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

2020

Report to the Bureau of Land Management, Roseburg District

Report prepared by Nadav Mouallem and Matt A. Bahm

Institute for Applied Ecology

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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.

Questions regarding this report or IAE should be directed to:

Thomas Kaye (Executive Director)

Institute for Applied Ecology

563 SW Jefferson Avenue

Corvallis, Oregon 97333

phone: 541-753-3099

email: tom@appliedeco.org

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

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EXECUTIVE SUMMARY

The objectives of this project are to visit known occurrences of Crinite mariposa lily (*Calochortus coxii*) in spring 2020, assess trends in populations, provide population estimates for the proposed pipeline areas, and provide management recommendations.

- In 2020 we monitored five transects at Bilger 1 and established and monitored six transects in an area north of Myrtle Creek named 'New Pipeline 1.'
- The major threats of C. *coxii* noted over the course of our study include encroachment by conifers and invasion by exotic species. While we found a steep decline in exotic species present on transects in 2020, there was an increase in canopy cover at Bilger 1 since thinning treatments in 2011-2012. Past treatments at Bilger 1 in close proximity to long-term monitoring transects indicated that careful canopy thinning led to an increased number of flowering individuals, though that response was short-lived and continued treatment is necessary. Canopy thinning treatments can be effective at increasing the number of flowering plants, however they must be carefully implemented to avoid spread of invasive species or impact C. *coxii*.
- While we had observed a decline of vegetative C. *coxii* from 2011 to 2014 in long-term monitoring transects, in 2015 and 2020 we noted an increase in vegetative plants which led to an overall increase in total number of individuals. In 2020, we found the highest total number of individuals at Bilger 1 since monitoring began.
- It is increasingly likely that a warming climate is 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. In forested areas, individual plants are predominately vegetative. These trends have been consistent over the course of this study.
- The New Pipeline transects are in close proximity to the route for the planned LNG Pipeline. 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* may pose a threat to the habitat and this species.

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INTRODUCTION

Status

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 2010-2019). 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. *C. COXII* IN FLOWER

Background

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).

FIGURE 2. *C. COXII* IN BUD

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*.

Threats

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 north of Myrtle Creek (New Pipeline 1) 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). The transects at New Pipeline 1 are immediately adjacent to or in close proximity to the proposed pipeline. The construction of the pipeline could result in significant disturbance of sensitive habitat and populations of this species.

Population locations

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

Monitoring

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.

Objectives

The objectives of this project are to:

1. Visit all known occurrences in spring 2020 and establish new transects north of Myrtle Creek
2. Assess trends in populations
3. Provide population estimates for the proposed pipeline areas and suggest management recommendations

METHODS

Permanent monitoring transects: Bilger 1 and Bilger 4 (2011-2015, 2020)

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. We returned to monitor Bilger 1 transects in June 2020, and were unable to monitor Bilger 4 due to time constraints. Transect locations were selected as areas with relatively high C. *coxii* abundance and differed by habitat (Table 1, Appendix B, Appendix C). 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 BILGER 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 1m^2 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 and 2020 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.

Permanent monitoring transects: New Pipeline Transects (2020)

In June 2020 we established six permanent monitoring transects along the route of the proposed LNG Pipeline about 5 miles north of Myrtle Creek, OR (Appendix D) to (1) characterize the habitat occupied by C. *coxii* in the area, (2) measure changes in the total number of plants and ratios of vegetative to reproductive individuals over time, and (3) improve our assessment of the limited C. *coxii* population in the area. Six permanent "New Pipeline" transects were established along the proposed route and were monitored. Transect locations were selected as areas with representative C. *coxii* habitat and abundance (Table 2, Appendix D). Habitat targeted included rocky slopes with relatively open canopy dominated by *F. roemeri*, mossy slopes, and rock outcrops along the serpentine ridge. Many of these transect locations were placed along or in close proximity to the route of the LNG Pipeline, which was visibly flagged and available to view on Jordan Cove LNG's website (https://www.jordancovelng.com/).

TABLE 2. HABITAT CHARACTERISTICS OF NEW PIPELINE TRANSECT LOCATIONS

Transect	Category	Habitat Characteristics
Transect 2	Forested	Forest opening, relatively open canopy, decaying biomass on ground, some recruitment of *P. jeffreyi* and C. *decurrens*
Transect 3	Forested	Relatively dense herbaceous vegetation, much moss as ground cover.
Transect 4	Dry	Rock outcrop in transect, much moss ground cover, dense herbaceous vegetation away from the outcrop, recruitment of *P. jeffreyi* and C. *decurrens*.
Transect 5	Dry/Forested	Rock outcrop with young pine canopy through transect and moderate herbaceous cover in open areas.
Transect 6	Dry	Open, rocky slope with large *P. jeffreyi* and C. *decurrens*. Large rock outcrop in transect with moderate herbaceous cover.
Transect 7	Dry	Dense C. *coxii* population in the area. *P. jeffreyi* at start and end of transect. Relatively open canopy with moderate herbaceous cover.

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 north side of the tape (downslope). We recorded azimuth of each transect from the origin to 25m, and from the origin to the belt. Six photopoints were selected (0m to 25m, N, E, S, W, 25m to 0m) and photographed. Habitat characteristics, absence of presence of exotic species, and other relevant observations were noted. 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.

Community data were collected on five randomly chosen $1m^2$ plots per transect in 2020, which will be 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 was 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 percent canopy cover for the entire transect.

RESULTS

Permanent monitoring transects: Bilger 1 (2011-2015, 2020)

In 2020, a total of 351 plants (207 vegetative, 144 reproductive) were found along the five transects at Bilger 1 (Table 3, Figure 3, Figure 4), which is the highest total plants found since we started monitoring in 2011. This is a slight increase from our last monitoring in 2015, when we observed 313 plants with fewer vegetative plants (161 vegetative, 152 reproductive). Like our results in 2015, in 2020 we observed a pronounced shift from dominance of reproductive plants found in 2014 to dominance of vegetative plants at Bilger 1. At Bilger 1, the percentage of vegetative plants has ranged from 27-80%, with 59% vegetative in 2020. Four of the five transects at Bilger 1 had more vegetative than reproductive plants, with Transect 5 having 117 and 57, respectively. A majority (64%) of the reproductive plants had one flower per plant. In 2020 we did not monitor flower herbivory by insects.

In 2020 we were unable to monitor transects at Bilger 4 due to limitations on field work caused by the Covid-19 pandemic. For more details on previous monitoring results see Gray and Bahm 2015.

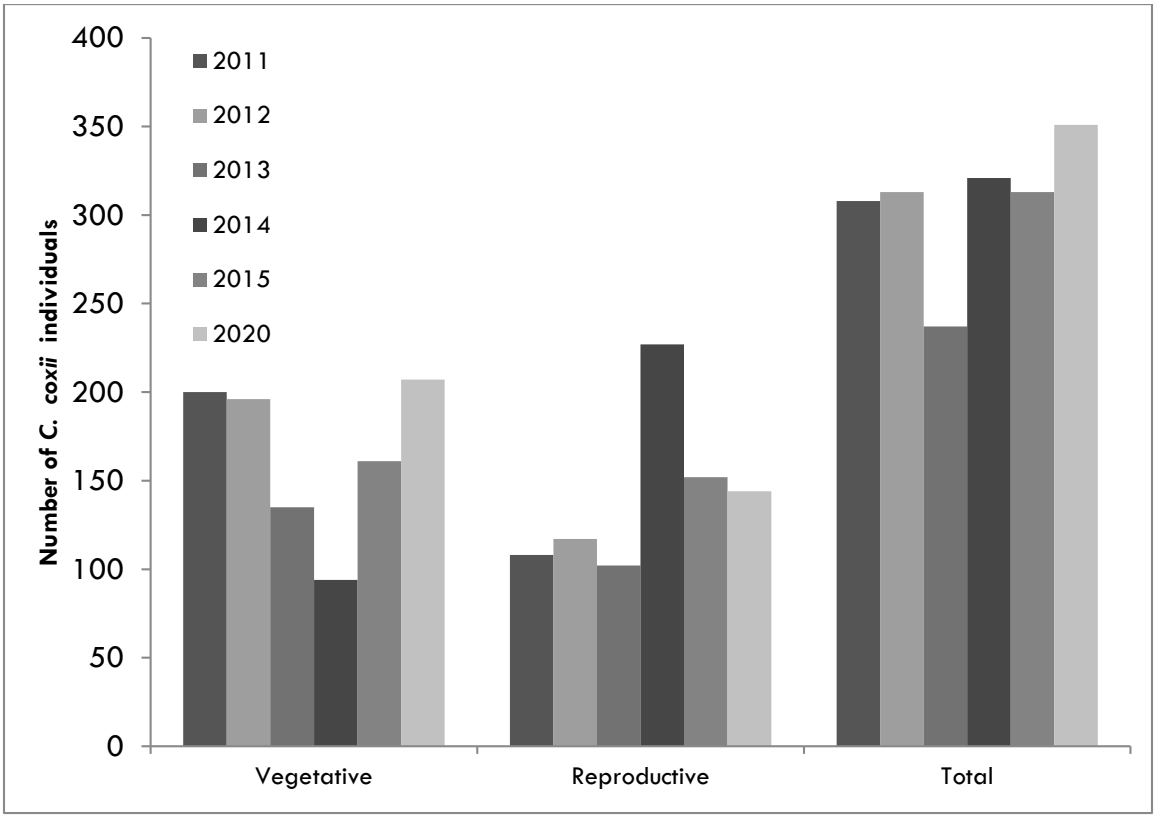


FIGURE 3. COMBINED TOTAL NUMBER OF *C. COXII* COUNTED IN PERMANENT MONITORING TRANSECTS AT BILGER 1; 2011-2020.

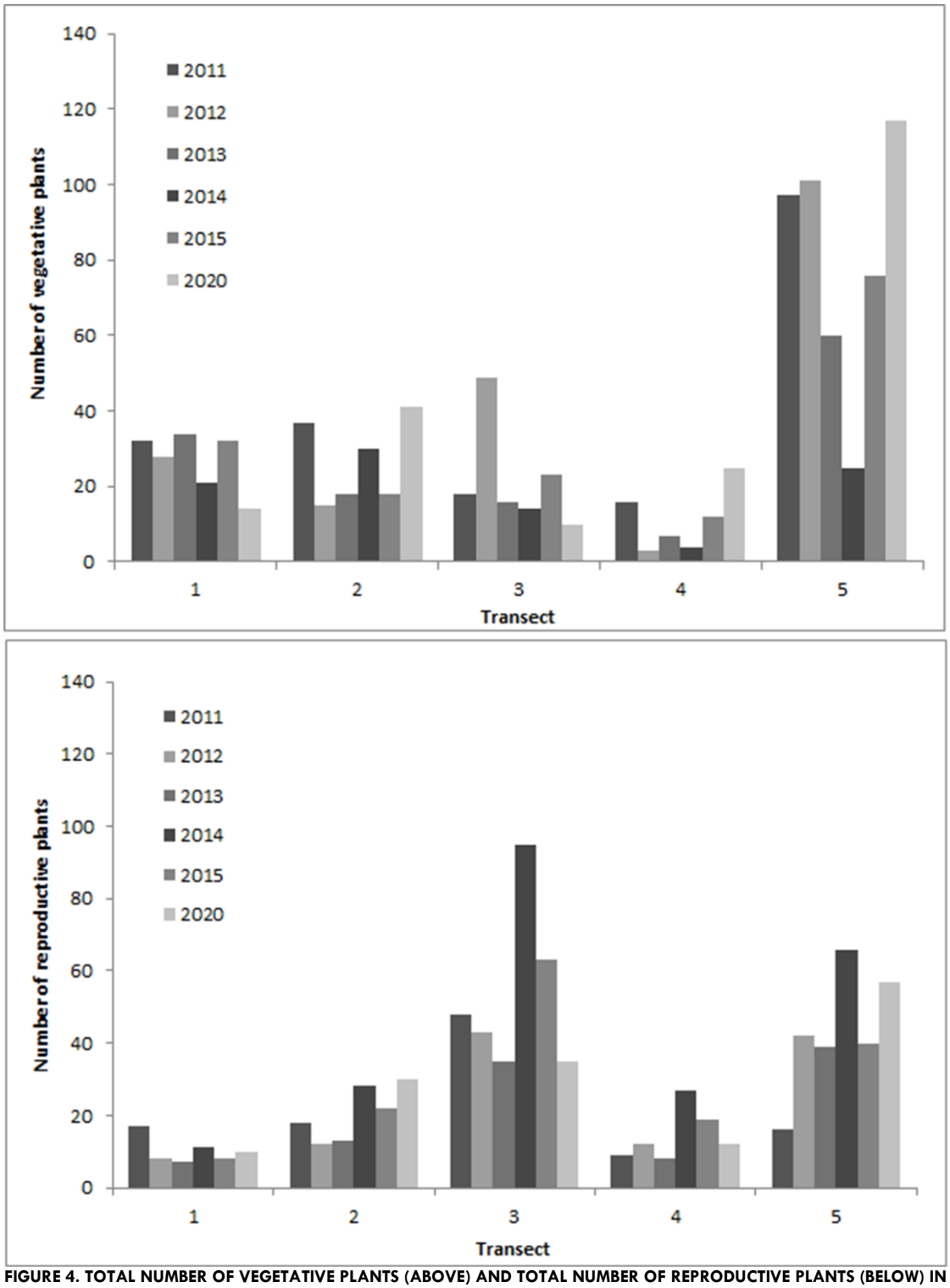


FIGURE 4. TOTAL NUMBER OF VEGETATIVE PLANTS (ABOVE) AND TOTAL NUMBER OF REPRODUCTIVE PLANTS (BELOW) IN INDIVIDUAL TRANSECTS AT BILGER 1 FROM 2011-2020.

TABLE 3. *C. COXII* TALLY WITHIN 1M X 25M BELT TRANSECTS AT BILGER 1 IN 2020. FLOWER BY INSECT HERBIVORY DATA WAS NOT COLLECTED IN 2020.

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	14	10	24	5	4	1	0	10	0	-	0	0
Bilger 1	2	41	30	71	21	6	3	0	30	2	-	0	1
Bilger 1	3	10	35	45	19	14	2	0	35	1	-	2	0
Bilger 1	4	25	12	37	9	3	0	0	12	0	-	5	2
Bilger 1	5	117	57	174	38	17	2	0	57	0	-	0	0
Mean		41	29	70	18	9	2	0	29	0.6		1	1
Total		207	144	351	92	44	8	0	144	3		7	3

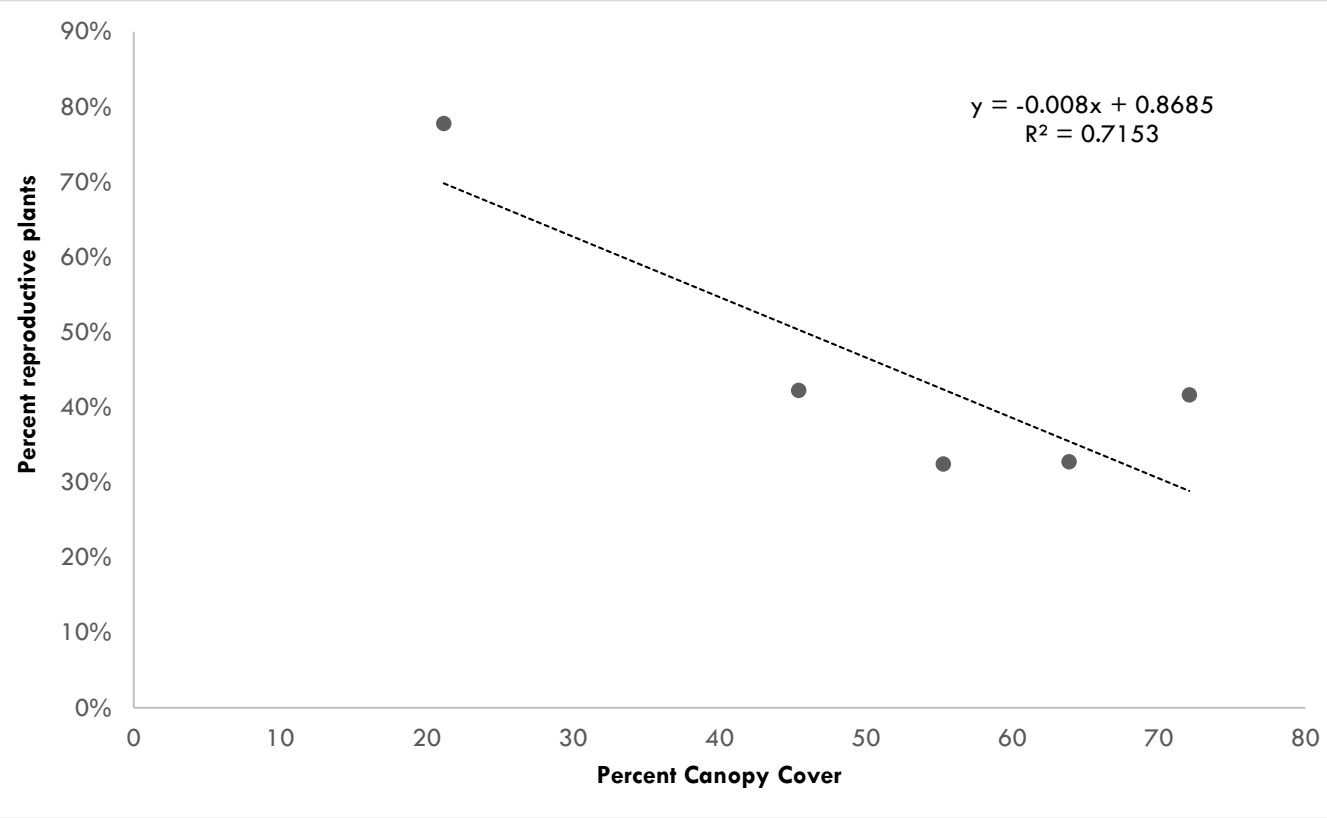


FIGURE 5. RELATIONSHIP BETWEEN MEAN PERCENT CANOPY COVER AND MEAN PERCENT REPRODUCTIVE PLANTS AT EACH TRANSECT AT BILGER 1 IN 2020.

Like 2015, percentage of reproductive plants and canopy cover were negatively correlated in 2020 (r^2 = 0.7, Figure 5), suggesting that canopy clearing can increase the 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 4). In 2014, 2015, and 2020 canopy cover rebounded in these areas, suggesting that continued canopy reduction treatments might be needed. Forest canopy cover varied across transects at Bilger 1, with percent canopy ranging from 21% to 72% (mean 51%).

TABLE 4. MEAN PERCENT CANOPY COVER AT BILGER 1 FROM 2011-2020.

		Mean Percent Canopy Cover					
Site	Transect	2011	2012	2013	2014	2015	2020
Bilger 1	1	88	86	90	83	84	72
	2	21	35	56	52	47	45
	3	8	11	7	18	14	21
	4	48	35	31	53	46	55
	5	86	47	45	64	58	64

While we did not monitor for flower by insect herbivory in 2020, we still observed a steep decline in herbivory from 2015 to 2020 In 2020 we observed herbivory on 3.7% of plants at Bilger 1, as compared to herbivory on 15% of all plants at Bilger 1 in 2015 (excluding flower by insect herbivory). Across all transects, 2.0% of plants experienced leaf herbivory by insects, 0.85% experienced leaf herbivory by mammals, and 0.85% experienced flower herbivory by mammals. (Table 3). The greater leaf herbivory in 2020 could be due to the increase in the proportion of vegetative plants compared to reproductive plants found on the transects in 2020.

In past years, we found that C. *coxii* had a greater proportion of vegetative plants in forested habitats, and higher proportion of reproductive plants in dry habitats. However, in 2020, we also found there were more C. coxii plants in general in dry/open habitats (Figure 5, Figure 6). While we found very little herbivory on the Bilger 1 transects, we did find slightly greater leaf herbivory in dry/open habitat and slightly more flower herbivory on forested areas (Figure 6)

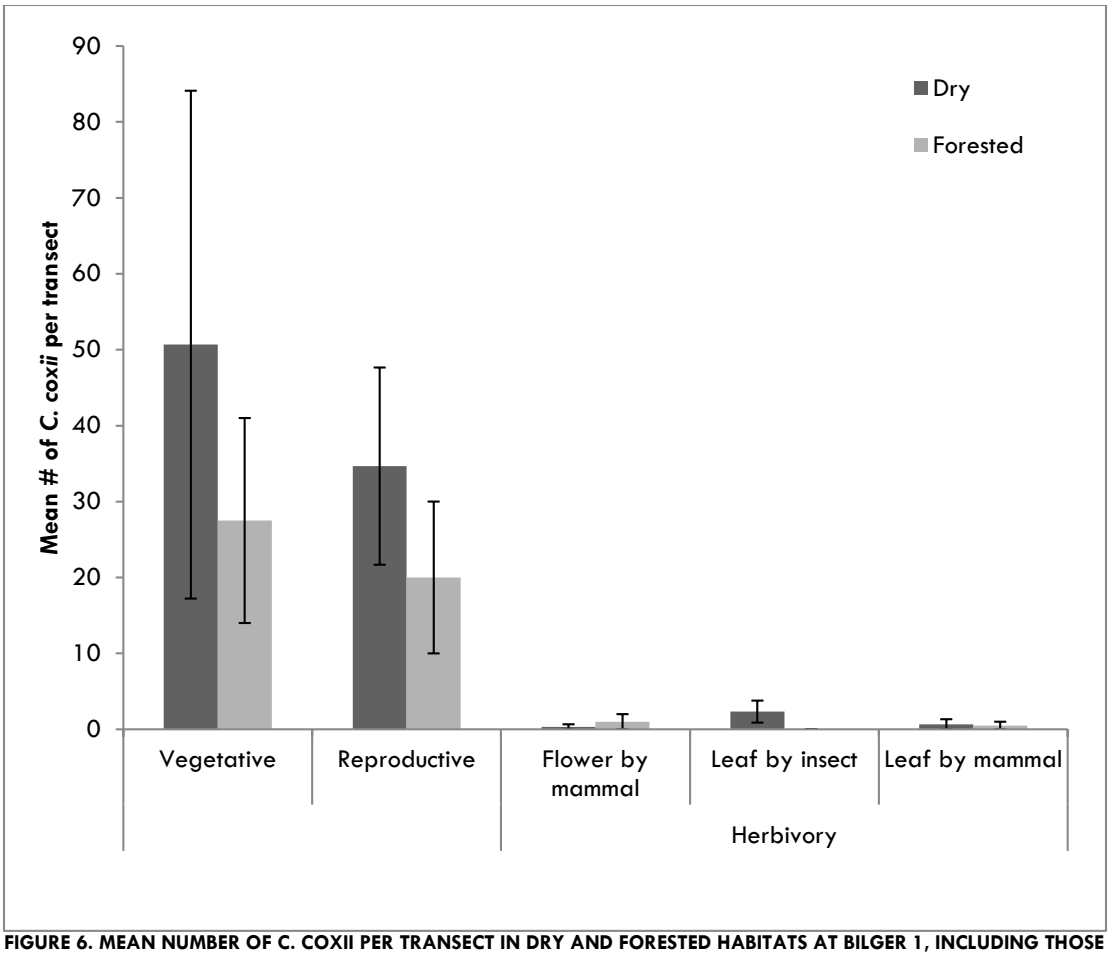


FIGURE 6. MEAN NUMBER OF C. COXII PER TRANSECT IN DRY AND FORESTED HABITATS AT BILGER 1, INCLUDING THOSE THAT EXHIBITED HERBIVORY; 2020. ERROR BARS REPRESENT 1 SE.

Across the five transects at Bilger 1 in 2020, 40 species were recorded. Of those species, 34 were native, 5 were exotic, and one was undetermined (*Hieracum sp.)*. Species richness ranged from 18 to 29 species per transect. Native species comprised 98.8% of total plant cover, exotic species accounted for 1% (Figure 7). Native graminoids were the most abundant, consisting primarily *Festeuca roemeri, Achnatherum lemmonii,* and *Melica geyeri* (Figure 7, Appendix A). *Aspidotis densa* was the most common forb. On most transects we found saplings of *Calocedrus decurrens*; while native, these could pose a threat regarding tree encroachment into serpentine habitats (Appendix A). Exotic graminoids composed very small percentages of total cover, but *Bromus hordeaceus* and *Luzula campestris* were the most abundant species with potential to impact C. *coxii*. Other exotic grasses in transects included *Aira caryophyllea* and *Cynosorus echinatus*. These results are a promising drop from those found in 2015, where we found 95% native and 5% exotic species across the Bilger transects.

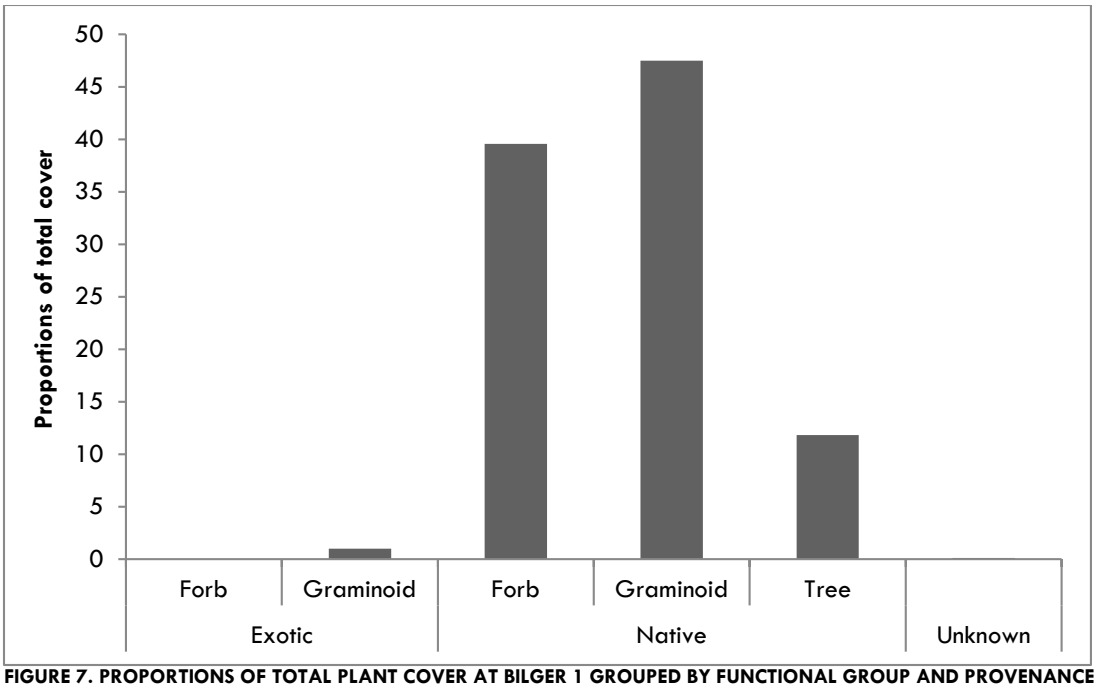


FIGURE 7. PROPORTIONS OF TOTAL PLANT COVER AT BILGER 1 GROUPED BY FUNCTIONAL GROUP AND PROVENANCE IN 2020.

Permanent monitoring transects: New Pipeline, Myrtle Creek (2020)

In 2020, a total of 435 plants (174 vegetative, 261 reproductive) were found along the six New Pipeline transects established north of Myrtle Creek, OR (Table 5, Figure 8, Figure 9). This is the first-year of data collection on these transects and sets a baseline for future monitoring efforts. Unlike our results at Bilger 1, the C. *coxii* population at the new transects is dominated by reproductive individuals (60%). Five of the six transects at New Pipeline had more reproductive than vegetative plants, with Transect 3 having 71 and 63, respectively. A majority (64%) of the reproductive plants had one flower per plant, while 28% had two flowers per plant and even fewer had three or four flowers per plant.

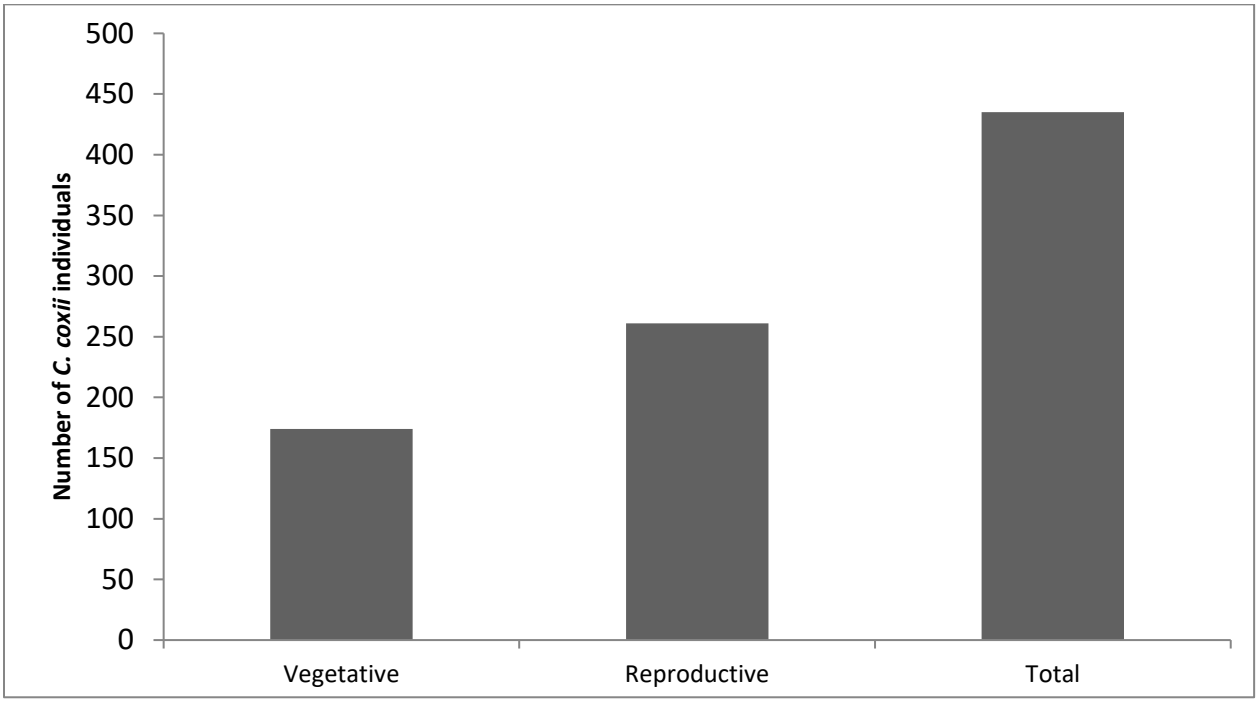


FIGURE 8. TOTAL NUMBER OF C. COXII COUNTED ACROSS SIX PERMANET MONITORING TRANSECTS INSTALLED AT NEW PIPELINE 1 IN 2020.

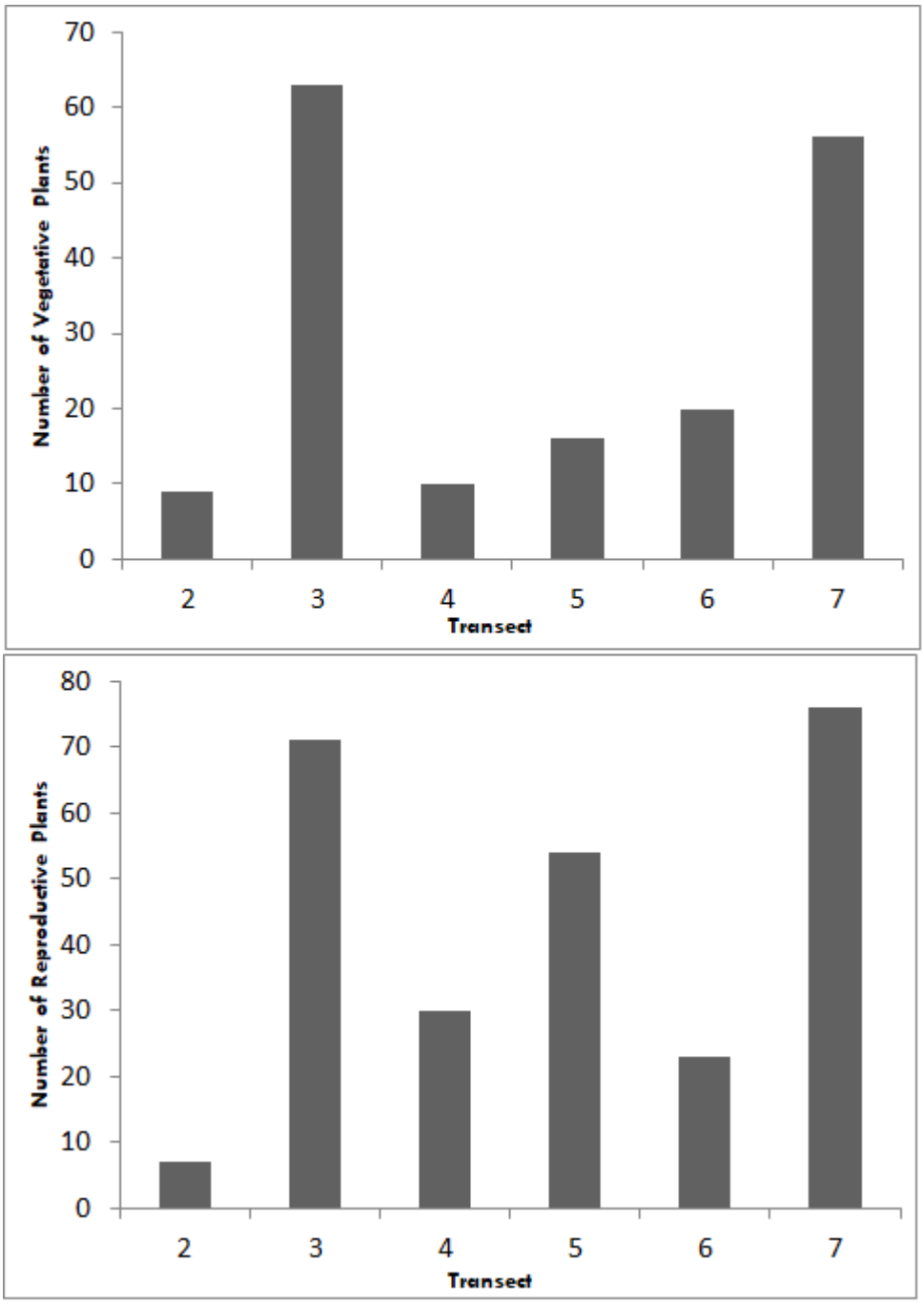


FIGURE 9. TOTAL NUMBER OF VEGETATIVE PLANTS (ABOVE) AND TOTAL NUMBER OF REPRODUCTIVE PLANTS (BELOW) IN TRANSECTS AT NEW PIPELINE IN 2020. [NOTE: TRANSECTS ARE NUMBERED 2-7 BECAUSE TRANSECT 1 FELL IN UNSUITABLE HABITAT AND WAS OMITTED].

TABLE 5. C. *COXII* TALLY WITHIN 1M X 25M BELT TRANSECTS AT NEW PIPELINE 1 IN 2020. FLOWER HERBIVORY BY INSECT WAS NOT COLLECTED IN 2020.

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
New pipeline	2	9	7	16	3	2	2	0	7	0	-	0	0
New pipeline	3	63	71	134	45	22	4	0	71	5	-	8	6
New pipeline	4	10	30	40	17	7	4	2	30	0	-	0	1
New pipeline	5	16	54	70	35	15	3	1	54	10	-	0	0
New pipeline	6	20	23	43	21	2	0	0	23	2	-	2	0
New pipeline	7	56	76	132	46	24	6	0	76	6	-	1	2
Mean		29	44	73	28	12	3	1	44	4		2	2
Total		174	261	435	167	72	19	3	261	23		11	9

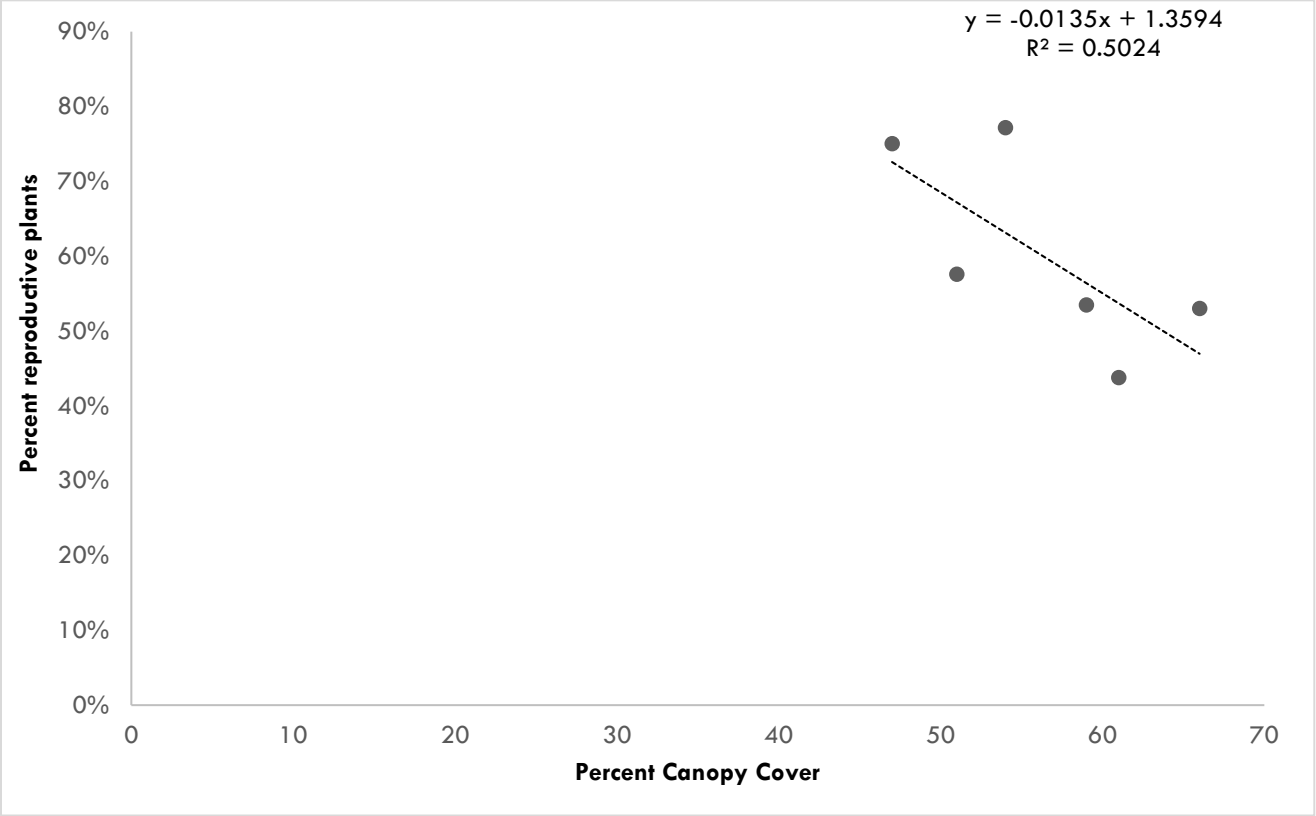


FIGURE 10. RELATIONSHIP BETWEEN MEAN PERCENT CANOPY COVER AND MEAN PERCENT REPRODUCTIVE PLANTS COMPOSING EACH TRANSECT AT NEW PIPELINE 1 IN 2020.

The percentage of reproductive plants and canopy cover were negatively correlated ($r^2 = 0.5$, Figure 10). As these transects were newly established in 2020, there is no prior history of canopy clearing at this site. However, this site shows a similar trend to what we observed at Bilger 1 in 2020 and may also benefit from canopy treatments may be needed after future years of monitoring. Canopy cover varied across transects at New Pipeline 1, with percent canopy ranging from 44% to 77% (mean 56%).

TABLE 6. . MEAN PERCENT CANOPY COVER AT NEW PIPELINE IN 2020

Site	Transect	Mean Percent Canopy Cover 2020
New Pipeline	2	61
	3	66
	4	47
	5	54
	6	59
	7	51

In 2020, we observed herbivory on 10% of plants at New Pipeline 1 in 2020, although we did not monitor insect herbivory in flowers in 2020. Across all transects, 3% of plants experienced leaf herbivory by insects, 2% experienced leaf herbivory by mammals, and 5% experienced flower herbivory by mammals. (Table 5).

Unlike our Bilger transects, we did not distinguish transects by dry and forested characteristics, as they all contained a mixture of conifer growth, rock outcrops, moss growth, and native grasses.

Across the six transects at New Pipeline, 37 species were recorded. Of those species, 33 were native, 3 were exotic, and one was undetermined (*Hieracum sp.)*. Species richness ranged from 12 to 23 species per transect. Native species comprised 99.1% of total plant cover, exotic species accounted for 0.4% (Figure 11). Native graminoids were the most abundant, consisting primarily of *Festeuca roemeri,* (Figure 11, Appendix A). *Aspidotis densa* was the most common forb. We also found *Calocedrus decurrens* and *Pinus jefferyi* cover on transects; while native, these could pose a threat regarding tree encroachment into serpentine habitats (Appendix A). Exotic graminoids composed very small percentages of total cover; *Aira caryophyllea* and *Luzula campestris* were the only exotic graminoids found. These results provide a baseline for future community transect monitoring on these transects at New Pipeline 1.

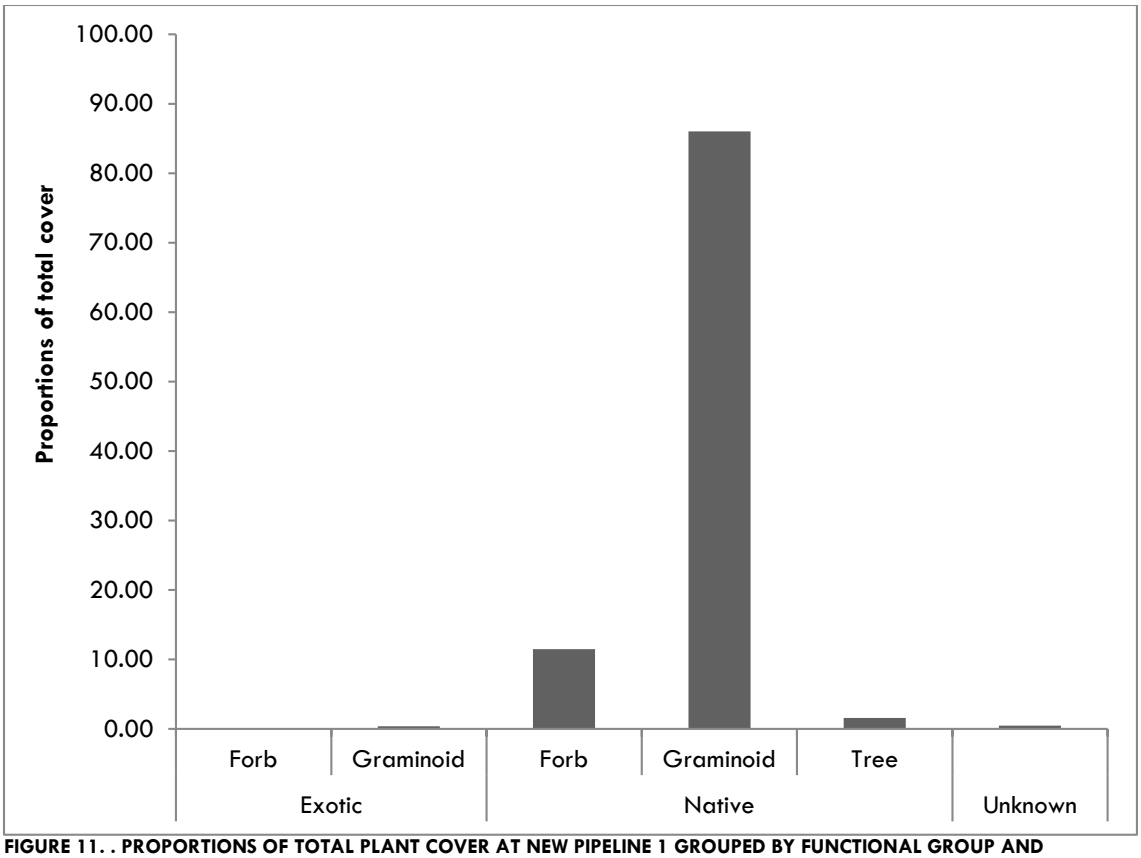


FIGURE 11. . PROPORTIONS OF TOTAL PLANT COVER AT NEW PIPELINE 1 GROUPED BY FUNCTIONAL GROUP AND PROVENANCE IN 2020

DISCUSSION

Permanent monitoring transects: Bilger 1 and Bilger 4

We found that C. *coxii* was highly associated with habitats dominated by native plant species, which is consistent with past observations. In turn, *Calochortus coxii* tended to be negatively associated with exotic species. C. *coxii* may have been extirpated from areas now characterized by high exotic abundance. *Bromus hordeaceus, Luzula campestris* and *Aira caryophyllea* were the most abundant exotic grasses in areas surrounding high C. *coxii* abundance, and they both show high potential to invade habitat of this sensitive endemic species. While exotic graminoid abundance was very low in 2020, the increased presence of *Bromus hordeaceus* from 2015 to 2020 is notable and should be monitored in future years.

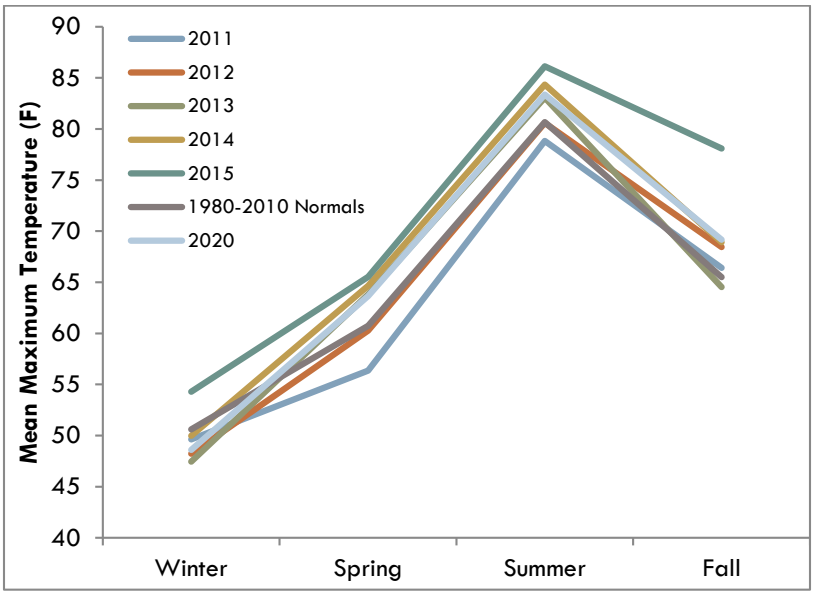
FIGURE 12. A SLUG FEEDING A ON *C. COXII* FLOWER.

Herbivory on the leaves and flowers of C. *coxii,* which may have a negative effect on reproduction, growth and survival, was present across all transects at Bilger Ridge. Historically, 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 uprotected sites (Fredricks 1992, USDI BLM and USFWS 2004). In past years 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 unprotected land with heavy cattle grazing. Similar observations have been noted in previous studies (Kagan 1993).

The primary threat to these populations continues to be encroachment by shrubs and trees into occupied habitat. In 2020 we saw an abundance of C. *decurrens* saplings on Bilger 1 transects. Some areas along the ridgelines within Bilger 1 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 occurred at Bilger 1 in the area of 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*, with a shift back to a preponderance of nonflowering plants in the past five years. These results indicate that careful thinning does not disturb patches of C. *coxii* and opening potential

habitat can be an effective way to stimulate flowering and reproduction in the species. While this area experienced an original decrease in canopy cover, in 2015 and 2020 canopy started to rebound in these areas. This suggests that the effects of canopy clearing might be short-lived and that encroachment by tree seedlings might also have potential to impact abundance of C. *coxii*. In 2015, we found that the ridgeline at Bilger 4 has become increasingly encroached by conifers with many areas becoming thick with seedlings and saplings of C. *decurrens* and *P. jeffreyi* (see 2015 transect notes). This trend has likely continued over the past five years, and we recommend additional careful canopy and tree thinning at the Bilger 4 ridgeline. While the serpentine habitat of this species tends to be more resistant to invasion, management activities that disturb and open the landscape, such as controlled burns or selective logging, should be considered with caution. While we noted a drop in exotic species cover at Bilger 1 in 2020, keeping an eye on invasive species will still be crucial in years to come.

While in previous years we observed a decline in vegetative C. *coxii* from in the transects monitored along Bilger Ridge, in 2020 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 over 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. Variation is weather as well as microclimate associated with canopy cover could be important drivers of population dynamics.



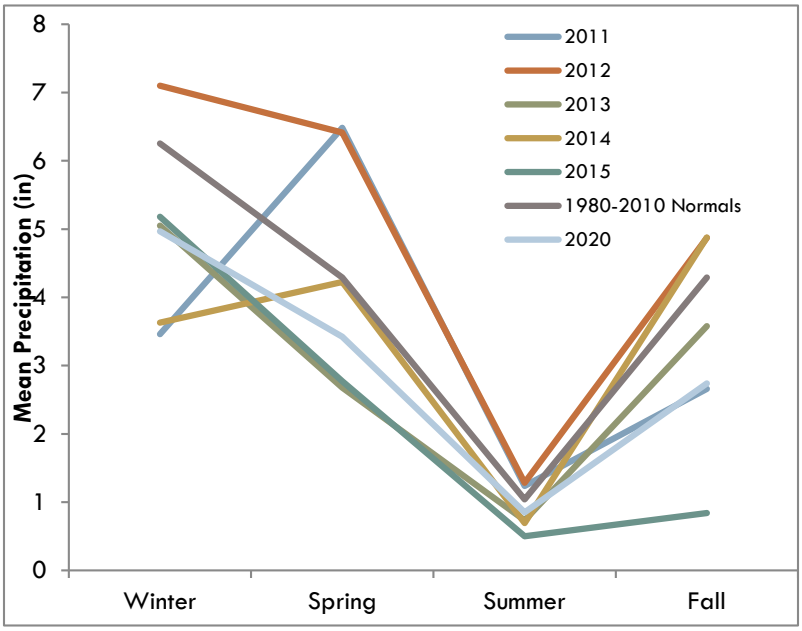


FIGURE 13. AVERAGE LONG-TERM TEMPERATURE AND MEAN PRECIPITATION (1980-2010) RELATIVE TO CONDITIONS EXPERIENCED AT BILGER RIDGE (2011-2015, 2020 PRISM 2006).

Temperatures in 2013 through 2015 and 2020 have been higher than long-term averages, while precipitation in these years has been lower than long-term normals (Figure 13). 2015 was the warmest year since 2011 across all seasons. While in 2014 we saw an increase in reproductive individuals in these transects, in 2015 we saw an increase in vegetative plants, which continued to 2020. 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.

Permanent monitoring transects: New Pipeline 1

The six transects installed and monitored north of Myrtle Creek in 2020 will be very helpful for getting a better picture of what the limited population of C. *coxii* looks like and sets a baseline for future monitoring at New Pipeline 1 in future years. Like our results at Bilger 1, we found that C. *coxii* at New Pipeline was very highly associated with native species cover, and very few exotic species were found along transects. *Luzula campestris* and *Aira caryophllea* were the only exotic forbs found on the New Pipeline transects, so future monitoring should keep an eye on the establishment of other grasses such as *Bromus hordeaceus* and *Cynosurus echinatus* in the area.

Compared to our results at Bilger 1, we found a greater level of herbivory on the newly established transects at New Pipeline (3.7% vs 10% herbivory, respectively). In future years we will be able to get a better idea of the correlation between the type of herbivory (mammal vs insect, flower vs. leaf) and the canopy/forest cover of C. *coxii* habitat in comparison to what we have found on the Bilger transects.

Due to the proximity of the New Pipeline population to the proposed LNG Pipeline (which will cut through this population), careful steps should be taken to limit any damage to this fragile population, such as population destruction and exotic species introduction from pipeline construction.

Surveys of previously known *Calochortus coxii* populations

While we have not surveyed the extent of C. *coxii* populations since 2011-2012, our new transects will assist in tracking the population dynamics and trends of C. *coxii* at both sites. For a further discussion of previous population surveys, see Gray and Bahm 2015.

FUTURE ACTIVITIES

We recommend continued monitoring of permanent transects at Bilger Ridge and the newly established New Pipeline transects to enable population trend assessment in relation to potential threats and habitat over time. Repeated surveys of historic occurrences should be conducted often to document changes in population dynamics, habitat changes, and document potential threats. In 2012, 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 improve understanding of patterns of dormancy will be necessary for a full understanding of the species population cycles. Population studies of this rare species will enable land managers to determine which additional actions are needed for its conservation.

FIGURE 14. MONITORING BILGER 1, TRANSECT 5 IN 2020. NOTE THE RECRUITMENT OF *CALOCEDRUS DECURRENS* IN AND ALONG THE TRANSECT.

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APPENDICES

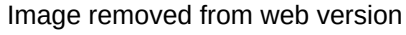
Appendix A. Mean percent cover in 2020 for Bilger 1 and New Pipeline transects.

Species	Nativity	Growth Form	Bilger 1 2020	New Pipeline
Achillea millefolium	Native	Forb	0.48	0.00
Achnatherum lemmonii	Native	Graminoid	4.20	0.00
Agoseris grandiflora	Native	Forb	0.10	0.00
Agoseris sp	Native	Forb	0.00	0.03
Aira caryophyllea	Exotic	Graminoid	0.01	0.04
Allium acuminatum	Native	Forb	0.00	0.00
Arrhenatherum elatius	Exotic	Graminoid	0.00	0.00
Aspidotis densa	Native	Forb	10.08	1.16
Asplenium viride	Native	Forb	0.00	0.00
Brodeia sp.	Native	Forb	0.00	0.00
Brodiaea elegans	Native	Forb	0.00	0.00
Bromus carinatus	Native	Graminoid	0.69	0.54
Bromus hordeaceus	Exotic	Graminoid	0.34	0.00
Bromus sp	Exotic	Graminoid	0.02	0.00
Calocedrus decurrens	Native	Tree	5.62	0.22
Calochortus coxii	Native	Forb	0.31	0.20
Camassia quamash	Native	Forb	0.00	0.47
Carex sp	Native	Graminoid	0.00	0.00
Centaureum erythrea	Exotic	Forb	0.00	0.00
Cerastium arvense	Native	Forb	0.78	0.22
Cerastium glomeratum	Exotic	Forb	0.00	0.00
Cerastium nutans	Native	Forb	0.00	0.03
Clarkia sp.	Native	Forb	0.00	0.00
Claytonia perfoliata	Native	Forb	0.00	0.00
Clintonia uniflora	Native	Forb	0.00	0.00
Cryptantha intermedia	Native	Forb	0.00	0.23
Cryptantha sp.	Native	Forb	0.00	0.00
Cryptantha sp.	Native	Forb	0.00	0.00
Cynosurus echinatus	Exotic	Graminoid	0.00	0.00
Danthonia californica	Native	Graminoid	0.00	0.00
Delphinium sp.	Native	Forb	0.00	0.00
Dodecatheon sp.	Native	Forb	0.00	0.00
Elymus glaucus	Native	Graminoid	0.08	0.63

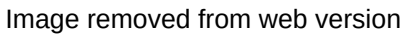
Epilobium minutum	Native	Forb	0.03	0.03
Epilobium sp.	Native	Forb	0.00	0.00
Eriopyllum lanatum	Native	Forb	0.00	0.07
Festuca occidentalis	Native	Graminoid	0.00	0.00
Festuca roemeri	Native	Graminoid	15.66	27.77
Galium aparine	Native	Forb	0.22	0.04
Galium parisiense	Exotic	Forb	0.00	0.00
Galium sp.	Exotic	Forb	0.00	0.00
Goodyera oblongifolia	Native	Forb	0.00	0.00
Hieracium albiflorum	Native	Forb	0.00	0.00
Hieracium scouleri	Native	Forb	0.00	0.02
Hieracium sp.			0.06	0.17
Holosteum sp.	Exotic	Forb	0.00	0.00
Hypochaeris radicata	Exotic	Forb	0.00	0.01
Iris chrysophylla	Native	Forb	0.28	0.46
Juncus sp.	Native	Graminoid	0.00	0.00
Koeleria sp.	Native	Graminoid	0.00	0.00
Listera caurina	Native	Forb	0.00	0.00
Lomatium dissectum	Native	Forb	0.00	0.00
Lomatium nudicaule	Native	Forb	0.64	0.08
Lomatium triternatum	Native	Forb	0.10	0.02
Lomatium utriculatum	Native	Forb	0.12	0.00
Lotus micranthus	Native	Forb	0.01	0.07
Luzula campestris	Exotic	Graminoid	0.12	0.09
Madia gracilis	Native	Forb	0.01	0.01
Melica geyeri	Native	Graminoid	1.72	0.16
Microsteris gracilis	Native	Forb	0.00	0.00
Microsteris sp.	Native	Forb	0.00	0.00
Minuartia californica	Native	Forb	0.00	0.00
Montia sp./clay perfoliolata	Native	Forb	0.06	0.00
Nemophila sp	Native	Forb	0.12	0.00
Nothocaulis sp.	Native	Forb	0.01	0.00
Osmorhiza sp.	Native	Forb	0.00	0.00
Perideridia oregana	Native	Forb	0.00	0.00
Pinus jeffreyi	Native	Tree	0.20	0.32
Plectritis congesta	Native	Forb	1.12	0.00
Poa secunda	Native	Graminoid	1.40	0.13
Polystichum munitum	Native	Forb	3.20	0.17
Pseudotsuga	Native	Tree	0.14	0.00

menziesii				
Ranunculus occidentalis	Native	Forb	1.64	0.33
Rumex acetosella	Exotic	Forb	0.00	0.00
Sedum stenopetalum	Native	Forb	0.00	0.10
Silene hookeri	Native	Forb	0.02	0.01
Solidago sp.	Native	Forb	0.00	0.00
Trisetum cernuum	Native	Graminoid	0.07	0.06
Viola hallii	Forb	Native	0.00	0.00
Vulpia microstachys	Native	Graminoid	0.09	0.07
Zigadenus venenosus	Native	Forb	0.58	0.17

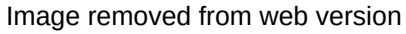
Appendix B. Locations of permanent monitoring transects (green circles) established in areas of high Calochortus coxii abundance at Bilger 1. Transects 1 & 2 are north of the road, whereas transects 3, 4, and 5 are south of the road. Blue stars indicate parking areas.



Appendix C. 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).



Appendix D. Locations of permanent monitoring transects (green dot is the transect start, red dot is the transect end) established in suitable habitat for Calochortus coxii at New Pipeline 1. The green line is the proposed route for the LNG Pipeline, the red line is Rock Creek Road (BLM 29-5-11), and blue dot is the preferred parking location for transect access.



Appendix E. Transect Notes (2020)

The notes below were collected in 2020 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 2020.

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. Very high moss cover, *Polystichum minutum* most abundant forb.	
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, Festuca roemeri, Lomatium nudicaule, Melica geyeri, Bromus carinatus* Greatest threat: conifer recruitment. Suggested management actions: keep an eye on conifer encroachment in opening.	

Bilger 1 Transect 3: Some invasive grasses (*Bromus hordeaceus* & *Aira caryophyllea*) present in the transect. High abundance of moss/lichen. Evidence of cattle here including fresh cowpies, some in the transect. 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* saplings present in and surrounding the transect. Overall the composition is mostly native, dominated by *Festuca roemeri* (over 40% cover) and various *Lomatium* species. *Calochortus coxii* was both vegetative and in flower. Suggested management actions: Remove *Calocedrus decurrens* seedlings in area surrounding transect.	

Bilger 1 Transect 5: Very high moss/lichen cover (94%). Lots of *Calocedrus decurrens* recruitment directly within areas of high *Calochortus coxii* density. Some *Pinus jeffreyi* present as well. Primarily native vegetation in this area. Suggested management actions: Remove *Calocedrus decurrens* seedlings taking care not to impact *Calochortus coxii* as it is very dense in this area.	
New Pipeline Transect 2: Site in area of relatively open canopy. Decaying biomass in transect as well as a large *Calocedrus*. Young saplings present, as well as *Aspidotis densa, Lomatium* species, *Iris tenax*, and *Zigadenus venenosus*.	

New Pipeline Transect 3. Relatively dense herbaceous and moss ground cover with a large abundance of *F. roemeri*. Transect surrounded by tall *Calocedrus* and shaded in the morning.	
New Pipeline Transect 4. Very high abundance of *F. roemeri* on the transect, as well as moss ground cover. Small saplings and rock outcrop in transect.	

New Pipeline Transect 5. Abundance of *F. roemeri* and *A. densa*. Rock with young pine canopy through transect – moderate herbaceous cover in open areas. Abundance of *F. roemeri*.	
New Pipeline Transect 6. Open, rocky slope with large *Pinus* and *Calocedrus*. Large rock outcrop in transect with moderate herbaceous cover. Abundance of *F. roemeri*.	

New Pipeline Transect 7: Dense C. *coxii* population in area. Pine trees at start and end of transect. Relatively open canopy with moderate herbaceous cover. Abundance of *F. roemeri*.