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

2013

Report to the Bureau of Land Management, Roseburg District

Report prepared by Denise E.L. Giles-Johnson

Institute for Applied Ecology

PREFACE

This report is the result of a cooperative Challenge Cost Share project 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.

Questions regarding this report or IAE should be directed to:

Denise Giles-Johnson

Institute for Applied Ecology

PO Box 2855

Corvallis, Oregon 97339-2855

phone: 541-753-3099

fax: 541-753-3098

email: denise@appliedeco.org

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Cover photograph: Kincaid's lupine (*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* on the BLM Roseburg District. In 2013, the eleventh year of the project, we monitored *L. oreganus* populations by assessing foliar (leaf) cover (a measure of abundance) and counting racemes, and numbers of fruits produced at a total of six sites on the Roseburg District. Data collected this year are from the ninth year of monitoring at Dickerson Heights and Stout's Creek, the tenth year of monitoring at China Ditch, and the eleventh year of monitoring at Loose Laces, Letitia Creek, and Callahan Meadows.

- From 2012 to 2013, foliar cover increased at China Ditch, Loose Laces and Stout's Creek sub-popualtion 2. Foliar cover of lupine decreased at Stout's Creek sub-population 1and Callahan Meadows, while remaining relatively stable at Dickerson Heights. (Letitia Creek was not monitored in 2013 due to the presence of a squatter camp in the vicinity.

- The number of racemes from 2012 -2013, increased at two sites (Loose Laces and Stout's Creek Sub-population 2) and decreased at Callahan Meadows, China Ditch, Dickerson Heights, Letitia Creek and Stout's Creek Sub-population 1.

- At Letitia Creek, both foliar cover and raceme count have declined precipitously since monitoring began in 2003. Since 2006 cover has steadily declined from more than $8m^2$ of foliar cover to just more than $1m^2$ in 2011. In 2012 foliar cover increased slightly to $1.5m^2$, however only 2 inflorescences were present at the site and no fruits were formed on either raceme. The site was not monitored in 2013 due to the presence of a squatter camp in the vicinity.

- The number of fruits/raceme in 2013 ranged from 2.9 – 6.0 (Stout's Creek and Loose Laces respectively). No viable fruits have ever been found at Callahan Meadows.

- In 2012 and 2013, meadow knapweed (*Centaurea pratensis)* was found along the roadside at China Ditch near the end of the Patch C Roadside transect. All flowering individuals were removed by IAE staff, however it is recommended that the area continue to be monitored for the noxious weed which could quickly invade the surrounding lupine population.

TABLE OF CONTENTS

LIST OF FIGURES

Figure 31. a) Flowers that failed to develop fruits in the pollen transfer experiment at Callahan Meadows, b) D. Giles-Johnson performing the pollen transfer at Callahan Meadows, c) raceme after pollination treatment. Photo: D. Giles-Johnson and A.S. Thorpe.

LIST OF TABLES

LIST OF MAPS

LIST OF APPENDICES

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 lupine; Figure 1), in the Roseburg District of Bureau of Land Management.

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

Species Status

Lupinus 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

Lupinus 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 protections provided by state and federal listing, increasing the importance of management by state and federal agencies on public land. Only 14 populations of *L. oreganus* exist 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 indicates a goal of 5,000 m^2 of occupied habitat consisting of at least two meta-populations.

Within the Willamette Valley, *L. oreganus* is a larval host plant for the endangered Fender's blue butterfly, making conservation of the lupine important for the lupine itself as well as the insect (Schultz et

al. 2003). Although there are no known sightings of Fender's blue in Douglas County, it is not known whether the two species co-occurred historically in that area.

Reproduction and Population Biology

Lupinus 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. *Lupinus 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).

- 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

We monitored six locations of L. oreganus) in the Southriver Resource Areas of the Bureau of Land Management Roseburg District which encompasses all Kincaid's lupine on BLM land in Douglas County: Loose Laces, Letitia Creek, Callahan Meadows (near Tiller), China Ditch (near the Historic Site northeast of Myrtle Creek), Dickerson Heights (southwest of Winston), and Stout's Creek (south of Milo). These six sites encompass all eight ORBIC occurrences of the Kincaid's lupine found on BLM land in Douglas County.

For complete site descriptions see Appendix 3

Figure 2. Monitoring *L. oreganus* along a roadside at Loose laces

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 sub-populations(Figure 11). Since each site, population or subpopulation differs in shape, size and density, different plot layouts were used for each population. Monitoring plots in units or transect segments allows 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.

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. 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). 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)

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, 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 5). 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-#514) was positioned closest to the road and the second transect (tag #517-#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

(2 subpopulations, monitoring established in 2003, Census)

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 *Aster vialis*, including additional "road" plots # 0-10 between *A. vialis* plots (Figure 7).

Callahan Meadows

(2 subpopulations, monitoring established in 2003 and 2004)

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 (most 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

(3 subpopulations & 1 transect established in 2004; 5 additional transects established in 2010)

This site was first located in 2003, and 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 China Ditch population and greatly improved access to the non-roadside patches. In 2010, we established five additional transects in non-roadside patches (Figure 10). These transects were placed in order to capture the variability in lupine 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 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 11). 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 25m long, and is marked by short and tall conduit at the beginning (E) and end (W) of the transect,

respectively. 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 1.5m 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 25m long, and captures more of the steep slope population. The beginning (E) and end (W) of the transect are marked by short and tall conduit, respectively. All *L. oreganus* within 1.5m to the north and south of the transect were monitored.

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. 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, and most plants were on the east side of the tape, on the east side of the road. There were a few plants on the east side of the road, but west side of the tape that were sampled. On the east side of the tape, 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 transect 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;). 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 25m long at 204°. 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 1.5m 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 25m long at 204°. 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 1.5m to the east and west 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 (). 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 25m long. Short and tall conduit mark the beginning and end of the transect, respectively. All *L. oreganus* within 1.5m 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 lupine cover in the subpopulation.

Dickerson Heights

(One population, monitoring established in 2005)

At this site, a 15m x 23m plot encompasses most of the population at the site (Figure 16). The plot is divided into a grid of 30 2 m x 5 m and two 1 m x 5 m segments, in which we count leaves and racemes. We also count leaves and racemes of plants not included in the plot, since they are on the cut bank between the plot and the road. Since 2007, foliar cover is estimated for the entire population above the cut bank as well.

Stout's Creek

(Two subpopulations, monitoring established in 2005)

Subpopulation 1: Four transects encompass all *L. oreganus* plants in this area Figure 18). 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 5 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: Above road 30-3-34, 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 runs 130 m. Most patches of *L. oreganus* were marked with red and blue pin flags and in cases where plants were found several meters beyond the crest of the road bank, we used flagging (blue dots on white) on nearby shrubs to assist in relocation. Plants are within 20 m of road. In 2009, few flags remained, and plants had shifted significantly from where flagging and pin flags were set in 2005. Placing pin flags and flagging should be repeated in 2010.

Below the road, we established three monitoring plots (Figure 20) Plot 1 is 10 m x 10 m, divided into four 5 m x 5 m segments, Plot 2 is 5 m x 7 m, divided into seven 1 m x 5 m segments and Plot 3 is 10 m x 5 m, divided into ten 1 m x 5 m segments.

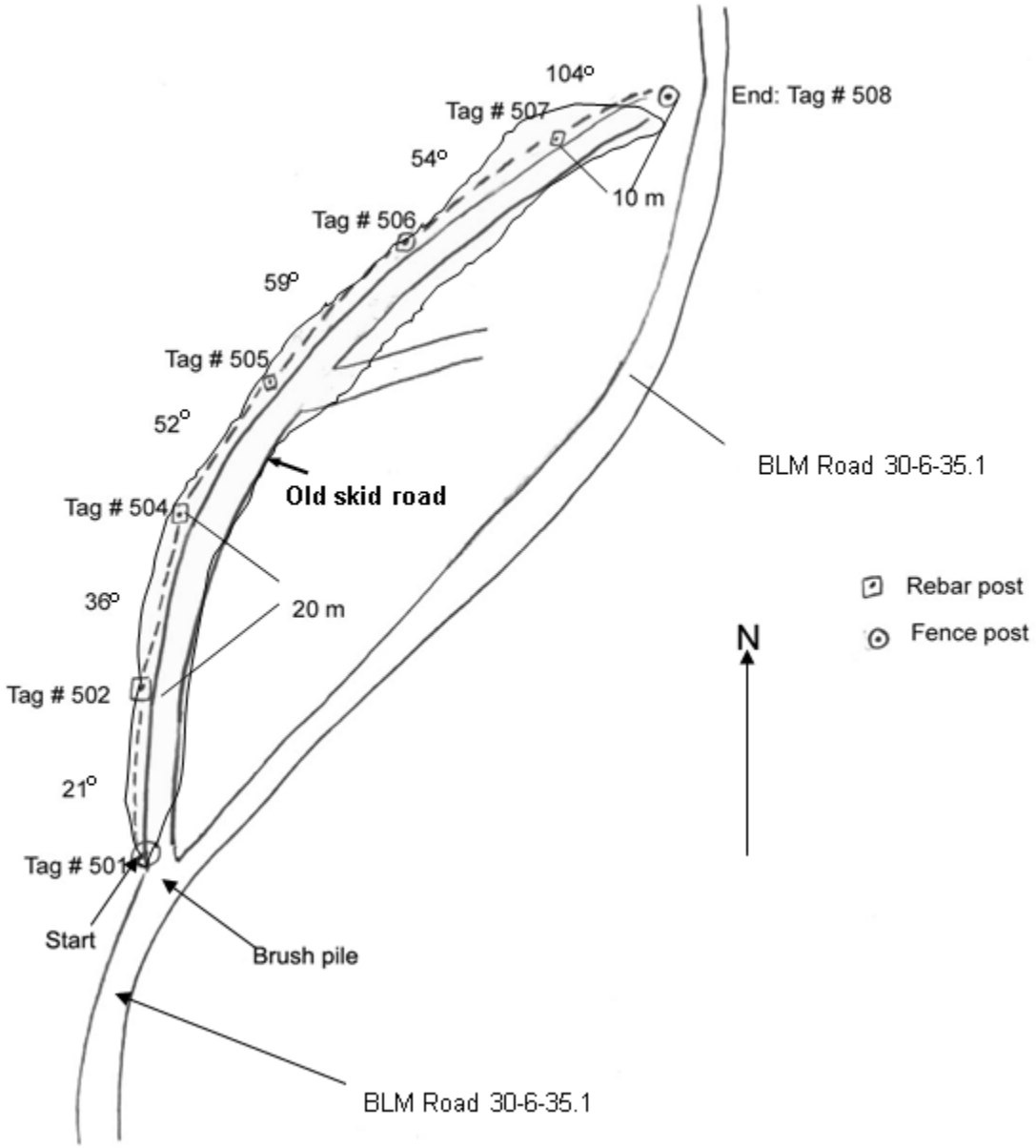

Figure 3. Diagram of Loose Laces *L. oreganus* subpopulation 1. The general outline of the population is shown in the shaded area. Start and end points of the reference transect are marked with tagged fence posts. Each 20 m segment of the transect is marked with tagged rebar posts. The final segment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

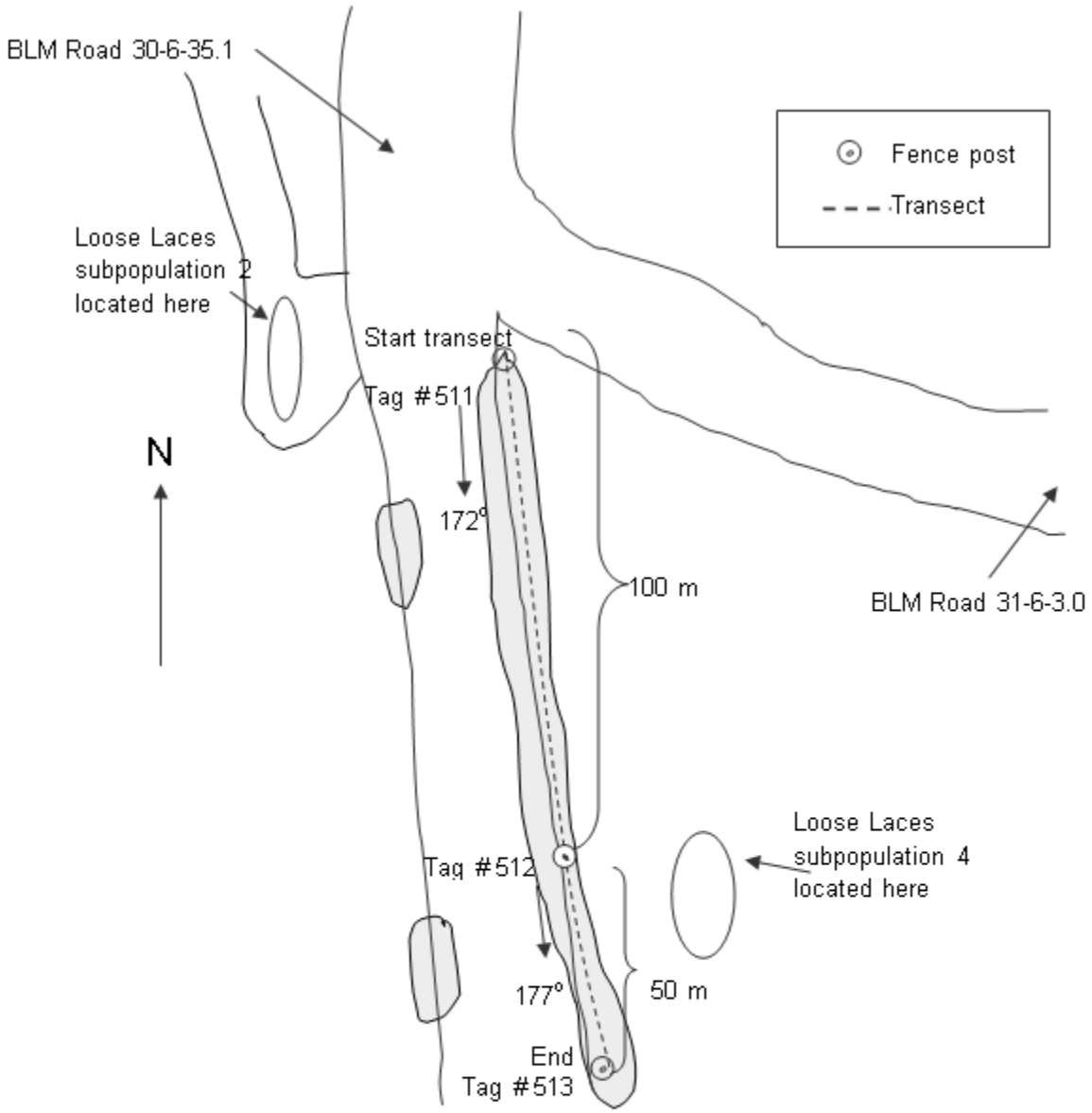

Figure 4. Diagram of Loose Laces *L. oreganus* subpopulation 3 monitoring transect layout. Approximate subpopulation border is shaded. Total transect length is 150 m. All leaves and racemes were counted on both sides of the transect in (including those on the west side of the road).

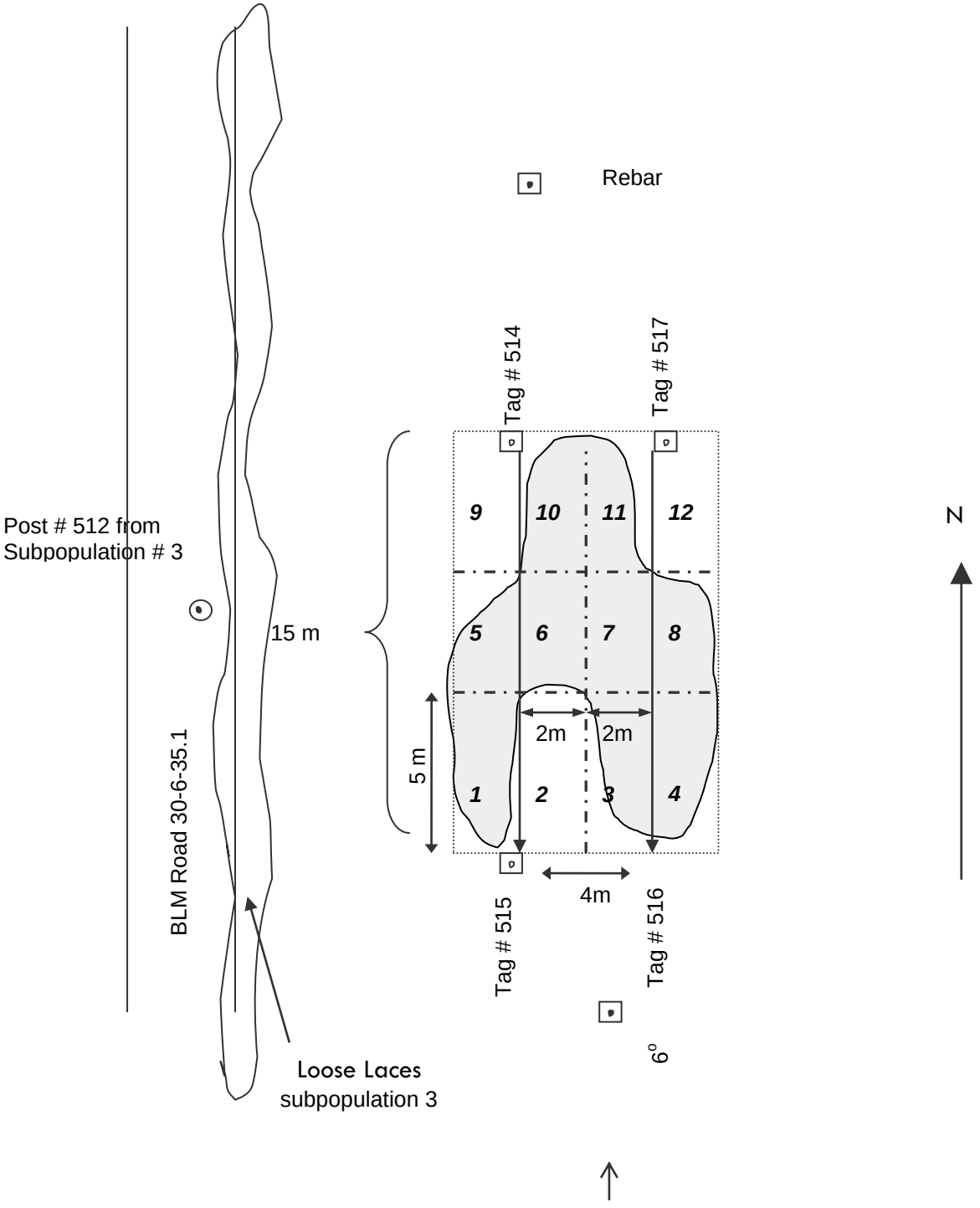

Figure 5. Diagram of Loose Laces *L. oreganus* subpopulation 4 monitoring transect layout. Approximate subpopulation border is shaded. There are two 15 m reference transects that are 4 m apart. All leaves and racemes were counted on both sides of both transects in 5 m segments, numbered as they are here.

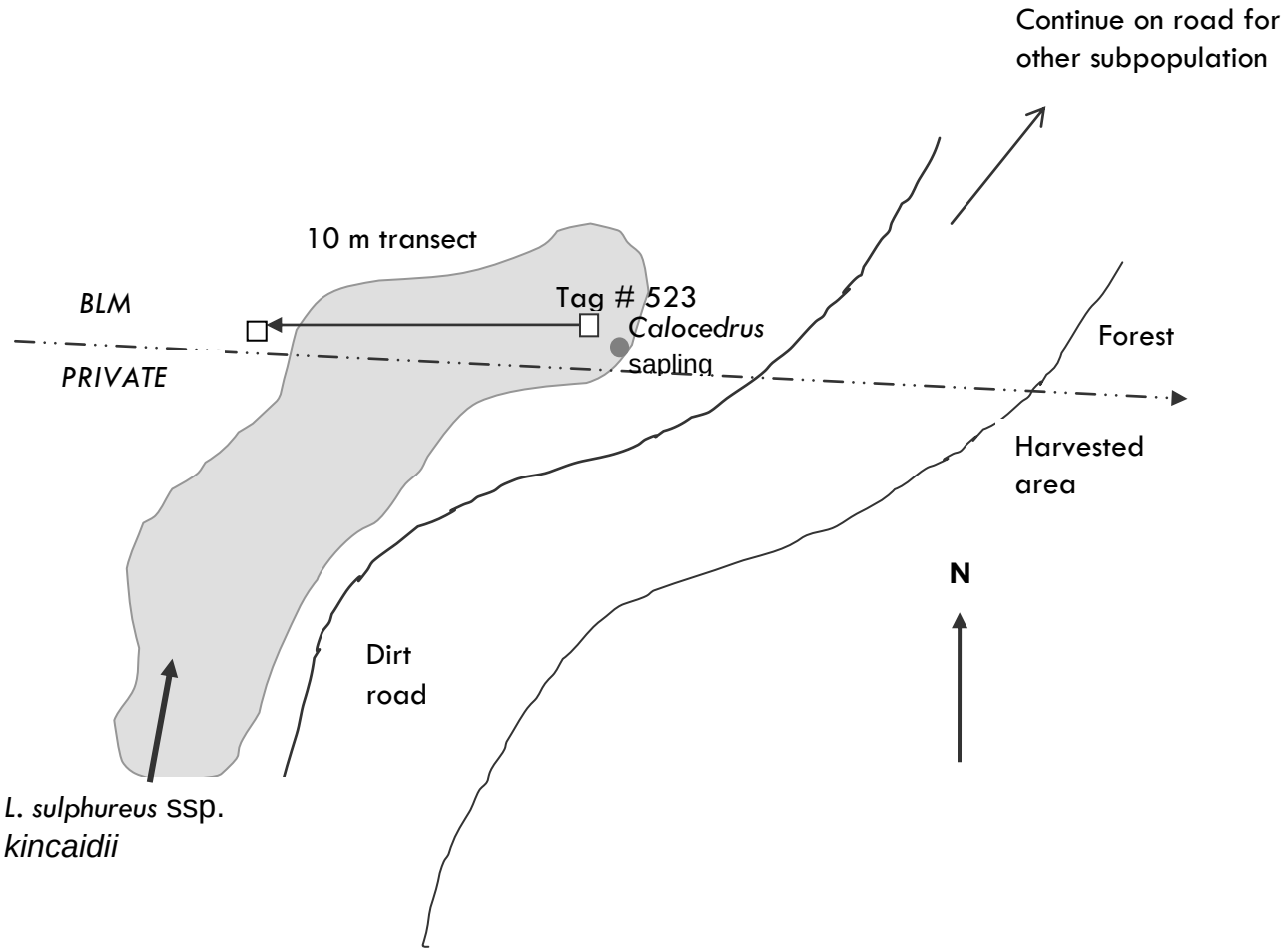

Figure 6. Diagram of the smaller Letitia Creek subpopulation, located on border between public and private land, south of the main, larger subpopulation. We established a 10 m transect heading due west. The *L. oreganus* plants are located in two main areas on BLM land: 4 m north and 1 m west of rebar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

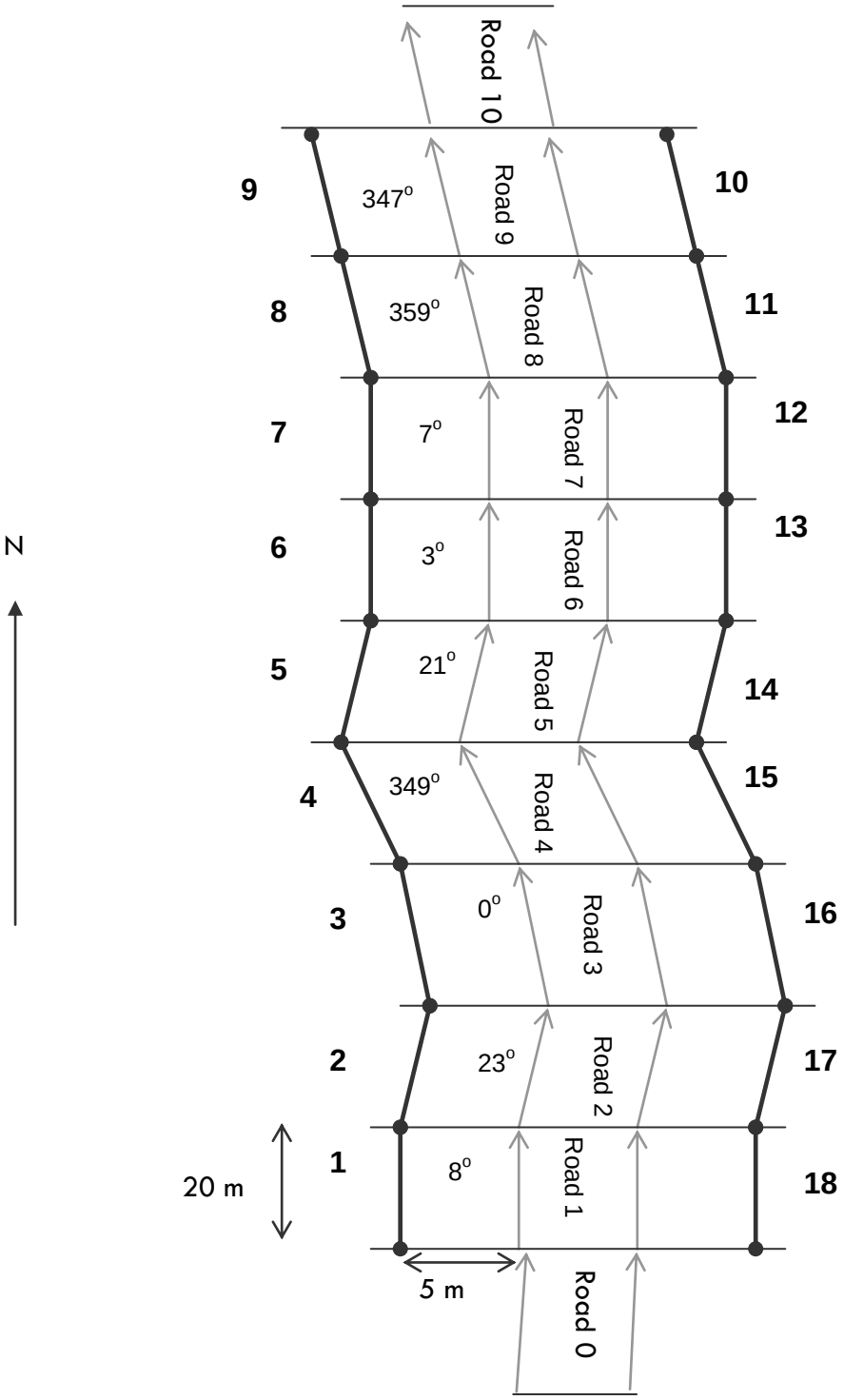

Figure 7. Placement of reference transects and plots along the ridge road at the larger, main Letitia Creek *L. oreganus* population. Plots are 5 m x 20 m in size, with corners marked by various types of posts. Plots #1-9 are read south to north on the west side of the road and plots # 10-18 are read 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 *A.vialis* monitoring layout.

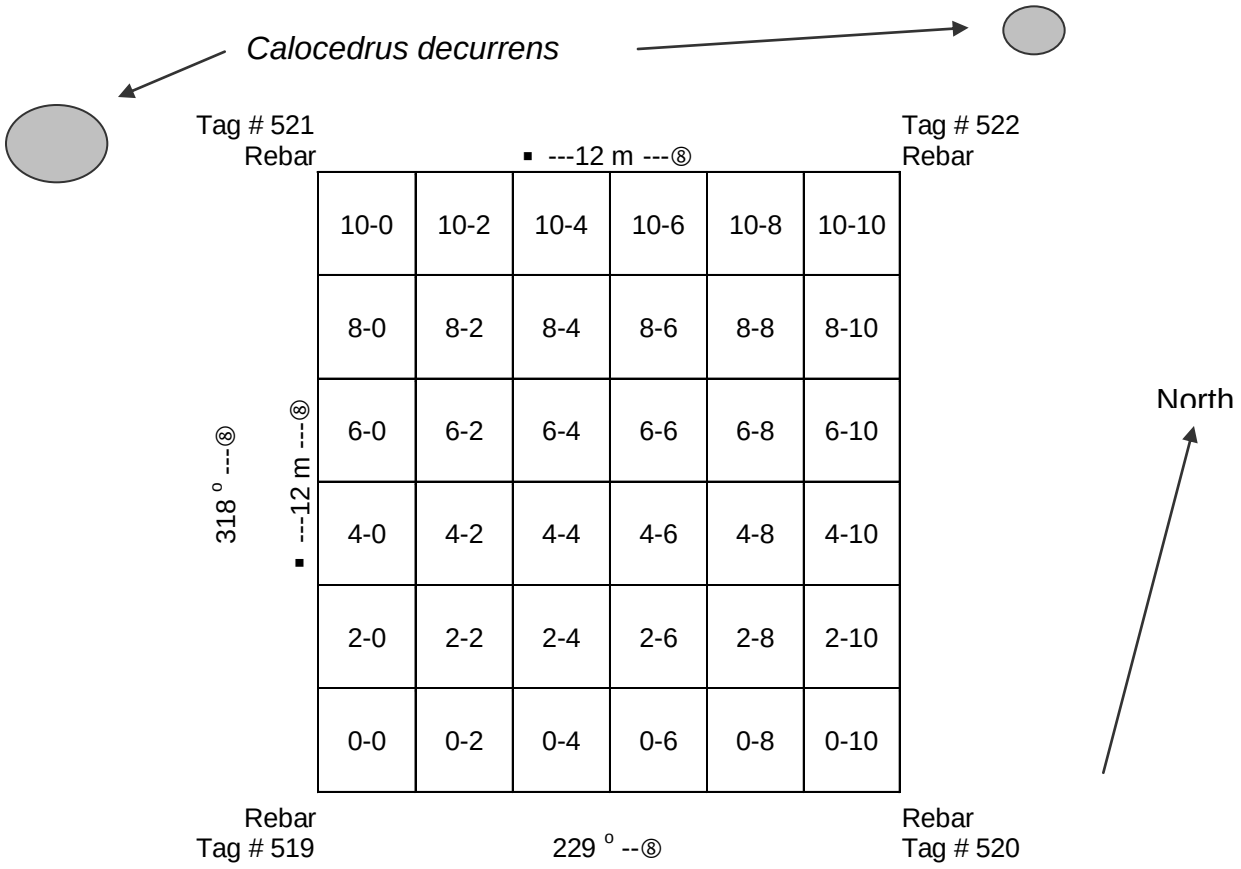

Figure 8. Map of the southern, larger Callahan Meadows *L. oreganus* monitoring plot layout (subpopulation 1). A 12 m x12 m plot was marked with tagged rebar posts. Within the plot, there are 36 2 m x 2 m sub-plots, each numbered by an x-y coordinate system. In each sub-plot all leaves and racemes were counted. At this site the number of grazed leaves and racemes per sub-plot were also counted.

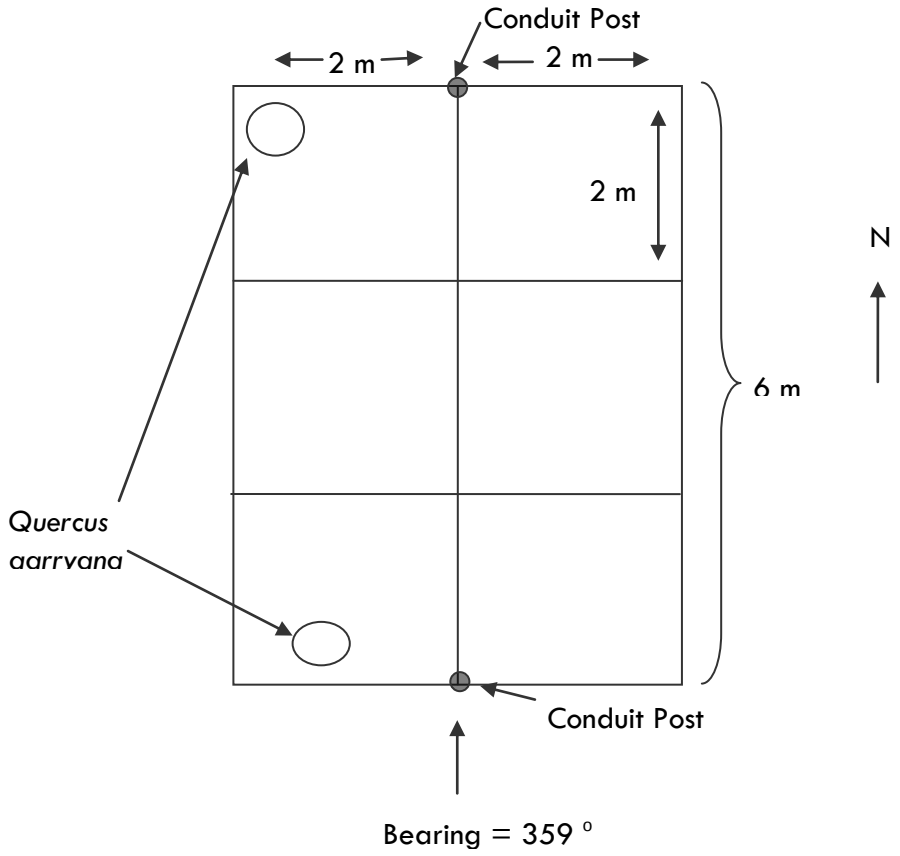

Figure 9. Map of the northern, smaller Callahan Meadows *L. oreganus* monitoring plot layout (subpopulation 2). A 6 m transect was established through the sub-population, with each end marked by conduit posts. Leaves and racemes were counted and cover calculated within 2 m of the transect, forming a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

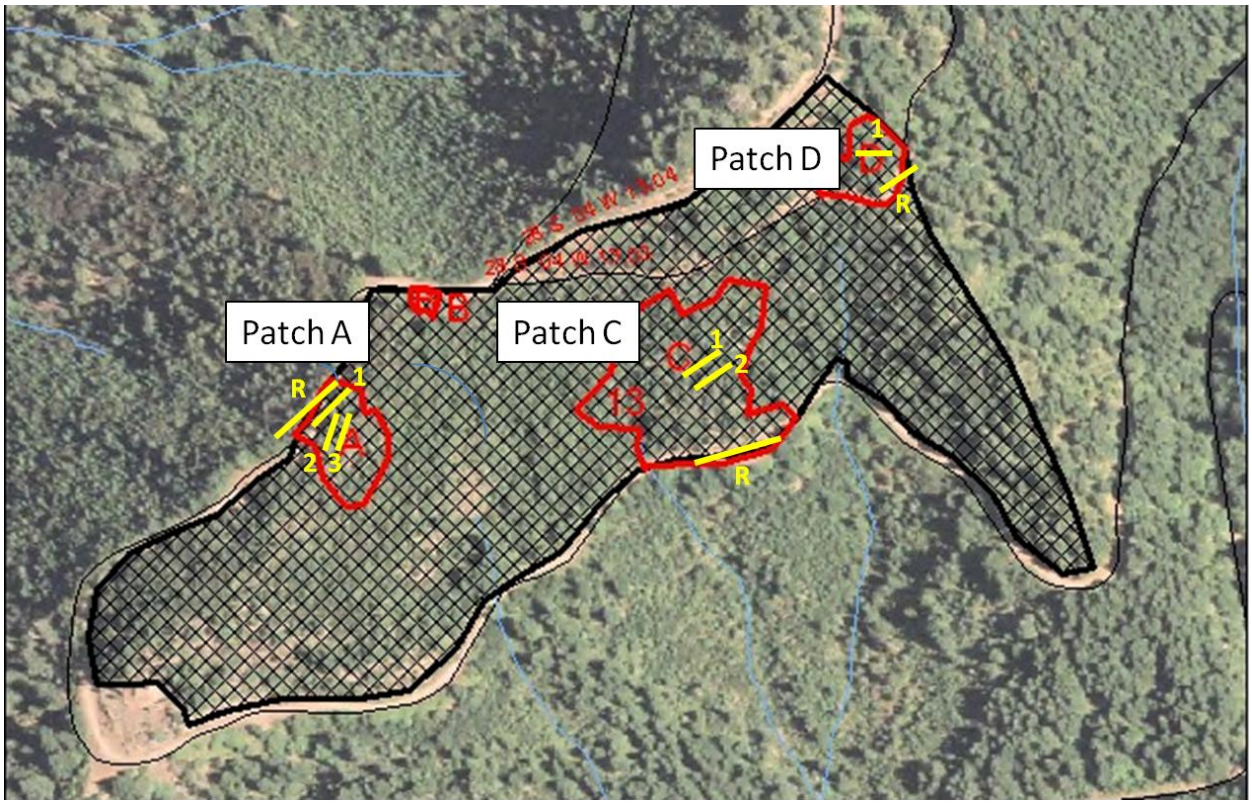

Figure 10. Aerial photo of China Ditch area showing approximate locations of transects for Patches A, C and D. R = roadside, 1 = transect 1, 2 = transect 2, 3= transect 3.

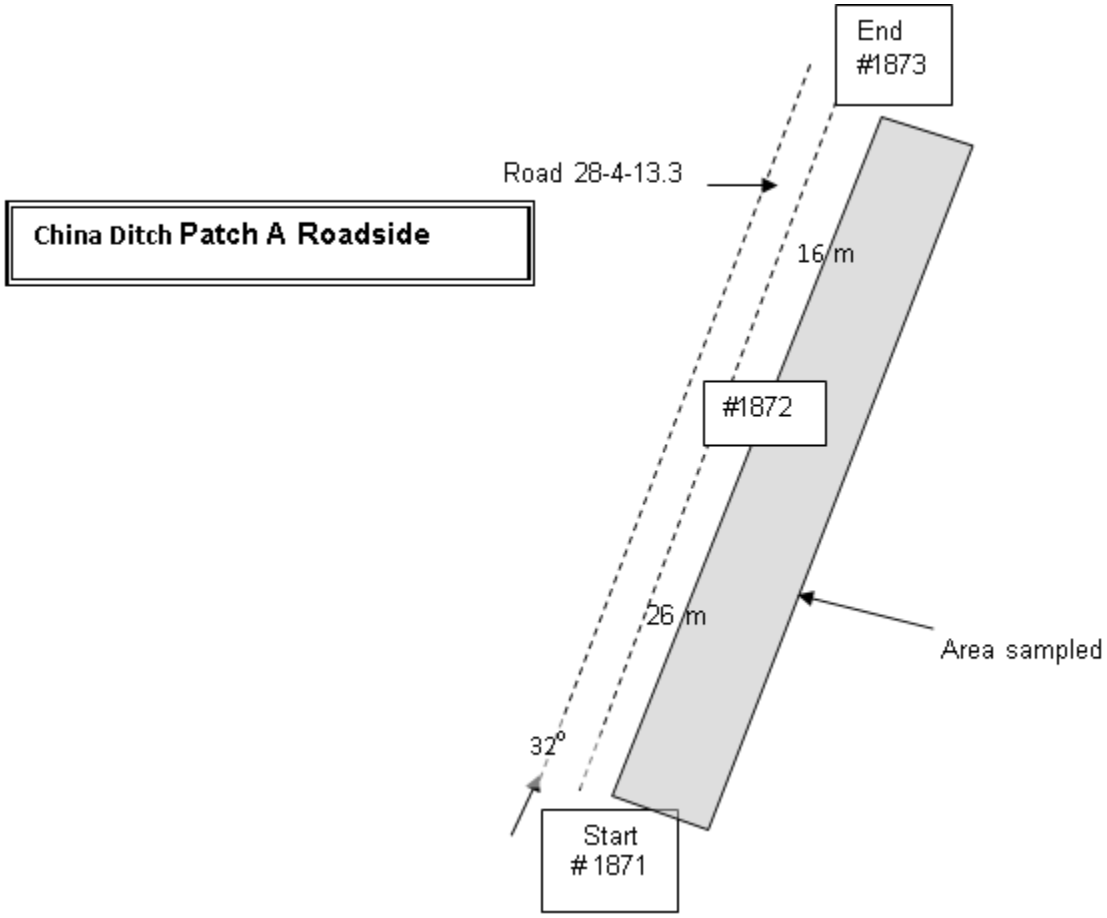

Figure 11. Monitoring transect established in China Ditch Patch A. The transect for Patch A Roadside (subpopulation 2) is 42 m long and is sampled on the east side of the road, to 3 m up the cut bank.

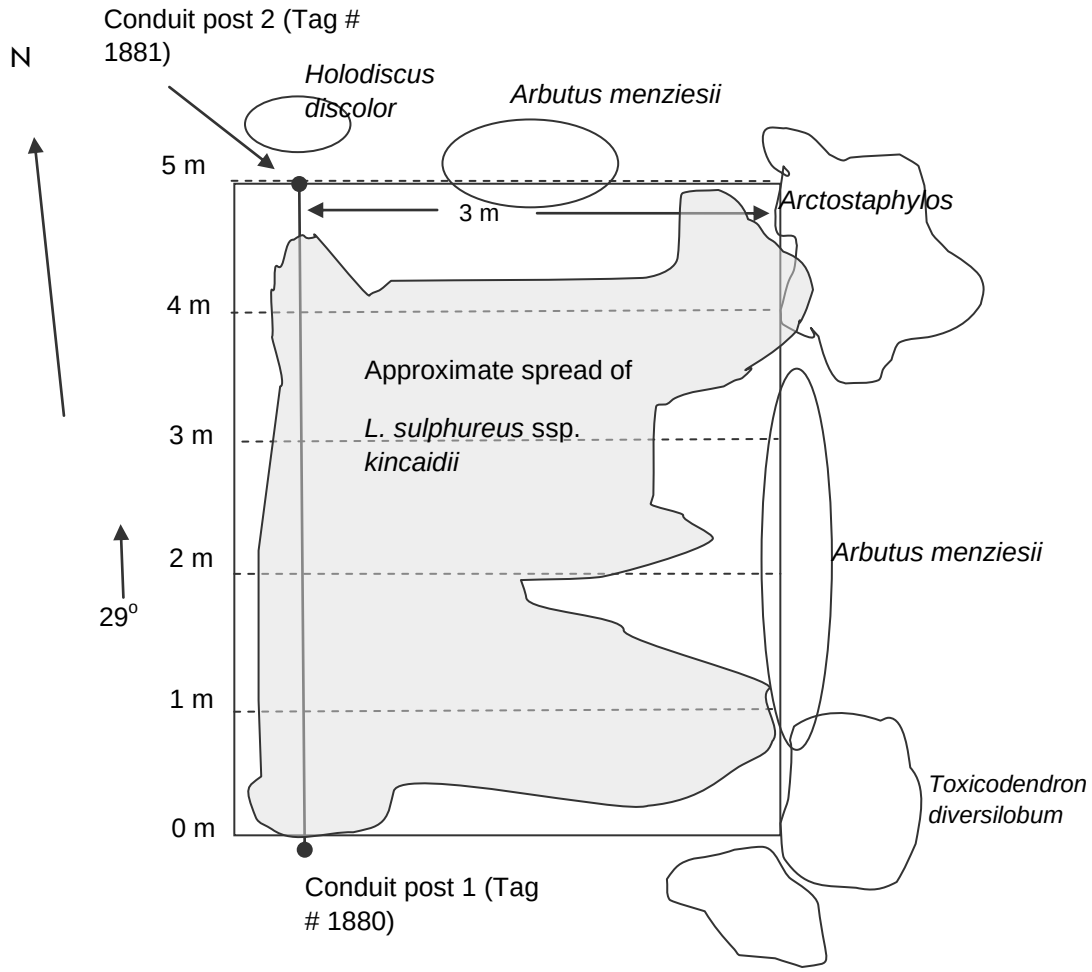

Figure 12. Transect established in "representative area" of China Ditch Patch A Transect 1 (previously representative transect above subpopulation 2). This transect is above the road cut and the roadside transect established in this subpopulation (beginning at about 30 m along the roadside transect). . 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.

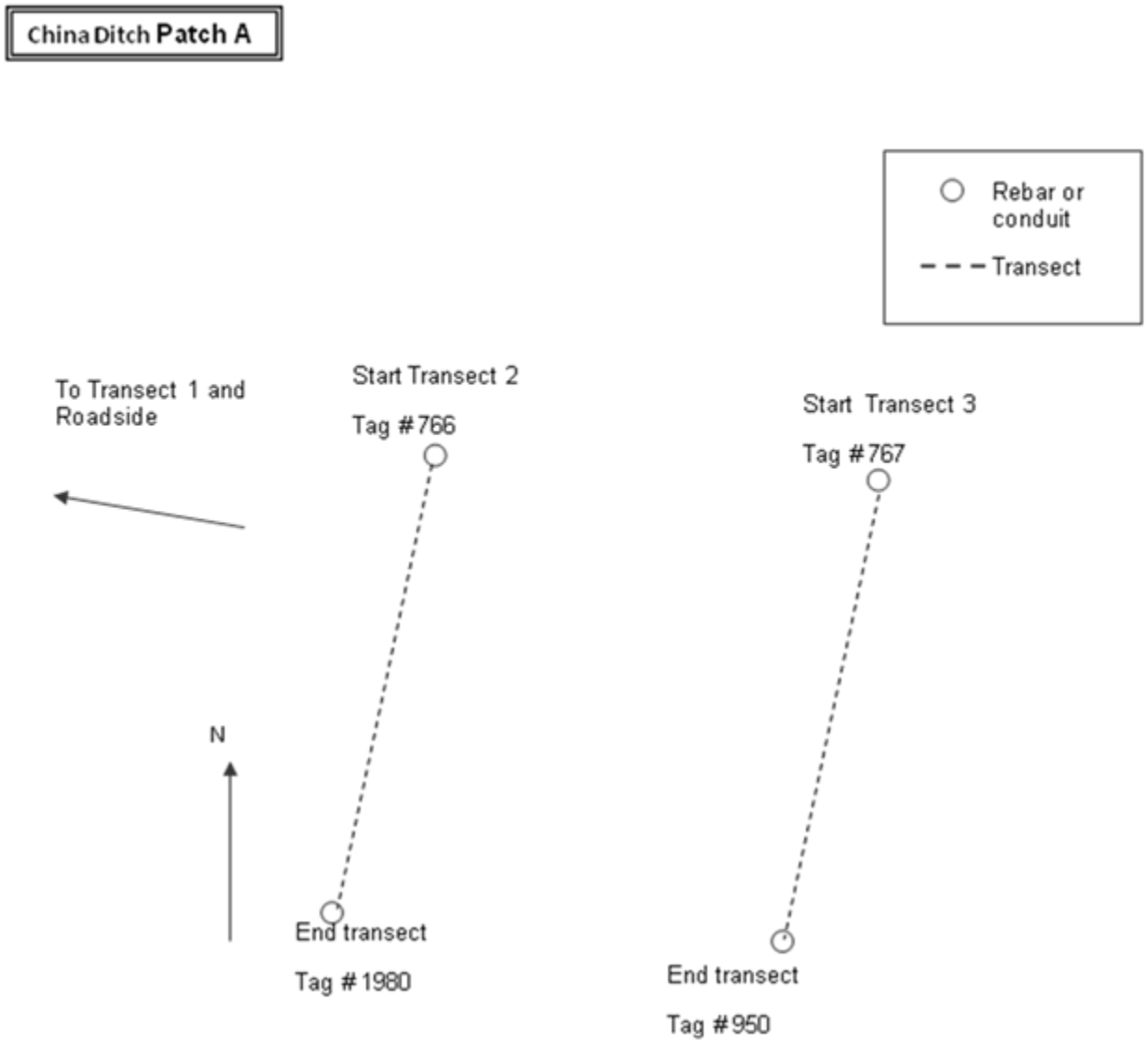

Figure 13. Schematic of Patch A Transects 1 and 2. The transects are located east of Transect 1 and Patch A Roadside, and are measured on both sides of the transect within 1.5 meters of the tape.

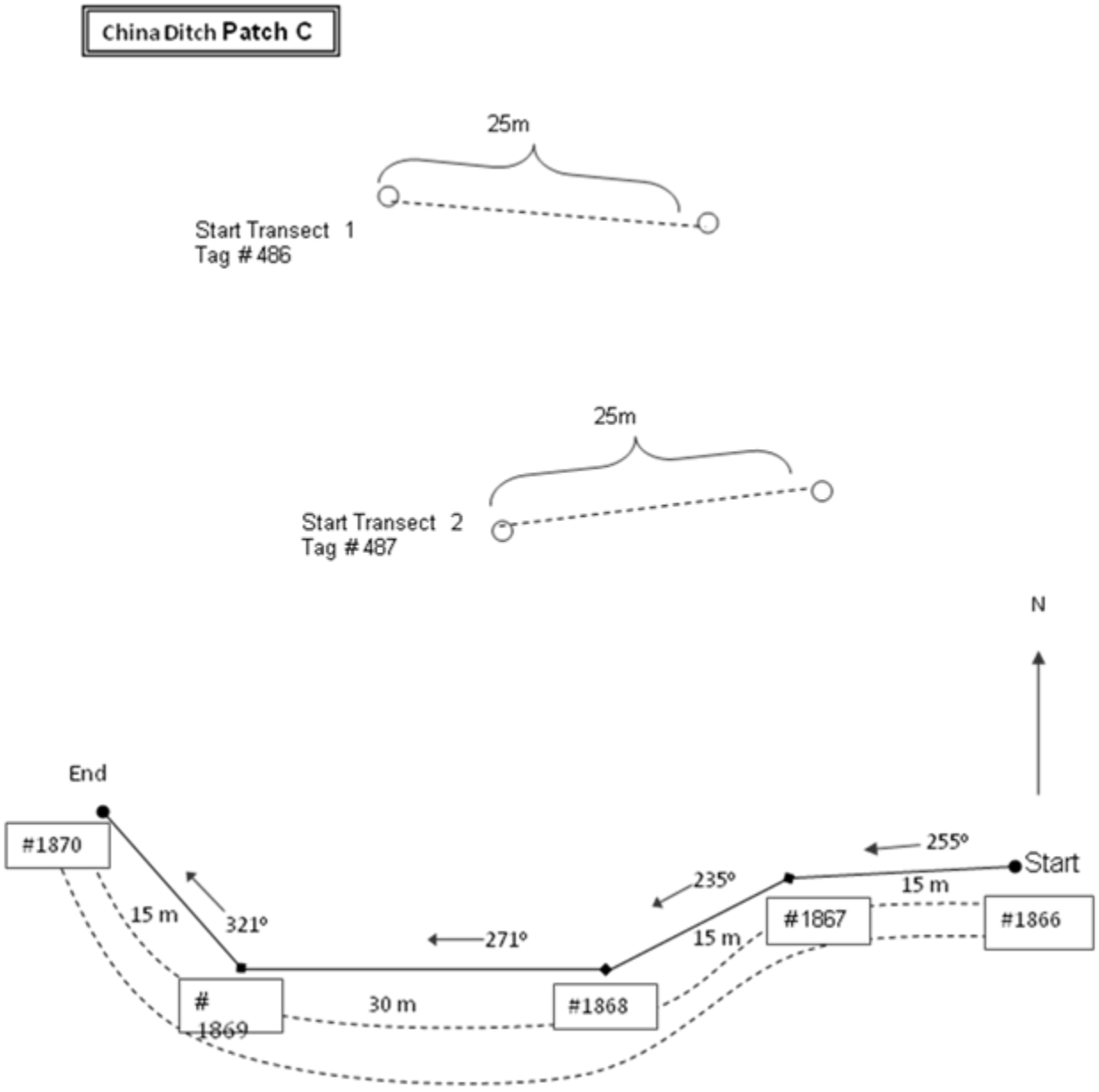

Figure 14. Schematic of monitoring transects in Patch C. The transect in Patch C Roadside (subpopulation 1) is 75 m long and is sampled on the north side of the road. Transects 1 and 2 are 25 m long, lupine is measured within 1.5m on both sides of the tape.

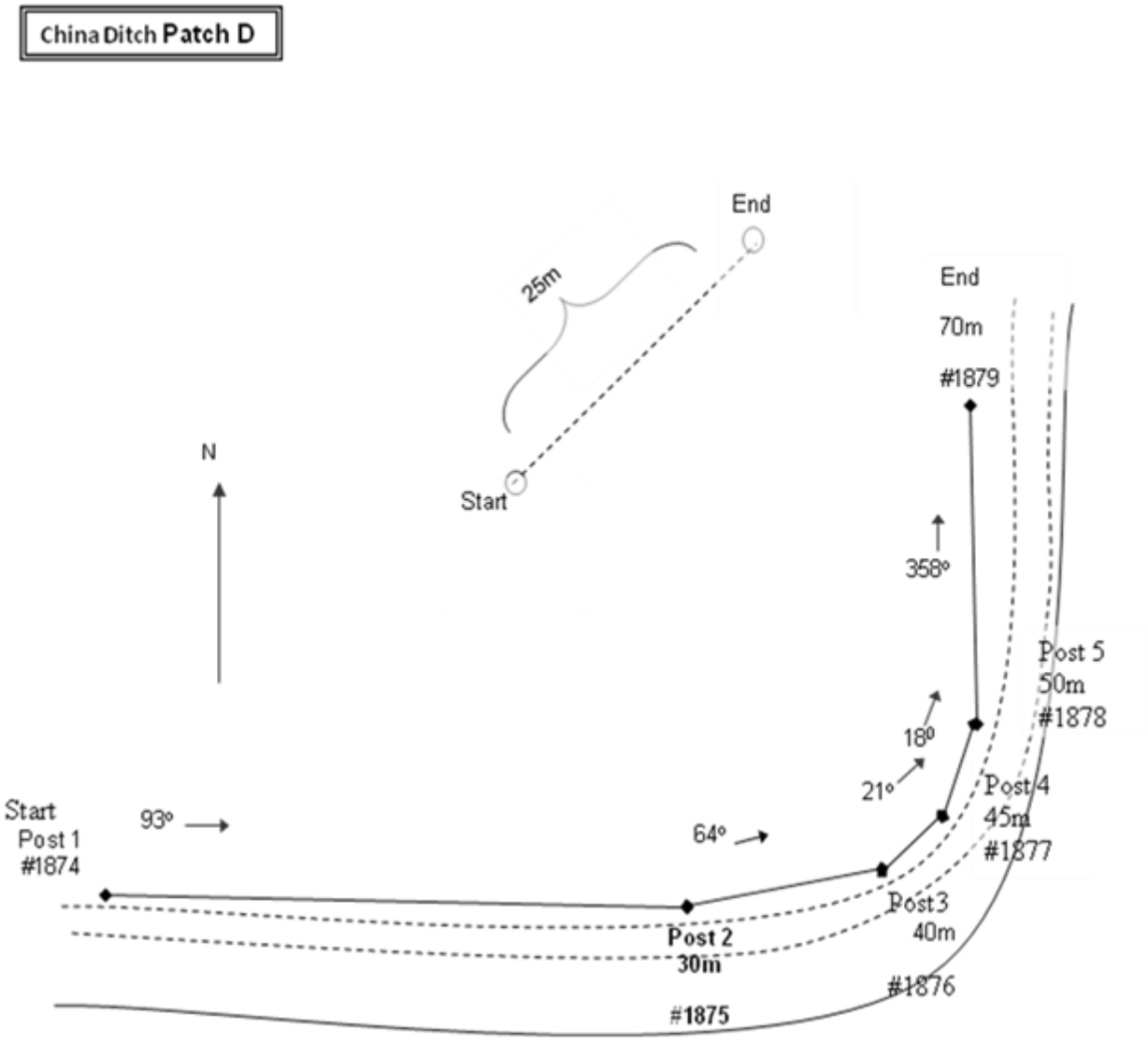

Figure 15. China Ditch Patch D, monitoring transects. 70 meter long transect established in China Ditch Patch D Roadside (previously subpopulation 3) and Patch D Transect 1. Plants were sampled on the inside curve of the road only (the north and west sides). Only plants on the roadside and cut bank were 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.

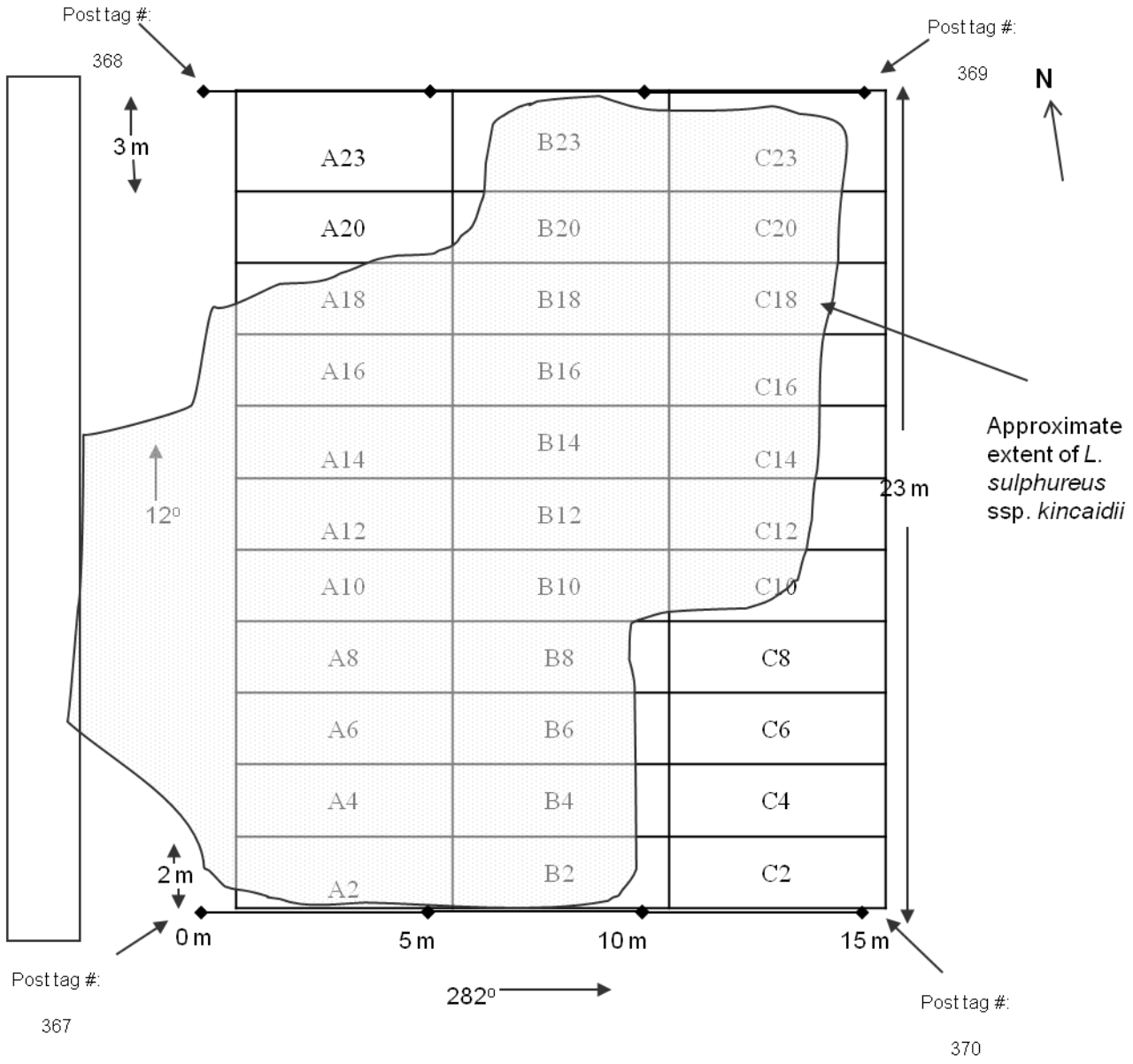

Figure 16. Plot (15 m x 23 m) established in 2005 to census Dickerson Heights population. Leaves and racemes on plants in each 2 m x 5 m cell of the grid were counted. Additional plants occur between west side of plot and road; leaves and racemes on these plants were also counted.

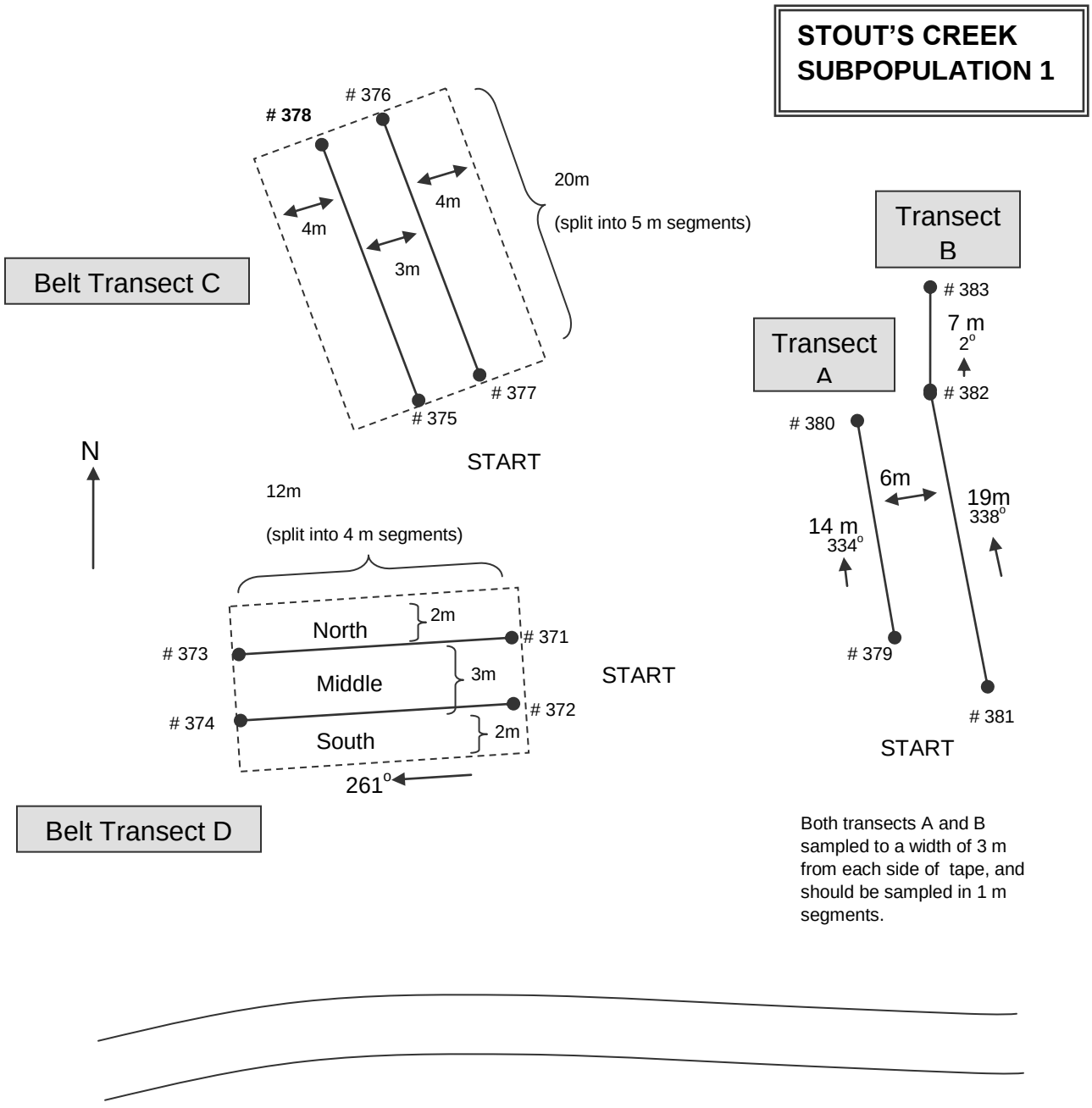

Figure 17. Diagram of the Stout's Creek Subpopulation 1 monitoring transect layout.

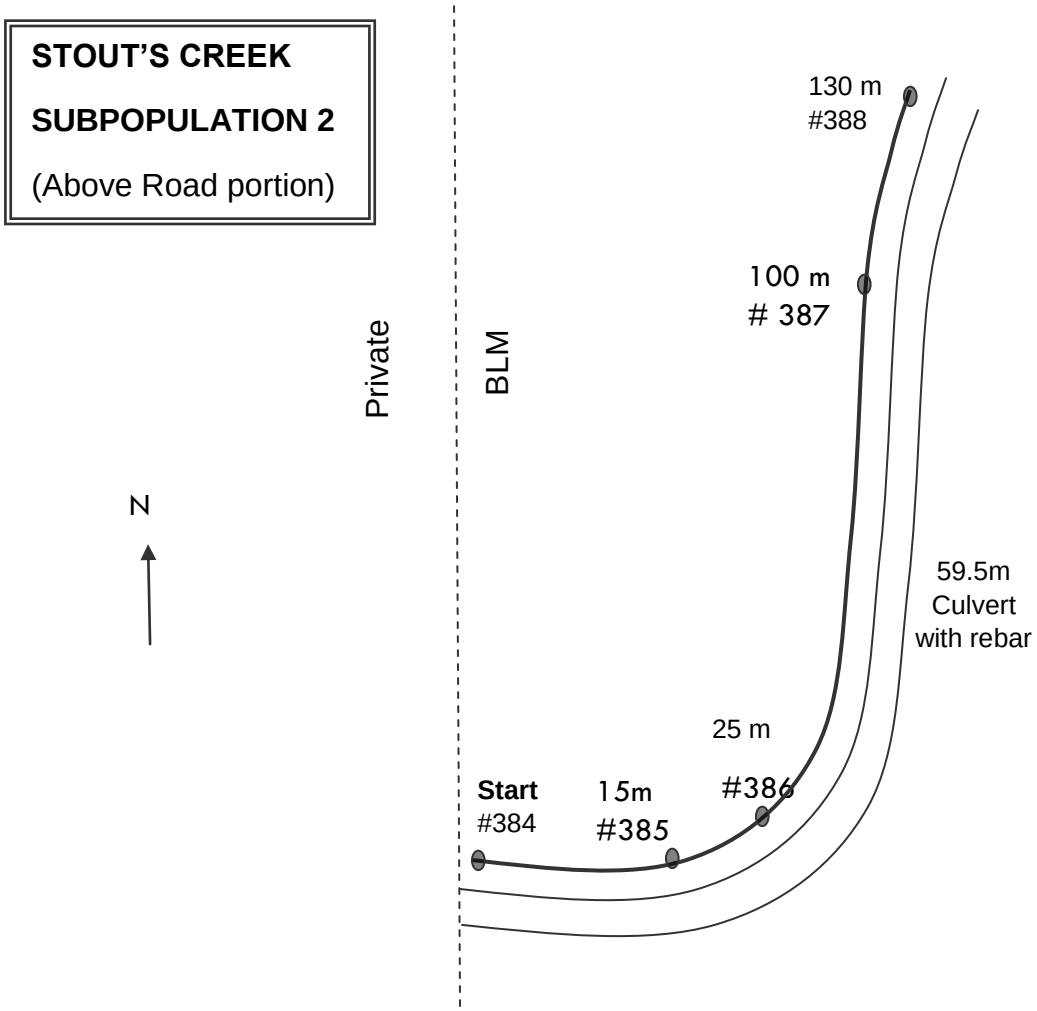

Figure 18. Diagram of Stout's Creek Subpopulation 2, above road transect. Meter tape should be run along road side ditch, in natural arc, but rebar should match up with distances on map. Plants extend about 20 m above transect.

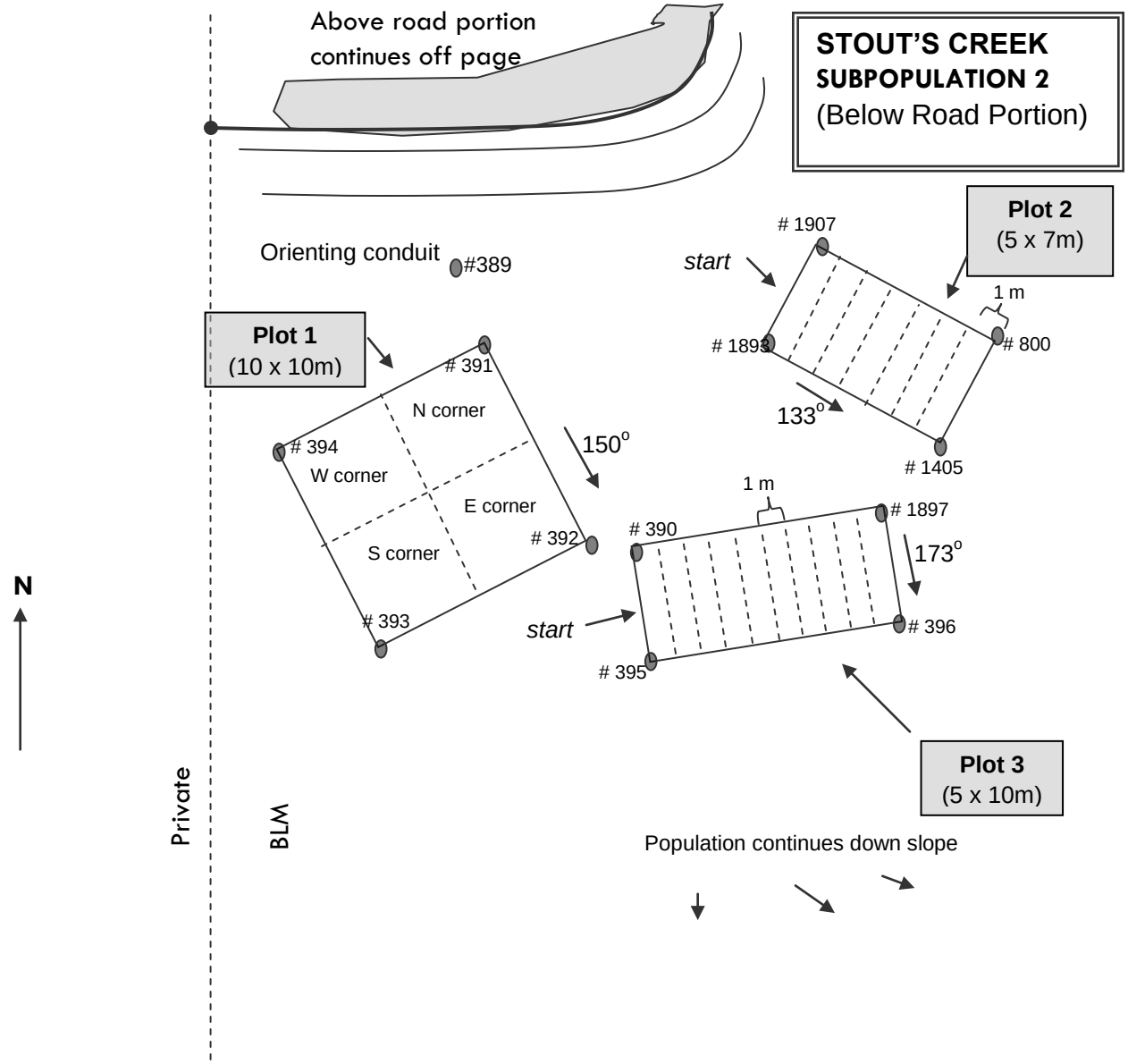

Figure 19. Diagram of Stout's Creek Subpopulation 2, focused on the portion of the subpopulation below the road. Three sub-sample plots were established. Bearings and tag numbers are indicated in diagram. Plot 2 was recreated in 2011, as 3 of the posts had been dislodged during thinning and brushclearing.

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 2007-2013, 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 21) and seeds were not removed from plants so that that year's seed production could contribute to the natural population at each site.

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

Fender's blue butterfly surveys

In 2007, we searched all monitored lupine 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 lupine leaves (Figure 22). Hatched eggs resemble unhatched eggs except they are burst in the center making them look like little white "donuts." Although not found, hatched and unhatched eggs would be counted together. Surveys were suspended in 2010.

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

RESULTS

There was significant variability in the different patterns of cover, raceme production, and fruit production at the six populations of *L. oreganus* we monitored in the Roseburg District. Between 2009 and 2010, all sites except Callahan Meadows and Letitia Creek were thinned to open up the canopy. Letitia Creek was thinned in 2010. 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, Stout's Creek), slash was placed outside of the existing lupine plots. Seedlings were commonly seen germinating in areas where slash had been burned and bare ground was exposed during monitoring in 2011 and 2012.

From 2012 to 2013, foliar cover increased or remained relatively stable at all sites (Table 1). The number of racemes also remained stable or increased at Stout's Creek, Loose Laces and China Ditch, and decreased at Callahan Meadows from 2012-2013. The number of fruits raceme^{-1} decreased or remained stable at all sites. As in previous years, no viable fruits were produced at Callahan Meadows. Letitia Creek was not monitored in 2013 due to the presence of a squatter camp in the vicinity.

Loose Laces

Cover of *L. oreganus* decreased steadily from 2003-2007 to a low of only 13.9m^2 of cover, but has generally increased since that time to 40.1m^2 in 2013 (Figure 22). Fruiting effort has varied, with a low of 2.0 fruits raceme^{-1} in 2009 and a high of 6.4 fruits raceme $^{-1}$ in 2012. Over the ten years of monitoring, plants at this location have averaged 3.6 fruits raceme^{-1}. Large pieces of plastic, most likely associated with the thinning operation, covered part of subpopulation 1 in 2011. Slash piles also covered a spur road near subpopulation 2 that had previously supported a small number of *L. oreganus* individuals.

Letitia Creek

*Letitia Creek was not monitored in 2013 due to the presence of a squatter camp in the vicinity.

Cover of *L. oreganus* at Letitia Creek has decreased steadily since 2006 (Figure 23). At the initiation of the study, lupine cover at the site was approximately 5.6 m^2, by 2011 cover had decreased to just 1.1 m^2. In 2012 foliar cover increased slightly to 1.5m^2, but remains alarmingly low. The number of racemes has also declined precipitously from a high of 157 to a low of only 2 in 2012. In 2012 no fruits were present in the BLM portion of the lupine population at this site.

Callahan Meadows

The cover of *L. oreganus* has varied between years, but overall has increased during the eleven years of monitoring the site (Figure 24). Foliar cover in 2012 was the highest recorded at the site with 15.7 m^2 of lupine. In 2013 lupine cover decreased to 13.2 m^2, but remains the second highest since monitoring began. The raceme count for the site has been decreasing since 2009. (from 466 to 425), however the number of racemes remains relatively high compared with past monitoring events.

China Ditch

Five new monitoring transects were established at China Ditch in 2010. Lupine cover values after 2010 are reported as a total (which includes all new and original) and for just the original transects. Since thinning treatments in 2010, foliar cover of lupine has increased to the highest ever recorded at the site, and raceme count has also remained high (Figure 25). Only 3.8 fruits raceme^{-1} were recorded in 2012, the lowest recorded at the site, and in 2013, only 4.3 fruits raceme^{-1} . The average number of fruits raceme^{-1} at the site is 5.8 (with a range of 3.8 in 2012 to 8.0 in 2004).

Dickerson Heights

Lupine cover has increased from 2008-2012; and increased significantly post-thinning in 2009. there was a 22% increase from 2010 to 2011, and an additional 16% increase from 2011-2012 (Figure 26). From 2012-2013 there was a slight decrease in lupine cover, from 47.1 m^2 to 45.6 m^2, however the cover remains significantly higher than the lupine cover pre-treatment. The number of racemes has fluctuated greatly at this site, but has generally increased since monitoring began in 2005. In 2010, the number of racemes increased 99% to 641; in 2012 to 854 and 684 in 2013. The average fruits raceme^{-1} at the site is 5.3. *Lupinus oreganus* has spread beyond the boundaries of our monitoring plots since their establishment, thus any disturbances to the site should only be done after marking the current distribution of the plants. A total of 131 seedlings were noted while taking foliar cover measurements in 2011 and 62 in 2012. (Seedlings were not counted in 2013.)

Stout's Creek

Foliar cover has decreased at 7 of the 8 monitoring plots at Stout's Creek since monitoring began in 2007. In the four transects in Sub-population 1, foliar cover has decreased to practically 0 m^2. Zero racemes were recorded in 2012 and 2013 in Sub-population 1. In Sub-population 2, Plots 1, 2 and 3 have remained relatively stable over the course of the study. The 'above road' portion of Sub-population 2 at Stout's Creek is the only sampled area that has experienced increases in foliar cover over the course of the study at Stout's Creek. In 2013 foliar cover increased to 27.8 m^2 the highest values recorded for the site, however all of the increase was from increases in cover in Sub-population 2 above the road (Figure 27). The number of racemes follows a similar pattern ending with 369 racemes in 2013 (from a low of 141 in 2009.) The number of fruits raceme^{-1} continued to rebound from a record low in 2008 of 0.1 and continued in 2011 to 5.6, the highest recorded at the site. In 2013 the fruits raceme^{-1} was 2.9, (average 3.0).

Despite increases in the overall cover of lupine at Stout's Creek, there have been significant changes in the distribution of the lupine with

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 2. Leaf and raceme totals for *Lupinus oreganus* populations monitored between 2007 and 2013. In 2007, foliar cover replaced leaf counting as a method for determining plant abundance.

Population	2007 Racemes	2007 Cover (m^2)	2008 Racemes	2008 Cover (m^2)	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)
LOOSE LACES TOTAL	**418**	**11.549**	**554**	**15.79**	**473**	**19.11**	**578**	**17.55**	**714**	**19.27**	**563**	**26.29**	**879**	**40.13**
Subpopulation 1	0	-	101	3.15	75	3.22	92	3.64	147	4.94	170	7.34	341	10.71
Subpopulation 2	0	-	35	1.10	9	1.17	3	0.82	13	0.79	47	2.14	52	3.51
Subpopulation 3	405	10.87	405	10.87	374	12.39	437	10.31	470	10.57	297	13.48	382	20.43
Subpopulation 4	13	0.6786	13	0.68	15	2.33	46	2.75	84	2.96	49	3.34	104	5.47
LETITIA CREEK TOTAL	**128**	**5.5723**	**125**	**4.9927**	**157**	**5.2499**	**24**	**2.98**	**5**	**1.17**	**2**	**1.54**	**Not monitored in 2013 due to squatter camp**	
Subpopulation 1	6	0.5446	3	0.51	3	0.54	22	2.64	5	1.00	0	0.38		
Subpopulation 2	122	5.0277	122	4.49	154	4.71	2	.33	0	0.162	2	1.16		
CALLAHAN MEADOWS TOTAL	**394**	**10.407**	**566**	**8.3591**	**338**	**9.433**	**510**	**13.12**	**475**	**9.07**	**425**	**15.74**	**239**	**13.23**
Subpopulation 1	394	10.23	565	8.21	334	9.23	509	12.83	473	8.91	425	15.49	239	12.97
Subpopulation 2	0	0.17	1	0.15	4	0.20	1	0.30	2	0.16	0	0.24	0	0.26
STOUT'S CREEK TOTAL[1,2]	**196**	**13.38**	**243**	**7.64**	**141**	**11**	**329**	**17.72**	**179**	**7.58**	**312**	**19.32**	**369**	**27.81**
Subpopulation 1														
Transect A	2	0.1964	8	0.13	-	0.00	0	0	1	0.01	0	0	0	0
Transect B	1	0.4388	6	0.17	-	0.12	0	0.15	0	0	0	0.08	0	0.02
Transect C	1	0.3411	2	0.13	-	0.13	0	0.05	0	0	0	0.01	0	0
Transect D	19	0.95	12	0.29	3	0.18	0	0.26	0	0.11	0	0.09	0	0.05
Subpopulation 2														
Above the road	118	6.3746	88	3.79	84	6.48	288	12.5	114	2.88	257	12.39	313	19.73
(Below the road) Plot 1	26	1.9103	33	0.70	30	1.51	7	1.42	16	1.26	23	1.65	32	2.66
(Below the road) Plot 2	7	0.80	24	0.68	5	0.71	5	0.57	32	1.75	12	2.70	5	2.58
(Below the road) Plot 3	22	2.36	70	1.73	19	1.99	29	2.77	16	7.58	20	2.39	19	2.76

TABLE 2. LEAF AND RACEME TOTALS FOR *LUPINUS OREGANUS* POPULATIONS MONITORED BETWEEN 2007 AND 2013. IN 2007, FOLIAR COVER REPLACED LEAF COUNTING AS A METHOD FOR DETERMINING PLANT ABUNDANCE.

Population	2007 Racemes	2007 Cover (m^2)	2008 Racemes	2008 Cover (m^2)	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
CHINA DITCH TOTAL[2]	**625**	**18.27**	**990**	**17.98**	**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]**
Patch A													
Roadside (prev. subpop. 2)	150	3.41	242	4.87	108	3.83	124	6.08	87	2.37	73	3.82	61
Transect 1 (prev. rep. transect 1)	21	1.99	63	1.70	-	0.52	5	0.36	33	0.68	54	4.18	83
Transect 2[3]	-	-	-	-	-	-	42	2.31	113	3.57	105	6.14	104
Transect 3[3]	-	-	-	-	-	-	10	0.48	84	3.01	23	1.37	50
Patch C													
Roadside (prev. subpop. 1)	364	9.59	544	9.77	312	8.90	327	12.00	201	5.89	377	14.48	222
Transect 1[3]	-	-	-	-	-	-	8	2.58	21	0.73	55	5.24	64
Transect 2[3]	-	-	-	-	-	-	84	5.77	155	3.27	67	5.38	91
Patch D													
Roadside (prev. subpop. 3)	261	8.69	446	8.20	308	10.28	217	8.79	99	4.46	209	10.00	156
Transect 1[3]	-	-	-	-	-	-	10	2.24	11	1.03	44	2.39	9
DICKERSON HEIGHTS TOTAL[1]	**189**	**14.90**	**618**	**15.53**	**322**	**20.65**	**641**	**24.32**	**704**	**31.38**	**844**	**47.42**	**684**
GRAND TOTALS	**1,950**	**74.08**	**3,096**	**70.29**	**2,051**	**84.74**	**2909**	**116.31**	**2,871**	**93.49**	**3,705**	**163.07**	**3,011**

[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.

[5] Letitia Creek was not monitored in 2013 due to the presence of a squatter camp in the vicinity.

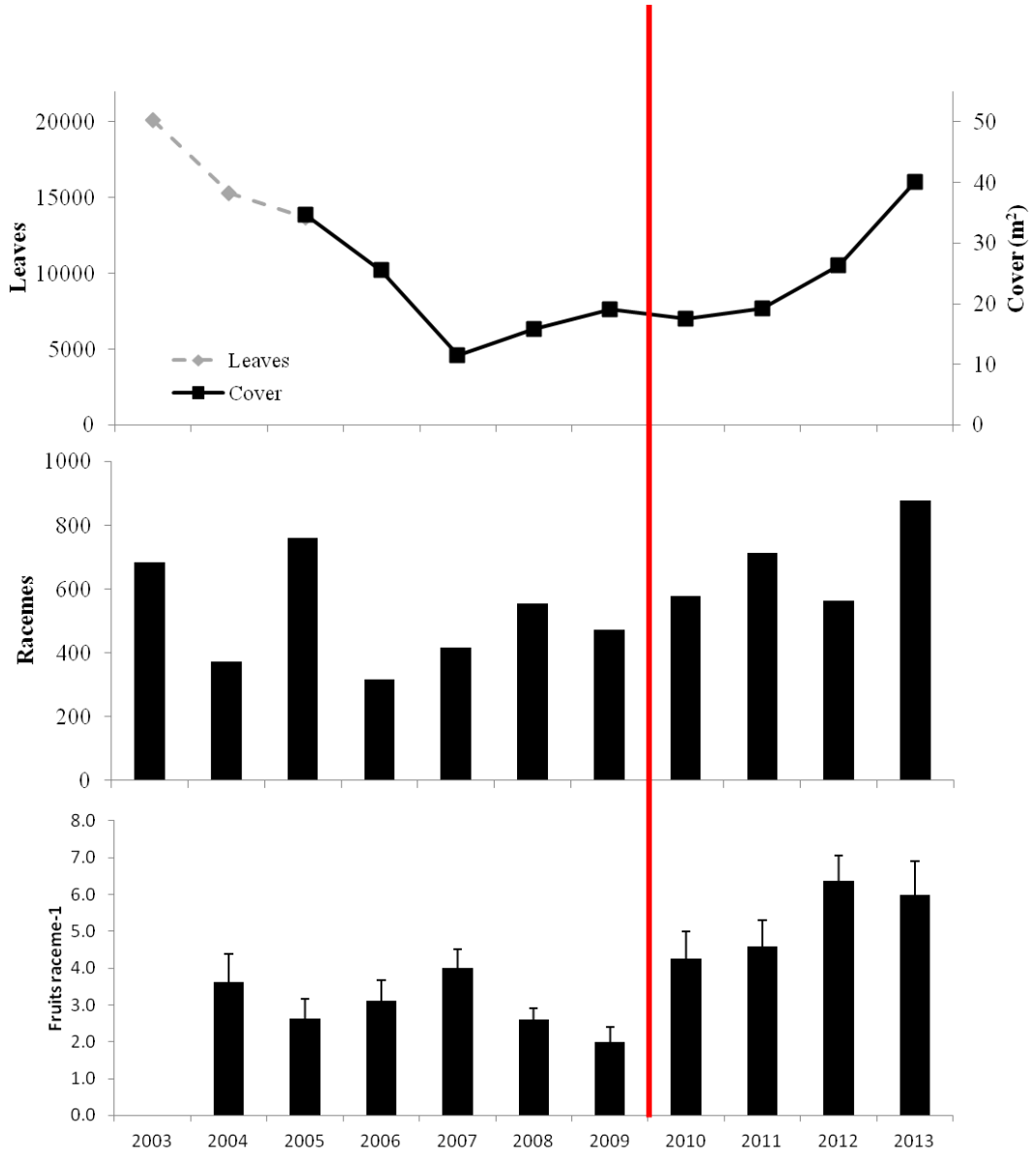

Figure 22. The number of leaves (2003 – 2005), foliar cover (2005 – 2013), number of racemes, and number of fruits raceme^{-1} of *L. oreganus* at Loose Laces. Error bars are 1 S.E. Red line represents timing of thinning treatments.

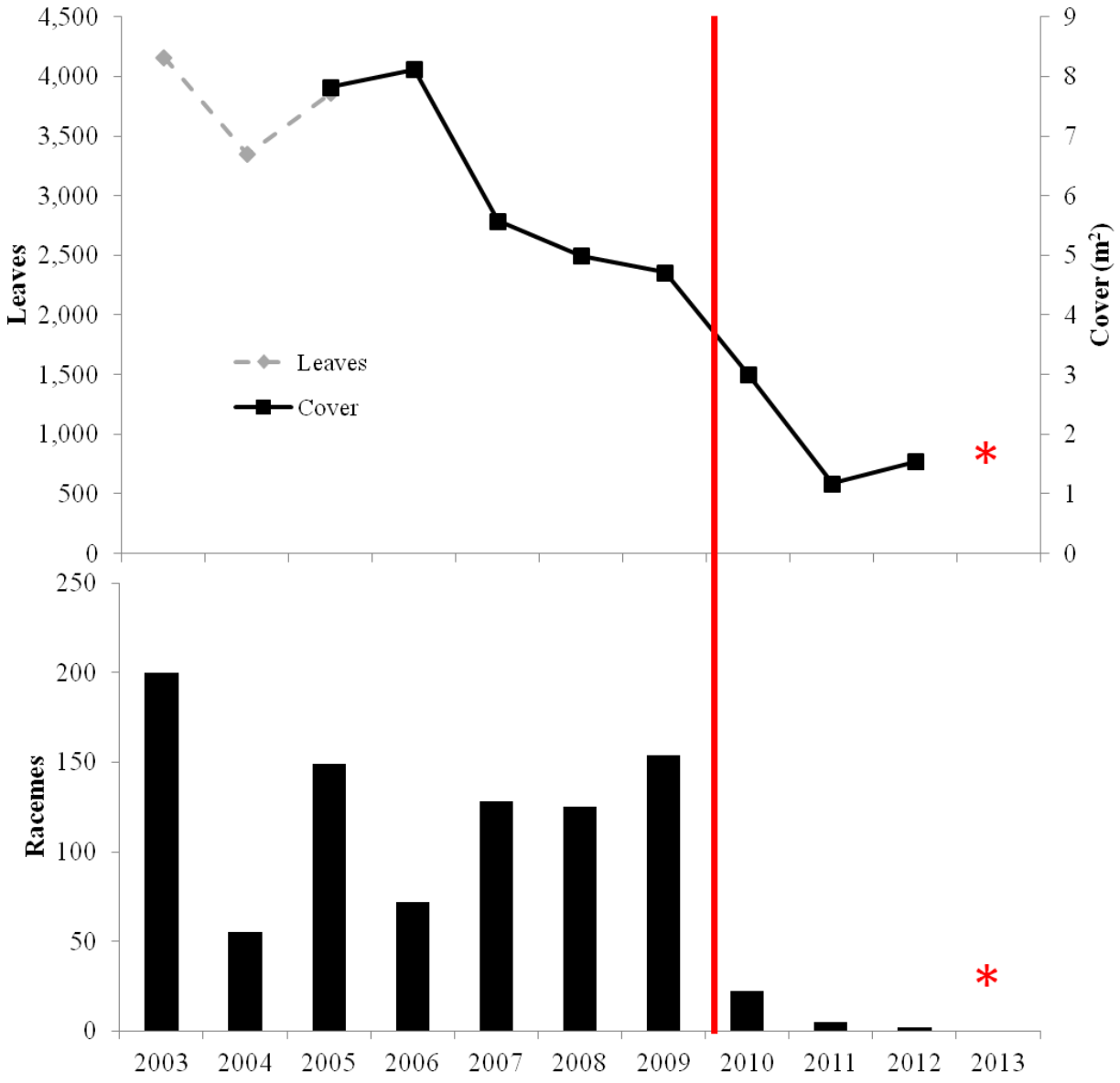

Figure 23. The number of leaves (2003 – 2005), foliar cover (2005 – 2012), and number of racemes of *L. oreganus* at Letitia Creek. Fruit data was only recorded in 2008 and 2012, see table 2). Red line represents timing of thinning treatments. *Plots were not monitored in 2013 due to the presence of a squatter camp in the vicinity.

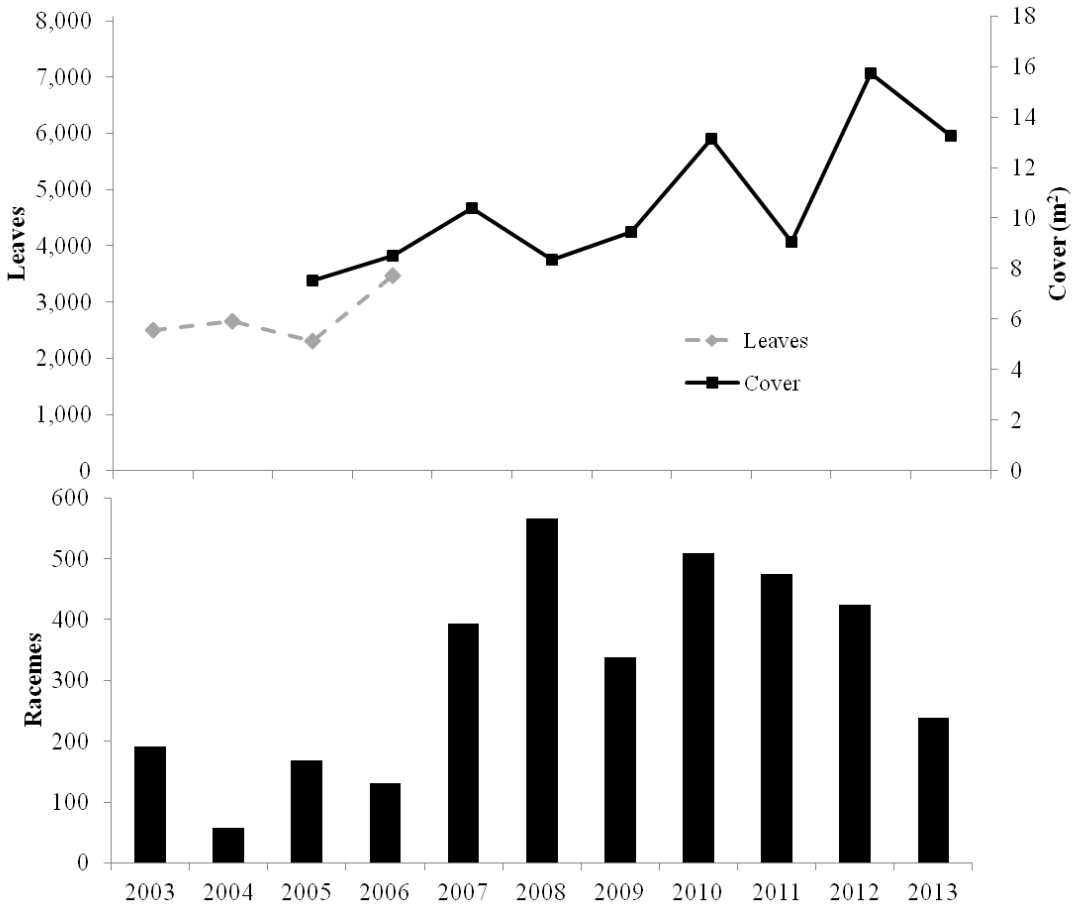

Figure 24. The number of leaves (2004 – 2005), foliar cover (2005 – 2013), and number of racemes of *L. oreganus* at Callahan Meadows. No fruits have been recorded at the site.

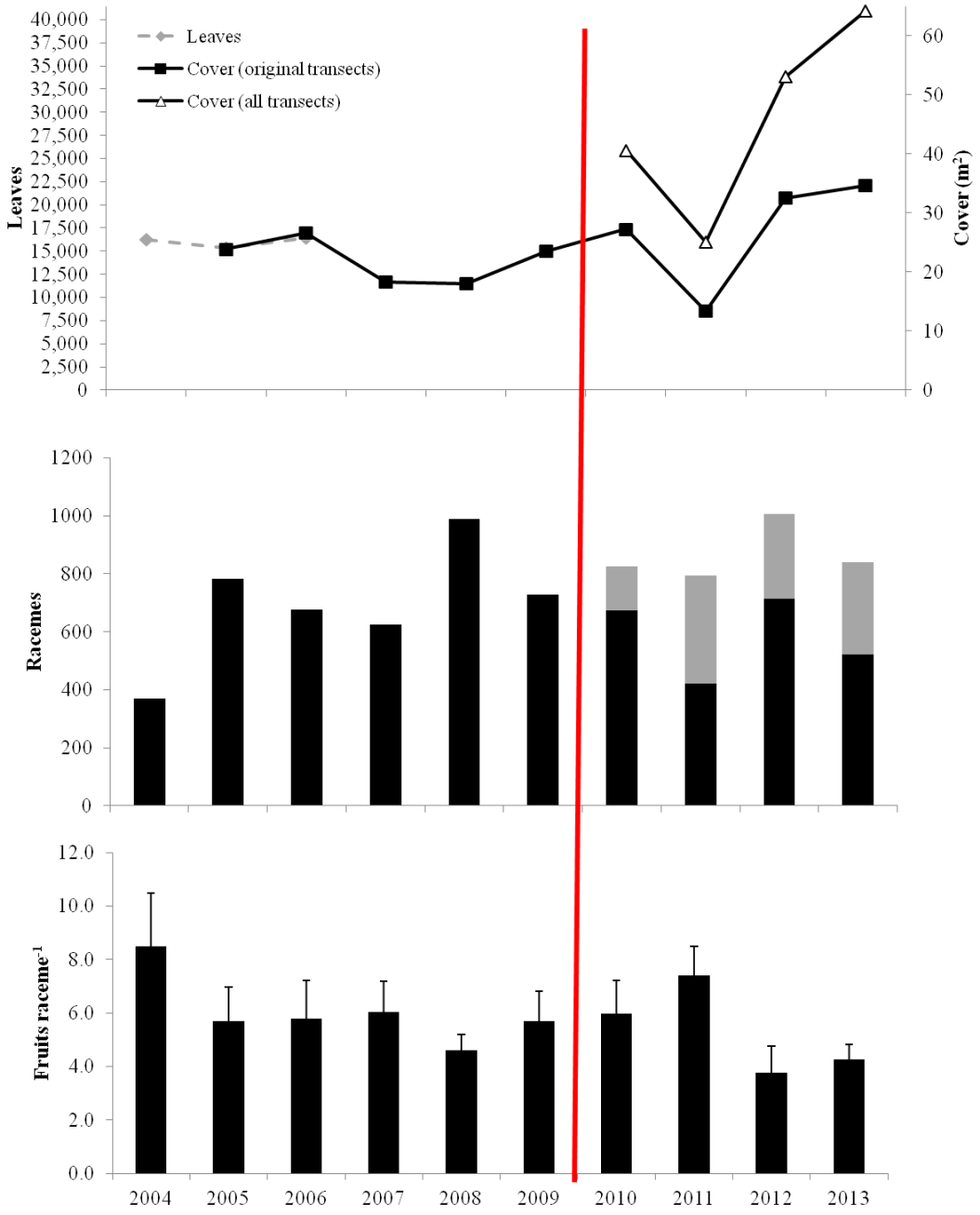

Figure 25. The number of leaves (2004 – 2006), foliar cover (2005 – 2013), number of racemes, and number of fruits raceme-1 of L. oreganus at China Ditch. Error bars where present are 1 S.E. 2010 marks the year that 5 new transects were added and one plot modified, thus the dramatic increase in cover. Grey bars represent the number of racemes from new transects. Red line indicates timing of thinning treatments.

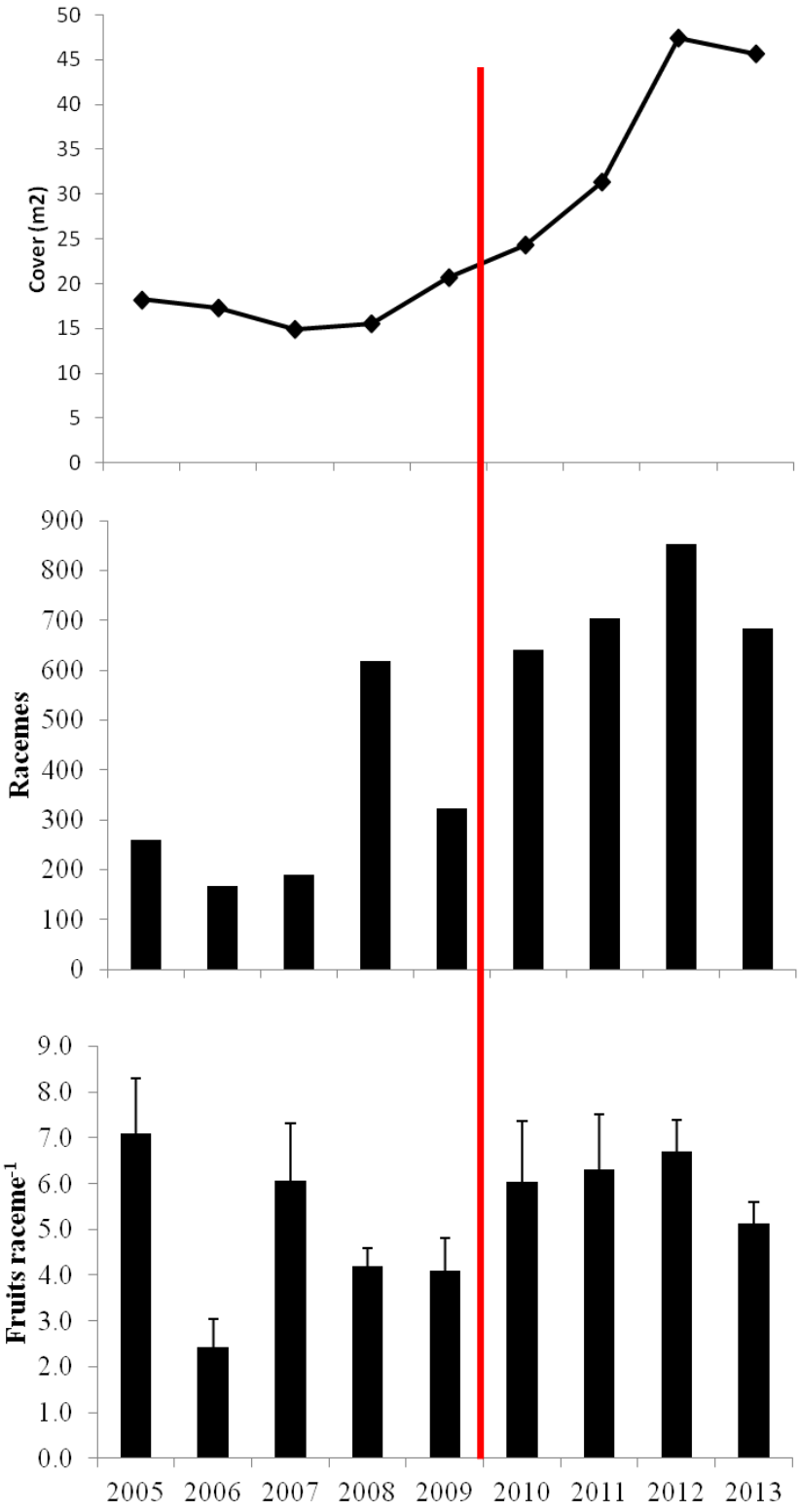

Figure 26. Foliar cover, number of racemes, and number of fruits raceme^{-1} of *L. oreganus* at Dickerson Heights from 2005-2013. Error bars where present are 1 S.E. Red line indicates timing of thinning treatments.

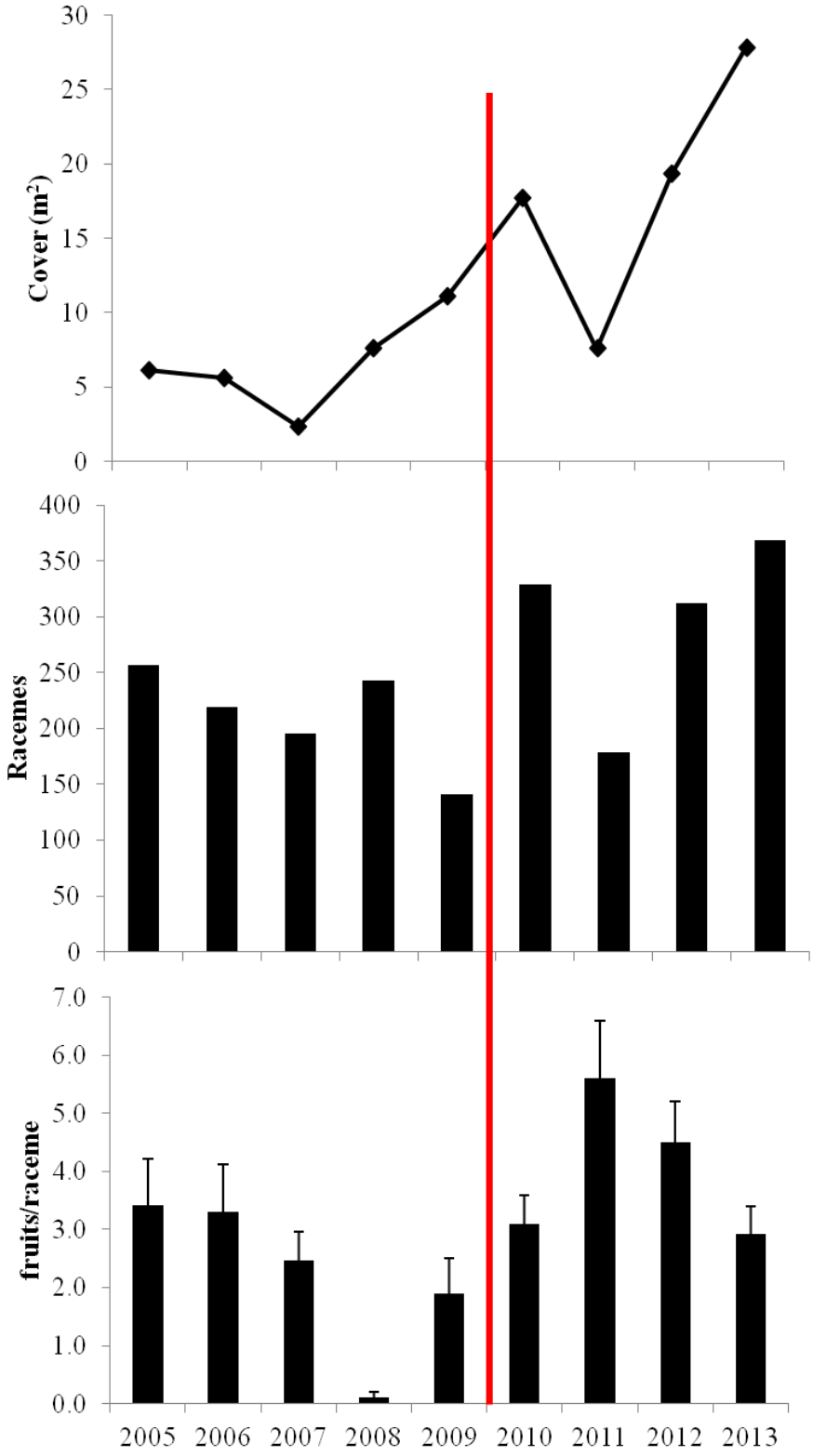

Figure 27. Foliar cover, number of racemes, and number of fruits raceme^{-1} of *L. oreganus* at Stout's Creek from 2005-2013. Error bars where present are 1 S.E. Red line indicates timing of thinning treatment.

DISCUSSION AND RECOMMENDATIONS

General Population Trends

2013 was the eleventh year of monitoring *L. oreganus* at Letitia Creek, Loose Laces, and Callahan Meadows, the tenth year for China Ditch, and the ninth year for Dickerson Heights and Stout's Creek in the Roseburg District of the Bureau of Land Management. There was significant variability in patterns of cover, raceme production, and fruit production at the six populations of *L. oreganus* we monitored in the Roseburg District.

Callahan Meadows

In the eleven years of monitoring at Callahan Meadows, 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 even the population is not only incompatible with other lupine populations, but is also self-incompatible.

China Ditch

Over the first six years of monitoring, there was little change in cover at China Ditch. This site also has a relatively high reproductive output compared to the other sites. 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.

In 2009, the BLM thinned trees in the vicinity of our plots to a spacing of about 21 feet. In the first year post-treatment there was little change in either lupine cover or reproductive effort. In 2011 both raceme count and foliar cover decreased, however both cover and raceme count in 2013 (three years post treatment) are the highest recorded in the ten years of monitoring (Figure 25). Much of this 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 lupine to the treatments. The BLM previously mapped the occupied lupine areas within the 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 lupine patches. Opening up the canopy is expected to increase the vigor of *L. s.* ssp. *kincaidii*. Additional monitoring is necessary to determine the impact of these treatments. *In 2012 and 2013, 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, however it is recommended that the area continue to be monitored for the noxious weed.

Stout's Creek

The population of *L. oreganus* at this site occurs in area of dense understory vegetation, including relatively high cover of *Toxicodendron diversilobum,* and some canopy cover. In 2009, the BLM thinned trees in the vicinity of all but one plot, which is expected to increase the vigor of *L. oreganus*.

Eight plots are monitored at Stout's Creek in two sub-populations. All four plots in Sub-population 1 have steadily decreased since monitoring began, and the sub-population is now practically gone. Thinning treatments did not occur in the portion of the population, however the area is generally open. Invasive grasses including *Schedonerus phoenix*

Seven of the eight plots have steadily declined since monitoring began at the site. Only in the plot "Sub-population 2, Above Road" has there been an increase in foliar cover of lupine over the course of the study at Stout's Creek. No thinning occurred in this plot which consists of the roadside, cut-bank and platform above the road. This population continues in patches to the road above. Most plants are found within 20m of the cutbank in dense cover of understory.

The remaining plots in sub-population 2 received thinning treatments, however there was not a concomitant increase in lupine cover as was noted at China Ditch and Dickerson Heights.

Severns (2008) noted that 5% of the Stout's Creek population was polyploidy, and it is possible that this portion of the population does not reproduce sexually.

It is recommended that seeds from other portions of the Stout's Creek population be spread in the area of the plots below the road to facilitate gene-flow within the Stout's Creek population.

Loose Laces

The Loose Laces population is primarily restricted to roadsides or small natural gaps adjacent to roads. After declining from 2006 to 2008, average cover has increased, but remains below that measured in 2006. Raceme count has increased steadily and was the third highest since monitoring began and in 2011, fruits raceme-1 were the highest recorded at the site. In 2009, the BLM thinned trees in the Loose Laces population and the population has slowly increased in foliar cover. The number of fruits per raceme has also increased steadily since thinning occurred. While it may take several years for the full impact of these treatments to be known, these populations are expected to increases or stabilize their growth, flowering, and reproduction.

Dickerson Heights

Like Loose Laces and Letitia Creek, Dickerson Heights is primarily restricted to small natural canopy gaps and adjacent roads. This population has increased in cover since 2007 and in 2011 had 14.9m^2 of cover and only 189 racemes, whereas in 2011, the foliar cover had doubled to 31.4 m^2 and raceme count more than tripled to 704. This pattern continued into 2012 with foliar cover increasing to 47.4 m^2 and 844 racemes. In 2011 over 140 seedlings were noted while monitoring at this site indicating that

sexual reproduction is successful at the site. In 2012, 65 seedlings were noted while monitoring. In 2009, the BLM thinned trees around our plots at the Dickerson Heights area however the impact on the canopy cover seemed to be less at this area as the cleared areas are generally downslope of the lupine population. While it may take several years for the full impact of these treatments to be known, 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 only two in 2012. This is likely due in part to the high levels of shading. In 2010, the BLM thinned trees around our plots at the Letitia Creek area. Thinning treatment in 2010 appears to have done little to increase foliar cover or raceme count. While it may take several years for the full impact of these treatments to be known, preservation of this population may require active management in the near future.

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.

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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 100m
8 Candy canes
Rulers- one per person
Flagging
4-5 rebars and pin flags to replace lost/bent rebars
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)

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 sub-populations, which are considered two separate populations in ORNHIC. Two of the subpopulations occur on overgrown skid roads, one is on the cut-bank of a maintained roadside (Figure 2), and one occurs above a road cut bank. These sites range from 1560–1990' 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, Oregon, and is concentrated along a ridge top dividing Letitia Creek and Long Wiley Creek at about 1760 ft 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 of this population. Significant thinning of small trees and shrubs occurred between the 2010 and 2011 monitoring of this population.

Figure 28. IAE field crew montiors lupine at Callahan Meadows.

Callahan Meadows

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 (Figure 29). 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

Figure 29. *L. oreganus* monitoring at Callahan Meadows

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 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, 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 checkermallow (*Sidalcea sp.*). 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 lupine population has not changed significantly.

Stout's Creek

Stout's Creek is located about three miles south of Milo, 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 orchardgrass (*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.

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 St.
- After 0.7 miles, turn right on Glenbrook Loop
- 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 1.2 miles, take a pullout to the right, park and walk around a brushy area onto an old skid road to reach sub-population 1.
- To reach sub-population 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 sub-population 3 begins. Sub-population 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 sub-population 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). Sub-population 3 begins on the left (east) side of the road.
- Sub-population 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 sub-population 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, then after 1.5 miles turn right onto rd 3220-300. In another 0.2 miles the road veers right onto dirt (road 3220-320) then passes through a gate after 0.8 more miles, 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 1998 ft in elevation. Another, smaller sub-population occurs ~200m 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 Ck. 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 road15). After about 12.4 miles you will pass over a bridge, 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 200m. 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, take exit 112 to Highway 42, (pass Roseburg Lumber and Particleboard Plant). Turn left onto Hwy 42 West.

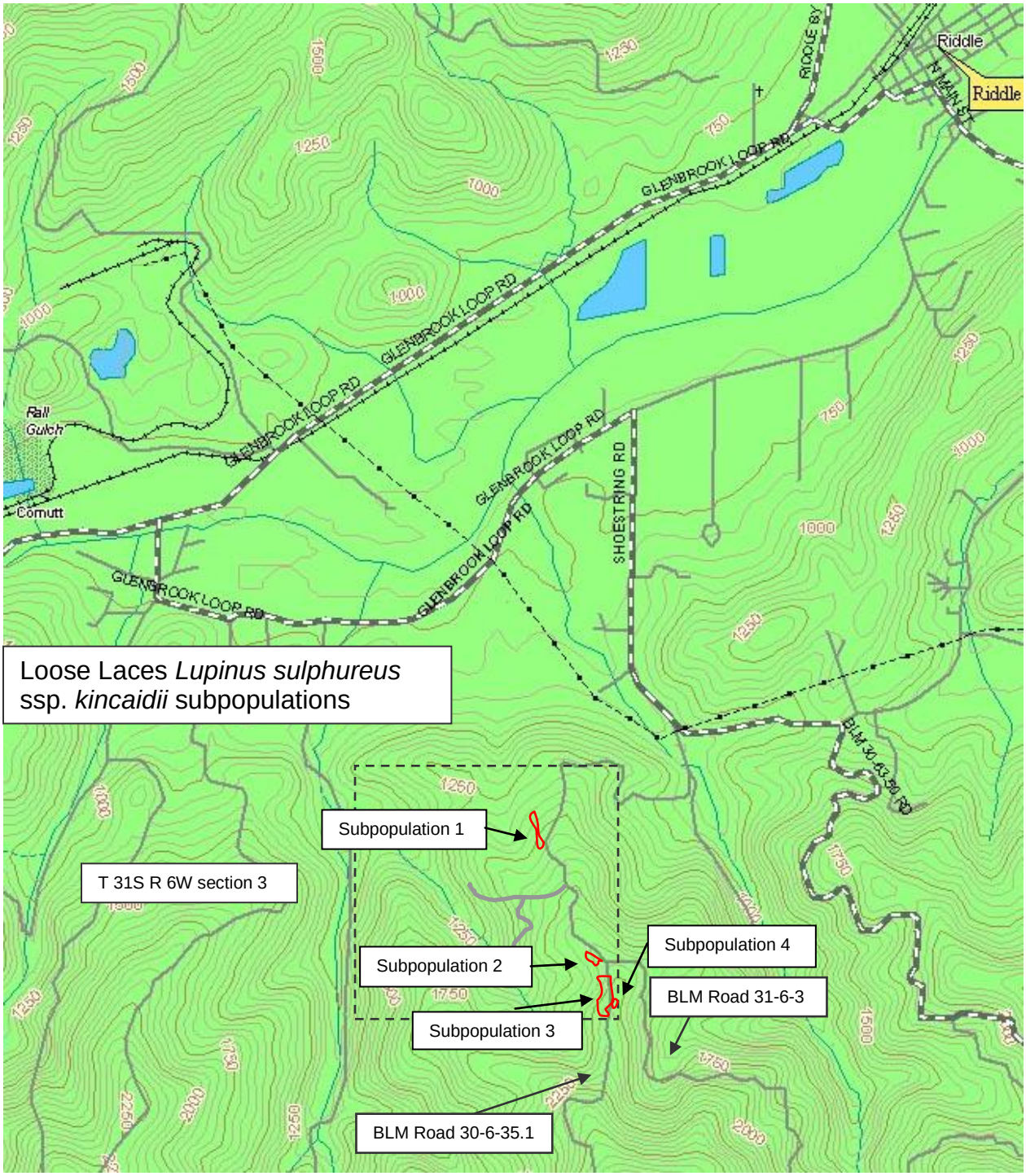
OR

Take exit 119 to Highway 42 to Winston (3.4 miles). Turn right onto Hwy 42 and stay on for 7.2 miles

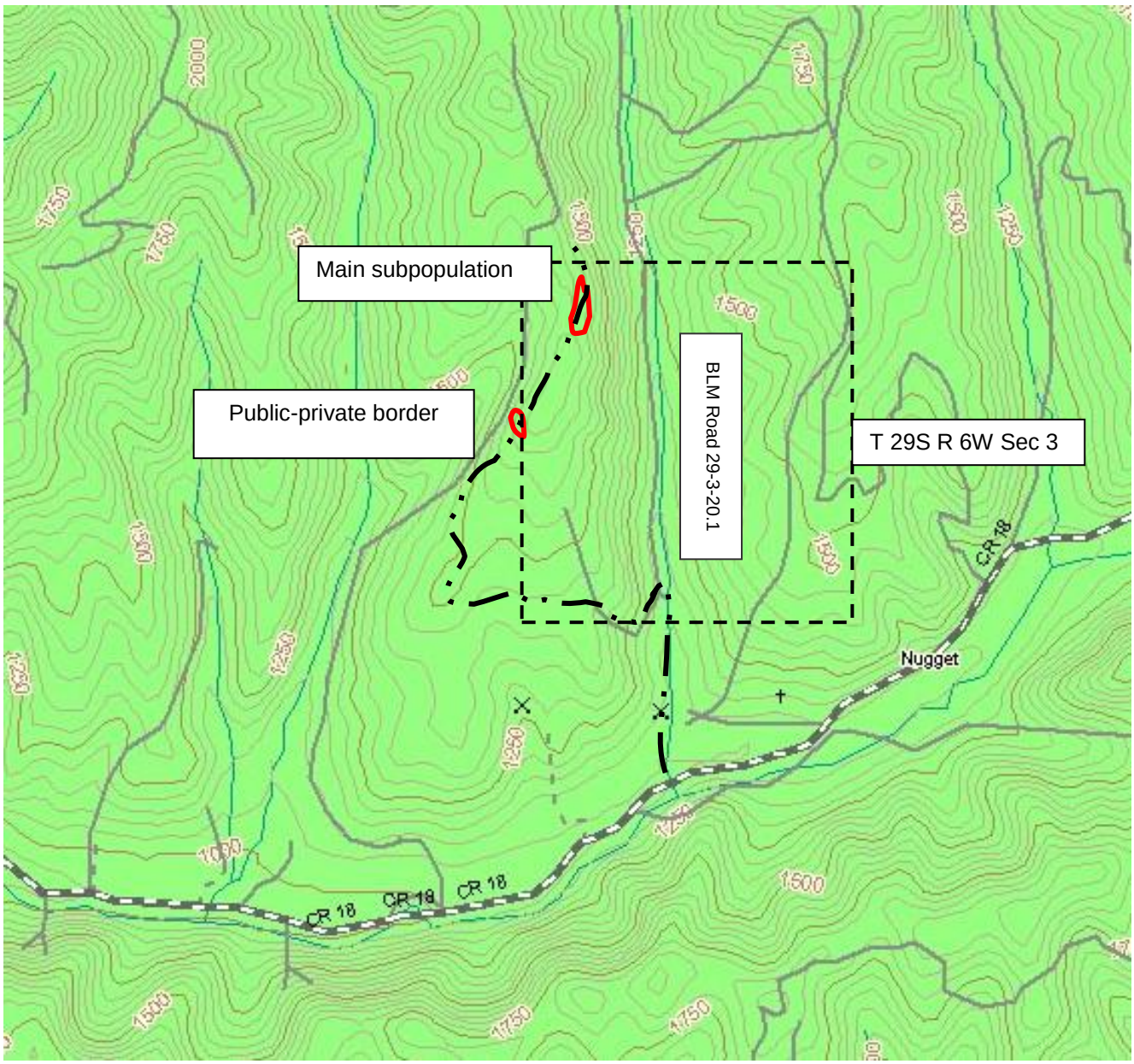
- From either starting point, turn left on Hoover Hill Road. (~1 miles outside of Winston) ***start odometer***
- After 2 miles, turn left at the stop sign onto Ollala Road.
- After 0.6 miles, turn left on BLM road 29.7.3 (sign says 2880)
- Stay on this road for 3.4 miles
- population will be on your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

Stouts Creek

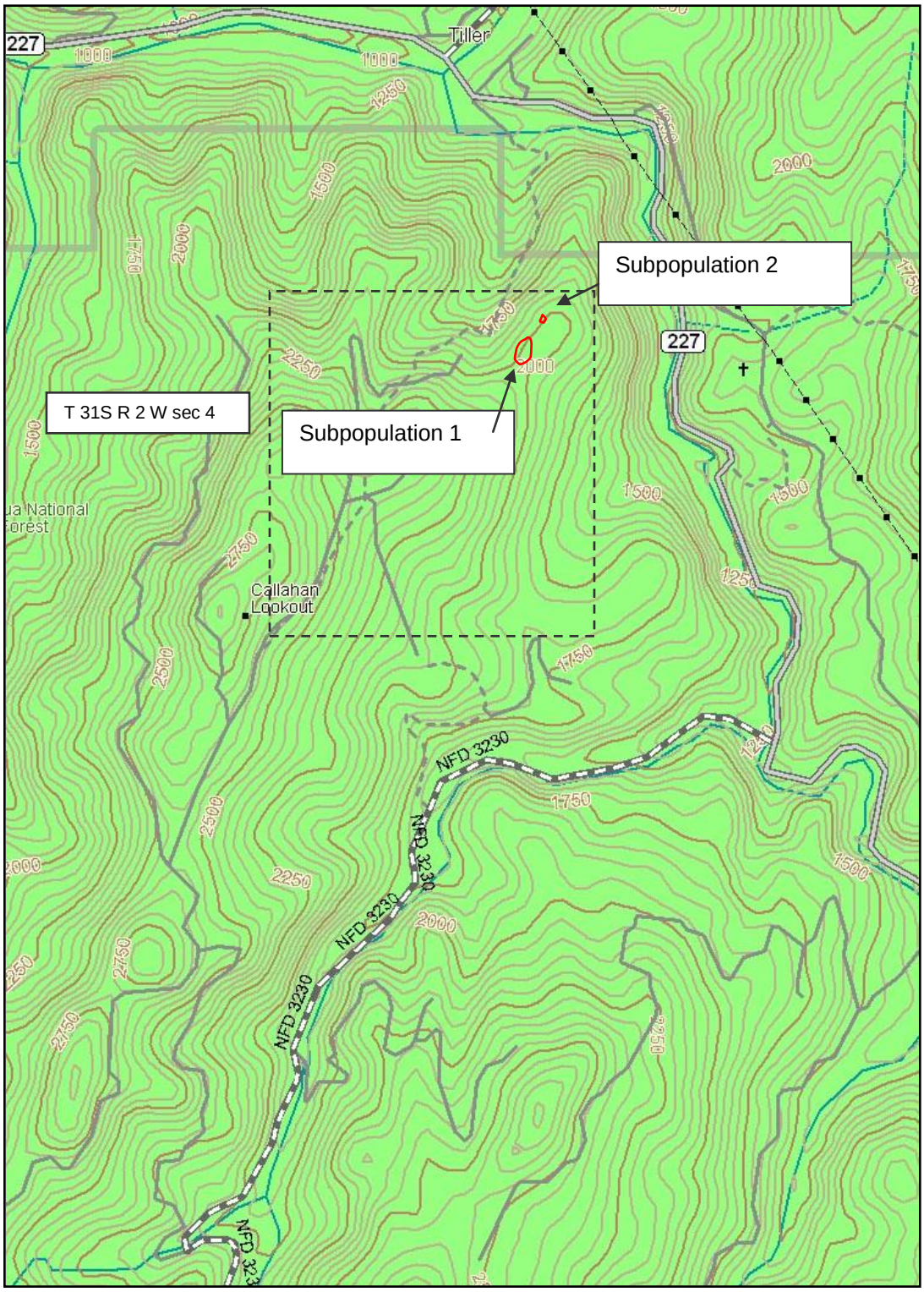
To reach this site from Canyonville, OR (I-5 exit 98), turn left on SE Third to head out of town (east). This road becomes Highway 1. After about 16.6 miles (just before Milo) turn right onto Stout's Creek Road. Stay on this road for about 1 mile, then veer right. (At 1.5 stay left, and go through yellow gate that is usually open. At 1.6 stay left.) Stay on this road until a total of about 2.75 miles to reach sub-population 1 (above road on right) then at 2.9 miles (total) turn left and at about 3.1 miles you will reach sub-population 2 (above and below road).



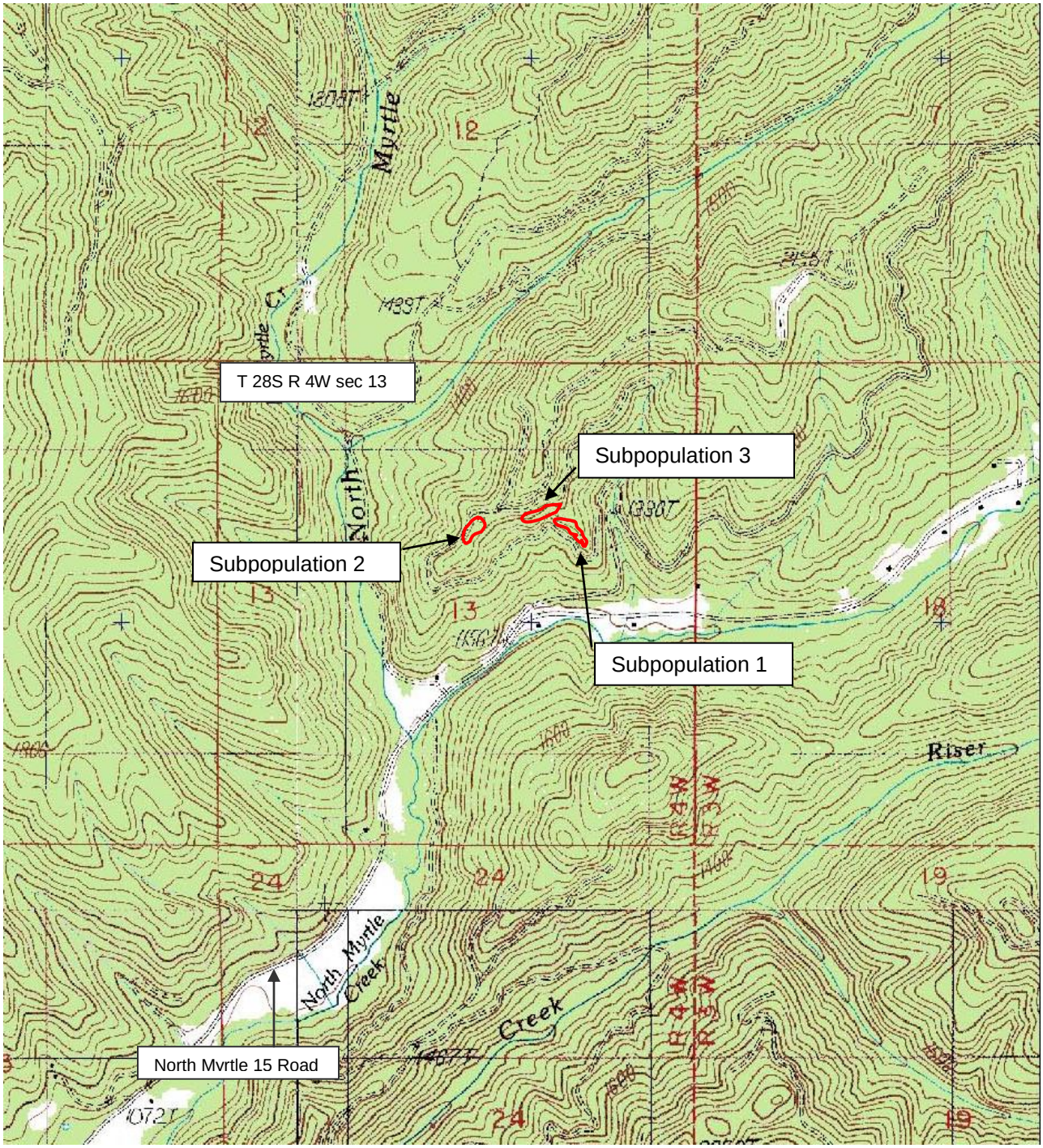
Map 1. Map showing location of Loose Laces site (T 31S R 6W sec 3). Approximate subpopulation locations are circled in red and labeled.



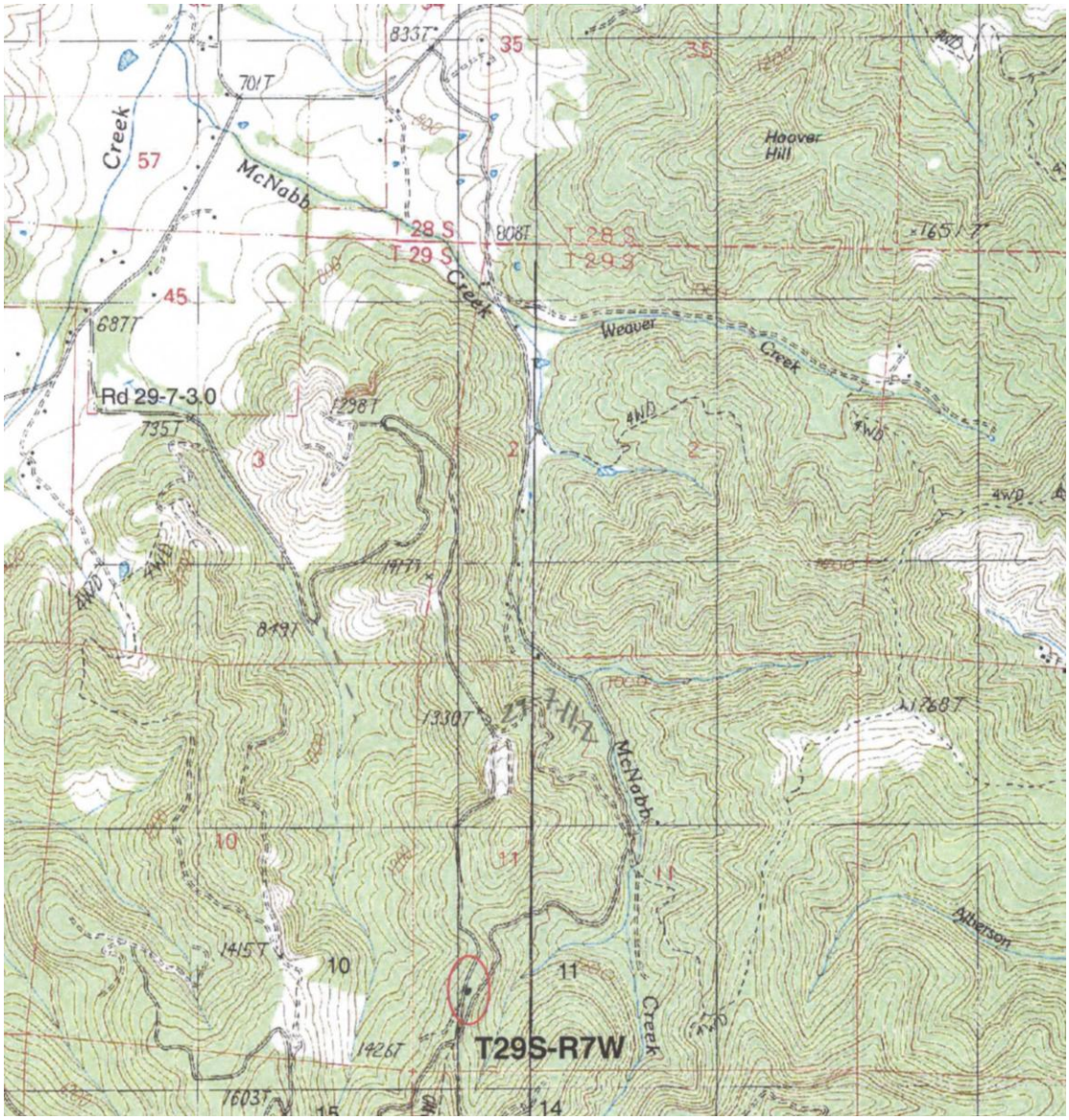
Map 2. Map location of Letitia Creek site (T 29S R 3W sec 17). Red circles indicate subpopulation locations on public land. The subpopulation further north is the larger population, *where L. sulphureus* ssp. *kincaidii* co-occurs with *Aster vialis*.



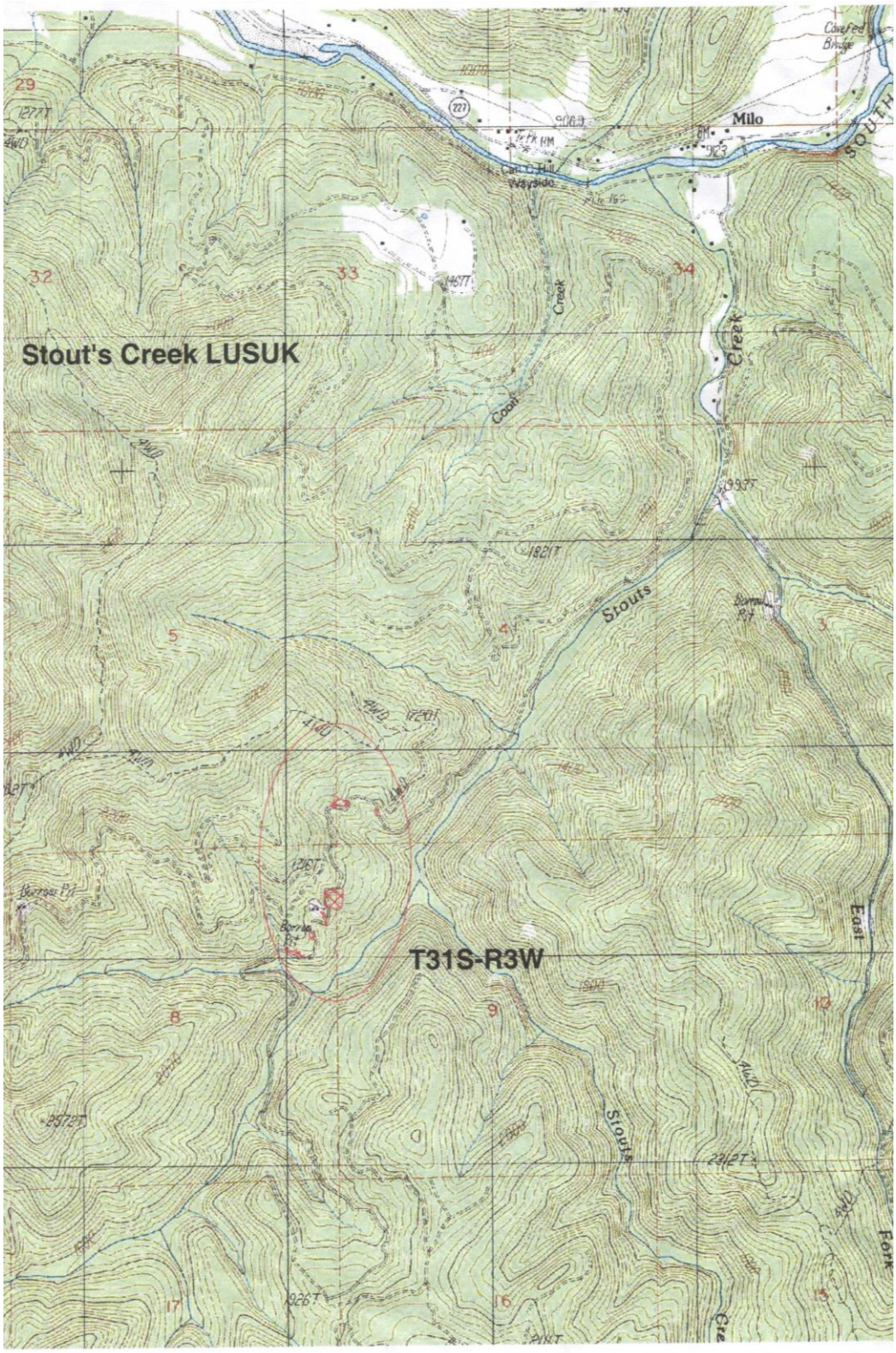
Map 3. Location of Callahan Meadows site (T 31S R 2W sec 4). WE monitored the southern population in 2003 and 2004 (circled in red): it is under the dripline of oaks on the upper meadow edge. The population located further north on the meadow edge was relocated in 2004, and now has a monitoring transect established throught 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 2006.

Table 1. Leaf and raceme totals for Lupinus oreganus populations monitored between 2003 and 2006.

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)
LOOSE LACES TOTAL	**20,102**	**684**	**15,312**	**373**	**13,664**	**762**	**34.66**	**n/a**	**316**	**25.48**
Subpopulation 1	5,032	148	4,243	119	4,314	180	13.45	n/a	33	3.3
Subpopulation 2	1,883	31	1,287	15	1,399	53	4.03	978	3	2.53
Subpopulation 3	10,132	432	7,345	214	5,760	473	14.85	n/a	231	14.96
Subpopulation 4	3,055	73	2,437	25	2,191	56	2.33	1,829	49	4.69
LETITIA CREEK TOTAL	**4,162**	**200**	**3,351**	**55**	**3,861**	**149**	**7.82**	**n/a**	**72**	**8.12**
Subpopulation 1	187	2	189	1	267	4	0.42	n/a	3	0.6
Subpopulation 2	3975	198	3,162	54	3,594	145	7.4	n/a	69	7.52
CALLAHAN MEADOWS TOTAL	**2,506**	**191**	**2,666**	**57**	**2,311**	**169**	**7.54**	**3,466**	**131**	**8.5**
Subpopulation 1	2,506	191	2,471	57	2,134	168	6.85	3,249	131	8.2
Subpopulation 2	-	-	195	0	177	1	0.69	217	0	0.3
STOUT'S CREEK TOTAL[1,2]	**-**	**-**	**-**	**-**	**12,191**	**257**	**22**	**n/a**	**219**	**21.24**
Subpopulation 1										
Transect A	-	-	-	-	248	5	0.5	116	4	0.31
Transect B	-	-	-	-	927	10	1.28	301	0	0.66
Transect C	-	-	-	-	631	5	1.04	375	5	0.88
Transect D	-	-	-	-	763	15	2.04	621	11	1.00
Subpopulation 2										
Above the road	-	-	-	-	4,439	96	7.05	n/a	110	8.21
(Below the road) Plot 1	-	-	-	-	1,272	41	3	1397	30	3.44
(Below the road) Plot 2	-	-	-	-	487	7	0.87	n/a	8	1.12
(Below the road) Plot 3	-	-	-	-	3,424	78	6	n/a	51	5.62

Appendix 4

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)
CHINA DITCH TOTAL[2]	**-**	**-**	**16,278**	**369**	**15,334**	**784**	**18.03**	**13,111**	**586**	**21.22**
Patch A										
Roadside (prev. subpop. 2)	-	-	3,065	78	3,197	166	4.01	2,348	70	3.35
Transect 1 (prev. rep. transect 1)	-	-	1,058	17	715	14	1.81	994	20	1.99
Transect 2[3]	-	-	-	-	-	-	-	-	-	-
Transect 3[3]	-	-	-	-	-	-	-	-	-	-
Patch C										
Roadside (prev. subpop. 1)	-	-	6,396	147	6,243	257	9.36	7,039	302	10.12
Transect 1[3]	-	-	-	-	-	-	-	-	-	-
Transect 2[3]	-	-	-	-	-	-	-	-	-	-
Patch D										
Roadside (prev. subpop. 3)	-	-	5,759	127	5,179	338	8.67	6,072	284	11.1
Transect 1[3]	-	-	-	-	-	-	-	-	-	-
DICKERSON HEIGHTS TOTAL[1]	-	-			**8,096**	**259**	**18.24**	**10,598**	**168**	**17.26**
GRAND TOTALS	**26,770**	**1,075**	**37,607**	**854**	**55,457**	**2,380**	**108**	**n/a**	**1,492**	**101.82**

[1] New monitoring transect(s) established in 2005

[2] Leaf and inflorescence totals are not a census.

[3] New monitoring transects established in 2010

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 clearly 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, 2008 and 2009. *Lupinus oreganus* inflorescences were collected from two neighboring populations: "The Ridge," approximately one mile away on land managed by the US 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, Callahan x Callahan (within patch crossing) (Table 2). 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 30). 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

Table 2. Replication of pollen transfer treatments at Callahan Meadows, 2008 and 2009.

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 (Figure 30). 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 relate 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 and cover has increased 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) suggest 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 lupine populations, but is also self-incompatible.

Figure 30. a) Flowers that failed to develop fruits in the pollen transfer experiment at Callahan Meadows, b) D. Giles-Johnson performing the pollen transfer at Callahan Meadows, c) raceme after pollination treatment. Photo: D. Giles-Johnson and A.S. Thorpe.