

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



2012

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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TABLE OF CONTENTS

PREFACE	II
ACKNOWLEDGEMENTS	III
TABLE OF CONTENTS	IV
LIST OF FIGURES	V
LIST OF TABLES	VI
INTRODUCTION	2
SPECIES BACKGROUND	3
Range	3
Habitat.....	3
Description.....	3
Reproductive Biology	3
Population Biology.....	4
Host Plants.....	4
Taxonomy	4
METHODS	5
Community Analysis.....	9
RESULTS	9
Population Survey.....	9
Community Analysis.....	13
Vegetation Removal.....	17
Habitat Mapping	18
CONCLUSIONS	18
RECOMMENDATIONS	18
LITERATURE CITED	22
APPENDIX A. SAMPLING TRANSECT PHOTOPOINTS	24
2010.....	24
2011	26
2012.....	30
APPENDIX B. VEGETATION REMOVAL PHOTOPOINTS	35

LIST OF FIGURES

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

Figure 2. Area surveyed for *Cordylanthus maritima ssp. palustris*. Blue lines indicate monitoring transects established in 2010-2012.

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). 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 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 26% of the variance.

Figure 4. Percent of habitat classes represented along transects in both protected and unprotected habitats (2012).

Figure 5. NMS ordination of community composition within the protected area and unprotected area of the *Cordylanthus maritimus ssp. palustris* population at the Coos Bay North Spit (2012 only). 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 and species abbreviations (in black, Table 7) indicate their locations in species space. Variance explained by Axis 1 was 69%, while Axis 2 explained 13% of the variance.

Figure 6. 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 and 2012 to test 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.

Figure 7. Habitat map of the *C. maritimus ssp. palustris* population at the Coos Bay North Spit, created in 2012 (left) and 2011 (right). Habitat codes are listed in Table 2. Major changes in 2012 include a significant decrease in the cover of both “*Cordylanthus* Flat!” (CF) and “*Limonium Cordylanthus* Flat, (LCF).

Figure 8. Habitat maps for both the protected and unprotected areas. Cross hatched area represents the disturbed habitat in the southern unprotected area.

LIST OF TABLES

Table 1. Schedule of activities for habitat monitoring and improvement for *Cordylanthus maritimus* ssp. *palustris* in 2010-2013

Table 2. Habitat codes used for mapping in 2011 & 2012.

Table 3. Number of plants per transect.

Table 4. Average number of branches per plant.

Table 5. Average number of flowers per plant.

Table 6. Areal cover and average number of *Cordylanthus* m⁻² in 2011 and 2012 for each of the mapped habitat units.

Table 7. Species list including nativity from plots within the *Cordylanthus maritimus* ssp. *palustris* population at the Coos Bay North Spit in 2012. 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.

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

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).

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.



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

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 2010-2013

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 <i>C. m. ssp. palustris</i> 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 <i>C. m. ssp. palustris</i> 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 <i>C. m. ssp. palustris</i> size and reproductive status Take photopoints
Winter 2012-2013	Enter and analyze data, write annual progress report.
March 31, 2013	Submit draft progress 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 2010-2012; *C. maritimus* ssp. *palustris* sampling occurred on four in 2010 and all transects in 2011 and 2012. Transects were oriented perpendicular to the habitat margin, and extended 20m. Percent cover for all species was recorded in 1m² increments along the right side of the transect, when viewed from the transect's origin. The number of branches and flowers for each *Cordylanthus maritimus* ssp. *palustris* individual was recorded within each plot. Photopoints were taken looking along each transect, from both the beginning and end (Appendix A. Sampling Transect Photopoints). 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{O}) by the total habitat area ($N = 2294 \text{ m}^2$):

$$\text{population size estimate} = \bar{O} * N$$

In 2011 the sampling method was modified to increase sampling efficiency. A habitat class was assigned to each 1 m² 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 1m² plot. To estimate total population size, the average number of plants per m² 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 both 2010-2012.

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 the unprotected area was also mapped using the same habitat class delineations used in the protected area in 2011 and 2012.

Table 2. Habitat codes used for mapping in 2011 & 2012.

Code	Habitat	Description
CF	<i>Cordylanthus</i> flat	<i>Cordylanthus</i> cover \geq 50%
LCF	<i>Limonium-Cordylanthus</i> flat	<i>Limonium</i> , <i>Cordylanthus</i> codominant
LF	<i>Limonium</i> flat	<i>Limonium</i> cover \geq 50%
GT	Grass transition	Differentiated by presence of <i>Ammophila</i> or <i>Leymus</i> , marks transition into small stabilized dune habitat. Some <i>Cordylanthus</i> present but only in trace amounts. This is the absolute upper boundary of COMAPA habitat.
SD	<i>Salicornia</i> depression	<i>Salicornia</i> dominant species; area of higher water during the tide. Differs from waterway by abundant <i>Salicornia</i> , and little to no bare sand.
SDD	<i>Salicornia-Distichlis</i> depression	<i>Salicornia</i> dominant, but <i>Distichlis</i> cover \geq 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	<i>Distichlis</i> rise	Small hill, <i>Distichlis</i> dominated, with minor patches of <i>Jaumea carnosa</i> nearest to the ocean.
Marsh	Marshy area	Marshy area dominated by <i>Scirpus</i> sp., area inundated by tides.



Figure 2. Area surveyed for *Cordylanthus maritima* ssp. *palustris*. Blue lines indicate monitoring transects established in 2010-2012.

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 2012 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 three years in the protected area.

Differences in plant community between protected and unprotected areas (in 2012) 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*. Both color morphs (green and purple) of *C. maritimus* ssp. *palustris* were evenly represented throughout the population.

In general, the population on the west side of the bay was sparser, but each plant had more branches and flowers per plant. However, due to the general patchiness throughout the site, there were no consistent patterns when the data were averaged (**Table 3-Table 5**). Variation in density and size of *C. maritimus* ssp. *palustris* may be due to a combination of plant community and abiotic factors. For example, the west side of the population tended to have higher cover of *S. virginica* and lower cover of *J. carnosa* and the east side became flooded when the tide came in.

We estimated that in 2010, the total number of *C. maritimus* ssp. *palustris* 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 m² in all habitat classifications and then multiplying by the area of each habitat class (Table 6). This method was selected because the habitat for *Cordylanthus 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. This precipitous drop coincides with significant decreases to the cover of *C. maritimus* ssp. *palustris* dominated habitat classes. Continued monitoring of the transects combined with habitat surveys will help to elucidate the population trends at this protected site.

Table 3. Number of plants per transect.

Transect #	Tag #	Plants m ⁻²		
		2010	2011	2012
0	750	174	285	128
2	516	--	279	48
4	751	80	93	0
7	752	85	61	0
11	753	349	688	32
13	514	--	85	976
15	754	--	216	1920
16	515	--	309	1104
17	517	--	16	0
18		--	--	1280
20		--	--	1168
21		--	--	0
22		--	--	592
23		--	--	2928
Average		172	226	727

Table 4. Average number of branches per plant.

Transect #	Tag #	Branches plant ⁻¹		
		2010	2011	2012
0	750	3.0	2.4	2.1
2	516	--	4.4	1.0
4	751	3.5	6.3	N/A
7	752	2.2	5.5	N/A
11	753	2.1	1.8	2.5
13	514	--	3.7	1.4
15	754	--	1.7	1.2
16	515	--	2.5	1.5
17	517	--	3.1	N/A
18		--	--	1.8
20		--	--	1.3
21		--	--	N/A
22		--	--	3.2
23		--	--	1.3
Average		2.7	3.5	1.7

Table 5. Average number of flowers per plant.

Transect #	Tag #	Flowers plant ⁻¹		
		2010	2011	2012
0	750	5.3	4.8	28.8
2	516	--	2.1	9.7
4	751	6.4	13.6	N/A
7	752	5.6	12.3	N/A
11	753	6.5	4.2	13.5
13	514	--	12.5	11.9
15	754	--	5.2	11.7
16	515	--	5.2	17.1
17	517	--	12.5	N/A
18		--	--	17.2
20		--	--	12.3
21		--	--	N/A
22		--	--	20.8
23		--	--	8.4
Average		6.0	8.0	15.1

Table 6. Areal cover and average number of *Cordylanthus* m⁻² in 2011 and 2012 for each of the mapped habitat units.

Code	Habitat	2011		2012	
		Area (m ²)	Ave. # <i>Cordylanthus</i> m ⁻²	Area (m ²)	Ave. # <i>Cordylanthus</i> m ⁻²
CF	<i>Cordylanthus</i> flat	293	978 plants/m ²	3	317 plants/m ²
LCF	<i>Limonium-Cordylanthus</i> flat	1,468	425 plants/m ²	337	253 plants/m ²
LF	<i>Limonium</i> flat	498	12 plants/m ²	1,398	16 plants/m ²
GT	Grass transition	928	N/A	930	N/A
SD	<i>Salicornia</i> depression	1,011	N/A	1,662	8
SDD	<i>Salicornia-Distichlis</i> depression	747	N/A	1,492	8
Sand	<i>Sand</i>	110	N/A	72	N/A
Waterway	Waterway	645	N/A	681	N/A
D	<i>Distichlis</i> dominant	973	N/A	0	N/A
D-Rise	<i>Distichlis</i> rise	393	N/A	353	N/A
Marsh	Marshy area	214	N/A	353	N/A

Community Analysis

The NMS ordination of sample units in species space (Figure 3) in the protected habitat (2010-2012) resulted in a 3-dimensional stable solution (final stress = 12.9, 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, and 2012 tended to be intermixed in species space. *Cordylanthus maritimus* ssp. *palustris* (COMAPA) was strongly positively correlated with Axis 1 ($r = 0.47$), along with natives *L. californicum* (LICA; $r = 0.84$), *Plantago maritima* (PLMA; $r = 0.49$), and *J. carnososa* (JACA; $r = 0.48$), while *S. depressa* (SAVI) had a strong negative correlation with the Axis ($r = -0.85$). Bareground was negatively associated with Axis 2 ($r = 0.09$), along with *Spergularia macrotheca* (SPMA; $r = -0.30$) and *P. pumila* (PUPU; $r = -0.32$). Ordination scores were similar to those in 2011, suggesting that these species associations remain over time but can shift slightly. From 2010 to 2012, sample units have shifted upward along Axis 2 in species space, which was most positively associated with *J. carnososa* ($r = 0.60$) and *P. maritima* ($r = 0.40$) and was negatively associated with bareground. These results indicate that *C. maritimus* ssp. *palustris* was strongly associated with species such as *L. californicum* and *J. carnososa* which are known as potential host plants for the hemi-parasite. *Cordylanthus maritimus* ssp. *palustris* was negatively associated with cover of litter, *D. spicata* and *S. depressa*. These trends are similar to those observed in previous years. Of interest, we found several *Cordylanthus maritimus* ssp. *palustris* parasitized by the holoparasite, *Cuscuta 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 2012 (MRPP; $A = 0.09$, $P < 0.0000$). Species richness was greater in protected habitat than in unprotected habitat (19 and 12, respectively). The NMS ordination of sample units in species space of the protected and unprotected habitats (2012 only) resulted in a 2-dimensional stable solution (final stress = 17, final instability = 0.000) and a randomization test confirmed that final stress was lower than expected by chance ($p = 0.02$). Results indicated similar trends of lower species diversity in the unprotected than the protected habitat in 2012 (Figure 5). Sample units from the protected habitat were more scattered in ordination space, indicating more heterogeneity of species composition. In contrast, in the unprotected habitat, sample units were more clustered in ordination space, indicating more homogenous species composition (Figure 5).

Many species were identified as indicators of either the protected or unprotected habitats (Table 7). *Cordylanthus maritimus* ssp. *palustris* was not an indicator species for either habitat ($P = 0.45$), suggesting that it was abundant in both. Indicator species of the unprotected habitat were *D. spicata* and *S. depressa*. Indicators of the protected area included *C. pacifica*, *J. carnososa*, *L. californicum*, *P. pumila*, *S. macrotheca*, and *T. maritima*. 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). Interestingly, *Cordylanthus* flat composed a greater percentage of transects in the unprotected habitat than in the protected habitat in 2012, however it was not found as an indicator of either habitat type.

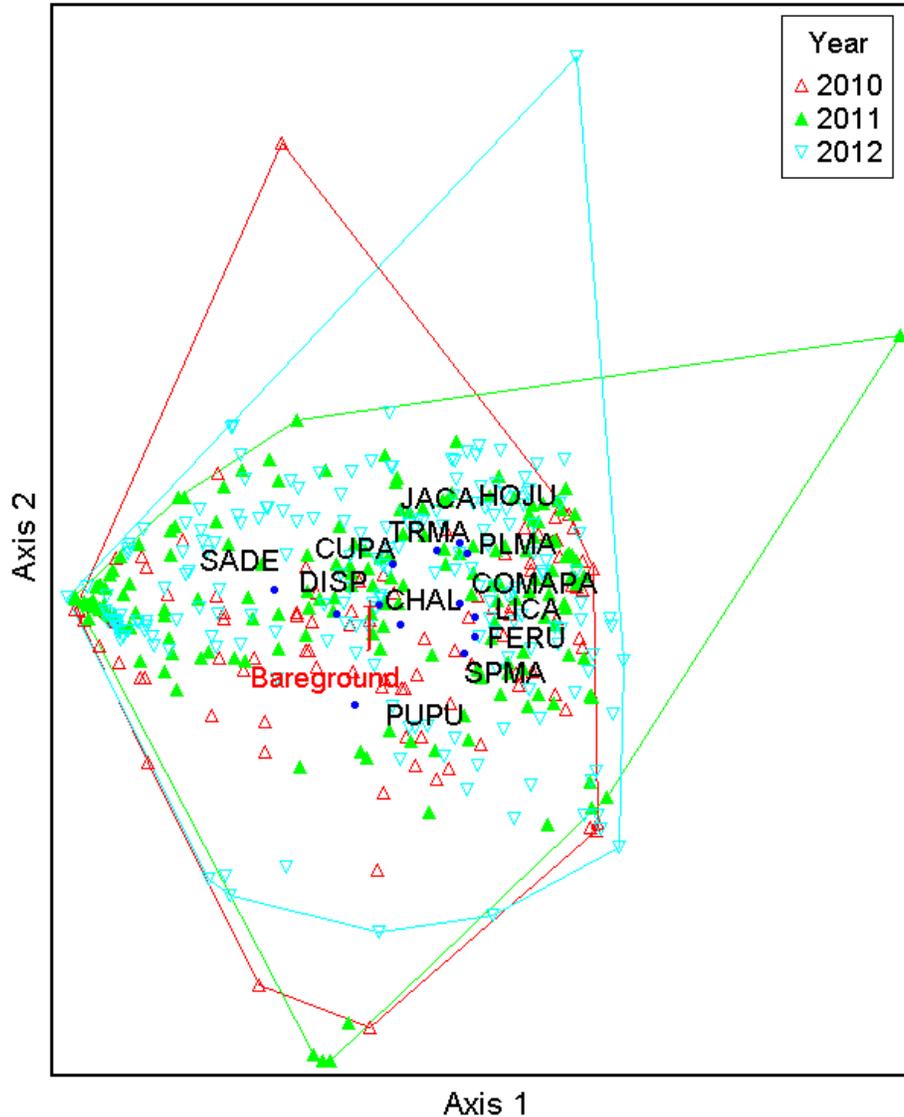


Figure 3. NMS ordination of community composition within the protected area of the *Cordylanthus maritimus* ssp. *palustris* population at the Coos Bay North Spit (2010, 2011, 2012). Triangles represent sample units (quadrats along transects) in species space, and distance between points indicates similarity of community composition by quadrat. Polygons outline the extent of all of the sample units in species space. Blue dots 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 26% 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 2012. 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
<i>Ammophila arenaria</i>	AMAR	Exotic	*		
<i>Cerastium glomeratum</i>	CEGL	Exotic	*		
<i>Chenopodium album</i>	CHAL	Exotic	Y	Protected	0.01
<i>Cordylanthus maritimus</i> ssp. <i>palustris</i>	COMAPA	Native	N		0.45
<i>Cuscuta pacifica</i>	CUPA	Native	Y	Protected	0.0002
<i>Distichlis spicata</i>	DISP	Native	Y	Unprotected	0.0002
<i>Festuca rubra</i> ssp. <i>littoralis</i>	FERU	Native	Y	Protected	0.001
<i>Grindelia stricta</i>	GRST	Native	*		
<i>Holcus lanatus</i>	HOLA	Exotic	*		
<i>Hordeum jubatum</i>	HOJU	Native	Y	Protected	0.0002
<i>Jaumea carnosa</i>	JACA	Native	Y	Protected	0.0002
<i>Juncus</i> sp.	Juncus	Native	*		
<i>Leymus mollis</i>	LEMO	Native	*		
<i>Limonium californicum</i>	LICA	Native	Y	Protected	0.0002
<i>Plantago maritima</i>	PLMA	Native	Y	Protected	0.05
<i>Puccinellia pumila</i>	PUPU	Native	Y	Protected	0.004
<i>Rumex acetosella</i>	RUAC	Exotic	*		
<i>Salicornia depressa</i>	SAVI	Native	Y	Unprotected	0.0002
<i>Spergularia macrotheca</i>	SPMA	Native	Y	Protected	0.0002
<i>Triglochin maritima</i>	TRMA	Native	Y	Protected	0.0008

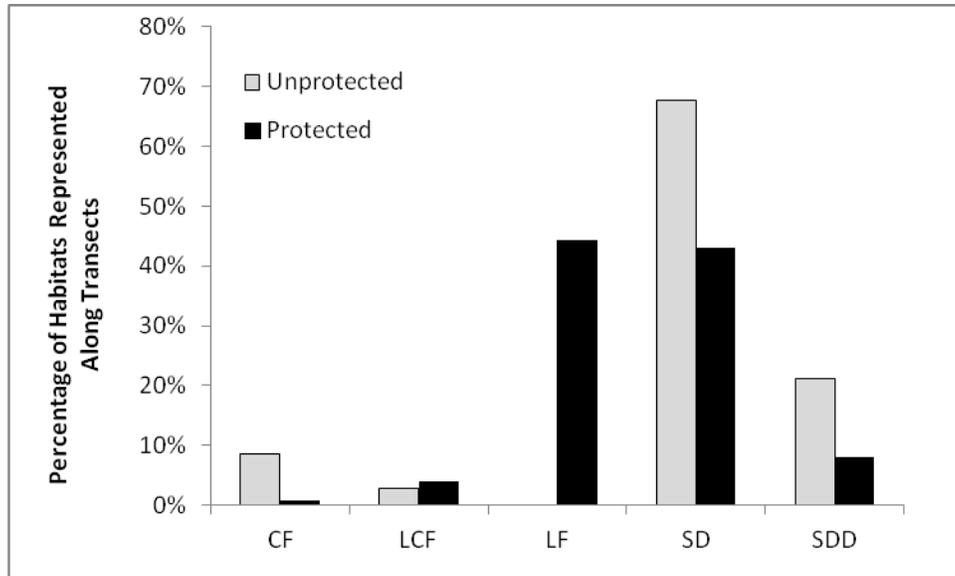


Figure 4. Percent of habitat classes represented along transects in both protected and unprotected habitats (2012).

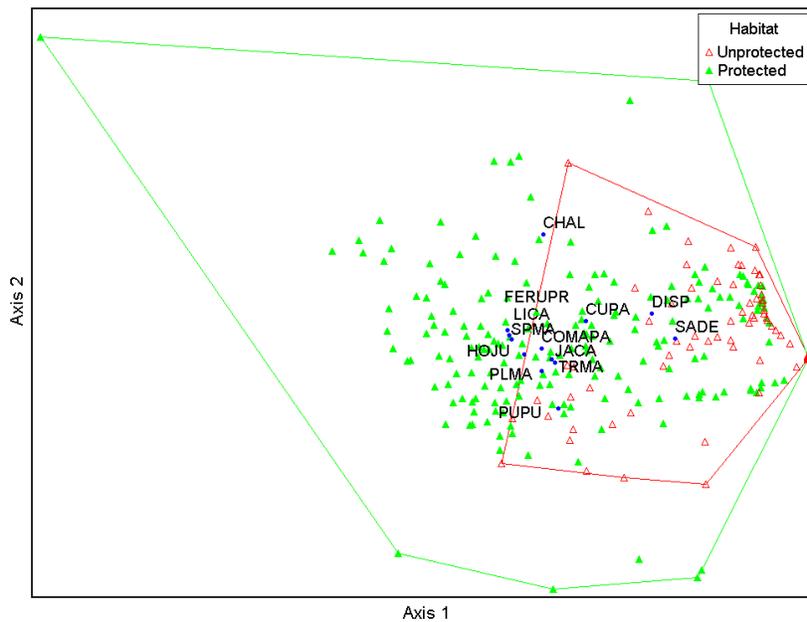


Figure 5. NMS ordination of community composition within the protected area and unprotected area of the *Cordylanthus maritimus* ssp. *palustris* population at the Coos Bay North Spit (2012 only). Triangles represent sample units (quadrats along transects) in species space, and distance between points indicates similarity of community composition by quadrat. Polygons outline the extent of all of the sample units in species space. Blue dots and species abbreviations (in black, Table 7) indicate their locations in species space. Variance explained by Axis 1 was 69%, while Axis 2 explained 13% of the variance.

Vegetation Removal

In 2011 and 2012, 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* and *Puccinellia pumila*, however the decreases in cover of these species were not associated with significant increase in *C. maritimus* ssp. *palustris* cover. 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 were consistent with decrease in cover of the species throughout the site.

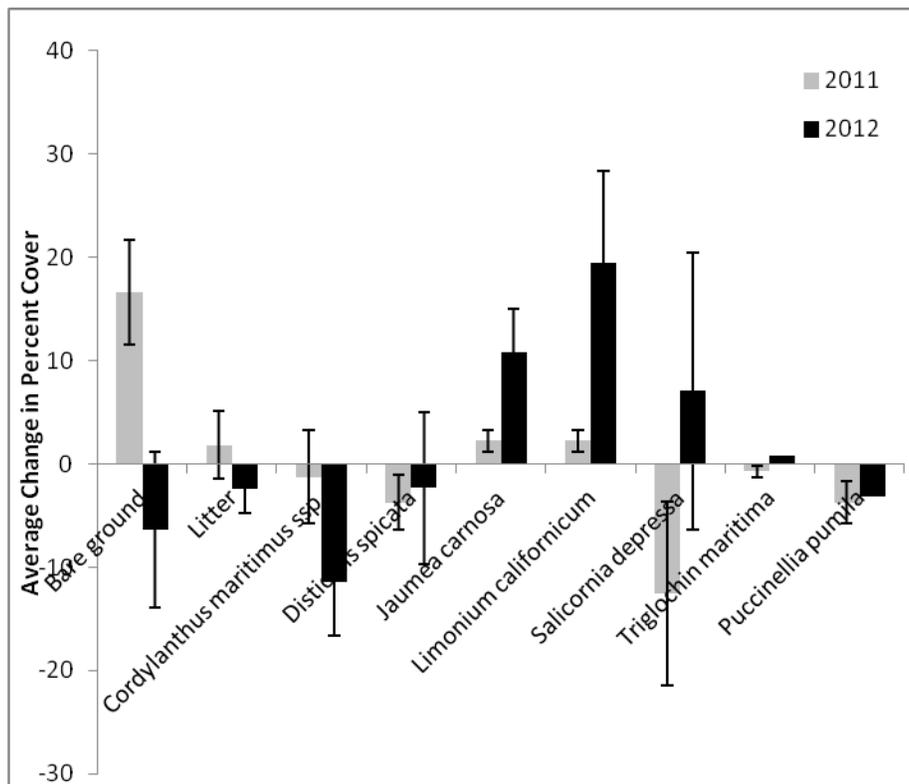


Figure 6. Average change in percent cover of select species in vegetation removal plots. Vegetation was removed so that total vegetative cover was approximately 70%. Plots were monitored in 2011 and 2012 to test the effectiveness of vegetation removal. Species not shown above had a less than 1% change in cover from 2010 to 2011. Error bars represent ± 1 SE.

Habitat Mapping

In 2011 and 2012 a habitat map was created using the habitat classes listed in Table 2 (**Figure 7**). The map will be updated annually to detect shifts in habitat type that may affect the success of *C. maritimus* ssp. *palustris*. In 2011, of the 7,282m² surveyed 293 m² were mapped as “*Cordylanthus* Flat” (CF) and 1,468 m² *Limonium-Cordylanthus* Flat (LCF). Occasionally, sparse *C. maritimus* ssp. *palustris* was found in sandy areas as well in *Limonium* Flats (LF). The average number of plants per m² in each of the habitat types varied from an average of 12 in LF, 425 in LCF and 978 in areas mapped as CF. In 2012 there were significant changes in cover of all habitats associated with *C. maritimus* ssp. *palustris* including CF, LCF and LF. There was also increases in both the “*Salicornia* Depressions” (SD) and “*Salicornia-Distichlis* Depressions” (SDD).

In 2012, the habitat in the southern 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 m² compared to 7,200 m²), 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 was SDD with *Distichlis spicata* co-occurring with *Salicornia* in 20,300 m². “*Cordylanthus* Flats” were the next most common habitat type covering approximately 1,200 m². In addition to habitat classes, the boundaries of the disturbed area was marked in 2012 and overlaid onto the habitat map (Figure 8).

The coarse resolution combined with the limited number of transects in the unprotected area does not allow for a population estimate in the same manner as the protected population.

CONCLUSIONS

There was significant variability in the number and size of *Cordylanthus* from 2010-2012. Vegetation removal experiments did not elucidate any potential effects of competitors on *Cordylanthus* 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 an effect of our treatment.

From 2011-2012 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”. Additionally it was noted that the *C. maritimus* ssp. *pacificus* was commonly associated with the disturbed areas in the unprotected area (Figure 8). Continued habitat mapping and population surveys will elucidate general population trends.

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 Bureua Sensitive *Limonium californicum* in the area. The presence of *C. maritimus* ssp. *pacificus* 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.

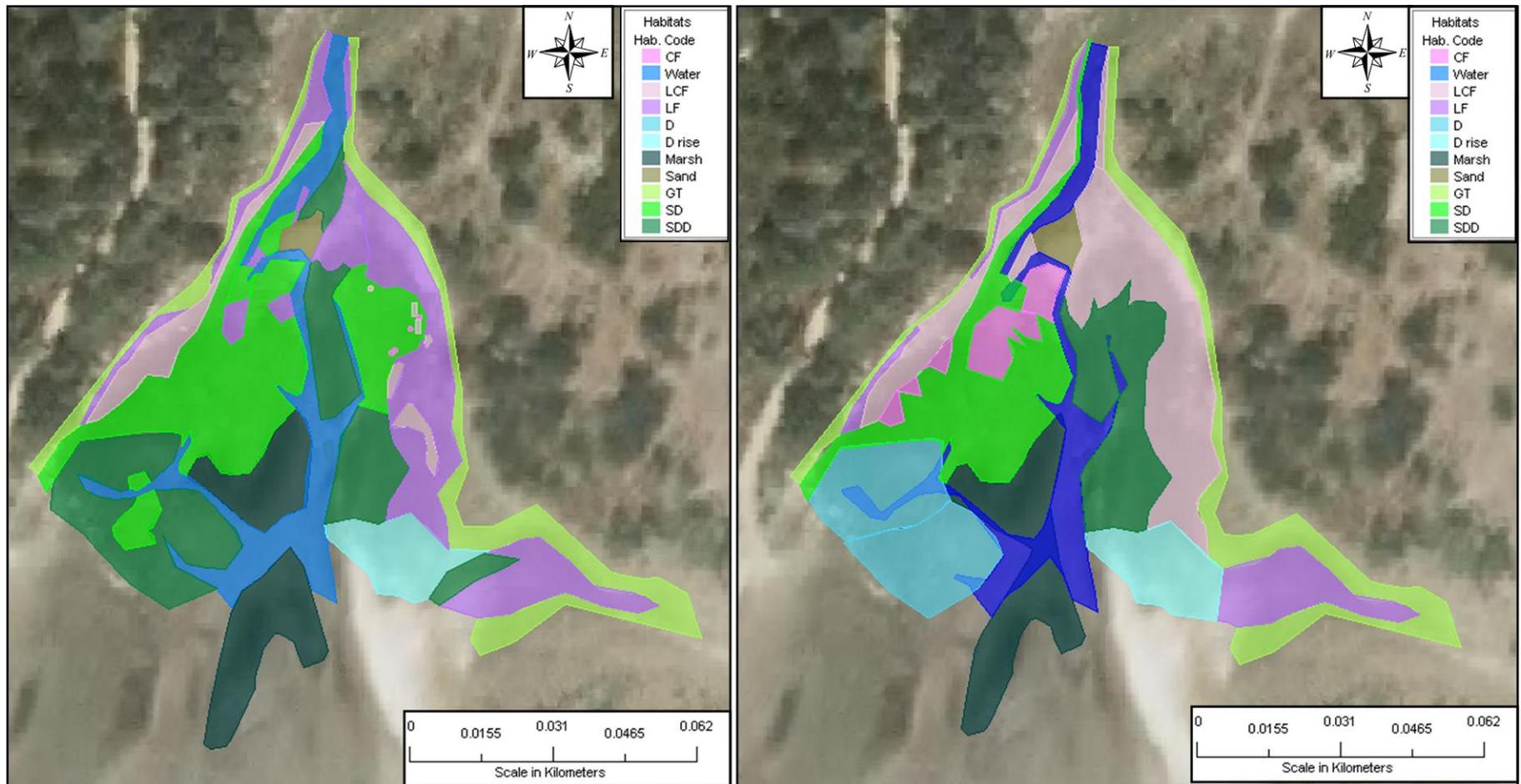


Figure 7. Habitat map of the *C. maritimus* ssp. *palustris* population at the Coos Bay North Spit, created in 2012 (left) and 2011 (right). Habitat codes are listed in Table 2. Major changes in 2012 include a significant decrease in the cover of both “*Cordylanthus* Flat!” (CF) and “*Limonium Cordylanthus* Flat, (LCF).

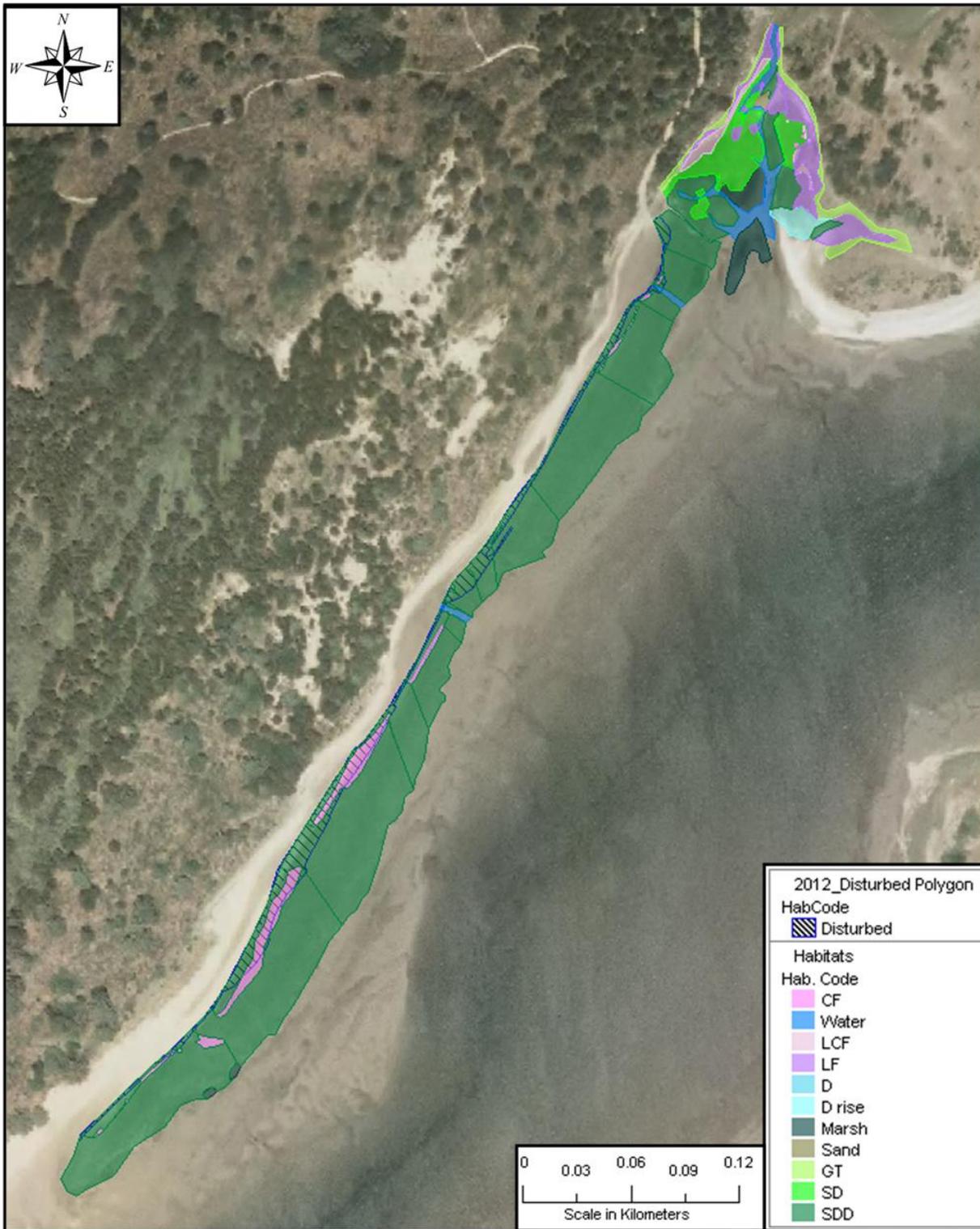


Figure 8. Habitat maps for both the protected and unprotected areas. Cross hatched area represents the disturbed habitat in the southern unprotected area.

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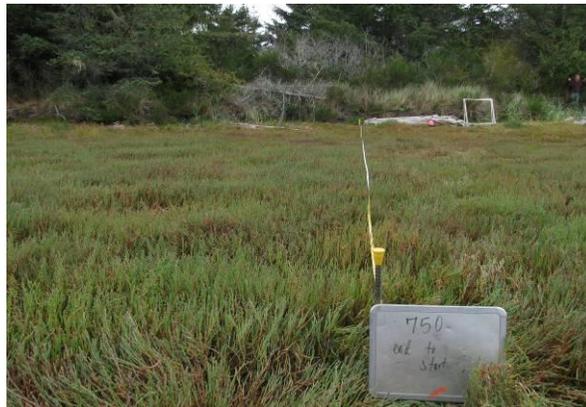
APPENDIX A. SAMPLING TRANSECT PHOTOPOINTS

2010

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



Transect 750, start to end



Transect 750, end to start



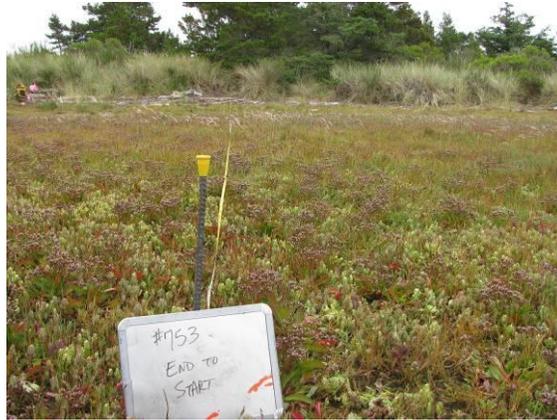
Transect 751, start to end



Transect 751, end to start



Transect 753, start to end



Transect 753, end to start



Transect 754, start to end



Transect 754, end to start

2011

Photopoints taken from the start (0m, upland edge) and end (20m, population interior) of *Cordylanthus maritimus* ssp. *palustris* sampling transects (August 2011)



Transect 750, start to end



Transect 750, end to start



Transect 516, start to end



Transect 516, end to start



Transect 751, start to end



Transect 751, end to start



Transect 752, start to end



Transect 752, end to start



Transect 753, start to end



Transect 753, end to start



Transect 514, start to end



Transect 514, end to start



Transect 754, start to end



Transect 754, end to start



Transect 515, start to end



Transect 515, end to start



Transect 517, start to end



Transect 517, end to start

2012

Photopoints taken from the start (0m, upland edge) and end (20m, population interior) of *Cordylanthus maritimus* ssp. *palustris* sampling transects (August 2012)



Transect 0 (#750) from start to end



Transect 0 (#750) from end to start



Transect 2 (#516) from start to end



Transect 2 (#516) from end to start



Transect 4 (#751) from start to end



Transect 4 (#751) from end to start



Transect 7 (#752) from start to end



Transect 7 (#752) from end to start



Transect 11 (#753) from start to end



Transect 11 (#753) from end to start



Transect 13 (#514) from start to end



Transect 13 (#514) from end to start



Transect 15 (#754) from start to end



Transect 15 (#754) from end to start



Transect 16 (#515) from start to end



Transect 16 (#515) from end to start



Transect 17 (#517) from start to end



Transect 17 (#517) from end to start



Transect 18 (#502) from start to end



Transect 18 (#502) from end to start



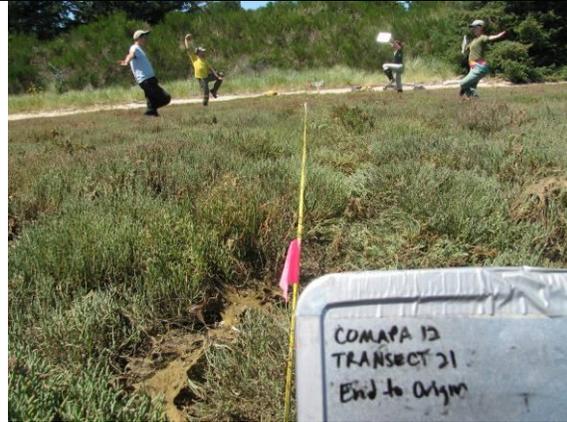
Transect 20 (#503) from vegetation start to end



Transect 20 (#503) from end to vegetated start



Transect 21 (#504) from vegetation start to end



Transect 21 (#504) from end to vegetated start



Transect 22 (#505) from vegetation start to end



Transect 22 (#505) from end to vegetated start



Transect 23 (#506) from vegetation start to end



Transect 23 (#506) from end to vegetated start

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



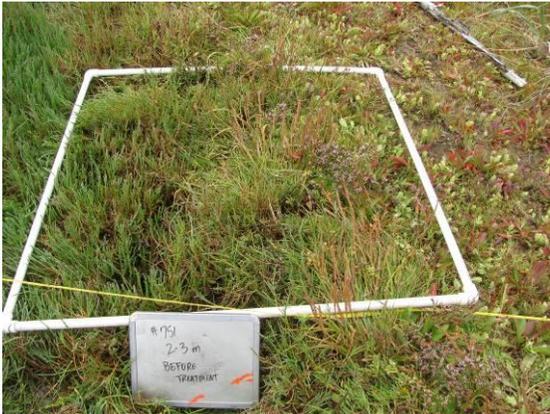
Transect 750, 8-9m, after treatment



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