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

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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.

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All photographs courtesy of IAE unless otherwise stated.

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Introduction

Figure 1. *Calochortus coxii* in flower

Calochortus coxii M. Godfrey & F. Callahan (Cox's or Crinite mariposa lily) 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 its discovery in 1988 and 2004, 24 populations have been identified (USDI BLM and USFWS 2004).

Calochortus coxii is a perennial forb in the Liliaceae. The vegetative form is composed of a single, simple leaf with a dark, smooth uppersurface 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). *Calochortus coxii* can co-occur with *Calochortus tolmei*, which when not in flower looks similar, however, *C. tolmei* 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 noted 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 *Calochortus 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 *Calochortus coxii* habitat, including *Centaurea solstitialis* (yellow starthistle), *Chondrilla juncea* (rush skeleton weed), *Taeniatherum caput-medusa* (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 to build a Liquified Natural Gas (LNG) pipeline through the population at Bilger Ridge and neighboring private lands that may also support populations of *Calochortus coxii*. There are concerns that this project will destroy numerous *Calochortus coxii* individuals and result in fragmentation of this population (Hatt 2008).

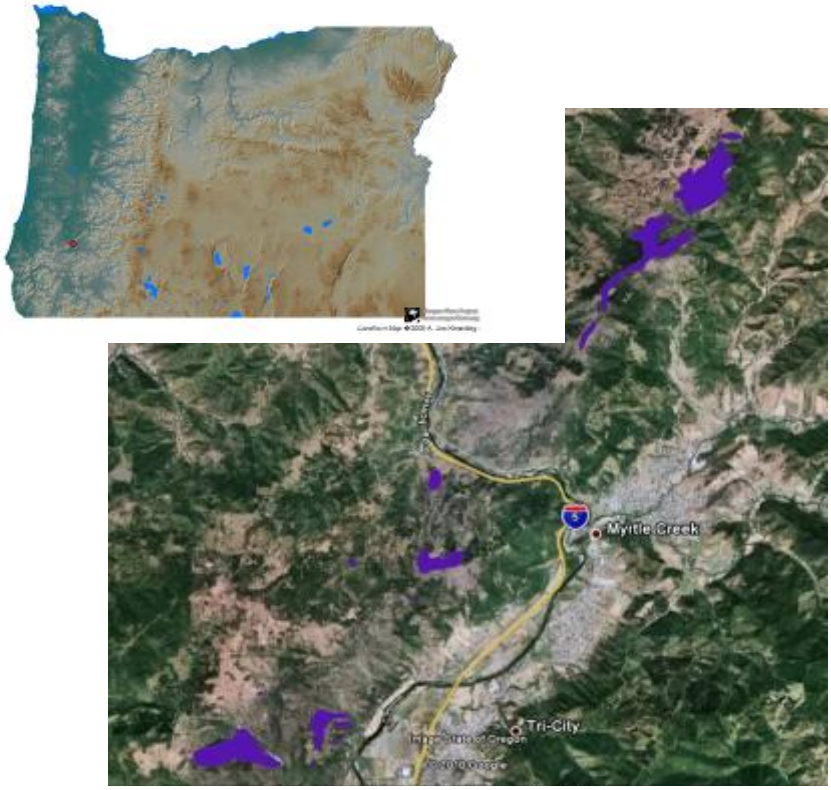

Figure 3. Project study sites. A red dot in the inset map shows the relative location in Oregon. In the close-up of the study area, known populations of *Calochortus coxii* in the BLM Roseburg District are highlighted in purple.

One of the challenges in managing this species is that accurate population estimates are unavailable. The most complete population surveys were completed by Nancy Fredricks in the late 1980's to early 1990's (Fredricks 1989, Fredricks 1993). A few of these populations have 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*). This project will determine if all populations of *Calochortus coxii* previously documented on BLM land are extant, estimate the size and extent of these populations, document threats to the populations, and establish a long-term monitoring protocol

at the largest site (Bilger Ridge) with the goal of providing accurate population estimates that will enable managers to determine trends in population size.

METHODS

Surveys of previously known Calochortus coxii populations

We visited all known occurrences (six sites) of *Calochortus coxii* on BLM land to estimate their size and extent and document potential threats to these populations. The BLM provided us with printed maps and shapefiles of each population. Due to the large areas covered by many of the population polygons, we were frequently unable to survey the entire site given reasonable time constraints. We used the Intuitive Controlled survey method (Whiteaker et al. 1998) to search for plants in habitat likely to support *Calochortus coxii* (open, meadow-like conditions, north facing slope, serpentine soils, etc.) at each site. We surveyed areas only on public land, and though there were times we inadvertently passed onto private land due to uncertain boundaries, plants noted in these areas were not included in total population estimates. Some areas included in the shapefiles were not surveyed as their characteristics did not indicate potential habitat (described in more detail in the results for each population). At all sites but Bilger, plants were tallied as in leaf, bud, or flower. Due to the large extent of area and some dense populations at Bilger, plants were tallied but not differentiated into life stages. Individuals or groups of individuals were marked using GPS to map population boundaries. Sighting report forms were completed for each site noting potential causes of disturbance, geology, plant community composition, presence of exotic species, and physical characteristics of the site.

Establishing permanent monitoring transects: Bilger 1 and Bilger 4

Five permanent transects were established at two sites, Bilger 1 and Bilger 4. Transect locations were selected as areas that had relatively high *Calochortus coxii* abundance and were in differing habitat types (Table 1, Appendix G, Appendix H). Habitat targeted included rocky slopes dominated by *Festuca roemeri,* mossy sites with *Plectritis 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 monitoring a few weeks prior.

Table 1. Habitat characteristics of transect locations.

Transect	Habitat Characteristics
Bilger 1	
Transect 1	Forest meadow, wet
Transect 2	Forest opening, high moss and *Plectritis congesta* cover. Presence of exotic grasses.
Transect 3	Rocky, dry, high graminoid composition (not *Festuca*).
Transect 4	Dry area surrounded by *Pinus jeffreyi*, some recruitment.
Transect 5	High *Calocedrus decurrens* recruitment, high moss cover.
Bilger 4	
Transect 1	Very steep with *F. roemeri* and rocky, serpentine habitat.
Transect 2	High graminoid cover.
Transect 3	Forest opening, some recruitment.
Transect 4	Forested, high levels of recruitment. High moss and *Plectritis congesta* cover.
Transect 5	Dry site in small meadow. Rocky, with moss & *Plectritis congesta* cover.

Transects were 25 m long. Both ends were marked with rebar capped with a yellow rebar cap and assigned a unique numbered tag. A 1 m belt was established to the left of the origin, and marked with 4 inch nails and washers. We recorded azimuth of each transect from the origin to 25 m, and from the origin towards the belt. Six photopoints were collected (0m to 25m, N, E, S, W, 25m to 0m). At each site, notes on habitat characteristics, presence or absence of exotic species, evidence of encroachment and dominant species were recorded.

We collected community data on five randomly chosen 1 m² plots per transect. 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. 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”. This was determined because *Calochortus coxii* is a geophyte whose establishment and growth would be impeded in a different manner by a rock (even with moss/lichen on it) than by moss/lichen growing directly on the ground. We calculated mean percent cover by each species or substrate for the entire transect. We used this data to determine the proportion of total plant cover occupied by each functional group (forb, graminoid, or tree) by nativity (native or exotic) combination. We used a densiometer to estimate the canopy cover over each plot.

We counted every *Calochortus coxii* individual within the 1 m x 25 m belt transects. We tallied vegetative and reproductive plants separately. These will enable us to have an understanding of the ratio of vegetative to flowering individuals for each transect. We also tallied the number of plants that showed signs of leaf herbivory (by mammals or insects), or flower herbivory by mammals, separate from the initial tally.

Table 2. 2011 population estimates for *Calochortus coxii* at previously known populations.

Site	# in leaf	# in bud	# in flower	# in fruit	Total # of plants	Prior population estimate
Bilger 1					2525	All Bilger 5.6 million
Bilger 3 & 4					1265	
Langell	236	185	122		543	1.7 million
Myrtle Creek 1					0	All Myrtle Creek 1406
Myrtle Creek 4	700		1400	100	2200-2700	
Myrtle Creek 5					0	
Red Ridge	61	136	234	2	433	1000
Sheep Hill					0	Number of plants undocumented on public land

RESULTS

Surveys of previously known *Calochortus coxii* populations

Bilger 1, 3, & 4:

We found a total of 3790 at Bilger 1, 3, and 4, which is significantly less than the past population estimate of 5.6 million for public land portions **(**Table 2, USDI BLM and USFWS 2004). We address potential for these discrepancies in the Discussion section of this report.

Bilger 1: Distributions of *Calochortus coxii* were more narrow than those indicated by maps provided by the BLM (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 indicated by the shapefile was primarily unsuitable habitat, composed of dense, moist forest, with some riparian areas. We did find a few patches of *Calochortus coxii* outside of the area noted by the shapefile. These were located in forest openings, often occurring on rocky outcroppings with high moss cover. We found some forest openings that had many of the associated species and habitat qualities that would be conducive for *Calochortus coxii*, however exotic grasses including *Cynosurus echinatus* were present and *Calochortus coxii* was not present. No *Calochortus coxii* was found in the most northerly portion indicated by the shapefile. Much of this area showed signs of logging, was highly mesic, and invaded by species such as *Cirsium arvense*, *Bromus tectorum*, *Cynosurus echinatus*, *Hypericum perforatum*, and *Rubus* sp. South of the road, we found many dry, rocky

serpentine grassland habitats that supported high densities of *Calochortus coxii* which were generally in flower. Associated species included *F. roemeri*, *Plectritis congesta*, and *Achnatherum lemmonii*. *Calochortus coxii* populations continued onto adjacent private land. We found no indication of *Calochortus 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.

Potential threats to Bilger 1: High abundance of exotic species such as *Hypericum perforatum* and *Cynosurus echinatus* in habitat suitable for *Calochortus coxii* is the primary threat to this population. There is a fairly high chance for further invasion as patches of *Calochortus coxii* are in close proximity to private land (with prominent cattle grazing) and roads . This site showed evidence of conifer recruitment, primarily *Calocedrus decurrens* seedlings and saplings in some forest openings and at the edge of serpentine grasslands. *Calochortus coxii* was often present in these areas, sometimes at high densities, suggesting that though recruitment by conifers may not currently be affecting *Calochortus coxii* abundance, they may pose a threat in the future. 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). *Calochortus 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 the *Calochortus coxii* distribution at these sites to be more narrow and patchy than that indicated by BLM maps (Appendix C). We also found individuals that occurred outside of the previously mapped population, between Bilger 3 & 4, indicating that these populations might be considered continuous. Most *Calochortus 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*, *Plectritis congesta*, and *Aspidotis densa*. *Calochortus coxii* was found in areas of variable canopy cover from open ridgelines to more mesic forest openings. Some small patches of *Calochortus coxii* were found in forest openings that were experiencing recruitment by conifers, particularly seedlings of *Calocedrus decurrens.*

Potential threats to Bilger 3 & 4: This area was composed of a wide range of habitat that supported *Calochortus coxii*, including mesic forest openings that were experiencing relatively recent conifer recruitment (*Calocedrus 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 *Calochortus coxii* from areas that were once suitable habitat. *Cynosurus echinatus* was the primary exotic species present in areas surrounding *Calochortus 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; however we only counted 543 individuals on public land (Table 2, USDI BLM and USFWS 2004). Much of the area identified by the shapefile at Langell (Appendix D) was composed of densely forested drainages and south-facing forests. We searched some of these areas and found no associated species or evidence of *Calochortus 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 *Calochortus coxii* in serpentine grassland with rocky outcroppings along the ridgeline and grassland openings in mixed *Pinus jeffreyi* & *Calocedrus 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 *Calochortus 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 *Calocedrus decurrens* seedlings in forest openings. Tree recruitment was not extremely common in suitable habitat. Many large *Pinus jeffreyi* showed sign of fire; while future fires may control invading trees, they may also increase the potential for invasion of *Calochortus coxii* habitat by exotic plant species. Exotic grasses (primarily *Cynosurus echinatus*) were present at the site however were not present in areas supporting *Calochortus coxii*. Human activities at the site could be a vector for continued invasion.

Myrtle Creek sites 1, 4 & 5, and Sheep Hill:
Myrtle Creek 1: Much of Myrtle Creek 1 is surrounded by private land, which appeared to have suitable habitat and patchy abundance of *Calochortus coxii* when driving to the public section of the site (Appendix E).

We did not find *Calochortus coxii* nor suitable habitat in the public land portion of Myrtle Creek 1. Vegetation at this site was very dense, and composed primarily of *Arbutus menziesii*, *Toxicodendron diversiloba*, and *Acer macrophyllum*.

Myrtle Creek 4: At Myrtle Creek 4, we estimated there to be 2200-2700 *Calochortus coxii*, almost twice as many as previous population estimates (Table 2, USDI BLM and USFWS 2004). A large portion of the Myrtle Creek 4 was on private land, which we did not survey. We found high abundances of *Calochortus coxii* in north-facing serpentine grasslands consisting of *Danthonia californica* and *F. roemeri*. There were few *Calochortus coxii* along forest edges and grassland openings, and no *Calochortus coxii* present in the mesic, densely vegetated, closed canopy forest indicated in BLM maps. We found a large patch of *Calochortus coxii* on a north-facing slope along the ridgeline in a *F. roemeri* grassland with serpentine outcroppings;

Calochortus coxii was associated with high abundance of *Sedum stenopetalum* & *Plectritis 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 *Calochortus 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 *Calochortus coxii* within suitable habitat on private land. On the ridge between Myrtle Creek 4 and Myrtle Creek 5, we found populations of *Centaurea solstitialis* and *Taeniatherum caput-medusae*, but not in areas that supported *Calochortus 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 *Centaurea solstitialis* and *Taeniatherum caput-medusae*, occurred in close proximity to *Calochortus coxii* and pose a potential threat, however these exotic species were not noted in *Calochortus coxii* patches. There appeared to be several patches of *Calochortus coxii* on private land, which showed signs 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*.

<u>Myrtle Creek 5</u>: Exotic species were common between Myrtle Creek 4 & 5, including *Taeniatherum caput-medusae* and *Centaurea solstitialis*. We surveyed the area upslope from Myrtle Creek 5 and down into the area marked by the shapefile and found no *Calochortus 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 are not suitable for *Calochortus coxii*.

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

Red Ridge:

The distribution of *Calochortus coxii* at Red Ridge was more restricted than indicated by BLM maps (Appendix F), and population estimates were half of those previously estimated for this population (Table 2, USDI BLM and USFWS 2004). The species was found mostly along the ridgeline near a pull-out, and down the north facing slope, in dry and rocky habitat. The population continued onto adjacent private land. Some *Calochortus coxii* was associated with patches of *Ceanothus cuneatus*. While there are currently spaces between *Ceanothus cuneatus*

individuals, continued growth may create a closed canopy, threatening *Calochortus coxii*. We found no evidence of fire. Invasive species were common throughout the site, though not directly in *Calochortus coxii* habitat. Invasive species included *Taeniatherum caput-medusae* and *Centaurea solstitialis* which was present along the road accessing the site as well as on the site, and on the southern end of the ridgeline.

Potential threats for Red Ridge: Invasion by exotic species presents one of the greatest threats to *Calochortus coxii* at this site. Invasive species, primarily *Centaurea solstitialis* and *Taeniatherum caput-medusae* are abundant along the access road and dense in some areas in close proximity to *Calochortus coxii* habitat. The lack of *Calochortus 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 *Calochortus coxii* may provide some level of resistance to invasion; however, disturbances (e.g. logging, fire) may open these areas to invasion. Expansion of *Ceanothus cuneatus* could become a threat to populations of *Calochortus coxii* along dry, north facing slopes.

Permanent Monitoring Plots: Bilger 1 and Bilger 4

We established permanent monitoring transects at Bilger 1 and 4 to (1) characterize the habitat occupied by *Calochortus coxii*, (2) provide a method by which changes in the total number of plants and ratios of vegetative to reproductive individuals can be reliably recorded through time, and (3) determine if population fluctuations differ depending on habitat characteristics. Across the two sites and ten transects, 53 species were recorded. Of those species, 40 were native, 7 were exotic, and 6 were unknown. Species richness ranged from 12 to 24 species per plot. Native species comprised 96% of total plant cover, exotic species accounted for 3%, and unknowns accounted for 1% (Figure 4). The most abundant native species were *Aspidotis densa*, *F. roemeri*, and *Calocedrus decurrens* (Appendix A). Five of the seven exotic species were grasses including *Aira caryophyllea*, *Arrhenatherum elatius*, *Bromus hordeaceus*, *Cynosurus echinatus*, and *Luzula campestris*.

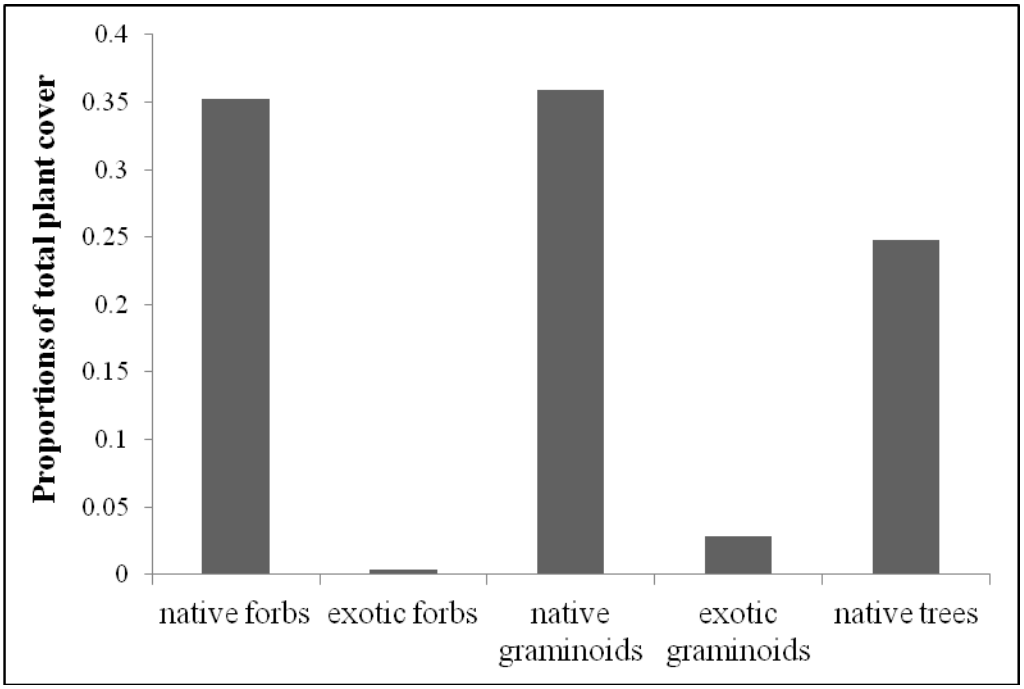

Figure 4. Proportions of total plant cover grouped by functional group and nativity.

A total of 308 *Calochortus coxii* (200 vegetative, 108 reproductive) were found along the five transects at Bilger 1. At Bilger 4, 333 plants (238 vegetative, 95 reproductive) were counted along the five transects (Table 3). Number of flowers per plant varied from one to three; plants with one flower were the most common (116), those with two were less common (71), and those with three flowers were few (16). Transects with more flowering plants tended to have fewer vegetative individuals, and those with more vegetative plants had fewer in flower (Figure 6). Across all transects, 41% of *Calochortus coxii* experienced herbivory, with more observed at Bilger 4 than in Bilger 1 (Table 3, Figure 5). Thirty three percent of plants in Bilger 1 experienced some form of herbivory, whereas 47% of plants in Bilger 4 had experienced herbivory. Across all transects, 20% of plants experienced leaf herbivory by insects, 17% experienced leaf herbivory by mammals, and 4% of flowers experienced herbivory by mammals. Drier transects experienced greater proportions of herbivory (0.43 vs. 0.36, respectively), including greater proportions of herbivory by mammals (Figure 5).

Table 3. *Calochortus coxii* tally within 1 m x 25 m belt transects at two sites, Bilger 1 and Bilger 4.

Site	Transect			Total	Reproductive classes			Herbivory		
		Vegetative	Reproductive		1 flower	2 flowers	3 flowers	Flower by mammal	Leaf by insect	Leaf by mammal
Bilger 1	1	32	17	49	8	7	2	4	9	10
Bilger 1	2	37	18	55	9	8	1	1	16	0
Bilger 1	3	18	48	66	19	18	11	1	16	8
Bilger 1	4	16	9	25	7	2	0	0	10	0
Bilger 1	5	97	16	113	16	0	0	1	7	20
Mean		40	21.6		11.8	7	2.8	1.4	11.6	7.6
Total		200	108	308	59	35	14	7	58	38
Bilger 4	1	55	31	86	17	14	0	3	7	22
Bilger 4	2	39	18	57	9	8	1	1	1	28
Bilger 4	3	37	1	38	1	0	0	0	1	3
Bilger 4	4	80	22	102	12	10	0	2	31	10
Bilger 4	5	27	23	50	18	4	1	15	27	5
Mean		47.6	19		11.4	7.2	0.4	4.2	13.4	13.6
Total		238	95	333	57	36	2	21	67	68

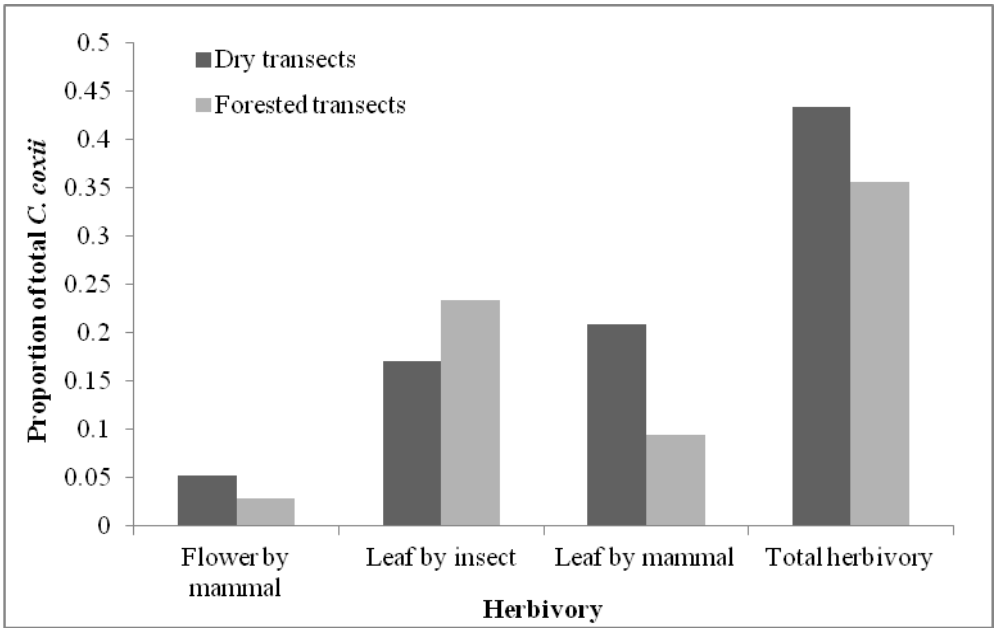

Figure 5. Proportions of total *Calochortus coxii* which experienced herbivory, separated into dry and forested habitat locations for transects.

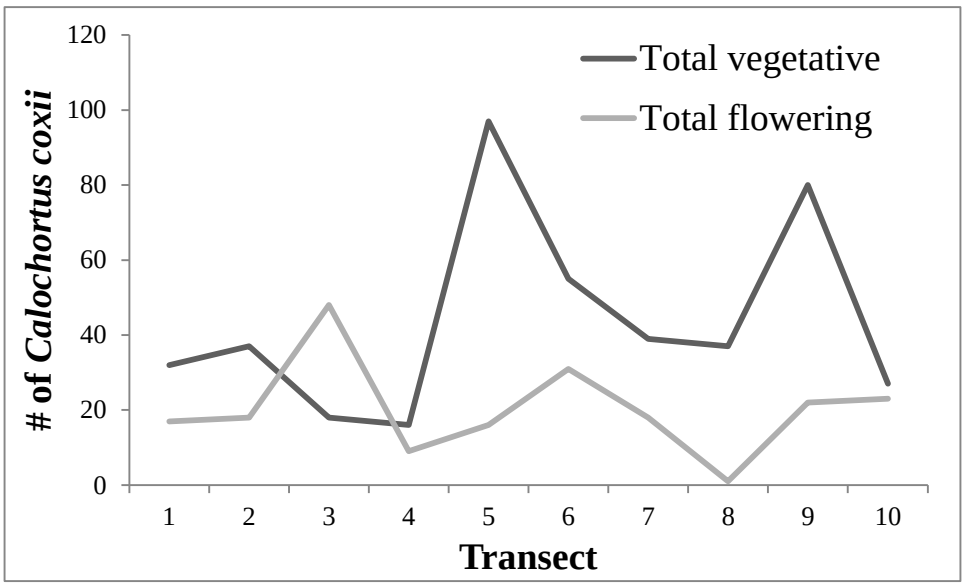

Figure 6. Total vegetative and total flowering *Calochortus coxii*, by transect.

Transects varied by the amount of canopy cover by conifers, and mean percent shade ranged from 12% to 92% across all transects. Transects in Bilger 1 tended to be more shaded than those in Bilger 4 (means = 50% and 40 %, respectively). In general, transects with more shade tended to have fewer *Calochortus coxii*, whereas transects with less shade had greater numbers of plants (Figure 7). Total *Calochortus coxii* per transect was positively associated with moss and lichen cover ($r^2 = 0.27$; Figure 8), and was negatively associated with litter cover ($r^2 = 0.20$, Figure 9).

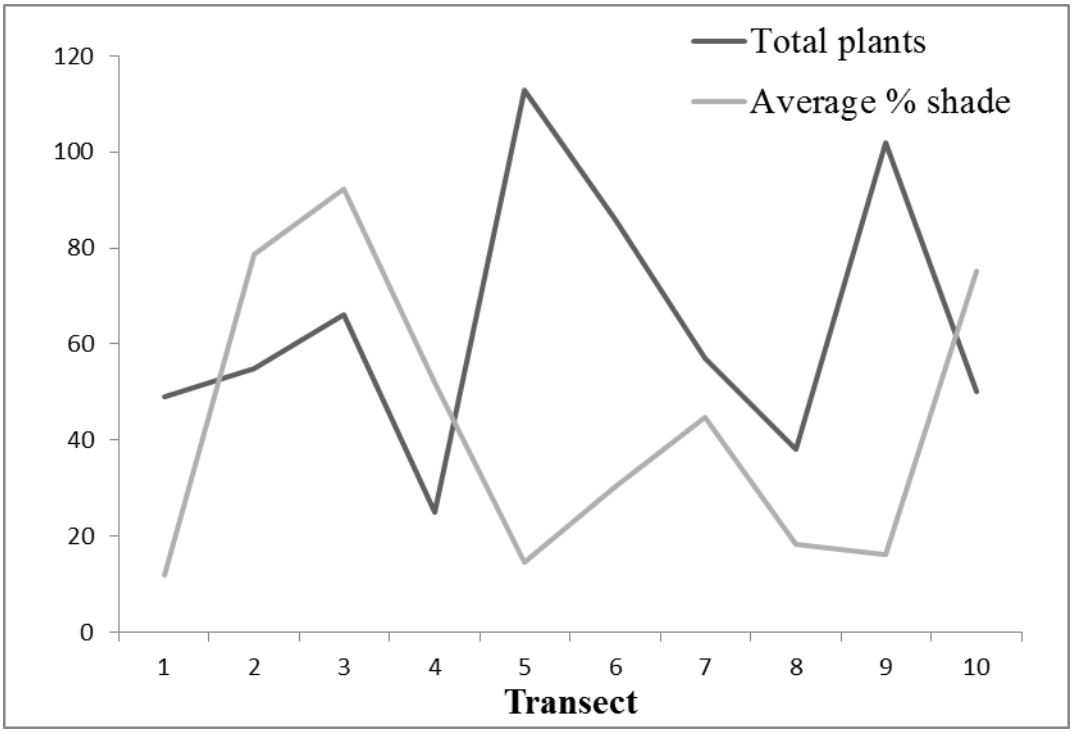

Figure 7. Total count of *Calochortus coxii* and average % shade, by transect.

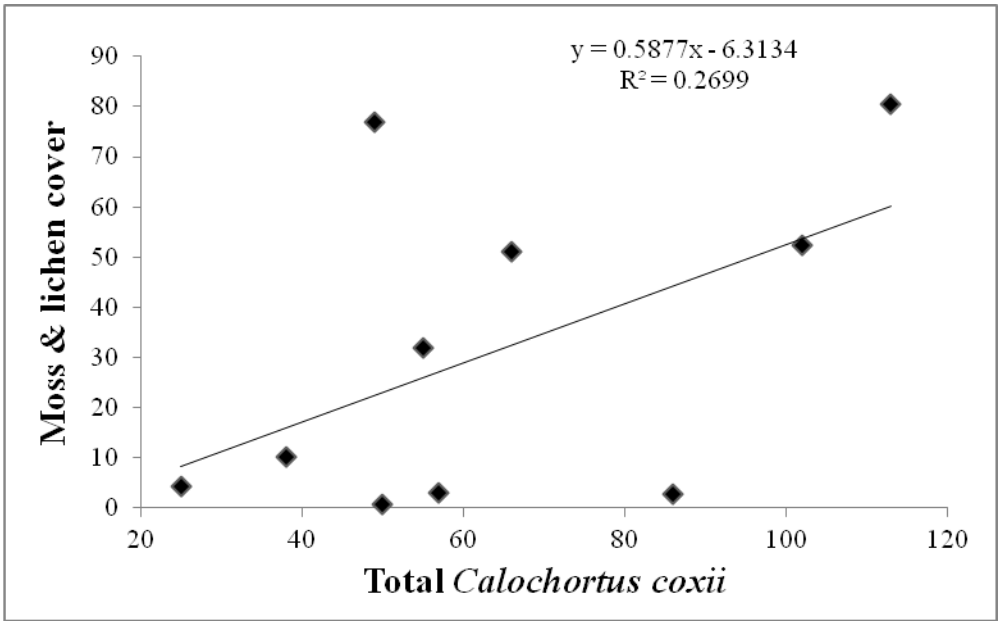

Figure 8. Total *Calochortus coxii* relative to % cover for moss & lichen, by transect.

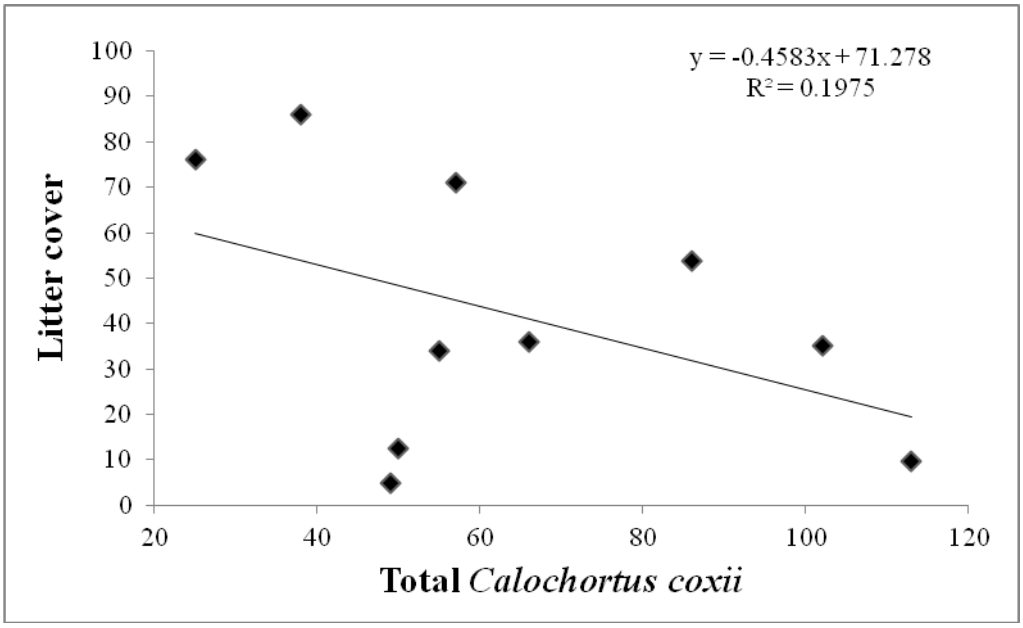

Figure 9. Total *Calochortus coxii* relative to % cover for litter, by transect.

DISCUSSION

Our estimates of the size and extent of the *Calochortus coxii* populations on BLM land were substantially different than existing records for these populations. 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; these estimates do not take into account variability 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 may result in some inaccuracies.

For all but one of the populations (Myrtle Creek 4), we counted significantly fewer *Calochortus 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 2011, we found only 3790 individuals. Likewise, at Langell, previous populations were estimated to support 1.7 million plants (over 40% private, 60% public land). In 2011, we found only 543 individuals on the public portion of this population. Potential causes for these discrepancies include population decline, inaccurate initial population size estimates (e.g. including plants on private land in population size estimates), observer errors, and/or large numbers of plant undetected in 2011 due to cryptic life stages.

Calochortus coxii is a serpentine endemic. Thus, its distribution matches the patchy distribution of this habitat. Though extent of occurrences tended to be less than that known previously, we found individuals outside of the known range at all sites but Red Ridge.

Figure 10. *Calochortus coxii* (center) among associated native species including *Aspidotis densa* and *Festuca roemeri* on a serpentine outcropping.

Consistent with past observations, we found that

Calochortus coxii was highly associated with native species, with very few non-native species in the associated plant community (Figure 10). We also found this species to be positively associated with moss and lichen cover, but negatively associated with litter cover, which is generally more abundant when invasive annual grasses are present. The negative relationship between *Calochortus coxii* and exotic species could be due its restriction to serpentine soils, which tend to be resistant to invasion. Alternatively, *Calochortus 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 *Calochortus coxii* abundance, and they both indicate potential to invade areas of this highly endemic species.

Figure 11. A slug preying on a *Calochortus coxii* flower.

Herbivory on the leaves and flowers of *Calochortus coxii* was widespread across all transects at Bilger Ridge (Figure 11). Herbivory, particularly by mammals, was greater in drier transects. 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). Previous studies have indicated that cattle grazing may negatively affect *Calochortus 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 *Calochortus 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).

The primary threats to these populations were invasion by exotic species and encroachment by shrubs and trees. While the serpentine habitat this species occurs on 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. However, some areas, such as the ridgelines within Bilger 1 and 4, may require careful thinning in order to prevent canopy closure and extirpation of *Calochortus coxii*. *Calochortus coxii* evolved in an area with high fire frequency, and with fire suppression in the early 20th Century, sites that were once open are experiencing encroachment by shrubs and conifer species, which

could negatively affect population trends for this species. We found that more dry, open transects tended to have higher abundance of *Calochortus coxii*, with greater numbers of reproductive plants. Likewise, transects with more shade tended to support fewer *Calochortus coxii*, suggesting that encroachment by conifers may cause decline in populations over time. As monitoring continues, we will be able to further understand population trends and how encroachment may affect *Calochortus coxii* population dynamics.

FUTURE ACTIVITIES

Permanent monitoring plots established at Bilger 1 and Bilger 4 will be monitored in the spring of 2012 and 2013, and trends will be assessed in population dynamics, with potential threats to this species documented. In fall 2013, our final report will include recommendations for management of this species based on population trends and assessed threats of this species.

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APPENDICES

Appendix A. Mean percent cover for all species within each transect

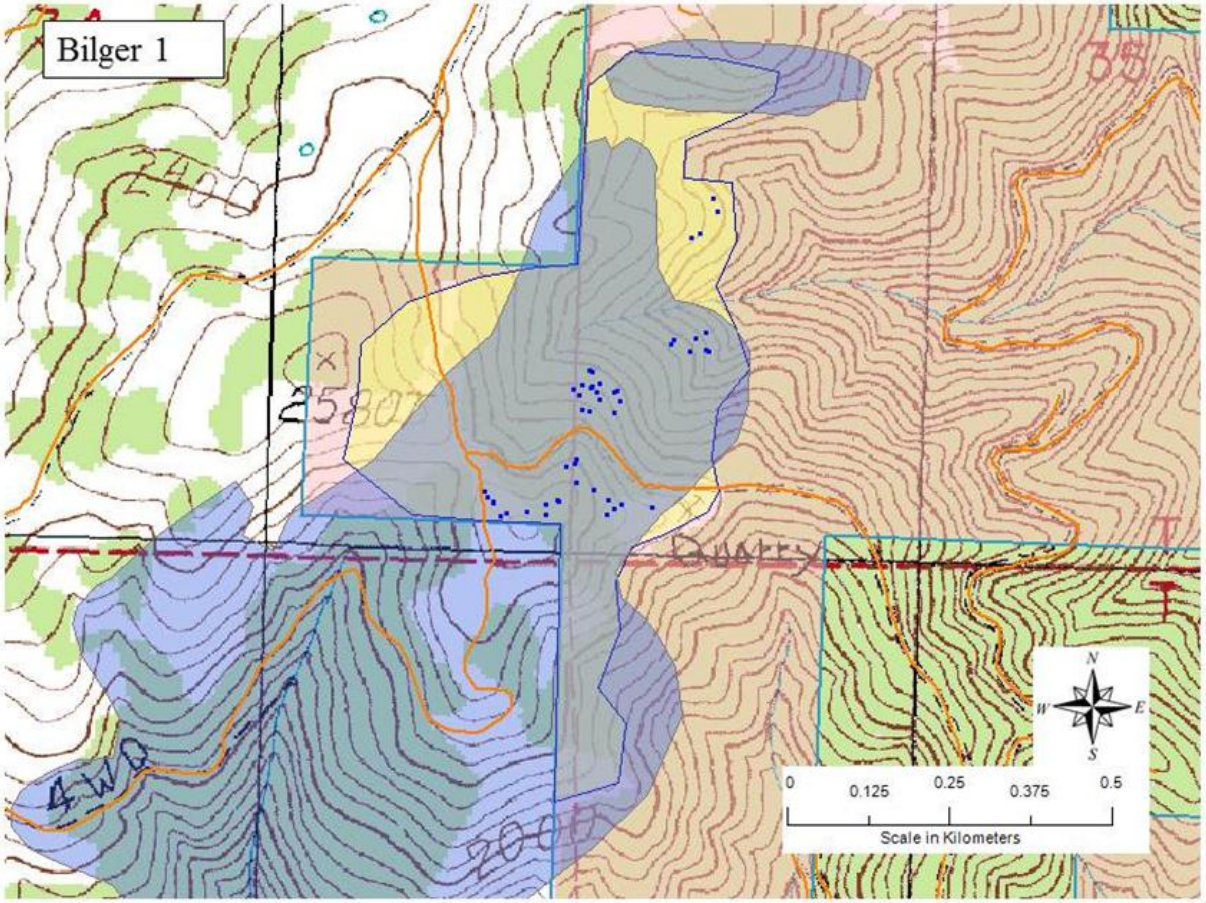
			Percent cover									
			Bilger 1					Bilger 4				
			T 1	T 2	T 3	T 4	T 5	T 1	T 2	T 3	T 4	T 5
Species	Nativity	Growth Form										
unk. Asteraceae	Unknown	Forb	0	0.4	0	0	0	0	0	0	0	0
Achillea millefolium	Native	Forb	0.32	0.26	0	0	0.04	0	0	0	0	0
Agoseris grandiflora	Native	Forb	0	0	0	0	0	0.06	0.02	0	0	0
Allium acuminatum	Native	Forb	0	0	0	0	0	0.08	0.06	0	0	0
Aspidotis densa	Native	Forb	7.8	10	0	0.2	1.2	0.74	0.6	0	0	5.02
Brodiaea elegans	Native	Forb	0	0	0.06	0	0	0	0	0	0	0
Calochortus coxii	Native	Forb	0.06	0.02	0.16	0.02	0.06	0.06	0.06	0.08	0.06	0.06
Camassia quamash	Native	Forb	0	0	0	0	0	0.3	0.52	0	0	0
Cerastium nutans	Native	Forb	0.08	0.08	0	0	0.04	0.42	0.04	0	0.06	0
Clarkia sp.	Unknown	Forb	0	0.08	0.04	0	0.02	0	0.02	0	0	0.04
Cryptantha intermedia	Native	Forb	0	0	0	0	0	0	0.04	0	0	0
Delphinium sp.	Native	Forb	0	0	0	0	0	0	0	0.02	0	0
Dodecatheon sp.	Native	Forb	0	0	0	0	0	0	0	1.2	0	0
Galium parisiense	Exotic	Forb	0.08	0	0	0	0	0.02	0.04	0.02	0	0
Goodyera oblongifolia	Native	Forb	0	0	0	0	0	0	0	0.02	0.02	0
Iris chrysophylla	Native	Forb	0.24	0.2	0	0	0	0	0.4	0.18	0.4	0
Listera caurina	Native	Forb	0	0	0	0	0	0	0	0.04	0	0
Lomatium dissectum	Native	Forb	0	0	0	0.02	0.02	0	0	0	0	0.2
Lomatium nudicaule	Native	Forb	0	0.6	0	0.44	0	0	0	0	0	0

Appendix A. continued

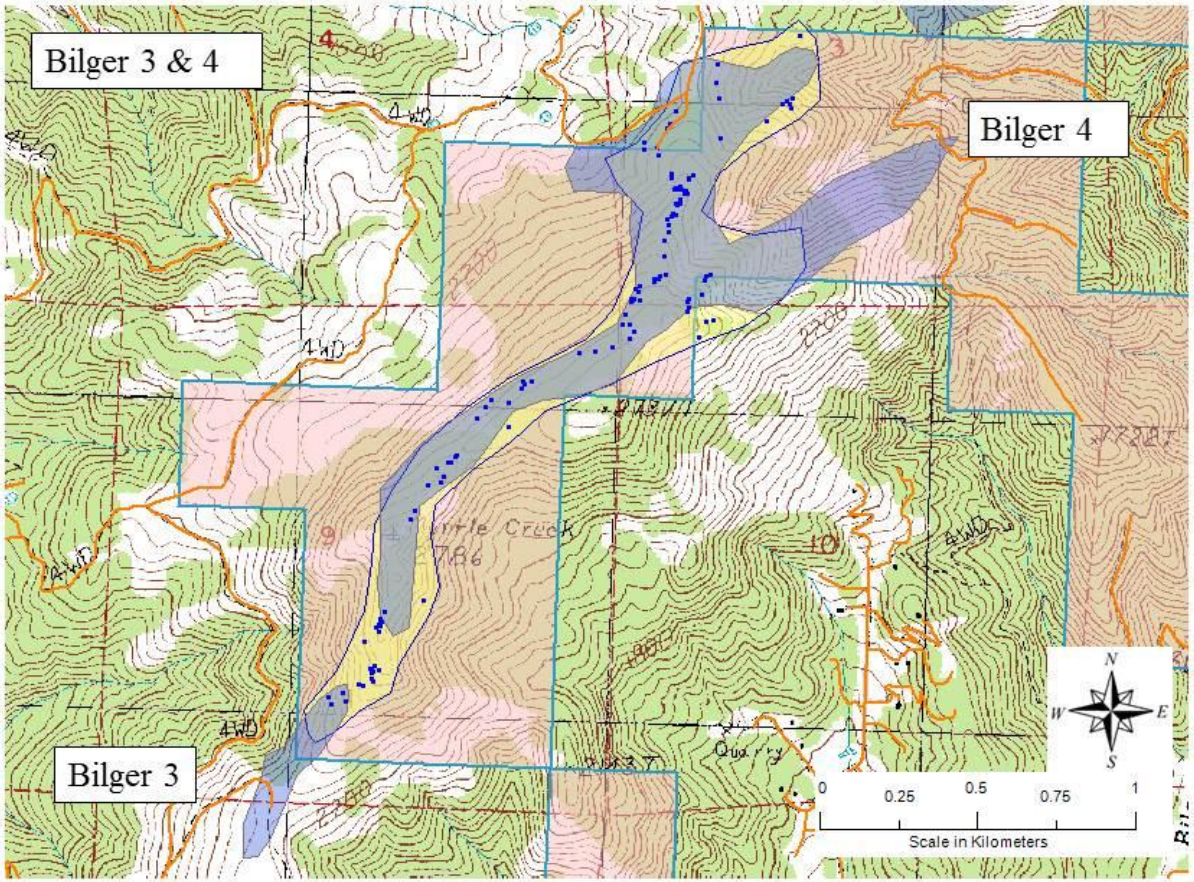
			Percent cover									
			Bilger 1					Bilger 4				
			T 1	T 2	T 3	T 4	T 5	T 1	T 2	T 3	T 4	T 5
Species	Nativity	Growth Form										
Lotus micranthus	Native	Forb	0	0	0.02	0	0	0	0.2	0	0	0
Madia gracilis	Native	Forb	0	0	0	0	0	0.06	0.02	0	0	0
Minuartia californica	Native	Forb	0	0.06	0	0	0	0	0	0	0	0.02
Osmorhiza sp.	Unknown	Forb	0	0	0	0	0	0	0	0.02	0	0
Perideridia oregana	Native	Forb	0	0	0	0	0	0	0	0	0	0.04
Plectritis congesta	Native	Forb	1.22	0	0	0	0	0	0	0	0.12	0.08
Polystichum munitum	Native	Forb	5	0.02	0	0	0	0	0	0	0.02	0
Ranunculus occidentalis	Native	Forb	0.4	0.06	0.02	0.04	0.04	0	0	0.18	0.22	0
Rumex acetosella	Exotic	Forb	0	0	0.02	0	0	0.22	0	0	0	0
Sedum stenopetalum	Native	Forb	0	0	0	0	0	0.02	0	0	0.1	0.2
Silene hookeri	Native	Forb	0	0	0.02	0	0	0	0.02	0	0.02	0
Solidago sp.	Unknown	Forb	0	0	0	0	0.04	0	0	0	0	0
Viola hallii	Native	Forb	0	0	0	0.1	0	0	0	0	0	0
Zigadenus venenosus	Native	Forb	0	0.06	0.02	0.42	0	0	0	0	0	0.02
Achnatherum lemmonii	Native	Graminoid	0	0	7.02	0	0	0	0.04	0	0	1.42
Agrostis sp.	Unknown	Graminoid	0	0	0	0	0	0	0.2	0	0	0
Aira caryophyllea	Exotic	Graminoid	0	0	2.42	0	0	0	0.02	0	0	0
Arrhenatherum elatius	Exotic	Graminoid	0	0	0	0	0	0	0.02	0	0	0
Bromus carinatus	Native	Graminoid	0.42	0.2	0	0	0	0	0	0	0	0
Bromus hordeaceus	Exotic	Graminoid	0	0	0.1	0	0	0	0.04	0.04	0	0
Cynosurus echinatus	Exotic	Graminoid	0.02	0	0	0	0	0.06	0.44	0	0	0

Appendix A. continued

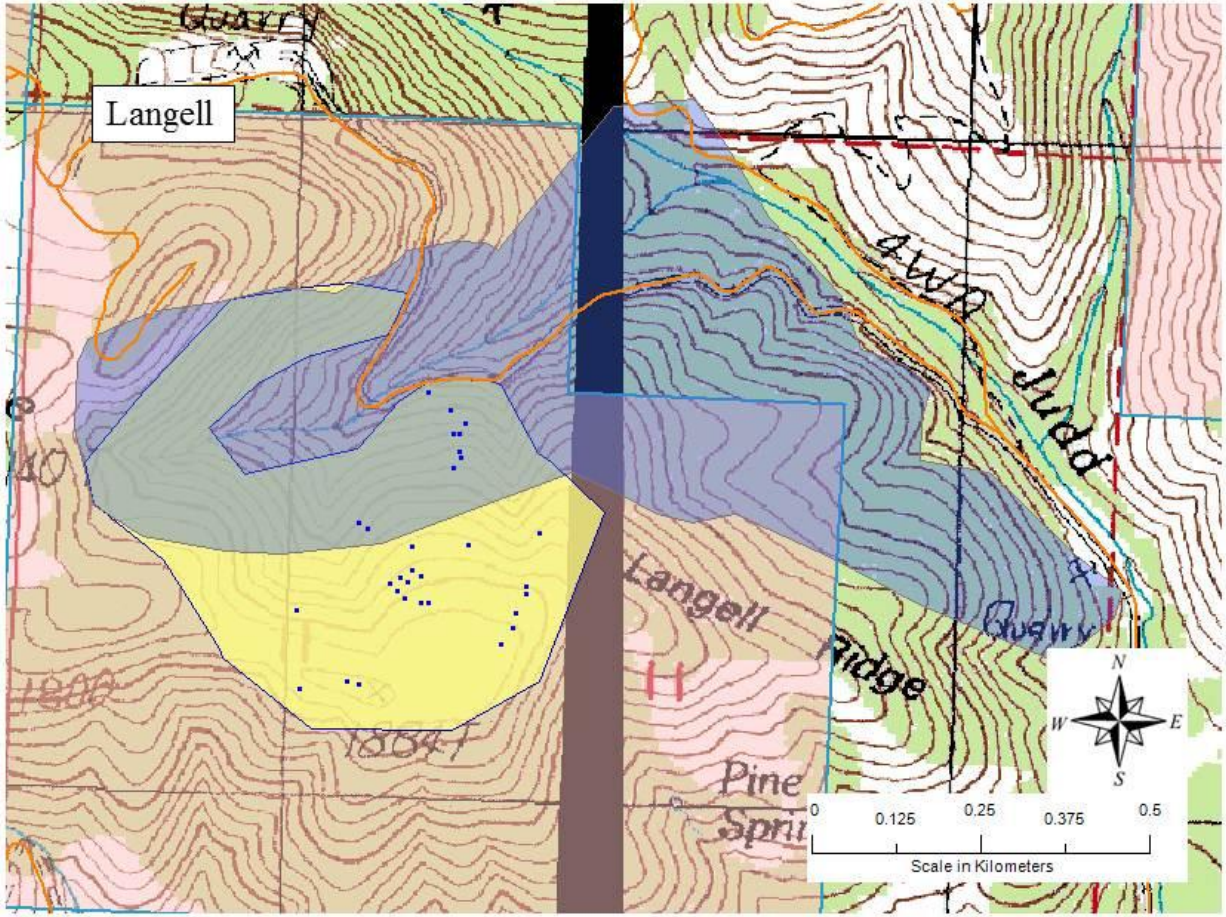
			Percent cover									
			Bilger 1					Bilger 4				
			T 1	T 2	T 3	T 4	T 5	T 1	T 2	T 3	T 4	T 5
Species	Nativity	Growth Form										
Danthonia californica	Native	Graminoid	0	0	0	0	0	0	0	0	0.2	0.6
Elymus glaucus	Native	Graminoid	0.04	0.02	0	0.04	0	0.44	0.16	0	0.44	0.02
Festuca occidentalis	Native	Graminoid	0	0	0	0	0	0	0	0.36	0	0
Festuca roemeri	Native	Graminoid	0.44	7	0	10.4	3.02	4.2	0.02	0	0.2	0
Juncus sp.	Unknown	Graminoid	0	0	0.12	0.02	0	0	0	0	0	0
Luzula campestris	Exotic	Graminoid	0	0.08	0	0.06	0.06	0	0	0	0.02	0
Melica geyeri	Native	Graminoid	0.26	0.04	0	0.04	0.1	0	0	0	0	0
Poa secunda	Native	Graminoid	0	0.02	0.02	0.02	0	0.42	0.22	0	0	3.62
Trisetum cernuum	Native	Graminoid	0	0.06	0	0	0	0	0.02	0.64	0	0
Vulpia microstachys	Native	Graminoid	0	0	0.04	0	0	0	0.04	0	0	0.02
Calocedrus decurrens	Native	Tree	1.16	0.64	0	1.48	14.8	1.42	0	0.16	4.42	0
Pinus jeffreyi	Native	Tree	0	1.4	0	0	0	3	0	0	0.2	0
Pseudotsuga menziesii	Native	Tree	0.42	0	0	0.06	0	0	0	0	0.06	0
Bare ground			0.06	11.8	2.24	0.08	0.82	9.2	0.08	0.22	0.04	33
Moss & lichen			77	31.8	51	4.24	80.4	2.82	3.04	10.2	52.4	0.66
Rock			0	1.6	2	6.82	1.8	21.6	22	0.4	6.04	43
Litter			5	34	36	76.2	9.6	53.8	71	86	35	12.4
Average % shade			12	79	92	52	14	30	45	18	16	75
Species Richness			16	21	14	15	12	16	24	13	16	14
Total % cover vegetation			19.0	23.3	13.1	17.4	24.4	12.5	5.3	6.0	10.6	16.4
Total % cover vegetation and substrate			100	101	101	101	112	99	99	100	100	100



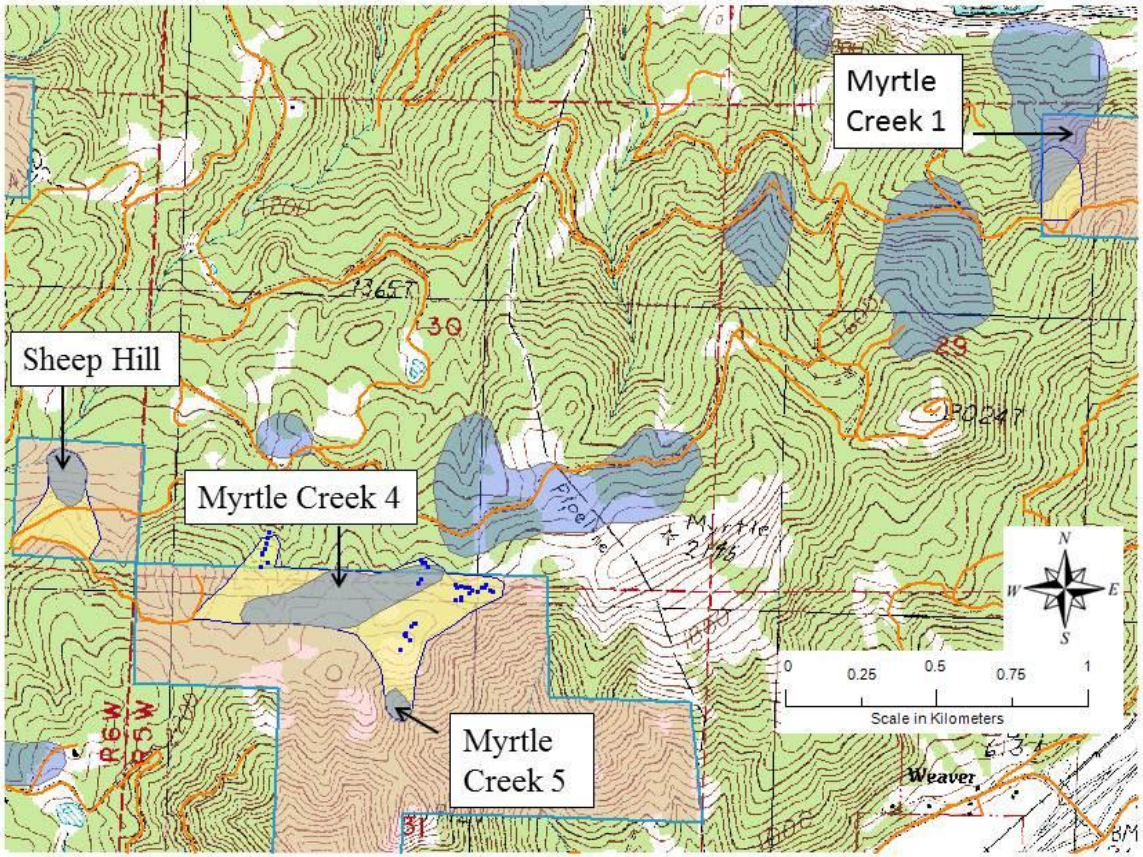
Appendix B. *Calochortus coxii* distribution at Bilger 1 in 2011. Blue dots indicate individuals or multiple individuals observed, pink represents public land (BLM) boundaries, purple represents distribution indicated by BLM shapefiles, yellow indicates the area surveyed by IAE in 2011.



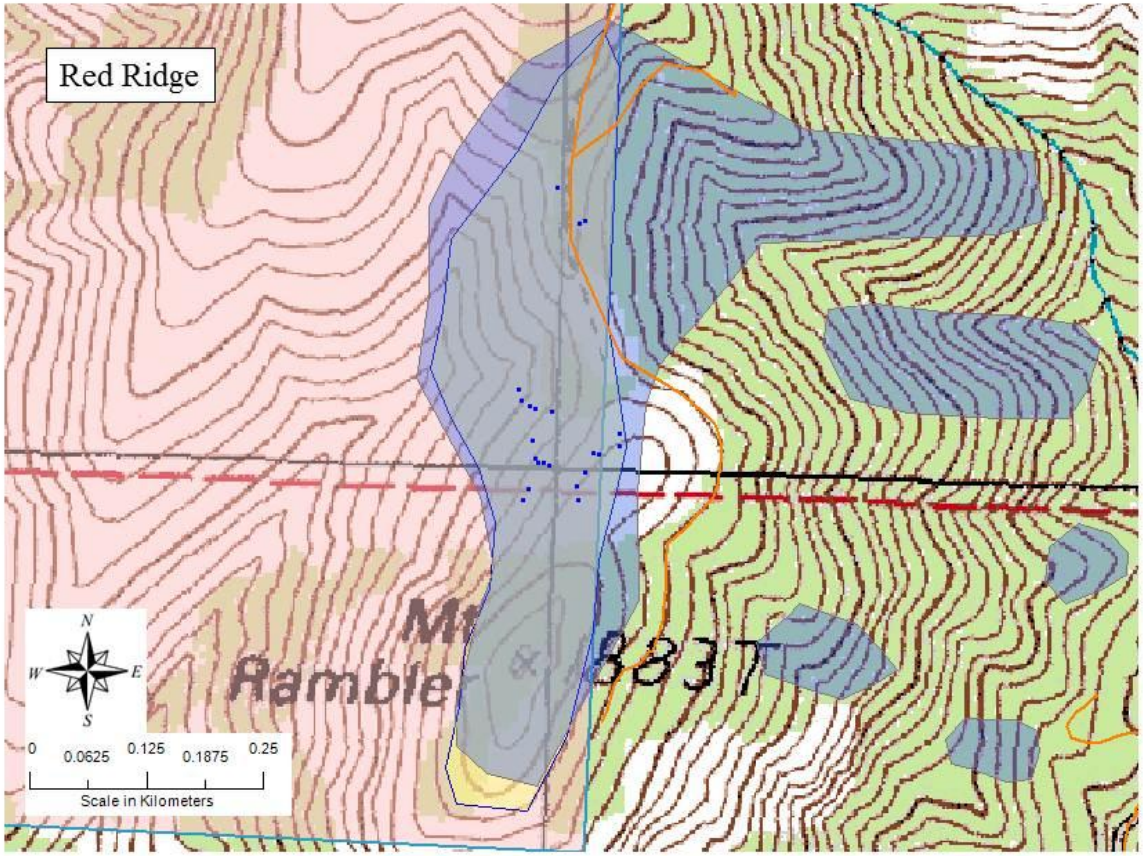
Appendix C. *Calochortus coxii* distribution at Bilger 3 & 4 in 2011. Blue dots indicate individuals or multiple individuals observed, pink represents public land (BLM) boundaries, purple represents distribution indicated by BLM shapefiles, yellow indicates the area surveyed by IAE in 2011. Note the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



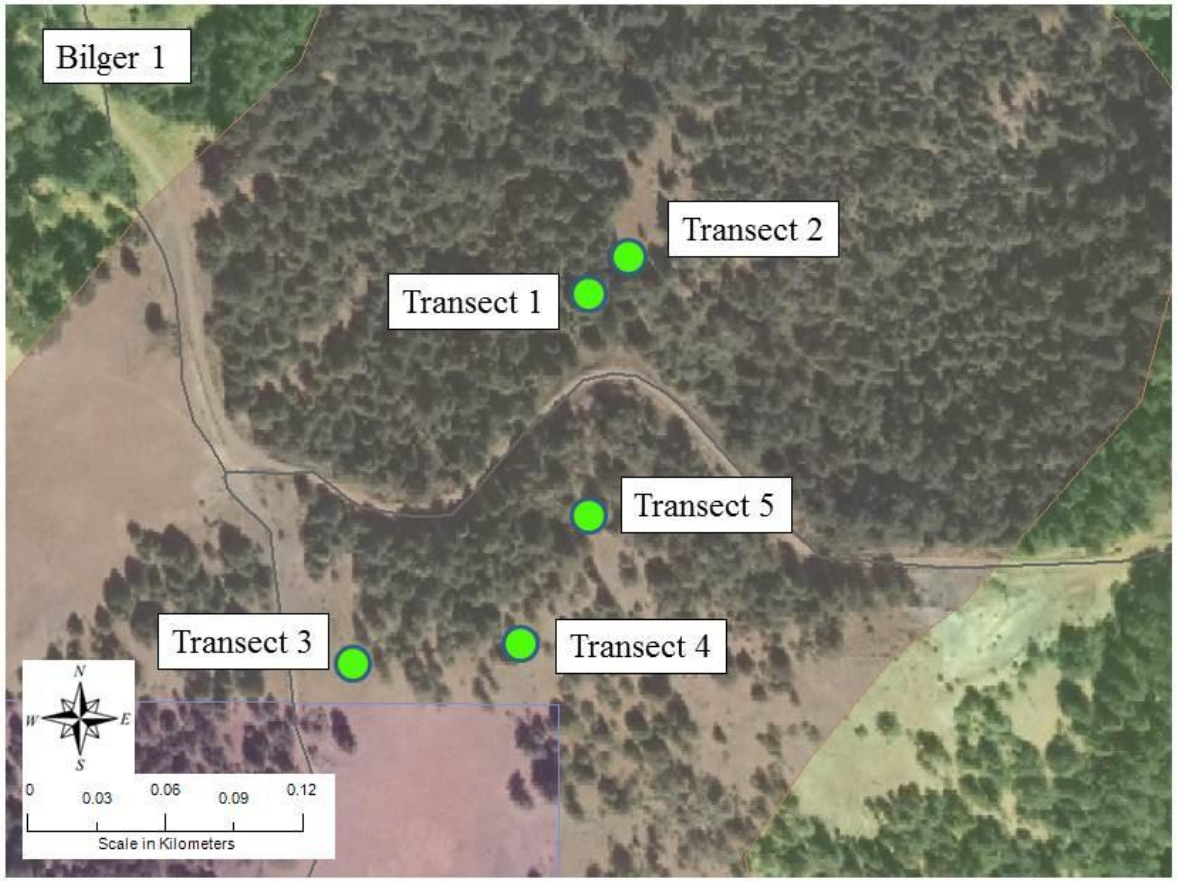
Appendix D. *Calochortus coxii* distribution at Langell in 2011. Blue dots indicate individuals or multiple individuals observed, pink represents public land (BLM) boundaries, purple represents distribution indicated by BLM shapefiles, yellow indicates the area surveyed by IAE in 2011. Note the individuals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



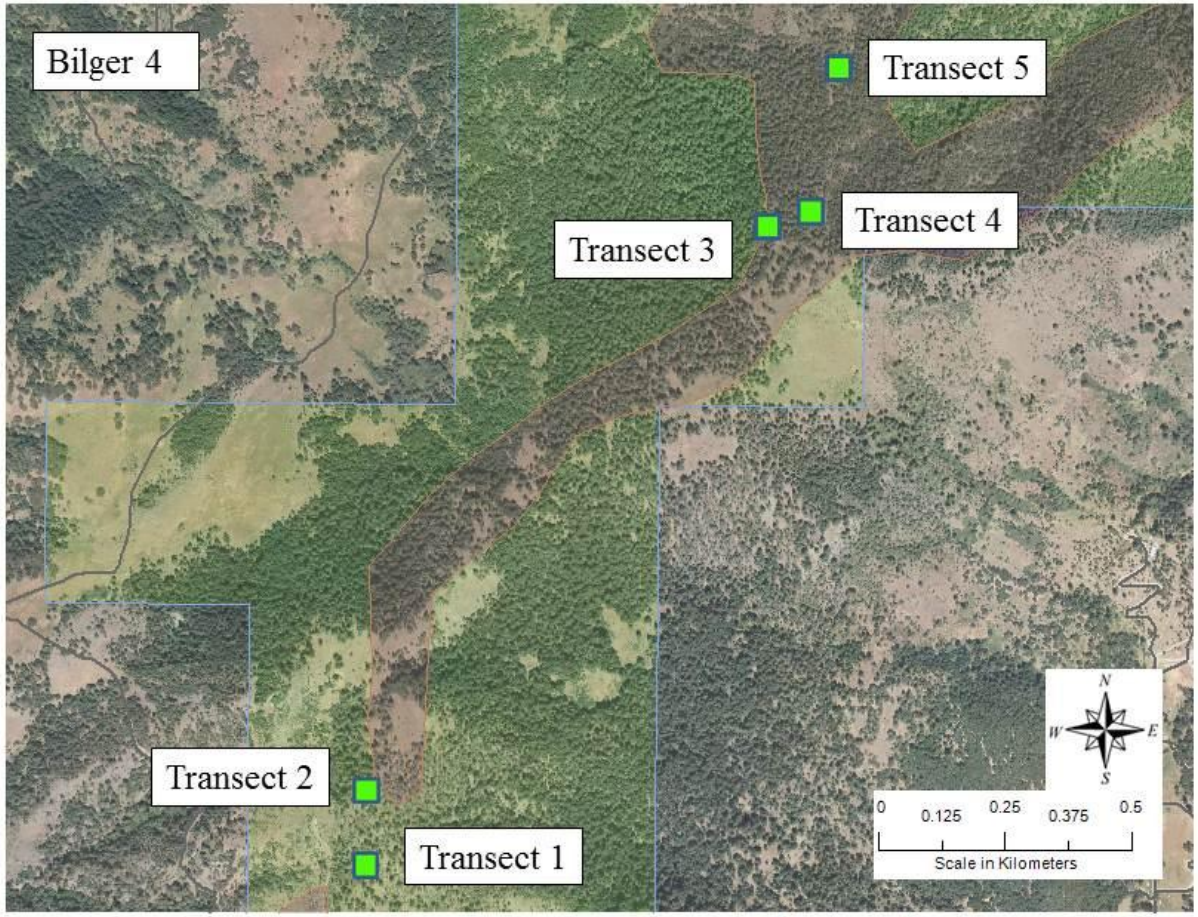
Appendix E. *Calochortus coxii* distribution at Myrtle Creek and Sheep Hill sites in 2011. Blue dots indicate individuals or multiple individuals observed, pink indicates public land (BLM) boundaries, purple represents distribution indicated by BLM shapefiles, yellow indicates the area surveyed by IAE in 2011. Note the continuous nature of distribution between the two sites.



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



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.



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).