Evaluation of population trends and potential threats to a rare serpentine endemic, *Calochortus coxii* (Crinite mariposa lily)

2015

Report to the Bureau of Land Management, Roseburg District

Report prepared by Erin C Gray and Matt A. Bahm

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:

Matt Bahm

Institute for Applied Ecology

PO Box 2855

Corvallis, Oregon 97339-2855

phone: 541-753-3099

fax: 541-753-3098

email: mattab@appliedeco.org

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Cover photograph: Crinite mariposa lily (*Calochortus coxii*)

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EXECUTIVE SUMMARY

- The major threats of C. *coxii* noted over the course of our study include encroachment by conifers and invasion by exotic species. Recent treatments at Bilger 1 in close proximity to long-term monitoring transects indicate that careful canopy thinning was associated with an increased number of flowering individuals in those areas, though response may be short-lived and continued maintenance will be necessary. These data suggest that canopy thinning treatments can be effective at increasing number of flowering plants, however they must be carefully implemented to not increase spread of invasive species or impact areas of dense C. *coxii* abundance.
- While we had observed a decline of vegetative C. *coxii* from 2011 to 2014 in long-term monitoring transects, in 2015 we noted an increase in vegetative plants which led to an overall increase in total number of individuals. This was following a year of increased reproductive individuals.
- Maximum temperature in 2015 exceeded temperatures experienced since 2011, including long-term normal, this was coupled with 2015 having one of the lowest precipitation years since 2011. It is increasingly likely that these climate trends are affecting population dynamics of C. *coxii* along with other factors including microclimate and canopy cover.
- *Calochortus coxii* has greater abundances of flowering individuals in open habitats without canopy cover. In forested areas, the species tends to be predominately vegetative. These trends have been consistent over the course of this study.
- Surveys of C. *coxii* historical populations in 2011 and 2012 indicate that for all but one of the populations (Myrtle Creek 4) there were significantly fewer C. *coxii* than had previously been recorded at these sites. At some sites the discrepancy was extremely large (for example 5.6 million plants reported at Bilger Ridge previously while we found only 6,118). Our results indicate that additional measures might be needed to improve habitat.
- Parts of Bilger 1 are in very close proximity to the area for the planned LNG Pipeline. While plans for the pipeline do not directly dissect areas that house this species, there are plants present, in some cases, just meters away from the proposed area. We have documented that population dynamics of this species can vary depending on changes in microclimate (canopy thinning) and that exotic species invasion is a continued threat in these sensitive systems. Implementation of the LNG Pipeline in very close proximity to this population C. *coxii* is cause for concern for these reasons.

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REPORT TO THE BUREAU OF LAND MANAGEMENT, ROSEBURG DISTRICT

INTRODUCTION

Calochortus coxii M. Godfrey & F. Callahan (Cox's or Crinite mariposa lily, Figure 1) is listed as endangered by the Oregon Department of Agriculture, a Federal Species of Concern, and a Heritage Rank G1 species (critically imperiled throughout its range; ORBIC 2010). This species is endemic to a ten-mile serpentine ridge system between Myrtle Creek and Riddle, Oregon (Fredricks 1992, USDI BLM and USFWS 2004). Since the species relatively recent discovery in 1988, 24 populations have been identified (USDI BLM and USFWS 2004).

Figure 1. *Calochortus coxii* in flower.

Calochortus coxii is a perennial forb in the Liliaceae family. The vegetative form is composed of a single, simple leaf with a dark, smooth upper surface and a pubescent undersurface (Figure 2). When in flower, the species is showy with three cream-colored petals which appear yellow due to hairs on the inside surface (Fredricks 1992; Figure 1). *Calochortus coxii* can co-occur with *Calochortus tolmiei*, which when not in flower looks similar, but C. *tolmiei* does not have pubescent leaves. Another mariposa lily endemic to similar areas in Douglas County is *Calochortus umpquaensis*, though the two species have not been observed to co-occur (Kagan 1993).

Calochortus coxii habitat is narrowly restricted to serpentine-derived soils in meadows to open woodlands and the ecotone between forest and meadow habitat, often with rocky substrate and a north-facing aspect (Fredricks 1992). Common associated species include *Pinus jeffreyi*, *Pseudotsuga menziesii*, *Calocedrus decurrens, Festuca roemeri, Aspidotis densa, Plectritis congesta, Sedum stenopetalum, Silene hookeri,* and *Zigadenus venenosus*.

Figure 2. *Calochortus coxii* in bud.

There are numerous threats to C. *coxii*. Fire exclusion over the past 90 years has resulted in encroachment of woody plant species, altering the habitat quality for this species. Several noxious weeds have been observed adjacent to and within C. *coxii* habitat, including *Centaurea solstitialis* (yellow star-thistle), *Chondrilla juncea* (rush skeleton weed), *Taeniatherum caput-medusae* (medusa-head), *Cirsium arvense* (Canada thistle), *Cirsium vulgare* (bull thistle), and *Carduus pycnocephalus* (Italian thistle). Additional threats include logging, grazing, mining, and road construction. The Pacific Gas Connector Gas Pipeline has proposed construction of a Liquified Natural Gas (LNG) pipeline through the population at Bilger Ridge and neighboring private lands that may also support populations of C. *coxii*. There are concerns that the LNG pipeline will fragment C. *coxii* populations and habitats (Hatt 2008). In 2015 areas that would be impacted by the proposed pipeline were in very close proximity (within meters) of the C. *coxii* population. The disturbance associated with this pipeline is cause for concern in these sensitive habitats.

The primary sites where the species is known to occur include Bilger Ridge (Appendices B and C), Langell Ridge (Appendix D), Myrtle Creek (Appendix E), and Red Ridge (Appendix F). Two of these areas, Bilger and Myrtle Creek, are large and sufficiently patchy that subareas of have been delineated for them for the purposes of mapping and reference.

One of the challenges in managing this species is that accurate population estimates are unavailable. The most complete population surveys were conducted by Nancy Fredricks in the late 1980's to early 1990's (Fredricks 1989, Fredricks 1993). A few of these populations had not been revisited since. Although Bilger Ridge and Langell Ridge were monitored in 1991, 1992, and 1993, these efforts resulted in only rough estimates of population size and extent (S. Carter, *personal communication*). In this study, we surveyed all occurrences of C. *coxii* previously documented on BLM land to determine their status, estimate their size and extent, and document potential threats. In addition, we established long-term plots at the largest site (Bilger Ridge) with the goal of providing accurate population estimates that will enable managers to determine trends in population size. This study will yield current population estimates that can be used to determine if additional measures are needed to conserve this unique endemic species.

METHODS

Permanent monitoring transects: Bilger 1 and Bilger 4 (2011-2015)

We established permanent monitoring transects at Bilger 1 and 4 to (1) characterize the habitat occupied by C. *coxii*, (2) measure changes in the total number of plants and ratios of vegetative to reproductive individuals over time, and (3) determine if population fluctuations differ depending on habitat characteristics. Five permanent transects were established at Bilger 1 and Bilger 4 in 2011 and were monitored each June from 2011 to 2015. Transect locations were selected as areas with relatively high C. *coxii* abundance and differed by habitat (Table 1, Appendix G, Appendix H). Habitat targeted included rocky slopes dominated by *F. roemeri,* mossy sites with *P. congesta,* forest openings with high grass cover, sites with some exotic grass cover, and areas with some conifer recruitment. Each transect location was selected *a priori* based upon surveys conducted a few weeks prior to the first sample in 2011.

Table 1. Habitat characteristics of transect locations

Transect	Category	Habitat Characteristics
Bilger 1		
Transect 1	Forested	Forest meadow, partially open canopy, high moss cover, wet.
Transect 2	Forested	Forest opening, high moss and *P. congesta* cover, some recruitment of *P. jeffreyi* and C. *decurrens*. Presence of exotic grasses.
Transect 3	Dry	Rocky, dry, high graminoid composition (not *Festuca*). Canopy thinning in the surrounding area occurred in winter 2011.
Transect 4	Dry	Dry area surrounded by *P. jeffreyi*, some C. *decurrens* recruitment in the transect. Canopy thinning in the surrounding area in winter 2011.
Transect 5	Dry	High C. *decurrens* recruitment, high moss cover. Canopy thinning occurred directly in the area and transect had to be re-established due to slash piles.
Bilger 4		
Transect 1	Dry	Very steep with *F. roemeri* and rocky, serpentine habitat. Recruitment in the surrounding area with some C. *decurrens* recruitment occurring in the transect.
Transect 2	Dry	Mixed open canopy, high graminoid cover. *P. jeffreyi* recruitment present around the transect.
Transect 3	Forested	Mixed canopy forest, semi-closed canopy of C. *decurrens, P. menziesii,* and *P. jeffreyi*. Understory moist, some C. *decurrens* recruitment.
Transect 4	Forested	Forested, high levels of C. *decurrens* recruitment. High moss and *P. congesta* cover.
Transect 5	Dry	Dry site in small meadow. Rocky, with moss & *P. congesta* cover. Very little soil development.

Transects were 25m long. Both ends were marked with rebar topped with a yellow cap and wired with a unique numbered tag. A 1m belt was established to the left of the origin (facing the end), and marked with 4 inch nails and washers. We recorded azimuth of each transect from the origin to 25m, and from the origin towards the belt. Six photopoints were selected (0m to 25m, N, E, S, W, 25m to 0m) and photographed with a digital camera. Habitat characteristics, presence or absence of exotic species, evidence of encroachment and dominant species were documented. We counted every C. *coxii* individual within the 1m x 25m belt transect, tallying vegetative and reproductive plants separately. Also tallied were the number of plants with leaf herbivory by mammals or insects, or flower herbivory by mammals or insects.

Community data were collected on five randomly chosen 1m² plots per transect in 2011, this was repeated in the same locations each year thereafter. All vascular species and ground surface substrates were assessed for percent cover. Total plot cover was thus at least 100% and exceeded 100% if there were overlapping layers of vegetation. Substrate categories included moss/lichen, litter, rock and bare ground. When moss or lichen were growing on the ground, they were classified as "moss/lichen", however if they were growing on a rock, they were classified as "rock". Mean percent cover by each species or substrate was calculated for the entire transect. These data were used to calculate the proportion of total plant cover occupied by each functional group (forb, graminoid, or tree) and by provenance (native or exotic). We estimated canopy cover for each plot using a densitometer and averaged values to obtain mean % canopy cover for the entire transect.

Climate data [monthly precipitation (in), monthly minimum temperature (°F), and monthly maximum temperature (°F)] from 2011- 2015 were acquired from the PRISM climate group (PRISM 2006). Monthly averages were combined into seasonal means (winter = December-February, spring = March-May, summer = June-August, fall = September-November) to look at trends over time.

Surveys of previously known *Calochortus coxii* populations (2011 and 2012)

We visited all reported occurrences (eight sites) of C. *coxii* on BLM land in 2011 to estimate their size and extent and document potential threats (Figure 3). Of those sites, three had no C. *coxii* or appropriate habitat. In 2012, we re-surveyed the five sites that supported C. *coxii* in 2011, and in addition, re-visited one of the unoccupied sites (Myrtle Creek 5) to confirm that there was no suitable habitat to support C. *coxii (*Table 4). We used the Intuitive Controlled survey method (Whiteaker et al. 1998) to search for plants in habitat likely to support C. *coxii* (open, meadow-like conditions, north facing slope, serpentine soils, etc.) at each site. Our surveys focused on public land, and population estimates in this report apply only to public lands, although some populations also occur on private lands. Some areas included in the shapefiles provided by the BLM were not surveyed as their characteristics did not indicate potential habitat (described in more detail in the results for each population). Also, some sites surveyed in 2011 were not surveyed in 2012 because they did not support appropriate habitat for C. *coxii* and no populations were located in 2011. When encountered, plants were tallied as in leaf, bud, fruit, or flower. At the Bilger site only, plants were tallied but not differentiated into life stages because of the large area and high density of C. *coxii* plants in some patches. Individuals or areas of high density were marked using GPS to map population boundaries. Sighting report forms were completed for each occurrence noting potential causes of disturbance, geology, plant community composition, presence of exotic species, and physical characteristics of the site.

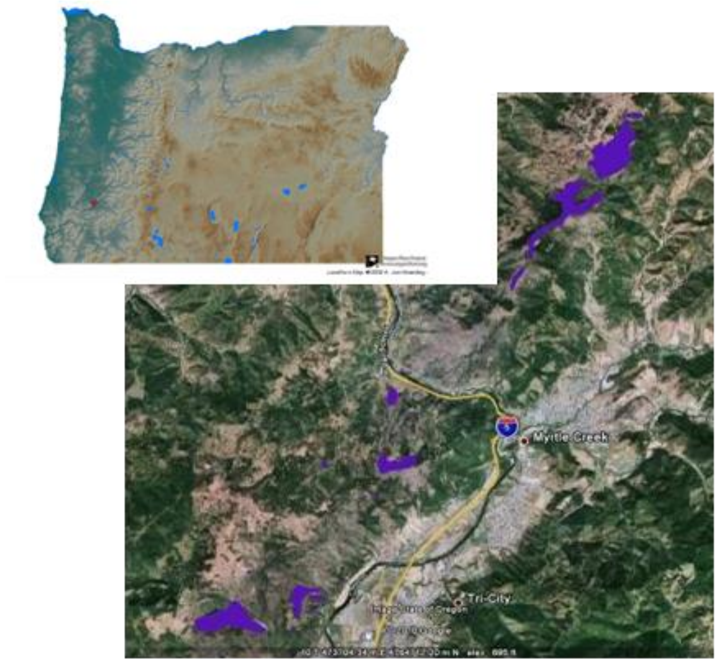

Figure 3. Project study sites. A red dot in the inset map shows the relative location in Oregon. In the close-up of the study area, known populations of Calochortus coxii in the BLM Roseburg District are highlighted in purple.

RESULTS

Permanent monitoring transects: Bilger 1 and Bilger 4 (2011-2015)

A total of 313 plants (161 vegetative, 152 reproductive) were found along the five transects at Bilger 1 (Table 2, Figure 5). This was a slight decrease from 2014 where we observed 321 plants with many more reproductive plants than vegetative (227 and 94, respectively). While in 2014 there was a large increase in number of reproductive plants at Bilger 1, number of vegetative and reproductive plants were very similar in 2015; plants at Bilger 1 experienced an increase in vegetative plants and a decrease in reproductive. At Bilger 4, transects increased from 194 plants to 288 plants from 2014 to 2015, with 203 vegetative and 85 reproductive plants (Table 2, Figure 4). This increase has similar numbers to those seen in 2012 at Bilger 4 (307). The relative amount of vegetative and reproductive plants differed between 2014 and 2015 at Bilger 4, with an increase seen in the number of vegetative plants and subsequent decline in reproductive plants. At both Bilger 1 and Bilger 4, vegetative plants increased in 2015 relative to 2014 values (Figure 5, Figure 6). This differed from a great increase in reproductive plants seen from 2013 to 2014. Over the years, we have observed a steady decline in vegetative plants within transects at Bilger 1 and 4 (Figure 4). Reproductive plants experienced a slight decline from 2011 to 2013, with a sharp increase in 2014. 2015 differed greatly from recent years with high numbers of vegetative plants and slightly lower reproductive count, but with an overall increase in total plants (Figure 4).

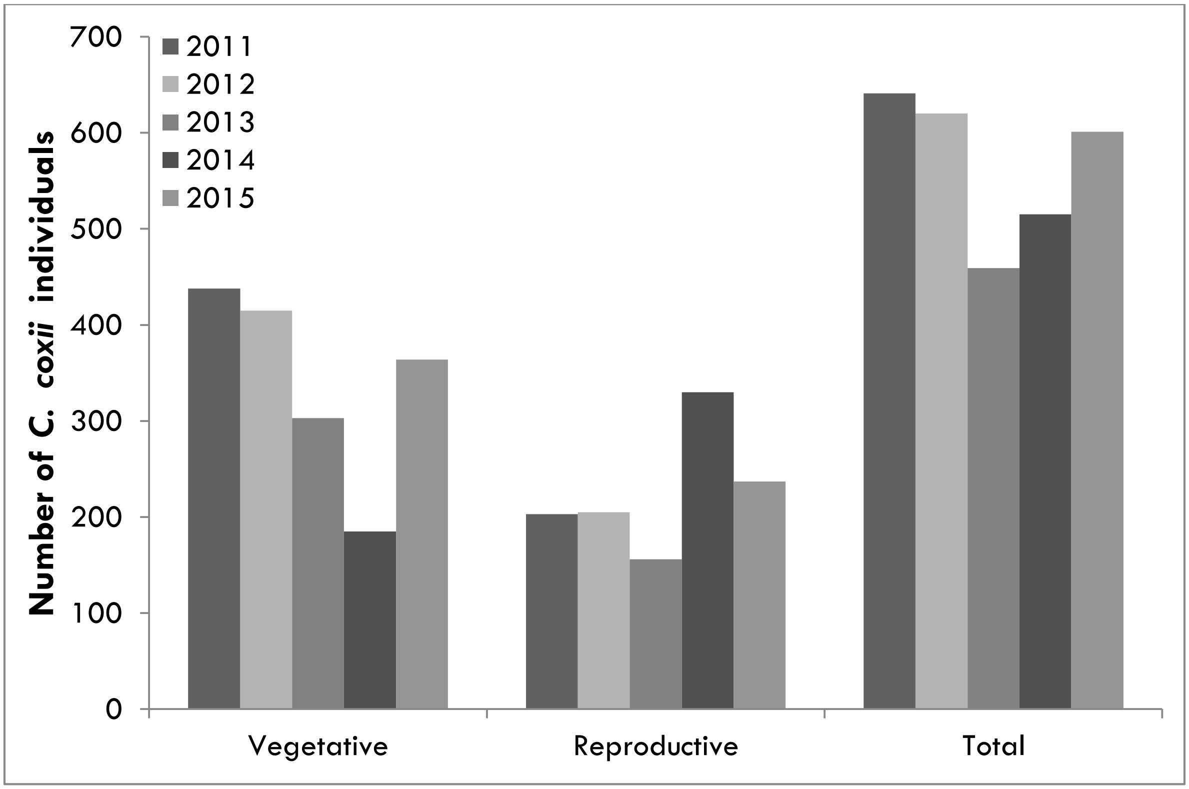

Figure 4. Total number of C. *coxii* counted in permanent monitoring transects at Bilger 1 and 4, 2011-2015.

In 2015, we observed a shift from dominance of reproductive plants to dominance of vegetative plants across Bilger 1 and Bilger 4. Number of vegetative plants noted in 2015 was similar to values in 2011 and 2012 (Figure 4). At Bilger 1, percentage of reproductive plants ranged from 20-73%, with reproductive plants dominating all transects except Transect 1 and Transect 5 (Figure 5). At Bilger 4, percentage of reproductive plants ranged from 0 to 62% (Figure 6). While in previous years there were many more reproductive plants in these transects, the number of vegetative increased greatly from 2014 to 2015. For example, Bilger 4 Transect 2 had 100% reproductive plants in it in 2014 but was dominated by vegetative (43% reproductive, 57% vegetative) in 2015.

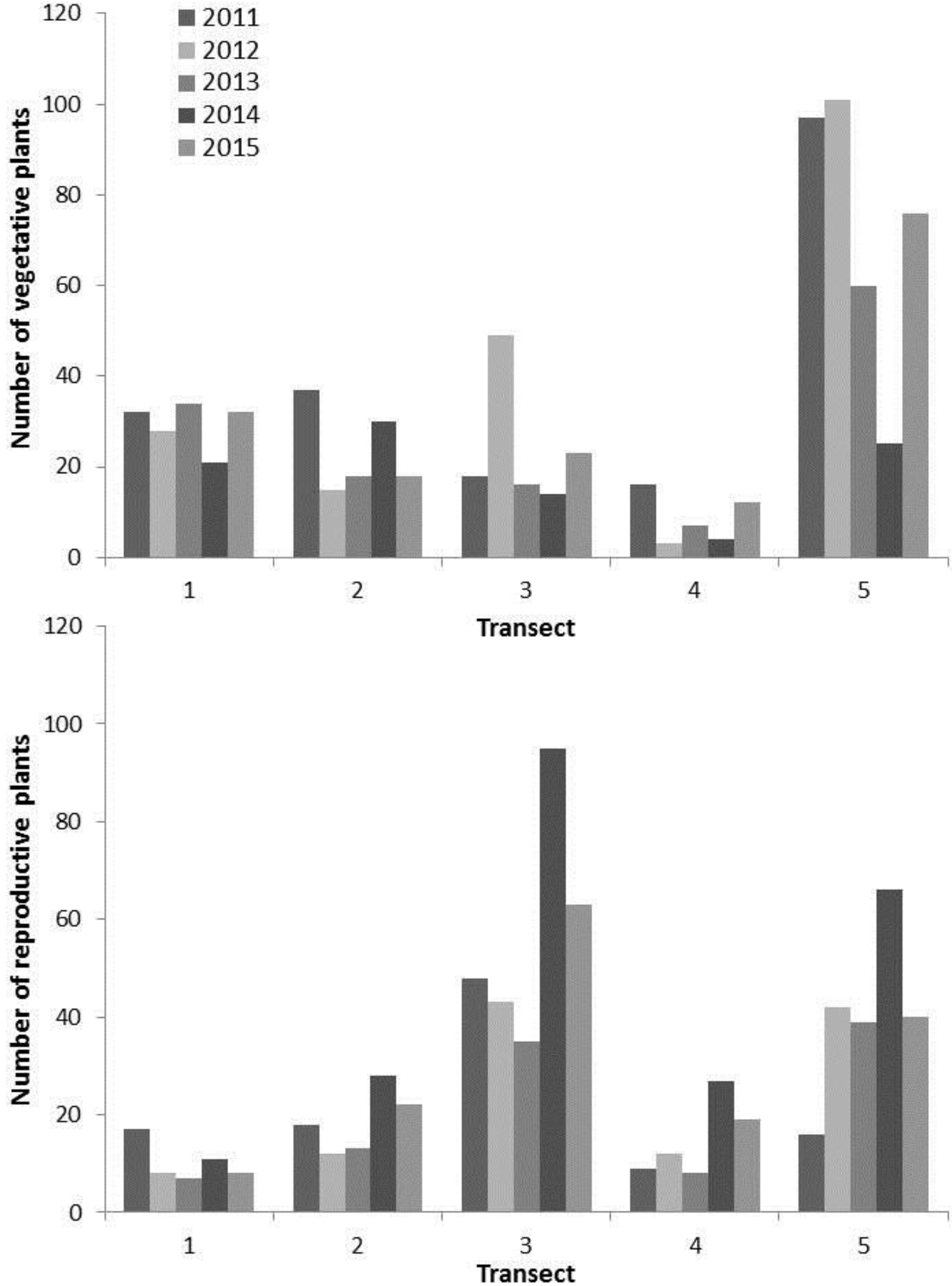

Figure 5. Total number of vegetative plants (above) and total number of reproductive plants (below) in transects at Bilger 1 from 2011-2015.

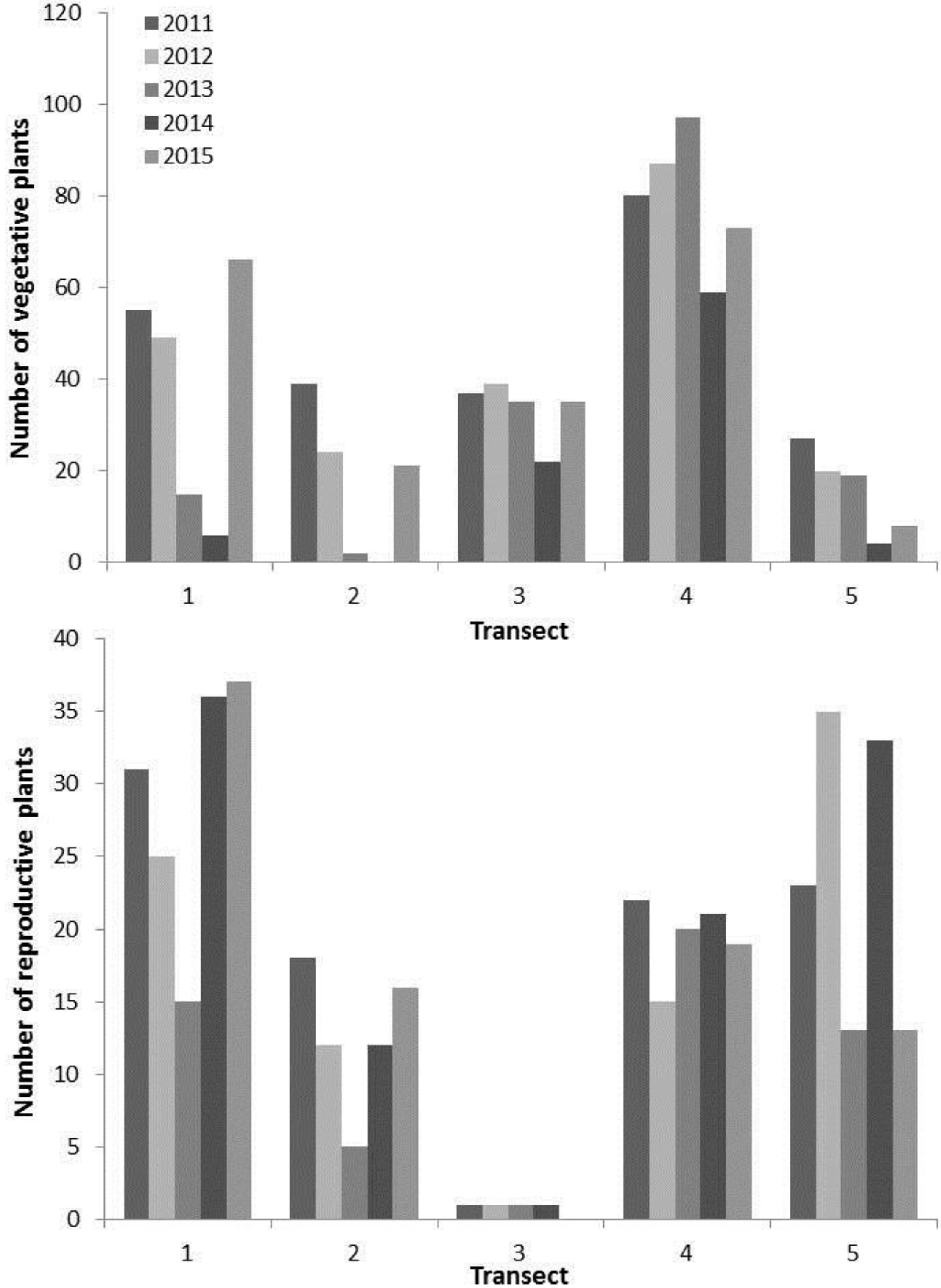

Figure 6. Total number of vegetative plants (above) and total number of reproductive plants (below) in transects at Bilger 4 from 2011-2015.

Table 2. *Calochortus coxii* tally within 1m x 25m belt transects at two sites, Bilger 1 and Bilger 4 in 2015

Site	Transect	Total	Total	Total All	# Flowers/plant (Tally)					Herbivory			
		Veg.	Repro.		1	2	3	4	Total	Flower by mammal	Flower by Insect	Leaf by insect	Leaf by mammal
Bilger 1	1	32	8	40	7	1	0	0	8	1	0	4	5
Bilger 1	2	18	22	40	15	7	0	0	22	0	7	3	1
Bilger 1	3	23	63	86	37	21	5	0	63	13	5	2	2
Bilger 1	4	12	19	31	16	3	0	0	19	6	6	1	2
Bilger 1	5	76	40	116	37	3	0	0	40	3	13	7	4
Mean		32	30		22	7	1	0		4.6	6.2	3	3
Total		161	152	313	112	35	5	0	152	23	31	17	14
Bilger 4	1	66	37	103	33	3	1	0	37	4	13	4	2
Bilger 4	2	21	16	37	11	4	1	0	16	0	2	0	1
Bilger 4	3	35	0	35	0	0	0	0	0	0	0	13	1
Bilger 4	4	73	19	92	16	3	0	0	19	0	8	27	0
Bilger 4	5	8	13	21	10	3	0	0	13	2	10	1	3
Mean		41	17		14	3	0	0		1.2	6.6	9	1
Total		203	85	288	70	13	2	0	85	6	33	45	7
Total all		364	237	601	182	48	7	0	237	29	64	62	21

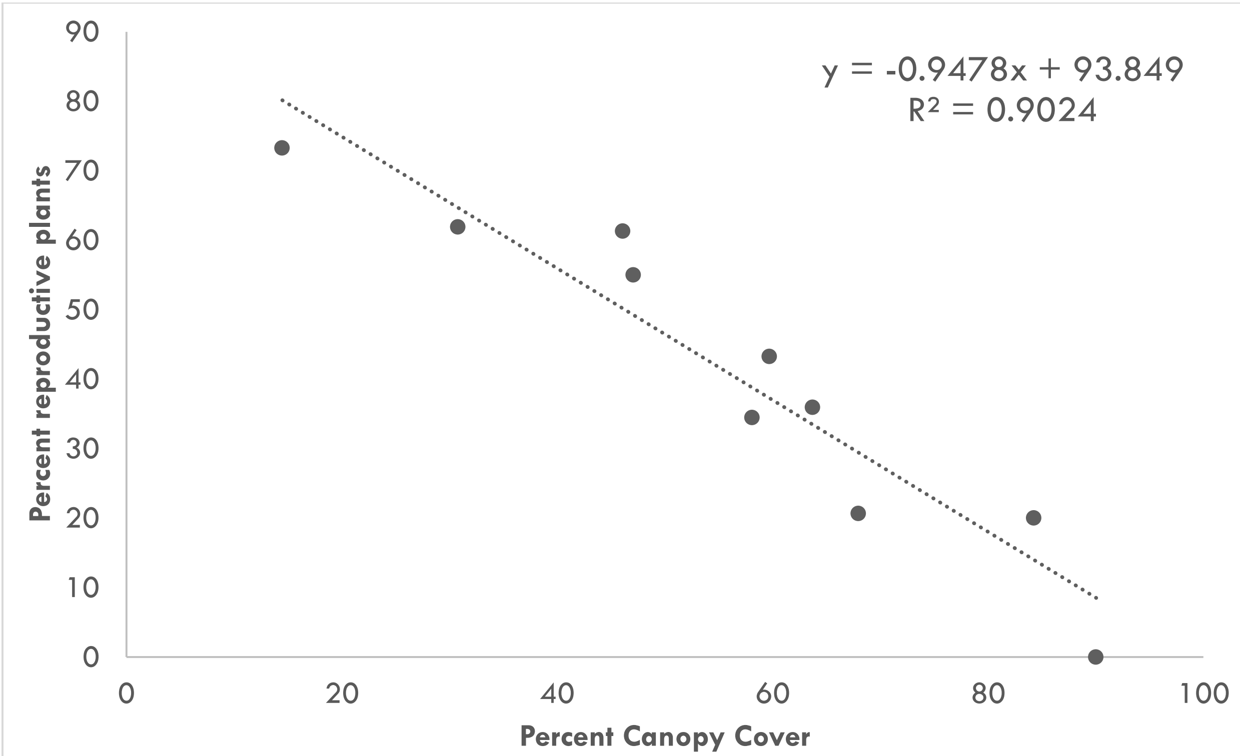

Figure 7. Relationship between mean percent canopy cover and mean percent reproductive plants composing each transect at Bilger 1 and Bilger 4.

Percentage of reproductive plants and canopy cover were negatively correlated in 2015 ($r^2 = 0.9$, Figure 7), suggesting that canopy clearing can increase number of reproductive plants. We have noticed this in the field where transects with very dense canopies have primarily vegetative plants whereas those in open habitats have higher cover of reproductive plants. At Bilger 1, canopy clearing around transects 3, 4, and 5 occurred between 2011 and 2012 and was followed by a short-term decrease in canopy cover in these areas (Table 3). In 2014 and 2015 canopy cover increased in these areas, suggesting that new recruitment is occurring in these areas and that multiple canopy treatments might be needed. Canopy cover tended to be fairly consistent across years at Bilger 4, with slight decreases in cover from 2014 to 2015 in transects 4 and 5 (Table 3). Canopy cover varied across transects, with percent shade ranging from 14% to 90% (mean 56%). Transects at Bilger 4 tended to be more shaded than those in Bilger 1 (means = 56% and 50 %, respectively).

Table 3. Mean percent canopy cover at Bilger 1 and Bilger 4 from 2011-2015

		Mean Percent Canopy Cover				
Site	Transect	2011	2012	2013	2014	2015
Bilger 1	1	88	86	90	83	84
	2	21	35	56	52	47
	3	8	11	7	18	14
	4	48	35	31	53	46
	5	86	47	45	64	58
Bilger 4	1	70	46	67	60	64
	2	55	57	67	61	60
	3	82	88	91	89	90
	4	84	53	67	81	68
	5	25	21	19	56	31

We observed a decline in herbivory from 2012 to 2015; in 2015 we observed herbivory on 27% of all plants, as compared to 41% that had experienced herbivory in 2011 and 2012. Across all transects, 7% of plants experienced leaf herbivory by insects, and 2% experienced leaf herbivory by mammals (Table 2). Herbivory on flowers decreased greatly from 2014 to 2015 with 3% flower herbivory by mammal and 16% flower herbivory by insects (relative to 22% by mammals and 16% by insects in 2014). This is likely the result of the greater number of reproductive plants (thus flowers available) noted in 2014. Overall, plants at Bilger 1 experienced slightly less herbivory than Bilger 4 (27% and 32%, respectively, Table 2), while in 2014 there was much more herbivory noted in Bilger 4 (70%).

Calochortus coxii tended to show different growth responses to the habitat types it occupied (Figure 8). While the number of vegetative plants were similar in forested and dry/open habitats, reproductive individuals tended to be more common in dry/open versus forested habitats (Figure 7, Figure 8). Herbivory also tended to differ between habitat types. Flower herbivory (both by mammals and insects) tended to be more common in dry habitats than in forested ones, likely because the flowering occurred mostly in dry habitats. Leaf herbivory by insects was much more common in forested habitats (Figure 8).

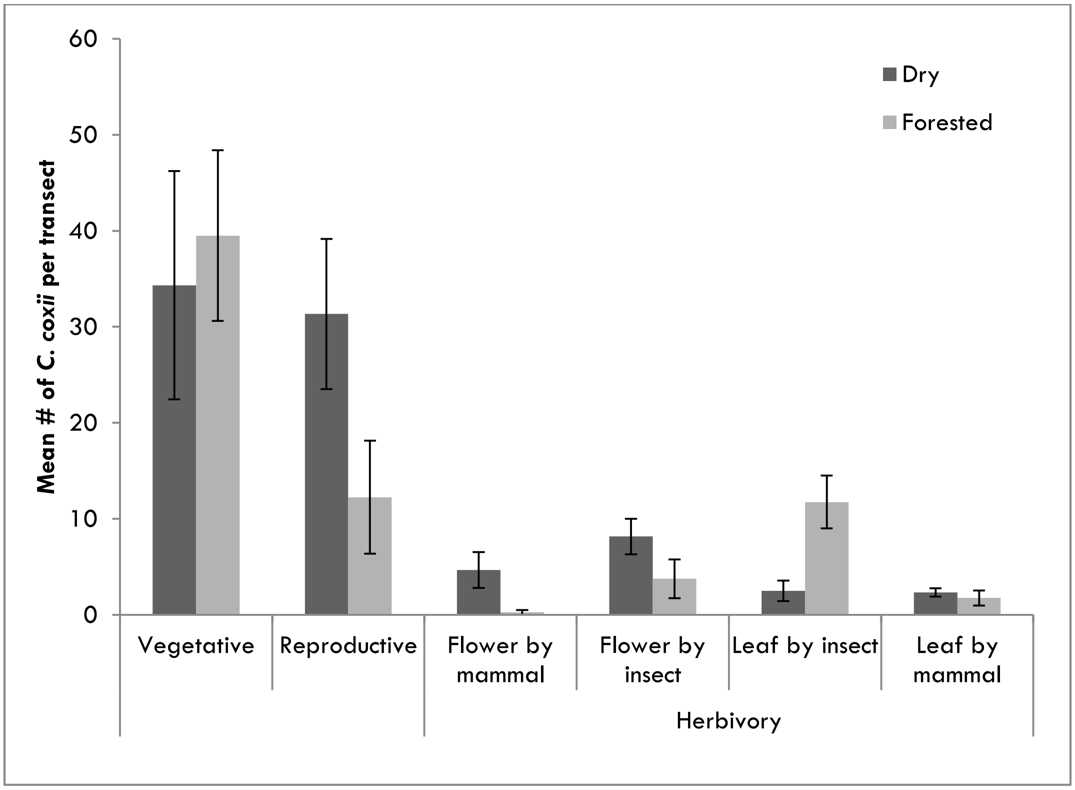

Figure 8. Mean number of C. *coxii* per transect in dry and forested habitats, including those that exhibited herbivory, 2015. Error bars represent 1 SE.

Across the two sites and ten transects, 47 species were recorded. Of those species, 40 were native and 7 were exotic. Species richness ranged from 13 to 22 species per transect. Native species comprised 95% of total plant cover, exotic species accounted for 5% (Figure 9). Native graminoids were the most abundant, consisting primarily of *Achnatherum lemmonii, Festuca roemeri,* and *Melica geyeri* (Figure 9, Appendix A). *Aspidotis densa* was the most common forb. There were a number of seedlings in our plots that consisted mostly of *Calocedrus decurrens*; while native, these could pose a threat in regards to tree encroachment into these serpentine habitats (Appendix A). Exotic species composed very small percentages of total cover, but of *Cynosurus echinatus* was the most abundant species with potential to impact C. *coxii*. Other exotic grasses in transects included *Aira caryophyllea, Bromus hordeaceous,* and *Luzula campestris.*

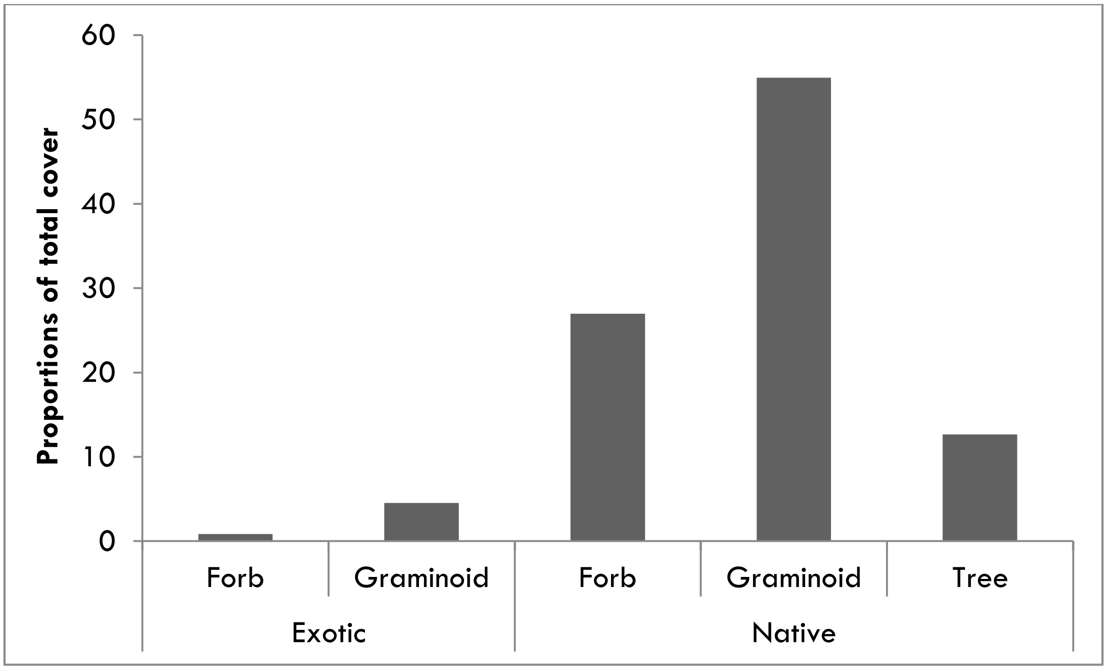

Figure 9. Proportions of total plant cover grouped by functional group and provenance in 2015.

Transect Notes (2015)

The notes below were collected in 2015 and give indication of habitat quality, potential threats in the surrounding areas, and potential management that could occur. Photos were taken along the transects in 2015.

Bilger 1 Transect 1: Lots of *Calocedrus decurrens* recruitment in the surrounding area with mixed canopy of *Pseudotsuga menziesii* and *Calocedrus decurrens*. Suggested management action: targeted canopy thinning.	
Bilger 1 Transect 2: Transect runs across slope in rocky, mossy, forested opening. Increasing *Pinus jeffreyi* and *Calocedrus decurrens* recruitment in opening. Very high native cover in and around transect. Most common species: *Aspidotis densa, Lomatium nudicaule, Pinus jeffreyi, Festuca roemeri, Melica geyeri, Cerastium nutans, Zigadenus venosus*. Greatest threat: conifer recruitment. Suggested management actions: keep an eye on conifer encroachment in opening.	

Bilger 1 Transect 3: Area much further along than in previous years, could have missed some species that have already senesced. *Calochortus coxii* mostly in fruit with a few still in flower. Some invasive grasses (*Bromus hordeaceus* & *Aira caryophyllea*) present and abundant in the transect. Evidence of cattle here including fresh cowpies, some in the transect. Lots of mammal grazing on both leaves and flowers. Greatest threat- invasion by exotics, keep an eye on grazing. Suggested management action: Nothing at the moment, but watch closely.	
Bilger 1 Transect 4: Canopy thinning has occurred in the surrounding area and while thinning occurred in mature trees, seedlings are starting to creep into the area that supports *Calochortus coxii*. Some *Calocedrus decurrens* seedlings present in the area very close to the transect. Overall the composition is mostly native, dominated by *Festuca roemeri* and *Lomatium*. *Calochortus coxii* was both vegetative and in flower. Relatively fresh cowpies are present both within and around the transect. Suggested management actions: Remove *Calocedrus decurrens* seedlings in area surrounding transect.	

Bilger 1 Transect 5: Lots of *Calocedrus decurrens* recruitment directly within areas of high *Calochortus coxii* density. Some *Pinus jeffreyi* present as well. *Calochortus coxii* was observed growing in and around many slash piles from canopy thinning. Primarily native vegetation in this area. Suggested management actions: Remove *Calocedrus decurrens* seedlings taking care not to impact *Calochortus coxii* as it is particularly dense in this area.	
Bilger 4 Transect 1: Site in area of high *Calocedrus decurrens* and *Pinus jeffreyi* recruitment. A few invasive species were present in the transect (*Cynosurus echinatus* and *Rumex acetosella*), both in trace amounts. *Calochortus coxii* here very far along. Cover estimate of other species could be slightly underestimating true cover due to the plants being so much further along than in previous years. Suggested management actions: Could benefit greatly from canopy thinning and removal of young trees.	

Bilger 4 Transect 2: Area impacted heavily by exotic grasses, primarily *Cynosurus echinatus*, but also *Bromus hordeaceus* and *Vulpia* sp. Very few *Calochortus coxii*, with lots of conifer recruitment in the surrounding area. Litter in plant community plots was mostly associated with conifer needles. Suggested management actions: targeted thinning/seedling removal could be effective but would have to take into account the non-native grasses present in the area.	
Bilger 4 Transect 3: Transect in slightly forested opening adjacent to very dense recruitment along ridgeline. Very mossy with various forest understory forbs. All *Calochortus coxii* vegetative. Some *Calocedrus decurrens* recruitment in the transect. Greatest threat is conifer encroachment. Suggested management actions: thin the dense patch along ridgeline.	

Bilger 4 Transect 4: Area of high *Calochortus coxii* abundance- both vegetative and reproductive. Could benefit greatly from some thinning and removal of seedlings. There was a lot of conifer recruitment in the area directly surrounding the transect. Few non-native species present, though *Cynosurus echinatus* is in the area. Suggested management actions: thin/clear seedlings in area but avoid disturbing native communities.	
Bilger 4 Transect 5: Area sparsely vegetated with native grasses (*Achnatherum lemmonii*, *Poa secunda, Danthonia californica*), with moss-covered soil and lots of rocks. Whole transect is located in large forested opening. Some conifer recruitment is occurring on sides of opening but not near the transect. Area seems very dry, *Calochortus coxii* in flower both within and outside of the transect. Suggested management actions: No immediate action, but keep in eye on area to assess conifer recruitment and maintain opening.	

Surveys of previously known *Calochortus coxii* populations (2011 and 2012)

There was a greater number of C. *coxii* in 2012 than in 2011 at all sites but Red Ridge; this increase is attributed to an increase in vegetative plants from 2011 to 2012 at Langell, Myrtle Creek 4, and Red Ridge. Red Ridge had substantially fewer reproductive plants in 2012 than in 2011. As in 2011, we found greater numbers of C. *coxii* at Myrtle Creek 4 than were estimated by the BLM. Our surveys indicate that populations of C. *coxii* can be variable from year to year. However, the scale of this variability is much less than the difference between our estimates and previous population estimates for Bilger and Langell (5.6 million and 1.7 million, respectively; USDI BLM and USFWS 2004). This second year of surveying supports to our population estimates and suggests that previously reported population sizes were much higher, and possibly over estimated. In general, distributions of C. *coxii* were more narrow and patchy than distributions provided in maps from BLM biologist. Our mapped population surveys provide a higher resolution understanding of its distribution across BLM land (Appendices B-F). In addition, at all sites but Red Ridge, we found new patches of plants in appropriate habitat outside of the area indicated by the BLM.

Bilger 1, 3, & 4

We tallied a greater number of C. *coxii* at Bilger Ridge in 2012 than in 2011 (10,118 and 3790, respectively), substantially less than the past population estimate of 5.6 million for public land portions (Table 4, USDI BLM and USFWS 2004).

<u>Bilger 1</u>: In 2011 we found 2,525 C. *coxii*, but in 2012 noted 5,218 plants, a nearly two-fold increase. While we surveyed the same locations as the year before, this year we came across some areas of high density that had not been noted the year before. While these numbers differ between years, they remain much lower than previous population estimates. Distributions of C. *coxii* were narrower than those previously mapped (Appendix B). Patches in this area varied in density, and occurred in a wide variety of habitats from more mesic forest openings to dry, rocky ridgelines, mostly on north-facing slopes. North of the road, the area previously mapped by BLM was primarily unsuitable habitat, composed of dense, moist forest, with some riparian areas. We found some patches of C. *coxii* outside of the area noted by the shapefile provided by BLM. These were located in forest openings, often occurring on rocky outcroppings with high moss cover. *Calochortus coxii* was not present in some forest openings composed of appropriate habitat but presence of exotic grasses including C. *echinatus*. We found no C. *coxii* in the most northerly portion indicated by the shapefile. Much of this area impacted by past logging, was highly mesic, and invaded by species such as C. *arvense*, *B. tectorum*, C. *echinatus, H. perforatum,* and *Rubus* sp. South of the road, we found many dry, rocky serpentine grassland habitats with high densities of C. *coxii* which were generally in flower. Associated species included *F. roemeri*, *P. congesta*, and *Achnatherum lemmonii*. *Calochortus coxii* populations also occurred on adjacent private land, and appeared healthy. We found no indication of C. *coxii* on the east-facing aspect at the southern end of the area previously mapped as part of the population; this area was extremely dry and rocky.

In the winter between 2011 and 2012, canopy thinning occurred in the area south of the road, where our transects 3, 4, and 5 had been established. It is likely that physical disturbance from these thinning activities has impacted localized patches of C. *coxii*. Though there were slash-piles in close proximity to transects 3 & 4, they did not seem to be impacted by the physical logging activities. Transect 5 was in the direct path of logging activities and the origin of the transect was buried by a slash-pile. Due to this disturbance, we had to establish a new transect in close proximity to the old one. Continued monitoring will provide insight into how population trends change with respect to these management efforts.

Potential threats to Bilger 1: High abundance of exotic species such as *H. perforatum* and *C. echinatus* in habitat suitable for *C. coxii* is the primary threat to this population. There is a fairly high chance for further invasion as patches of *C. coxii* are in close proximity to private land and roads. Conifer recruitment in *C. coxii* habitat, primarily *C. decurrens* seedlings and saplings in some forest openings and at the edge of serpentine grasslands, may pose a threat to this rare species. *C. coxii* was often present in these areas, sometimes at high densities, suggesting that though recruitment by conifers may not currently be affecting *C. coxii* abundance, they may pose a threat in the future. Monitoring after canopy-thinning efforts that occurred in 2011 will enable us to further understand the effects of these actions on this rare species. Another serious threat to this population is the proposed LNG pipeline which is planned to intersect this area along the narrow bend in the roadway (Appendix B). *C. coxii* occurs in high densities both above and below this road, and there is potential that these subpopulations could be impacted by construction and face adverse effects including increased invasion by exotic species and further fragmentation.

<u>Bilger 3 & 4</u>: We found 4,900 *C. coxii* at Bilger 3 & 4 in 2012, compared to 1,265 in 2011. This discrepancy is similar to that noted in Bilger 1. We found the *C. coxii* distribution at these occurrences to be more narrow and patchy than indicated by previous BLM maps (Appendix C). We also found individuals that occurred outside of the previously mapped occurrences, between Bilger 3 & 4, indicating that these occurrences might be considered continuous. Most *C. coxii* was found along the ridgeline, often along rocky outcroppings. *Calochortus coxii* was also present in small mossy forest openings and areas with rocky soil. Associated species included *F. roemeri*, *P. congesta,* and *A. densa*. *Calochortus coxii* was found in areas of variable canopy cover from open ridgelines to more mesic forest openings. Some small patches of *C. coxii* were found in forest openings that were experiencing recruitment by conifers, particularly seedlings of *C. decurrens*.

Potential threats to Bilger 3 & 4: This area was composed of a wide range of habitat that supported *C. coxii*, including mesic forest openings that were experiencing relatively recent conifer recruitment (*C. decurrens*, *P. menziesii*). Conifer encroachment and canopy closure, particularly along the ridgeline, is the primary threat to habitat for this species. Recruitment in some areas was very dense, which could have excluded *C. coxii* from areas that were once suitable habitat. *Cynosurus echinatus* was the primary exotic species present in areas surrounding *C. coxii* patches, however it was rarely found associated with the species. The close proximity to private lands and roads increases the potential for further invasion by noxious species.

Langell

Previous population estimates for both private and public portions of Langell were 1.7 million, but we only counted 761 individuals on public land in 2012 (Table 4, USDI BLM and USFWS 2004). This is slightly higher than in 2011, when we counted 543 individuals. In 2012, we surveyed a small area outside of the area previously surveyed, which could account for some of this discrepancy. Many of the plants found at Langell were outside of the area represented in the BLM shapefile. Much of the area identified by the shapefile at Langell (Appendix D) was composed of inappropriate habitat including densely forested drainages and south-facing forests. We searched some of these areas and found no associated species or evidence of *C. coxii*. Based on our observations and previous descriptions of suitable vs. unsuitable habitat, we did not survey all of these areas. We targeted our surveys to areas characterized by patchy canopy cover, forest meadows, and serpentine grassland along ridgelines, primarily with north-facing slopes. We found C. *coxii* in serpentine grassland with rocky outcroppings along the ridgeline and grassland openings in mixed *P. jeffreyi* & C. *decurrens* forest. These areas were characterized by an open canopy with many mature and widely-spaced trees. *Cynosurus echinatus* was often present in surrounding areas but not in direct association with C. *coxii*. *Calochortus coxii* occurrences were often patchy, with variable density and proportion of reproductive and vegetative forms.

Potential threats to Langell: The primary threat to Langell appears to be human disturbance (e.g. roads and logging) and invasion by exotic species. This site showed some evidence of secondary succession, mostly C. *decurrens* seedlings in forest openings. Tree recruitment was not extremely common in suitable habitat. Many large *P. jeffreyi* had experienced past fire; while future fires may control invading trees, they may also increase the potential for invasion of C. *coxii* habitat by exotic plant species. Exotic grasses (primarily C. *echinatus*) were present at the site however were not present in areas supporting C. *coxii*. Human activities at the site could be a vector for continued invasion.

Myrtle Creek sites 1, 4, & 5, and Sheep Hill

<u>Myrtle Creek 1</u>: Much of Myrtle Creek 1 is surrounded by private land, which appeared to have suitable habitat and patchy abundance of C. *coxii* when driving to the public section of the site (Appendix E). We did not find C*alochortus coxii* nor suitable habitat in the public land portion of Myrtle Creek 1in 2011, due to this, we did not survey Myrtle Creek 1 in 2012. Vegetation at this site was very dense, and composed primarily of *Arbutus menziesii*, *Toxicodendron diversiloba*, and *Acer macrophyllum*.

<u>Myrtle Creek 4</u>: At Myrtle Creek 4, we estimated there to be 2,200-2,700 C. *coxii* in 2011, and 2,725 in 2012; almost twice as many as past population estimates (1,406; Table 4). A large portion of the Myrtle Creek 4 occurrence was on private land, which we did not survey. We found high abundances of C. *coxii* in north-facing serpentine grasslands consisting of *Danthonia californica* and *F. roemeri*. There were few C. *coxii* along forest edges and grassland openings, and no C. *coxii* present in the mesic, densely vegetated, closed canopy forest indicated in BLM maps. The majority of the population was part of a large patch of C. *coxii* on a north-facing slope along the ridgeline in a *F. roemeri* grassland with serpentine outcroppings; C. *coxii* was associated with high abundance of *S. stenopetalum* & *P. congesta*. This patch extended along the ridgeline, far beyond the previously mapped boundary. The population was extremely dense in some areas, with many plants in flower and some in fruit. Some dry, rocky areas with high native abundance including *Penstemon* sp., and *Eriogonum* sp. did not support C. *coxii*, however few grasses were present, indicating that these areas might be too dry for this species. There was evidence of grazing on adjacent private land, however we did see C. *coxii* within suitable habitat on private land. On the ridge between Myrtle Creek 4 and Myrtle Creek 5, we found populations of C. *solstitialis* and *T. caput-medusae*, but not in areas that supported C. *coxii*.

Potential threats for Myrtle Creek 4: Overall, populations at Myrtle Creek 4 (and likely into private lands) seemed very dense and healthy, with many reproductive individuals. Exotic species, including C. *solstitialis* pose a great threat; along the ridgeline there was a very large patch that had increased in size since 2011. There appeared to be several patches of C. *coxii* on private land, which had evidence of grazing, however many of these subpopulations appeared vigorous. Along one portion of the public/private boundary, evidence of heavy grazing on private lands was associated with an abrupt change in plant community composition and an absence of Calochortus coxii.

Myrtle Creek 5: Exotic species were common between Myrtle Creek 4 & 5, including *T. caput-medusae* and C. *solstitialis*. In both 2011 and 2012, we surveyed the area upslope from Myrtle Creek 5 and the forested area marked by the shapefile and found no C. *coxii*. We only found one meadow in this area, characterized by exotic grasses and high abundance of *Ceanothus cuneatus*. The remaining area identified on the BLM maps was occupied by dense forest and riparian habitats, which did not support C. *coxii*.

Sheep Hill: We surveyed the area at Sheep Hill mapped as occupied by C. *coxii* on two separate occasions in 2011; despite extensive searching through the area, we did not locate any C. *coxii*, nor habitat suitable for C. *coxii*. We did not survey Sheep Hill in 2012. This area was densely forested and dominated by *T. diversilobum* (poison oak) and *A. menziesii*. We found many indications of logging in the surrounding area. We also surveyed the slope south of the road which contained habitat characteristic of C. *coxii*, including rocky areas close to the road with *F. roemeri*. However, we did not observe any C. *coxii*.

Red Ridge

The distribution of_*Calochortus coxii* at Red Ridge was more restricted than indicated by BLM maps (Appendix F), and population estimates in 2012 (261 plants) were a quarter of those previously estimated for this population (1,000 plants, USDI BLM and USFWS 2004). Red Ridge was the only site where we documented a decline in C. *coxii* from 2011 to 2012 (Table 4). The species was found mostly along the ridgeline near a pull-out, and down the north facing slope, in dry and rocky habitat, continuing onto adjacent private land. We found C. *coxii* within spaces between C. *cuneatus*, where continued growth may create a more closed canopy, threatening C. *coxii*. We found no evidence of fire.

Potential threats for Red Ridge: Invasion by exotic species presents one of the greatest threats to C. *coxii* at this site. Invasive species, primarily C. *solstitialis* and *T. caput-medusae* are abundant along the access road and dense in some areas in close proximity to C. *coxii* habitat. The lack of C. *coxii* in these areas could be due to exclusion by these exotic species. Logging on adjacent private lands could increase the invasion potential at this site. The serpentine soils typical of C. *coxii* may provide some level of resistance to invasion; however, disturbances (e.g. logging, fire) may open these areas to invasion. Expansion of C. *cuneatus* could become a threat to populations of C. *coxii* along dry, north facing slopes.

Table 4. 2011 and 2012 population estimates for *Calochortus coxii* at previously known populations. Surveys were not completed in 2013, 2014, or 2015.

Site	# in leaf		# in bud		# in flower		# in fruit		Total # of plants		Prior population estimate*
	2011	2012	2011	2012	2011	2012	2011	2012	2011	2012	
Bilger 1									2525	5218	All Bilger 5.6 million
Bilger 3 & 4									1265	4900	
Langell	236	337	185	47	122	371	0	6	543	761	1.7 million
Myrtle Creek 1									0	Not surveyed	All Myrtle Creek 1406
Myrtle Creek 4	700	1722	0	1358	1400	550	100	0	2200-2700	2725	
Myrtle Creek 5									0	0	
Red Ridge	61	121	136	1	234	71	2	68	433	261	1000
Sheep Hill									0	Not surveyed	Number of plants undocumented on public land

* USDI BLM and USFWS 2004

DISCUSSION

Permanent monitoring transects: Bilger 1 and Bilger 4

Figure 10. A slug preying on a *C. coxii* flower.

Consistent with past observations, we found that *C. coxii* was highly associated with native species, with very few non-native species in the associated plant community. *Calochortus coxii* tended to be negatively associated with exotic species, which could be due its restriction to serpentine soils, which tend to be resistant to invasion (Going et al. 2009). Alternatively, *C. coxii* may have been extirpated from areas now characterized by high exotic abundance. *Cynosurus echinatus* and *Aira caryophyllea* were the most abundant exotic grasses in areas surrounding high *C. coxii* abundance, and they both indicate potential to invade habitat of this highly endemic species.

Herbivory on the leaves and flowers of *C. coxii* was present across all transects at Bilger Ridge (Figure 10). Overall, herbivory was most abundant in dry habitats with the most occurring on flowers by mammals or insects. In dry habitats, herbivory on flowers by mammals was more abundant than in forested habitats, however this is likely due to the lack of abundance of flowers in forested habitats. Leaf herbivory was more common in forested habitats. Though effects of native mammal and insect herbivory are unknown, herbivory is likely to negatively affect seed production and proliferation of this species (Kagan 1993). The removal of leaf tissue may deplete carbohydrate reserves and slow recovery for this slow-growing species, and grazing has been observed to nearly eliminate all capsules from some sites (USDI BLM and USFWS 2004). Herbivory by small mammals and ungulates was found to negatively impact *Calochortus greenei* (Greene's mariposa lily), a similar species in Oregon (Menke et al. 2013). Previous studies have indicated that cattle grazing may negatively affect *C. coxii*, especially on private lands where cattle is unregulated (Fredricks 1992, USDI BLM and USFWS 2004). At Myrtle Creek 4, we observed a healthy population of *C. coxii* on public land, however its distribution ended at the public/private property boundary where cattle grazing was clearly evident on the private land. Similar observations have been noted in previous studies (Kagan 1993). On Bilger Ridge, we did observe healthy patches of *C. coxii* on private land that had evidence of cattle in the surrounding vicinity and leaf herbivory by mammals was minimal.

The primary threat to these populations continues to be encroachment by shrubs and trees (Figure 12) into occupied habitat. Some areas along the ridgelines within Bilger 1 and 4 may require careful thinning in order to prevent canopy closure and extirpation of *C. coxii*. *Calochortus coxii* evolved in an area with high fire frequency, and with fire suppression since the early 20th Century, sites that were once open have experienced encroachment by shrubs and conifer species, which could negatively affect population trends for this species. We found that canopy cover and reproductive plants were negatively correlated, indicating that high canopy cover might suppress flowering in this lily. Canopy thinning did occur at Bilger 1 in the area surrounding the transects in the winter of 2011-2012. In the years following the canopy thinning, we observed a short-term increase of flowering C. *coxii*. These results are promising and indicate that careful thinning that does not disturb patches of C. *coxii* and opening potential habitat can be an effective way to help perpetuate this species. While this area experienced an original decrease in canopy cover, in 2015 cover started to increase in these areas. This suggests that the effects of canopy clearing might be short-lived and that encroachment by seedlings might also have potential to impact abundance of C. *coxii*. The ridgeline at Bilger 4 is becoming increasingly encroached by conifers with many areas becoming thick with recruiting seedlings and saplings of C. *decurrens* and *P. jeffreyi* (see transect notes). The Bilger 4 ridgeline would be a highly recommended area for careful treatment. While the serpentine habitat of this species tends to be more resistant to invasion, management activities that open the landscape, such as controlled burns or selective logging, should be considered with caution as they may facilitate invasion. We did note some invasive species in close proximity to C. *coxii* so keeping an eye on invasive species will be critical.

While in previous years we observed a decline in vegetative C. *coxii* from in the transects monitored along Bilger Ridge, in 2015 numerous transects exhibited a slight increase in vegetative plants. Even with a slight decline in reproductive plants within these transects, the increase in vegetative plants has resulted in a net increase in plants from previous years. It is likely that climate could be greatly impacting abundance of C. *coxii* and the population dynamics we have observed over the years. This, and microclimate associated with canopy cover could greatly affect annual population dynamics.

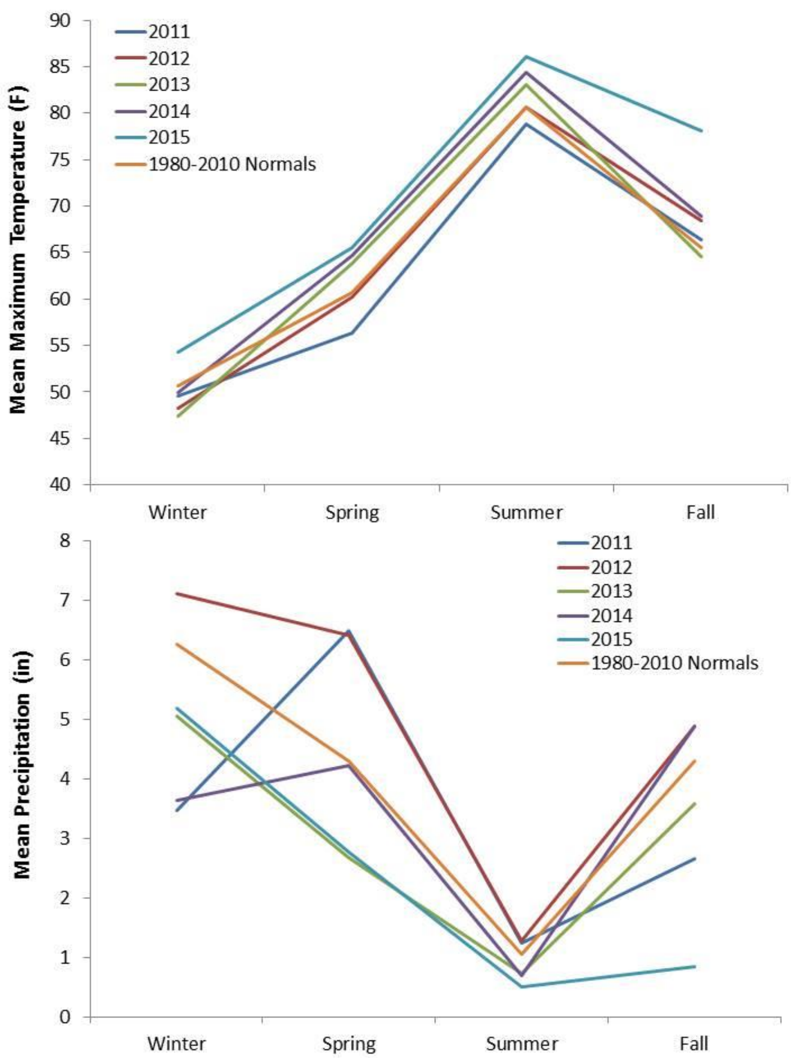

Figure 11. Average long-term temperature (1980-2010) relative to conditions experienced at Bilger Ridge (2011-2015, PRISM 2006).

Temperatures in 2013 through 2015 have been higher than long-term averages, while precipitation in these years has been lower than long-term normals (Figure 11). 2015 was the warmest year since 2011 across all seasons. While last year we saw an increase in reproductive individuals in these transects, in 2015 we saw an increase in vegetative ones. This suggests that climate might play a role, but microclimate is could be just as important in population trends of this species. Additional years of monitoring will be necessary to gain a better understanding of population dynamics of this species and how those might relate to habitat characteristics and threats. Better understanding of patterns of dormancy would be extremely helpful in documenting population trends of this rare plant.

Surveys of previously known *Calochortus coxii* populations

Our estimates of the size and extent of the C. *coxii* populations on BLM land were substantially different than previous reports for these populations (USDI BLM and USFWS 2004). Transects had previously been used for monitoring at Bilger and Langell, and it is likely that population estimates came from extrapolating from transect monitoring data to whole-site estimates and that these estimates did not take into account the patchiness of suitable habitat within mapped population boundaries (S. Carter, *personal communication*). Previous mapping efforts appeared to draw course population boundaries that included multiple sub-populations as well as unsuitable habitat, such as closed canopies and mesic habitats. Furthermore, population shapefiles were likely derived from a number of sources, including digitizing old sighting report forms, which might have resulted in some inaccuracies. Population estimates from both years were more consistent with estimates noted by Kagan (1993).

For all but one of the populations (Myrtle Creek 4), we counted significantly fewer C. *coxii* than had previously been recorded at these sites. The most extreme discrepancy was at Bilger, where it was previously estimated that there were 5.6 million plants on the public land portions of the population; in 2012, we found only 6,118 (3,790 individuals in 2011). Likewise, at Langell, the occurrence was estimated to support 1.7 million plants (over 40% private, 60% public land). In 2012, we found only 761 (543 individuals in 2011) on the public portion of this occurrence. Our estimates of population sizes were lower than previous estimated despite the fact that we found individuals outside of the area noted by BLM shapefiles at all sites but Red Ridge. Potential causes for discrepancies include population decline and inaccurate initial population size estimates (e.g. including plants on private land in population size estimates). However, the second year of surveying provides evidence that previous population estimates are likely inflated beyond what would be accountable by human error in surveying or population stochasticity. As a serpentine endemic, the distribution of *Calochortus coxii* matches the patchy distribution of this habitat and should not be assumed to occur in the intervening but inappropriate habitat.

Our 2012 population estimates were greater than those in 2011at all sites but Red Ridge. At Bilger, our estimates increased from 2011 to 2012 (3,790 and 10,118, respectively). In all populations, the increase in C. *coxii* was consistent with an increase in vegetative individuals from 2011 to 2012. These estimates indicate population variability from year to year. The observed increase in vegetative plants is encouraging because in general, healthy, growing populations have a high proportion of young or vegetative plants, indicating successful reproduction and recruitment of new individuals. Even so, a decline in the number of reproductive plants can be cause for concern if it continues as a steady trend because, like other *Calochortus* species, C. *coxii* relies on reproductive plants for continued persistence (Fiedler et al. 1998). At both Myrtle Creek 4 and Red Ridge, reproductive plants were in decline from 2011 to 2012.

FUTURE ACTIVITIES

We recommend continued monitoring of permanent transects at Bilger Ridge each year until 2016, and every three years thereafter. This will enable population trends to be assessed in relation to potential threats and habitat over time (Figure 12). Repeated surveys of historic occurrences should be conducted often to determine document changes in population dynamics, habitat changes, and document potential threats. We found that this species had far fewer plants on BLM lands than was previously thought and continued surveys will be essential to inform future conservation measures. Conducting research on plant demographics to lead to a better understanding of patterns of dormancy would be very beneficial. Understanding population dynamics of this rare species will enable land managers to determine which additional actions are needed for its conservation.

Figure 12. Monitoring Bilger 4, Transect 1. Note the recruitment of *Pinus Jeffreyi* and *Calocedrus decurrens* in the adjacent area.

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APPENDICES

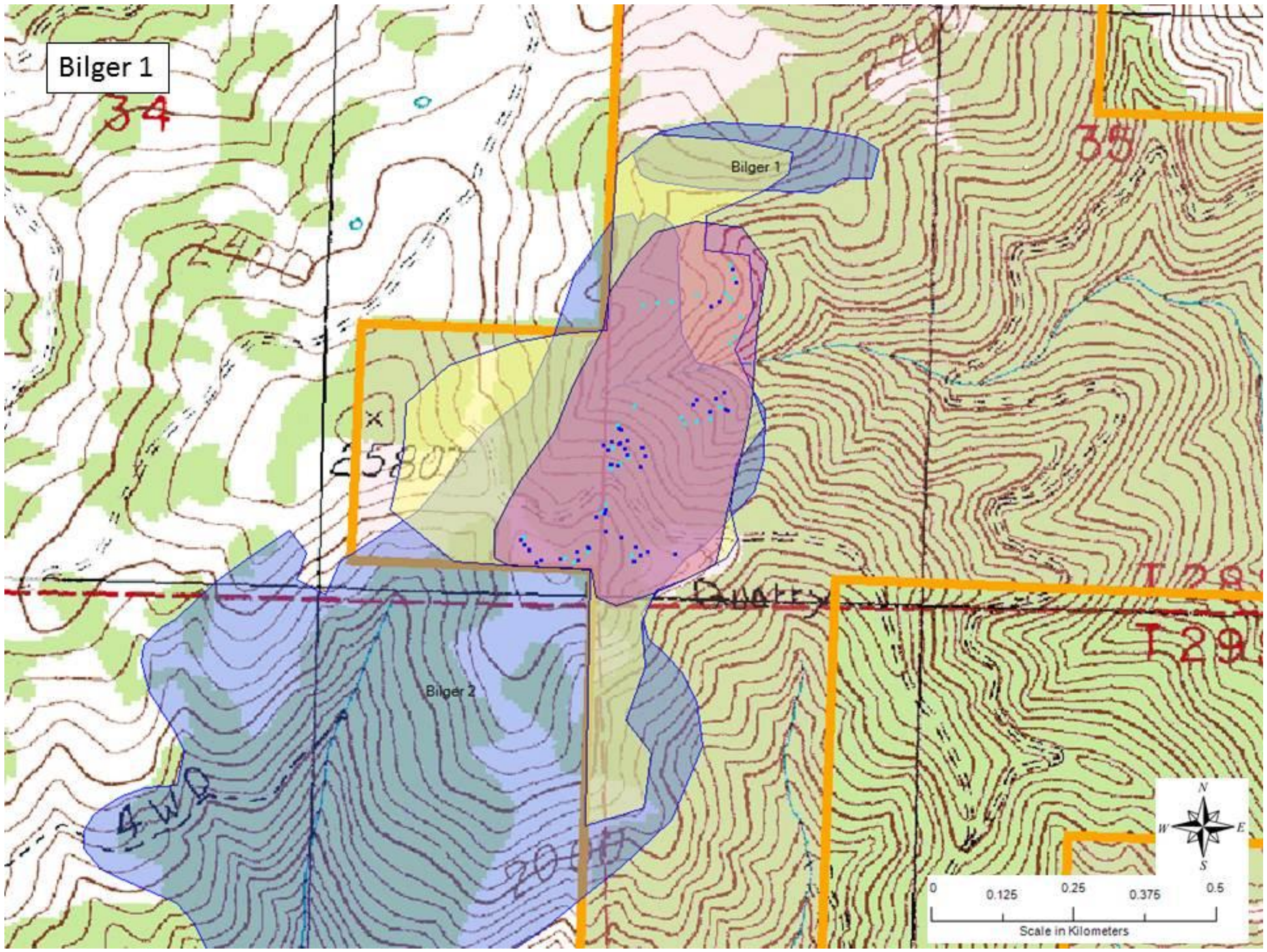
Appendix A. Mean percent cover for across all transects by year.

Species	Nativity	Growth Form	Bilger 1 2011	Bilger 1 2012	Bilger 1 2013	Bilger 1 2014	Bilger 1 2015	Bilger 4 2011	Bilger 4 2012	Bilger 4 2013	Bilger 4 2014	Bilger 4 2015
Achillea millefolium	Native	Forb	0.1	1.1	0.7	0.5	0.3	0.0	0.0	0.0	0.0	0.0
Achnatherum lemmonii	Native	Graminoid	1.4	3.8	4.0	4.2	4.8	0.3	2.1	1.4	2.9	2.2
Agoseris grandiflora	Native	Forb	0.0	0.1	0.2	0.2	0.1	0.0	0.1	0.0	0.0	0.0
Aira caryophyllea	Exotic	Graminoid	0.5	0.6	1.2	1.4	1.1	0.0	0.0	0.0	0.0	0.0
Allium acuminatum	Native	Forb	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.1
Aspidotis densa	Native	Forb	3.8	7.9	6.4	6.0	5.4	1.3	1.7	1.9	1.8	1.5
Brodiaea elegans	Native	Forb	0.0	0.0	0.0	0.1	0.0	0.0	0.2	0.0	0.0	0.0
Bromus carinatus	Native	Graminoid	0.1	0.2	1.3	0.8	0.7	0.0	0.9	1.7	2.0	0.7
Bromus hordeaceus	Exotic	Graminoid	0.0	1.1	1.0	0.5	1.0	0.0	0.1	0.2	0.4	0.2
Calocedrus decurrens	Native	Tree	3.6	4.6	3.7	3.9	4.9	1.2	2.8	2.9	2.3	2.4
Calochortus coxii	Native	Forb	0.1	0.4	0.5	0.4	0.4	0.1	0.4	0.2	0.1	0.2
Camassia quamash	Native	Forb	0.0	0.0	0.0	0.0	0.0	0.2	0.5	0.1	0.1	0.3
Carex sp.	Native	Graminoid	0.0	0.4	0.2	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Cerastium nutans	Native	Forb	0.0	1.2	1.8	1.7	1.0	0.1	0.5	0.9	0.9	0.3
Cryptantha sp.	Native	Forb	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.1
Cynosurus echinatus	Exotic	Graminoid	0.0	0.0	0.0	0.0	0.0	0.1	1.0	1.6	0.8	0.3
Danthonia californica	Native	Graminoid	0.0	0.2	0.0	0.0	0.0	0.2	0.3	0.3	0.1	0.2
Dodecatheon sp.	Native	Forb	0.0	0.0	0.0	0.0	0.0	0.2	0.6	0.1	0.0	0.0
Elymus glaucus	Native	Graminoid	0.0	0.0	0.2	0.1	0.1	0.2	2.0	2.5	2.2	2.7
Epilobium sp.	Native	Forb	0.0	0.1	0.0	0.3	0.0	0.0	0.3	0.2	0.4	0.0
Festuca occidentalis	Native	Graminoid	0.0	0.0	0.0	0.0	0.0	0.1	0.0	0.0	0.0	0.0
Festuca roemeri	Native	Graminoid	4.2	11.4	11.0	14.2	16.7	0.9	2.6	2.1	1.9	1.3

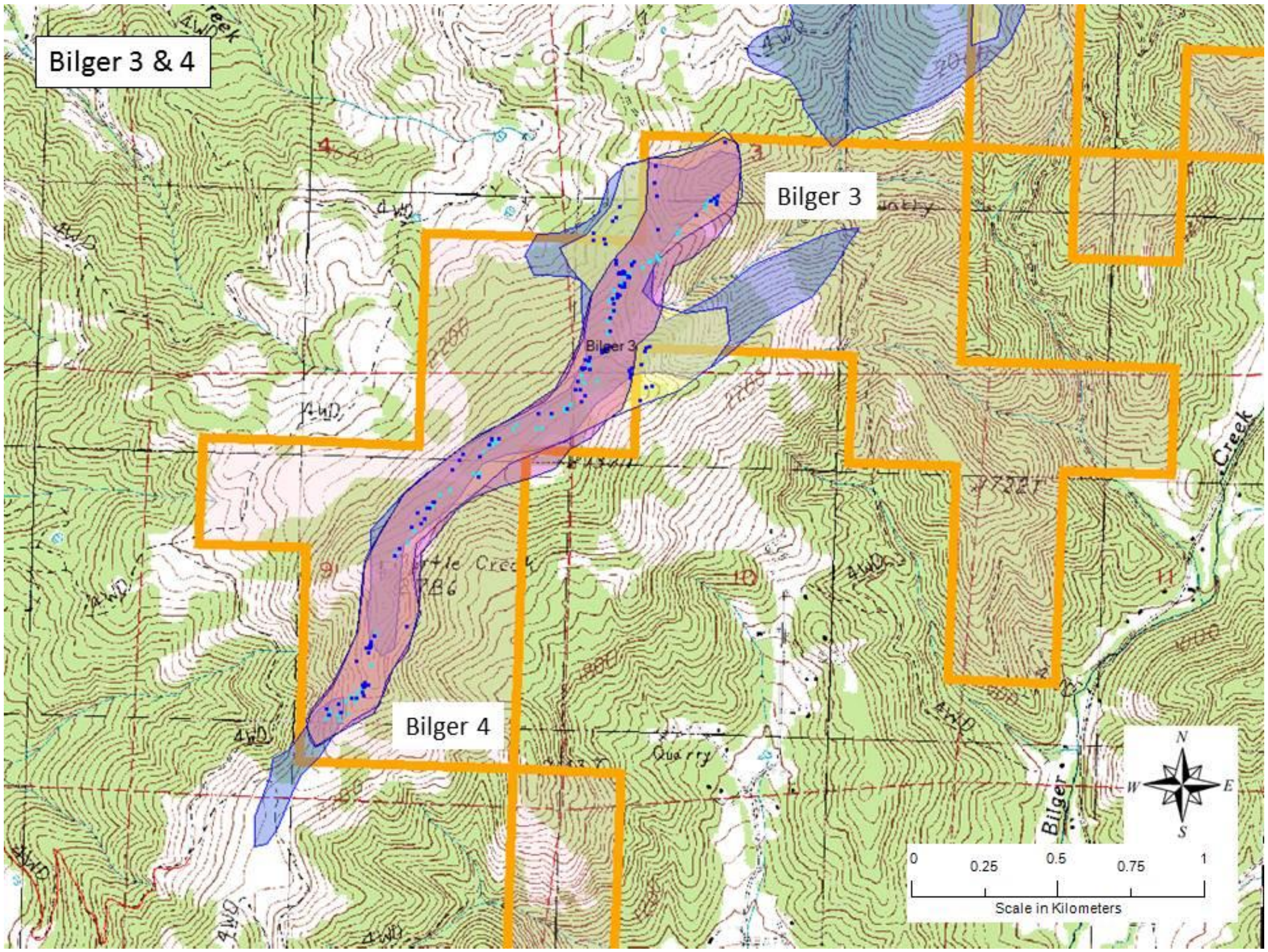
Galium sp.	Exotic	Forb	0.0	0.4	0.3	0.1	0.1	0.0	0.4	0.0	0.3	0.2
Goodyera oblongifolia	Native	Forb	0.0	0.0	0.0	0.0	0.0	0.0	0.1	0.1	0.1	0.1
Hieracium albiflorum	Native	Forb	0.0	0.1	0.1	0.2	0.0	0.0	0.0	0.0	0.0	0.0
Iris chrysophylla	Native	Forb	0.1	1.0	0.8	0.7	0.4	0.2	1.4	1.5	1.4	0.8
Koeleria cristata	Native	Graminoid	0.0	0.0	0.0	0.0	0.0	0.0	0.1	0.0	0.0	0.0
Listera caurina	Native	Forb	0.0	0.0	0.0	0.0	0.0	0.0	0.1	0.0	0.0	0.0
Lomatium nudicaule	Native	Forb	0.2	0.8	1.0	0.7	0.6	0.0	0.0	0.0	0.0	0.0
Lomatium triternatum	Native	Forb	0.0	0.2	0.3	0.1	0.1	0.0	0.0	0.0	0.0	0.0
Lomatium utriculatum	Native	Forb	0.0	0.2	0.3	0.3	0.2	0.0	0.1	0.1	0.1	0.1
Lotus micranthus	Native	Forb	0.0	0.1	0.1	0.2	0.0	0.0	0.1	0.0	0.0	0.2
Luzula campestris	Exotic	Graminoid	0.0	0.4	0.3	0.5	0.4	0.0	0.0	0.0	0.0	0.0
Madia gracilis	Native	Forb	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.1	0.0	0.1
Melica geyeri	Native	Graminoid	0.1	1.3	1.8	1.7	1.7	0.0	2.7	2.5	2.6	3.2
Microsteris gracilis	Native	Forb	0.0	0.0	0.0	0.0	0.1	0.0	0.0	0.0	0.1	0.9
Osmorhiza sp.	Native	Forb	0.0	0.0	0.0	0.0	0.0	0.0	0.1	0.0	0.0	0.0
Perideridia oregana	Native	Forb	0.0	0.0	0.0	0.0	0.0	0.0	0.1	0.0	0.1	0.0
Pinus jeffreyi	Native	Tree	0.3	0.2	0.1	0.4	0.0	0.6	0.9	1.0	0.5	0.5
Plectritis congesta	Native	Forb	0.2	2.0	1.0	0.5	0.8	0.0	0.3	0.1	0.3	0.4
Poa secunda	Native	Graminoid	0.0	0.3	0.1	0.6	1.3	0.9	2.0	1.9	1.5	0.6
Polystichum munitum	Native	Forb	1.0	1.8	2.1	2.1	1.9	0.0	0.0	0.0	0.0	0.0
Pseudotsuga menziesii	Native	Tree	0.1	0.5	0.2	0.1	0.2	0.0	0.6	0.6	0.5	0.5
Ranunculus occidentalis	Native	Forb	0.1	0.9	0.9	0.5	0.8	0.1	0.5	0.4	0.1	0.2
Rumex acetosella	Exotic	Forb	0.0	0.3	0.5	0.5	0.1	0.0	0.2	0.1	0.1	0.2
Sedum stenopetalum	Native	Forb	0.0	0.0	0.0	0.0	0.0	0.1	0.0	0.0	0.1	0.0
Silene hookeri	Native	Forb	0.0	0.1	0.3	0.4	0.1	0.0	0.3	0.3	0.0	0.1
Trisetum cernuum	Native	Graminoid	0.0	0.4	0.1	0.1	0.0	0.1	0.4	0.0	0.0	0.0
unk. *Asteraceae*	Unknown	Forb	0.1	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Vulpia microstachys	Native	Graminoid	0.0	0.1	0.0	0.1	0.1	0.0	0.2	0.0	0.7	0.5
Zigadenus venenosus	Native	Forb	0.1	0.8	0.3	0.4	0.5	0.0	0.3	0.2	0.0	0.1

Moss & lichen	48.9	64.1	60.1	68.9	65.1	13.8	23.0	21.0	30.8	31.3
Bare ground	3	7.3	5.5	9.5	8.9	8.5	6.8	4.1	12.0	10.6
Rock	2.4	2	41.9	25.3	32.7	18.6	10.6	73.5	55.0	54.6
Litter	32.2	41.1	4.1	2.2	1.9	51.6	64.1	12.8	11.7	12.4
Species Richness	18	34	32	36	38	18	36	27	38	40

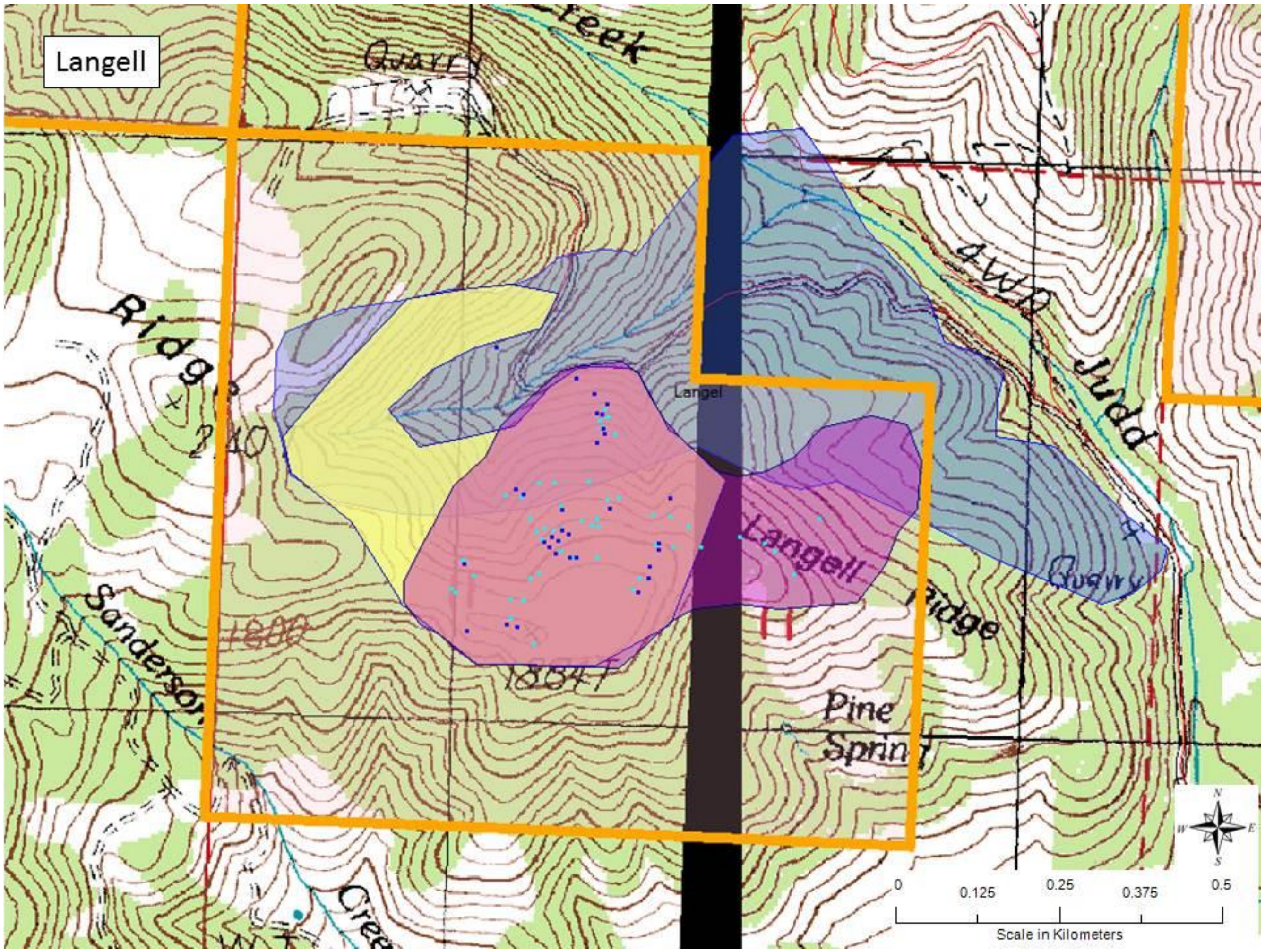
Appendix B. *Calochortus coxii* distribution at Bilger 1 in 2011 and 2012. Blue dots indicate individuals or multiple individuals observed in 2011, turquoise dots indicate those in 2012. Orange represents public land (BLM) boundaries, purple represents distribution indicated by BLM shapefiles, yellow indicates the area surveyed by IAE in 2011, pink indicates the area surveyed by IAE in 2012. Note the individuals found outside of the previously known distribution.



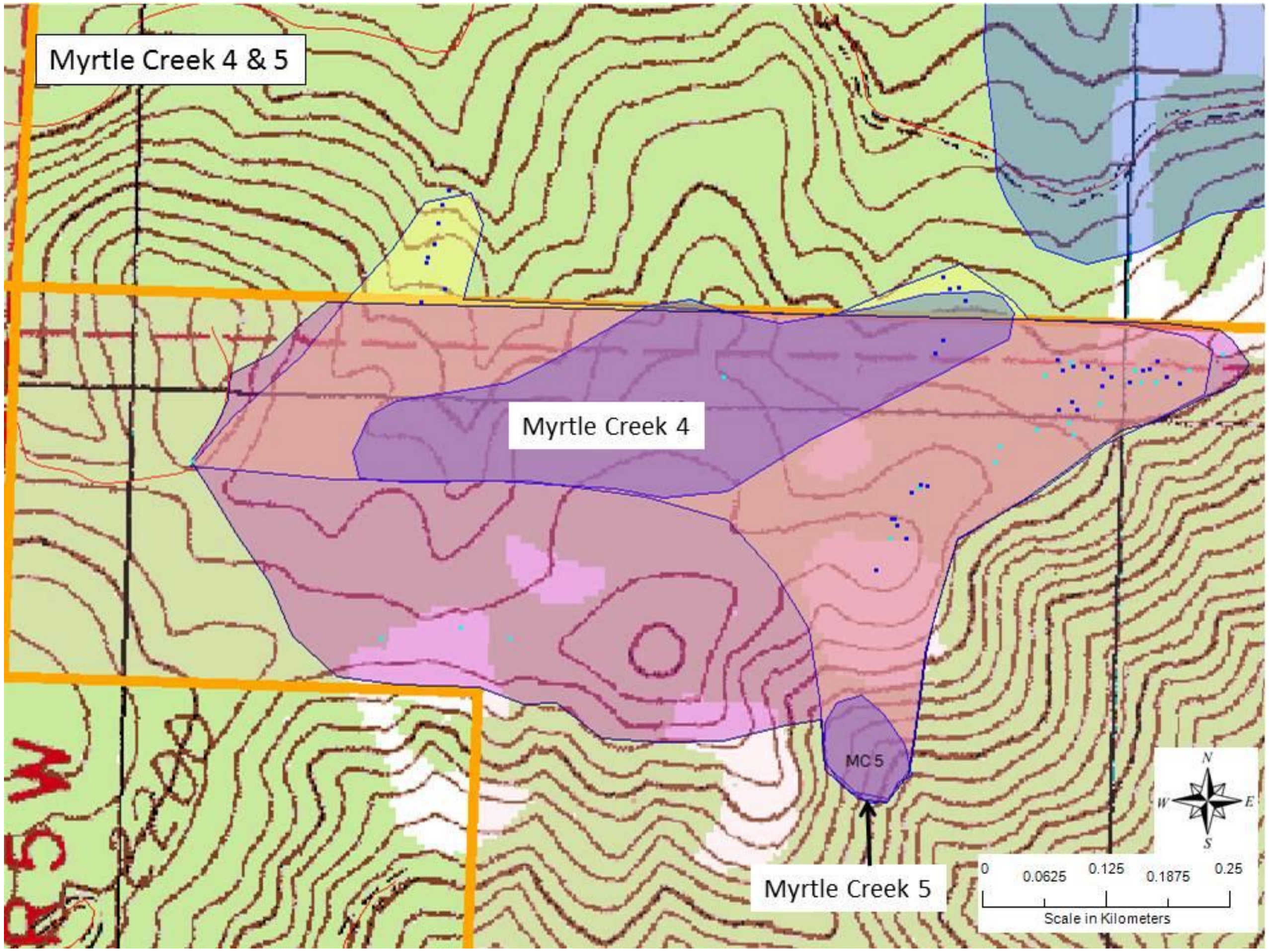
Appendix C. *Calochortus coxii* distribution at Bilger 3 & 4 in 2011 and 2012. Blue dots indicate individuals or multiple individuals observed in 2011, turquoise dots indicate those in 2012. Orange represents public land (BLM) boundaries, purple represents distribution indicated by BLM shapefiles, yellow indicates the area surveyed by IAE in 2011, pink indicates the area surveyed by IAE in 2012. Note the continuous nature of distribution between the two sites and the individuals found outside of the previously known distribution.



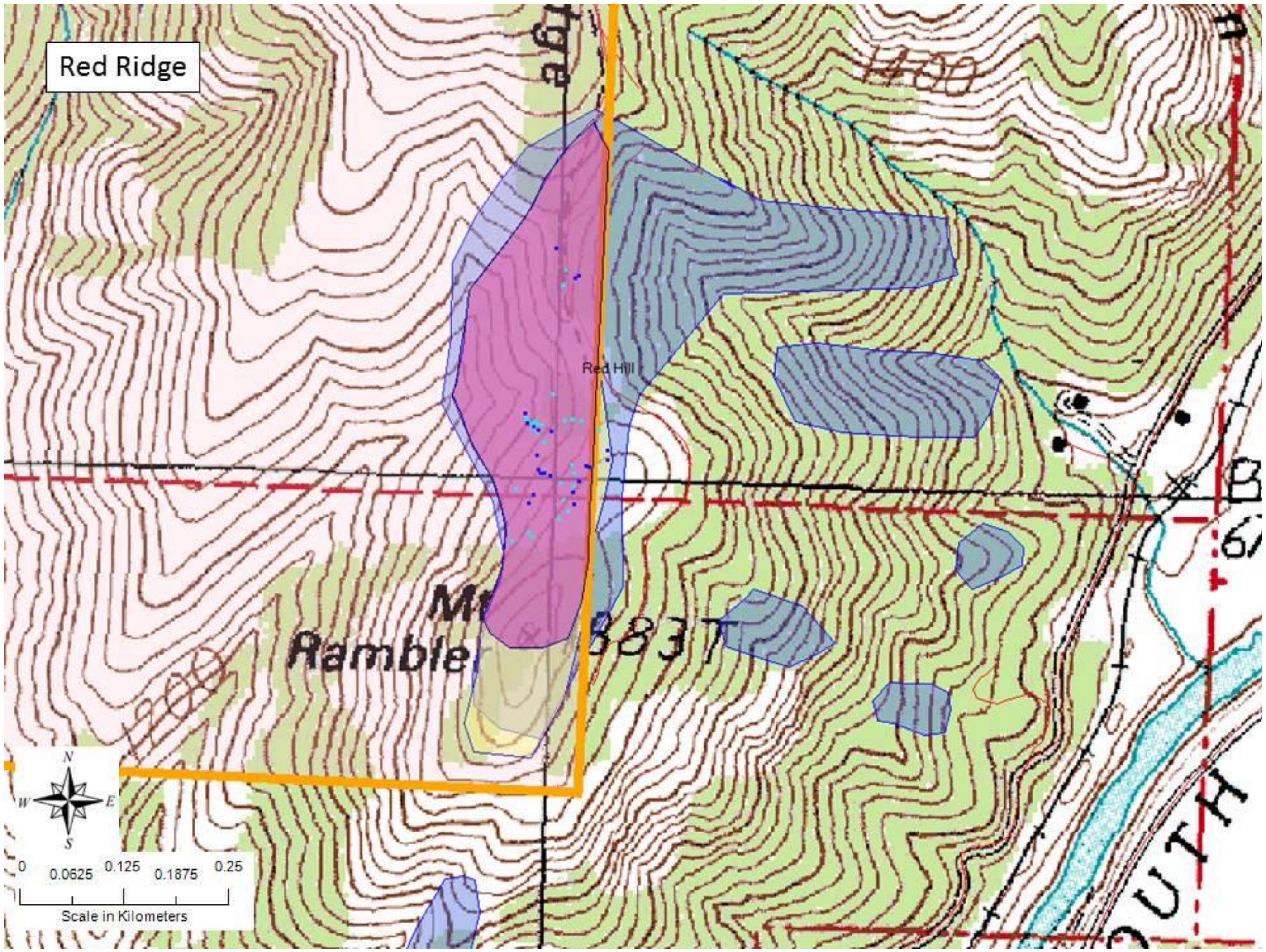
Appendix D. *Calochortus coxii* distribution at Langell in 2011 and 2012. Blue dots indicate individuals or multiple individuals observed in 2011, turquoise dots indicate those in 2012. Orange represents public land (BLM) boundaries, purple represents distribution indicated by BLM shapefiles, yellow indicates the area surveyed by IAE in 2011, pink indicates the area surveyed by IAE in 2012. Note the individuals found outside of the previously known distribution.



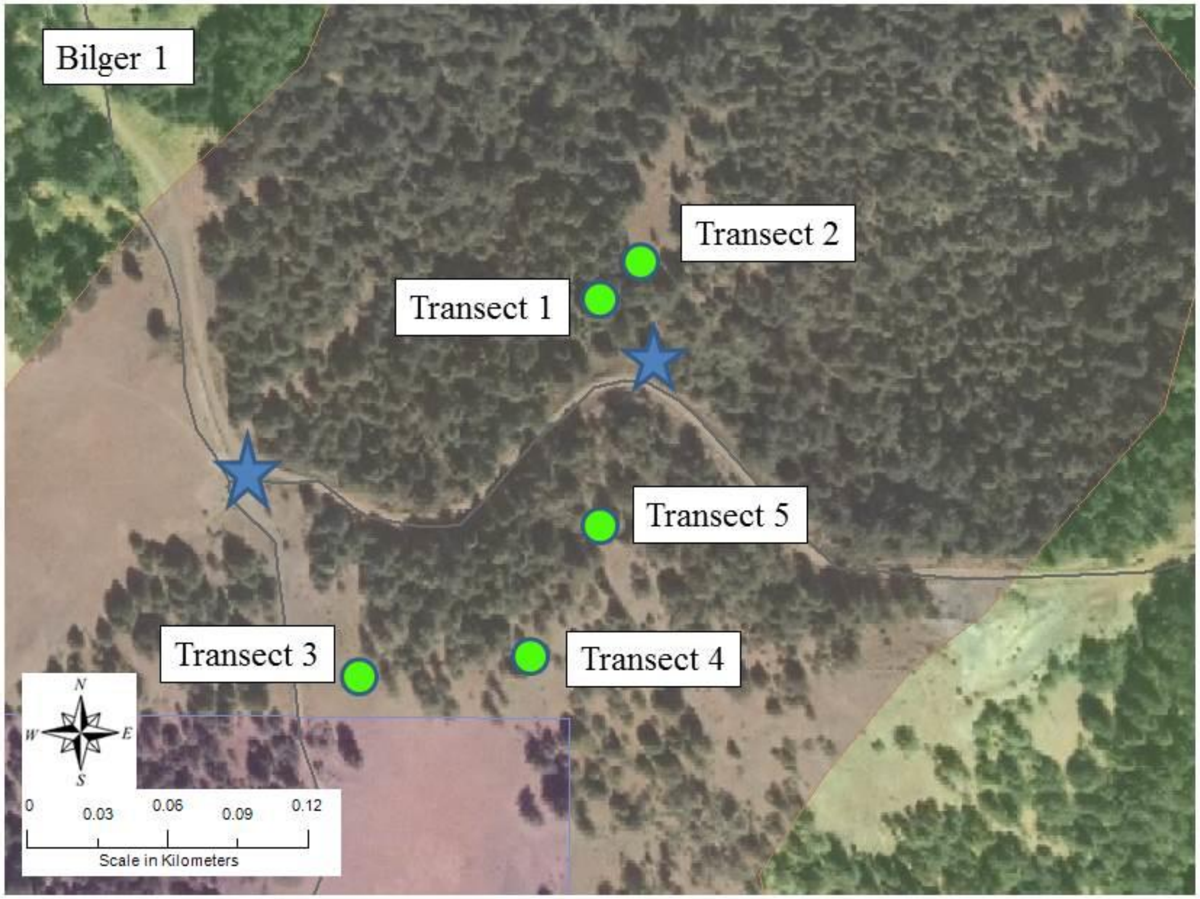
Appendix E. *Calochortus coxii* distribution at Myrtle Creek 4 & 5 in 2011 and 2012. Blue dots indicate individuals or multiple individuals observed in 2011, turquoise dots indicate those in 2012. Orange represents public land (BLM) boundaries, purple represents distribution indicated by BLM shapefiles, yellow indicates the area surveyed by IAE in 2011, pink indicates the area surveyed by IAE in 2012. Note the individuals found outside of the previously known distribution.



Appendix F. *Calochortus coxii* distribution at Red Ridge in 2011 and 2012. Blue dots indicate individuals or multiple individuals observed in 2011, turquoise dots indicate those in 2012. Orange represents public land (BLM) boundaries, purple represents distribution indicated by BLM shapefiles, yellow indicates the area surveyed by IAE in 2011, pink indicates the area surveyed by IAE in 2012.



Appendix G. Locations of permanent monitoring transects (green circles) established in areas of high *Calochortus coxii* abundance at Bilger 1. Transects 1 & 2 are north of the road, whereas transects 3, 4, and 5 are south of the road. Blue stars indicate parking areas.



Appendix H. Locations of permanent monitoring transects (green squares) established in areas of high *Calochortus coxii* abundance at Bilger 3 & 4. Note that transects 1 & 2 are between Bilger 3 & 4, and are outside of the area indicated by the BLM shapefile (in pink).