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

2011 Report

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PREFACE

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

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EXECUTIVE SUMMARY

Pink sand-verbena (*Abronia umbellata* var. *breviflora*) is listed by the Oregon Department of Agriculture as endangered, 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 dwindled from around ten down to about five. The primary threats to the species include competition from European beachgrass (*Ammophila arenaria*) and habitat disturbance by off road vehicles. This report summarizes 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 **2011**, our actions and observations included:

1. USDA Forest Service, Siuslaw National Forest sites
 - a. Tahkenitch: 80,00 seeds were distributed at Tahkenitch in 2011, resulting in 95 plants (38 reproductive). This was the first seeding at the site since 2005.
 - b. Siltcoos Creek: 50,000 seeds were distributed, resulting in 415 plants (309 reproductive). This is a nearly triple the number of plants recorded in 2010 and an order of magnitude increase in the number of reproductive individuals (28 in 2010 to 309 in 2011). Plants at this site were among the most robust observed in 2011 surveys.
 - c. Overlook: This population is now one of the largest in Oregon and we strongly recommend continued beachgrass removal and seed addition. Both North and South Overlook had increased numbers of plants in 2011.
 - i. North: 60,000 seeds were distributed, resulting in 1,938 plants (794 reproductive)
 - ii. South: 60,000 seeds were distributed resulting in 2,349 plants (988 reproductive).
2. USDI Bureau of Land Management, Coos Bay District sites
 - a. New River: In 2010, 100,000 seeds were distributed, resulting in 810 plants (369 reproductive). After four years without control, beachgrass removal occurred in fall 2009 and likely contributed to the increase in population size observed in 2010. Continued beachgrass removal in 2011 expanded the suitable habitat and 80,000 seeds were distributed resulting in a total of 237 plants (44 reproductive). Continued seeding at the site should augment the existing seed bank.
 - b. Coos Bay North Spit: 100,000 seeds were distributed. Monitoring of the area was divided into three sub-sections and the entire

population was subsampled. Only reproductive plants were counted and the estimated population size is 185,623 reproductive plants, a 23% decrease from 2010.

3. Oregon Parks and Recreation Department sites
 - a. Bandon Beach (restoration area approximately 2 miles south of China Creek): In 2011, 100,000 seeds were distributed, resulting in 476 plants (173 reproductive).
4. Elk River (private land managed by the USFWS)
 - a. Elk River: 100,000 seeds were distributed resulting in 307 plants (202 reproductive).
5. Additional sites
 - a. Port Orford: This is a natural population that has been augmented with seeding and transplants in 1996. In 2011 146 plants were found at the site.

We observed that in 2011 as in previous years, the most successful sites were those with continued disturbance and the removal of European beachgrass (Overlook, Coos Bay North Spit, Elk River, New River, Siltcoos). Competition from European beachgrass continues to be a major factor in the success of pink sand-verbena populations, however there also appear to be unidentified factors (potentially including precipitation and temperature) that contribute to yearly fluctuations in population size. Although some seedings did not result in large numbers of plants in 2011, the added seed will contribute to the seed bank for recruitment in future years.

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INTRODUCTION

Pink sand-verbena (*Abronia umbellata* var. *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 populations in Oregon has dwindled from around ten down to about five (Figure 2). The primary threats to the species include competition from 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.

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 these species and others may be most effective if coordinated or combined.

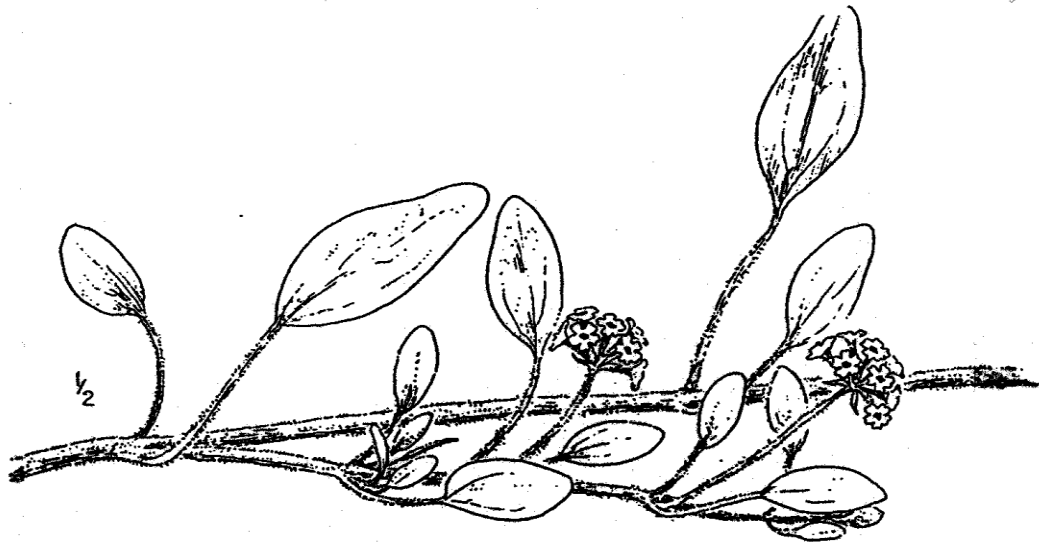


Figure 1. Pink sand-verbena (*Abronia umbellata* var. *breviflora*; from Hitchcock et al. 1964).

Since the mid-1990's, research has been conducted on methods for reintroduction of pink sand-verbena. Research on suitability of dredged material as habitat for pink sand-verbena suggests that if this substrate is placed adjacent to the shore, it may provide excellent conditions for the species in the short term (Kaye 1999). Information is still needed on the reintroduction potential of the species in various beach habitats 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, transplanting, and monitoring efforts at several beaches and dune habitats along the Oregon coast since 1997. This report focuses on recent efforts in the Siuslaw National Forest (Baker Beach Tahkenitch Creek, Siltcoos Creek, Sutton Creek, Tenmile Creek, and the Overlook site), Coos Bay District Bureau of Land Management (Coos Bay North Spit and New River), Oregon Parks and Recreation Department (Bandon Beach and Pistol River) and managed by the US Fish and Wildlife Service (Elk River and Crook Point). Information on additional populations can be found in Appendix III.

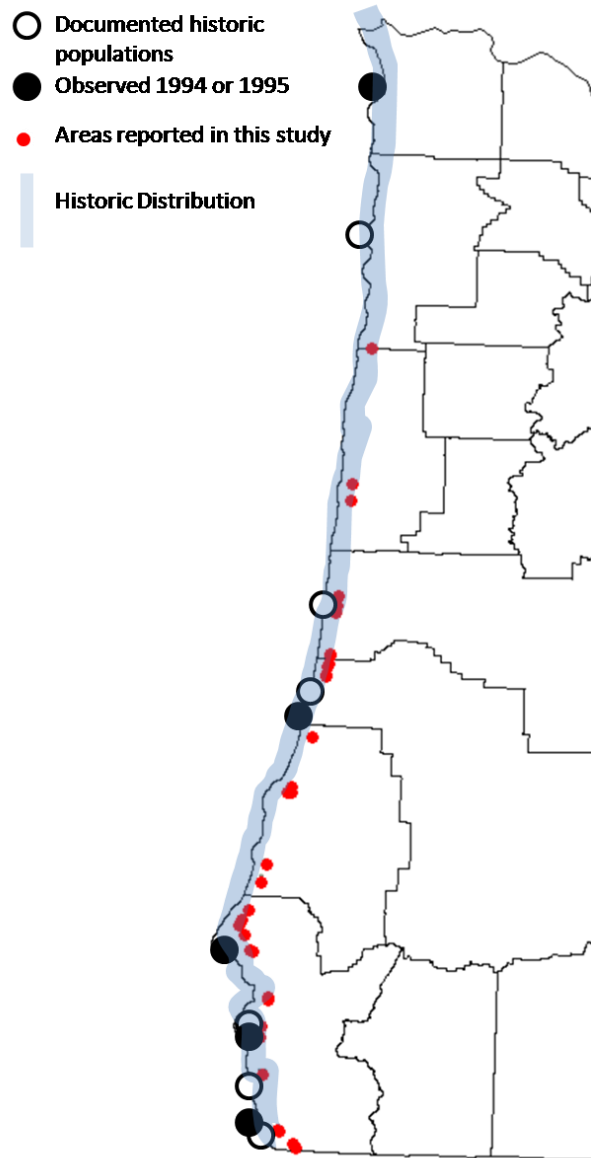


Figure 2. Historic and current distribution of pink sand-verbena (*Abronia umbellata* var. *breviflora*) in Oregon.

SEEDING AND MONITORING OVERVIEW

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 2011 were collected from populations at Port Orford or Coos Bay, Oregon. 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). From 1995-1997, seeds were collected from the natural population at Port Orford. 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.

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.

Study sites

Seed dispersal and/or transplanting were conducted at all or a subset of 17 Oregon sites from 1997 through 2011. Information on location, seeding and transplanting efforts, and brief habitat descriptions, is presented in Appendix III. Maps of sites seeded in 2011 are in Appendix II

Transplanting

Transplanting occurred at various sites over multiple years. Detailed descriptions and results of transplanting can be found in “Experimental Reintroduction of Pink Sand-Verbena on the Oregon Coast: Transplanting and Seeding”, 2005. Sites transplanted are also included in Appendix III.

Direct Seeding

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. Prior to dispersal, the release technique was

calibrated so that seeding was at a rate of approximately 50 fruits per linear meter of beach. A total of 50,000 seeds were released on each beach or foredune in each year except as noted in Table 1 (range: 40,000-150,000). More than 15 sites have been seeded since this project began in 1997 (for information about sites not listed in Table 1, see “Experimental Reintroduction of Pink Sand-Verbena on the Oregon Coast: Transplanting and Seeding”, 2005). All seeded sites were revisited the following late summer/early fall to survey for pink sand-verbena plants

Population surveys

General protocol - Beginning in 2000 we started surveying known pink sand-verbena habitat. Sites were selected based on population and reintroduction history and 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). In large populations we only counted reproductive plants. Because pink sand-verbena is an annual, vegetative plants do not contribute to future populations.

Table 1. Reintroduction sites, 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)	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)	Foredune beachgrass treatment area and open sand
<i>Private Land, managed by USFWS</i>				
	Elk River	North of Port Orford, off of McKenzie Road	<u>Seeding:</u> Feb. '09 (100k), March '10 (100k, Feb '11 (100k)	Beach, mouth of creek, beachgrass treatment area
<i>Siuslaw National Forest</i>				
	Baker Beach	Lily Lake, north side of Berry Creek, approximately 7 miles north of Florence	<u>Seeding:</u> Feb. '03, March '04, March '05, March '06, March '07, March '08, March '09	Beach, beachgrass treatment area.
	Floras Lake		<u>Seeding:</u> Dec. '96, March '00	Beach (high wave disturbance with coarse sand, small cove with pond)

Table 1. Reintroduction sites, 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)	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	Foredune beachgrass treatment area and open beach, mouth of creek
	Sutton Creek	6 miles north of Florence, Lane County	<u>Seeding:</u> March '04, March '06	Mouth of creek, foredune beachgrass treatment area and open sand
	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)	Foredune beachgrass treatment area and open beach, mouth of creek
	Tenmile Creek	7 miles south of the mouth of the Umpqua River	<u>Transplanting:</u> '99	Open beach (sand spit), mouth of creek

Table 1. Reintroduction sites, 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>Oregon Parks and Recreation Department</i>				
	Pistol River	Curry County about 10.5 miles south of Gold Beach	<u>Seeding</u> : April '08 (80k)	Foredune, open beach, abandoned river course
	Driftwood Beach	Driftwood Creek State Wayside	<u>Seeding</u> : Feb. '98	Beach
	Bandon Beach (China Creek & Bandon South)	Bradley Creek about 4 miles south of Bandon	<u>Seeding</u> : Feb. '98, March '02, March '05 (100k), March '06, March '07, March '08, Apr. '10 (120k), March '11(100k)	
	Bastendorff Beach	about 1 mile south of the mouth of Coos Bay	<u>Transplanting</u> : '95, '96 <u>Seeding</u> : Dec. '96, Feb. '98, March '02, March '04, March '05	
	Euchre Creek/Ophir	7 miles south of Humbug Mountain	<u>Seeding</u> : March '99, March '00, March '02	Beach

RESULTS

Table 2. Results of surveys for pink sand-verbena at Coos Bay District Bureau of Land Management sites along the Oregon Coast. IAE conducted surveys from 2000-2011. 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.	10/6/11	~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.)	---
		9/14/2001	~45,257 (repro.)	---
		9/19/2000	~45,000 (repro.)	---
	1996	---	Seeded (50K seeds)	
New River	reintro.	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 3. Results of surveys for pink sand-verbena sites managed by the Siuslaw National Forest along the Oregon Coast. IAE conducted surveys from 2000-2011. Population data for years prior to 2000 are from various sources.

Site	natural or reintroduced	date surveyed	population size	Reintroduction history and other comments
Tahkenitch Cr.	reintro.	10/5/2011	95 plants (38 repro., 57 veg.)	Seeded (80k seeds)
		10/2009	4 plants (2 repro., 2 veg.) *briefly surveyed by Marty Stein 1 veg.	---
		10/4/2006	0 plants	---
		9/14/2005	121 plants (72 repro., 49 veg.)	Seeded (50K seeds)
		9/29/2004	0 plants	Seeded (50K seeds)
		9/18/2003	22 plants (14 repro., 8 veg.)	---
		9/25/2002	50 plants (45 repro., 5 veg.)	Seeded (50K seeds)
		9/18/2001	32 plants (repro.)	Seeded (50K seeds) +50 transplants 50 transplants
		9/20/2000		
Overlook North	reintro.	10/4/2011	1,938 plants (794 repro., 1,194 veg.)	Seeded (60k seeds)
		9/26/2010	730 plants (238 repro., 492 veg.)	Seeded (50K seeds)
		10/6/2009	789 plants (466 repro., 323 veg.)	Seeded (50K seeds)
		10/2/2008	2,395 plants (811 repro., 1,584 veg.)	Seeded (100K seeds)
		9/24/2007	3,445 plants (2,790 repro., 655 veg.)	Seeded (80K seeds)
		10/4/2006	7,825 plants (1,976 repro., 5,840 veg.)	---
		9/14/2005	3,210 plants (1,191 repro., 2,019 veg.)	---
		9/29/2004	3,741 plants (2,632 repro., 1,109 veg.)	---
		9/18/2003	1,478 plants (1,359 repro., 119 veg.)	---
		9/25/2002	1,091 plants (574 repro., 517 veg.)	---
		9/18/2001	482 plants (390 repro., 92 veg.)	Seeded (50K seeds)
		9/20/2000	2 plants (repro.)	50 transplants (most pulled by accident)
Overlook South	reintro.	10/4/2011	2,349 plants (988 repro., 1,361 veg.)	Seeded (60k seeds)
		9/26/2010	1,052 plants (424 repro., 628 veg.)	Seeded (50K seeds)

		10/6/2009	2,073 plants (1518 repro., 555 veg.)	Seeded (50K seeds)
		2008	Informal survey noted plants as present	Seeded (50K seeds)
		9/24/2007	98 plants (76 repro., 22 veg.)	Seeded (50K seeds)
		10/4/2006	10 plants (4 repro., 6 veg.)	---
		9/14/2005	4,340 plants (2,581 repro., 1,759 veg.)	Seeded (50K seeds)
		9/29/2004	9,554 plants (6,325 repro., 3,229 veg.)	---
		9/18/2003	2,107 plants (1,954 repro., 153 veg.)	---
		9/25/2002	1,726 plants (1,435 repro., 291 veg.)	Seeded (50K seeds)
		9/18/2001	658 plants (427 repro., 231 veg.)	Seeded (50K seeds)
Baker Beach	reintro.	10/6/2009	6 plants (5 repro., 1 veg.)	Seeded (40K seeds)
		10/2/2008	70 plants (32 repro., 38 veg.)	Seeded (50K seeds)
		9/24/2007	42 plants (30 repro., 12 veg.)	Seeded (50K seeds)
		9/5/2006	12 plants (6 repro., 6 veg.)	Seeded (50K seeds)
		9/14/2005	72 plants (11 repro., 61 veg.)	Seeded (50K seeds)
		10/28/2004	93 plants (37 repro., 56 veg.)	Seeded (50K seeds)
		9/18/2003	55 plants (27 repro., 28 veg.)	Seeded (50K seeds)
Siltcoos Cr.	reintro.	10/5/2011	415 plants (309 repro., 106 veg.)	
		9/27/2010	148 plants (28 repro., 120 veg.)	Seeded (50K seeds)
		10/6/2009	36 plants (15 repro., 21 veg.)	Seeded (55K seeds)
		10/2/2008	41 plants (14 repro., 27 veg.)	Seeded (60K seeds)
		9/24/2007	66 plants (54 repro., 12 veg.)	Seeded (100K seeds)
		10/4/2006	385 plants (202 repro., 183 veg.)	Seeded (50K seeds)
		9/14/2005	989 plants (961 repro., 28 veg.)	Seeded (50K seeds)
		10/28/2004	355 plants (311 repro., 44 veg.)	Seeded (50K seeds)
		9/18/2003	215 plants (195 repro., 20 veg.)	---
		9/25/2002	19 plants (12 repro., 7 veg.)	Seeded (60K seeds)
		9/18/2001	7 plants (all repro.)	45 Transplants
		9/20/2000	249 plants (135 repro., 114 veg.)	Seeded (50K seeds)
		1999	---	Seeded (50K seeds)
Sutton Creek	reintro.	9/24/2007	0 plants	---
		9/5/2006	0 plants	Seeded (50K seeds)
		2005	0 plants	Seeded (50K seeds)
		10/28/2004	150 plants (28 repro., 122 veg.)	Seeded (50K seeds)

Tenmile Cr.	natural and augmented	10/23/2003	1 plant (repro.)	---
		9/25/2002	0 plants	---
		9/18/2001	0 plants	---
		9/20/2000	0 plants	---
		1999	---	150 transplants

Table 4. Results of surveys for pink sand-verbena sites managed by the Oregon Department of Recreation along the Oregon Coast. IAE conducted surveys from 2000-2011. 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.	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)
		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 Seeded & transplanted		
1995	---	---		
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	reintro.	9/15/2004	2 veg. plants	---
		9/30/2003	7 plants (4 repro., 3 veg.)	---
		9/10/02	9 plants (all repro.)	Seeded (50K seeds)
		9/13/01		
		8/16/2000	0 plants	---
		1999	1 veg. plant	Seeded (50K seeds)
			---	Seeded (50K seeds)

Table 5. Results of surveys for pink sand-verbena sites managed by the **USFWS** along the Oregon Coast. IAE conducted surveys from 2000-2011. Population data for years prior to 2000 are from various sources.

Site	natural or reintroduced	date surveyed	population size	Reintroduction history and other comments
Elk River	Intro	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	Intro	9/21/2010	2 (1 repro., 1 veg.)	Seeded (50k seeds)

Table 6. Results of surveys for pink sand-verbena sites along the Oregon Coast managed by various land managers.. IAE conducted surveys from 2000-2011. 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	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
		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.	natural	9/12/2009	1 flowering plant	N42.8655 W124.53432 (identified by D. & D.)

				Bilderback)
Cape Blanco	natural	9/26/2006	1 veg. plant	---
		9/15/2004	7 plants (3 repro., 4 veg.)	---
		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.	10/6/2009	0 plants	---
		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	---
		10/1/2003	0 plants	---
		9/11/2002	0 plants	---
		8/15/2000	0 plants	---
		1999	1 plant	---
		1996	---	Seeded & transplanted
		1995	---	Seeded & transplanted
Port Orford	natural & augmented	10/2011	146 reproductive plants	---
		9/21/2010	136 reproductive plants	---
		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
		8/16/2000	5 repro., 1 veg.	
Salmon River	reintro.	9/26/2009	0 plants	---
		10/22/2005	92 plants (52 repro., 40 veg.)	---
		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)

General trends

Pink sand-verbena seed sown by hand resulted in plant establishment in 75 out of 87 attempts between 1997 and 2011 (Table 2 - 6, Figure 3). At least some of the seedlings failed because the sites were subjected to high disturbance; exposed beaches experience high winds and waves and the mouths of rivers may flood, potentially causing seed to be washed away or covered by sediment. The highest establishment for the first year of seeding was at the Coos Bay North Spit (3.4%). At all other sites, establishment varied from 0.0% (no plants) to 1.85% (741 plants), with an average of 0.46% (Figure 3).

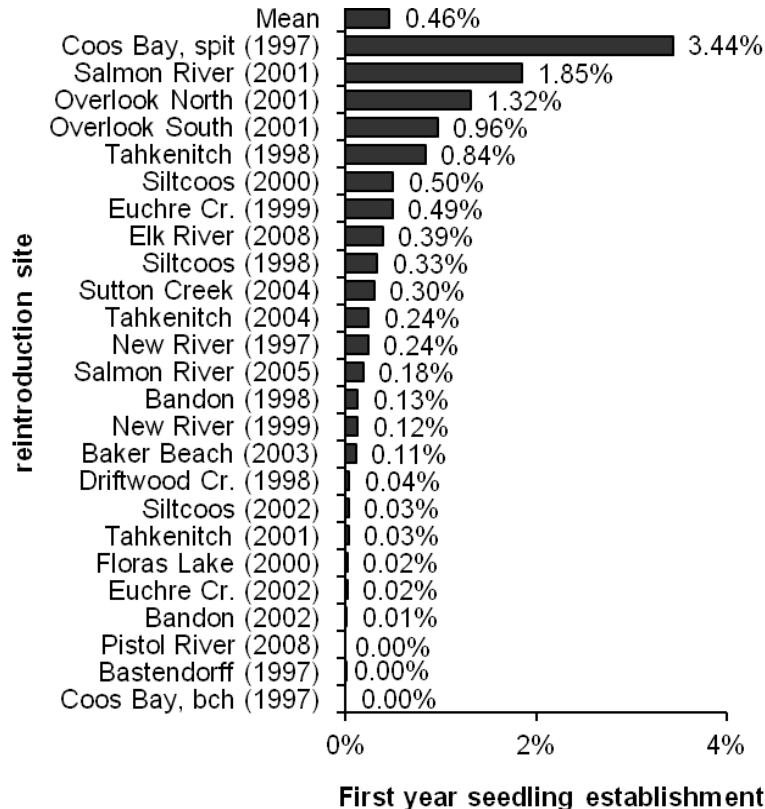


Figure 3. Plant establishment rates within one year of seed-sowing on beaches and restored dunes. Bar length and the value to the right indicate the percentage of seeds establishing as vegetative or reproductive plants. Only sites that were seeded at least two years after an earlier seeding attempt are shown. The year of seed sowing is indicated in parentheses after each location name. At New River in 1999, the seeding area was partially destroyed prior to observation, so the value presented may be an underestimate of the actual number of plants established there. A total of 50,000 seeds were sown at each site, except where noted in Table 1.

Inventories for pink sand-verbena were conducted at several reintroduction and natural populations on the central and southern Oregon Coast in the late summer and early fall of 2000-2011 (Table 2-6). Notable findings from the natural sites in 2000 included the discovery of plants at the mouth of the Winchuck River and confirmation of a small population (two plants) at Ona Beach State Park. A subsequent visit to Ona Beach in 2001 did not locate any plants, but plants were again seen at the mouth of the Winchuck River in 2002. One vegetative plant was found at the natural population at Cape Blanco, in 2006. The last observation of pink sand-verbena at Cape Blanco was in 2004, when three reproductive plants and four vegetative plants were found. In 2009, two new populations were identified, one just north of Tish-A-Tang in Bandon with 45 plants (30 reproductive) and the other at Arizona Beach State Park with 3 plants (2 reproductive).

Population size and population response to seeding varies substantially from year to year. Two of the largest drivers appear to be amount of disturbance (e.g. the exposed beach on Coos Bay North Spit) and competition by European beach-grass. Climate is also likely an important driver. For example, three populations (Bastendorff Beach, Siltcoos Creek, and Bandon Beach) expanded in 2003 despite a lack of seeding in that year. Although the 2002-2003 winter had been extremely dry, March and April of 2003 were extremely wet months and several rainfall records were broken in western Oregon. 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. The germination of seeds from previous seeding efforts (including 2002) may have been assisted by the lack of severe winter storms that would have buried and/or moved seeds followed by substantial precipitation.

Restoration at Siuslaw National Forest sites

Active restoration at sites managed by the Siuslaw National Forest in 2011 include Siltcoos, Tahkenitch and Overlook, for information about other sites see

Appendix III.

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 989 (nearly all of which were reproductive) in 2005 (Figure 4, Table 3). There was a significant decline in the number of pink sand-verbena at most sites on the Oregon coast in 2008 and 2009 and the low number of plants found at Siltcoos in these years is potentially not due to site-specific factors. In 2010, 148 plants were found (28 reproductive and 120 vegetative). In 2011, 100,000 seeds were distributed in the spring and we counted 415 plants (309 reproductive and 106 vegetative) in the fall. Plants at this site were generally larger and had more fruits per plant compared to the other sites we monitored this year. Siltcoos has consistently had one of the highest reintroduction success rates and we recommend continued seed addition efforts and beachgrass removal.

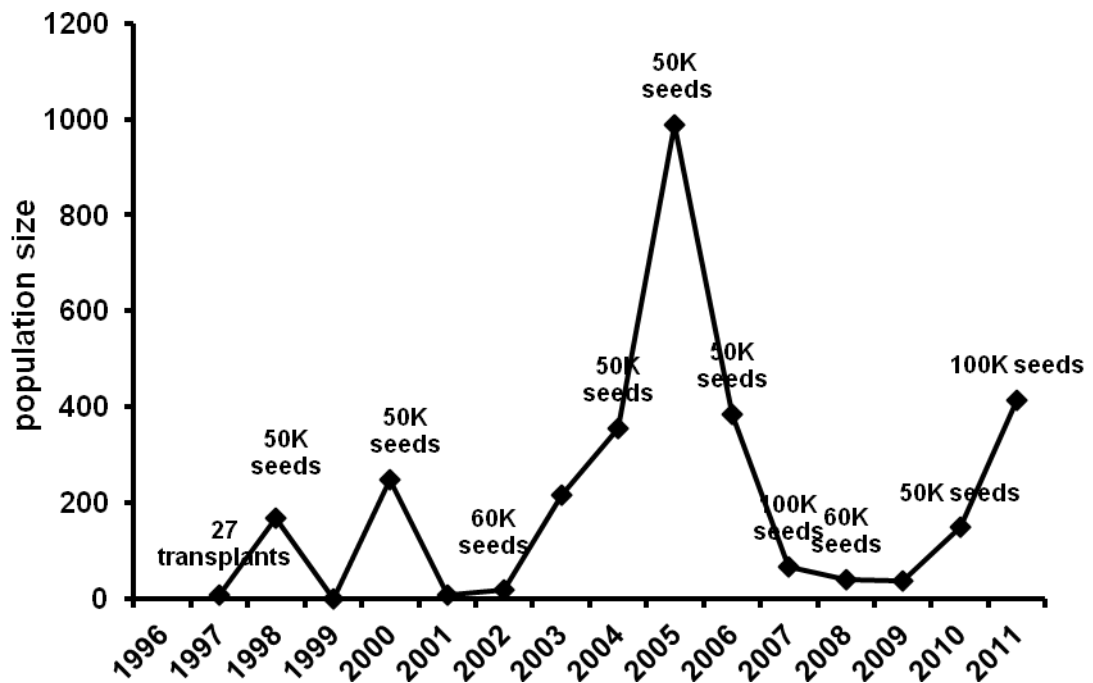


Figure 4. . Population trends and seeding history at Siltcoos Creek, 1996 – 2011.

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 was followed by planting 27 plants in 1997 and 34

plants in 1998. Fifty thousand seeds were added in 1998. Over 450 plants were counted in 1998 but no plants were found in 1999. The outplanting of 50 individuals in 2000 and 2001 resulted in 32 and 50 plants, respectively. Seeding with 50,000 seeds in 2002 resulted in a relatively small number of plants (22) and no plants were observed in 2003 (Table 2). In 2004, 121 plants were observed after seeding with 50,000 seeds, the largest population this site has supported since 1998. In 2005 we again found no plants and in 2006 we found only one vegetative plant. 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). Continued seeding in the area will help to build the seed bank at this site.

Overlook North and South

European beachgrass 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. All but two of these were uprooted accidentally by a crew that was pulling European beachgrass from the restoration site. 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). In 2002, the south site received an additional 50,000 seeds and the number of plants counted in the fall at both sites combined was 2,817. No seeding or planting was conducted in 2003 and 2004, but bulldozing was conducted in both years and the population continued to grow to 3,585 in 2003 and 13,397 in 2004 (Table 3, Figure 5). In 2004, the area of the population expanded to include the beachfront between the two Overlook sites and the area north of Overlook North. The population generally decline from 2005 through 2008. In 2008 the Overlook North site was expanded, and it initially appeared that Overlook North and South had been combined into one large area. This was not the case, but Overlook South was not formally surveyed. Several pink sand-verbena were observed at Overlook South during a site visit in November 2008; as the area was not seeded in 2008, these plants most likely recruited from the seedbank. Since 2008, the population has remained relatively stable. In 2011 both sites were seeded with 60,000 seeds and in the fall, North Overlook had 1,938 plants (1194 vegetative and 744 reproductive) and South Overlook had 2,349 plants (1,361 vegetative and 988 reproductive).

The reintroduced population at the Overlook sites is now the second largest population in Oregon (Coos Bay North Spit is the largest). The substantial growth in 2003 and 2004 in the absence of additional seeding appears to be due to the topographic position of the restoration area which is well above the reach of winter storm waves; winter waves typically would remove a large proportion of any seeds that were produced the previous year. However, because the habitat is

protected from winter storms, European beachgrass is re-invading the site and will require additional control measures to keep it from re-occupying the pink sand-verbena habitat. Without continual beachgrass 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 at the north end. 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. We also recommend continued observations of the spread and potential impact of *Leymus*.

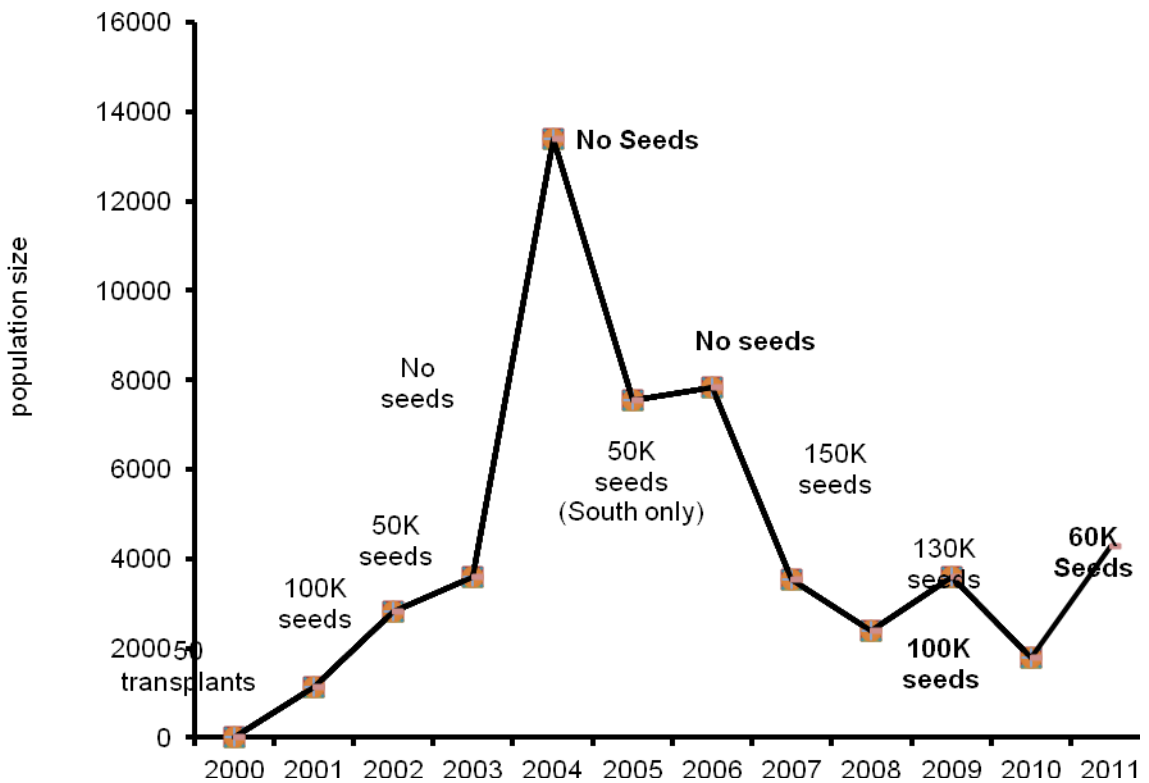


Figure 5. Total number of pink sand-verbena plants counted at North and South Overlook sites, 2000-2011. Seeding and transplanting events are marked at each applicable year. South Overlook was not surveyed in 2008; the datapoint refers only to North Overlook.

Bureau of Land Management

Coos Bay North Spit

Seeding and monitoring - Efforts to eliminate European beachgrass from a roughly 170 acre Habitat Restoration Area (HRA) on the Coos Bay North Spit (Figures 3 and 4) 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 and 2011. All habitat at the North Spit was disced in October (2008) or November (2009-2011).

In 2009, the population 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 2011 in the southeast 36 transects were monitored, in the west 20 transects were monitored and in the north 20 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 ($\bar{0}$) by the total number of possible plot locations (N):

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

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

$$\text{95\% confidence interval} = \bar{0} \pm [1.96 * \pi(N^2 * SE_0^2 * (N-n/N))]$$

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).

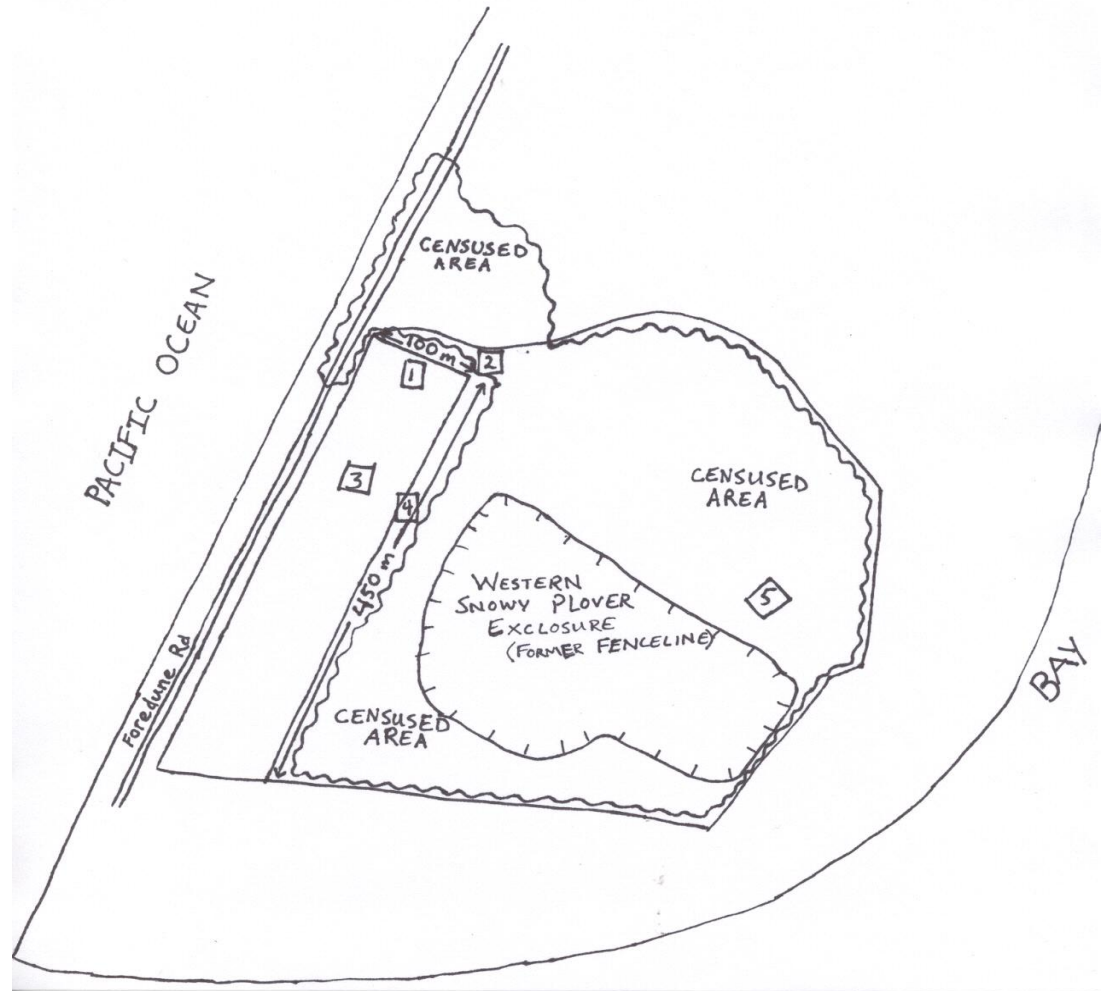


Figure 6. Coos Bay North Spit pink sand-verbena reintroduction area. The open squares numbered 1-5 represent the original seeding plots; 10,000 seeds were sown in each plot in January 1997. The long rectangular area on the west side of the spit is the reference area established in 2000 (and expanded in 2002) used for subsampling reproductive pink sand-verbena abundance. The area delineated with a wavy line is censused instead of subsampled. North is toward the top of the page. The area seeded from 2006 to present west of the Foredune Road is not shown.

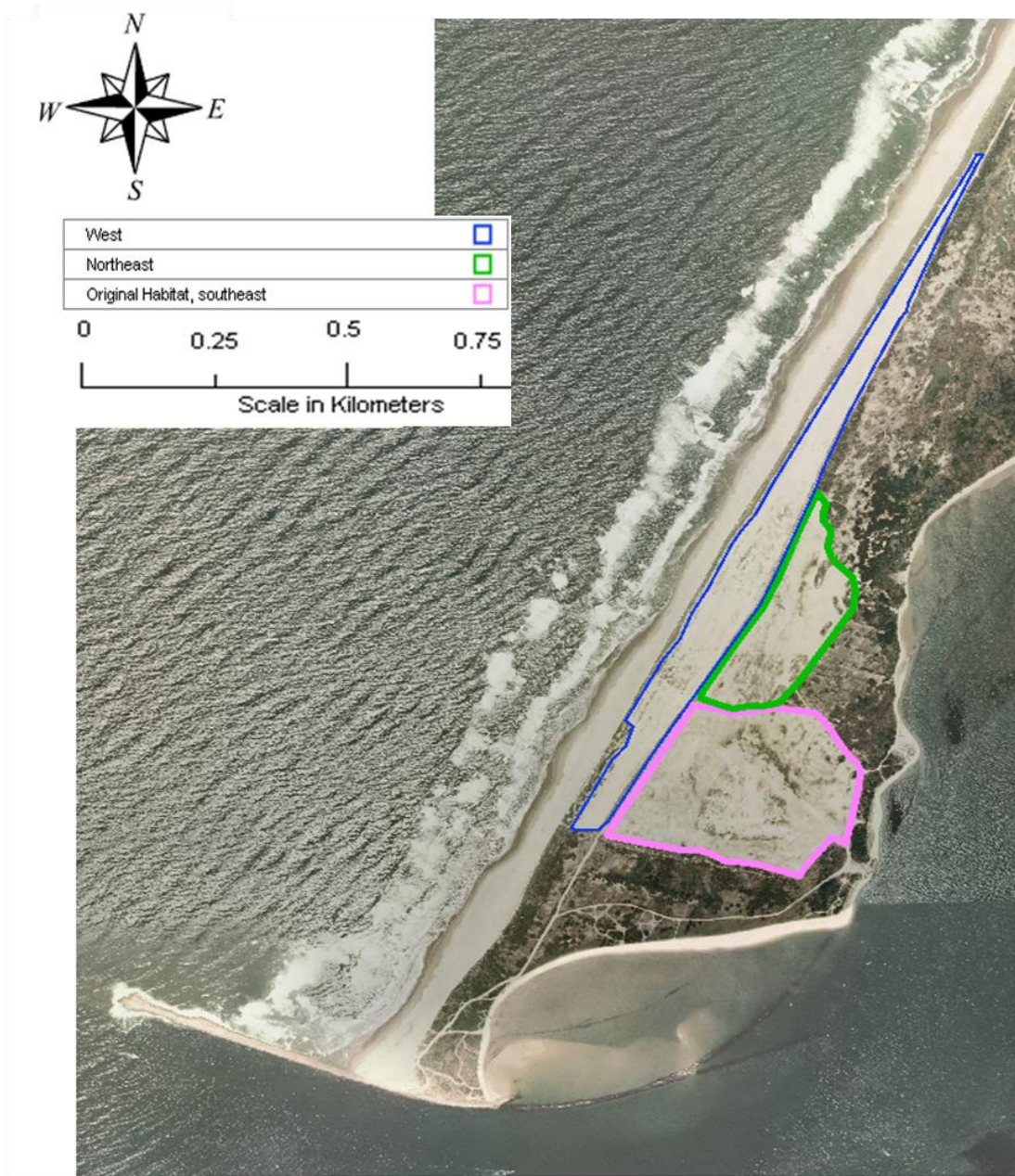


Figure 7. In 2009, the populated area was divided into three section, 1) the original habitat (southeast), 2) northeast and 3) west of the foredune road. Each area was subsampled using the methods described in the text.

Population trends - Following re-introduction in 1997, pink sand-verbena populations grew steadily to an estimated peak of 240,488 in 2010 (Figure 8). The increase in population size from 2007 to 2010 likely is a result of both population growth and improved monitoring techniques initiated in 2009. The increase in the number of reproductive plants in the last few years may have been accompanied with a decrease in plant size and number of flowers per plant.

In 2008 we were not able to estimate the total population size because the area west of Foredune Road and the southeastern area were disced prior to the population census. We estimated the reproductive plant population size within the reference area to be 2,231 (95% C.I.: 962 – 3,498). This was a 95% reduction compared to the estimated population size in the reference area in 2007 of 41,081 reproductive plants (95% C.I.: 26,301 – 53,860). We observed that many of the plants in the reference area were very small and the population appeared less dense compared to 2006 and 2007. The estimated population size in the north census area was approximately 20% of the 2007 total; these numbers should be compared with caution as the southern boundary of the north census area is not consistent from year to year.

In 2009, we changed our monitoring technique so that the entire population was subsampled. We estimated the 2009 population size to be 203,959 reproductive plants. In the western area, there were 9,684 reproductive plants (C.I.: 4,922 – 14,447). In the northeastern area, 78,079 reproductive plants (C.I. 52,072 – 104,087) and in the original habitat (southeast), 113,612 reproductive plants (C.I.: 73,081 – 154,144). In 2010 a similar sampling method was followed and the estimated population size increased slightly, except for the western area. In the original habitat (southeastern area) there were 154,502 reproductive plants (C.I.: 71,459-237,545), in the northern area 79,437 (C.I.: 47,327-111,547) and in the western area 6,549 (C.I.: 2,137-10,961). In 2011, the population decreased in size to an estimated 185,623 plants. Both the western area and the original habitat saw a decrease in the number of plants observed. The western area had 5,376 reproductive plants (C.I. 2,722 – 8,030), and the original habitat had 71,731 reproductive plants (C.I. 35,006 – 107,736). The northern area had a slight increase in the number of reproductive plants observed to 108,874 (C.I. 78,257 – 139,492), however consistent with observations made in 2009 and 2010, the size of reproductive plants seems to be diminishing as does the seed yield. In 2012 we will take plant measurements in addition to our population survey.

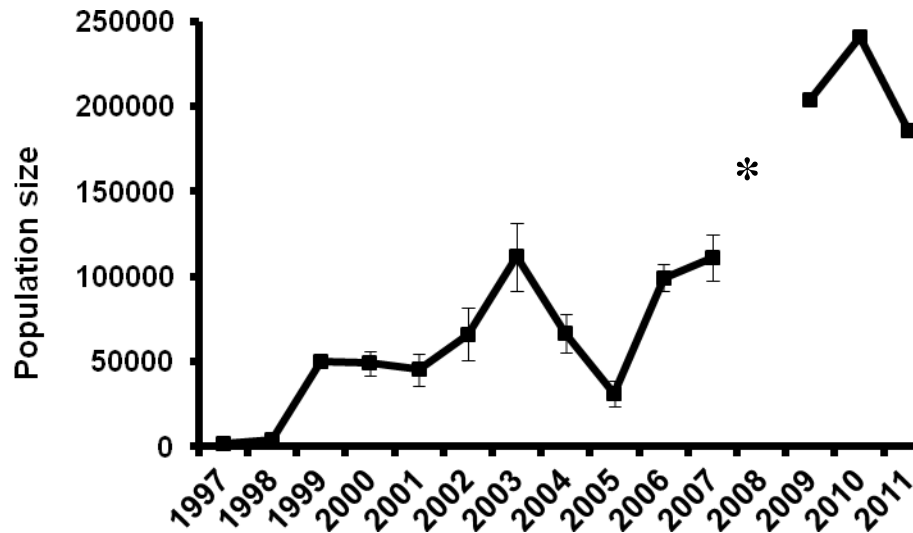


Figure 8. Population trends at the Coos Bay North Spit reintroduction site. The area was seeded in January 1997 with 50,000 seeds from Port Orford. Population size estimates for 1997-1999 are complete censuses of all plants in the population, while those from 2000-2008 are estimated from a subsample 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 2009-2011 is not reported because the population estimate is a combination of 3 different populations, each with their own CI.

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 beachgrass on the spit (described in Pickart and Sawyer [1998] and Kaye [1998]). Some of the continued growth of this population in 2002 was due to northward expansion of the plant into areas more recently cleared of European beachgrass and other established vegetation outside of the HRA (formerly called HCA). No beachgrass control was conducted in 2004 and 2005, and the population declined in both of those years. In 2008, we observed that many of the plants in the north census area followed the previous

year's disc line (Figure 13), suggesting that the discing may have exposed seeds to the proper conditions for germination. Thus, 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.

New River ACEC–

Seeding and monitoring - At New River, 50,000-150,000 seeds were dispersed within swales through the foredune almost every year from 1997 to 2011 (Table 1). 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 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. In the process, an unknown number of pink sand-verbena plants may have been buried, so the estimate of plant abundance at this site in 1999 may be below the actual number present. Estimates of population size from this site were not included in calculations of average plant establishment presented later in this report.

Population trends - The pink sand verbena population at New River has been sustained by direct seeding with 50,000 - 150,000 seeds from 1997-2011 (Figure 9). In the first year of seeding (1997), 118 plants established. In 1998, seeding was not conducted and no plants were found. Seeding in subsequent years resulted in the continual establishment of populations. In 2002, a total of 490 plants (339 reproductive) were observed in the over-wash swales, beach front, and low foredunes of the beachgrass control areas. Yearly beachgrass control and seeding led to continued population increases to a high of 2,174 plants (1,114 reproductive) in 2005. Beachgrass control did not occur from fall 2005 through spring 2009. Despite repeated seeding, the population declined to 62 plants (42 reproductive and 20 vegetative) in 2009. Beachgrass control resumed fall 2009, and in 2010 (after the distribution of 100,000 seeds) 810 plants were found at the site (369 reproductive) in the fall. In 2011, only 237 plants were found (193 vegetative and 44 reproductive). These patterns suggest that increased competition from European beachgrass is likely to have contributed to the

decrease in population size from 2006-2009. We recommend that seeding and beachgrass removal efforts continue at this site using the current approach of seeding following disturbance in the fall.

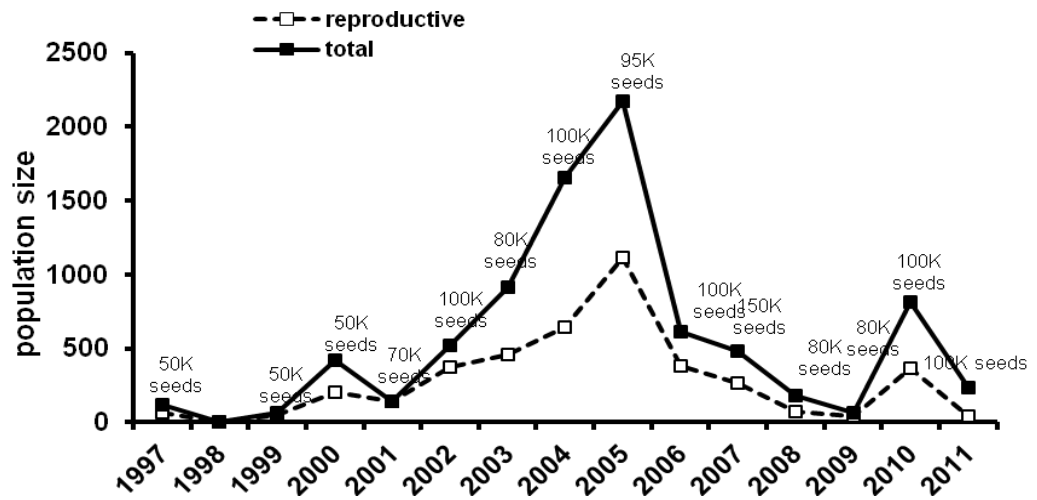


Figure 9. Population trends at the New River ACEC reintroduction site. Seeding has been conducted in all years except 1998.

Oregon Parks and Recreation Department

Bandon Beach South - In 2005, a new reintroduction site was established within the HRA approximately one mile south of the China Creek parking area (Appendix II). Prior to reintroduction work in the area, pink sand-verbena plants were located only at the mouth of China Creek.

In 2005, Oregon State Parks removed beachgrass and lowered the foredune in the area. In September 2005, we censused the site and found that although a substantial amount of beachgrass had re-grown into the habitat, 139 pink sand-verbena had become established. The relatively low number of plants in the project area in 2008 might reflect reduced habitat quality due to regrowth of European beachgrass. However, it is also likely that climate played a significant role. Since 2008 the population has continued to grow. In 2011, 476 plants were found (303 vegetative and 173 reproductive). Many large plants were found on the south end on the protected side of the dunes as in previous years. The majority of plants were in the main beachgrass removal area; however a few plants were found on the beach near the base of the dunes just south of the treatment area. The persistence of plants and strong recruitment in previous years suggests that with continued beachgrass removal, pink sand-verbena reintroduction may be successful at this site.

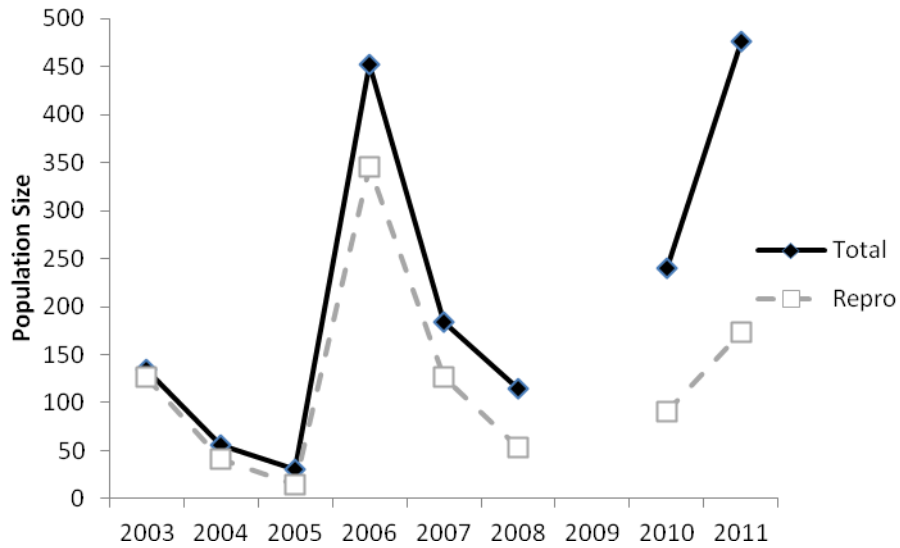


Figure 10. Population trends at Bandon State Park. European beachgrass removal and lowering of the foredune occurred in 2005. At that time the area was seeded and the natural population augmented. The area was not surveyed or seeded in 2009.

US Fish and Wildlife Service

In 2010 and 2011, the USFWS funded seeding and monitoring at Bandon Beach south, owned by the Oregon Parks and Recreation Department (described above)

Elk River

In 2009 this area was bulldozed and efforts were made to reduce cover of European beachgrass. In 2009 seeding efforts were initiated at the site and 100,000 seeds were distributed. This resulted in 389 plants (353 reproductive). In 2010 and 2011, 100,000 seeds were distributed resulting in 122 and 307 plants respectively (Figure 11). Continued seeding at this site will contribute to the seed bank. Continued beachgrass control will be necessary for the success of pink sand-verbena at this site.

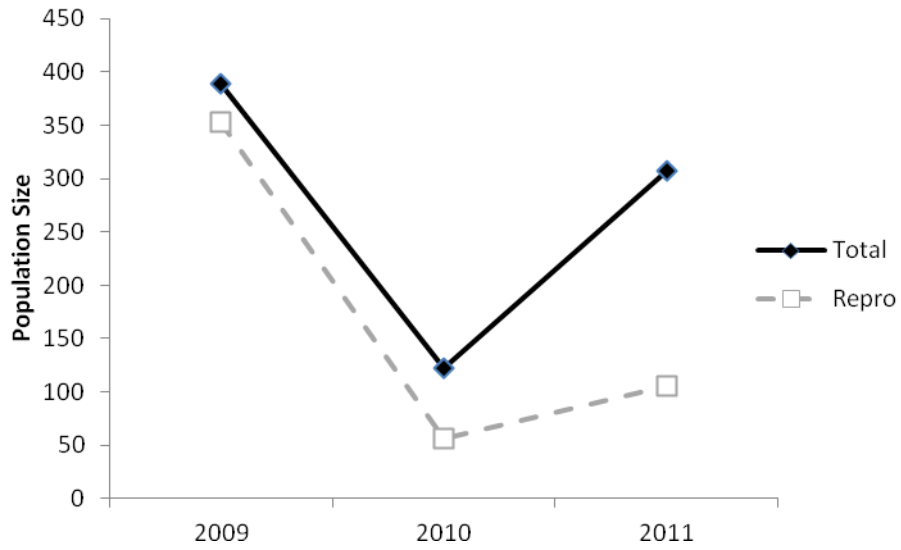


Figure 11. Population trends at Elk River. Seeding began in 2009.

Crook Point

In 2010 50,000 seeds were distributed at this site resulting in only 2 plants (1 reproductive). This area was not seeded in 2011, however it is recommended that the site be monitored in 2012.

DISCUSSION

Transplanting

Transplanting pink sand-verbena can be a successful reintroduction technique. Survival of transplants at Tahkenitch, Siltcoos, and Tenmile averaged 47%, a value typical of earlier transplant efforts at a number of sites. Previous tests of transplant success resulted in an overall average of 51% survival (Kaye 1995, 1996). Factors that affect survival of transplants at any given site appear to include amount of wind blown sand that buries or excavates the plants, moisture availability in the sand at the time of transplanting, and the abundance or proximity of competing vegetation, especially European beachgrass. For example, in 2001, transplants at Tahkenitch did relatively well (76% survival), especially those near the shore and those that did not show evidence of intense wind damage. Transplants at Siltcoos in 2001 were extensively damaged by the wind; their root systems were excavated and overall survival was relatively low survival (16%).

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. So far, offspring from transplants have been relatively uncommon, except after the 1997 Siltcoos transplanting that produced abundant plants the following year (but not the year after that).

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 that year.

The success of seeding is increased with a greater number of seeds. 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 75 out of 87 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).

The populations at Coos Bay North Spit and the Overlook sites are examples of reintroductions into beachgrass control areas that have done

remarkably well. In 1996, 50,000 seeds were distributed at the Coos Bay North Spit. The population quickly grew from over 1,700 plants in 1997, to 4,111 in 1998 and at least 50,000 in 1999. From 2000 on, the plants were so abundant that a reference area was subsampled with randomly placed plots (Figure 4) 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, 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 2010 was estimated at 240,488, (95% C.I.: $\pm 119,565$), the highest population size recorded to date at any known site. Much of the population growth has been due to expansion into adjacent areas that have been cleared of vegetation, including a new area that was seeded in spring 2006. Plants in the central part of the sampled zone on the west edge of the population tended to occur in high density patches.

At Coos Bay North Spit in recent years 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 seems to have 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 our monitoring at North Spit will include some plant measurements which will serve as a baseline for comparison in the future.

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 ($>2 \text{ m}^2$) and produced copious amounts of seed. Where possible, plants that appear to be overwintering at the time of seeding will be noted and checked on in the fall to determine if the plants survived a second growing season.

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 12).

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 can 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.

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.

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 3.

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.

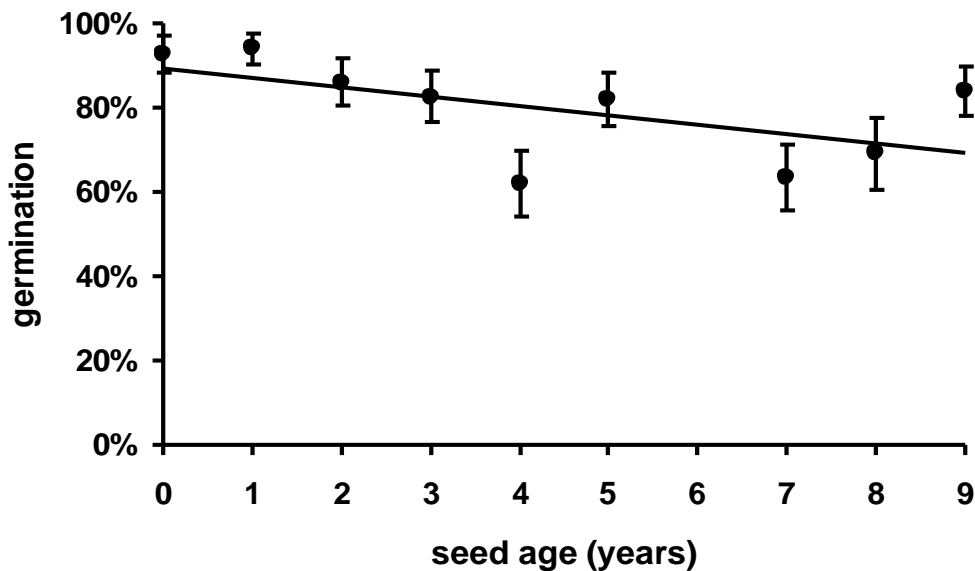


Figure 12. The percent germination of seeds stored from 0 – 9 years. The equation for the linear regression is $y = -0.036x + 0.955$, $R^2 = 0.81$, $P = 0.015$.

Table 7. Plant species native to Oregon beaches and dunes: 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>
black knotweed	<i>Polygonum paronychia</i>
American dunegrass	<i>Elymus mollis</i>
American glehnia	<i>Glehnia 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.

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. 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.

RECOMMENDATIONS FOR 2012

In 2011~ 250,000seeds were collected from Coos Bay, for distribution in 2012.

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 2012:

Management Agency	Site	Recommended 2010 Number of Seeds	Action Taken 2011	Recommended Action. 2012
US Forest Service, Siuslaw N.F.	Siltcoos Creek	40,000	50,000	50,000
	Overlook, North	50,000	60,000	60,000
	Overlook, South	60,000	60,000	60,000
Bureau of Land Management, Coos Bay	Tahkenitch	50,000	80,000	100,000
	New River	120,000	100,000	100,000
	Coos Bay North Spit	120,000	100,000	100,000
Private land (managed by USFWS)	Elk River	100,000	100,000	100,000
Oregon Parks and Rec. (restoration by USFWS)	Bandon Natural Area	100,000	100,000	100,000

We recommend that population surveys be conducted at the following sites in the fall of 2012:

County	Site
Lane County	Siltcoos Creek
“	Baker Beach
“	Sutton Creek
Curry County	Cape Blanco
“	Elk River
“	Euchre Creek
“	Floras Lake
“	New River
“	Otter Point
“	Port Orford
Douglas County	Overlook North and South
Coos County	Bandon Beach China Creek
“	Bandon Beach South
“	Coos Bay North Spit
Lincoln county	Salmon River

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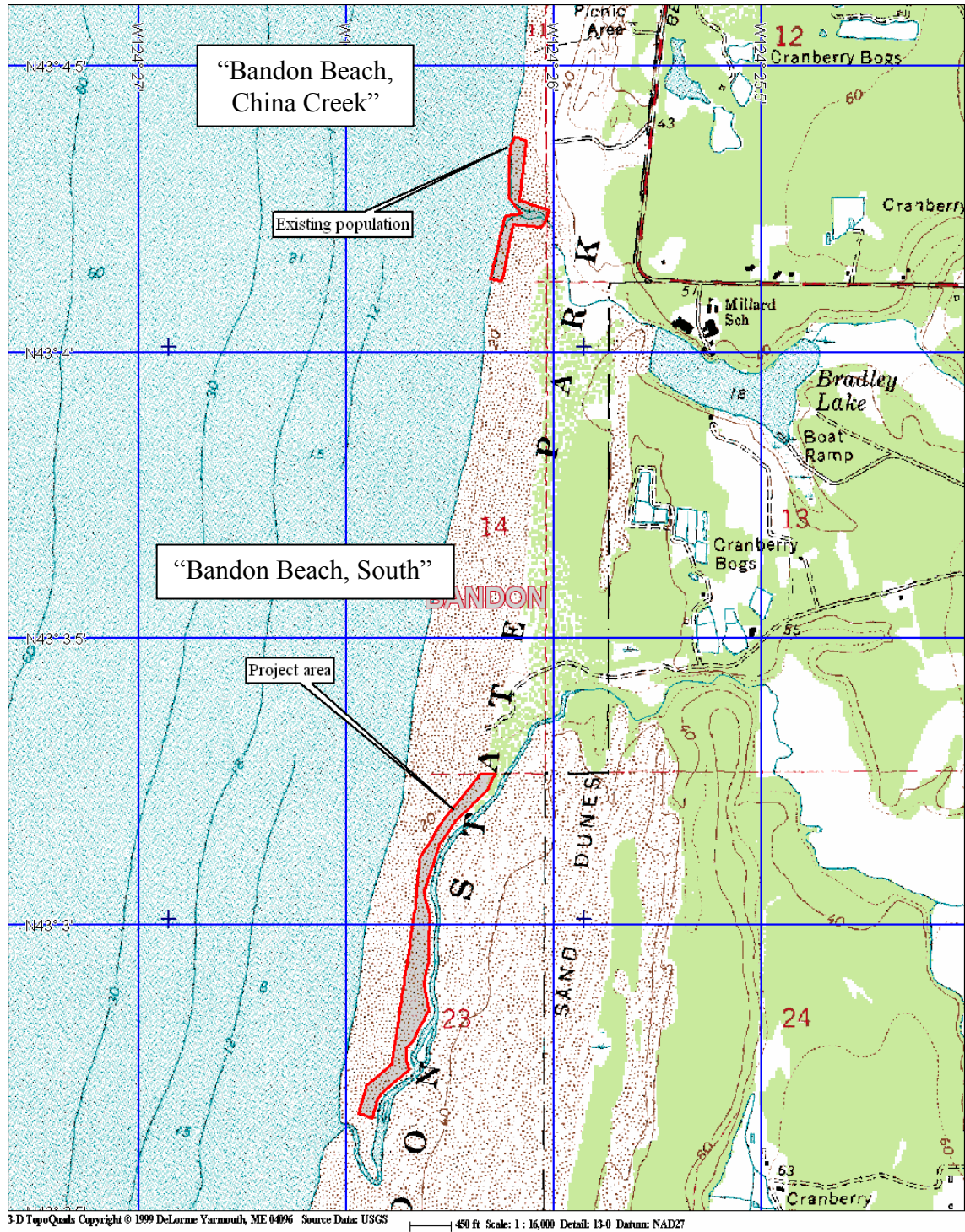
APPENDIX I MATERIALS REQUIRED FOR POPULATION MONITORING

pin flags
data sheets
GPS
previous year's report
6 100m tapes (Coos Bay only)
flagging

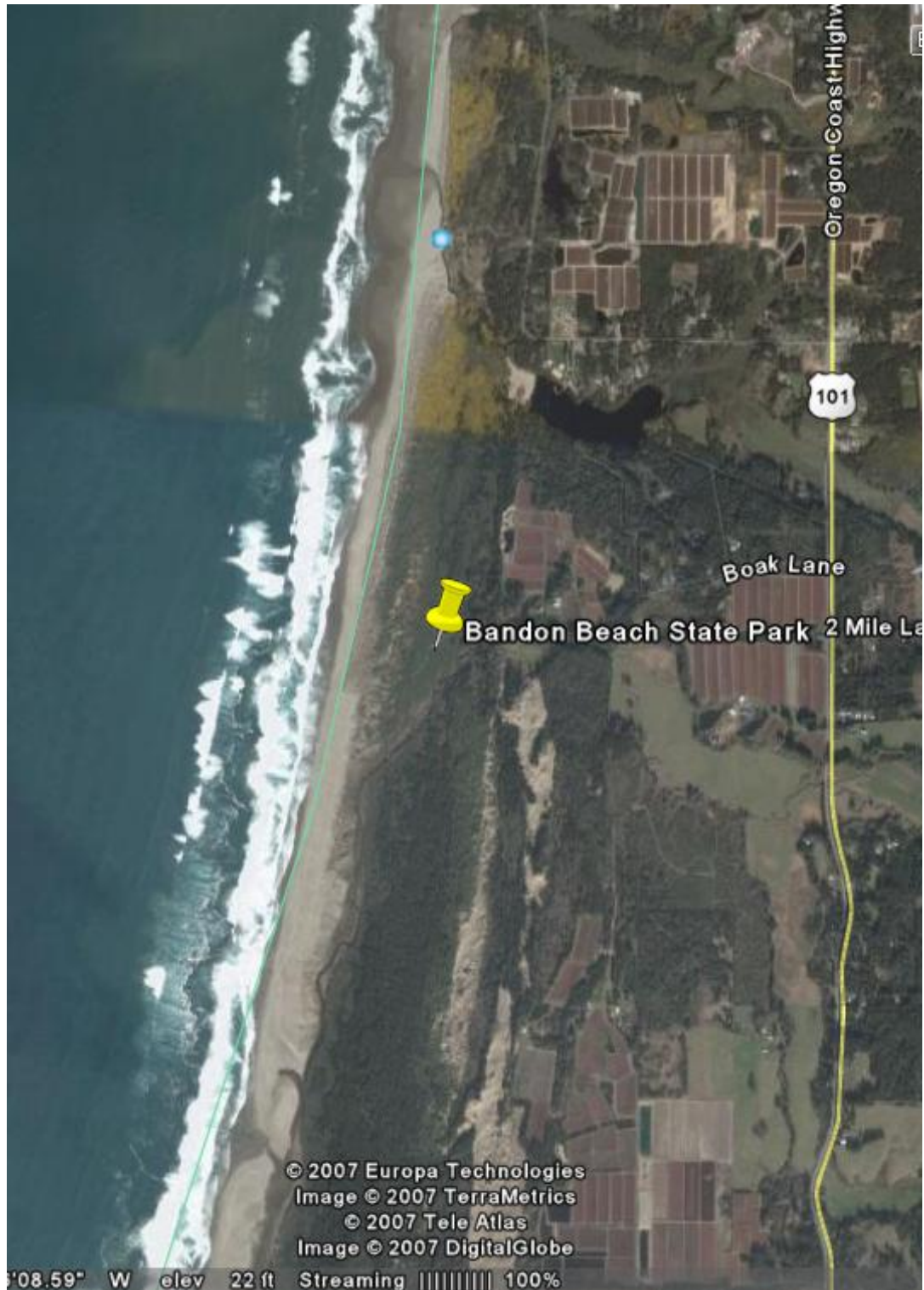
APPENDIX II MAPS OF SELECTED SITES SEEDED OR MONITORED

Bandon Beach State Park

Project location map at Bandon Beach State Park. "Project area" refers to the beachgrass control



Bandon Beach



Abronia umbellata var. *breviflora* reintroduction and monitoring, 2011

Bastendorff Beach



Floras Lake



Port Orford

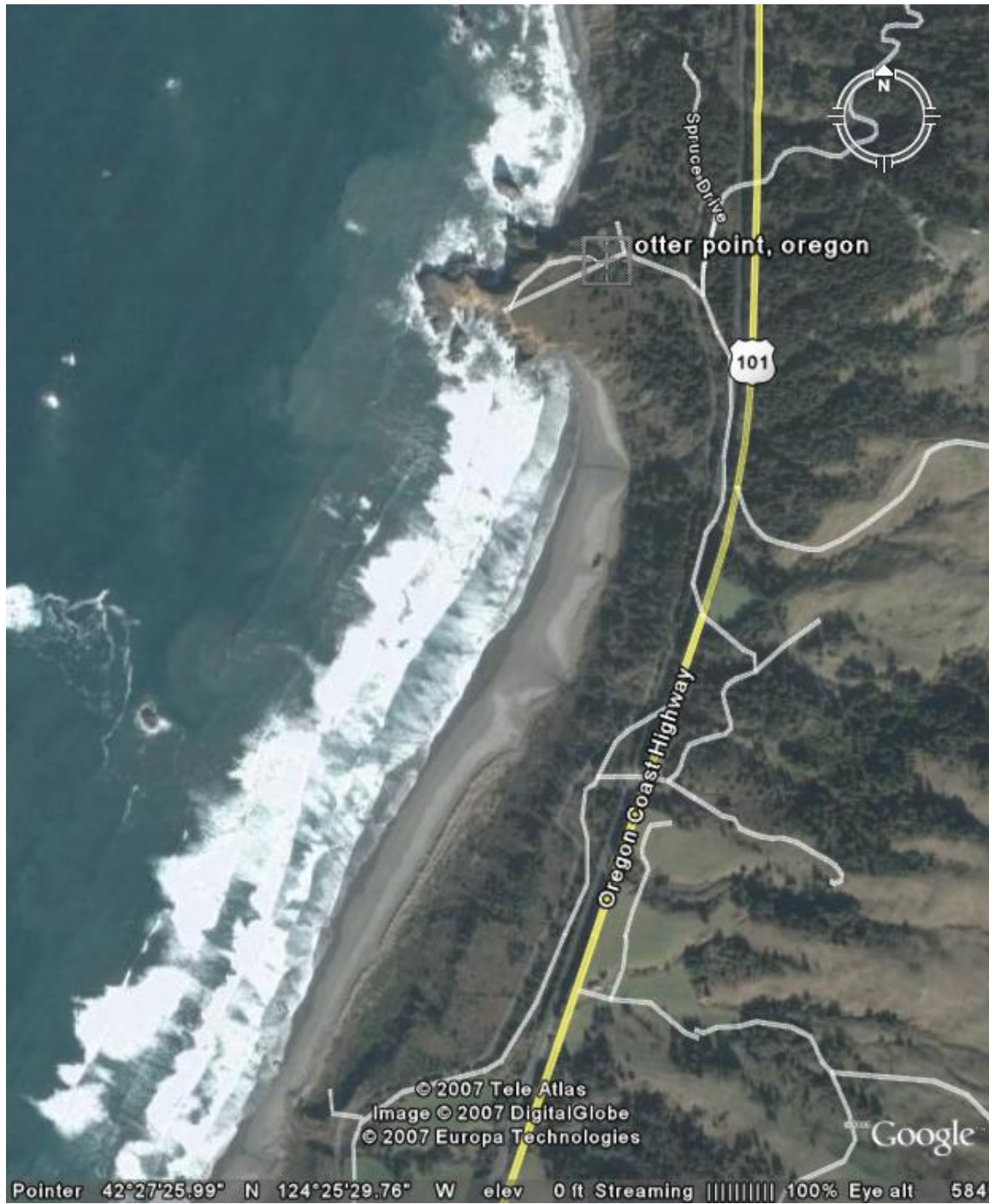


Ophir/Euchre Creek

park on highway, walk down gravel road (ignoring no trespassing sign), knock on door of house on way to beach. a few years ago, Nancy Brian (BLM) talked to them and they were nice ... if not home, continue to do survey, but stop by house again on way back.



Otter Point



APPENDIX III. POPULATION MONITORING AND SEED ADDITION AT OTHER SITES

Baker Beach --Seeding at Baker Beach has consistently had moderate success, resulting in a range from 12 plants (6 reproductive) in 2006 to 93 plants (37 reproductive) in 2004 (Table 2). We generally found plants south and east of the snowy plover habitat area in areas protected by larger dunes. In 2009, 6 plants were found (5 reproductive and 1 vegetative). In 2010 and 2011, no seeds were distributed at this site and it was not monitored.

Bastendorff Beach – This site received both transplants (1995 and 1996) and seeding (most years between 1995 and 2005, Table 6). No plants were found until 2002, when 8 reproductive and 5 vegetative plants were counted. The population continued to increase to its maximum level in 2005 of 536 plants (410 reproductive). Seeding last occurred in 2005 and although small (between 2 and 11 plants), we have observed plants each year we have monitored, including nine plants (six reproductive) in 2008 and 2 plants (both reproductive) in 2010.



Figure 13. Pink sand-verbena in the north census area at the Coos Bay North Spit. Pink sand-verbena tended to be found along the ridges left by the disc harrow. This pattern was also noted at the Overlook sites in 2009.

Bandon Beach, China Creek –

The China Creek population has varied substantially since 1998, when the species was first seeded into the site by the Oregon Department of Agriculture. Plants have typically been observed in a protected depression between two large expanses of dunes. We counted 20 reproductive plants at this site in 2006; in 2007, the number declined to 6. We have not observed any plants since then. Poor recruitments at this site could be due to the high level of disturbance in the area, including shifting creek banks, shifting dunes, and human recreation.

Cape Blanco – The natural population at Cape Blanco has been below seven individuals in the five surveys conducted since 1999.

Driftwood Creek – Fifty thousand seeds were distributed at Driftwood Creek in 1998. No plants were counted in 1998, 2000, or 2001 surveys. In 2010 the site was revisited and no plants were found at the site.

Euchre Creek – Although seeding resulted in only a few plants in 2000 and 2002, individuals continued to germinate in 2003 and 2004. We recommend that this site be resurveyed in 2011.

Floras Lake – Direct seeding at Floras Lake in 1996 (5,000 seeds) and 2000 (50,000 seeds) resulted in only seven and 10 plants in each year (respectively). However, in 2004, 220 plants were observed growing in an area protected from wave action by a sandstone outcrop. We counted 65 plants in 2006. No plants were found in 2007 or 2009. The persistence of the Floras Lake population, despite low reintroduction effort, suggests that this habitat may be a good site for future seeding.

Ona Beach – In 2000, two plants were counted at the mouth of Beaver Creek; this was the first time plants had been documented at this site. In 2001, no plants were found and no surveys have been completed since that time.

Otter Point – The wild population of pink sand-verbena at Otter Point has shown dramatic swings in size since 1993. From 1993-1996, the number of plants varied from 9 to 16, but in 1997 and 1998, the population rose to 177 and 136 plants, respectively. The population declined substantially after that, dropping to 0 in 2000 and rebounding to only 3 plants in 2001 and 2002. No plants were observed from 2003-2007 (the site was not surveyed in 2005; Figure 9). Re-colonization of the site after dropping to 0 plants in 2000 suggests that the population at Otter Point (and possibly others) can re-establish from a persistent seedbank. Monitoring should continue at this location, and if the species continues to be absent, the possibility of reintroducing the species should be evaluated.

Pistol River--Plant establishment at Pistol River State Park was extremely low. Eighty thousand seeds were distributed at the site in April 2008. In October 2008, only one vegetative plant was located. Although seeding pink sand-verbena in April has been successful in the past, there may not have been sufficient time for cold stratification in the weeks following seeding in 2008. This likely contributed to the low germination rate. In addition, a bench that had been seeded in April had eroded to beach level during the summer, significantly reducing the amount of pink sand-verbena habitat present at the site. In 2009, no plants were found at the site.

Port Orford– The population at Port Orford is both natural and augmented. In 1999, over 7,000 plants were counted; since that time there has been a downward trend in yearly population numbers (Table 6). In 2007, the population size more than doubled compared to the previous year (1,412 plants, 846 reproductive). Of these, 168 plants (118 reproductive) appeared to be hybrids with yellow sand-verbena. In 2008, 226 reproductive plants were counted, 79 of which were potential hybrids. In 2009, 269 plants were counted, 237 reproductive and 32 vegetative. In 2010, 194 plants were counted, 58 of which appeared to be hybrids. In 2011 146 plants were counted at the site. This habitat is relatively well protected from ocean storms and has the potential to be quite large. Given that this is one of the few (partially) natural populations that remains on the Oregon coast, we strongly recommend renewed attempts to remove European beachgrass.

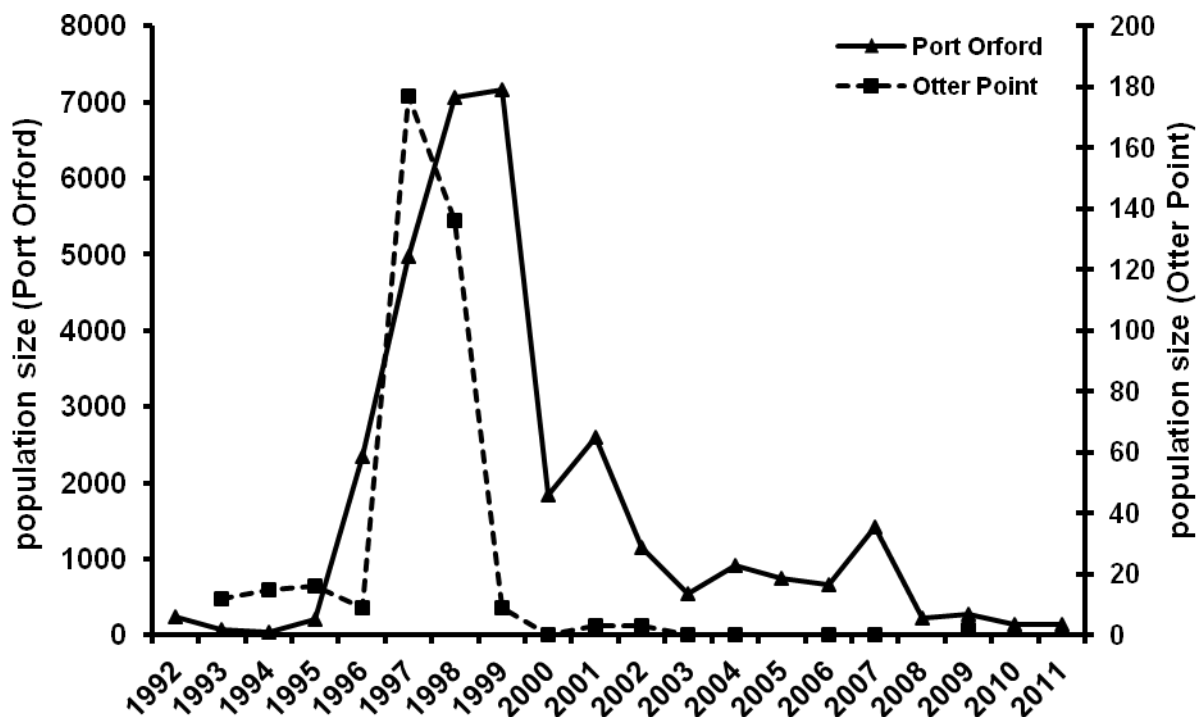


Figure 14. Population trends of pink sand-verbena at Otter Point, a natural, unmanipulated population and Port Orford, antatural population htat has received intensive restoration in the form of augmentation (transplanting), partial elimination of beach grass behind the foredune, and disturbance with machinery (1992-1999). There are no data for Otter Point in 2005 or 2008 to present.

Salmon River – Restoration seeding took place at Salmon River in 2001 and 2002. These efforts resulted in 741 and 163 total plants in 2001 and 2002, respectively. In 2005, 92 plants (52 reproductive) were present, despite no seeding that year. This site was not surveyed in 2006, 2007, or 2008. The recruitment of plants from the seedbank in 2005 suggests that this population could be maintained with management activities including beachgrass control and seeding.

Sutton Creek --Seeding at Sutton Creek had low success in two out of the three years it was seeded. In 2004, 150 plants (28 reproductive) established after a spring seeding. No plants were found at the site in 2005, 2006, or 2007 despite seeding in 2005 and 2006. This site appears to receive a relatively high level of disturbance from wind, wave action, flooding, and bed-movement by Sutton Creek. Due to the disturbance and the poor recruitment, we did not seed the site in 2007 and subsequently found no new plants.