Habitat monitoring and improvement for *Cordylanthus maritimus* ssp. *palustris*

2013

Report to the Bureau of Land Management, Coos Bay District

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PREFACE

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

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Cover photograph: *Cordylanthus maritimus* ssp. *palustris* (Point Reyes bird's-beak) at the Coos Bay North Spit.

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REPORT TO THE BUREAU OF LAND MANAGEMENT, COOS BAY DISTRICT

INTRODUCTION

Cordylanthus maritimus ssp. *palustris* (Point Reyes bird's-beak) is a USFWS Species of Concern, listed as Endangered by the state of Oregon, considered endangered or threatened throughout its range (list 1) by the Oregon Biological Information Center, and a Bureau Sensitive Species with the Bureau of Land Management. *Cordylanthus maritimus* ssp. *palustris* is known to occur at 18 sites in Oregon, primarily the Coos Bay area, Yaquina Bay, and Netarts spit (Kaye 1991).

Figure 1. The two color variants of *Cordylanthus maritimus* ssp. *palustris*.

The population of C. *maritimus* ssp. *palustris* at the Coos Bay North Spit has relatively recently been protected from Off Highway Vehicle (OHV) use which had caused significant damage to the population. The population at the Coos Bay North Spit is one of the only protected populations of C. *maritimus* ssp. *palustris*. The population increased substantially following protection; however, in recent years, it appears to be declining (Jennie Sperling, Eugene BLM, *personal communication*). It has been hypothesized that in the absence of disturbance, the density of other salt marsh plants, particularly *Salicornia depressa* (pickleweed) and *Limonium californicum* (western marsh-rosemary) has increased, and may be inhibiting recruitment, growth, and/or reproduction of C. *maritimus* ssp. *palustris*. Changes in the plant community and industrial use of the surrounding bay may have also altered hydrology and sand accretion rates, thus changing site microtopography.

There are two primary objectives of this project.

1. Through a combination of annual mapping and monitoring of the population, we will track changes in population size and location through time.
2. We will test the effect interspecific competition on recruitment by experimentally removing neighboring species in a subset of the plots.

SPECIES BACKGROUND

Background information is repeated from Kaye 1991. Additional information can be found in Brian 2002.

Range

Cordylanthus maritimus ssp. *palustris* occurs along the Pacific Coast of North America from Morro Bay, San Luis Obispo County, California, north to Netarts Spit, Tillamook County, Oregon. In Oregon, the majority of the populations are located in the Coos Bay area.

Habitat

Cordylanthus maritimus ssp. *palustris* is a salt marsh species. It occurs in low-sand salt marshes dominated by *Salicornia depressa*, *Distichlis spicata*, and *Jaumea carnosa*. Elevations are typically at, or just above, sea level. The Pacific Ocean exerts a strong marine influence over the climate of coastal wetlands, moderating environmental extremes. The annual precipitation along the Oregon coast averages about 180 cm, with an average January minimum temperature of 2-5°C, and an average July maximum of 20°C (Franklin and Dyrness 1973).

Description

Cordylanthus maritimus ssp. *palustris* grows to 10 to 31 cm in height. Flowers are less than 3.5 cm in length, usually pinkish to purple, though some yellowish-white color variation may be seen. Floral bracts are oblong with a pair of short teeth at the tip. Foliage is grayish green and often villous (Eastman 1990).

Reproductive Biology

Cordylanthus maritimus ssp. *palustris* is an annual, reproducing from seed each year. It blooms from June through September (or October) and forms fruits from August through November. Seedlings have been observed in February at Yaquina Bay (Kaye, pers. obs.) and seeds may germinate throughout the winter and early spring. Laboratory studies of the non-marine species of *Cordylanthus* show that the seeds from low-elevation species germinate well at moderate temperatures (10°C) and not at high temperatures (27°C), and seeds of high-elevation species require a cold pre-treatment (-14 to -13°C) to germinate (Chuang and Heckard 1971). Seeds of C. *maritimus* ssp. *maritimus*, a different subspecies found in salt marshes in southern California, require fresh water and six weeks of cold storage for germination (Fink and Zedler 1990a, 1990b), and benefit from 1 or 2 years of after-ripening and scarification (Newman 1981). The flower and attendant bracts of C. *maritimus* ssp. *palustris* form showy inflorescences similar to Indian paintbrush (*Castilleja*, a related genus), but no insects have been observed visiting this subspecies

to date (Kaye et al. 1990). It is possible that C. *maritimus* ssp. *palustris* flowers are pollinated by a nocturnal visitor that was not observed, but we suspect that the flowers are self-pollinating. Fruit-set and seed-set were fairly high on most individuals from which seeds were collected in 1990, a trait typical of self-pollinating, annual plants (Weins 1984). In contrast, solitary bees that nest in nearby upland habitats are required for pollination of C. *maritimus* ssp. *maritimus*, and where pollinators are lacking, seed production is reduced (Lincoln 1985).

Population Biology

The *Cordylanthus maritimus* ssp. *palustris* colony size in Oregon is about 2000 plants (range: 30 to ~900,000) (Kaye et al. 1990). At several sites in the Coos Bay area, C. *maritimus* ssp. *palustris* grows in dense patches and as dispersed individuals. This demographic pattern may relate to seed dispersal by water and to suitability of microsites for seedling establishment. If "safe-sites" are patchily distributed, then we would expect ssp. *palustris* individuals also to be distributed in patches. Alternatively, if seeds are dispersed by water, they may either spread over a wide area or accumulate in areas where suspended particles settle from the water. Each of these mechanisms may operate to some degree. Work with C. *maritimus* ssp. *maritimus* indicates a heterogeneous microtopography causes seed entrapment and population establishment (Fink and Zedler 1990a).

Host Plants

All species of *Cordylanthus* are hemi-parasites, i.e., they derive some of their resources directly through photosynthesis and also from other plants through underground root connections (Chuang and Heckard 1971). Some species of *Cordylanthus* are facultative hemi-parasites in that they are capable of completing their life-cycle without a host under the favorable conditions of a greenhouse, but the plants are almost certainly parasitic in the wild (Chuang and Heckard 1971). The natural hosts for C. *maritimus* ssp. *palustris* are probably *Salicornia depressa*, *Distichlis spicata*, *Limonium californicum*, *Deschampsia caespitosa*, and *Jaumea carnosa* (Chuang and Heckard 1971). Evidently, C. *maritimus* ssp. *palustris* lack host specificity. Instead, the species may have strong habitat preferences that maintain the associations with its standard hosts (Chuang and Heckard 1971). Vanderwier and Newman (1984) have shown that haustoria of C. *maritimus* ssp. *maritimus*, from southern California, are capable of inter- and even intra-specific parasitism in the field and the laboratory. It is not known how soon after germination a seedling in the field will establish a root-connection with a host.

Taxonomy

Cordylanthus maritimus ssp. *palustris* is a member of the subgenus *Hemistegia*. Chuang and Heckard (1973) used seed coat morphology to identify relationships within the genus. They revised this species in 1973, recognizing the Oregon coastal plants as the more northern subspecies *palustris*, and retaining subspecies *maritimus* for the southern California and Baja California plants. The latter subspecies is also a candidate for listing by the USFWS.

METHODS

This project was initiated in the C. *maritimus* ssp. *palustris* population on the Coos Bay North Spit Area of Critical Environmental Concern (T25S, R13W, Section 19, NNW) in Coos County, Oregon (managed by the Coos Bay District of the Bureau of Land Management) in summer 2010 (Table 1). In July 2010, we surveyed the population and delineated the population boundaries using GPS. This information was used to design the sampling and experimental protocols that were initiated in August 2010 and repeated in August 2011. In August 2011 the western portion of the population (beyond the protective barrier) was surveyed for appropriate plot locations. In 2012, four additional transects were established in the unprotected area, and one in the unprotected area so that comparisons can be made between the protected and unprotected portions of the population.

Table 1. Schedule of activities for habitat monitoring and improvement for *Cordylanthus maritimus* ssp. *palustris* in 2010-2014

Time period	Activity
July 2010	Delineate extent of population (GPS) Design sampling protocol
August 2010	Establish long-term monitoring transects and experimental plots Take plot measurements, including cover of all species and C. *m.* ssp. *palustris* size and reproductive status Remove competitors in a subsample of plots Take photopoints
Winter 2010-2011	Enter and analyze data, write annual progress report.
January 31, 2010	Submit draft report (final report due September 1, 2011)
August 2011	Evaluate extent of population (GPS), including sub-population west of blockades. Take plot measurements, including cover of all species and C. *m.* ssp. *palustris* size and reproductive status Take photopoints
Winter 2011-2012	Enter and analyze data, write annual progress report.
March 31, 2012	Submit progress report.
August 2012	Delineate extent of population (GPS) Establish transects in sub-population west of blockade. Take plot measurements, including cover of all species and C. *m.* ssp. *palustris* size and reproductive status Take photopoints
Winter 2012-2013	Enter and analyze data, write annual progress report.
March 31, 2013	Submit draft progress report
August 2013	Delineate extent of population (GPS)
	Take plot measurements, including cover of all species and C. *m.* ssp. *palustris* size and reproductive status in protected and unprotected areas
	Take photopoints
Winter 2013-2014	Enter and analyze data, write annual progress report.
Winter/Spring 2014	Submit final report

Five permanent monitoring transects were set up in early August 2010 and an additional 4 transects were set up in August 2011. Five additional transects were added in August of 2012. Transects were marked at each end with a nail and piece of rebar. In the unprotected area the head of the transect is marked with rebar placed on the interior side of the road to prevent damage to vehicles using the area. We used a modified random method to select transect starting points. Points on the upland edge of the population were randomly selected; from these we selected five points in 2010 and an additional four in 2011 that would ensure sampling throughout the population. Community composition data was recorded for all transects in 2010-2013; C. *maritimus* ssp. *palustris* sampling occurred on four in 2010 and all transects in 2011-2013. Transects were oriented perpendicular to the habitat margin, and extended 20m. Percent cover for all species was recorded in $1m^2$ increments along the right side of the transect, when viewed from the transect's origin. The number of branches and flowers for each C*ordylanthus maritimus* ssp. *palustris* individual was recorded within each plot. Photopoints were taken looking along each transect, from both the beginning and end (Appendix A). In 2010, information from the sample-plots was used to estimate the total population size by multiplying the average number of plants m^{-2} ($\bar{0}$) by the total habitat area (N = 2294 m^2):

$$\textbf{\textit{population size estimate}} = \bar{0} * N$$

In 2011 the sampling method was modified to increase sampling efficiency. A habitat class was assigned to each 1 m^2 plot (Table 2). All C. *maritimus* ssp. *palustris* were counted in plots where more than one habitat type was present. In homogenous plots, C. *maritimus* ssp. *palustris* was monitored in a 25cm x 25 cm subplot that was randomly placed within the $1m^2$ plot. To estimate total population size, the average number of plants per m^2 in each habitat type was determined and multiplied by the area covered by each habitat type.

In 2010, we selected nine plots for evaluation of the effects of competition. In order to minimize damage to C. *maritimus* ssp. *palustris*, plots were selected if they had relatively low cover of this species (5-35%). We removed neighboring plant species, generally *S. virginica*, *J. carnosa*, *Puccinellia pumila*, and *Triglochin maritima* until total vegetation cover was 70%. This cover level was selected as previous research has indicated that this is the minimum vegetation cover with which C. *maritimus* ssp. *palustris* is associated (Kaye 1992). Neighboring species were carefully handpulled, avoiding C. *maritimus* ssp. *palustris* individuals. Photos were taken of each plot before and after treatment (Appendix B. Vegetation removal Photopoints). Cover of all plant species and abundance, size, and reproduction of C. *maritimus* spp. *palustris* were assessed in all or a subset of treated plots in 2010-2013.

In addition to monitoring transects, the area occupied by the C. *maritimus* spp. *palustris* population was mapped by habitat class. Habitat classes were defined as described in Table 2. Boundaries between habitat classes were delineated using an Oregon GPS 450 handheld unit. Data was compiled using MapWindow, an open source GIS software to delineate boundaries between habitat types. In 2012 and 2013, the unprotected area was also mapped using the same habitat class delineations used in the protected area.

Table 2. Habitat codes used for mapping in 2011-2013. Heavily disturbed areas (with rutted tire tracks) were also noted in the unprotected area.

Code	Habitat	Description
CF	*Cordylanthus* flat	*Cordylanthus* cover ≥ 50%
LCF	*Limonium*-*Cordylanthus* flat	*Limonium, Cordylanthus* codominant
LF	*Limonium* flat	*Limonium* cover ≥ 50%
GT	Grass transition	Differentiated by presence of *Ammophila* or *Leymus,* marks transition into small stabilized dune habitat. Some *Cordylanthus* present but only in trace amounts. This is the absolute upper boundary of COMAPA habitat.
SD	*Salicornia* depression	*Salicornia* dominant species; area of higher water during the tide. Differs from waterway by abundant *Salicornia*, and little to no bare sand.
SDD	*Salicornia-Distichlis* depression	*Salicornia* dominant, but *Distichlis* cover ≥ 25%
Sand	*Sand*	Highest reach of the tide, but water does not linger here for long. At least some COMAPA in trace amounts.
Waterway	Waterway	Other plants may be here, but not appropriate habitat for COMAPA. Various courses throughout entire area, usually adjacent to SD, SDD.
D-Rise	*Distichlis* rise	Small hill, *Distichlis* dominated, with minor patches of *Jaumea carnosa* nearest to the ocean.
Marsh	Marshy area	Marshy area dominated by *Scirpus sp.*, area inundated by tides.

Figure 2. Area surveyed for *Cordylanthus maritima* ssp. *palustris*. Blue lines indicate monitoring transects established in 2010-2013.

Community Analysis

We used a common ordination method, non-metric multidimensional scaling (NMS) ordinations (Kruskal 1964), to assess relationships of individual species cover relative to primary gradients in the plant community (ordination axes). NMS is an ordination method that is best used for community analyses, often with non-normal data with non-linear relationships (McCune and Grace 2002). Due to heterogeneity in the data set, rare species that occurred in 5% or less of the plots were deleted and species cover data was log(x+1) transformed to reduce skewness. We assessed species data relative to an environmental matrix with cover data of bare ground, litter, and algae. NMS ordinations were performed using PC-ORD version 6.0 (McCune and Mefford 2011) with the autopilot setting "slow and thorough" mode, Sørensen distance measure, and no penalty for ties. We ordinated data from 2013 only to look at trends related to the plant community in protected and unprotected areas. In addition, we conducted an ordination on data from all four years in the protected area.

Differences in plant community between protected and unprotected areas (in 2012 and 2013) were tested with multi-response permutation procedure (MRPP; Mielke and Berry 2001) using the Sørensen distance measure, in PC-ORD. Due to differences found using MRPP, we conducted an Indicator Species Analysis to investigate if species were associated with the protected or unprotected area. Indicator Species Analysis combines relative abundance and relative frequency of a species in defined groups, and produces indicator values (IVs), which are the percentage of perfect indication for a species within a particular group (McCune and Grace 2002). Statistical significance of indicator values (*p*-value) is evaluated using a Monte Carlo method of randomizations; 1000 randomizations were run to determine the proportion of random trials that gave indicators equal to or greater than the observed.

RESULTS

Population Survey

The edges of the C. *maritimus* ssp. *palustris* population at the North Spit were defined by *Pinus contorta*/*Cytisus scoparius* scrub transitioning to *Ammophila arenaria*/sand with scattered *Leymus mollis*. This drops off into an area more regularly impacted by tides/waves. *Cordylanthus maritimus* ssp. *palustris* distribution is patchy, from clumps of plants scattered in dense stands of *S. virginica*, to large swathes interspersed with *L. californicum*. *L. californicum* is nearly absent in the disturbed area. Both color morphs (green and purple) of C. *maritimus* ssp. *palustris* were evenly represented throughout the population.

Variation in density and size of C. *maritimus* ssp. *palustris* may be due to a combination of plant community and abiotic factors (**Table 4**-**Table 6**). For example, the central portion of the protected population tended to have higher cover of *S. virginica* and lower cover of *J. carnosa*. Microtopographic variations also effect the levels of inundation experienced on site; the establishment (and subsequent stabilization) of substrate has been noted particularly in the protected area, where *L. californicum* cover has increased –most likely due to decreases in disturbance to this perennial species. Very little *L. californicum* is present in the disturbed portion of the C. *maritimus* ssp. *palustris* population.

We estimated that in 2010, the total number of C. *maritimus* ssp. *palustris* in the protected area at the North Spit was 380,991 plants. In 2011 and 2012 the population size in the protected area was estimated by calculating the average number of plants per m^2 in all habitat classifications and then multiplying by the area of each habitat class (Table 3). This method was selected because the habitat for C*ordylanthus maritimus* ssp. *palustris* is so patchy that the best way to estimate the population size was to evaluate the average number of plants in each habitat type and then scale up based on the areal cover for each habitat type. The population estimate for 2011 is 916,079 plants in the surveyed area. The increase from 2010 is likely due to improved monitoring in 2011 as well as normal annual fluctuations. In 2012 the estimated population size decreased to 133,770 plants in the protected area, with an estimated 545,000 in the unprotected area (2012 was the first year that transects were monitored in the unprotected area.)

The precipitous drop of C. *maritimus* ssp. *palustris* in 2012 in the protected area coincides with significant decreases in the cover of C. *maritimus* spp. *palustris* dominated habitat classes (CF and less so LCF) and significant increases in the cover of *Limonium* dominated habitat types (LF). The protected area in 2013 is estimated to support a population of approximately 214,238 C. *maritimus* ssp. *palustris*. The unprotected area is estimated to host an additional 296,422 of the annual hemi-parasite. Continued monitoring of the transects combined with habitat surveys is recommended to elucidate the population trends for both listed species in the protected and unprotected portions of the site.

Table 3. Areal cover, average number of Cordylanthus/m² in the protected area 2011-2013 and unprotected area 2012-2013 for each of the mapped habitat units. The unprotected area was not mapped in 2011.

		Area (m^2)			Comapa/m^2			Population Estimate		
	Habitat Code	**2011**	**2012**	**2013**	**2011**	**2012**	**2013**	**2011**	**2012**	**2013**
PROTECTED AREA	**CF**	293	3	7	978	256	256	286554	768	1675
	D	973	-	103	0	0	0			
	DRise	393	353	271	0	0	0			
	GT	928	930	435	0	0	0			
	LCF	1468	337	693	425	254	254	623900	85598	175995
	LF	498	1398	1386	12	15.5	15	5976	21674	20291
	Marsh	214	353	178	0	0.0	0			
	Sand	110	72	33	0	0.0	0			
	SD	1011	1662	2379	0	1.8	2		2955	4229
	SDD	747	1492	1339	0	9.0	9.0		13428	12047
	Waterway	645	681	626	0	0.0	0			
	Population Estimate							**916430**	**124423**	**214238**

		Area (m^2)			Comapa/m^2			Population Estimate		
	Habitat Code	2011	2012	2013	2011	2012	2013	2011	2012	2013
UNPROTECTED AREA	**CF**		1268	973		331	181		419285	176354
	D		-	-		0	0			
	DRise		-	1268		0	0			0
	GT		-	-		0	0			
	LCF		-	-		245	0			
	LF		-	-		0	0			
	Marsh		66	36		0	0			0
	Sand		-	-		0	0			
	SD		-	-		19.1	0			
	SDD		20310	19297		6.2	6.2		126373	120069
	Waterway	N/A	132	92	N/A	0	0	N/A		0
	Population Estimate								**545659**	**296422**

Table 4. **Number of *Cordylanthes maritimus* ssp. *palustris* plants per m² by transect.**

		Plants m^{-2}			
Transect #	Tag #	2010	2011	2012	2013
0	750	174	285	128	160
2	516	-	279	48	30
4	751	80	93	0	7
7	752	85	61	0	4
11	753	349	688	32	65
13	514	-	85	976	179
15	754	-	216	1920	195
16	515	-	309	1104	183
17	517	-	16	0	2
18		-	-	1280	177
20		-	-	1168	225
21		-	-	0	1
22		-	-	592	49
23		-	-	2928	40
Average		**172**	**226**	**727**	**91**

Table 5. **Average number of branches per plant.**

		Branches $plant^{-1}$			
Transect #	Tag #	2010	2011	2012	2013
0	750	3.0	2.4	2.1	4.4
2	516	--	4.4	1.0	5.0
4	751	3.5	6.3	N/A	5.0
7	752	2.2	5.5	N/A	4.1
11	753	2.1	1.8	2.5	3.7
13	514	--	3.7	1.4	3.2
15	754	--	1.7	1.2	1.9
16	515	--	2.5	1.5	2.5
17	517	--	3.1	N/A	7.7
18		--	--	1.8	3.1
20		--	--	1.3	1.9
21		--	--	N/A	9.5
22		--	--	3.2	2.8
23		--	--	1.3	3.4
Average		**2.7**	**3.5**	**1.7**	**2.9**

Table 6. **Average number of flowers per plant.**

		Flowers plant^{-1}			
Transect #	Tag #	2010	2011	2012	2013
0	750	5.3	4.8	28.8	7.4
2	516	--	2.1	9.7	9.4
4	751	6.4	13.6	N/A	31.6
7	752	5.6	12.3	N/A	15
11	753	6.5	4.2	13.5	7.2
13	514	--	12.5	11.9	12.8
15	754	--	5.2	11.7	4.8
16	515	--	5.2	17.1	2.8
17	517	--	12.5	N/A	14.3
18		--	--	17.2	12.0
20		--	--	12.3	5.1
21		--	--	N/A	8.5
22		--	--	20.8	7.3
23		--	--	8.4	8.8
Average		**6.0**	**8.0**	**15.1**	**7.7**

Community Analysis

The NMS ordination of sample units in species space (Figure 3) in the protected habitat (2010-2013) resulted in a 3-dimensional stable solution (final stress = 11.6, final instability = 0.000). A randomization test confirmed that final stress was lower than expected by chance ($p = 0.05$). Sample units from 2010, 2011, 2012, and 2013 tended to be intermixed in species space. *Cordylanthus maritimus* ssp. *palustris* (COMAPA) was strongly negatively correlated with Axis 1 (r = -0.47), along with natives *L. californicum* (LICA; r = -0.87), *Plantago maritima* (PLMA; r = -0.52), and *J. carnosa* (JACA; r = -0.47), while *S. depressa* (SADE) had a strong positive correlation with the Axis (r = -0.85). *Distichlis spicata* was also positively associated with axis 1 (DISP; r = 0.22). Litter was negatively associated with Axis 2 (r = -0.44), along with *D. spicata* (r = -0.61) and C. *pacifica* (CUPA; r = -0.36). Ordination scores were similar to those in 2012, suggesting that these species associations remain over time but can shift slightly. From 2010 to 2013, sample units have shifted downward along Axis 2, which was most associated with *D. spicata* (r = -0.61), C. *album* (r = -0.35), and litter. This suggests that these communities could be slowly moving toward species associations that are not necessarily supportive of C. *maritimus* ssp. *palustris.* In 2013, C. *maritimus* ssp. *palustris* was associated with species such as *L. californicum* and *J. carnosa* which are known as potential host plants for the hemi-parasite. These trends are similar to those observed in previous years. Of interest, we found several C. *maritimus* ssp. *palustris* parasitized by the holoparasite, C. *pacifica*. However, C. *pacifica* was more abundant on *S. depressa* and *S. macrotheca*, which were separated in species space.

Protected and unprotected habitats differed significantly in community composition in 2013 (MRPP; A = 0.09, $P < 0.0000$). Species richness was greater in protected habitat than in unprotected habitat (19 and 11, respectively). Many species were identified as indicators of either the protected or unprotected habitats (Table 7). *Cordylanthus maritimus* ssp. *palustris* was an indicator of the protected area ($p = 0.01$), whereas in 2012 it was not an indicator of either area. Indicators of the protected area also included C. *pacifica, C. album, F. rubra, J. carnosa, L. californicum, S. macrotheca,* and *T. maritima.* Indicator species of the unprotected habitat were *D. spicata* and *S. depressa*. *Cordylanthus maritimus* ssp. *palustris* occurred in both habitats it had higher average cover in the protected area than in the unprotected (6.2% and 4.2%, respectively). *Limonium californicum* occurred in both habitats but was much more prevalent in the protected area than in the unprotected area (22.8% and 0.9%, respectively). This very large difference in cover suggests that *L. californicum* does not tolerate disturbance as well as C. *maritimus* ssp. *palustris* does. These results were consistent with the percentage of transects composed or specific habitat classes; protected habitats had much greater composition of *Limonium* flat than unprotected in 2012 (Figure 4). Likewise, transects in the unprotected habitat had greater percentages of *Salicornia* depression, or *Salicornia-Distichlis* depression than in protected habitats (Figure 4). *Cordylanthus* flat was present in both protected and unprotected habitats, occupying slightly greater percentage of transects in the unprotected habitat than in the protected habitat. While C. *maritimus* ssp. *palustris* was present in both habitats, the dominance of *Salicornia* and *Distichlis* based plant communities suggests that the species will never thrive under these conditions.

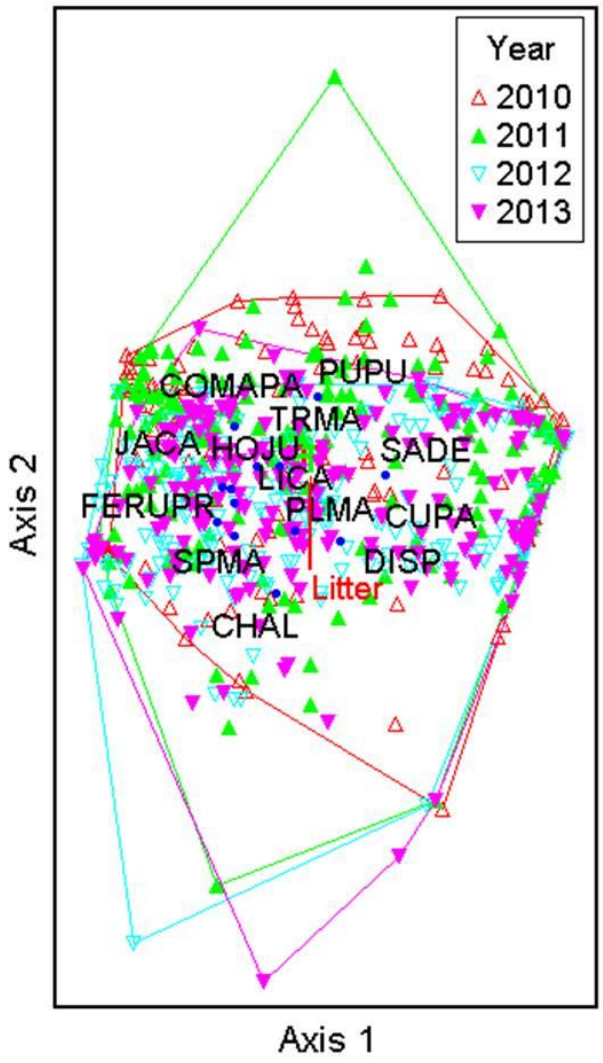


Figure 3. NMS ordination of community composition within the protected area of the *Cordylanthus maritimus* ssp. *palustris* population at the Coos Bay North Spit (2010, 2011, 2012, 2013). Triangles represent sample units (quadrats along transects) in species space, and distance between points indicates similarity of community composition by quadrat. Polygons outline the extent of all of the sample units in species space. Blue dots indicate the centroid for species locations in species space. Blue dots and species abbreviations (in black, Table 7) indicate their locations in species space. Environmental variables with notable relationships with the ordination axes ($r^2 > 0.1$) are indicated by vector lines (red), with the length of the line representing the strength of the correlation with parallel axes. Variance explained by Axis 1 was 50%, while Axis 2 explained 22% of the variance.

Table 7. Species list including nativity from plots within the *Cordylanthus maritimus* ssp. *palustris* population at the Coos Bay North Spit in 2013. Species codes are from the USDA PLANTS database (USDA NRCS 2012). Species included in the indicator species analysis noted Indicator Species column, 'Habitat' refers to the area they indicate and '*P* value' is associated with the indicator value for that species. * indicates species that occurred in less than 5% of the sample units and were not included in the Indicator Species Analysis.

Species	Code	Nativity	Indicator species?	Habitat	*P* value
Ammophila arenaria	AMAR	Exotic	*		
Cerastium glomeratum	CEGL	Exotic	*		
Chenopodium album	CHAL	Exotic	Y	Protected	0.002
Cordylanthus maritimus ssp. *palustris*	COMAPA	Native	Y	Protected	0.01
Cuscuta pacifica	CUPA	Native	Y	Protected	0.0002
Distichlis spicata	DISP	Native	Y	Unprotected	0.0006
Grindelia stricta	GRST	Native	*		
Holcus lanatus	HOLA	Exotic	*		
Hordeum jubatum	HOJU	Native	Y	Protected	0.0002
Jaumea carnosa	JACA	Native	Y	Protected	0.0002
Juncus sp.	Juncus	Native	*		
Leymus mollis	LEMO	Native	*		
Limonium californicum	LICA	Native	Y	Protected	0.0002
Plantago maritima	PLMA	Native	Y	Protected	0.002
Puccinellia pumila	PUPU	Native	*		
Rumex acetosella	RUAC	Exotic	*		
Salicornia depressa	SADE	Native	Y	Unprotected	0.0002
Spergularia macrotheca	SPMA	Native	Y	Protected	0.0006
Triglochin maritima	TRMA	Native	Y	Protected	0.05

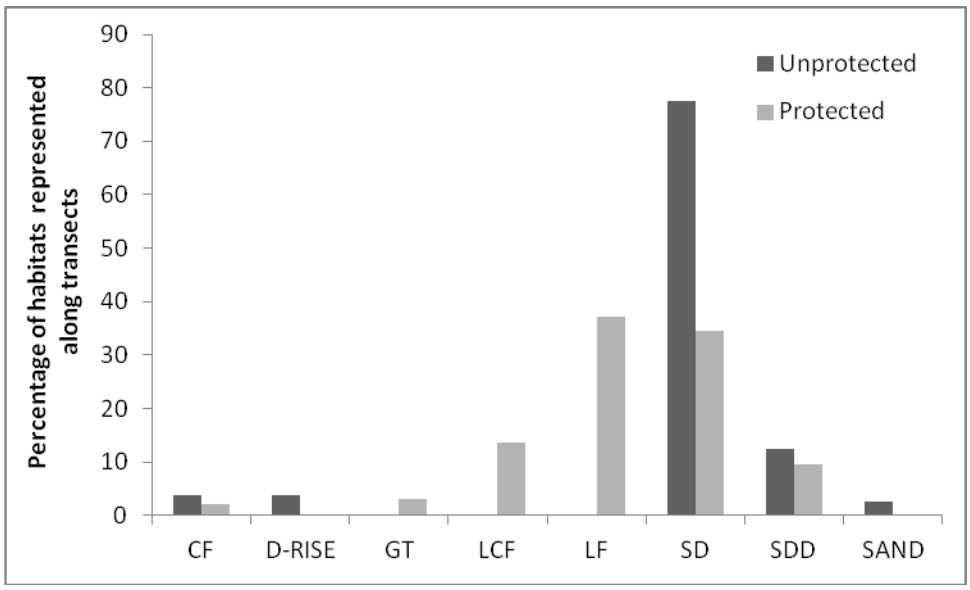


Figure 4. Percent of habitat classes represented along transects in both protected and unprotected habitats (2013). Habitat classes correspond to Table 6.

Vegetation Removal

In 2011-2013, we compared the percent change in community composition and population size of C. *maritimus* ssp. *palustris* in treated plots to that of untreated plots to determine if vegetation removal had any effect on C. *maritimus* ssp. *palustris*. Removal of vegetation did not have a significant effect on the cover of C. *maritimus* ssp. *palustris*. There was a significant positive effect of vegetation removal on the cover of *Jaumea carnosa,* and *Limonium californicum*. Removal of vegetation had a slight negative effect on *Salicornia depressa* in the first year after vegetation removal, however this was not accompanied by increases in vegetation but rather increases in bareground. *Puccinellia pumila* and *Distichlis spicata* cover was lower in areas where vegetation removal had occurred, however the overall cover of these species is low. In the first year following treatment bare ground increased, however by 2012 vegetation had filled in and there was not a significant change in cover of bare ground. Decreases in C. *maritimus* ssp. *palustris* in 2012 and 2013 were consistent with decrease in cover of the species throughout the site.

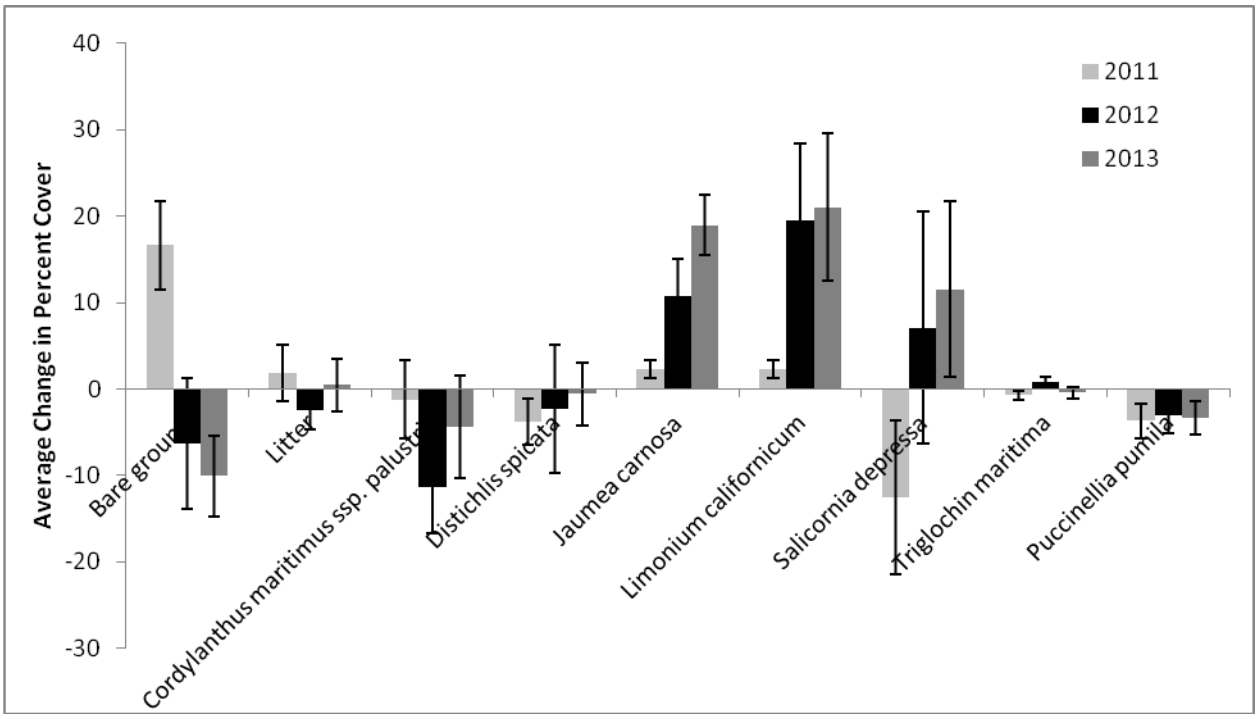


Figure 5. Average change in percent cover of select species in vegetation removal plots. Vegetation was removed so that total vegetative cover was approximately 70%. Plots were monitored in 2011-2013 to evaluate the effectiveness of vegetation removal. Species not shown above had a less than 1% change in cover from 2010 to 2011. Error bars represent ± 1 SE.

Habitat Mapping

In 2011-2013 a habitat map was created using the habitat classes listed in Table 2 (**Figure 6**). The map has been updated annually to detect shifts in habitat type that may affect the success of C. *maritimus* ssp. *palustris*. In 2011, of the ~7,000m^2 surveyed 293 m^2 were mapped as "C*ordylanthus* Flat" (CF) and 1,468 m^2 *Limonium*-C*ordylanthus* Flat (LCF). In 2012 there were significant changes in cover of all habitats associated with C. *maritimus* ssp. *palustris*; CF cover decreased to only 3m2, and the cover of LF increased significantly. From 2011-2012, there were also increases in both the "*Salicornia* Depressions" (SD) and "*Salicornia-Distichlis* Depressions" (SDD) cover. In 2013, this trend continued with a continued shift towards *Limonium* dominated plant communities with decreasing cover of C. *maritimus* ssp. *palustris*.

In 2012, the habitat in the southern, disturbed portion of the area was also mapped using the same habitat classifications. Because the southern area is so much larger than the protected area, (~22,000 m^2 compared to ~7,200 m^2), the habitat mapping in the unprotected area is at a much coarser resolution than that in the protected area. In the southern unprotected area the dominant habitat class is SDD with *Distichlis spicata* co-occurring with *Salicornia* in more than 90% of the habitat. "C*ordylanthus* Flats" were the next most common habitat type covering approximately 1,200 m^2 in 2012 and ~1,000m^2 in 2013. In addition to habitat classes, the boundaries of the disturbed area was marked in 2012 and 2013 and overlaid onto the habitat map (Figure 7).

The coarser resolution of mapping and relatively low number of transects in the unprotected area makes the population estimate less accurate than in the protected area, however in 2012 the population was estimated to contain ~545,000 plants and in 2013, this number decreased to 296,000. The cover of CF habitat remained relatively stable over this time, however the density of C. *maritimus* ssp. *palustris* in the CF habitat decreased from 978 /m^2 in 2011 to 256/m^2 in 2013 (**Table 4**).

CONCLUSIONS

There was significant variability in the number C*ordylanthus* from 2010-2013. Vegetation removal experiments did not elucidate any potential effects of competitors on C*ordylanthus* growth. As this species is a hemiparasite and known to be associated with higher cover of select species, it is not surprising that we did not find a positive effect of our vegetation treatment.

From 2011-2013 there were great changes in the cover of different habitat classes in the protected area particularly in the cover of habitat types associated with *Limonium californicum*. It is likely that this perennial plant is benefitting from the lack of disturbance in the protected area. Very little *L. californicum* was found in the unprotected area, and never enough to classify the habitat as "LCF" or "LF" at the scale mapped. Additionally it was noted that the C. *maritimus* ssp. *palustris* was commonly associated with the disturbed areas in the unprotected area (Figure 7). Continued habitat mapping and population surveys will elucidate general population trends of these two bureau sensitive species.

RECOMMENDATIONS

It is recommended that transects in both the protected and unprotected area continue to be monitored into the future. We also recommend that additional transects and data collection be added to monitor the Bureau Sensitive *Limonium californicum* in the area. The presence of C. *maritimus* ssp. *palustris* in the

disturbed portion of the unprotected area, and the increasing dominance of *L. californicum* in the protected area indicates that further work may be necessary to balance the needs of both species.

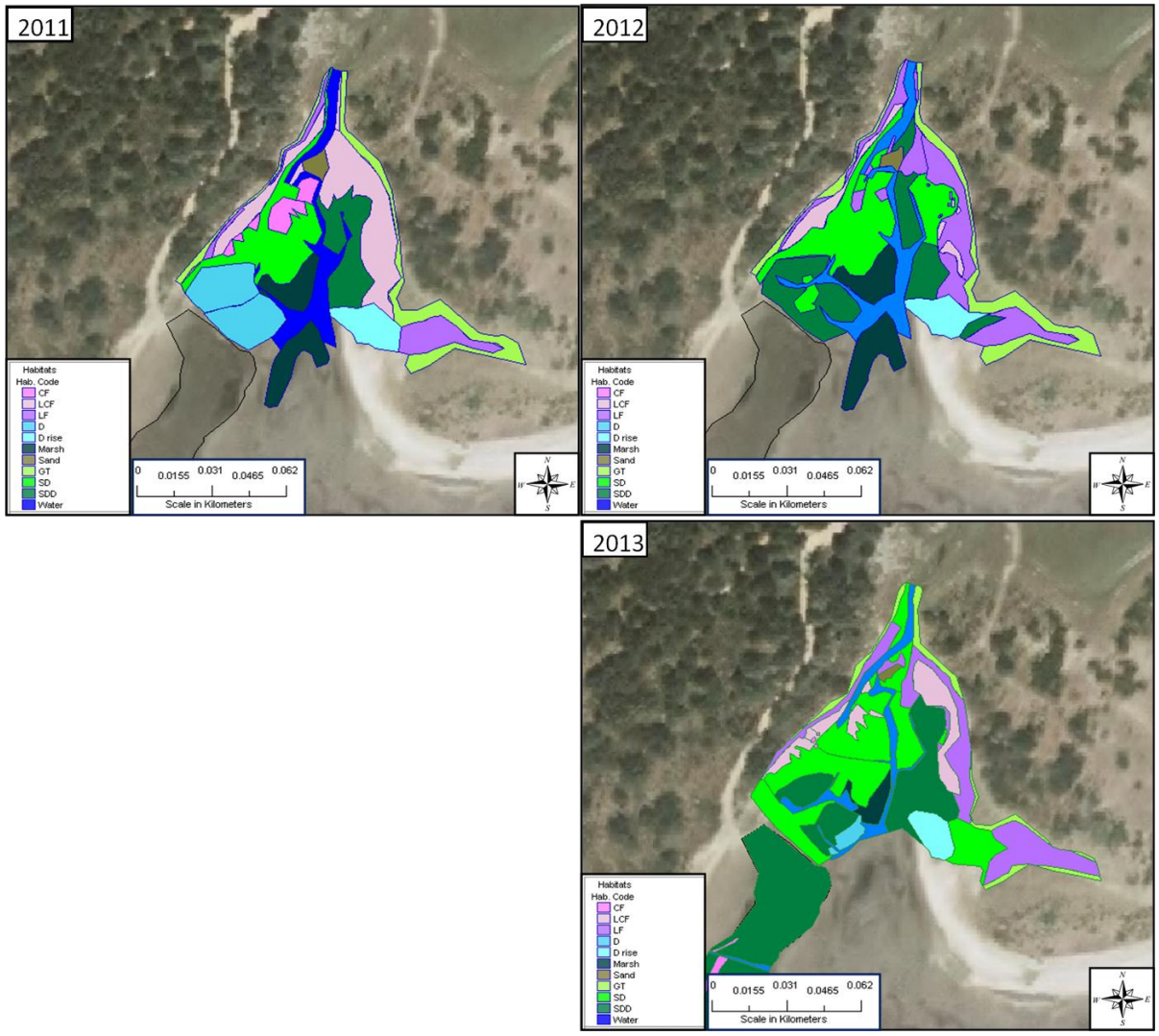


Figure 6. **Habitat map of the C. *maritumus* ssp. *palustris* population at the Coos Bay North Spit, created in 2011-2013. Habitat codes are listed in Table 2. Major changes from 2011-2013 include a significant decrease in the cover of both "*Cordylanthus* Flatl" (CF) and increases in the cover of "*Limonium Cordylanthus* Flat, (LCF) and "*Limonium* Flat" (LF).**

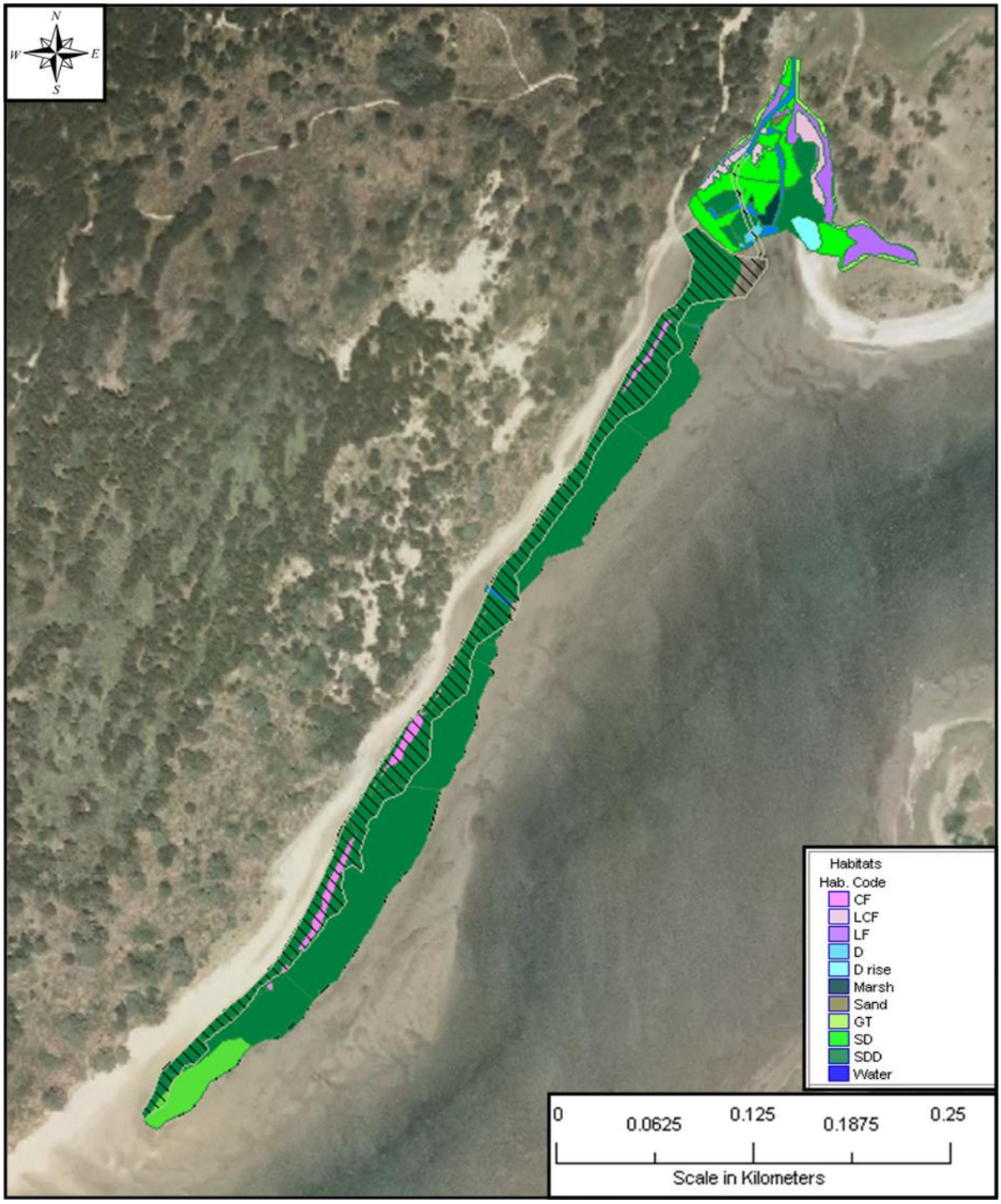


Figure 7. 2013 habitat maps for both the protected and unprotected areas. Cross hatched area represents the disturbed habitat. From 2012 to 2013 there was an increase in the portion of habitat that was disturbed in the unprotected area; additionally, at least one set of ATV tracks were noted in the "protected area". Very little *L. californicum* was present in the unprotected area in 2012 or 2013.

LITERATURE CITED

Chuang, T.I., and L.R. Heckard. 1971. Observation on root-parasitism in *Cordylanthus* (Scrophulariaceae). American Journal of Botany 58:218-228.

Chuang, T.I., and L.R. Heckard. 1971. Seed coat morphology in *Cordylanthus* (Scrophulariaceae). American Journal of Botany 59:258-265.

Chuang, T.I., and L.R. Heckard. 1973. Taxonomy of *Cordylanthus* subgenus *Hemistegia* (Scrophulariaceae). Brittonia 25:135-158.

Brian, N. Status Report: *Cordylanthus maritimus* Bentham spp. *palustris* (Behr) Chuang & Heckard (Point Reyes bird's beak). Umpqua Field Office, Coos Bay District Office, Bureau of Land Management.

Eastman, D.C. 1990. Rare and endangered plants of Oregon. Beautiful America Publishing Company, Wilsonville, Oregon. p. 53.

Franklin, J.f., and D.T. Dyrness. 1973. Natural vegetation of Oregon and Washington. USDA Forest Service General Technical Report PNW-8. U.S. Forest Service, Portland, Oregon. 417 pp.

Fink, B., and J. Zedler. 1990a. Maximizing growth of *Cordylanthus maritimus* spp. *maritimus*, an endangered salt marsh plant. Final report for the California Department of Transportation. Interagency Agreement #11B351.26.

Fink, B., and J. Zedler. 1990b. Endangered plant recovery: experimental approaches with *Cordylanthus maritimus* spp. *maritimus*. Proceedings of the Society for Ecological Restoration and Management. 460-468.

Kaye, T. 1991. Population monitoring and habitat analysis for salt marsh bird's beak, *Cordylanthus maritimus* ssp. *palustris*. Cooperative Challenge Cost Share Project jointly funded by BLM and Oregon Department of Agriculture. Unpub. report on file at ODA.

Kaye, T., B. Meinke, S. Massey, and R. Frenkel. 1991. *Cordylanthus maritimus* ssp. *palustris* inventory and habitat analysis. Cooperative Challenge Cost Share Project jointly funded by BLM and Oregon Department of Agriculture, 90-2. Unpub. report on file at ODA.

Kaye, T. 1992. Population monitoring and habitat analysis for salt marsh bird's beak, *Cordylanthus maritimus* ssp. *palustris*. Second year summary. Cooperative Challenge Cost Share Project jointly funded by BLM and Oregon Department of Agriculture. Unpub. report on file at ODA.

Kruskal, J. B. 1964. Nonmetric multidimensional scaling: a numerical method. Psychometrika 29: 115-129.

Lincoln, P.G. 1985. Pollinator effectiveness and ecology of seed set in *Cordylanthus maritimus* ssp. *maritimus* at Point Mugu, California. Final report to U.S. Fish and Wildlife Service, Sacramento, California. No. 10181-9750.

McCune, B. and J. B. Grace. 2002. Analysis of Ecological Communities, 2nd Printing. Gleneden Beach, Oregon, U.S.A.: MjM Software Design. 300 p.

McCune, B. and M. J. Mefford. 2011. PC-ORD. Mulitvariate Analysis of Ecological Data. Version 6.0. MJM Software, Gleneden Beach, Oregon, U.S.A.

Mielke, P. W., Jr. and K. J. Berry. 2001. Permutation Methods: a Distance Function Approach. Springer Series in Statistics. Springer Science + Business Media, New York.

Newman, J. 1981. Aspects of *Cordylanthus maritimus* spp. *maritimus* germination tests examined. Notes on studies performed at Pacific Missile Test Center, Naval Air Station, Poin Mugu, California.

USDA NRCS. 2012. The PLANTS Database (http://plants.usda.gov, 22 March 2012). National Plant Data Team, Greensboro, NC 27401-4901 USA.

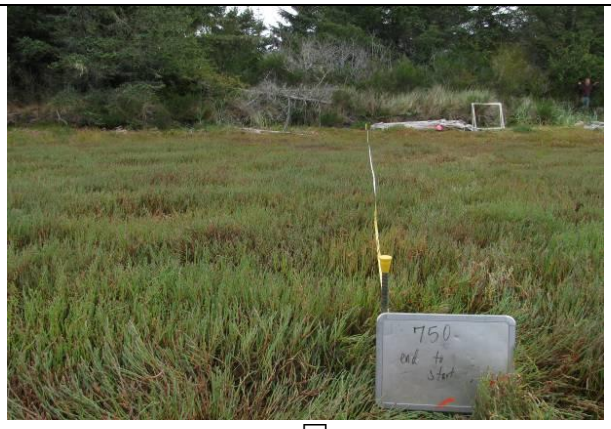
Weins, D. 1984. Ovule survivorship, brood size, life history, breeding systems, and reproductive fitness in plants. Oecologia 64:47-53.

APPENDIX A. SAMPLING TRANSECT PHOTOPOINTS

2010-2013

Photopoints taken from the start (0m, upland edge) and end (20m, population interior) of *Cordylanthus maritimus* ssp. *palustris* sampling transects in August 2010-2013.

Transect 0, Tag #750

☐ **0m-20m**	☐ **20m-0m**
☐ **2010**	
 ☐	 ☐
☐ **2011**	
☐ 	☐ 
☐ ☐	

2012


COMAPA 2012
TRANSECT 0
0-20 m


COMAPA 2012
TRANSECT 0
20-0 m

2013

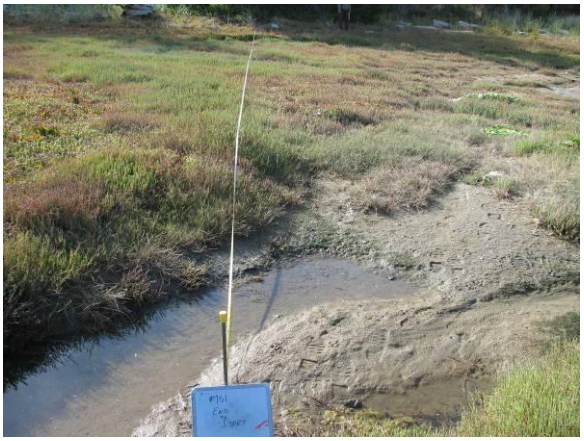

ComaPa
2013
Transect 0
0 - 20m


ComaPa
2013
Transect 0
20-0 m

Transect 2, Tag #516 (501)

☐ 0m-20m	☐ 20m-0m
☐ 2011	
☐ 	☐ 
☐ 2012	
☐ 	☐ 
☐ 2013	
☐ 	☐ 

Transect 4, Tag #751

☐ 0m-20m	☐ 20m-0m
☐ 2010	
 ☐	 ☐
☐ 2011	
☐ 	☐ 
☐ ☐ ☐ ☐ ☐ ☐	

☐ **2012**


COMAPA 2012
TRANSECT 4
0-20 m


COMAPA 201
TRANSECT
20-0 m

☐ **2013**


Comapa
2013
Transect 4


Comapa
2013
Transect 4

Transect 7, Tag #752

☐ 0m-20m	☐ 20m-0m
☐ 2011	
☐ 	☐ 
☐ 2012	
☐ 	☐ 
☐ 2013	
☐ 	☐ 

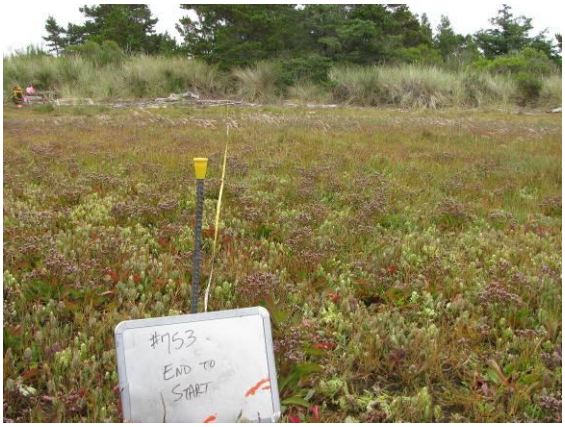
Transect 11, Tag #753

☐ 0m-20m

☐ 20m-0m

☐ 2010

☐



☐

☐ 2011

☐

☐

☐

☐

☐

☐

☐

☐

☐ **2012**


COMAPA 12
TRANSECT 11
0-20m


COMAPA 12
TRANSECT 11
20-0m

☐ **2013**

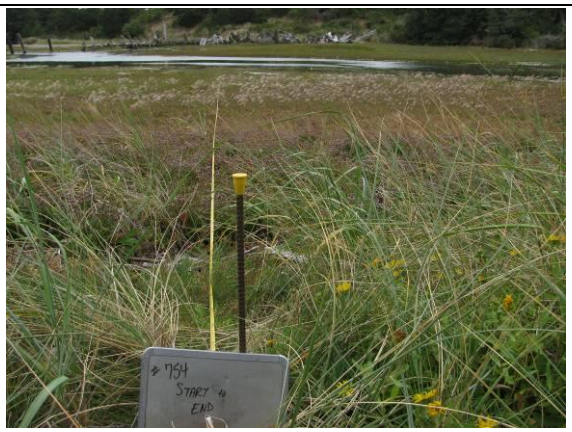
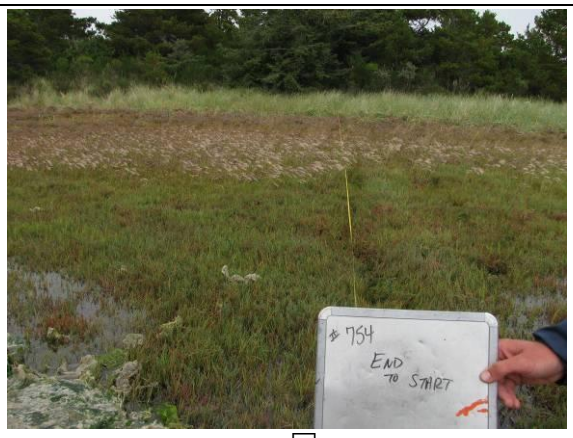

Comap 12
2013
Transect 11


Comap 12
2013
Transect 11

Transect 13, Tag #514

☐ 0m-20m	☐ 20m-0m
☐ 2011	
☐ 	☐ 
☐ 2012	
☐ 	☐ 
☐ 2013	
☐ 	☐ 

Transect 15, Tag #754

☐ 0m-20m	☐ 20m-0m
☐ 2010	
 ☐	 ☐
☐ 2011	
☐ 	☐ 
☐ ☐ ☐ ☐ ☐ ☐	

☐

☐ **2012**


COMAPA 12
TRANSECT, 15
0-20m


COMAPA 12
TRANSECT, 15
20-0 m

☐ **2013**


COMAPA 2013
Transect 15
Tag # 252
0-20m


COMAPA 2013
Transect 15
Tag # 252
20-0m

Transect 16, Tag #515

☐ 0m-20m	☐ 20m-0m
☐ 2011	
☐ 	☐ 
☐ 2012	
☐ 	☐ 
☐ 2013	
☐ 	☐ 

Transect 17, Tag #517

☐ 0m-20m	☐ 20m-0m
☐ 2011	
☐ 	☐ 
☐ 2012	
☐ 	☐ 
☐ 2013	
☐ 	☐ 

Transect 18, Tag #502

☐ 0m-20m	☐ 20m-0m
☐ 2012	
☐ 	☐ 
☐ 2013	
☐ 	☐ 

Transect 20, Tag #503

☐ 0m-20m	☐ 20m-0m
☐ 2012	
☐ 	☐ 
☐ 2013	
☐ 	☐ 

Transect 21, Tag #504

☐ 0m-20m	☐ 20m-0m
☐ 2012	
☐ 	☐ 
☐ 2013	
☐ 	☐ 

Transect 22, Tag #505

☐ 0m-20m	☐ 20m-0m
☐ 2012	
☐ 	☐ 
☐ 2013	
☐ 	☐ 

Transect 23, Tag #506

☐ 0m-20m	☐ 20m-0m
☐ 2012	
☐ 	☐ 
☐ 2013	
☐ 	☐ 

APPENDIX B. VEGETATION REMOVAL PHOTOPOINTS

Photopoints taken from before and after vegetation removal in select *Cordylanthus maritimus* ssp. *palustris* sampling plots (August 2010).

Transect 750, 7-8m, before treatment

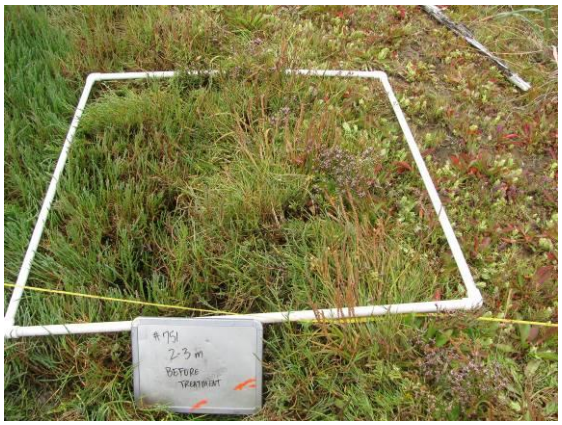
Transect 750, 7-8m, after treatment

Transect 750, 8-9m, before treatment

Transect 750, 8-9m, after treatment

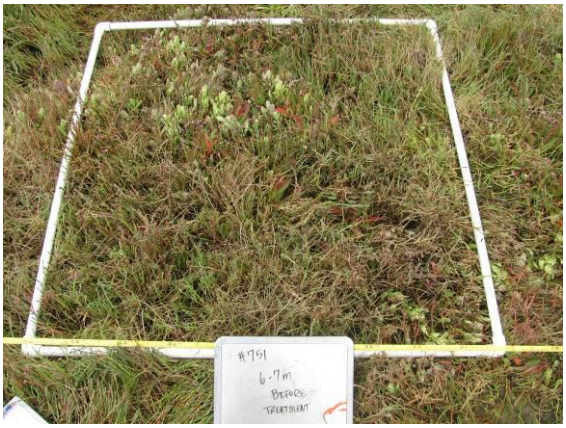
Transect 750, 10-11m, before treatment

Transect 750, 10-11m, after treatment



Transect 751, 2-3m, before treatment

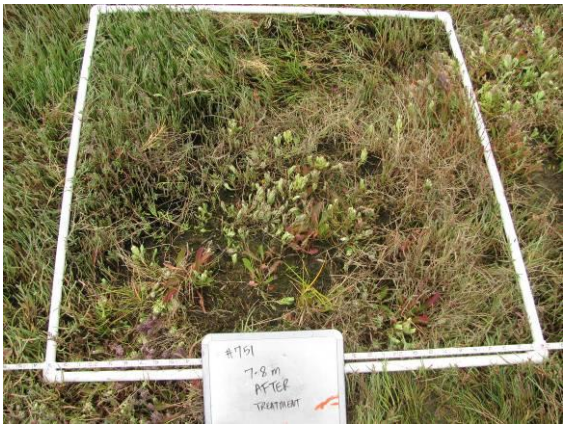
Transect 751, 2-3m, after treatment



Transect 751, 6-7m, before treatment

Transect 751, 6-7m, after treatment

Transect 751, 7-8m, before treatment



Transect 751, 7-8m, after treatment