Clatsop Plains – Long Beach Peninsula Coastal Prairie Restoration

2015

2015 Progress Report to the USDI, US Fish and Wildlife Service

Report prepared by Matt A. Bahm and Denise E. Giles

Institute for Applied Ecology

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: Herbicide treated plot at North Coast Land Conservancy's Surf Pines property.

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EXECUTIVE SUMMARY

In 2015, treatments varied by site and establishment of seeded species was low across sites. Future monitoring will help to elucidate treatment effectiveness and aid in management recommendations.

NCLC Sites

Treatments did reduce cover of both exotic forbs and graminoids, in comparison to control plots. Native species cover was minimal across treatments, due to low establishment of seeded species. Future monitoring is necessary to allow slow growing native seeded species to establish, and to determine the successional trajectory of the individual treatments.

Willapa NWR

Invasive grasses continue to be a management issue at the site. Although the treatments did reduce invasive graminoid cover compared to the controls, all maintained levels that will require intensive management. Future monitoring will provide next steps for management of the pasture grasses at the site.

Yeon (National Park Service)

This site was very different from the other sites. While vegetative cover was low in general at the site, the treatments actually increased the cover of invasive graminoids. Future monitoring will determine the successional trajectory of the site, but currently, none of the treatments offer a practical alternative to the current state of the site. Similar to the other sites, seeded species have been slow to establish and future monitoring will likely find higher cover of native species.

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PROGRESS REPORT TO THE USDI, US FISH AND WILDLIFE SERVICE

INTRODUCTION

Current established techniques for restoring prairies have shown various results on a single- and multiple-treatment scale. Commonly employed restoration techniques generally aim either to reintroduce disturbance or to reduce non-native grasses, other graminoids, forbs, shrubs, and nitrogen-fixing legumes—or a combination of both techniques. Management techniques such as prescribed fire, mowing, herbicide application, solarization (e.g., heating the weed seed bank to lethal temperatures using clear plastic ground cloth), grazing, topsoil removal, and topsoil inversion have been used to mimic non-climatic natural disturbance processes, and to foster restoration of biodiversity of native plants and animals on managed sites (Van Dyke et al. 2004).

Studies conducted on coastal prairie habitat in central California and northwest Wales, UK, have shown promise in reintroducing the historic natural disturbance regime of blowing sand. Plant growth and establishment of coastal prairie species increased when combined with topsoil inversion or topsoil removal (Jones et al. 2010, Buisson et al. 2006).

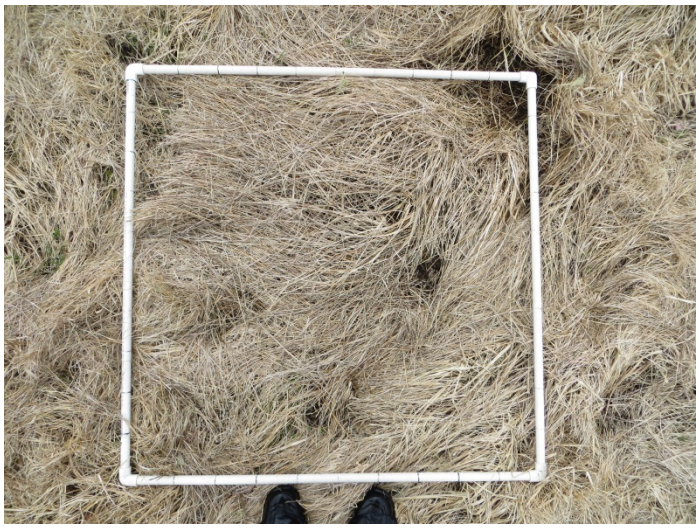


FIGURE 1. Herbicide treated plot showing dense thatch that must be considered when planning reseeding efforts.

The Nature Conservancy (TNC) and U.S. Fish and Wildlife Service (USFWS) have been most active in restoration efforts on the Clatsop Plains and Long Beach Peninsula. Following the designation of the Clatsop Plains in the OSB Recovery Plan, various partners charged with managing coastal prairie habitat in this region gathered together to develop a comprehensive, ecologically-based planning document, facilitated by The Nature Conservancy's Conservation Action Planning (CAP) process, for the protection and restoration of the Clatsop Plains coastal corridor (Pickering 2005).

During 2002-2007, TNC tested various combinations of treatments to evaluate the best approach for maintaining and enhancing coastal prairie communities. Primary treatments included mowing, prescribed fire, and grazing, with overlain treatments of heat (infrared weed burner), soil impoverishment, and applications of organic herbicide. While several of these treatments reduced the abundance of specific

groups of invasive plants or increased the abundance of native species, none of the treatment combinations was successful in meeting all of the restoration objectives. Restoration at Long Beach has similarly included various combinations of prescribed fire, herbicide application, mowing, hand removal, rototilling, seeding, and planting. To date, no treatment combination has been proven to be effective at maintaining coastal prairie habitat on the peninsula.

METHODS

Initial Site Conditions

National Park Service, Yeon Property

This site is a remnant dune with cover of beach grass and other dune species not found at other Clatsop Plains study sites, and higher initial cover of bareground (sand) than any other site. (Soil Inversion was not considered as a treatment here, due to feasibility constraints including site size and equipment restrictions. However, when soil removal occurred, one control plot was covered with spoils, and there was a large amount of ground disturbance, thus a 4th treatment is considered in one plot as a soil inversion/addition treatment.)

NCLC

The three sites managed by the North Coast Land Conservancy include Neacoxie Forest, Surf Pines and Reed Ranch. These three sites have high cover of exotic perennial grasses including *Schedonorus arundinaceus*. At these three sites, the ratio of native to exotic forb and graminoid species is low (<1:10).

NEACOXIE FOREST
Exotic graminoid cover is very high, with average cover of exotic graminoid species >100%.

SURF PINES
This site has a handful of remnant *Viola adunca*.

REED RANCH
In addition to the aforementioned suite of exotic perennial grasses, this site also has abundant *Cytisus scoparius*, that has been kept at bay with frequent mowing.

USFWS, Willapa NWR, OSB Field 3

Unlike the remaining sites, the plant community at Willapa also includes *Lotus corniculatus*, and extremely low cover of native forb species. This site also contains higher cover of the perennial and mat-forming *Agrostis sp.* than other sites.

Experimental design and data collection

At each site, there were initially four replicates of each of four treatments (see Appendix A). Modifications were made at several sites due to specific site conditions/issues and are documented in Appendix A. A complete schedule of treatments for each site through the Spring of 2015 is available in Appendix C. For the control, herbicide, and soil removal treatments, there are three, 5 x 5 meter plots

and one 15 x 15 meter plot. For the soil inversion treatment, plot size is 15 x 15 meters for all four plots in order to accommodate the size of the equipment. Regardless of the treatment area, the sampling will occur at the 5 x 5 meter scale (see Figure 2).

For each 5 x 5 meter plot, we established four 1m^2 sampling plots (Figure 2). Each meter square plot is set one meter from the edges and one meter from each other.

Pretreatment data was collected in 2013 and is presented in Appendix B. The presence of both native and nonnative species was documented at all sites. The nonnative species documented had been noted by land managers prior to our sampling and will be monitored throughout the study to determine the treatment impacts. Post-treatment monitoring will take place annually to document plant survival and natural regeneration of native and nonnative species.

Qualitative monitoring was conducted in 2014 due to budget constraints, and documented an initial reduction in vegetation cover in the herbicide treatment plots.

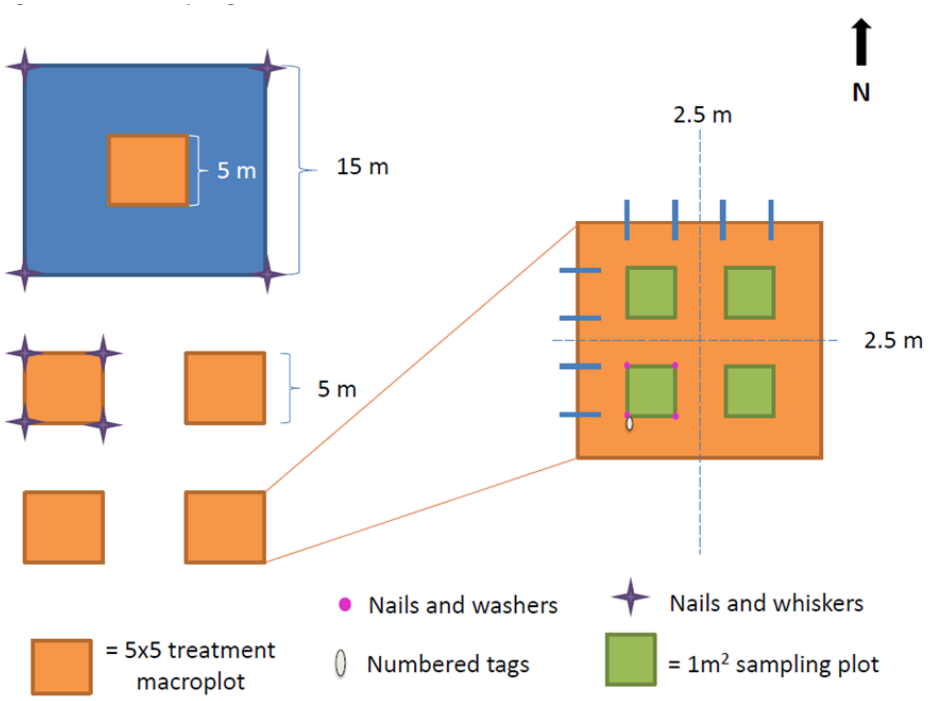


FIGURE 2. PLOT DESIGN AND SAMPLING PROTOCOL FOR COASTAL PRAIRIE RESTORATION STUDY.

Seeding:

In the fall/winter of 2014 five species were seeded into the 5 x 5 meter plots, while in the larger plots the area outside the 5 x 5 meter plots was seeded with *Festuca rubra* only (Figure 2; Table 1). All sites received the same species mix, with the exception of Willapa, which had *Cirsium brevistylem* substituted for *Lupinus littoralis* due to seed limitation (Table 1).

TABLE 1. SPECIES AND AMOUNTS SEEDED INTO COASTAL PRAIRIE RESTORATION RESEARCH PLOTS.

5 x 5 meter plots						
Species	**Pure Live Seeds/ft^2**	**Pure Live Seeds /m^2**	**seeds/lb**	**g/m^2**	**purity**	**germ**
Festuca rubra	30	323	400,000	0.37	90	80
Achillea millefolium	50	538	2,000,000	0.12	70	70
Solidago canadensis	50	538	2,000,000	0.12	50	50
Aster subspicatus	20	215	1,000,000	0.09	40	40
Lupinus littoralis	2	22	70,000	0.14	100	90
Cirsium brevistylum	36	385	175,000	0.95	95	90
Large plot area outside 5 x 5 meter plots						
Festuca rubra	50	538	400,000	0.6	90	80

RESULTS

Success of seeded species:

Overall, seeded species had minimal cover at all sites (Figure 3). Both native grasses and native forbs had less than 5% cover in all treatments and invasive graminoid cover dominating all treatments (Figure 3). Species and responses did vary by site and specific details are listed below.

In the NCLC sites (Surf Pines, Neacoxie Forest, Reed Ranch), the herbicide treatments had the highest cover of seeded species (particularly *Festuca rubra* and *Achillea millefolium*.) At Yeon, the soil removal plots had the highest success of seeded species, and again *F. rubra* and *A. millefolium* made up the greatest percent cover of the seeded species.

At Willapa NWR, the control plots had the highest cover of *F. rubra*. *F. rubra* was not seeded in the control plots, but was present at similar levels in our pretreatment data (Appendix B). When evaluating the success of seeded forb species, no treatment resulted in significantly more cover of seeded species than controls at Willapa. The soil addition plot had slightly higher cover of vegetation than the soil removal plots, however much of this was contributed by species that were likely brought in on the sandy substrate and included *Cakile* sp. and *Rumex acetosella*.

Success of seeded species into the future may be more telling as it will take at least one growing season for longer-lived species like *Lupinus littoralis, Aster subspicatus* and *Solidago canadensis* to establish. Germinants of lupine were commonly found in all plots, however cover of this species remained low. It may take more than one growing season for differences between treatments in establishment and plant cover to become clear.

Solidago canadensis was only found at Surf Pines in an herbicide plot.

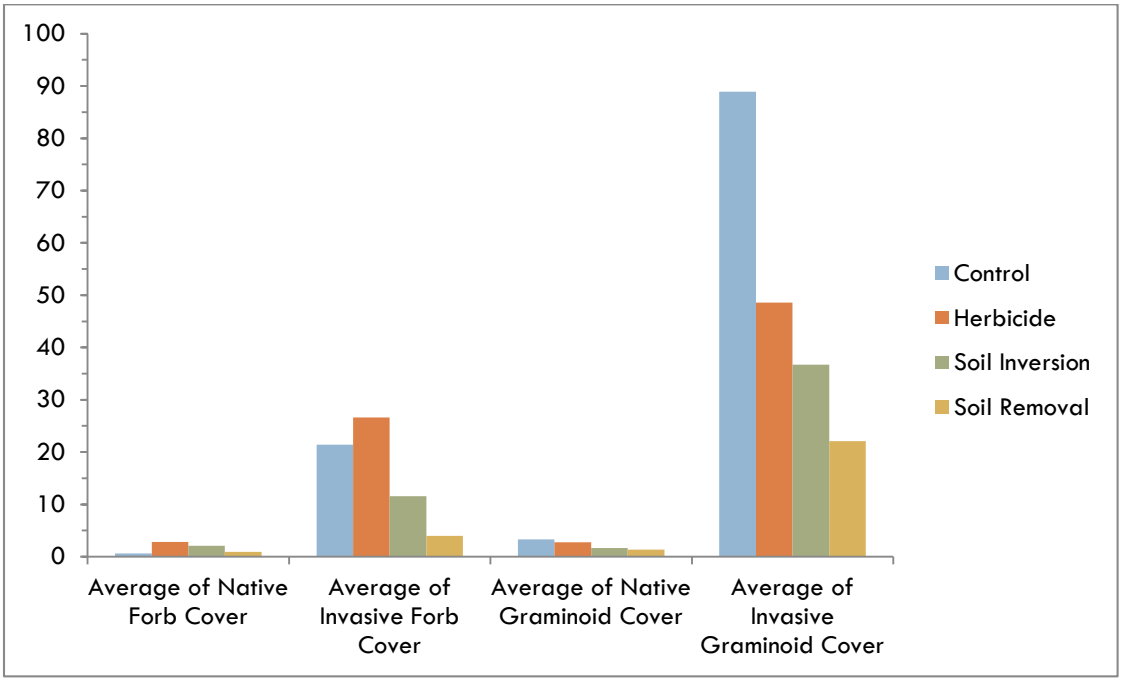


FIGURE 3. COVER OF NATIVE FORBS, INVASIVE FORBS, NATIVE GRAMINOIDS, AND INVASIVE GRAMINOIDS IN TREATED PLOTS AVERAGED AMONG ALL SITES IN 2015.

Effects of Treatments-By Site

NCLC Sites

FORB COVER

The ratio of native to exotic forb species remained stable independent of treatments at the NCLC sites. Soil removal and inversion had lower cover of all forbs (Figure 4). In controls, forb cover ranged from 17%-39%. In treated plots, forb cover was as low as 1% in soil removal plots (Reed Ranch) to as high as 51% in herbicide plots (again at Reed Ranch; Figure 4).

GRAMINOID COVER

Again, all treatments significantly decreased cover of graminoid species. All treatments slightly increased the ratio of native:exotic graminoids, however cover of native graminoid species was never above 3%, and exotic cover was as high as 120% (Figure 5).

SHRUB COVER

There was no clear effect of treatments on shrub cover, likely due to low initial levels at the sites (<4%). However at Reed Ranch, where *Cytisus scoparius* is more common, herbicide and soil removal treatments had lowest cover of shrubby species (<1%).

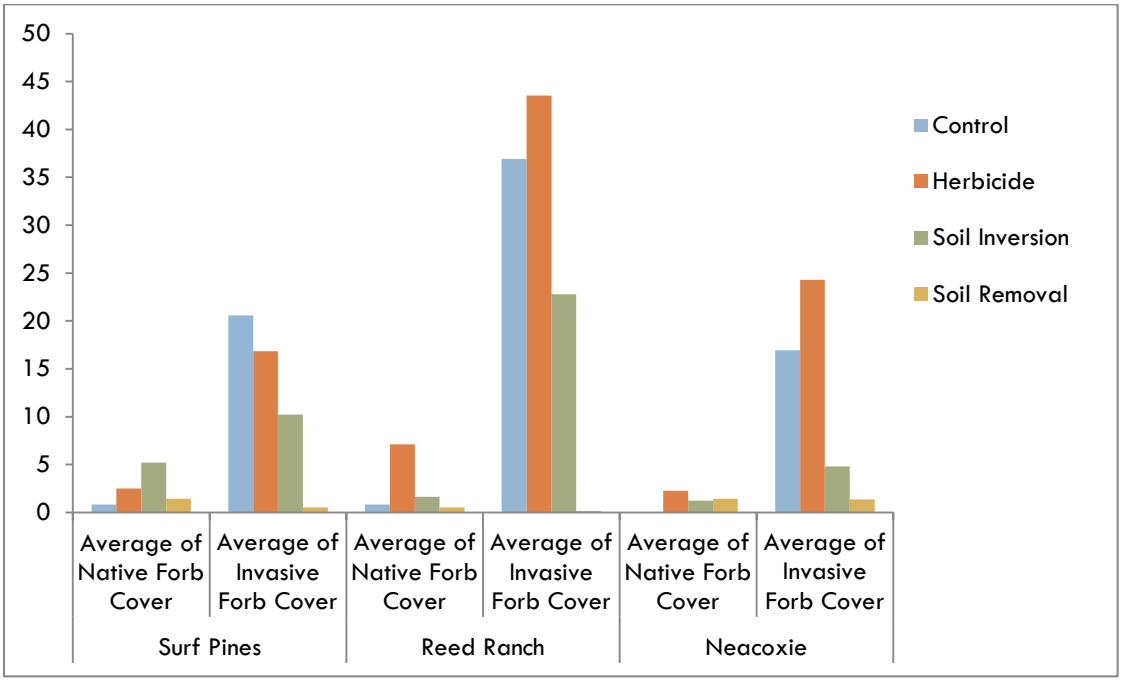


FIGURE 4. COVER OF NATIVE AND INVASIVE FORBS AT NCLC SITES IN 2015.

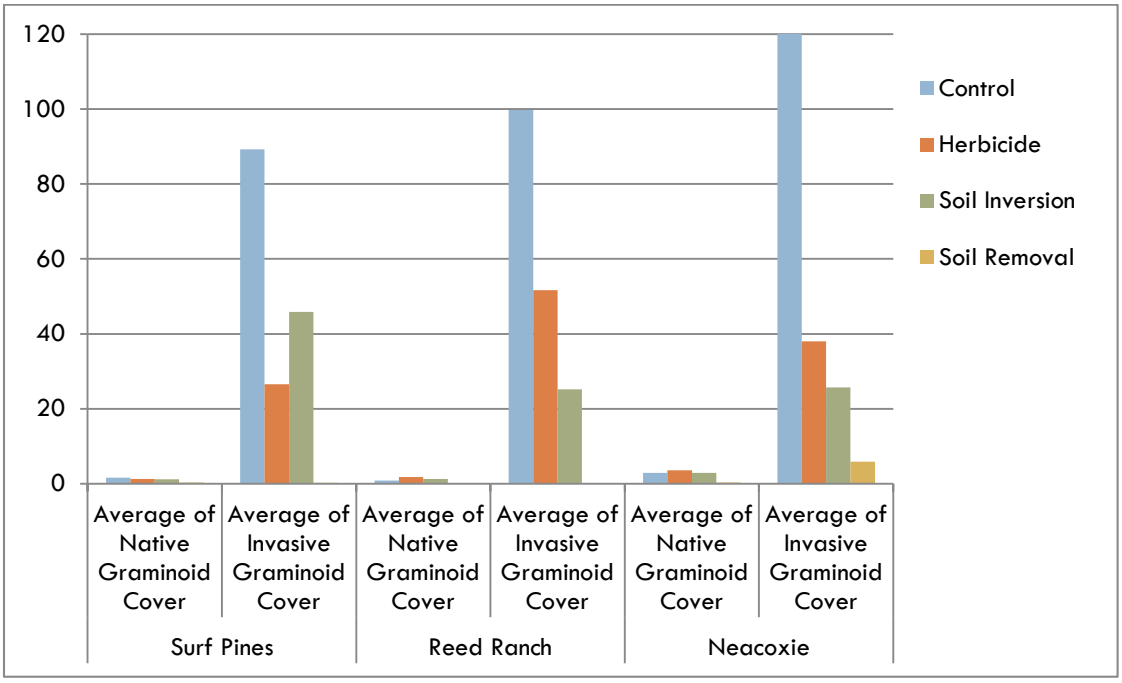


FIGURE 5. COVER OF NATIVE AND INVASIVE GRAMINOIDS AT NCLC SITES IN 2015.

Willapa NWR

At this site, two of the soil removal plots were dug sufficiently below the water table, such that water ponded in the plots during the rainy season: subsequently, the two easternmost soil removal plots were infilled with sand, these plots are considered here with the soil removal plots.

Herbicide applications were most patchy at this site, due to large amounts of thatch impeding contact of the chemicals with live plant materials.

FORB COVER

Herbicide plots had higher cover of forb species than controls, whereas soil inversion and removal had lower cover of forbs than controls (Figure 6). However, the ratio of native:exotic species remained stable independent of treatment.

GRAMINOID COVER

Again, all treatments decreased cover of graminoid species. Of the treated plots, herbicide plots had the highest ratio of native:exotic species, however as with other sites, native graminoid cover is very low for this site (1-10%; Figure 6).

SHRUB COVER

Shrubs are not common at the Willapa site.

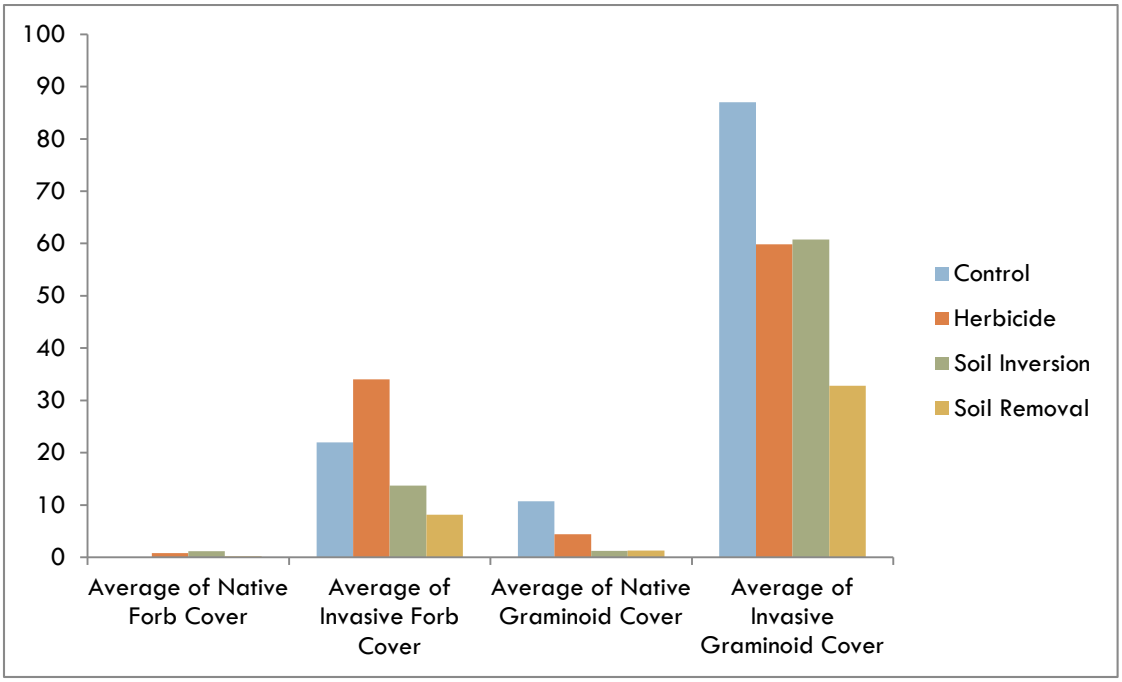


FIGURE 6. COVER OF NATIVE FORBS, INVASIVE FORBS, NATIVE GRAMINOIDS, AND INVASIVE GRAMINOIDS AT WILLAPA NWR IN 2015.

Yeon (National Park Service)

FORB COVER

Forb cover was generally low at this site (<6%; Figure 7). The soil inversion and soil removal treatments resulted in higher amounts of invasive forb cover that will be monitored closely in the future to determine what treatment may be required. Native forb cover was minimal and did not show treatment effects.

GRAMINOID COVER

Native graminoid cover was low across all treatments (<5%; Figure 7). Invasive graminoid cover increased in all treatments compared to control plots (Figure 7). While future monitoring will be important to note how this changes over time, initial results indicate that current treatments may be excessive for the site and will likely need to be modified.

SHRUB COVER

Shrubs are not common at the Yeon site.

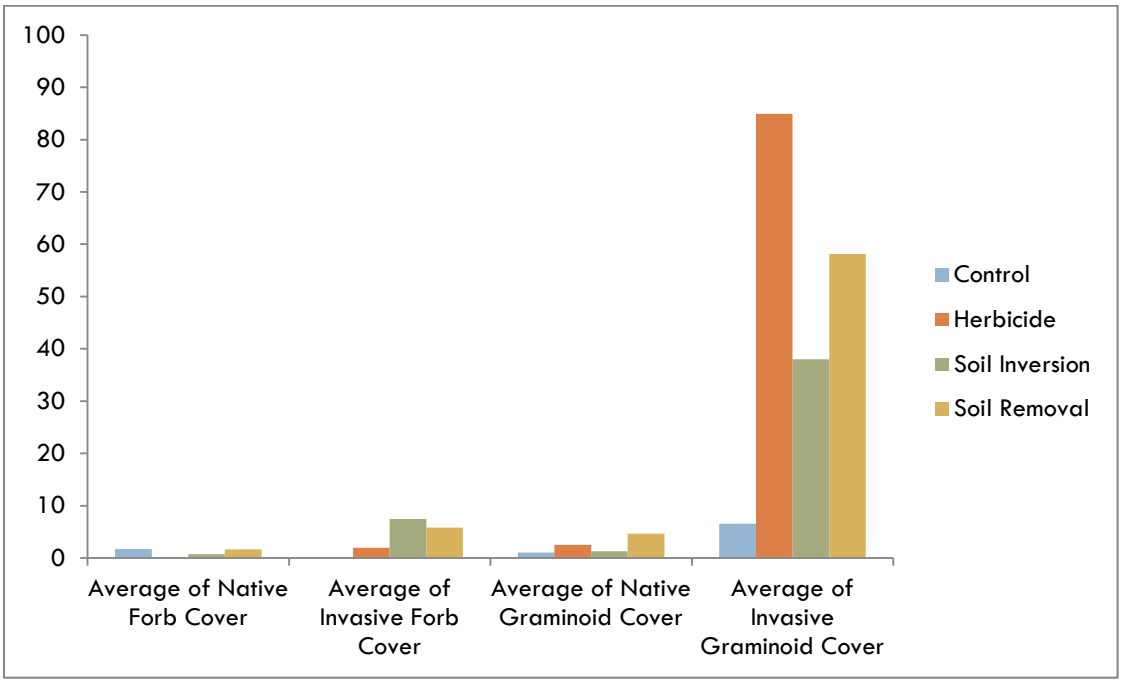


FIGURE 7. COVER OF NATIVE FORB, INVASIVE FORB, NATIVE GRAMINOID, AND INVASIVE GRAMINOID AT NPS YEON PROPOERTY IN 2015.

NEXT STEPS

Data collection will continue through the 2016 field season at all sites; results will be used to inform restoration efforts at these and similar sites in the Clatsop Plains managed by the NCLC and USFWS. Currently not further treatment(s) are scheduled to allow establishment of seeded species, and determine the successional trajectory of current treatment(s).

LITERATURE CITED

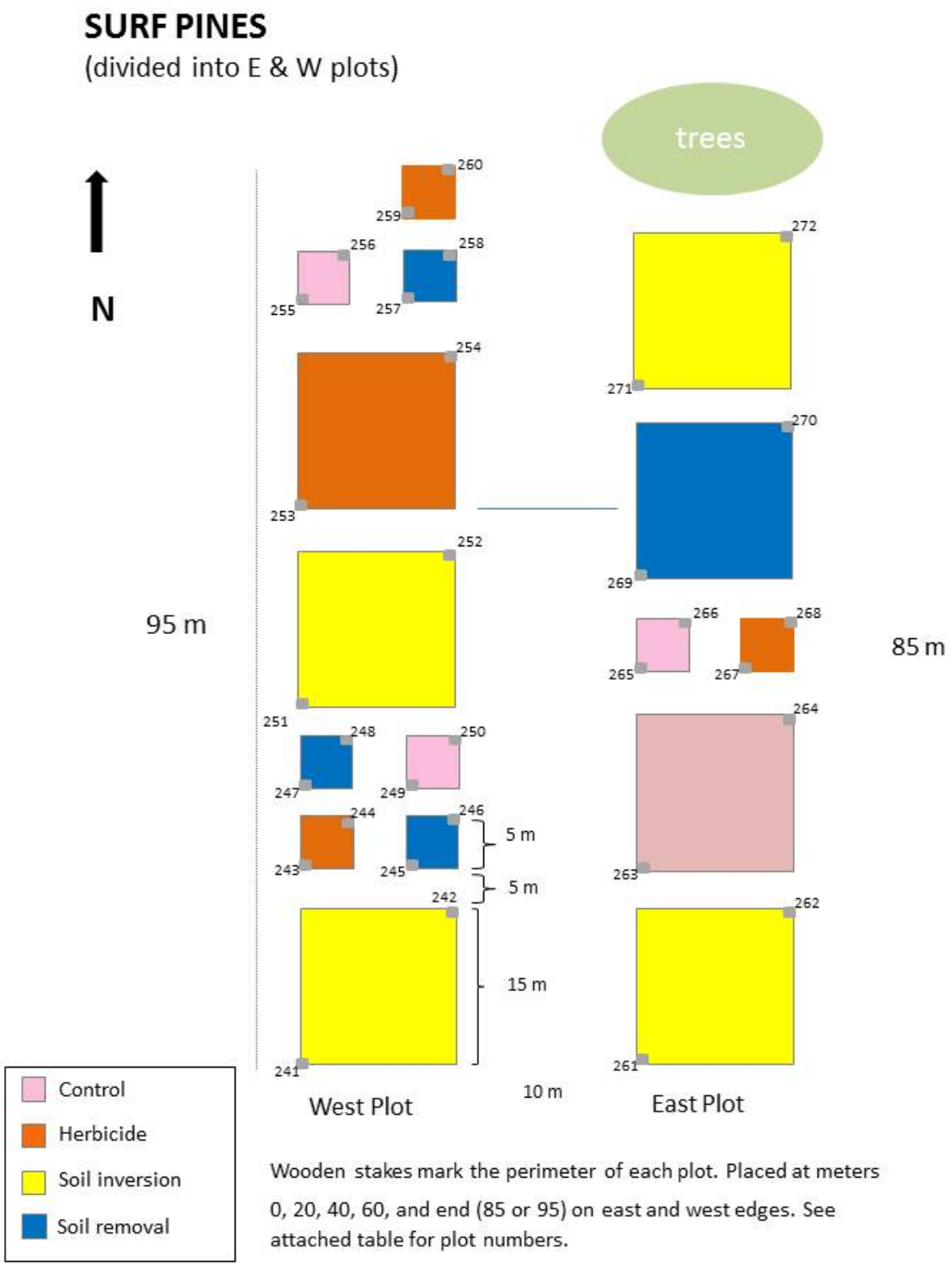
Buisson, E., Holl, K.D., Anderson, S., Corcket, E., Hayes, G.F., Torre, F., Peteers, A., and Dutoit, T. 2006. Effect of seed source, topsoil removal, and plant neighbor removal on restoring California coastal prairies. Restoration Ecology: Vol.14, No. 4, pp. 569-577.

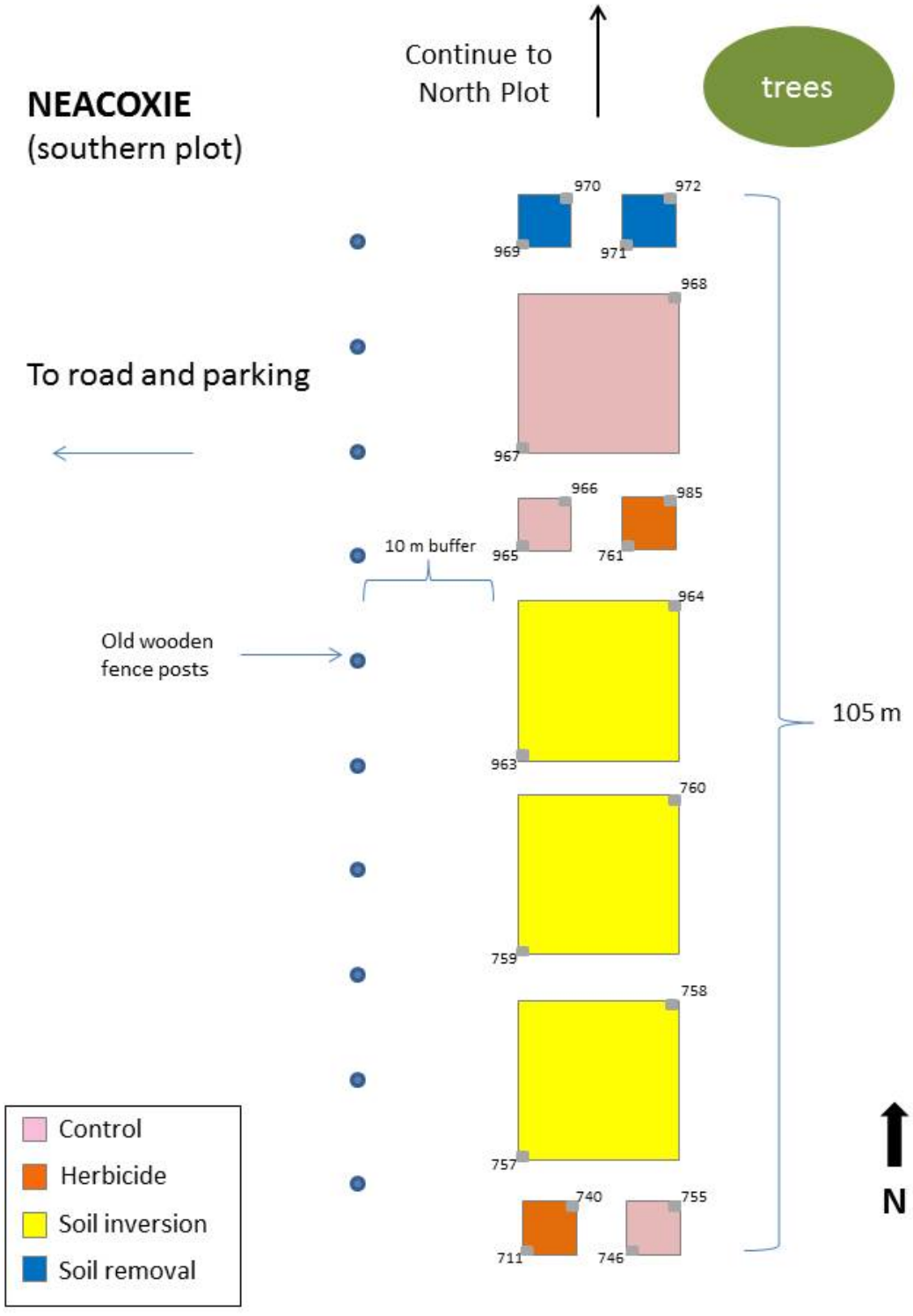
Jones, M.L.M., Norman, K., and Rhind, P.M. 2010. Topsoil inversion as a restoration measure in sand dunes, early results from a UK field-trial. Journal of Coastal Conservation: 14:139-151.

Pickering, D.L., Rudd, N., and Lesh, T. 2006. U.S. Fish and Wildlife Service Clatsop Plains Prairie Research Annual Report – Coastal Program Cooperative Agreement: # 1448-13420-02-J209 & Or. Division of State Lands/USFWS contract # 52210-465. Submitted to USFWS Oregon Fish and Wildlife Office, Portland, OR.

Van Dyke, F., Van Kley, S.E., Page, C.E., and Van Beek, J.G. 2004. Restoration efforts for plant and bird communities in tallgrass prairies using prescribed burning and mowing. Restoration Ecology: Vol.12, No. 4, pp. 575-485.

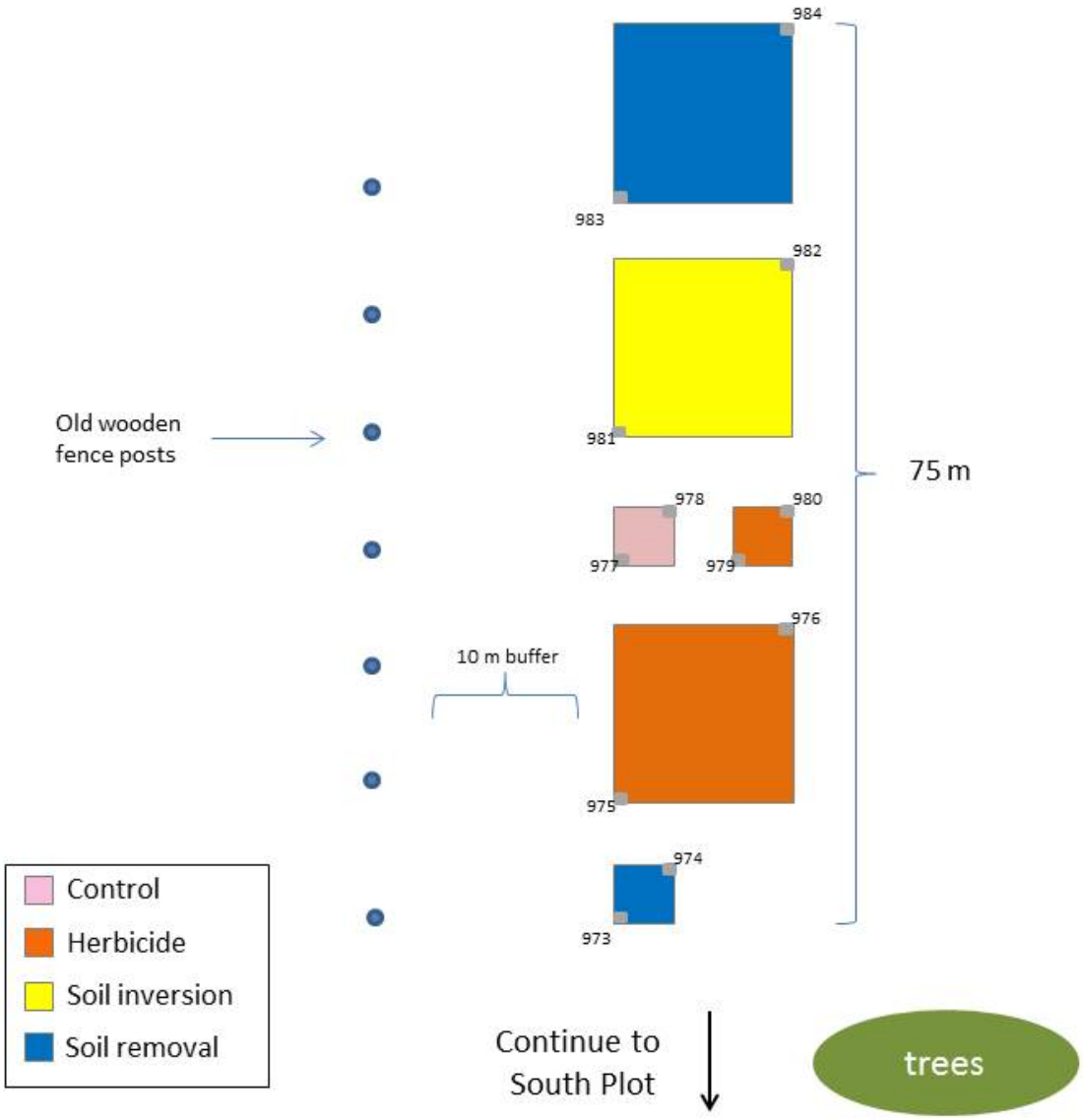
APPENDIX A. SITE MAPS AND PLOT TAG NUMBERS FOR EACH OF THE CLATSOP PLAINS RESTORATION STUDY.

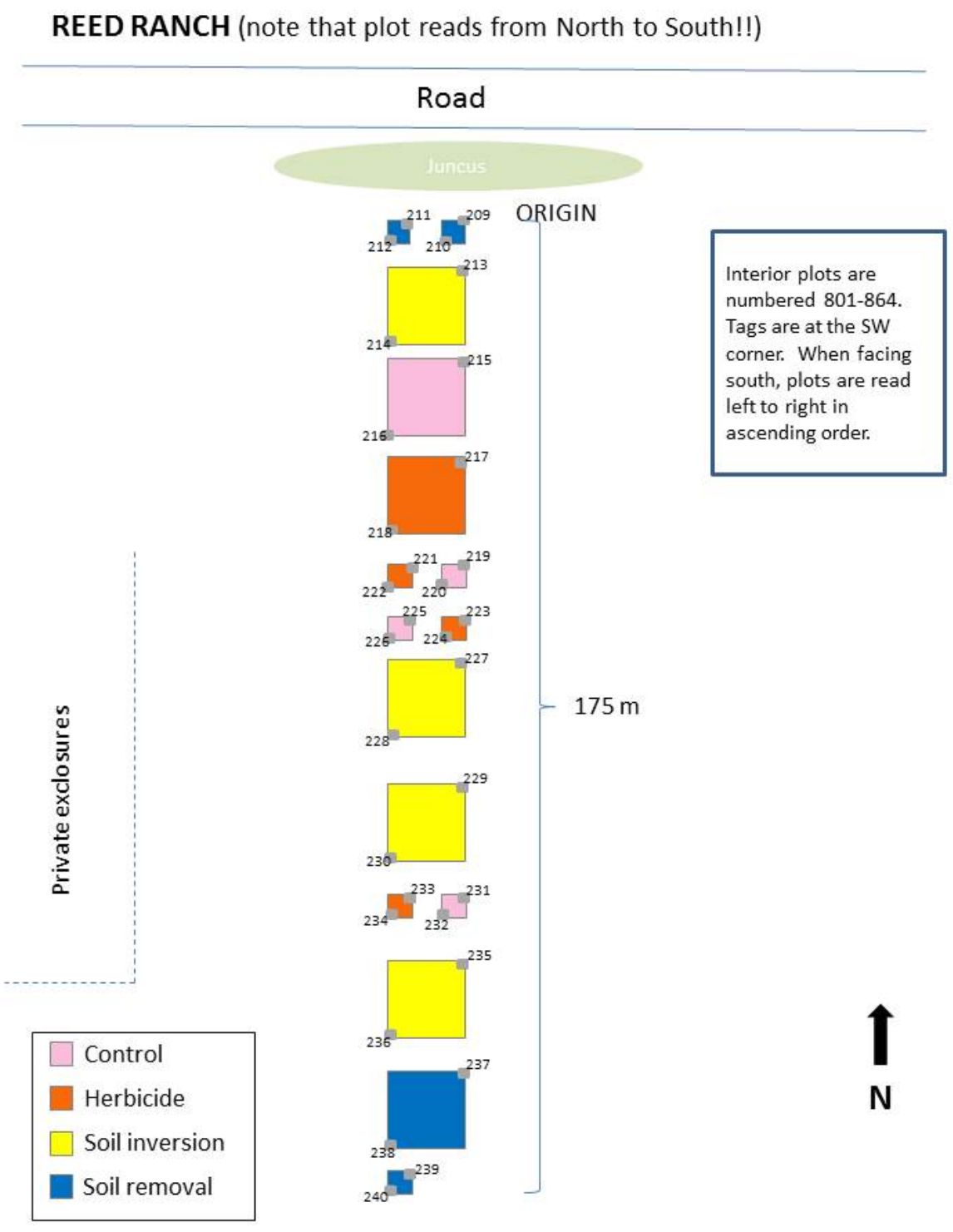


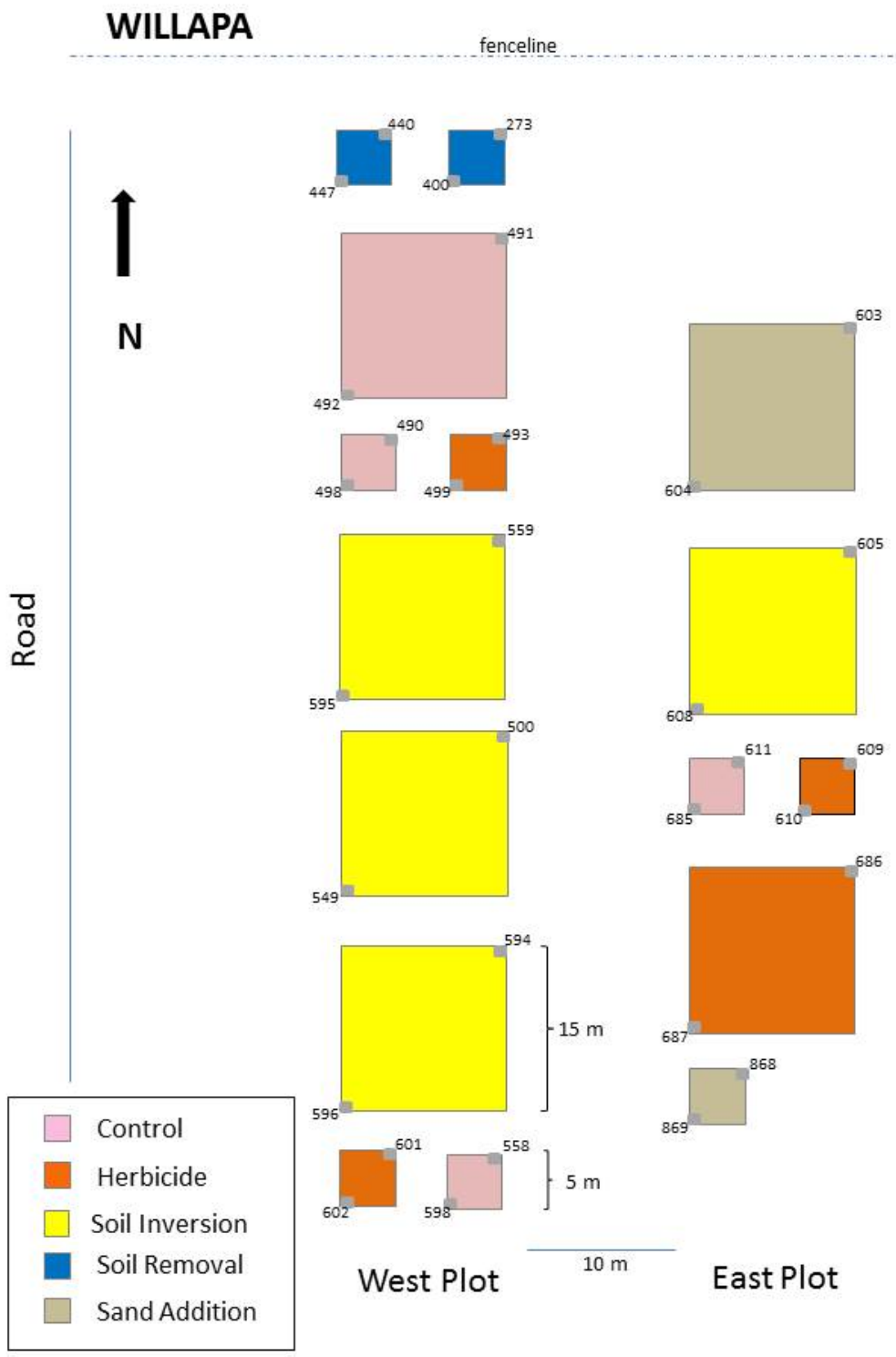

NEACOXIE
(southern plot)
Continue to
North Plot
trees
To road and parking
970
972
969
971
968
967
966
985
965
761
10 m buffer
964
Old wooden
fence posts
963
105 m
760
759
758
757
740
755
711
746
N
Control
Herbicide
Soil inversion
Soil removal

NEACOXIE
(northern plot)

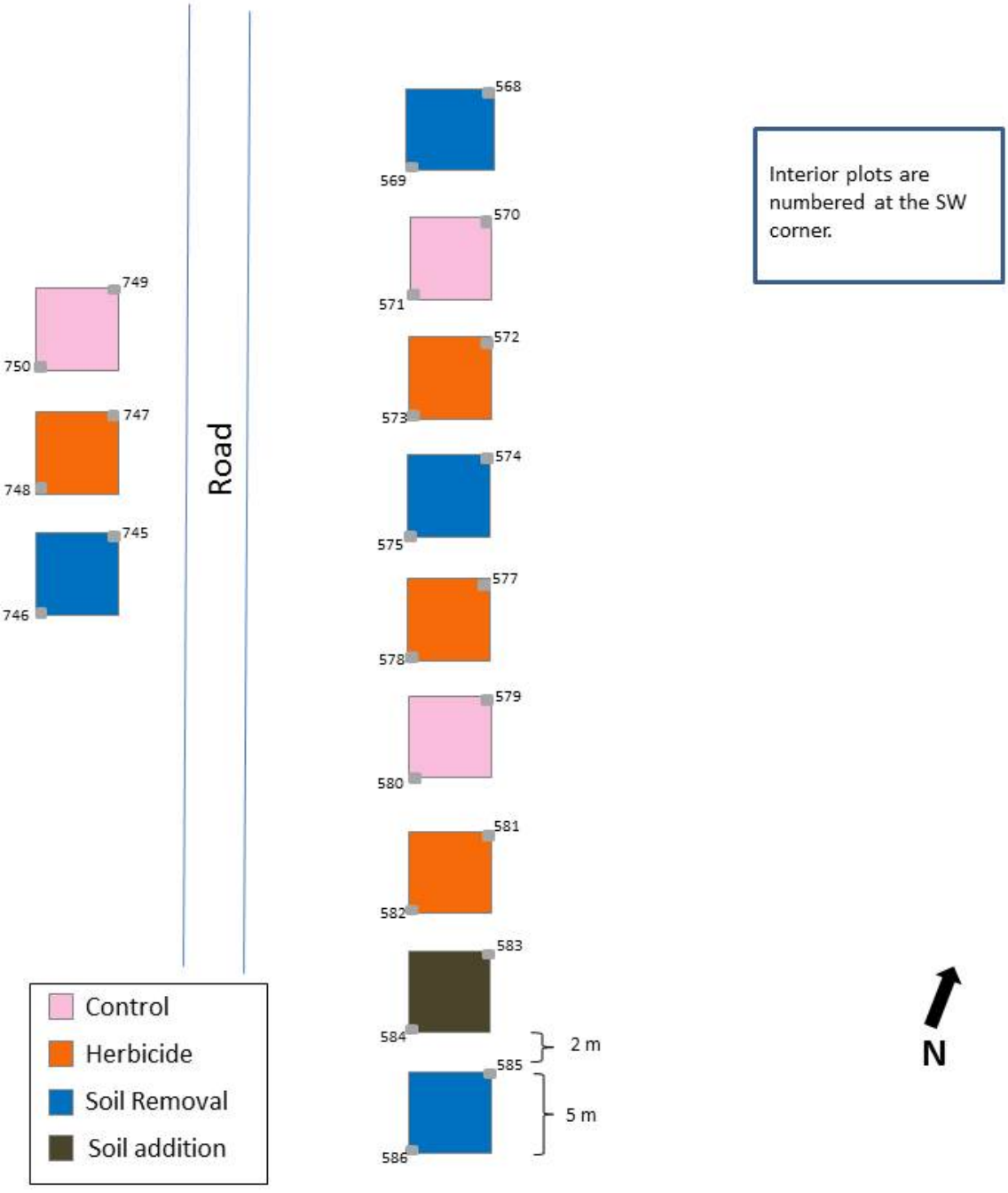
Wooden stakes mark the perimeter of each plot. They are placed at meters 0, 25, 50, 75, and 105 (south plot)




REED RANCH (note that plot reads from North to South!!)
Road
Juncus
ORIGIN
211
209
212
210
213
214
215
216
217
218
221
219
222
220
225
223
226
224
227
228
229
230
233
231
234
232
235
236
237
238
239
240
175 m
Interior plots are numbered 801-864. Tags are at the SW corner. When facing south, plots are read left to right in ascending order.
Private exclosures
Control
Herbicide
Soil inversion
Soil removal
N


WILLAPA
fenceline
N
Road
440
273
447
400
491
492
603
604
490
493
498
499
559
595
605
608
500
549
611
609
685
610
686
687
594
596
15 m
868
869
601
558
602
598
5 m
10 m
West Plot
East Plot
Control
Herbicide
Soil Inversion
Soil Removal
Sand Addition

Yeon Proerty (note that plot reads from North to South!!)



APPENDIX B. AVERAGE COVER OF ALL SPECIES OBSERVED AT COASTAL PRAIRIE RESTORATION SITES IN 2013

	Surfpines	Neacoxie	Reed Ranch	Willapa	Yeon
Bare	0.4	0.6	0.4	1.2	0.0
Moss/lichen	12.4	3.0	0.4	24.1	15.9
Litter	79.3	81.9	84.1	68.0	20.0
Graminoids					
Agrostis alba	21.1	52.3	3.2	27.0	41.1
Ammophilia arenaria	0.0	0.0	0.0	0.0	22.3
Ammophilia breviligulata	0.0	0.0	0.0	0.0	32.2
Anthoxanthum odoratum	27.7	29.1	20.5	32.9	15.4
Bromus hordeaceous	0.5	3.6	33.0	0.0	0.0
Carex panza	0.1	0.0	0.3	0.1	0.0
Carex scoparia	0.0	0.0	0.0	0.2	0.0
Dactylis glomeratum	5.1	11.4	10.2	0.1	1.3
*Danthonia californica**	0.0	0.0	0.0	0.0	0.0
Festuca arundinacea	20.8	12.9	10.0	0.2	5.0
Festuca rubra	0.0	4.2	1.0	12.9	29.7
Holcus lanatus	0.4	0.3	1.5	7.2	12.3
Juncus sp.	0.7	0.7	0.6	0.1	0.0
Lotus micranthos	0.0	0.0	1.8	0.0	0.0
*Luzula comosa**	0.0	0.0	0.0	0.0	0.0
Phleum pratense *	0.0	0.0	0.0	0.0	0.0
Vulpia sp.*	0.0	0.0	0.0	0.0	0.0
Forbs					
Achillea millefolium	0.0	0.0	0.0	0.0	0.0
Brassica (slender sil.)*	0.0	0.0	0.0	0.0	0.0
Brassica sp (rounder sil.)*	0.0	0.0	0.0	0.0	0.0
Cerastium arvense	0.1	0.0	0.1	0.0	0.0
*Cerastium fontanum**	0.0	0.0	0.0	0.0	0.0
Cerastium glomeratum	0.1	0.0	0.0	0.0	0.0
*Centaurium**	0.0	0.0	0.0	0.0	0.0
Cirsium vulgare	0.2	0.0	0.0	0.0	0.0
*Crepis setosa**	0.0	0.0	0.0	0.0	0.0
Erodium cicutarim	0.0	0.0	0.1	0.0	0.0
Equisetem sp.	0.1	0.1	0.0	0.0	1.8
Fragaria sp.	0.0	0.0	0.0	0.0	7.5
*Galium aparine**	0.0	0.0	0.0	0.0	0.0
Geranium dissectum	0.2	0.1	4.9	0.0	0.0
Hypochaeris radicata	15.5	9.9	11.1	25.1	6.3

Leucanthemum vulgare	0.0	0.1	0.0	0.0	0.0
Lotus corniculatus	0.0	0.0	0.0	10.0	0.0
Lupinus sp.	0.0	0.0	0.0	0.0	1.7
Myosotis discolor	0.0	0.5	0.2	0.0	0.0
*Parentucellia viscosa**	0.0	0.0	0.0	0.0	0.0
Plantago lanceolata	0.0	0.0	0.9	6.1	3.5
Polystichum munitum	0.0	0.0	0.0	0.0	4.0
Pteridium aquilinum	0.0	0.4	0.0	0.0	0.0
Ranunculus occidentalis	1.9	1.7	1.0	0.5	0.0
Rumex acetosella	0.8	1.2	2.6	1.3	5.4
Senecio jacobea	0.0	0.1	0.6	0.0	0.0
Sisyrnchium sp.*	0.0	0.0	0.0	0.0	0.0
Solidago sp. *	0.0	0.0	0.0	0.0	0.0
Stellaria sp. *	0.0	0.0	0.0	0.0	0.0
Tanacetum sp.*	0.0	0.0	0.0	0.0	0.0
Taraxacum officinale	0.1	0.1	0.0	0.3	0.0
Trifolium dubium	0.2	0.0	2.5	2.5	0.0
Trifolium repens	0.0	0.0	0.0	3.1	0.0
Tryphysaria pusilla	0.0	0.0	0.6	0.0	0.0
Veronica americana	0.7	0.4	2.7	0.0	0.0
Vicia sativa	0.0	0.0	5.2	0.0	0.9
Vicia tetrasperma	0.0	0.0	0.3	0.0	0.0
Viola adunca	0.0	0.0	0.1	0.0	0.0
Shrubs					
Amalenchier sp.*	0.0	0.0	0.0	0.0	0.0
Cytisus scoparius	11.0	0.0	0.3	0.0	3.8
Rosa sp.	0.0	0.1	0.0	0.0	8.8
Rubus armeniacus	0.0	1.4	0.0	0.0	0.0
Rubus ursinus	0.0	0.0	0.0	0.0	3.7

*Species present, but <0.1% cover.

APPENDIX C. TREATMENT AND IMPLEMENTATION SCHEDULES BY SITE THROUGH SPRING 2015.

General Treatment Schedule for the Clatsop Plains Restoration Study

			Herbicide Treatment (Fall 2013 Imazapyr + Spring 2014 Glyphosate + Fall 2014 Glyphosate)	**Soil Inversion** (Fall 2014 Soil Inversion)	**Soil Removal** (Fall 2014 Soil Removal)	**(Sand Addition*)** (Addition of dune sand to plots below water table in 2014*Willapa Only)
2013	Spring	June	Mow Monument Monitor	Mow Monument Monitor	Mow Monument Monitor	Mow Monument Monitor
	Fall	September October	Mow Imazapyr	Mow -	Mow -	Mow -
2014	Spring	April April May May/June	- Qualitative Monitor Mow Glyphosate	- Qualitative Monitor Mow -	- Qualitative Monitor Mow -	- Qualitative Monitor Mow -
	Fall	September September October November	Mow - Glyphosate Seed	Mow Invert Soil - Seed	Mow Remove soil - Seed	Mow Remove Soil - Seed
2015	Spring	May/June June	- Monitor Mow	- Monitor Mow	- Monitor Mow	Sand addition Monitor Mow

Willapa Wildlife Refuge, OSB Field 3

			Herbicide Treatment (Fall 2013 Imazapyr + Spring 2014 Glyphosate + Fall 2014 Glyphosate)	**Soil Inversion** (Fall 2014 Soil Inversion)	**Soil Removal** (Fall 2014 Soil Removal)	**(Sand Addition*)** (Filled soil removal plots that were below water table)
2013	Spring	June	Mow Monument Monitor	Mow Monument Monitor	Mow Monument Monitor	Mow Monument Monitor
	Fall	September October	Mow Imazapyr	Mow -	Mow -	Mow -
2014	Spring	April April May May/June	- Qualitative Monitor Mow Glyphosate	- Qualitative Monitor Mow -	- Qualitative Monitor Mow -	- Qualitative Monitor Mow -
	Fall	September September October November	Mow - Glyphosate Seed	Mow Invert Soil - Seed	Mow Remove soil - Seed	Mow Remove Soil - Seed
2015	Spring	May/June June	- Monitor Mow	- Monitor Mow	- Monitor Mow	Sand addition Monitor Mow

Neacoxie Forest (NCLC)

			Herbicide Treatment	Soil Inversion	Soil Removal
			(Fall 2013 Imazapyr + Spring 2014 Glyphosate + Fall 2014 Glyphosate)	(Fall 2014 Soil Inversion)	(Fall 2014 Soil Removal)
2013	Spring	5/29/2013	Mow Monument Monitor	Mow Monument Monitor	Mow Monument Monitor
	Fall	September October	Mow Imazapyr	Mow -	Mow -
2014	Spring	April April May May/June	- Qualitative Monitor Mow Glyphosate	- Qualitative Monitor Mow -	- Qualitative Monitor Mow -
	Fall	September September October	Mow - Glyphosate	Mow Invert Soil -	Mow Remove soil -
2015	Spring	May/June June	Monitor Mow	Monitor Mow	Monitor Mow

Surf Pines (NCLC)

			Herbicide Treatment (Fall 2013 Imazapyr + Spring 2014 Glyphosate + Fall 2014 Glyphosate)	Soil Inversion (Fall 2014 Soil Inversion)	Soil Removal (Fall 2014 Soil Removal)
2013	Spring	5/22/2013	Mow Monument Monitor	Mow Monument Monitor	Mow Monument Monitor
	Fall	September October	Mow Imazapyr	Mow -	Mow -
2014	Spring	April April May May/June	- Qualitative Monitor Mow Glyphosate	- Qualitative Monitor Mow -	- Qualitative Monitor Mow -
	Fall	September September October	Mow - Glyphosate	Mow Invert Soil -	Mow Remove soil -
2015	Spring	May/June June	Monitor Mow	Monitor Mow	Monitor Mow

Reed Ranch (NCLC)

			Herbicide Treatment	Soil Inversion	Soil Removal
			(Fall 2013 Imazapyr + Spring 2014 Glyphosate + Fall 2014 Glyphosate)	(Fall 2014 Soil Inversion)	(Fall 2014 Soil Removal)
2013	Spring	5/21/2013	Mow Monument Monitor	Mow Monument Monitor	Mow Monument Monitor
	Fall	September October	Mow Imazapyr	Mow -	Mow -
2014	Spring	April April May May/June	- Qualitative Monitor Mow Glyphosate	- Qualitative Monitor Mow -	- Qualitative Monitor Mow -
	Fall	September September October	Mow - Glyphosate	Mow Invert Soil -	Mow Remove soil -
2015	Spring	May/June June	Monitor Mow	Monitor Mow	Monitor Mow

Yeon (NPS)

** Soil Removal (and addition) Treatment(s) not included here

			Herbicide Treatment (Fall 2013 Imazapyr + Spring 2014 Glyphosate + Fall 2014 Glyphosate)	**Soil Inversion** (Fall 2014 Soil Inversion)
2013	Spring	June	Mow Monument Monitor	Mow Monument Monitor
	Fall	September October	Mow Imazapyr	Mow -
2014	Spring	April April May May/June	- Qualitative Monitor Mow Glyphosate	- Qualitative Monitor Mow -
	Fall	September September October	Mow - Glyphosate	Mow Invert Soil -
2015	Spring	May/June June	Monitor Mow	Monitor Mow