

# *Abronia umbellata* ssp. *breviflora* on the Oregon coast: Reintroduction and population monitoring



2016

Report to the Bureau of Land Management, and USDA  
Forest Service

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## PREFACE

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



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**Cover photograph:** Pink sand verbena (*Abronia umbellata* ssp. *breviflora*).

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# TABLE OF CONTENTS

<b>PREFACE</b> .....	<b>II</b>
<b>ACKNOWLEDGEMENTS</b> .....	<b>III</b>
<b>TABLE OF CONTENTS</b> .....	<b>IV</b>
<b>LIST OF FIGURES</b> .....	<b>VI</b>
<b>LIST OF TABLES</b> .....	<b>VII</b>
<b>EXECUTIVE SUMMARY</b> .....	<b>VIII</b>
<b>INTRODUCTION</b> .....	<b>1</b>
<b>METHODS</b> .....	<b>3</b>
Seed Source.....	3
Direct Seeding.....	3
Population Surveys.....	3
Coos Bay North Spit.....	4
Seeded Transects.....	4
Plant Measurements.....	4
Overwintering Plants.....	6
Substrate Assessment.....	6
<b>RESULTS</b> .....	<b>9</b>
Population Surveys.....	9
General Trend.....	9
Siuslaw National Forest.....	9
Siltcoos Creek.....	9
Tahkenitch Creek.....	10
Overlook North and South.....	11
Bureau of Land Management.....	14
Coos Bay North Spit.....	14
New River ACEC.....	18
Plant Measurements.....	21
Plant Size and Reproductive Effort.....	21
Plant Density.....	21
Plant Community.....	21
Substrate Assessments.....	23
<b>DISCUSSION</b> .....	<b>24</b>
Transplanting.....	24
Seeding.....	24
Importance of a seedbank.....	25
Plant Measurements.....	26
Substrate Assessments.....	26

<b>ADDITIONAL RESEARCH .....</b>	<b>26</b>
Population modeling to assess recovery objectives.....	26
Restoration with additional beach species.....	27
Hypotheses for Future Research.....	27
<b>RECOMMENDATIONS FOR 2017 .....</b>	<b>30</b>
<b>LITERATURE CITED .....</b>	<b>31</b>
<b>APPENDIX I. MATERIALS REQUIRED FOR POPULATION MONITORING .....</b>	<b>33</b>
<b>APPENDIX II. SURVEY RESULTS FOR SEEDED AND NATURAL POPULATIONS.....</b>	<b>34</b>
<b>APPENDIX III. MAPS OF SELECTED SITES- SEEDED OR MONITORED.....</b>	<b>44</b>
New River.....	44
Overlook North and South .....	45
Siltcoos .....	46
Tahkenitch.....	47

## LIST OF FIGURES

Figure 1. Pink sand-verbena (*Abronia umbellata* ssp. *breviflora*; (from Hitchcock et al 1964)

Figure 2. Historic and current distribution of pink sand-verbena (*Abronia umbellata* subsp. *breviflora*) in Oregon.

Figure 3. In 2009, the populated area was divided into three section, 1) the original habitat (southeast), 2) northeast and 3) west of the Foredune Road. Each area was subsampled using the methods described in the text.

Figure 4. Population trends and seeding history at Siltcoos Creek, 1996 – 2016. An erosion event in the winter of 2012/2013 resulted in significant loss of habitable habitat, thus the decrease in seeding effort and the number of plants observed at the site.

Figure 5. Population trends and seeding history of pink sand verbena at Tahkenitch Creek from 2001-2016.

Figure 6. Population trends and seeding history of pink sand verbena at North Overlook site, 2000-2016.

Figure 7. Population trends and seeding history of pink sand verbena at South Overlook site, 2000-2016. \* South Overlook was not surveyed in 2008, however it was seeded.

Figure 8. Population trends at the Coos Bay North Spit reintroduction site. The area was seeded in January 1997 with 50,000 seeds from Port Orford. Population size estimates for 1997-1999 are complete censuses of all plants in the population, while those from 2000-2008 are estimated from a subsample of a reference area and census of the remainder of the population. The error bars for 2000-2008 estimates represent 95% confidence intervals. \*In 2008, an estimate of the entire population size was not possible because over 50% of the population had been disced prior to our surveys. See text for a discussion of population trends. In 2009, the sampling methods were modified so that the entire population was sub-sampled (and no areas censused). In this chart the CI for 2009-2016 are not reported because the population estimate is a combination of 3 different populations, each with their own CI.

Figure 9. Average size of plants on the Coos Bay North Spit from 2012-2016.

Figure 10. Density of plants per m<sup>2</sup> at the Coos Bay North Spit from 2009-2016. the decrease in all areas from 2012-2013 coincided with lack of habitat management.

Figure 11. Population trends and seeding history of pink sand verbena at the New River ACEC reintroduction site. Seeding has been conducted in all years except 1998.

Figure 12. Nearly all plants in 2015 at New River were found against the back of the dune in an area that had been overwashed. The area circled in red had hundreds of small pink sand verbena plants, as compared to the single, large reproductive plant in the foreground.

Figure 13. Average Length of longest branch vs. pH of substrate samples collected in 2012 and 2015. Note that extreme pH values (both high and Low) generally are smaller.

Figure 14. The percent of seeds stored from 0-9 years. The equation for the linear regression is  $y = -0.03x + 0.955$ ,  $R^2 = 0.81$ ,  $P = 0.015$ .

## LIST OF TABLES

Table 1. Reintroduction sites for the Coos Bay BLM District, methods used, and habitats for seeding and transplanting efforts discussed in this report. Seedlings reported here all involved the use of 50,000 seeds per site, except where noted.

Table 2. Reintroduction sites of the Siuslaw National Forest, methods used, and habitats for seeding and transplanting efforts discussed in this report. Seedlings reported here all involved the use of 50,000 seeds per site except where noted.

Table 3. Average length of longest stem, number of inflorescences and density of plants at all sites monitored in 2012. Detailed measurements were not taken at all sites in subsequent years and are listed in Table 4.

Table 4. Average size of plants and number of flowers in 2012-2016 at select sites. “-“ indicates data was not collected in that year.

Table 5. Average, Sum and Count of Plant Species within 0.5m of Randomly Selected pink sand-verbena plants in 2012-2016 at the Coos Bay North Spit. Names in Bold indicate native species. \*Because it is difficult to Distinguish between individuals of both American and European Beachgrass, Presence/Absence only was noted.

Table 6. Range and average pH at select sites monitored in 2012 and 2015. Note that the sand from the areas with cover of shell greater than 5% had the highest pH.

Table 7. Plant species native to Oregon beaches and dunes that are candidates for use in ecosystem restoration projects. More information is needed on techniques for germination and propagation of these taxa.

Table 8. Results of surveys for pink sand-verbena at Coos Bay District Bureau of Land Management sites along the Oregon Coast. IAE conducted surveys from 2000-2012. Population data for years prior to 2000 are from various sources.

Table 9. Results of surveys for pink sand-verbena sites managed by the Siuslaw National Forest along the Oregon Coast. IAE conducted surveys from 2000-2012. Population data for years prior to 2000 are from various sources.

Table 10. Results of surveys for pink sand-verbena sites managed by the Oregon Department of Parks and Recreation along the Oregon Coast. IAE conducted surveys from 2000-2012. Population data for years prior to 2000 are from various sources.

Table 11. Results of surveys for pink sand-verbena sites managed by the USFWS along the Oregon Coast. IAE conducted surveys from 2009-2012.

Table 12. Results of surveys for pink sand-verbena sites along the Oregon Coast managed by various land managers including the State Parks Department. IAE conducted surveys from 2000-2012. Population data for years prior to 2000 are from various sources.

## EXECUTIVE SUMMARY

Pink sand-verbena (*Abronia umbellata* ssp. *breviflora*) is listed as endangered by the Oregon Department of Agriculture, and a Species of Concern by the U.S. Fish and Wildlife Service. Since the late 1970's, the number of natural populations in Oregon has decreased by approximately 50% (~10 to ~5). The primary threats to the species include competition from European beachgrass (*Ammophila arenaria*) and other weedy beach species, and other human-influenced habitat changes.

This report includes information about pink sand-verbena research along the Oregon coast since 1997, including seeding and transplantation experiments, and population monitoring at several beach and dune habitats.

In 2016 our actions and observations included activities at the sites listed below:

1. USDA Forest Service, Siuslaw National Forest sites
  - a. Tahkenitch: ~80,000 seeds were distributed at Tahkenitch in 2016, resulting in a total of 141 plants (76 reproductive). This was the sixth seeding at the site since 2005. In 2014-2016, seeding was focused in the southern 1/3 of the site, as this was the area that had been most successful in previous years.
  - b. Siltcoos Creek: ~53,000 seeds were distributed in the habitat still present at the site and 427 plants (330 reproductive) were found in the fall of 2016. Natural disturbance at the site in 2011 resulted in the erosion of more than 80% of the area occupied by *A. umbellata* ssp. *breviflora* in the 2010-11 growing season. Despite the significant loss of habitat several plants were present in 2012-2015, and in 2016 the site had rebounded to 427 plants (330 reproductive). Continued seeding is recommended for the site to maintain a seedbank as the habitat re-establishes.
  - c. Overlook: Despite substantial decreases in this population in 2014 and again in 2015, this population is now the second largest in Oregon and we strongly recommend continued beachgrass control and seed addition. In 2016, both Overlook sites increased from 2015 numbers; however remained relatively low for the history of the site.
    - i. North: ~63,000 seeds were distributed, resulting in 269 plants (158 reproductive)
    - ii. South: ~60,000 seeds were distributed resulting in 614 plants (375 reproductive).
2. USDI Bureau of Land Management, Coos Bay District sites
  - a. New River: ~100,000 seeds were distributed by BLM staff, resulting in just 108 plants (30 reproductive). This represents a substantial decrease from previous years, particularly 2015. In 2016, as in previous years (2012-2015), most plants were found in areas where breaks in the foredune had allowed overwash to occur-- highlighting the affinity of pink sand-verbena for areas with repeated disturbance (and possibly nutrient input). Continued seeding at the site to augment the existing seed bank, and management in the form of continued European beachgrass control, as well as control of other non-native species including *Hypochaeris radicata*, *Cakile maritima*, and *Rumex acetosella*, will be vital in maintaining suitable coastal dune habitat for this and other dune species.
  - b. Coos Bay North Spit: ~100,000 seeds were distributed by BLM staff. In 2016, it is estimated that there are approximately 306,000 pink sand-verbena plants on the Coos Bay North Spit. Over the course of this study, we have seen an increase in the number and diversity of weed species at this site. This is likely due to soil formation related to sand stabilization and the lack of overwash and salt-spray in the area that contribute to natural soil formation processes on this coastal dune. Without natural disturbance on the site, management to reduce beachgrass includes discing at least annually. There was a



precipitous drop in the population when beach grass management was discontinued for just one year in 2013 in the southern portion of the population; this portion of the population rebounded when discing resumed in 2014-2016.

In 2016 we observed increases from 2014 in nearly all populations monitored, however 2013 and 2014 had some of the lowest values ever recorded for each site. In those years, many sites monitored not only had fewer plants, but plant measurements of reproductive individuals were also smaller plants with fewer flowers/infructescences.

As in previous years, competition from European beachgrass continues to be a major factor in the success of pink sand-verbena populations. At the Coos Bay North Spit, other weeds including *Cakile* spp., *Hypochaeris radicata* and *Rumex acetosella* also compete for habitat.

The population of pink sand verbena on the Coos Bay North Spit is the largest known population in Oregon and currently the only population large enough to provide significant quantities of seed for restoration of the species. Continued management of the population is key to the success of this disturbance dependent species across its range in Oregon.

# Abronia umbellata ssp. breviflora on the Oregon coast: Reintroduction and population monitoring

REPORT TO THE BUREAU OF LAND MANAGEMENT AND USDA FOREST SERVICE

## INTRODUCTION

Pink sand-verbena (*Abronia umbellata* ssp. *breviflora*; Figure 1) is listed by the Oregon Department of Agriculture as endangered, and it is considered a Species of Concern by the U.S. Fish and Wildlife Service. Historically, the species was known from beaches along the Pacific Coast from Vancouver Island (British Columbia) south to northern California. Until two plants were discovered in Willapa Bay in 2006, the species had been believed to be extinct in Washington. In 2000, a small population (two plants) was rediscovered on Vancouver Island, but this population did not re-establish in subsequent years. Since the late 1970's, the number of natural populations in Oregon has dwindled from around ten down to about five (Figure 2). The primary threats to the species include, the stabilization of dunes across the Pacific Northwest coast, competition from non-native species including (but not limited to) European beachgrass (*Ammophila arenaria*) and to a lesser extent European searocket (*Cakile maritima*), American searocket (*Cakile edentula*), as well as habitat disturbance by off road vehicles and the unknown effects of climate change.

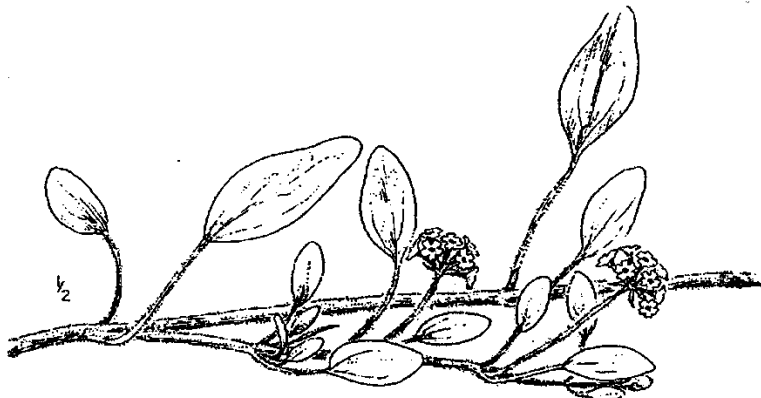


FIGURE 1. PINK SAND-VERBENA (*ABRONIA UMBELLATA* SPP. *BREVIFLORA*); (FROM HITCHCOCK ET AL 1964)

The decline of pink sand-verbena along the coast is correlated with the reduction in number of many beach species, including native plants and wildlife. For example, the Western Snowy Plover has suffered a well-documented decline (Oregon Department of Fish and Wildlife 1994) that parallels that of pink sand-verbena. There is some historical evidence that snowy plovers used native vegetation, specifically sand-verbenas, for foraging and cover (Gabrielson and Jewett 1970, p.238). Recovery efforts for a variety of these dune species may be most effective if coordinated or combined.

Since the mid-1990's, research has been conducted on methods for reintroduction of pink sand-verbena. Information is still needed on the reintroduction potential of the species in various beach habitats, and an understanding of 'successful' introduction or augmentation sites developed in order to develop a range-wide conservation and recovery plan. The ultimate goal of this reintroduction effort is to support the requirements of a Conservation Strategy (Kaye 2006) and remove the species from the endangered list.

In this report, we summarize recent seeding and monitoring efforts at several beaches and dune habitats along the Oregon coast managed by the US Forest Service and BLM. This report focuses on recent efforts at the Forest Service sites: Tahkenitch Creek, Siltcoos Creek, North and South Overlook); and the Coos Bay District Bureau of Land Management sites, Coos Bay North Spit and New River. Information on additional populations, previous seeding and transplanting efforts at various sites can be found in previous year's reports (Giles-Johson 2014).

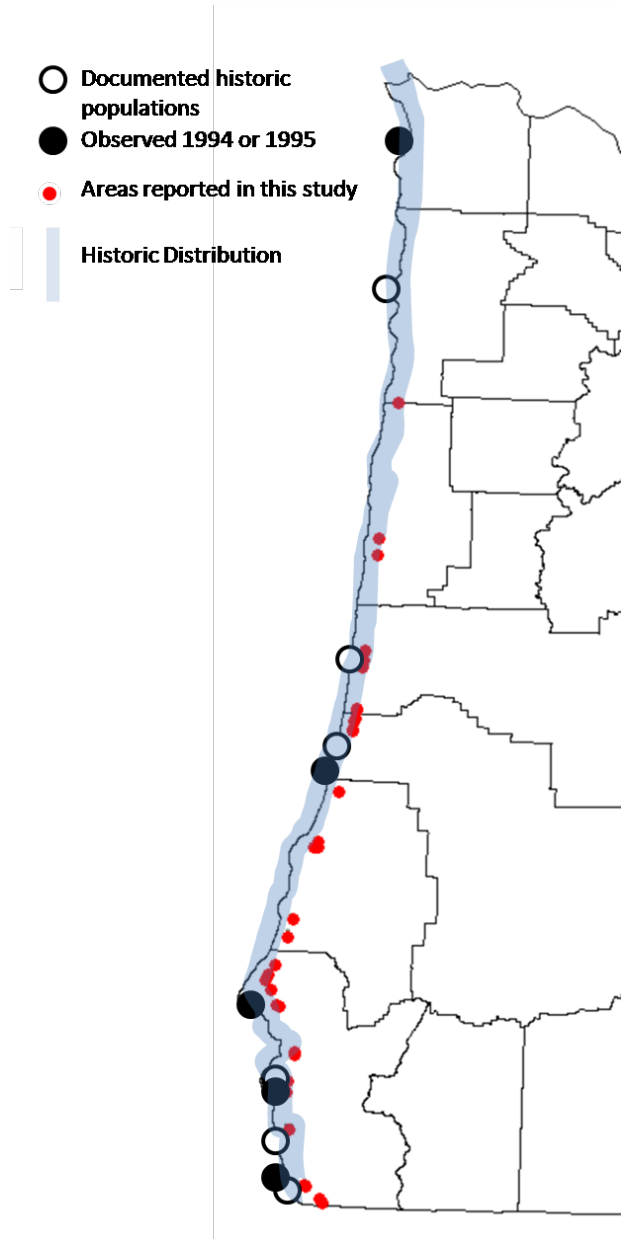


FIGURE 2. HISTORIC AND CURRENT DISTRIBUTION OF PINK SAND-VERBENA (*ABRONIA UMBELLATA* SUBSP. *BREVIFLORA*) IN OREGON.

## METHODS

General seeding and monitoring information is reviewed here. Site-specific information is included with the results of each site, below.

### Seed Source

All of the seed materials manually dispersed to sites in Oregon in 1997 through 2016 were collected from populations at Port Orford (1995-1997) or Coos Bay, Oregon (1999-2016). The pink sand-verbena population at Coos Bay was established from seeds originally collected at Port Orford and are therefore of the same genetic lineage (McGlaughlin et al., 2002). Due to the decline in population size at Port Orford, in 1999 we began collecting seeds at the introduced site at Coos Bay North Spit. Seeds have been collected annually with the exception of 2008 when seed collection was not possible as the Coos Bay North Spit was bulldozed and disced in mid-October prior to fruit set for most individuals. These seeds were also the source for transplants grown in greenhouses at Oregon State University and IAE in Corvallis, Oregon. We use screens to sieve mature fruits from the sand. Fruits are collected from at least 20 areas distributed throughout the population. Immature seeds and areas where non-native species are present are avoided. In 2012 and 2013, seed was collected by BLM staff at the North Spit. In 2014-2016, BLM and IAE staff collected seed. In 2014-2016, seed cleaning included the removal of seeds of weedy species including *Hypochaeris radicata* and *Cakile* spp.

The seeds of pink sand-verbena occur in single-seeded fruits. After collection, fruits were cleaned of residual sand and other foreign material (such as twigs and leaves) and dried. In 1999, groups of 100 fruits were weighed to determine average fruit weight, and groups of 10 fruits were clipped open to determine average seed set. In subsequent years, this information was used to weigh out bags of ~10,000 seeds (154 g) each for dispersal to beaches.

### Direct Seeding

More than 15 sites have been seeded since this project began in 1997 (for information about sites not listed in Table 12, see Kaye and Cramer 2005). Seeded sites were revisited the following late summer/early fall to survey for pink sand-verbena plants.

Pink sand-verbena fruits were scattered in February through early April of each year by hand by walking along the beach and slowly releasing handfuls of material until all were dispersed.

### Population Surveys

Beginning in 2000 we started surveying known pink sand-verbena habitat. Sites were selected based on population and reintroduction history, as well as time limitations. When populations were found, we documented the number of reproductive and vegetative individuals, and occasionally, measurements of plant size [length of the longest stem, longest width, and perpendicular width (see below)]. In large populations we only counted reproductive plants. Because pink sand-verbena is an annual, vegetative plants do not contribute to future populations. In 2009, due to the increase in the population size at the Coos Bay North Spit, sampling was modified so that the habitable area is divided into three sections and each is sub-sampled and the population size estimated; these methods are discussed in more detail below.

## Coos Bay North Spit

In 2009, the population at Coos Bay North Spit had expanded such that a census of the habitat (as performed from 2000-2008) was no longer feasible. We divided the occupied habitat into three sections and sub-sampled within each area counting only reproductive plants. The three areas included 1) the original habitat (Southeast) which includes the reference area used in population counts from 2000-2008 as well as part of the areas censused, 2) the area West of the foredune road, and 3) the area to the north of the original reference area. Starting points for 100m transects were randomly selected within the 3 areas, and sampled as in 2000-2008, counting only reproductive individuals within 1 meter of either side of the tape. In 2012 in the southeast 38 transects were monitored, in the west 20 transects were monitored and in the north 13 transects were monitored. (To see details of sampling methods in previous years, see Thorpe 2009).

The total population size was estimated by multiplying the average number of plants per 100 m x 2 m plot ( $\theta$ ) by the total number of possible plot locations ( $N$ ):

$$\text{population size estimate} = \theta * N$$

In addition, a 95% confidence interval for this estimate was calculated as:

$$95\% \text{ confidence interval} = \bar{X} [1.96 * \pi(N^2 * SE_0^2 * (N-n/N))$$

where  $SE_0$  is the standard error of the mean plot density and  $N-n/N$  is the finite population correction factor, which is applied because the population area ( $N$ ) is of limited size (not infinite or extremely large).

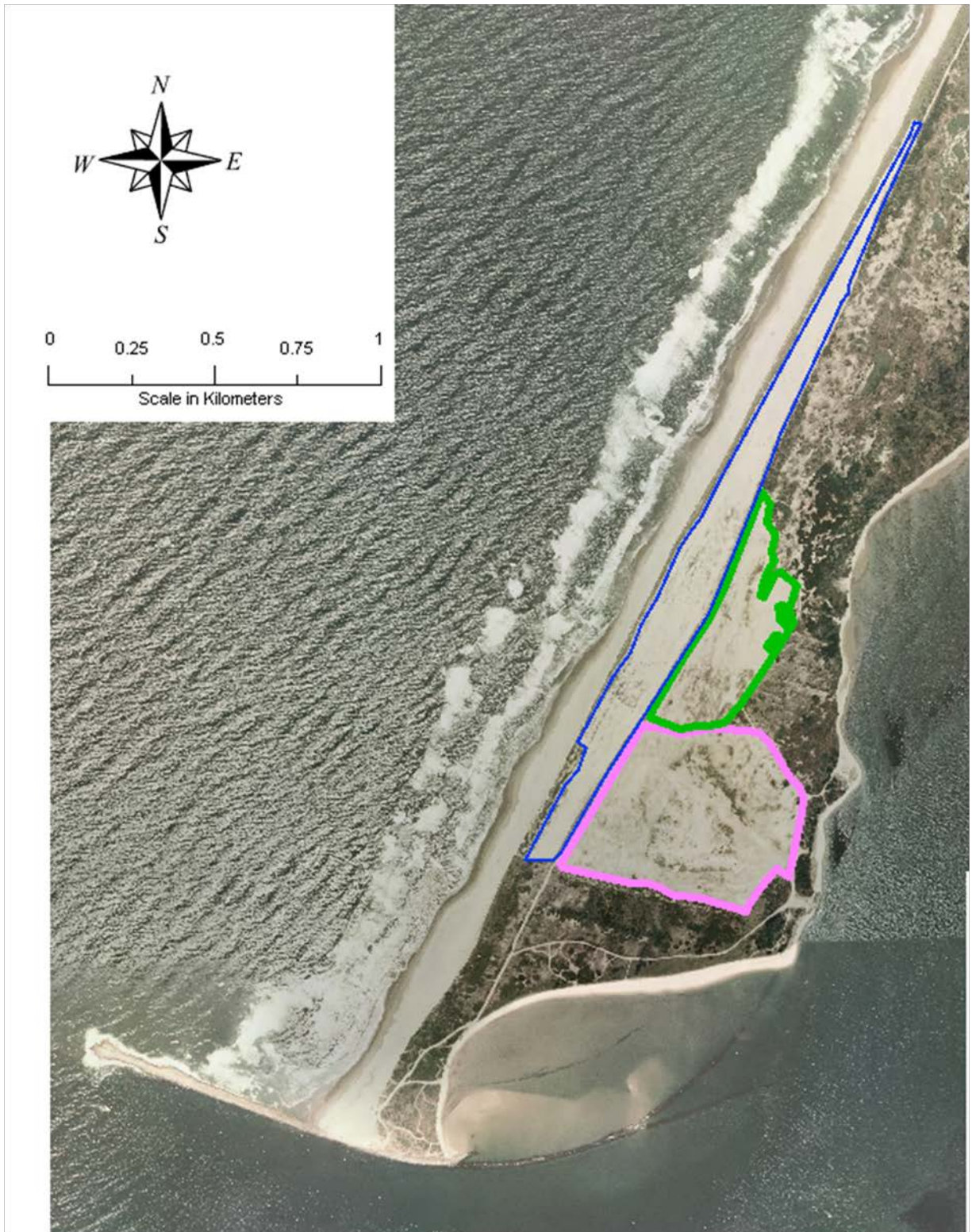
In 2012-2016, plant measurements including length of longest branch and the number of inflorescences were collected on 3 plants selected at random along each transect. This data can be used to track changes in plant size and reproductive vigor, and is discussed below. To investigate the substrate of the population, the percent cover of shell within a 0.5 meter radius as well as the number and species of associated plants were recorded.

## Seeded Transects

In the spring of 2016, multiple 5m transects were established at Overlook North and Siltcoos, and both *Abronia umbellata* ssp. *breviflora* (~1,000) and *Glehnia littoralis* (~500) were planted in a narrow 5-10 cm deep trench with sand compacted over the seeds. These transects were monitored in the fall of 2016 for survivorship.

## Plant Measurements

In 2012-2016, additional plant measurements were recorded on selected sand-verbena plants on the North Spit. At Coos Bay North Spit, three plants along each survey transect were randomly selected to be monitored. In addition, at the sites listed in Table 4, 20 points were randomly selected using GIS and uploaded points to handheld GPS units. In the field, the closest flowering plant to the preselected GPS point was monitored. Plant measurements included length of longest branch, number of



**FIGURE 3. IN 2009, THE POPULATED AREA WAS DIVIDED INTO THREE SECTION, 1) THE ORIGINAL HABITAT (SOUTHEAST), 2) NORTHEAST AND 3) WEST OF THE FOREDUNE ROAD. EACH AREA WAS SUBSAMPLED USING THE METHODS DESCRIBED IN THE TEXT.**

infructescences on the entire plant, and the number and species of plants within 0.5m. Notes about substrate and habitat were recorded.

### **Overwintering Plants**

At Overlook North and South and Siltcoos, plant characteristics were measured on selected overwintering plants. At the time of seeding in March 2012, a number of robust plants were found apparently overwintering, and 18 of these plants were marked with wooden stakes, GPS coordinates and spatial notes relative to the marking stake were taken. Six plants at Overlook North, South and Siltcoos were marked (although more overwintering plants were present at all sites). It is not uncommon for a few of the usually annual plants to perennate. In the fall these plants were monitored and the longest branch and number of inflorescences counted in 2013, 2015 and 2016 (if the plant was present).

In the spring of 2016, additional overwintering plants were marked at Overlook North and Overlook South and were monitored for presence/absence as well as plant measurements in the fall of 2016.

### **Substrate Assessment**

At all sites monitored in 2012, at least three substrate samples were collected for analysis. Substrate samples were repeated in 2015 at the Coos Bay North Spit (Table 6, Figure 13).

Substrate sample collected in 2012 and 2015 were analyzed for pH using a Milwaukee pH55 pH meter with accuracy of 0.1 pH units. The unit was calibrated between each measurement. A 50 mg portion of each substrate sample was placed in 100 mL of distilled water and allowed to equilibrate for a minimum of 10 minutes (and no more than 2 hours,) before a measurement was taken.

At this time, only the pH of each sample has been determined. In the future, samples can be analyzed for sediment size, sorting and composition to help us to determine characteristics that may be common among successful pink sand-verbena sites.

TABLE 1. REINTRODUCTION SITES FOR THE COOS BAY BLM DISTRICT, METHODS USED, AND HABITATS FOR SEEDING AND TRANSPLANTING EFFORTS DISCUSSED IN THIS REPORT. SEEDINGS REPORTED HERE ALL INVOLVED THE USE OF 50,000 SEEDS PER SITE, EXCEPT WHERE NOTED.

Land Manager	Site	Location	Method	Habitat
<i>Coos Bay District Bureau of Land Management</i>				
	Coos Bay, North Spit	North of Coos Bay	<u>Seeding:</u> Dec. '96, March '06 (100k; newly restored area), March '07 (100k), March '08 (90k), Feb '09 (90k), Feb '10 (100k), Feb '11 (100k), Feb '12 (100k), Mar '13 (100k), Mar '14 (100k), Mar '15 (100k), Mar '16 (100k)	Open beach and beachgrass treatment area (sand spit)
	New River ACEC	sand spit near the mouth of Fourmile Creek about 8 miles south of Bandon	<u>Seeding:</u> Jan. '97, March '99, '00, '01 (70k), '02 (100k), March '03 (80k), March '04 (100k), March '05 (95k), March '06 (100k), March '07 (150k), March '08 (80k), Feb. '09, (80k) Feb. '10 (100k), Feb '11 (100k), Feb '12 (120k)*, Mar '13 (120k), Mar '14 (100k), Mar '15 (100k), Mar '16 (100k)	Foredune beachgrass treatment area and open sand * In 2012, 20k seeds were distributed in an area ~1.5 miles to the south near Butte Creek. It is recommended that additional beach grass removal occur at the site prior to any future seeding efforts.



**TABLE 2. REINTRODUCTION SITES OF THE SIUSLAW NATIONAL FOREST, METHODS USED, AND HABITATS FOR SEEDING AND TRANSPLANTING EFFORTS DISCUSSED IN THIS REPORT. SEEDINGS REPORTED HERE ALL INVOLVED THE USE OF 50,000 SEEDS PER SITE EXCEPT WHERE NOTED.**

Land Manager	Site	Location	Method	Habitat
<i>Siuslaw National Forest</i>				
	Overlook (N and S)	Douglas County about 2.5 miles south of the Lane/Douglas County line (in T20S R12W Sec 17 NW)	<u>Transplanting:</u> '00 <u>Seeding:</u> March '01 (N 50k and S 50k), March '02 (S only), March '05 (S only), March '07 (N 80k and S 50k), March '08 (N 100k), March '09 (N 50k and S 50k), March '10 (N 50k and S 50k), March '11 (N 60k and S 60k), March '12 (N 60k and S 60k), March '13 (N 60k and S 60k), March '14 (N 60k and S 60k), March '15 (N 60k and S 60k) March '16 (N 60k and S 60k)	Foredune beachgrass treatment area and open sand
	Siltcoos Creek	10 miles north of Reedsport	<u>Transplanting:</u> '97 and '01 <u>Seeding:</u> Feb. '98, March '00, March '02 (60K), March '04, March '05, March '06, March '07 (15k to small beach north of creek and 85k to large plover area), March '08 (60k), March '09 (55k), March '10, March '11, March '12 (12.5k), Mar '13 (12.5k), Mar '14 (10k), Mar '15 (50k), March '16 (53k)	Foredune beachgrass treatment area and open beach, mouth of creek
	Tahkenitch Creek	7 miles north of Reedsport	<u>Transplanting:</u> '97-98, '00-01 <u>Seeding:</u> Feb. '98, March '01, March '02, March '04, March '05, March '11 (80k), March '12 (100k), Mar '13 (100k), Mar '15 (80k in southern portion- focus in southern portion), Mar '16 (80k - focus in southern portion)	Foredune beachgrass treatment area and open beach, mouth of creek

## RESULTS

### Population Surveys

#### General Trend

The population of pink sand-verbena at every site monitored in 2016 increased from 2015, however counts in recent years have been among some of the lowest ever recorded for these sites. Of the four Forest Service Sites, only Siltcoos showed substantial increases in population size. Tahkentich remained stable with 141 plants, while both Overlook North and South have shown a general downward trend since 2013. At New River plants counts were down from nearly 2,000 to just over 100 plants. At Coos Bay North Spit, the population remained relatively stable with an estimated population size of ~300,000 reproductive individuals.

Despite increases in population size in 2016, most populations remain fewer than 1,000 individuals, and the substantial declines observed in 2013 and 2014, are cause for alarm (Figure 8, Figure 11). Two of the largest drivers appear to be amount of disturbance (e.g. the exposed beach at New River and Siltcoos) and competition by European beach-grass. At the North Spit, there was a clear difference in the density, size and reproductive effort between plants in areas that had (or had not) received discing (and beach grass removal) treatments in 2013 (Figure 8). Climate is also likely an important driver. On a local scale, coastal climate may also be influenced by landscape features such as headlands and nearshore rocks, which may result in differences in wave action between sites in the same year.

For a summary of inventories for pink sand-verbena conducted from 2000-2015 on the central and southern Oregon Coast see Giles-Johnson and Kaye (2015).

#### Siuslaw National Forest

Monitoring activities for pink sand verbena occurred on four Forest Service Sites, Siltcoos, Overlook North, Overlook South and Tahkenitch.

##### SILTCOOS CREEK

Pink sand-verbena restoration and reintroduction was initiated at the mouth of Siltcoos Creek in 1997, when 27 plants were outplanted at the site. The population has fluctuated dramatically over time, from zero in 1999, to a high of 989 (nearly all of which were reproductive) in 2005 (Figure 3, Table 9). In the winter of 2012/2013 a substantial portion of the previously occupied habitat eroded leaving less than 20% of the original habitat. In 2014 only ten plants were noted, however in 2015, the population had increased to 298 (174 reproductive), and again increased in 2016 to 427 plants (330 reproductive). Despite the apparent loss of habitat in 2012, Siltcoos has consistently had one of the highest reintroduction success rates, and we recommend continued seed addition efforts and beach-grass removal.

In 2011, 2015 and 2016 plants at this site were generally larger and had more fruits per plant compared to the other sites monitored (Table 3).

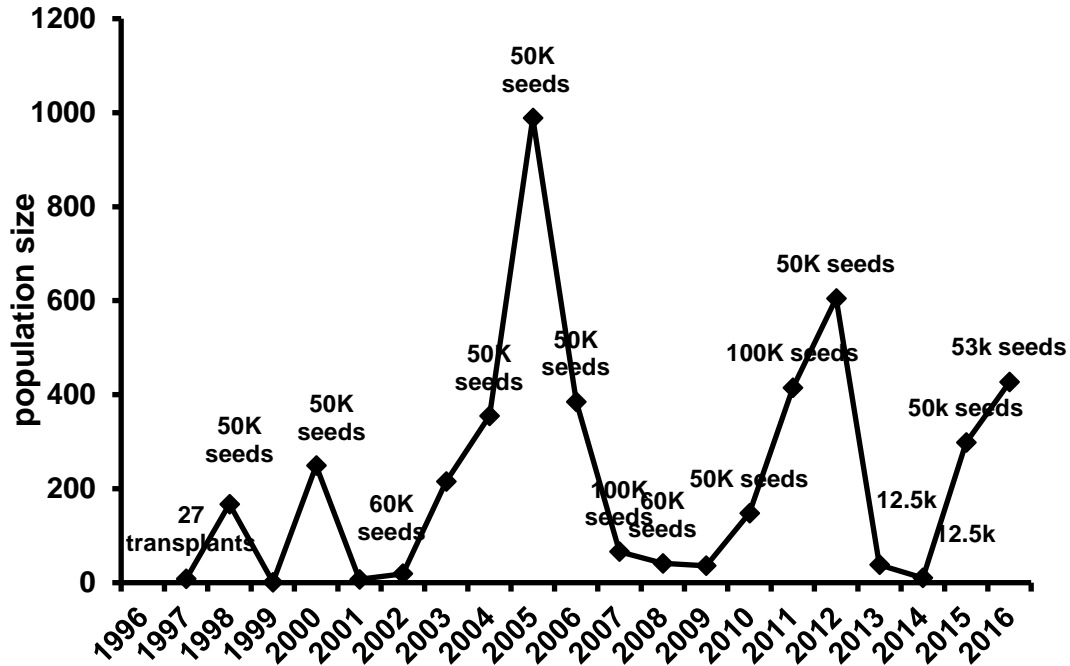


FIGURE 4. POPULATION TRENDS AND SEEDING HISTORY AT SILCOOS CREEK, 1996 – 2016. AN EROSION EVENT IN THE WINTER OF 2012/2013 RESULTED IN SIGNIFICANT LOSS OF HABITABLE HABITAT, THUS THE DECREASE IN SEEDING EFFORT AND THE NUMBER OF PLANTS OBSERVED AT THE SITE.

**TAHKENITCH CREEK**

In 1996, 34 transplanted pink sand-verbenas and 5,000 seeds were dispersed at Tahkenitch Creek as part of an early effort to establish plants on Oregon beaches. This effort has been followed with two additional transplanting efforts and seeding. Prior to 2005, the area was divided into two sections, North Tahkenitch and South Tahkenitch. The Tahkenitch stream channel has shifted to the south and now the entire area is north of the creek. In 2005 no plants were found, and in 2006, only one vegetative plant was present.

An informal survey in 2009 by Marty Stein, located 4 plants, 2 reproductive and 2 vegetative, suggesting that this site may be suitable for future reintroduction efforts. In 2011, 80,000 seeds were distributed resulting in 95 plants (57 vegetative and 38 reproductive). In 2012, 100,000 seeds were distributed resulting in 381 plants (246 vegetative and 135 reproductive.) Seeding continued in 2013-2015 resulting in 10, 100 and 100 plants respectively. Despite the relatively small number of plants, we recommend continued seeding in the area combined with beach grass control to build the seed bank at this site.

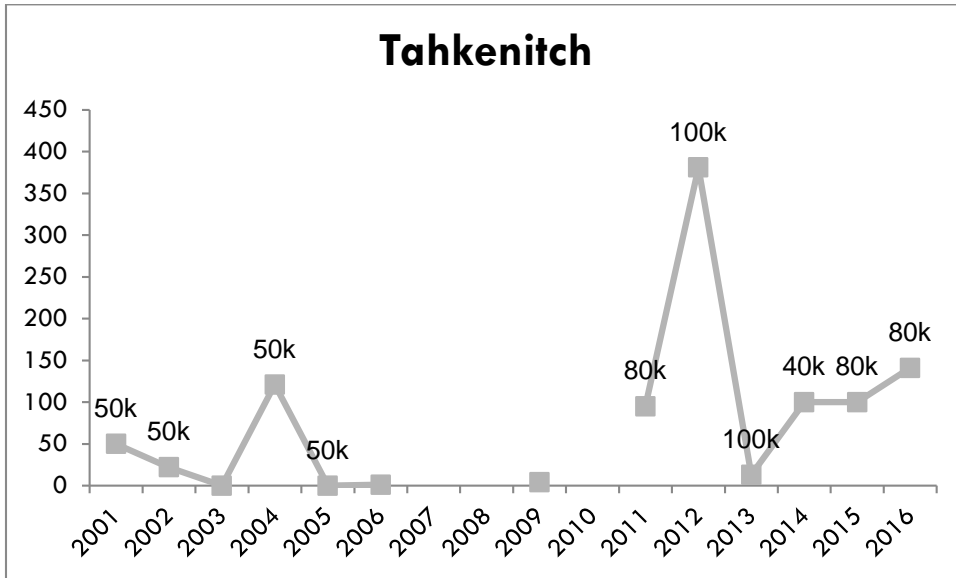


FIGURE 5. POPULATION TRENDS AND SEEDING HISTORY OF PINK SAND VERBENA AT TAHKENITCH CREEK FROM 2001-2016.

#### OVERLOOK NORTH AND SOUTH

European beach-grass control was initiated at the Overlook sites in the fall of 1999 through the use of bulldozers operated by the Oregon National Guard in coordination with the Siuslaw National Forest. Pink sand-verbena reintroduction at the Overlook sites began in spring 2000 with the planting of 50 individuals. In 2001, both the north and south sites received 50,000 seeds which resulted in the establishment of 482 and 658 plants, respectively (1,140 total).

At Overlook North from 2002-2006 no seeding occurred. Seeding resumed in 2007 and has continued annually (Table 9). The population remained relatively stable from 2008-2012. In 2012, North Overlook had 4,860 plants (3,233 vegetative and 1,627 reproductive). This is the second highest number of plants found at the site however the ratio of reproductive to vegetative plants was lower. At South Overlook seeding has occurred annually with the exceptions of 2002, 2003, and 2006. In 2012 South Overlook had 2,247 plants (1,619 vegetative and 928 reproductive). In 2013, as with other sites, the number of plants decreased at both Overlook North and Overlook South. This pattern continued into 2015, where only 124 and 158 plants were noted respectively. In 2016, numbers slightly increased at both Overlook sites, however remain among the lowest observed (Figure 5, Figure 6, Table 9).

Despite the precipitous drop in the population from 2012-2016, the reintroduced population at the Overlook sites is now the second largest population in Oregon (Coos Bay North Spit is the largest). Without continual beach-grass control, the substantial population growth at this site will likely reverse and the population will decline. In 2010, at Overlook South there was an increase in the amount of *Leymus mollis* at the site, particularly at the north end and a corresponding decrease in the number of pink sand verbena. Although this species is native, it may negatively interact with pink sand verbena. We recommend that seeding continue at both sites, with higher priority given to the Overlook South treatment area with the potential addition of other native dune species (see Recommendations section). We also recommend continued observations of the spread and potential impact of *Leymus* on the other native dune species.

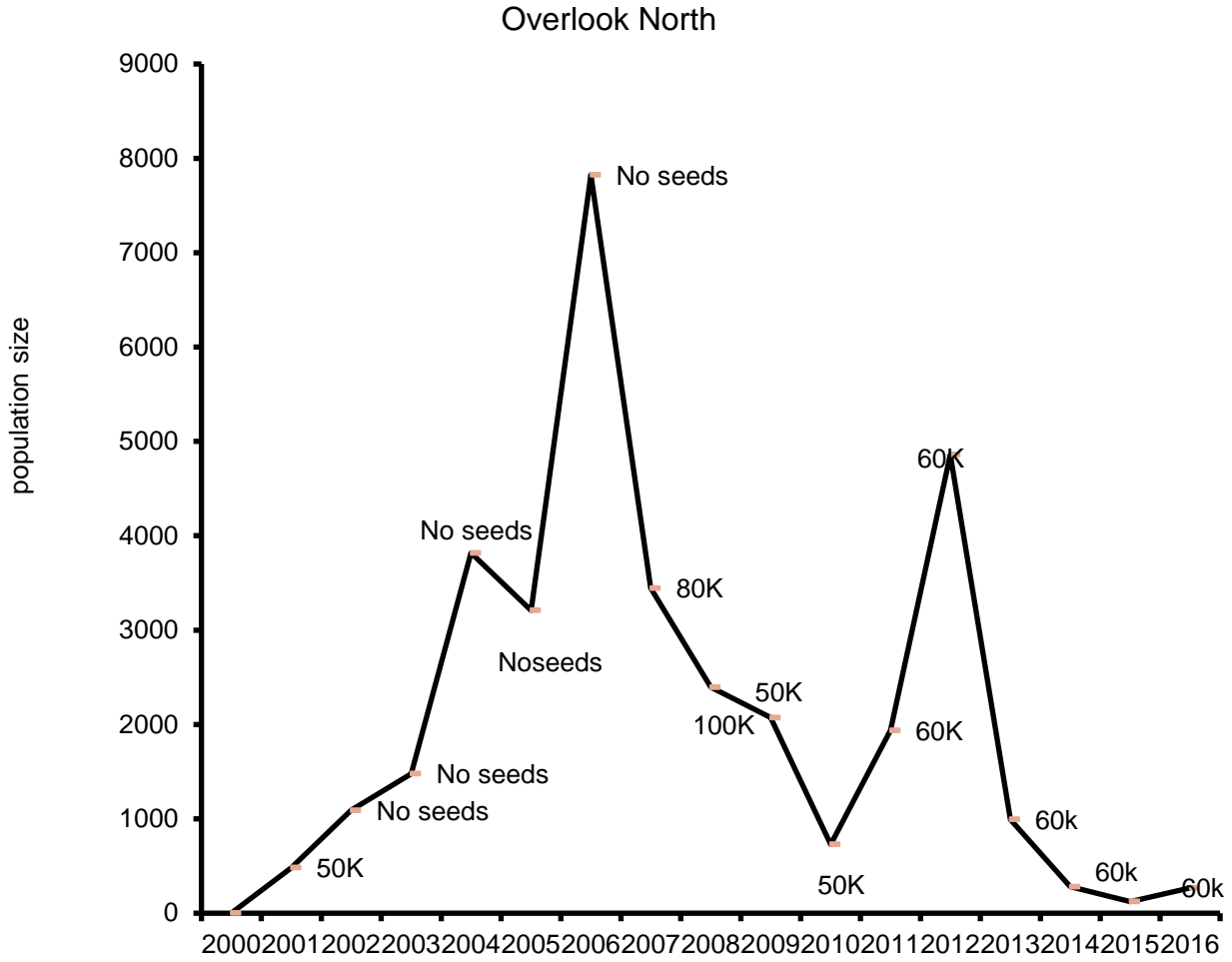


FIGURE 6. POPULATION TRENDS AND SEEDING HISTORY OF PINK SAND VERBENA AT NORTH OVERLOOK SITE, 2000-2016.

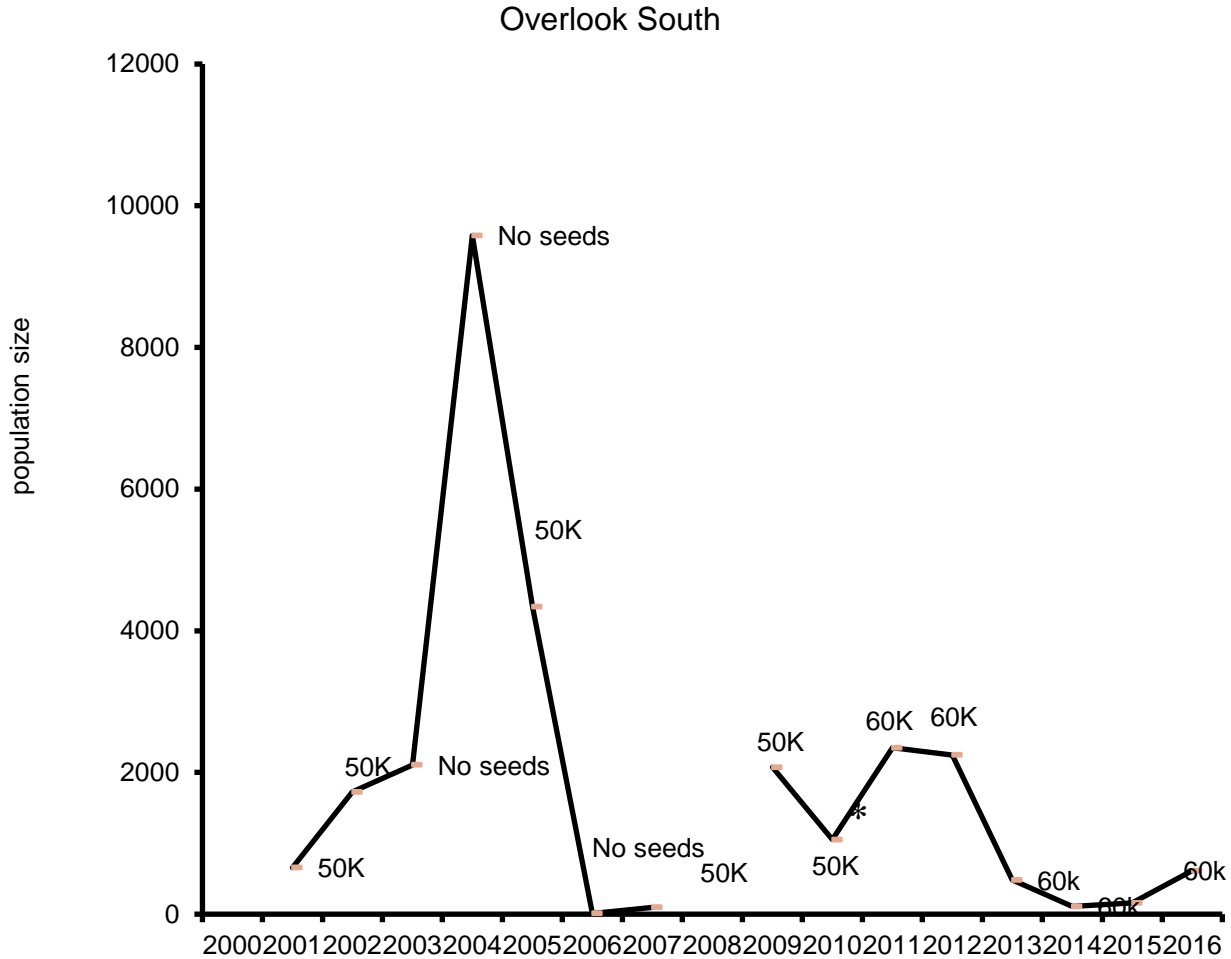


FIGURE 7. POPULATION TRENDS AND SEEDING HISTORY OF PINK SAND VERBENA AT SOUTH OVERLOOK SITE, 2000-2016. \* SOUTH OVERLOOK WAS NOT SURVEYED IN 2008, HOWEVER IT WAS SEEDED.

**Seeded Transects**

In the spring of 2016, a total of six transects were planted, each with approximately 500 *Glehnia littoralis* and 1,000 *A. umbellata* ssp. *breviflora* (three transects at Overlook South and three transects at Siltcoos.) In the fall of 2016, there were no plants found along the transects at Overlook, and a handful of vegetative plants were present at Siltcoos. At Overlook (where no plants were found on the transect), the seeded trench was excavated, and no seeds were recovered in the area where seeds had been placed. Shifting sands and winds, seed predation, or decay of seeds in the sand could have been factors contributing to the lack of success of these transects, and the apparent absence of seeds in the fall.

**Overwintering Plants**

At both North and South Overlook nearly all overwintering plants were still present in the fall of 2012. At Siltcoos, none of the overwintering plants noted in the spring of 2012 were found in the fall of 2012. In that year, the average length of the longest stem on overwintering plants at South Overlook was 96 cm, with an average inflorescence count of 620. This is substantially higher than the average for the rest of the population at South Overlook which had an average longest branch of 24 cm and only 6.3

inflorescences. North Overlook followed a similar pattern for overwintering plants with the average longest branch of 57 cm and 97 inflorescences compared to 44 cm and 25 inflorescences. It was also noted that the overwintering plants generally had more branches per plant than other plants.

In the fall of 2013 measurements were repeated on any overwintering plants that were still present, (none at Siltcoos and three at Overlook.) In 2015, a single plant remained from those originally marked in 2012 and remained reproductive but was not recorded in 2016. Of the 12 overwintering plants marked at Overlook North in spring 2016, only 3 were still alive during the fall sample. All 3 of the overwintering plants marked at Overlook South in spring 2016 were alive during the fall sample.

## **Bureau of Land Management**

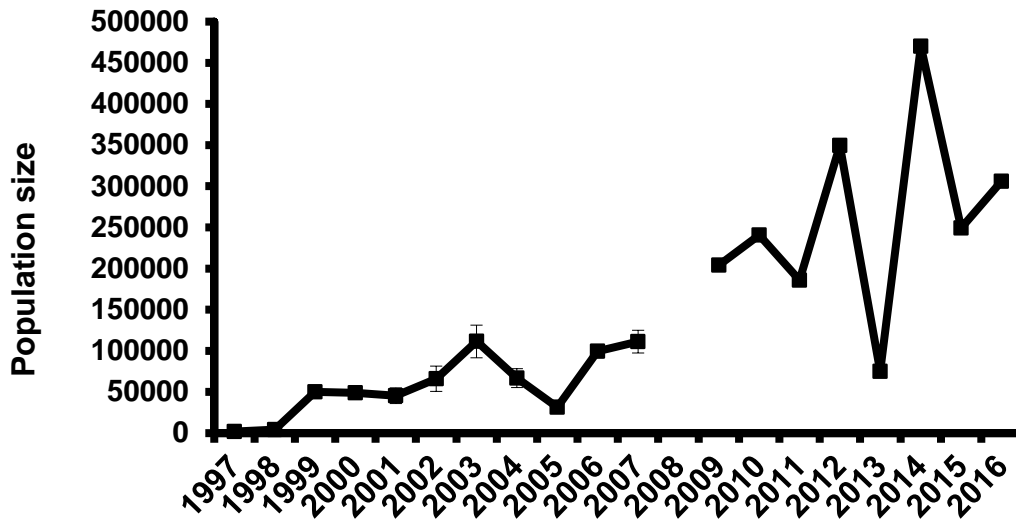
### COOS BAY NORTH SPIT

Efforts to eliminate European beachgrass from a roughly 170 acre Habitat Restoration Area (HRA) on the Coos Bay North Spit ( ) have included machine ripping and discing (with a tractor), herbicide (Rodeo), burning, saltwater irrigation, hand pulling, and various combinations of these techniques. Ten thousand pink sand-verbena seeds were sown in each of five 30 x 30 m plots randomly placed in areas with different beachgrass management histories on January 15, 1997 (50,000 seeds total). In the winter of 2005-2006 an area closer to the beach on the west side of the access road was cleared of European beach grass. One hundred thousand seeds were added to this area in both 2006 and 2007, 90,000 seeds were added in 2008 and 2009, and 100,000 seeds were added in 2010-2012. All habitat at the North Spit was disced in October (2008) or November (2009-2013).

### **Population surveys**

Following re-introduction in 1997, pink sand-verbena populations grew steadily to an estimated peak of 349,658 in 2012 (Figure 8). The dramatic increase in population size from 2007 to 2009 likely is a result of both population growth and improved monitoring techniques initiated in 2009. In 2009, we modified our monitoring technique so that the entire population was subsampled. Despite the large increase in population size from 2011 to 2012, and again in 2014, the size of reproductive plants seems to be diminishing as does seed yield (Table 3, Table 4, Figure 8, Figure 10). Additionally, there was a significant decline in the size of the population from 2012-2013 that coincided with a year of no discing treatments in the southern portion of the occupied habitat.

In 2012-2016, plant measurements were taken on 3 randomly selected plants along each transect (Table 3, Table 4). These data allow us to track changes in plant size and reproductive vigor at the Coos Bay North Spit, and compare the size of the plants to other occupied sites (Table 3, Table 4, Figure 9). In addition to plant measurements, the number and species of plants within 0.5m were recorded as well as the percent cover of oyster shell. In recent years, the number of plants has increased dramatically, however the overall health of pink sand-verbena at the site is thought to be decreasing with less fruits per plant and more small plants.



**FIGURE 8. POPULATION TRENDS AT THE COOS BAY NORTH SPIT REINTRODUCTION SITE. THE AREA WAS SEEDED IN JANUARY 1997 WITH 50,000 SEEDS FROM PORT ORFORD. POPULATION SIZE ESTIMATES FOR 1997-1999 ARE COMPLETE CENSUSES OF ALL PLANTS IN THE POPULATION, WHILE THOSE FROM 2000-2008 ARE ESTIMATED FROM A SUBSAMPLE OF A REFERENCE AREA AND CENSUS OF THE REMAINDER OF THE POPULATION. THE ERROR BARS FOR 2000-2008 ESTIMATES REPRESENT 95% CONFIDENCE INTERVALS. \*IN 2008, AN ESTIMATE OF THE ENTIRE POPULATION SIZE WAS NOT POSSIBLE BECAUSE OVER 50% OF THE POPULATION HAD BEEN DISCED PRIOR TO OUR SURVEYS. SEE TEXT FOR A DISCUSSION OF POPULATION TRENDS. IN 2009, THE SAMPLING METHODS WERE MODIFIED SO THAT THE ENTIRE POPULATION WAS SUB-SAMPLED (AND NO AREAS CENSUSED). IN THIS CHART THE CI FOR 2009-2016 ARE NOT REPORTED BECAUSE THE POPULATION ESTIMATE IS A COMBINATION OF 3 DIFFERENT POPULATIONS, EACH WITH THEIR OWN CI.**



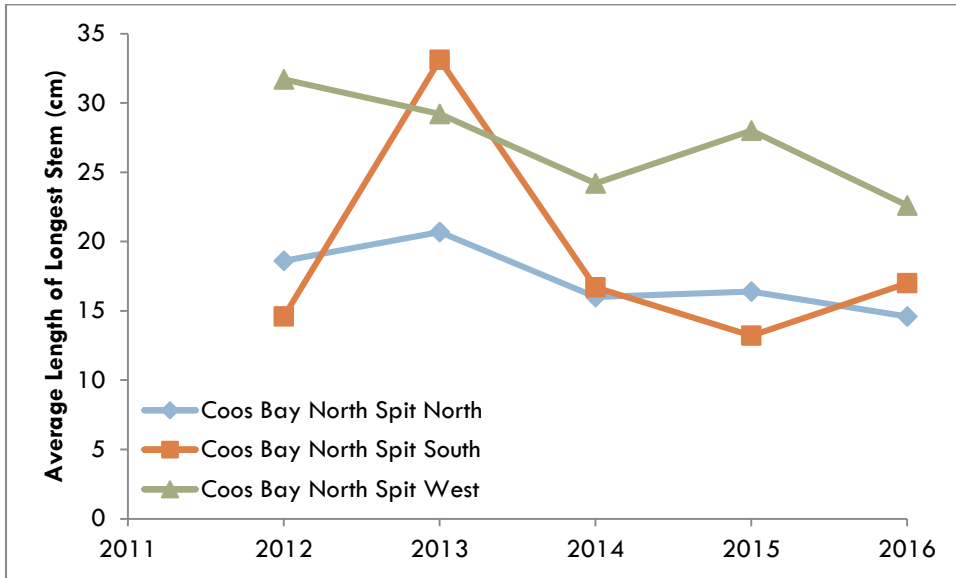


FIGURE 9. AVERAGE SIZE OF PLANTS ON THE COOS BAY NORTH SPIT FROM 2012-2016.

In 2012 it was noted that although there are fewer plants per m<sup>2</sup> in the west habitat, the plants were larger than those in the rest of the population. This trend has stayed consistent throughout the course of the study, with the largest plants being found in the west portion of the habitat. In 2016, the western area also had the most infructescences per individual (Table 4, Figure 9).

Density of plants in the north habitat was the highest at 2.0 plants/m<sup>2</sup> and lowest on the west side with only 0.05 plants/m<sup>2</sup> (Table 3, Figure 10). In 2013, the density of plants decreased in the southern portion of the habitat that did not receive discing treatments, which highlights the tenuous hold that the species has and the importance of continued management. In 2014, after management resumed in the southern portion of the habitat, plant density returned to levels observed in previous years (when management occurred).

The Coos Bay North Spit is now the largest pink sand-verbena population in Oregon and serves as the primary seed source for reintroduction efforts in Oregon. Successful plant establishment and population growth has followed successful control measures for European beach-grass on the spit (described in Pickart and Sawyer [1998] and Kaye [1998]). No beach-grass control was conducted in 2004 and 2005, and the pink sand-verbena population declined in both of those years. Although the seedbank appears large enough for continual recruitment, the success of this site appears dependent on sustained management activities, particularly annual discing to control plant invasion and additional vegetation control north of the HRA. This pattern was again highlighted in 2013, when the density of pink sand verbena plants decreased from 1.5 to 0.02 /m<sup>2</sup> in just one year without discing treatment (Figure 10).

However, we have also learned that second year plants can become substantially larger than first year plants if left undisturbed. In 2013, in the southern area where discing did not occur, the few remaining plants were larger than in previous years (Table 4). Therefore, in areas with no European beachgrass and abundant pink sand verbena, we recommend that discing be postponed to allow for some individual plants to reach larger sizes and produce larger amounts of seed (Table 3). This could be accomplished by lifting the disc on the tractor to skip areas with no beach grass.

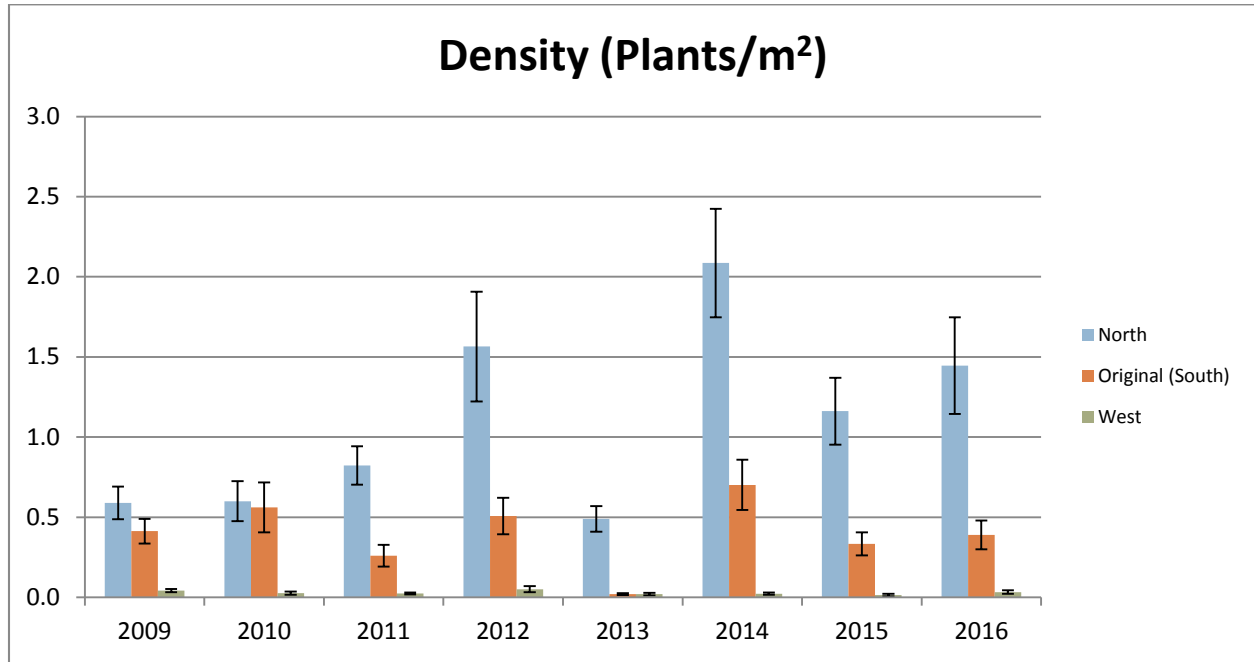


FIGURE 10. DENSITY OF PLANTS PER M<sup>2</sup> AT THE COOS BAY NORTH SPIT FROM 2009-2016. THE DECREASE IN ALL AREAS FROM 2012-2013 COINCIDED WITH LACK OF HABITAT MANAGEMENT.

TABLE 3. AVERAGE LENGTH OF LONGEST STEM, NUMBER OF INFLORESCENCES AND DENSITY OF PLANTS AT ALL SITES MONITORED IN 2012. DETAILED MEASUREMENTS WERE NOT TAKEN AT ALL SITES IN SUBSEQUENT YEARS AND ARE LISTED IN TABLE 4.

Site- 2012	Average Length of Longest Stem (cm)	Average Number of Inflorescences	Occupied Area (m <sup>2</sup> )	Number of reproductive plants	Density (plants/m <sup>2</sup> )	
Coos Bay North Spit, North	18.6	8.6	126,558	198,063	1.5650	
Coos Bay North Spit, Southeast (Original)	14.6	8.7	275,388	139,614	0.5070	
Coos Bay North Spit, West	31.7	11.7	233,758	11,746	0.0502	
New River	18.8	14.7	167,423	26	0.0002	
Butte Creek	29.9	41.4	107,945	10	0.0001	
Overlook, North	44.2	24.6	84,410	1,627	0.0193	
Overlook, North	Overwintering	56.8	97.5	-	-	-
Overlook, South		23.6	6.3	70,569	628	0.0089
Overlook, South	Overwintering	96.5	620.2	-	-	-
Tahkenitch			233,547	135	0.0006	
Siltcoos			97,235	135	0.0014	
Elk River			103,225	384	0.0037	
Bandon South			53,859	84	0.0016	

TABLE 4. AVERAGE SIZE OF PLANTS AND NUMBER OF FLOWERS IN 2012-2016 AT SELECT SITES. “-“ INDICATES DATA WAS NOT COLLECTED IN THAT YEAR.

Site	Average of Longest stem (cm)					Average of # Flowers					
	2012	2013	2014	2015	2016	2012	2013	2014	2015	2016	
Tahkenitch	-	-	-	34.2	-	-	-	-	6.6	-	
Siltcoos	-	-	-	66.1	90.0	-	-	-	46.3	23.2	
Coos Bay North Spit	North	18.6	20.7	16.0	16.4	14.6	8.6	7.8	13.1	-	9.5
	South	14.6	33.1	16.7	13.2	17.0	8.7	11.5	14.5	6.6	11.0
	West	31.7	29.2	24.2	28.0	22.6	11.7	12.6	9.7	-	14.2
New River		18.8	24.5	-	34.5	67.0	14.0	6.5	-	14.1	4.3
	North	44.2	24.2	-	24.9	37.2	24.0	7.2	-	9.3	26.5
Overlook		23.6	33.9	-	49.5	50.3	6.3	14.6	-	33.7	47.5
	South										

NEW RIVER ACEC

At New River, 50,000-150,000 seeds were dispersed within swales through the foredune almost every year from 1997 to 2016 (Figure 11). The spit at New River has been breached in various places by storm waves, creating swales that have low vegetative cover but are bordered on two sides by established plants, primarily European beachgrass. From 1998 to 2005, the BLM made aggressive attempts each fall to reduce the abundance of European beachgrass and lower the foredune using heavy machinery. There was no disturbance in winter 2006 – 2008 and European beachgrass rapidly reinvaded the dunes. Discing resumed winter 2009. Although beachgrass remained throughout the site, the habitat was much more open in 2010 compared to previous years. Discing occurred on a portion of the area in 2010, and was repeated at least bi-annually through 2016, reducing the cover of beach grass in the disced area. Population surveys occurred in September or October of each year since 1996. Immediately prior to the 1999 site visit, much of the area that had been seeded with pink sand-verbena was worked by a bull dozer to destroy European beachgrass.

**Population surveys**

The pink sand verbena population at New River has been sustained by direct seeding with 50,000 - 150,000 seeds from 1997-2016 (Figure 11). In the first year of seeding (1997), 118 plants established. Since that time, the population has ranged from 0- 2,172 plants (in 1998 and 2005 respectively) (Figure 11). We recommend that seeding and beachgrass removal efforts continue at this site using the current approach of seeding following disturbance in the fall. In 2012 -16 most plants at the site were found in areas that had been overwashed in winter/spring storms as well as on the shore side of the foredune, highlighting the species affinity for disturbed habitats.

In the fall of 2015, a large proportion of the plants (1,630 of the 1,824 plants observed) were found in an area that had received extensive overwash and temporary pool formation- as evidenced by the presence of fine sediment materials (Figure 12). Increased nutrient and water availability to the disturbed seed bank likely contributed to the high numbers of plants in the area, which also included large amounts of *Rumex acetosella* (as well as the native *Rumex maritimus*)(Figure 12). Although total

numbers were up for the site in 2015, the number of reproductive plants remained relatively low with only 287 flowering (18%); only 198 plants were found in the remaining portion of the population in 2015. In 2016 only 108 plants were found, and as in previous years, the largest plants with most flowers were found in and along the edges of overwashes.

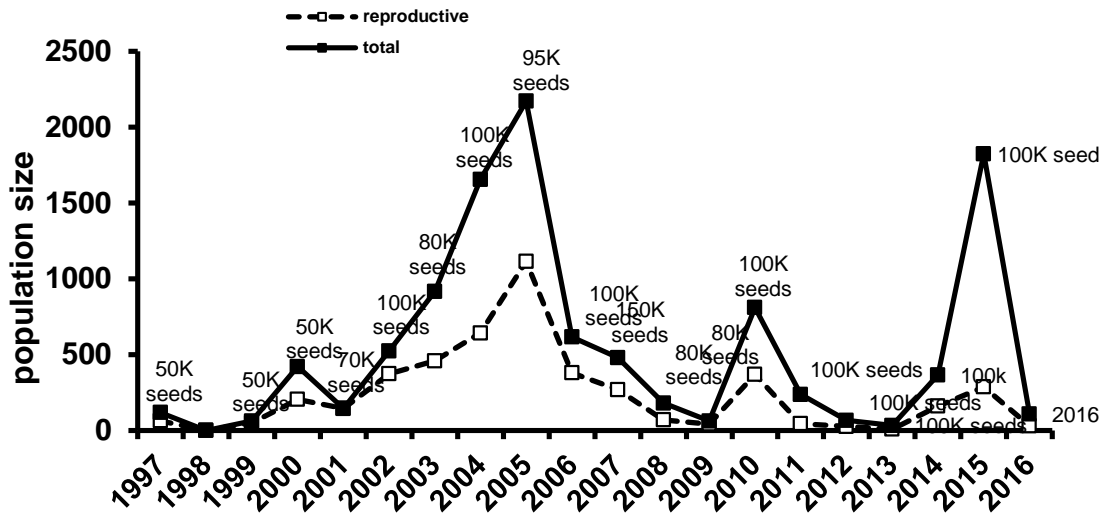


FIGURE 11. POPULATION TRENDS AND SEEDING HISTORY OF PINK SAND VERBENA AT THE NEW RIVER ACEC REINTRODUCTION SITE. SEEDING HAS BEEN CONDUCTED IN ALL YEARS EXCEPT 1998.



**FIGURE 12. NEARLY ALL PLANTS IN 2015 AT NEW RIVER WERE FOUND AGAINST THE BACK OF THE DUNE IN AN AREA THAT HAD BEEN OVERWASHED. THE AREA CIRCLED IN RED HAD HUNDREDS OF SMALL PINK SAND VERBENA PLANTS, AS COMPARED TO THE SINGLE, LARGE REPRODUCTIVE PLANT IN THE FOREGROUND.**

## Plant Measurements

### Plant Size and Reproductive Effort

The average length of the longest branch and the average number of inflorescences per plant and select sites monitored in 2012 is listed in Table 3. Since 2012, plant size has been measured on randomly selected reproductive plants at selected sites (Table 4). The largest plants, (as measured by the length of the longest stem), were found at Siltcoos, New River and Overlook South (Table 4). Plants at Coos Bay North Spit are generally larger on the west side (where density is also much lower), than in the other portions of the habitat. In 2012-2104 plants at Coos Bay were similar in size to their counterparts measured at other sites, however in 2015 and 2016, the plants at Coos Bay were smaller on average than those at all other sites.

The highest number of flowers per individual have been noted at Siltcoos and Overlook North and Overlook South, with 26-47 fruits per plant as compared to an average of 14 at the Coos Bay North Spit (Table 4).

### Plant Density

In addition to measurements of plant size and reproductive effort, plant density was also estimated for all monitored populations in 2012, and at the Coos Bay North Spit annually since that date. The estimated density of plants/m<sup>2</sup> at the sites monitored in 2012 is 0.001-1.5 plants/m<sup>2</sup>. Coos Bay North Spit had the highest density of plants overall with a high of 1.5 plants/m<sup>2</sup> in the northern portion of the population. In contrast, Overlook North (what we consider a fairly successful site) had only 0.02 plants/m<sup>2</sup>. In 2013, plant density was lower at all sites, but the general pattern of density remained the same with Coos Bay North Spit the most dense, and other sites with densities as low as 0.001 plants/m<sup>2</sup>. This general pattern for density was the same in 2014-2016 (Figure 10, Table 4).

### Plant Community

The presence(s) and count of plants within a 0.5 m radius of each measured sand-verbena plant was also noted at the North Spit from 2012-2016, and at most other sites in 2012-2016. There was a total of 19 different plant species found growing adjacent to sand-verbena, these species are listed Table 5. The most common plant species found within a 0.5 m radius of pink sand-verbena were *Cakile* sp. (sea rocket) followed by *Ammophila arenaria*, (European beachgrass), *Abronia umbellata* (pink sand-verbena) and *Camissonia cheiranthifolia* (Beach suncup) (Table 5). *Leymus mollis* (American beachgrass) was also common at both Overlook sites as well as in the western portion at Coos Bay North Spit.

**Abronia umbellata ssp. breviflora on the Oregon coast: Reintroduction and population monitoring**

**TABLE 5. AVERAGE, SUM AND COUNT OF PLANT SPECIES WITHIN 0.5M OF RANDOMLY SELECTED PINK SAND-VERBENA PLANTS IN 2012-2016 AT THE COOS BAY NORTH SPIT. NAMES IN BOLD INDICATE NATIVE SPECIES. \*BECAUSE IT IS DIFFICULT TO DISTINGUISH BETWEEN INDIVIDUALS OF BOTH AMERICAN AND EUROPEAN BEACHGRASS, PRESENCE/ABSENCE ONLY WAS NOTED.**

Species	Count					SUM					Average # when detected					% of monitored pink-sand verbena with species present				
	2012	2013	2014	2015	2016	2012	2013	2014	2015	2016	2012	2013	2014	2015	2016	2012	2013	2014	2015	2016
Number of plants monitored each year											178	60	158	83	115					
<b><i>Abronia umbellata ssp. breviflora</i></b>	124	37	88	68	74	604	145	509	431	423	4.9	3.9	5.8	6.3	5.7	70	62	56	82	64
<i>Achillea millefolium</i>	0	0	1	0	0	0	0	1	0	0			1.0			0	0	1	0	0
<i>Anaphalis margaritacea</i>	3	0	2	1	0	21	0	8	1	0	7.0		4.0	1.0		2	0	1	1	0
<i>Cakile edentula/maritima</i>	132	29	97	58	54	869	73	415	250	376	6.6	2.5	4.3	4.3	7.0	74	48	61	70	47
<i>Camissonia cheiranthifolia</i>	66	33	25	26	38	145	161	45	63	90	2.2	4.9	1.8	2.4	2.4	37	55	16	31	33
<i>Convolvulus soldanella</i>	1	0	1	0	0	6	0	7	0	0	6.0		7.0			1	0	1	0	0
<i>Fragaria chiloensis</i>	1	2	0	0	6	1	2	0	0	8	1.0	1.0			1.3	1	3	0	0	5
<i>Glehnia littoralis</i>	6	2	14	19	7	8	3	28	50	10	1.3	1.5	2.0	2.6	1.4	3	3	9	23	6
<i>Hypochaeris radicata</i>	45	21	41	24	24	156	54	105	78	50	3.5	2.6	2.6	3.3	2.1	25	35	26	29	21
<i>Juncus lesueurii</i>	4	1	2	0	2	36	2	16	0	19	9.0	2.0	8.0		9.5	2	2	1	0	2
<i>Lathyrus japonicus</i>	5	3	5	1	1	7	4	5	1	1	1.4	1.3	1.0	1.0	1.0	3	5	3	1	1
<i>Lathyrus littoralis</i>	1	0	0	2	0	1	0	0	8	0	1.0			4.0		1	0	0	2	0
<i>Lupinus littoralis</i>	22	18	5	8	13	26	21	7	9	14	1.2	1.2	1.4	1.1	1.1	12	30	3	10	11
<i>Rumex acetosella</i>	9	10	9	9	11	40	213	30	54	42	4.4	21.3	3.3	6.0	3.8	5	17	6	11	10
<i>Ammophila arenaria</i>	112	31	81	42	51											63	52	51	51	44
<i>Leymus mollis</i>	14	13	23	8	23											8	22	15	10	20
Shell %											2.6	2	3.2	2.1	1.4					
Wood %											-	0.3	0.3	1	0.4					

### Substrate Assessments

The pH of the substrate samples ranged from 4.9-8.4 in 2012 and 5.2-9.0 in 2015. The highest pH values were recorded at the North Spit. Areas where the cover of oyster shell was high, had higher average pH than areas with lower cover of shell (Table 6).

TABLE 6. RANGE AND AVERAGE PH AT SELECT SITES MONITORED IN 2012 AND 2015. NOTE THAT THE SAND FROM THE AREAS WITH COVER OF SHELL GREATER THAN 5% HAD THE HIGHEST PH.

Site Name	pH Range - 2012	Average pH - 2012	pH Range - 2015	Average pH - 2015
Coos Bay North Spit (Shell cover < 5%)	4.6-6.1	5.5	5.2-9.0	6.4
Coos Bay North Spit (Shell cover > 5%)	6.6-8.4	7.4	6.0-8.9	7.2
Elk River	6.4-7.0	6.6	-	-
Floras Lake	5.2-5.9	5.6	-	-
New River	5.1-5.9	5.6	-	-
Overlook	5.4-6.3	5.9	-	-
Tahkenitch	5.0-6.0	5.6	-	-

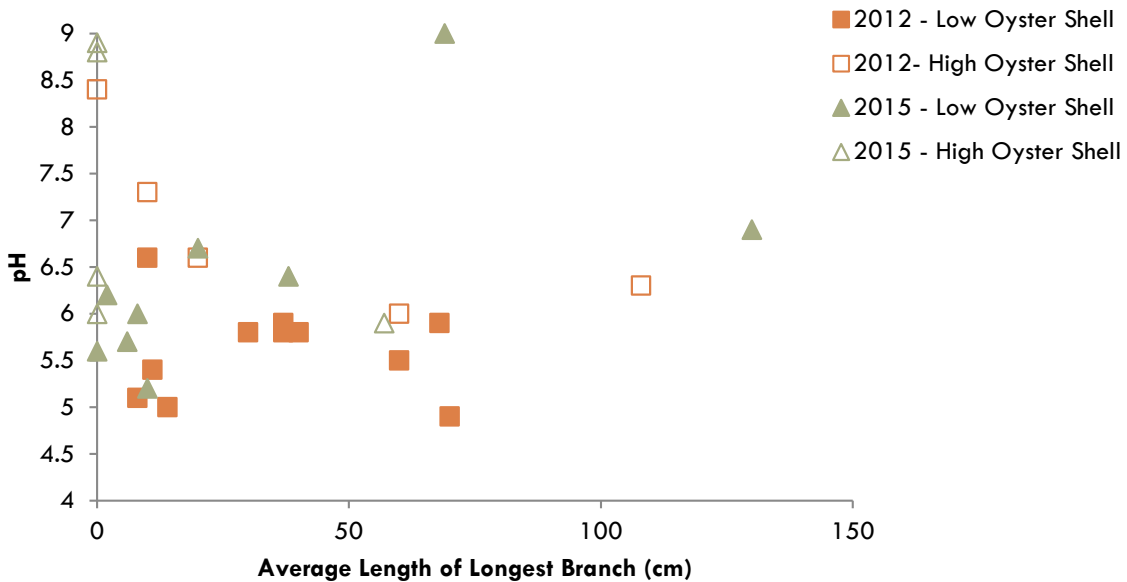


FIGURE 13. AVERAGE LENGTH OF LONGEST BRANCH VS. PH OF SUBSTRATE SAMPLES COLLECTED IN 2012 AND 2015. NOTE THAT EXTREME PH VALUES (BOTH HIGH AND LOW) GENERALLY ARE SMALLER.



## DISCUSSION

### Transplanting

Transplanting pink sand-verbena can be a successful reintroduction technique. Survival of transplants in the first year at Tahkenitch, Siltcoos, and Tenmile averaged 47%, a value typical of earlier transplant efforts at a number of sites. However, offspring from transplants have been relatively uncommon, except after the 1997 Siltcoos transplanting that produced abundant plants the following year (but not subsequently). Most pink sand-verbena plants are short-lived (mostly annual). Therefore, the success of populations reintroduced by transplants hinges on recruitment of new individuals from seed produced by the transplants or the planting of additional transplants.

Previous tests of transplant success, and factors effecting survivorship of transplants are discussed in Kaye 1995 and Kaye 1996.

### Seeding

Similar to the results of the transplanting efforts, we found that seeding was often successful in establishing a pink sand-verbena population the year of seed addition, but that these populations did not usually persist in subsequent years without continued seed additions and beachgrass control. For example, no plants were present the second year following seeding at New River (1997), Bandon Beach (1998), or Driftwood Creek (1998). However, this obstacle to reintroduction may be addressed through repeated seeding efforts to build up a local seedbank (see seedbank discussion). At four reintroduction sites that have received multiple seeding or transplants attempts, (Siltcoos Creek 2003, Bastendorff Beach 2003, Floras Lake 2004 - 2006, Tahkenitch 2000 - 2004 and Bandon Beach 2003), medium to relatively large numbers of plants have been observed despite no seeding in those years at those sites.

Recent seeding efforts have improved establishment rates, compared to initial efforts. Seeding with 40,000-100,000 (typically 50,000) seeds produced an average of 232 plants per site (0.46% establishment rate), and at least some plants in 84 out of 95 attempts. Earlier seedings with only 5,000 seeds resulted in an average of only 4 plants (0.071% establishment rate), and only 6 of 13 attempts produced at least 1 plant (Kaye 1995, 1998).

We have occasionally observed plants in the interior of the beachgrass control zone at Coos Bay North Spit, on the lee side of the eastern dune edge at Overlook, and in other protected areas at several sites that had over-wintered from the year before. These plants achieved very large sizes (>2 m<sup>2</sup>) and produced copious amounts of seed. Data collected in 2012-2016 indicates that overwintering plants are both significantly larger and produce more seed than annual plants and may play an important role in developing a natural seedbank (Table 4).

The populations at Coos Bay North Spit and the Overlook sites are examples of reintroductions into beachgrass control areas that have done reasonably well. In 1996, 50,000 seeds were distributed at the Coos Bay North Spit. The population quickly grew from over 1700 plants in 1997, to 4111 in 1998 and at least 50,000 in 1999. Since 2000, the plants were so abundant that a reference area was subsampled with randomly placed plots and the abundance of the species in the rest of the spit was counted. Since vegetative plants do not contribute to the population (pink sand-verbena is usually an annual) and counting all plants would be infeasible because of time constraints, we counted only

reproductive individuals at this site since 2000. It is important to note that in 2004 and 2005 and again in 2013, the Coos Bay North Spit population declined significantly, which may be due to the lack of beachgrass management during the prior fall and winter. Without repeated discing to reduce invading vegetation such as European beachgrass, pink sand-verbena may fail to increase in numbers and expand its area at this site. The total reproductive plant abundance in 2016 was estimated at 306,176.

Since the initiation of the project on the Coos Bay North Spit, there has been an increase in the number of plants in the original habitat and in the northern area and an expansion of the habitat to include an area west of the foredune road, however, the size of the plants has decreased since initiation of this study. This could be due to a number of factors including; annual variability in the populations due to climactic factors, intra-specific competition, competition with other annuals including *Cakile edentula*, *Cakile maritima* and *Hypochaeris radicata*, a decrease in the availability of nutrients, the timing and intensity of discing and plowing, a change in the pH caused by the oyster shells and the possible (if unlikely) presence of a contaminant on the oyster shells brought in for the plover habitat. In 2012-2016, our monitoring at North Spit included some plant measurements which will serve as a baseline for comparison in the future.

As with transplanting, the success of seeding may be related to habitat quality and susceptibility to the scouring effects of winter storms. For example, the presence of competing vegetation, especially in foredune habitats, may result in small plants that produce few or no seeds. Also, winter storms on the Oregon coast can have dramatic effects on beaches, removing large amounts of sand and even established foredunes. Any plants or recently deposited seeds on a beach could be removed from the site and carried away on ocean currents. For example, the seeding attempt at Floras Lake in 2000 resulted in only ten plants, but the beach at this site is subject to strong surf and winter storms, as evidenced by coarse sand and a short shelf and steep slope on the beach. Also, some recent winters in Oregon have been characterized by La Niña climatic patterns that include more frequent and intense winter storms. Harsh winters in 1997-2000 may have resulted in less population carryover after seeding attempts. The habitats at the Coos Bay North Spit and the Overlook sites are protected from these winter storms.

At the North Spit, the population is located in the interior of the sand spit and at the Overlook site, populations are on the elevated foredune. This protection allows all seeds produced from the pink sand-verbena plants that grow there to remain on site, maximizing their chances of establishing seedlings the following year. Furthermore, the habitat at the Overlook site has repeatedly been disturbed during fall and winter months each year since seeding in 1996. This disturbance, which included discing and manual removal of beachgrass (Kaye 1998), has kept competing plant species from revegetating the site and has probably been crucial to the successful population growth of pink sand-verbena. Initial plant establishment at the Coos Bay North Spit in 1997 was highly negatively correlated with the local abundance of European beachgrass (Kaye 1998). Competition studies at Port Orford and Gold Beach on dredge material also suggest that competing vegetation is a major factor affecting establishment and survival of pink sand-verbena (Kaye 1999).

### **Importance of a seedbank**

Long-term persistence of pink sand-verbena at sites on the Oregon coast may depend on the development and maintenance of a long-lived persistent seedbank. Results from germination tests with

seeds of various ages (stored in paper sacks at room temperature) show that seeds of this species can remain viable for long periods of time. Loss of viability over time appears to be very slow; seeds stored for nine years retained over 80% viability (Figure 14).

The stochastic behavior of natural and reintroduced pink sand-verbena populations suggests that seedbanks buffer populations from sharp declines and can allow re-colonization of a site. At Otter Point, a population decline to zero plants in 2000 was followed by the emergence of three plants in 2001; seven plants were counted at Cape Blanco in 2004 although none had been observed there in 2003. Seeding in 2002 at three reintroduction sites, Siltcoos Creek, Bastendorff Beach, and Bandon Beach, resulted in low plant establishment (fewer than 20 plants each) that year, but much higher populations (>100 plants) in 2003 without additional seeding. The appearance of some populations of pink sand-verbena long distances from natural populations, such as at Tenmile in 1995, Gearhart in 1993, and Vancouver Island in 2000 (after nearly 60 years of absence), suggest that some populations may establish from seed many years after the presence of any adult plants. Two new sightings (Tish-A-Tang and Arizona Beach) this year indicate that seeds may establish from the seedbank. Taken together, these lines of evidence provide strong support for the notion that pink sand-verbena is capable of maintaining a persistent seedbank, and that buried seeds may play an important role in the population dynamics of this species and should be fostered in reintroduction attempts.

## Plant Measurements

In 2012-2015 measurements taken on randomly selected reproductive plants at Overlook, Coos Bay North Spit and New River were taken. This data will be used in the future to track changes in the population of pink sand-verbena as well as the associated plant community.

## Substrate Assessments

Preliminary work in 2012, and again in 2015 shows that addition of oyster shells may cause changes in pH. Substrate samples collected from areas with high cover of oyster shell were also associated with higher pH levels and smaller pink sand-verbena with few inflorescences (Figure 13). Future research could focus on evaluating abiotic habitat factors that influence the success of introduced and existing sand-verbena populations.

## ADDITIONAL RESEARCH

### Population modeling to assess recovery objectives

The Conservation Strategy for pink sand-verbena (Kaye 2006) calls for the development of recovery objectives that take into account our ability to successfully reintroduce populations of the species. However, we have no estimate of the number of populations needed to establish a successful pink sand-verbena meta-population. Data gathered from population monitoring on natural population dynamics, population establishment success, and estimations of dispersal rates can be used to simulate population dynamics over time. Through the use of matrix models, the viability of individual populations may be estimated based on observations of individuals in populations through time. Pink sand-verbena may be a suitable 'model system' for structuring reintroduction programs and setting objectives, especially for rare beach plant species.

## Restoration with additional beach species

Pink sand-verbena is only one of several beach species in decline on the Oregon coast. Efforts to control European beachgrass to improve habitat conditions for native species such as pink sand-verbena and the western snowy plover create large, open areas devoid of vegetation (if successful), similar to the type of habitats that were plentiful prior to beachgrass introduction. These areas would also likely provide good habitat for other native beach and dune plant species. Unfortunately, propagation methods for many beach species have not been developed. A preliminary list of 11 native plant species that could be useful in restoration projects of beach ecosystems is provided in Table 7.

## Hypotheses for Future Research

The results of attempts to reintroduce pink sand-verbena to beach and dune habitats in Oregon, combined with observations made during field visits, have led to several hypotheses that require further testing before they can be used to guide additional reintroduction efforts.

**Recently deposited or disturbed sand is a more suitable substrate for pink sand-verbena growth than older substrates.** Natural and transplanted plants at Port Orford and Gold Beach consistently thrived on freshly deposited dredge material, but tended to decline in vigor two to three years after the sand was deposited. In 1995 at Coos Bay North Spit, transplants placed in an area that had recently (within three months) been disturbed during treatment for beachgrass thrived and achieved large size (greater than 50-cm) with substantial flowering (over 50 inflorescences each) while plants transplanted in an area where beachgrass had been removed two years before showed only moderate survival and growth. Furthermore, natural populations in southern Oregon and northern California often occur near the mouths of rivers and creeks where fresh sand is consistently deposited and disturbance is frequent.

**Plants that grow close to shore (on the upper beach) are more likely to thrive in the short-term, but plants in the foredune are more likely to survive fall and winter storms.** Observations of mortality patterns of transplants at Tillamook Bay and Hubbard Creek, where plants were positioned in sets both on the upper beach and in the foredune, suggest that the upper beach can be a very suitable (even superior) habitat for growth. However, fall and late summer storms damaged vigorous plants on the upper beach. The foredune transplants were not damaged and continued to thrive into fall (as late as November), and may survive the winter. Additional evidence suggests that competition from dune grasses can be detrimental to pink sand-verbena growth. Therefore, a strategy that places transplants among both habitats may improve overall success.

**A persistent seedbank may be a necessary component of a viable population; repeated seedings or transplantings may be required for successful reintroduction and recovery.** Pink sand-verbena seeds are long-lived and appear to be capable of persistence in beach sands for long periods of time (up to several decades). Therefore, buried seeds may play an important role in viable populations of pink sand-verbena, acting as a mechanism for population re-establishment after catastrophes or stochastic swings in population size; similar to what was observed at Siltcoos after major shifts in sand during the 2010/2011 winter season. They may also serve to provide some genetic stability to populations by containing samples of genetic variability that are occasionally lost from the above-ground population. Successful reintroduction of this species may require the development of a large pool of buried seeds, so that introduced populations can rebound after periods of population decline. This suggests that at each site, repeated seedings or transplantings over several years may be required to build-up a seedbank.

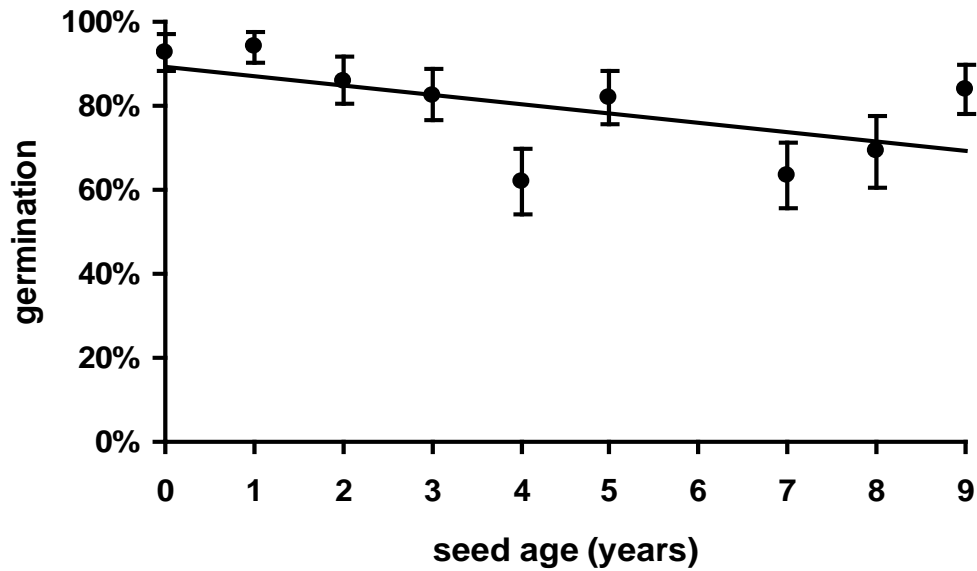


FIGURE 14. THE PERCENT OF SEEDS STORED FROM 0-9 YEARS. THE EQUATION FOR THE LINEAR REGRESSION IS  $Y = -0.03X + 0.955$ ,  $R^2 = 0.81$ ,  $P = 0.015$ .

TABLE 7. PLANT SPECIES NATIVE TO OREGON BEACHES AND DUNES THAT ARE CANDIDATES FOR USE IN ECOSYSTEM RESTORATION PROJECTS. MORE INFORMATION IS NEEDED ON TECHNIQUES FOR GERMINATION AND PROPAGATION OF THESE TAXA.

Common name	Latin name
yellow sand-verbena	<i>Abronia latifolia</i>
beach pea	<i>Lathyrus littoralis</i>
maritime pea	<i>Lathyrus japonicus</i>
beach morning-glory	<i>Convolvulus soldanella</i>
silver bursage	<i>Ambrosia chamissonis</i>
American beach-cup	<i>Camissonia cheiranthifolia</i>
black knotweed	<i>Polygonum paronychia</i>
American dunegrass	<i>Elymus mollis</i>
American glehnia	<i>Glehnia littoralis</i> var. <i>leiocarpa</i>
silvery phacelia*	<i>Phacelia argentea</i>
Wolf's evening primrose*	<i>Oenothera wolfii</i>
seaside dock	<i>Rumex maritimus</i>

\*Listed as Threatened with the Oregon Dept. of Agriculture; Species of Concern with the U.S. Fish and Wildlife Service.

**Overwintering plants play an important role in the creation of a self-sustaining population.** Large overwintering plants are larger and produce significantly more seed than annual plants under some conditions. Mechanical methods of discing and bulldozing commonly used for invasive beach grass control at many of the sand-verbena sites may need to be balanced with the need to allow at least some plants to overwinter and grow for a second year. Manual removal (where feasible), targeted herbicide use, or staggered discing treatments are possible ways to allow for both the control of beach grass and for some sand verbena plants to perennate. Especially in habitat patches where beachgrass is not established in any given year, lifting the disc equipment temporarily may allow more second year plants to flourish.

## RECOMMENDATIONS FOR 2017

In 2016, seeds were collected from Coos Bay by IAE, BLM staff and volunteers, for distribution in 2017. Based on the success of seeding and transplant efforts in previous years, we recommend that the following sites be the focus of seeding and restoration efforts in 2017:

Management Agency	Site	Seeding Conducted in 2016	Recommended Action in 2017
US Forest Service, Siuslaw N.F.	Siltcoos Creek	50,000	50,000
	Overlook, North	60,000	60,000
	Overlook, South	60,000	60,000
	Tahkenitch	80,000	100,000
Bureau of Land Management, Coos Bay	New River	100,000	100,000
	Coos Bay North Spit	100,000	100,000

With the exception of the sites monitored in 2016, the status of the populations below are unknown and it is recommend that population surveys be conducted at the following sites in the fall of 2017. Sites listed in bold were monitored in 2016 by IAE staff or volunteers:

County (Listed North – South)	Site
Lincoln County	Salmon River
Lane County	<b>Siltcoos Creek</b>
	Sutton Creek
Douglas County	<b>Overlook North and South</b>
	<b>Tahkenitch</b>
Coos County	Bandon Beach China Creek
	Bandon Beach South
	<b>Coos Bay North Spit</b>
Curry County	Cape Blanco
	Elk River
	Euchre Creek (Ophir)
	Floras Lake
	<b>New River</b>
	Otter Point
	<b>Port Orford</b>
Pistol River	

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## APPENDIX I. MATERIALS REQUIRED FOR POPULATION MONITORING

### Population Monitoring:

pin flags

data sheets

GPS

previous year's report

6 100m tapes (Coos Bay only)

Flagging

Candy canes

Meter poles (1 per person)-- for measuring distance from tape, as well plant species within 0.5 meter of select plants)

### Seeding:

GPS

Seed

Wooden Stakes

Mallet

Sharpie

## APPENDIX II. SURVEY RESULTS FOR SEEDED AND NATURAL POPULATIONS

TABLE 8. RESULTS OF SURVEYS FOR PINK SAND-VERBENA AT COOS BAY DISTRICT BUREAU OF LAND MANAGEMENT SITES ALONG THE OREGON COAST. IAE CONDUCTED SURVEYS FROM 2000-2012. POPULATION DATA FOR YEARS PRIOR TO 2000 ARE FROM VARIOUS SOURCES.

Site	natural or reintroduced	date surveyed	population size	Reintroduction history and other comments
Coos Bay	reintro.	9/26/2012	~349,658 (repro.)	Seeded (100K seeds)
		10/6/2011	~185,623 (repro.)	Seeded (100K seeds)
		9/22/2010	~240,488 (repro.)	Seeded (100K seeds)
		10/14/2009	~203,959 (repro.)	Seeded (90K seeds)
		10/15/2008	>10,929 (repro.)*	Seeded (90K seeds)
		2007	~111,063 (repro.)	Seeded (100K seeds)
		9/27/2006	~99,354 (repro.)	Seeded (100K seeds)
		10/3/2005	~31,411 (repro.)	---
		10/12/2004	~66,697 (repro.)	---
		10/2/2003	~111,496 (repro.)	---
		9/25/2002	~65,922 (repro.)	---
New River	reintro.	9/27/2012	66 plants (26 repro., 40 veg.)	Seeded (120k seeds)
		10/5/2011	*237 plants (44 repro., 193 veg.)	Seeded (100k seeds)
		9/21/2010	810 plants (369 repro., 441 veg.)	Seeded (100K seeds)
		10/5/2009	62 plants (42 repro., 20 veg.)	Seeded (80K seeds)
		10/16/2008	180 plants (69 repro., 111 veg.)	Seeded (80K seeds)
		9/29/2007	480 plants (269 repro., 211 veg.)	Seeded (150K seeds)
		9/25/2006	616 plants (380 repro., 236 veg.)	Seeded (100K seeds)
		10/4/2005	2,174 plants (1,114 repro., 1,058 veg.)	Seeded (95K seeds)
		9/14/2004	1,628 plants (1,014 repro., 614 veg.)	Seeded (100K seeds)
		10/1/2003	917 plants (459 repro., 458 veg.)	Seeded (80K seeds)
		9/11/2002	524 plants (373 repro., 151 veg.)	Seeded (100K seeds)
9/12/2001	145 plants	Seeded (70K seeds)		
8/15/2000	421 plants	Seeded (50K seeds)		
1999	---	Seeded (50K seeds)		
1997	---	Seeded (50K seeds)		

TABLE 9. RESULTS OF SURVEYS FOR PINK SAND-VERBENA SITES MANAGED BY THE SIUSLAW NATIONAL FOREST ALONG THE OREGON COAST. IAE CONDUCTED SURVEYS FROM 2000-2012. POPULATION DATA FOR YEARS PRIOR TO 2000 ARE FROM VARIOUS SOURCES.

Site	natural or reintroduced	date surveyed	population size	Reintroduction history and other comments
Tahkeni tch Cr.	reintro.	10/1/12	381 plants (135 repro., 246 veg.)	Seeded (100k seeds)
		10/5/11	95 plants (38 repro., 57 veg.)	Seeded (80k seeds)
		10/09	4 plants (2 repro., 2 veg.) *briefly surveyed by Marty Stein 1 veg.	---
		10/4/06	0 plants	---
		9/14/05	121 plants (72 repro., 49 veg.)	Seeded (50K seeds)
		9/29/04	0 plants	Seeded (50K seeds)
		9/18/03	22 plants (14 repro., 8 veg.)	---
		9/25/02	50 plants (45 repro., 5 veg.)	Seeded (50K seeds)
		9/18/01		Seeded (50K seeds) +50 transplants
		9/20/00	32 plants (repro.)	50 transplants
Overlo ok North	reintro.	10/1/12	4,860 plants (1,627 repro., 3,233 veg.)	Seeded (60k seeds)
		10/4/11	1,938 plants (794 repro., 1,194 veg.)	Seeded (60k seeds)
		9/26/10	730 plants (238 repro., 492 veg.)	Seeded (50K seeds)
		10/6/09	789 plants (466 repro., 323 veg.)	Seeded (50K seeds)
		10/2/08	2,395 plants (811 repro., 1,584 veg.)	Seeded (100K seeds)
		9/24/07	3,445 plants (2,790 repro., 655 veg.)	Seeded (80K seeds)
		10/4/06	7,825 plants (1,976 repro., 5,840 veg.)	---
		9/14/05	3,210 plants (1,191 repro., 2,019 veg.)	---
		9/29/04	3,741 plants (2,632 repro., 1,109 veg.)	---
		9/18/03	1,478 plants (1,359 repro., 119 veg.)	---
		9/25/02	1,091 plants (574 repro., 517 veg.)	---
		9/18/01	482 plants (390 repro., 92 veg.)	Seeded (50K seeds)
		9/20/00	2 plants (repro.)	50 transplants (most pulled by accident)
Overlo ok South	reintro.	10/1/12	2,247 plants (628 repro., 1,619 veg.)	Seeded (60k seeds)
		10/4/11	2,349 plants (988 repro., 1,361 veg.)	Seeded (60k seeds)

		9/26/10	1,052 plants (424 repro., 628 veg.)	Seeded (50K seeds)
		10/6/09	2,073 plants (1518 repro., 555 veg.)	Seeded (50K seeds)
		2008	Informal survey noted plants as present	Seeded (50K seeds)
		9/24/07	98 plants (76 repro., 22 veg.)	Seeded (50K seeds)
		10/4/06	10 plants (4 repro., 6 veg.)	---
		9/14/05	4,340 plants (2,581 repro., 1,759 veg.)	Seeded (50K seeds)
		9/29/04	9,554 plants (6,325 repro., 3,229 veg.)	---
		9/18/03	2,107 plants (1,954 repro., 153 veg.)	---
		9/25/02	1,726 plants (1,435 repro., 291 veg.)	Seeded (50K seeds)
		9/18/01	658 plants (427 repro., 231 veg.)	Seeded (50K seeds)
Baker Beach	reintro.	10/6/09	6 plants (5 repro., 1 veg.)	Seeded (40K seeds)
		10/2/08	70 plants (32 repro., 38 veg.)	Seeded (50K seeds)
		9/24/07	42 plants (30 repro., 12 veg.)	Seeded (50K seeds)
		9/5/06	12 plants (6 repro., 6 veg.)	Seeded (50K seeds)
		9/14/05	72 plants (11 repro., 61 veg.)	Seeded (50K seeds)
		10/28/04	93 plants (37 repro., 56 veg.)	Seeded (50K seeds)
		9/18/03	55 plants (27 repro., 28 veg.)	Seeded (50K seeds)
Siltcoos Cr.	reintro.	10/1/12	605 plants (135 repro., 470 veg.)	Seeded (50K seeds)
		10/5/11	415 plants (309 repro., 106 veg.)	Seeded (100K seeds)
		9/27/10	148 plants (28 repro., 120 veg.)	Seeded (50K seeds)
		10/6/09	36 plants (15 repro., 21 veg.)	Seeded (55K seeds)
		10/2/08	41 plants (14 repro., 27 veg.)	Seeded (60K seeds)
		9/24/07	66 plants (54 repro., 12 veg.)	Seeded (100K seeds)
		10/4/06	385 plants (202 repro., 183 veg.)	Seeded (50K seeds)
		9/14/05	989 plants (961 repro., 28 veg.)	Seeded (50K seeds)
		10/28/04	355 plants (311 repro., 44 veg.)	Seeded (50K seeds)
		9/18/03	215 plants (195 repro., 20 veg.)	---
		9/25/02	19 plants (12 repro., 7 veg.)	Seeded (60K seeds)
		9/18/01	7 plants (all repro.)	45 Transplants
		9/20/00	249 plants (135 repro., 114 veg.)	Seeded (50K seeds)
		1999		---
Sutton Creek	reintro.	9/24/07	0 plants	---
		9/5/06	0 plants	Seeded (50K seeds)
		2005	0 plants	Seeded (50K seeds)
		10/28/04	150 plants (28 repro., 122 veg.)	Seeded (50K seeds)

---

Tenmile Cr.	natural and reintro.	10/23/03	1 plant (repro.)	---
		9/25/02	0 plants	---
		9/18/01	0 plants	---
		9/20/00	0 plants	---
		1999	---	150 transplants

---

TABLE 10. RESULTS OF SURVEYS FOR PINK SAND-VERBENA SITES MANAGED BY THE OREGON DEPARTMENT OF PARKS AND RECREATION ALONG THE OREGON COAST. IAE CONDUCTED SURVEYS FROM 2000-2012. POPULATION DATA FOR YEARS PRIOR TO 2000 ARE FROM VARIOUS SOURCES.

Site	natural or reintroduced	date surveyed	population size	Reintroduction history and other comments
Bandon Beach South	reintro.	9/27/2012	161 plants (84 repro., 77 veg.)	Seeded (100K seeds)
		10/2011	476 plants (173 repro., 303 veg.)	Seeded (100K seeds)
		9/21/2010	260 plants (91 repro., 149 veg.)	Seeded (120K seeds)
		10/14/2008	113 plants (52 repro., 61 veg.)	Seeded (50K seeds)
China Creek (Bandon Beach)		9/27/2012	6 plants (3 repro., 3 veg.)	---
		9/13/2007	173 plants (121 repro., 52 veg.)	Seeded (50K seeds)
		9/26/2006	452 plants (346 repro., 106 veg.)	Seeded (50K seeds)
		10/4/2005	139 plants (124 repro., 15 veg.)	Seeded (100K seeds)
Bastendorff Beach	reintro.	9/21/2010	2 plants (2 repro., 0 veg.)	---
		10/15/2008	9 plants (6 repro., 3 veg.)	---
		9/13/2007	2 plants (repro.)	---
		9/26/2006	11 plants (8 repro., 3 veg.)	---
		10/5/2005	536 plants (410 repro., 126 veg.)	Seeded (50K seeds)
		9/13/2004	371 plants (245 repro., 126 veg.)	Seeded (50K seeds)
		10/2/2003	110 plants (104 repro., 6 veg.)	---
		9/11/2002	13 plants (8 repro., 5 veg.)	Seeded (50K seeds)
		8/15/2000	0 plants	---
		1998	---	Seeded (50K seeds)
1997	---	Seeded (50K seeds)		
1996	---	Seeded & transplanted		
1995	---	Seeded & transplanted		

Abronia umbellata ssp. breviflora on the Oregon coast: Reintroduction and population monitoring

Harris Beach State Park	natural	9/15/2004	0 plants	Natural pop'n, but also seeded (5,000 seeds) in 1995 and transplanted
		9/10/2002	0 plants	
		9/13/2001	0 plants	
		8/16/2000	0 plants	
McVay Park	natural	8/16/2000	0 plants	appeared unsuitable
Pistol River	reintro.	10/5/2009	0 plants	---
		10/14/2008	1 veg.	Seeded (80K seeds)
Euchre Creek (Ophir)	reintro.	9/15/2004	2 veg. plants	---
		9/30/2003	7 plants (4 repro., 3 veg.)	---
		9/10/02 9/13/01	9 plants (all repro.)	Seeded (50K seeds)
		8/16/2000	0 plants	---
		1999	1 veg. plant	Seeded (50K seeds)
			---	Seeded (50K seeds)



TABLE 11. RESULTS OF SURVEYS FOR PINK SAND-VERBENA SITES MANAGED BY THE USFWS ALONG THE OREGON COAST. IAE CONDUCTED SURVEYS FROM 2009-2012.

Site	natural or reintroduced	date surveyed	population size	Reintroduction history and other comments
Elk River	reintro	9/25/2012	556 plants (384 repro., 172 veg.)	Seeded (100k seeds)
		10/4/2011	307 plants (105 repro., 202 veg.)	Seeded (100k seeds)
		9/21/2010	113 plants (86 repro, 27 veg.)	Seeded (100k seeds)
		9/20/2009	389 plants (353 repro., 36 veg.)	Seeded (100k seeds)
Crook Point	reintro	9/21/2010	2 (1 repro., 1 veg.)	Seeded (50k seeds)

TABLE 12. RESULTS OF SURVEYS FOR PINK SAND-VERBENA SITES ALONG THE OREGON COAST MANAGED BY VARIOUS LAND MANAGERS INCLUDING THE STATE PARKS DEPARTMENT. IAE CONDUCTED SURVEYS FROM 2000-2012. POPULATION DATA FOR YEARS PRIOR TO 2000 ARE FROM VARIOUS SOURCES.

Site	natural or reintroduced	date surveyed	population size	Reintroduction history and other comments
Charleston Beach  (State and County Parks)	reintro.	9/21/2010	0 plants	---
		9/11/2002	0 plants	---
		8/15/2000	0 plants	---
		1996	---	Seeded and transplanted
		1995	---	Seeded and transplanted
Otter Point	natural	9/13/2007	0 plants	2000 was the first year since 1993 that no plants were observed at this site
Oregon Department of Parks and Recreation		9/26/2006	0 plants	---
		9/15/2004	0 plants	
		9/30/2003	0 plants	
		9/10/2002	9 repro. plants	
		9/13/2001	3 repro. plants	
		8/16/2000	0 plants	
		1999	9 plants	
Heceta Beach	reintro.	9/12/2001	0 plants	---
		10/18/2000	0 plants	---
		1995	---	Seeded (5K seeds)
N of Cape Blanco/ S of Blacklock pt. Oregon Department of Parks and	natural	9/12/2009	1 flowering plant	N42.8655 W124.53432  (identified by D. & D. Bilderback)

Recreation				
Cape Blanco	natural	9/26/2006	1 veg. plant	---
Oregon		9/15/2004	7 plants (3 repro., 4 veg.)	---
Department of				
Parks and				
Recreation		10/1/2003	0 plants	---
		8/16/2000	2 repro., 1 N & 1 S of creek.	---
		1999	1 plant	---
		1984	several plants	---
Floras Lake	reintro.	9/25/2012	67 plants (8 repro., 59 veg.)	---
Oregon		10/6/2009	0 plants	---
Department of				
Parks and				
Recreation/BLM		9/13/2007	0 plants	---
		9/26/2006	65 plants (41 repro., 24 veg.)	---
		10/4/2005	20 plants (all repro.)	---
		9/14/2004	220 plants (81 repro., 139 veg.)	---
		10/19/2000	10 plants (7 repro., 3 veg.)	Seeded (50K seeds)
		1996	7 plants	Seeded (5K seeds)
Hubbard Creek	reintro.	9/14/2004	4 repro. plants	---
Oregon		10/1/2003	0 plants	---
Department of				
Parks and				
Recreation		9/11/2002	0 plants	---
		8/15/2000	0 plants	---
		1999	1 plant	---
		1996	---	Seeded & transplanted
		1995	---	Seeded & transplanted
Port Orford	natural & reintro	10/2011	146 reproductive plants	---
Oregon		9/21/2010	136 reproductive plants	---
Department of				

Parks and Recreation		10/20/2009	269 plants (237 repro., 32 veg.)	---
		10/16/2008	226 plants (only repro. counted)	---
		9/13/2007	1,412 plants (846 repro., 566 veg.)	---
		9/26/2006	660 plants (454 repro., 206 veg.)	---
		10/4/2005	740 plants (392 repro., 348 veg.)	---
		9/14/2004	909 plants (556 repro., 353 veg.)	---
		9/30/2003	552 plants (159 repro. plants, 393 veg.)	---
		9/10/2002	1,146 plants (480 repro. and 666 veg.)	---
		9/13/2001	2,607 (1,467 repro. and 1,140 veg.)	---
		2000	1,834 plants	---
		1999	7,169 plants	---
Winchuck River	natural	9/10/2002	6 repro. plants	New site in 2000; N & S of creek mouth
Oregon Department of Parks and Recreation		8/16/2000	5 repro., 1 veg.	
Salmon River	reintro.	9/22/2012	0 plants	---
		9/26/2009	0 plants	---
Camp Westwind		10/22/2005	92 plants (52 repro., 40 veg.)	---
(Westwind Stewardship Group)		11/20/2004	1 repro. plant	---
		10/24/2002	163 plants (129 repro., 34 veg.)	Seeded (50K seeds)
		9/10/2001	741 plants (488 repro. 253 veg.)	Seeded (40K seeds)

## APPENDIX III. MAPS OF SELECTED SITES- SEEDED OR MONITORED

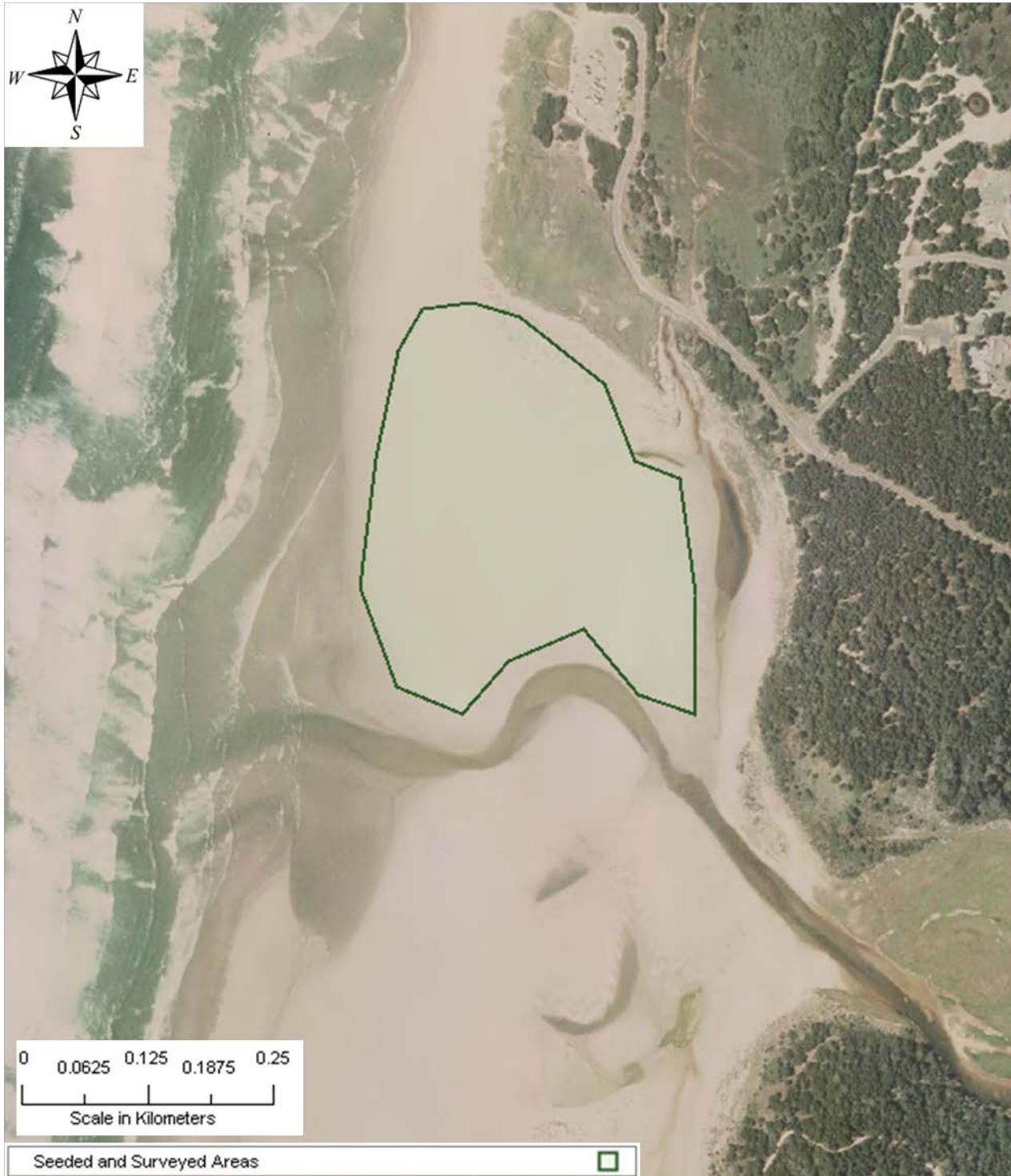
### New River



## Overlook North and South



## Siltcoos



## Tahkenitch

