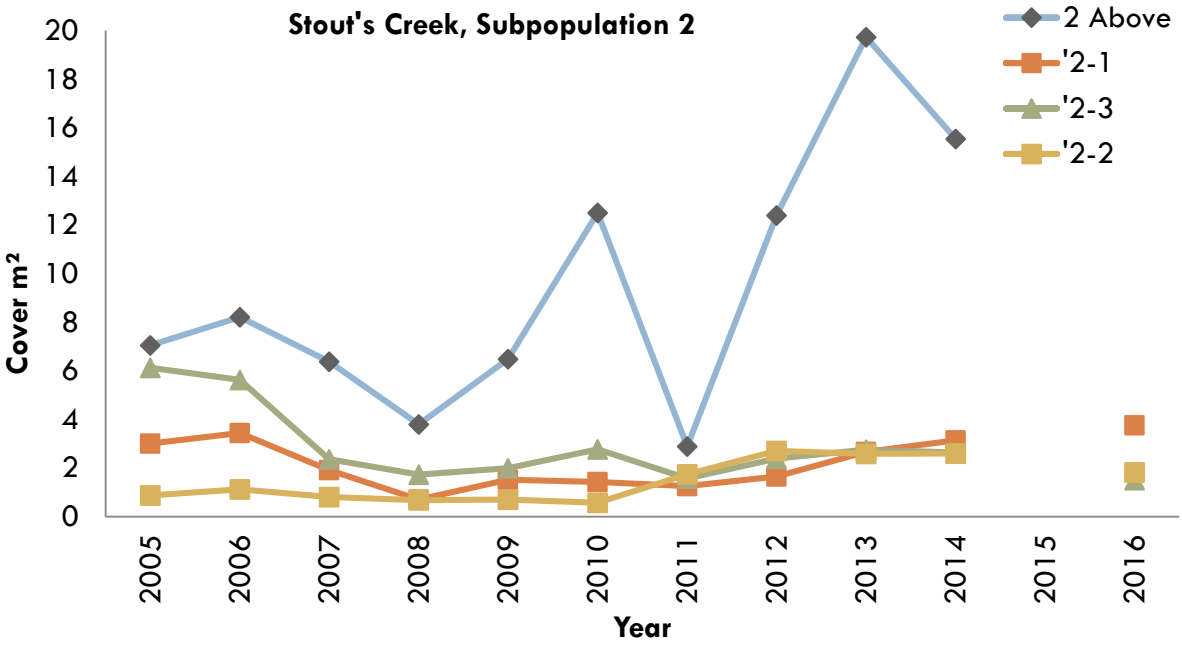

Figure 30. Foliar cover of *L. oreganus* at Stout's Creek subpopulation 2. This site was not monitored in 2015 due to site access issues.

DISCUSSION AND RECOMMENDATIONS

General Population Trends

In 2016, the general trend across all six populations of *L. oreganus* monitored in the Roseburg District was a slight reduction in foliar cover and an increase in reproductive effort from 2015.

Callahan Meadows

In the fifteen years of monitoring at Callahan Meadows, foliar cover has not fluctuated as much as the other sites and indicates a stable trend. It is worrisome, however, that the site cannot recruit new, genetically diverse individuals and relies solely on growth and expansion of current individuals. Recruitment is limited as evidence of only one poorly developed (unviable) fruit has been observed (in 2008). Pollination experiments in 2008 and 2009 indicate that the population is sterile as no fruits were produced independent of pollen source. Experimental transfer of pollen from within the population and from two large populations of *L. oreganus* failed to result in successful fruit production, suggesting that reproductive failure at this site is most likely not due to low genetic diversity. Recent analyses have found that the population of *L. oreganus* at Callahan Meadows is polyploid (Severns 2008). Polyploidy may limit the ability to successfully fertilize eggs if pollen is from a population with a different ploidy level. The rhizomatous nature of the plants at Callahan Meadows and finding of only one cpDNA haplotype in the population (Severns 2008) suggest that these plants may be closely related. Repetition of the pollen transfer study in 2009 again resulted in no viable fruits independent of pollen source, providing further support that the population is not only incompatible with other *L. oreganus* populations, but is also self-incompatible. Suitable habitat near subpopulation two, across a habitat gradient would be recommended for augmentation efforts at this site.

China Ditch

Because of past fire disturbance, the China Ditch area has far less canopy closure than the other *L. oreganus* populations on the BLM Roseburg district. Compared to the other sites, China Ditch has a relatively high reproductive output. Over the first seven years of monitoring, there were slight changes in *L. oreganus* cover. From 2011 through 2014, the site experienced steady growth in foliar cover, total racemes and fruits per raceme in response to management treatments. However, in 2015 and 2016 foliar cover decreased, while there was a large increase in raceme count between 2015 and 2016.

In 2009, the BLM thinned trees in the vicinity of our plots to a spacing of ~21 feet. In the first year post-treatment, there was little change in either *L. oreganus* cover or reproductive effort. In 2011, both raceme count and foliar cover decreased. Interestingly, both cover and raceme count have steadily increased since 2012 (two years after thinning) to the highest recorded values in the eleven years of monitoring in 2014 (Figure 26).

Much of the thinning treatment area (19 acres) was outside of our existing plots and so, in 2010, additional plots were established within the treated areas to determine the response of the *L. oreganus* to the treatments. The BLM previously mapped the occupied *L. oreganus* areas within China Ditch and found approximately 3.5 acres of occupied habitat within the treatment area. Additionally, in 2010, we surveyed the area and mapped new *L. oreganus* patches. Opening up the canopy was expected to

increase the vigor and reproductive effort of *L. oreganus*, and those trends were observed through 2014, however, the increasing cover of shrubby species, as well as the harsh environmental conditions of 2015, likely contributed to the dramatic decline in both foliar cover and reproductive effort in 2015. In 2016, milder environmental conditions may have supported the increase in raceme production.

A repeated brush-clearing treatment is recommended for the area in the fall of 2016 in order to maintain open patches for *L. oreganus*

In 2012-2016, some meadow knapweed *(Centaurea pratensis)* was found along the roadside near the end of the Patch C Roadside transect. The majority of the plants were removed by IAE staff, as feasible, however it is recommended that the area continue to be monitored for the noxious weed.

Stout's Creek

In 2016, only plots 1, 2 and 3 were monitored from subpopulation 2 and the site was not monitored in 2015 due to access issues.

The population of *L. oreganus* at this site occurs in area of dense understory vegetation, including relatively high cover of *Toxicodendron diversilobum* and coniferous canopy cover. In 2009, the BLM thinned trees in the vicinity of subpopulation 2, which was expected to increase the vigor of *L. oreganus*. In 2015, the area was on the periphery of an area subject to fire. While the area with *L. oreganus* did not burn, subpopulation 1 and the roadside/above road portion of subpopulation 2 were impacted by road construction activities. Due to time constraints we were not able to monitor these plots in 2016.

Eight plots are monitored at Stout's Creek from two subpopulations. All four plots in subpopulation 1 have steadily decreased since monitoring began and the subpopulation has basically disappeared (only 1 individual found in 2014). Thinning treatments did not occur in this portion of the population and the area is heavily overgrown with young trees, shrubs and invasive grasses. In 2016, this area was impacted by road maintenance activities, and it is recommended that plots be re-established in the area in order to assess the impacts of these activities.

All plots from subpopulation 2 (4 total) have increased in foliar cover and raceme production from 2006 to 2014. The "subpopulation 2, Above Road" plot has shown the greatest increase with the "subpopulation 2, Below Road" plots improving, but only slightly. Oddly, no thinning occurred in "subpopulation 2, Above Road" plot, which consists of the roadside, cut-bank and platform above the road; however, the openness of the road seems to contribute to the expansion of *L. oreganus* at this site. Most plants are found within 20 m of the cut bank. This area was *heavily* impacted by road activity, when most of the topsoil was removed from the cutbank. The deeply tap-rooted native remained entrenched in a few patches along the cutbank, however total cover of "subpopulation 2, Roadside" decreased from a cover of 15.54m^2 in 2014, to an ocular estimate of no more than 5m^2 observed in 2016.

The remaining plots, "subpopulation 2, Below Road" plots 1-3, received thinning treatments in 2009; although there was a slight increase in *L. oreganus* foliar cover and raceme totals, there was not a drastic increase as was noted at China Ditch and Dickerson Heights. Further thinning treatments are recommended to increase connectivity between patches of lupine downslope.

Loose Laces

The Loose Laces population is primarily restricted to roadsides or small natural gaps adjacent to roads. Three of the four subpopulations have shown general increases (subpopulations 1, 2, and 4), whereas the roadside populations have shown a general decline. Raceme count fluctuated early in the study but there is an increasing trend since 2009. In 2011, Loose Laces had the highest fruits per raceme value recorded out of all sites since monitoring began. In 2015, while seed set was low at all Roseburg District sites, Loose Laces had the greatest reproductive effort per raceme. In 2016, the number of racemes and fruits per raceme increased from 2015 values, while overall foliar cover decreased. The BLM thinned trees at the Loose Laces site in 2009. Foliar cover, raceme production, and fruits per raceme have all responded positively.

Negative effects of traffic, including dust and effects of road maintenance are a concern for subpopulation 3. Outplanting is recommended at subpopulations 1, 2 and 4.

Dickerson Heights

Like Loose Laces and Letitia Creek, Dickerson Heights is primarily restricted to small natural canopy gaps and adjacent roadsides. This population has shown a positive trend since 2007; in 2007, 15.5 m^2 of foliar cover and only 189 racemes were recorded, whereas in 2014, the foliar cover had tripled to 49.9 m^2 and raceme production has quadrupled to 770 (Figure 27). Racemes were not counted in 2016. In 2011, 2012 and 2014, there were 131, 62 and 198 seedlings counted while monitoring at this site, respectively; this indicates that sexual reproduction is successful at the site, thus improving genetic diversity and sustainability.

In 2009, the BLM thinned trees around our plots at the Dickerson Heights area. The impact on the canopy cover thinning seemed to be less at this area, as the cleared areas are generally downslope of the *L. oreganus* population. These populations will most likely continue to respond favorably to creation of additional canopy gaps or reduction in forest cover.

Letitia Creek

Like Loose Laces and Dickerson Heights, Letitia Creek is primarily restricted to roadsides or small natural canopy gaps adjacent to roads. This site has declined to approximately one-fifth of the population size recorded when monitoring began in 2003 and the raceme count has dwindled from hundreds to three in 2016. This is likely due in part to the high levels of shading. In 2010, the BLM thinned coniferous trees around our plots at the Letitia Creek area. Thinning treatment in 2010 appears to have done little to increase foliar cover or raceme production, as there still was a great deal of shading from *Arbutus menziesii* (madrone), which was not targeted in thinning. While it may take several years for the full impact of these treatments to be known, preservation of this population requires active management now; otherwise, the *L. oreganus* population at Letitia Creek will be completely extirpated.

Fender's blue butterfly

We found no evidence of Fender's blue butterfly at any of the sites during intensive surveys 2007 to 2009.

Related studies and recommendations for further research

While we are confident that the populations that we surveyed in Douglas County are *L. oreganus* as currently described, there appears to be substantial variation in the habit and morphological characteristics of the species along its north to south distribution. While a recent study concluded that all populations in Douglas County are *L. oreganus*, there was a relatively high amount of genetic divergence among the populations (Severns 2008). In addition, the Callahan Meadows and Stout's Creek populations displayed evidence of polyploidy (100% and 5% of tested individuals, respectively).

We recommend additional surveys for *L. oreganus* on the BLM Roseburg District. We found the habitat (plant community and abiotic environment) at *L. oreganus* populations to be extremely variable in Douglas County. Due to this lack of consistency, we are unable to provide key habitat characteristics to help focus survey efforts. Because the vegetation at most *L. oreganus* sites is disturbed, we suggest that additional characterization of soils at *L. oreganus* sites may be a useful and efficient approach for ranking future survey sites.

Reintroduction efforts of *L. oreganus* at select sites in Douglas County by Institute for Applied Ecology will begin in 2017, with seed collection and site identification and selection conducted in 2016, and a report detailing these activities will be available in 2017. Although not currently funded, monitoring of outplanted *L. oreganus* should be a high priority to determine establishment rates at each site and to inform future management/augmentation efforts.

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APPENDIX 1 GEAR LIST

Roseburg BLM Key
Last year's report
Last year's datasheets
Blank datasheets, some write-in-the-rain
Clipboards/pencils
Maps/gazetteer
5 tapes, at least one 100 m
8 candy canes
Rulers- one per person
Flagging
4-5 rebar and pin flags to replace lost/bent rebar
Extra plots tags/wire (for replacements as necessary)
Compass
Health and safety box – *double check for Tecnu*
Extra water
Bug spray (ticks are common, particularly at China Ditch and Letitia Creek)

APPENDIX 2. DETAILED SITE DESCRIPTIONS

Loose Laces

The population of *L. oreganus* at Loose Laces is located approximately 7 miles south of Riddle, OR, and 5 miles west of Interstate 5 (I-5). This population is composed of four subpopulations, which are considered two separate populations in ORNHIC. Two of the subpopulations occur on overgrown skid roads (subpopulations 1 and 2), one is on the cut-bank of a maintained roadside (subpopulation 3), and one occurs above a road cut bank (subpopulation 4). These sites range from 1,560–1,990' in elevation and are part of a proposed timber thin/sale. Significant thinning of small trees and shrubs occurred between the 2009 and 2010 monitoring of this population.

Letitia Creek

The *L. oreganus* population near Letitia Creek is about 11 miles east of Myrtle Creek, OR, and is concentrated along a ridge top dividing Letitia Creek and Long Wiley Creek at about 1,760' elevation. There are two populations on public land. One population is located on the border between public and private land, with most plants on private property (which IAE did not survey). At the other larger population, the monitoring system was originally established to track the population of *Eucephalis vialis* (nee *Aster vialis*; wayside aster) that co-occurs with *L. oreganus* (Kaye 1993). The monitoring transects follow a ridge-top road and most *L. oreganus* plants are within 10 m of the road. Most of the surrounding area, including the ridge top, was cut for timber 30-40 years ago (Kaye 1993). Significant thinning of small trees and shrubs occurred between the 2009 and 2010 monitoring and the 2010 and 2011 monitoring of this population.

Callahan Meadows

Figure 31. IAE field crew monitors *L. oreganus* at Letitia Creek.

Callahan Meadows is located just south of Tiller, OR, about 26 miles east of Canyonville and I-5. Two subpopulations of *L. oreganus* are located on a small section of public land adjacent to a privately grazed meadow. A fence was erected in 2004 to exclude livestock. Both of the subpopulations are relatively small, but this is the only known *L. oreganus* site on the Roseburg District that is not along a roadside and that has a plant community with potential nectar species to support Fender's blue butterfly. The meadow adjacent to the *L. oreganus* contains a diversity of

native forb species, including white brodiaea (*Brodiaea hyacinthina*), mule's ears (*Wyethia angustifolia*), checkermallow (*Sidalcea* spp.), and Hooker's silene (*Silene hookeri*).

China Ditch

The China Ditch population of *L. oreganus* is located near the China Ditch Historic Site, approximately 14 miles east and slightly north of Myrtle Creek, OR. There are three connected subpopulations, all of which intersect roadsides and the cut banks above and below roads, with almost full sun exposure. Some areas of the site have a patchy canopy of Douglas-fir (*Pseudotsuga menziesii)* and Pacific madrone (*Arbutus menziesii)*. This site has substantial shrub cover, especially of manzanita (*Arctostaphylos* spp.), poison oak (*Toxicodendron diversilobum)*, and oceanspray (*Holodiscus discolor)*. This area burned about 15 years ago, which may have stimulated extensive shrub re-sprout and re-growth. Significant thinning of small trees and shrubs occurred between the 2009 and 2010 monitoring of this population.

Dickerson Heights

The Dickerson Heights populations of *L. oreganus* are located about 9 miles southwest of Winston, OR, on a ridgeline adjacent to BLM road 29-7-3.0. There is a fairly dense overstory of *Pseudotsuga menziesii,* with some *Arbutus menziesii* and incense cedar (*Calocedrus decurrens)*. Native shrubs include *Toxicodendron diversilobum, Holodiscus discolor,* and *Arctostaphylos columbiana*. Native forbs include common whipplea (*Whipplea modesta)*, leafy pea (*Lathyrus polyphyllus)*, pink honeysuckle (*Lonicera hispidula)* and *Sidalcea* spp. Significant thinning of small trees and shrubs in the midstory occurred between the 2009 and 2010 monitoring of this population; however, the overstory canopy cover at the *L. oreganus* population has not changed significantly.

Stout's Creek

Stout's Creek is located about three miles south of Milo, OR, and is quite large both in terms of spatial extent and abundance of *L. oreganus*. The population extends over both BLM and private land, and we established monitoring transects in two of the subpopulations on public land. Subpopulation 1 includes several diffuse clusters of plants north of (above) the road. Subpopulation 2 is much larger and extends both above and well below the road.

The plant community in this area includes a sparse overstory/shrub layer of young *Pseudotsuga menziesii* and some *Arbutus menziesii* and deerbrush (*Ceanothus integerrimus)*. Native graminoids include California fescue (*Festuca californica)* and blue wildrye (*Elymus glaucus)*. Introduced grasses include orchard grass (*Dactylis glomerata)*, silver hairgrass (*Aira caryophyllea)*, and soft chess (*Bromus hordeaceus)*. Shrub species include *Toxicodendron diversilobum, Holodiscus discolor,* salal (*Gaultheria shallon)*, holly leaved barberry (*Mahonia aquifolium)* and snowberry (*Symphoricarpos albus)*. Native forbs include *Whipplea modesta,* desert deervetch (*Lotus micranthus)*, strawberry (*Fragaria virginiana)*, Tolmie's startulip (*Calochortus tolmiei)*, *ookow (Dichelostemma congestum)*, western brackenfern (*Pteridium aquilinum)*, and hairy Indian paintbrush (*Castilleja tenuis)*. Introduced forbs include European centaurea (*Centaurium erythraea)* and Queen Anne's lace (*Daucus carota*). Significant thinning of small trees and shrubs occurred between the 2009 and 2010 monitoring of this population but not at the subpopulation 2 Roadside plot.

APPENDIX 3 DIRECTIONS AND MAPS TO SITE LOCATIONS

Loose Laces

- From I-5, take Exit 103 and head west towards Riddle, Oregon
- After 2.4 miles, turn left on to Main Street
- After 0.7 miles, turn right on Glenbrook Loop (right after bridge)
- After 1.8 miles turn left on the Shoestring Road
- After 1.2 miles take a right on Silver Butte Rd (BLM # 30-6-35.1)
- After another 0.5 miles, take right at Y
- After 1.2 miles (0.7 miles past Y), take a pullout to the right, park and walk around a brushy area onto an old skid road to reach subpopulation 1.
- To reach subpopulation 2, continue driving on the 30-6-35 road 0.7 miles more, then pullout on the right. The pullout is just below where the road forms a "Y" and subpopulation 3 begins. Subpopulation 2 is on the right side, roughly 10-15 m below the road, on a small, flat area that may be an old skid road.
- To reach subpopulation 3, continue up the 30-6-35.1 road to the "Y", the fork to the east is BLM #31-6-3. Continue on the west fork of the road (30-6-35.1). Subpopulation 3 begins on the left (east) side of the road.
- Subpopulation 4 is on the left (east) side of the road fork to the west (right), above the cut bank and approximately 100 m from the previously mentioned intersection.

Letitia Creek

- From I-5, take the Myrtle Creek Exit
- Go east to Myrtle Creek
- Turn left on 3rd St, after two blocks 3rd will merge into Division St., turn Right.
- After ~.7 miles veer right onto S. Myrtle Rd.
- Drive east about 11.1 miles to Letitia Creek Road (BLM # 29-3-20.1), between mile marker 11 and 12
- Stop at road with locked gate that is just past a creek and ***just before a white barn/aluminum building***
- Go north (left) through a locked gate at the beginning of Letitia Creek Road for 0.5 miles.
- Just after crossing a bridge, head left up a small dirt road, you will pass through a 'gate' (a wire hung between two posts).
- Hike about 1.0 mile to the ridge. On the right, there will be a small spur road that runs approximately along the ridge (If you reach a clear-cut, you have gone too far).
- Hike about 0.8 miles to the larger *L. sulphureus* ssp. *kincaidii* population, passing the smaller subpopulation on the way on the boundary between public and private land.

Callahan Meadows

To reach this site from Canyonville, OR (I-5 Exit 98), turn left on SE Third to head out of town (east). This road becomes Highway 1. After 25.9 miles, there is a right turn over a bridge onto road 3230. Continue for an additional 3 miles, then turn right on road 3220, and then after 1.5 miles turn right onto road 3220-300. In another 0.2 miles, the road veers right onto dirt (road 3220-320), passes through a gate after 0.8 more miles, and then veers right in another 0.6 miles. Park at the end of the road (to the left side of a large rock pile/pseudo-quarry) and head down slope, following the west (left) edge of a large meadow. The *L. sulphureus* ssp. *kincaidii* population occurs under the drip line of black oak (*Quercus kelloggii)* trees on the edge of the meadow at 1,998' in elevation. Another, smaller subpopulation occurs ~200 m north of this location, just before the land begins to slope more steeply and was first monitored for this project in 2004.

China Ditch

To reach the China Ditch site, take I-5 to the Myrtle Creek exit (108), and follow it into town. Turn left onto 3rd St. (and start the odometer) at the Chevron gas station on the left side. After 0.1 miles, turn right on Division Street (the first stop sign). Continue on Division, then after 0.7 miles, veer left on to N. Myrtle (county road 15). After about 12.4 miles, you will pass over a bridge, and then at 12.7 miles, turn left onto the 28-4-13.2 road. At the first split in the road, at about 13.1 miles, take a left onto the 28-4-13.3 road. Continue on this road until you reach a total of 13.6 miles, Patch C roadside (previously "subpopulation 3") will be on the right. To reach the Patch A roadside (previously "subpopulation 2"), continue up the road < ¼ mile. Continue up the road to the fork and park by the spur road off to the right. To reach Patch A, transects 1-3 (transect 1 was previously known as "subpopulation 2, representative transect"), walk west on a faint trail along the small ridge, approximately 200 m. Patch A Transect 1 is near the road cut, Transect 2 is near the top of the ridge, and Transect 2 is approximately 60 m south of Transect 2. For Patch D roadside, (previously "subpopulation 1"), walk up the spur road approximately 1/8 mile. Patch D Transect 1 is on the slope above the roadside transect. Patch C Transects 1 and 2 are located approximately mid-way between the spur road and 28-4-13.3. To access these transects, walk approximately 100 meters, then walk downslope.

Dickerson Heights

From I-5 south, either:

Take exit 112 a total of 3.2 miles to Highway 42, (passed Roseburg Lumber and Particleboard Plant). Turn left onto Hwy 42 West (turn will be in downtown Winston).

OR

Take exit 119 to Highway 42 to Winston (3.4 miles). Turn right onto Hwy 42 West.

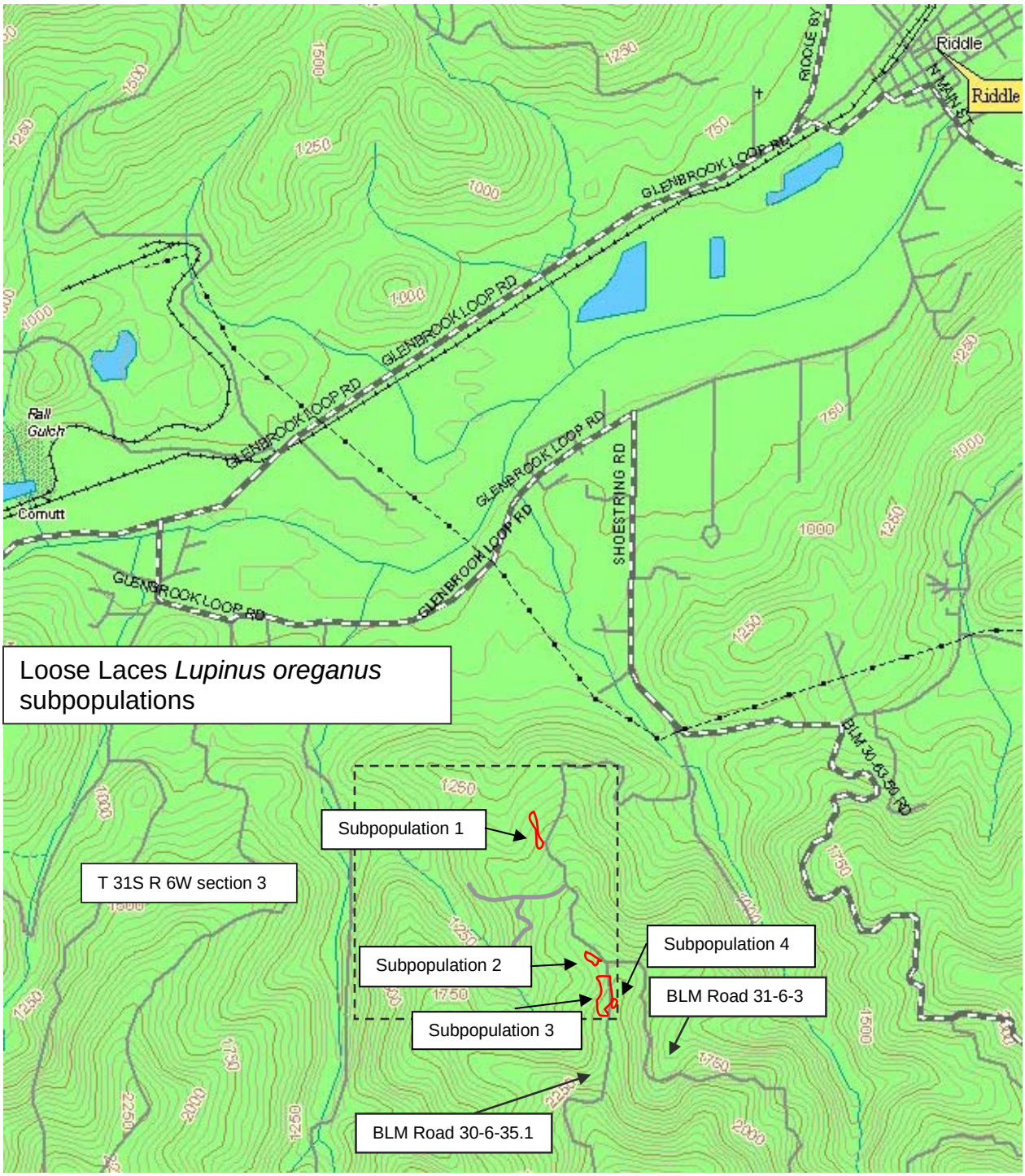
THEN:

- Stay on Hwy 42 for 7.2 miles

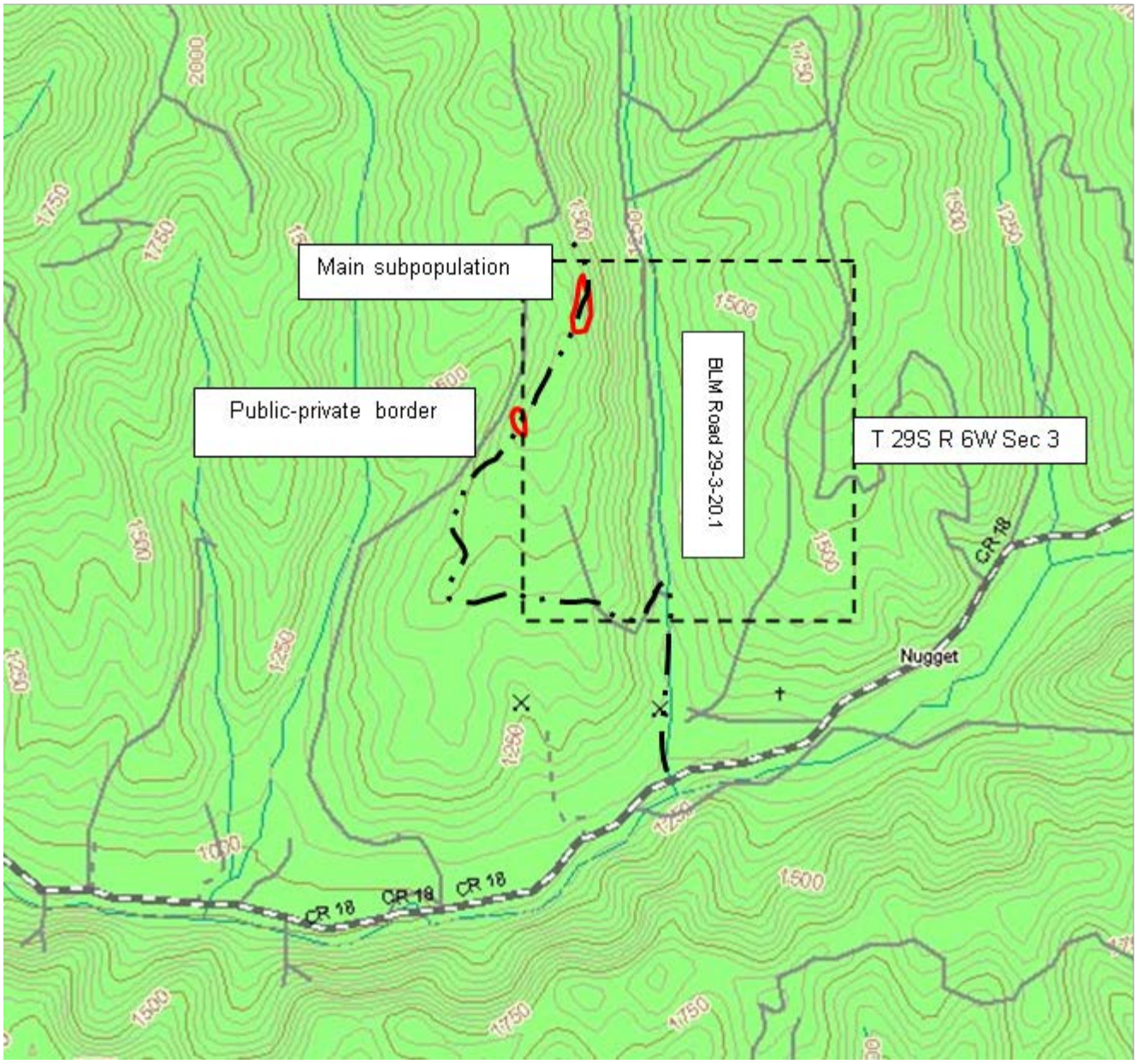
- From either starting point, turn left on Hoover Hill Road. (~1 miles outside of Winston) ***start odometer***
- After 2 miles, turn left at the stop sign onto Ollala Road.
- After 0.6 miles, turn left on BLM road 29.7.3 (sign says 2880)
- Stay on this road for 3.4 miles
- Population will be on your left (east side of the road)

Stouts Creek

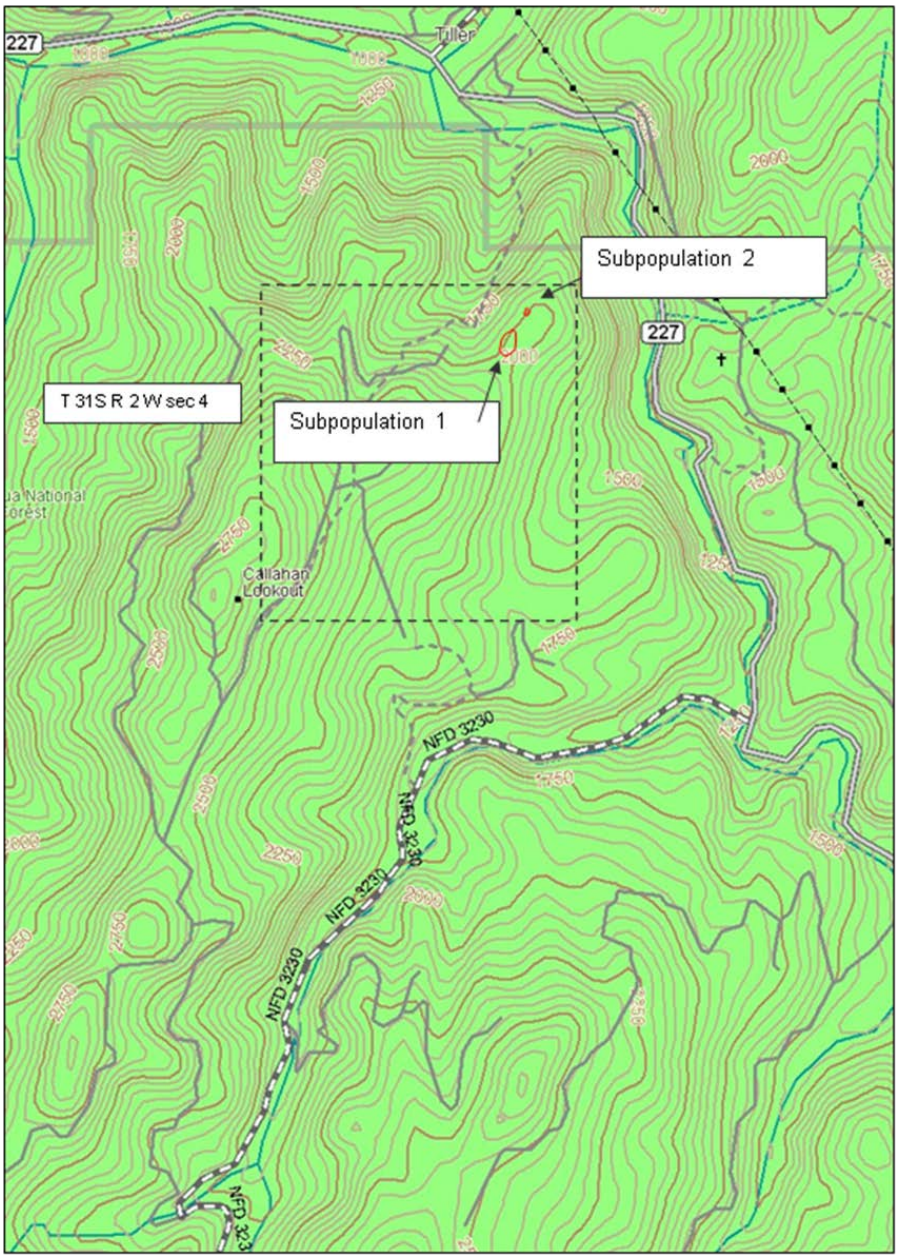
To reach this site from Canyonville, OR (I-5 exit 98), turn left on SE 3rd to head out of town (east). This road becomes Highway 1. After about 16.6 miles (just before Milo), turn right onto Stout's Creek Road. At 0.2 miles, stay left on Stout's Creek Rd, do not turn onto Ferguson (which veers to the right). Stay on Stout's Creek for a total of 1 mile and then veer right. At 1.5 miles stay left, go through yellow gate that is usually open (only if you have the key, can you get through this gate; otherwise, you have to hike in), and at 1.6 stay left. Stay on this road until a total of about 2.75 miles to reach subpopulation 1 (above road on right). At 2.9 miles (total), turn left and at about 3.1 miles you will reach subpopulation 2 (above and below road).



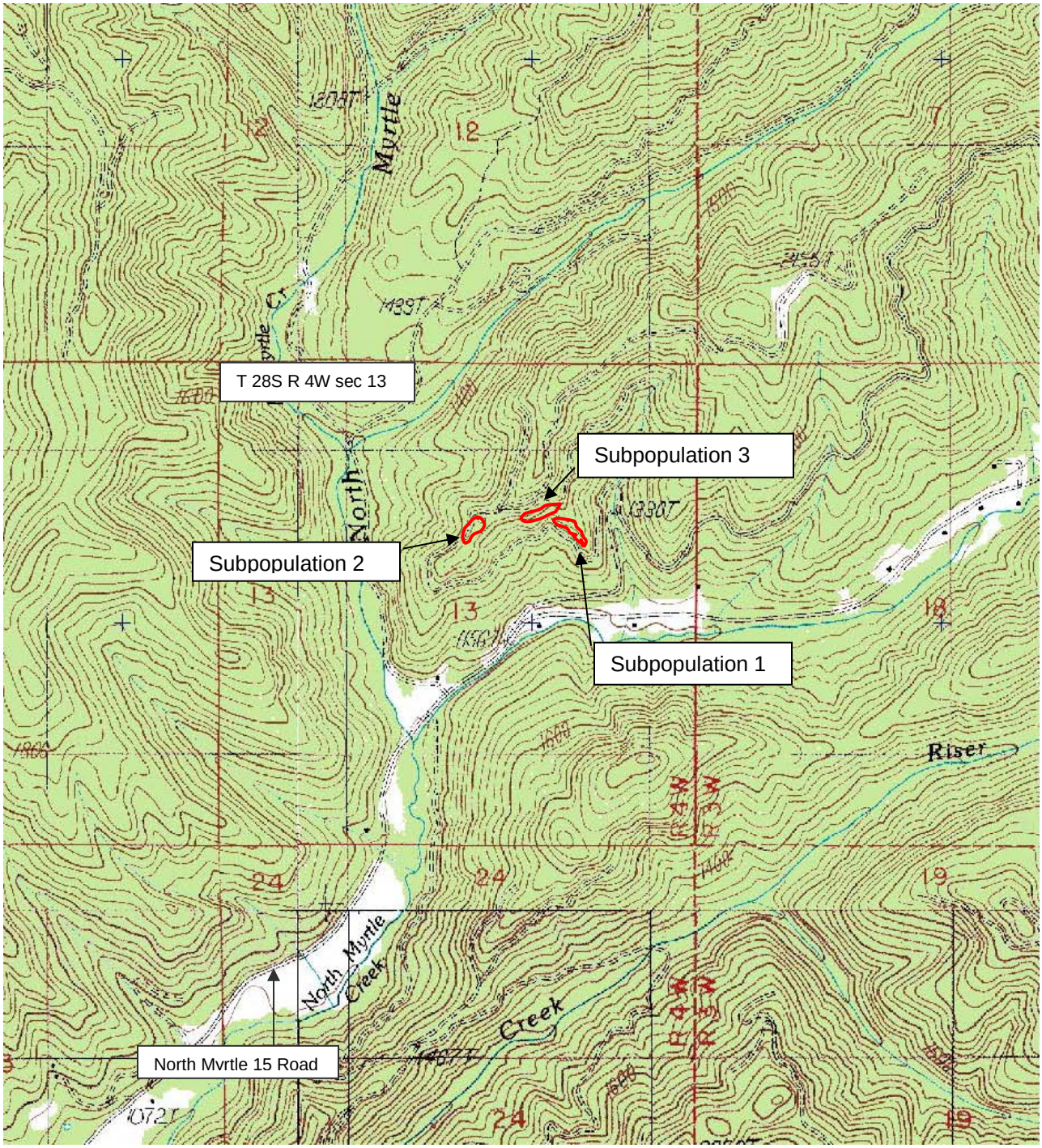
Map 1. Map showing location of Loose Laces site (T 31S R 6W sec 3). Approximate subpopulation locations are circled in red and labeled.



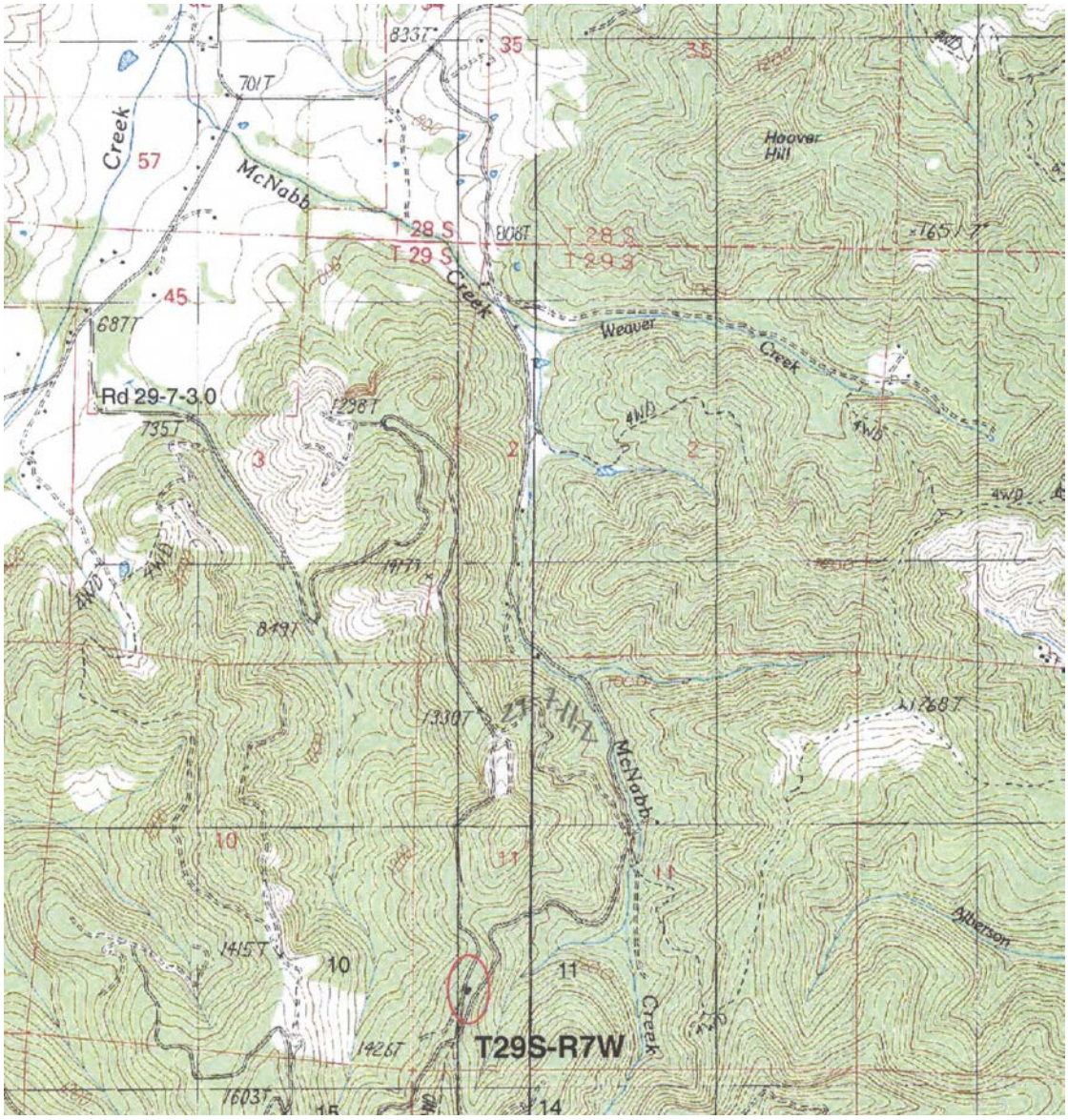
Map 2. Map location of Letitia Creek site (T 29S R 3W sec 17). Red circles indicate subpopulation locations on public land. The subpopulation further north is the larger population *where L. oreganus* co-occurs with *E. vialis*.



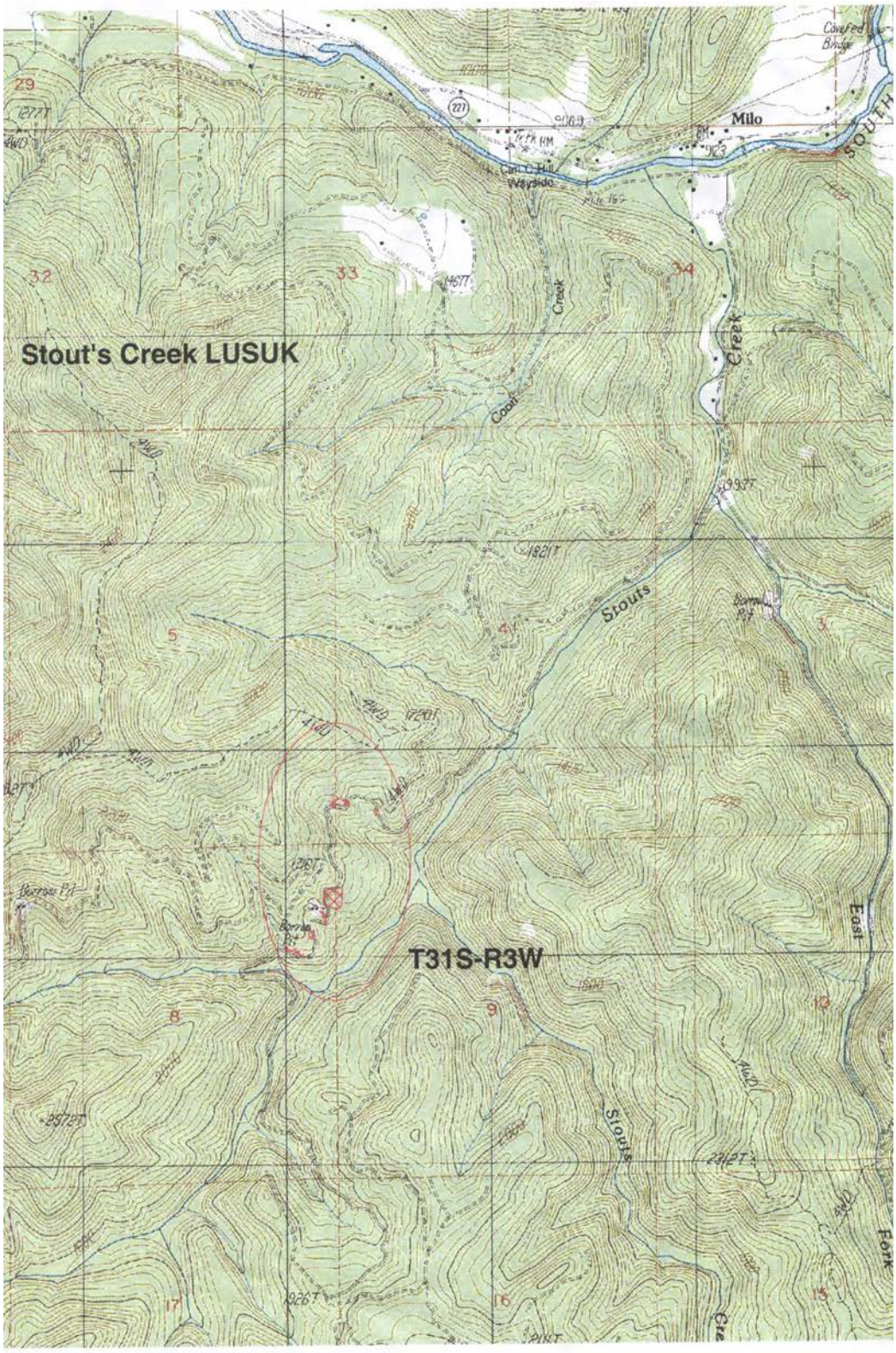
Map 3. Location of Callahan Meadows site (T 31S R 2W sec 4). We monitored the southern population in 2003 and 2004 (circled in red). It is under the drip line of oaks on the upper meadow edge. The population located further north on the meadow edge was relocated in 2004 and now has a monitoring transect established through it.



Map 4. Location of the China Ditch population (T 28S R 4W sec 13). Red circles indicate approximate subpopulation locations.



Map 5. Location of Dickerson Heights population (T 29S R 7W sec 11).



Map 6. Location of Stout's Creek populations (T 31S R 3W sec 5, 9).

APPENDIX 4. LEAF AND RACEME TOTALS FOR *LUPINUS OREGANUS* POPULATIONS MONITORED BETWEEN 2003 AND 2008.

Population	2003 Leaves	2003 Racemes	2004 Leaves	2004 Racemes	2005 Leaves	2005 Racemes	2005 Cover (m^2)	2006 Leaves	2006 Racemes	2006 Cover (m^2)	2007 Racemes	2007 Cover (m^2)	2008 Racemes	2008 Cover (m^2)
LOOSE LACES TOTAL	**20,102.0**	**684.0**	**15,312.0**	**373.0**	**13,664.0**	**762.0**	**34.7**	**n/a**	**316.0**	**25.5**	**418.0**	**11.5**	**554.0**	**15.8**
Subpopulation 1	5,032.0	148.0	4,243.0	119.0	4,314.0	180.0	13.5	n/a	33.0	3.3	0.0	-	101.0	3.2
Subpopulation 2	1,883.0	31.0	1,287.0	15.0	1,399.0	53.0	4.0	978.0	3.0	2.5	0.0	-	35.0	1.1
Subpopulation 3	10,132.0	432.0	7,345.0	214.0	5,760.0	473.0	14.9	n/a	231.0	15.0	405.0	10.9	405.0	10.9
Subpopulation 4	3,055.0	73.0	2,437.0	25.0	2,191.0	56.0	2.3	1,829.0	49.0	4.7	13.0	0.7	13.0	0.7
LETITIA CREEK TOTAL	**4,162.0**	**200.0**	**3,351.0**	**55.0**	**3,861.0**	**149.0**	**7.8**	**n/a**	**72.0**	**8.1**	**128.0**	**5.6**	**125.0**	**5.0**
Subpopulation 1	187.0	2.0	189.0	1.0	267.0	4.0	0.4	n/a	3.0	0.6	6.0	0.5	3.0	0.5
Subpopulation 2	3,975.0	198.0	3,162.0	54.0	3,594.0	145.0	7.4	n/a	69.0	7.5	122.0	5.0	122.0	4.5
CALLAHAN MEADOWS TOTAL	**2,506.0**	**191.0**	**2,666.0**	**57.0**	**2,311.0**	**169.0**	**7.5**	**3,466.0**	**131.0**	**8.5**	**394.0**	**10.4**	**566.0**	**8.4**

Subpopulation 1	2,506.0	191.0	2,471.0	57.0	2,134.0	168.0	6.9	3,249.0	131.0	8.2	394.0	10.2	565.0	8.2
Subpopulation 2	-	-	195.0	0.0	177.0	1.0	0.7	217.0	0.0	0.3	0.0	0.2	1.0	0.2
STOUT'S CREEK TOTAL[1,2]	**-**	**-**	**-**	**-**	**12,191.0**	**257.0**	**22.0**	**n/a**	**219.0**	**21.2**	**196.0**	**13.4**	**243.0**	**7.6**
Subpopulation 1														
Transect A	-	-	-	-	248.0	5.0	0.5	116.0	4.0	0.3	2.0	0.2	8.0	0.1
Transect B	-	-	-	-	927.0	10.0	1.3	301.0	0.0	0.7	1.0	0.4	6.0	0.2
Transect C	-	-	-	-	631.0	5.0	1.0	375.0	5.0	0.9	1.0	0.3	2.0	0.1
Transect D	-	-	-	-	763.0	15.0	2.0	621.0	11.0	1.0	19.0	1.0	12.0	0.3
Subpopulation 2														
Above the road	-	-	-	-	4,439.0	96.0	7.1	n/a	110.0	8.2	118.0	6.4	88.0	3.8
(Below the road) Plot 1	-	-	-	-	1,272.0	41.0	3.0	1,397.0	30.0	3.4	26.0	1.9	33.0	0.7
(Below the road) Plot 2	-	-	-	-	487.0	7.0	0.9	n/a	8.0	1.1	7.0	0.8	24.0	0.7
(Below the road) Plot 3	-	-	-	-	3,424.0	78.0	6.0	n/a	51.0	5.6	22.0	2.4	70.0	1.7
CHINA DITCH TOTAL[2]	**-**	**-**	**16,278.0**	**369.0**	**15,334.0**	**784.0**	**18.0**	**13,111.0**	**586.0**	**21.2**	**625.0**	**18.3**	**990.0**	**18.0**
Patch A														
Roadside (prev. Subpop. 2)	-	-	3,065.0	78.0	3,197.0	166.0	4.0	2,348.0	70.0	3.4	**150.0**	**3.4**	**242.0**	**4.9**
Transect 1 (prev. rep. Transect 1)	-	-	1,058.0	17.0	715.0	14.0	1.8	994.0	20.0	2.0	21.0	2.0	63.0	1.7
Transect 2[3]	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Transect 3[3]	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Patch C														
Roadside (prev. Subpop. 1)	-	-	6,396.0	147.0	6,243.0	257.0	9.4	7,039.0	302.0	10.1	364.0	9.6	544.0	9.8
Transect 1[3]	-	-	-	-	-	-	-	-	-	-	-	-	-	-

Transect 2[3]	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Patch D														
Roadside (prev. Subpop. 3)	-	-	5,759.0	127.0	5,179.0	338.0	8.7	6,072.0	284.0	11.1	261.0	8.7	446.0	8.2
Transect 1[3]	-	-	-	-	-	-	-	-	-	-	-	-	-	-
DICKERSON HEIGHTS TOTAL[1]	-	-			**8,096.0**	**259.0**	**18.2**	**10,598.0**	**168.0**	**17.3**	**189.0**	**14.9**	**618.0**	**15.5**
GRAND TOTALS	**26,770.0**	**1,075.0**	**37,607.0**	**854.0**	**55,457.0**	**2,380.0**	**108.0**	**n/a**	**1,492.0**	**101.8**	**1,950.0**	**74.1**	**3,096.0**	**70.3**

APPENDIX 5. POLLEN TRANSFER METHODS AND RESULTS

Objective:

- *Study the effects of pollen transfer on seed production at Callahan Meadows (2008-2009).*

Introduction

The *L. oreganus* population at Callahan Meadows suffers from chronic reproductive failure despite the production of numerous flower stalks. No fruits were observed 2004 through 2006; one fruit was observed in 2008, however the seeds contained were not viable. This chronic lack of reproduction may be the result of poor genetic diversity at this site, especially if the patch of plants represents a single clone. In 2008 and 2009, we transferred pollen from the closest population (within about one mile on land managed by the US Forest Service), Stout's Creek (managed by the BLM) and within the population to determine if importation of pollen from an adjacent genetic neighborhood would result in seed production.

Methods

The pollen transfer study was conducted in June and July of 2008 and 2009. *L. oreganus* inflorescences were collected from two neighboring populations: "The Ridge," approximately one mile away on land managed by the U.S. Forest Service and Stout's Creek (discussed in this report). Five inflorescences were collected from each population for a total of ten inflorescences. Cut stems were wrapped in moistened paper towels and placed in plastic bags for transport to Callahan Meadows. Inflorescences were randomly assigned one of four pollen transfer treatments: geitonogamy (crossing within an inflorescence), Ridge x Callahan, Stout's Creek x Callahan or Callahan x Callahan (within patch crossing; Table 5). A total of 75 inflorescences were treated. For each treated inflorescence, we extracted pollen using forceps and transferred it to the stigmas of three flowers. Forceps were washed with hydrogen peroxide between the pollination of each inflorescence. Treated flowers were tied with a colored string to indicate the treatment, and a numbered paper tag and pink flagging were tied around each treated inflorescence (Figure 32). We placed mesh bags over roughly half of the treated inflorescences to prevent herbivory; no bags were placed on the within-patch crosses. Treated inflorescences were revisited approximately four weeks later to determine fruit set success.

2008- Callahan Meadows		
Treatment	**# treated (# bagged)**	**Thread Color**
Geitonogamy	20 (13)	Black
Ridge x Callahan	25 (13)	White
Stout's Creek x Callahan	25 (13)	Gold
Callahan x Callahan (within-patch)	5 (0)	Blue
2009- Callahan Meadows		

Treatment	# treated (# bagged)	Thread Color
Geitonogamy	20 (10)	Green
Ridge x Callahan	20 (10)	Red
Stout's Creek x Callahan	20 (10)	Blue
Callahan x Callahan (within-patch)	5 (5)	White

2009-Callahan Ridge

Treatment	# treated (# bagged)	Thread Color
Geitonogamy	5 (5)	Green
Ridge x Callahan	10 (10)	Red
Stout's Creek x Callahan	5 (5)	Glue
Ridge x Ridge (within-patch)	5 (5)	White

Results

No mature fruits were produced in any of our pollen transfer treatments at Callahan Meadows in 2008 or 2009 (Table 5). During these studies, we observed a large proportion of the flowers at Callahan Meadows being fed upon by thrips. The thrips, in turn, were being fed upon by Syrphid flies. Blister beetles (Meloidae family) observed on the flowers were most likely pollinating the flowers (J. Young, pers. comm.).

Discussion

The lack of fruit development at Callahan Meadows may be related to pollination limitation, insufficient diversity of mating genotypes or resource limitation (Wilson et al. 2003). Since this pattern appears to be consistent across many years with cover increasing in most years, resource limitation is unlikely to be what limits this population. In comparison to the other *L. oreganus* populations monitored in the area, Callahan Meadows also has the greatest diversity and abundance of native plant species to attract pollinators; therefore, pollinator limitation is unlikely the limiting factor. However, experimental transfer of pollen from within the population and from two large populations of *L. oreganus* failed to result in successful fruit production, suggesting that reproductive failure at this site is most likely not due to low genetic diversity. Recent analyses have found that the population of *L. oreganus* at Callahan Meadows is polyploid (Severns 2008). Polyploidy may limit the ability to successfully fertilize eggs if pollen is from a population with a different ploidy level. The rhizomatous nature of the plants at Callahan Meadows and finding of only one cpDNA haplotype in the population (Severns 2008) suggests that these plants may be closely related. Thus, although fertilization from individuals in the population with the same ploidy level might lead to successful reproduction, this may not be possible due to self-incompatibility. Repetition of the pollen transfer study in 2009 again resulted in no viable fruits independent of pollen source, providing further support that even the population is not only incompatible with other *L. oreganus* populations, but is also self-incompatible.

Figure 32. A) Flowers that failed to develop fruits in the pollen transfer experiment at Callahan meadows, b) D. Giles performing the pollen transfer at Callahan Meadows, and c) raceme after pollination treatment.