Conservation Strategy
for
Pink Sand-verbena
(*Abronia umbellata* ssp. *breviflora*)

July 2006

U.S.D.I. Bureau of Land Management
Coos Bay District

U.S.D.A. Forest Service
Siuslaw National Forest

Oregon Parks and Recreation Department

Conservation Strategy Approval

The USDA Siuslaw National Forest, Coos Bay District BLM, Redwood National Park, and Redwood State Park agree to implement this Conservation Strategy for pink sand-verbena as available funding permits.

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Acknowledgments

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Executive Summary

Pink sand-verbena (*Abronia umbellata* ssp. *breviflora*) is a northwestern United States regional endemic of shoreline habitat along the Pacific Coast of North America, from British Columbia to California. It is a Species of Concern with the USFWS and listed as endangered by the State of Oregon. The species is also considered endangered in Washington (Washington Natural Heritage Program 1994), and it is considered threatened or endangered throughout its range by the Oregon Natural Heritage Information Center (ORNHIC) and the California Native Plant Society (Skinner and Pavlik 1994, ONHP 2001, ORNHIC 2004). Pink sand-verbena is on the BLM and USFS Sensitive Species lists.

- Extensive field surveys have been conducted for this species in Washington, Oregon, and California, primarily on public lands, by qualified botanists from federal and state agencies as well as non-governmental organizations (e.g., Gamon, Alverson, and Sprague 1986, Kaye 2003).

- Known populations in Oregon occur on land managed by the Siuslaw National Forest, Bureau of Land Management's Coos Bay District, as well as Oregon Parks and Recreation Department. Most of the remaining populations are widely isolated from one another providing little opportunity for genetic exchange except through long-distance seed dispersal.

- Primary threats include low population numbers and isolation, competition and habitat alteration by invasive plants, such as European beachgrass (*Ammophila arenaria*), off-road vehicles, winter storms, and herbivory by wildlife and insects.

- The purpose of this Conservation Strategy is to identify and support management and restoration actions that will remove or limit threats to pink sand-verbena and provide for its long term survival range-wide, and thus reduce the need to federally list the species as threatened or endangered.

- Successful implementation throughout the range of the species will require the cooperation of the U.S. Forest Service, Bureau of Land Management, National Park Service, U.S. Fish and Wildlife Service, and state agencies in Washington, Oregon and California as well as agencies in British Columbia.

- Because information on this species will continue to accumulate and new populations may be discovered, this document may be amended at intervals as needed.

The life of this Conservation Strategy will be ten years (through 2016), after which time the status of pink sand-verbena, along with the objectives and methods included in the strategy, will be re-evaluated, and if necessary, extended. At three year intervals the participating parties will review progress achieved at each managed population.

Purpose of this Conservation Strategy

This Conservation Strategy is intended to review available information on pink sand-verbena, establish conservation objectives, and identify management actions needed to accomplish those objectives. The ultimate goal of this process is to improve conditions for this species and reduce the need to list it as threatened or endangered. All actions recommended here are consistent with resource management plans on public lands covered by this document, which include the USDA Siuslaw National Forest and USDI BLM Coos Bay District.

Biological Information

Species Description and Taxonomy

Pink sand-verbena (*Abronia umbellata* Lam. ssp. *breviflora* [Standley] Munz) (Figure 1) is a low-growing annual to short-lived perennial forb in the four-o'clock family (Nyctaginaceae) that blooms from July through October, depending on location. Technical descriptions are provided in Tillet (1967) and Hitchcock and Cronquist (1964). The following general, non-technical description was modified from both of those sources.

> Pink sand-verbena is a tap-rooted annual to short-lived perennial with sticky glands on the stems, leaves, and especially in the flower clusters. The main stems are typically 30 cm to 150 cm long, bearing alternate leaves, and growing close to the ground. The plant does not root at the nodes. The leaves are roughly spoon-shaped and green to dull-green in color, 2-6 cm long. The 8-10 mm long flowers are pinkish purple, covered with sticky glands on the outside, and born in clusters of 10-20 at the tips of 20-70 cm long stalks. Each flower produces a single-seeded fruit (achene), with 3-4 prominent, broad wings that are often wider than the body of the fruit and may be prolonged above the fruit apex.

In this document, pink sand-verbena includes populations from British Columbia to northern California, following the treatment of the species in *Vascular Plants of the Pacific Northwest* (Hitchcock et al. 1964). Another taxonomic assessment (Tillet 1967) considers *A. umbellata* ssp. *breviflora* to range only as far north as southern Oregon, and recognizes the populations in Washington and British Columbia as ssp. *acutalata* (Standley) Tillet. This assessment was based partly on the author's belief that there was a "great geographical separation" between the taxa and "scanty knowledge of its variation and distribution" (Tillet 1967). Since the time of Tillet's treatment, additional populations have been located in northern Oregon reducing the geographical separation between the subspecies. Also, a study of chloroplast DNA found no difference between British Columbia plants and those in Oregon and northern California (Karoly 2001), and a morphometric analysis (Kaye unpublished data) based on a common garden

experiment found only small differences between them. Therefore, ssp. *breviflora* includes ssp. *acutalata* in this conservation strategy. A recent treatment of the genus changes the subspecies of *A. umbellata* to varieties to improve nomenclatural consistency in the family for the Flora of North America North of Mexico project (Spellenberg and Poole 2003). By this treatment, the scientific name for pink sand-verbena becomes *A. umbellata* var. *breviflora* (Standley) L.A. Galloway.

Hybrids between *A. umbellata* ssp. *umbellata* and two other species, *A. latifolia* (yellow sand-verbena) and *A. maritima* (beach sand-verbena), have been reported from the California coast (Tillet 1967, Pimentel 1981). Hybrids between *A. latifolia* and *A. umbellata* ssp. *brevifolia* have been observed in northern California and southern Oregon (e.g., at Port Orford) by various researchers (T.N. Kaye pers. obs., K. Samis personal communication). However, these hybrids appear to be relatively infrequent, especially in Oregon. Work by Tillet in the late 1960s did not reveal any hybrids in northern California or southern Oregon, and Kaye (personal observation) found no hybrids until 2003, despite the fact that *A. latifolia* and *A. umbellata* ssp. *breviflora* often co-occur in northern California and Oregon. Hybrids observed at Port Orford by Kaye were pale pink in flower color, scented (*A. umbellata* is usually unscented), and the fruits were easy to tear open with fingers (*A. umbellata* fruits are normally very difficult to open while those of *A. latifolia* are weak) and usually empty of seeds.

Range and Distribution

Pink sand-verbena historically occurred in British Columbia, Washington, Oregon, and California (Appendix A) in coastal locations. Although formerly widespread, pink sand-verbena generally occurs in scattered populations composed of few individuals. A few populations have hundreds or even thousands of individuals, depending on the year. In Washington, pink sand-verbena is currently considered extirpated, but was historically found in Clallam and Kitsap counties on the Olympic Peninsula and Puget Sound (Gamon, Alverson, and Sprague 1986). Two British Columbia populations were known from the west side of Vancouver Island, but until recently the plant had not been seen in the area since 1927 (Douglas, Straley, and Meidinger 1998); in 2000, two plants were discovered in Pacific Rim National Park (Douglas 2000), re-establishing the plant in Canada for the first time in over 70 years. However, the plants were not relocated in the area in 2001, and current condition of this population is uncertain.

In Oregon, pink sand-verbena has occurred from as far north as Gearhart in Clatsop County, but is currently extant only from Tenmile Creek (Douglas County), and south, including sites in Coos and Curry counties. Wild populations appear to be most stable along the southern Oregon Coast, such as at Port Orford, Otter Point, and near Brookings (Curry County). Some wild populations north of there are small and extremely variable, sometimes occurring for only one or a few years at a time. Over the last ten years, the number of wild populations in Oregon in any given year has ranged from three to five. The California populations are more numerous and occur primarily in

Humboldt and Del Norte counties, as well as Mendocino, Sonoma, and Marin counties. These populations also vary in size and presence from year to year. A reintroduction program for pink sand-verbena in Oregon has resulted in the temporary establishment of new populations at several sites (see Reintroduction, below).

Figure 1. Pink sand-verbena (*Abronia umbellata* ssp. *breviflora*) plant (left) and fruit (right), from Hitchcock et al. (1964).

Status

Pink sand-verbena is listed by the Oregon Department of Agriculture as endangered [OAR 603-73-070 (1)] because of its steady decline in geographic range and the numerous threats posed to a very small number of extant populations. The Washington Department of Natural Resources (1997) lists pink sand-verbena as Extirpated, and the California Native Plant Society (2001) considers it to be "Rare, Threatened or Endangered in California and Elsewhere" (List 1B). It is currently considered a Species of Concern by the U.S. Fish and Wildlife Service (ONHP 2001). In Canada, the species is on the British Columbia Red List, indicating that it is extremely rare (British Columbia Conservation Data Centre 2001). Pink sand-verbena is also on the BLM (USDI BLM 2004) and USFS Sensitive Species lists.

Habitat

Beaches and foredunes of the Pacific Coast of North America are the primary habitat of pink sand-verbena. In Oregon and northward, the species is restricted to beaches, and rarely occurs in foredune environments. In this region, pink sand-verbena plants generally occur on fine sand between the high-tide line and the long-term driftwood zone, below the foredune. Pink sand-verbena plants appear to be restricted to areas of

active sand movement, mostly by wind but also by ocean waves during winter storms. Most populations occur on broad beaches and/or near the mouths of creeks and rivers.

Often the only associated species are European and American sea rocket (*Cakile maritima* and *C. edentula*, respectively) and yellow sand-verbena (*Abronia latifolia*), but other beach-loving plants commonly in the vicinity, especially on adjacent foredunes, include European beachgrass (*Ammophila arenaria*), American dunegrass (*Leymus mollis* = *Elymus mollis*), beach pea (*Lathyrus japonicus* and *L. littoralis*), sea purslane (*Honkenya peploides*), beach morning-glory (*Convolvulus soldanella*), and silver burrweed (*Ambrosia chamissonis*). No other rare plants occupy this same habitat type (open beaches) in Oregon, but Wolf's evening primrose (*Oenothera wolfii*) and silvery phacelia (*Phacelia argentea*) may occur on adjacent upland slopes in southern Oregon and northern California. These species are both listed by the Oregon Department of Agriculture as Threatened. In addition, many-leaf gily flower (*Gilia millefoliata*), yellow sand-verbena, swaying bulrush (*Schoenoplectus subterminalis*), and coastal cryptantha (*Cryptantha leiocarpa*) can occur in the vicinity in wetlands, uplands, or adjacent dunes and these are included on Bureau of Land Management's Assessment and Tracking lists. An infrequently observed plant species on Oregon beaches, beach saltbush (*Atriplex leucophylla*), is not currently considered rare or endangered, but it could deserve this status if additional information becomes available to document its status.

The plant associations of foredunes and vegetated upper beaches in this region can generally be classified as Seashore bluegrass or Seashore lupine alliance as described by Christy, Kagan, and Wiedemann (1998). This vegetation type is composed of plants that occupy recently and chronically disturbed sandy habitats adjacent to or near beaches. Typical disturbances that maintain them are erosion and sand deposition due to oceanic processes and wind. Restoration in these habitats often involves disturbance with heavy equipment, herbicides, or manual removal of invasive species. Recreation and off-road vehicle use can also keep some coastal habitats open, but may result in establishment of invasive weeds or indiscriminate destruction of sensitive areas. These vegetation types do not usually include the beach itself, which pink sand-verbena predominantly occupies, but they are closely associated with beaches and shore processes.

In California, pink sand-verbena also occupies open beaches and it is capable of growing on dunes and dune openings away from the beach, especially in the southern portion of its geographic range. Various observers (e.g., Tillet 1967, Imper 1987, Kaye pers. obs.) have noted that pink sand-verbena (specifically *A. umbellata* ssp. *breviflora*) may be found in foredunes and more stabilized sand in California, and that this tendency increases from northern California southward. The southern subspecies of pink sand-verbena (*A. umbellata* ssp. *umbellata*) is considered weedy and generally occurs only on sand dunes and areas of stable sand on the lee side of the foredune, often where the sand is at least partly mixed with soil material (Tillet 1967). Imper (1987) pointed out that the ability of ssp. *breviflora* to occupy sand dunes toward the south may represent a gradient of genetic similarity with ssp. *umbellata*, or that

environmental conditions to the north may be different than those southward such that the species is excluded from sand dunes. Experiments in Oregon with pink sand-verbena and exotic dune species like European beachgrass show that this sand-verbena is a poor competitor against dune vegetation (Kaye 1999), which might explain its exclusion from sand dunes over part of its range.

Population Biology

Life-history

Pink sand-verbena has a predominantly annual life cycle and individuals reproduce by seed only. The plants are tap-rooted and do not root adventitiously from the stems. Most individuals observed in demographic studies behave as annuals, flowering and dying in their first year of growth (Kaye 1999; Kaye, Kirkland and Testa 1999). However, a small percentage of individuals in a natural population at Port Orford, Oregon, grew and flowered for two years, and transplanted individuals on dredged sand had a high probability of living for two seasons. At Otter Point, Oregon, however, where a typical wild population occurs on a beach, all individuals lived for only one season (Kaye 1999; Kaye, Kirkland and Testa 1999). The difference between these two populations is that the Port Orford habitat was partially protected from winter storms, while Otter Point was exposed to the full strength of extreme climatic conditions experienced by coastal beaches. Therefore, pink sand-verbena appears to be capable of growing for more than one year if protected conditions are available without too much competition from associated vegetation.

Several other *Abronia* species are described as being both annual or perennial, or biennial and perennial; perennation of *A. angustifolia*, for example, is possible only when individuals occur in highly favorable locations, such as protected micro-sites with high moisture availability (Royce and Cunningham 1982). Such flexibility can improve the ability of pink sand-verbena to persist at a given site or disperse seeds to new locations, since individuals that live for more than one season may be very large, produce thousands of fruits, and therefore contribute a large proportion of a population's annual seed production (Kaye, Kirkland and Testa 1999).

Population dynamics

Because pink sand-verbena populations typically occur on beaches, generally at or below the zone of driftwood accumulation, most are obliterated each winter by storms that reshape the shore. Each spring, populations re-establish from seeds that persist in the sand or that are washed into the site from another location. Because oceanic processes may result in sand being removed from beaches and stored in off-shore sand deposits during winter, then re-deposited on beaches during summer (Orr and Orr 2002), pink sand-verbena seeds may be stored in this way as well for one or more years at a time.

Because of the highly stochastic nature of its habitat, population sizes of pink sand-verbena are variable from one year to the next. Long-term monitoring of a wild population at Otter Point, Oregon, has documented this type of annual variation (Kaye 2002), which is consistent with the changes in population sizes of this species noticed at other locations (Kaye, Kirkland, and Testa 1999). At Otter Point, the population had nearly 200 plants in 1997, but declined to zero individuals in 2000, then recovered to three plants the following year (Figure 2). At some sites, such as Ona Beach, Oregon, only one or a few plants have been observed, and only in one year. At others, such as Cape Blanco, Oregon, several years may pass between observations of individuals. Long distance dispersal of seeds by ocean currents to suitable habitat and exchange of seed between a long-lived, persistent seed bank and mature plants, are significant processes in the dynamics of pink sand-verbena populations (see Seed Bank, below).

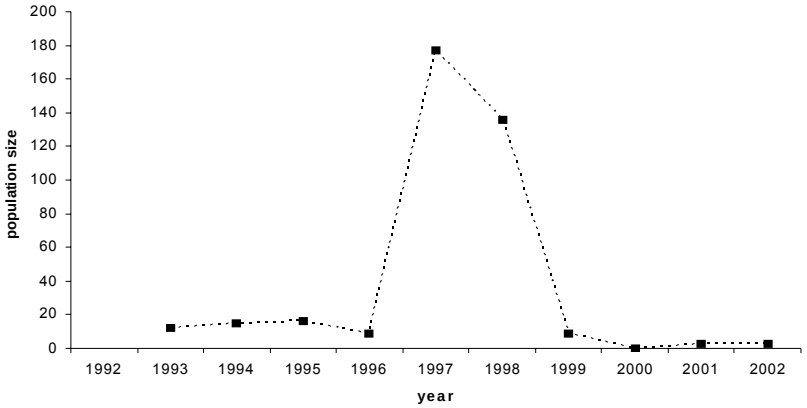

Figure 2. Population trends of pink sand-verbena population at Otter Point in natural, unmanipulated habitat.

Population genetics

Populations of pink sand-verbena appear to have a high degree of genetic similarity with one another. Published reports by McGlaughlin, Karoly, and Kaye (2002) and McGlaughlin (1999) found that all 14 sampled populations in southern Oregon and California had a genetic identity of greater than 92%. There was some geographic pattern to the genetic variability they observed, especially in the Humboldt Bay area, and genetic distance and geographic distance were positively correlated. However, there was great similarity between all populations, and some widely-separated populations were more similar to one another than some closer populations. This pattern may reflect occasional long-distance dispersal events of seeds from a source population to available habitat many miles away, as well as more frequent short-distance dispersal. Overall, there was no evidence of significant genetic differentiation among populations (F=0.0196) of pink sand-verbena (McGlaughlin 1999). Most populations observed were also moderately genetically diverse, with heterozygosity

ranging from 0.102-0.261 (0.377-0.441 for polymorphic loci only and corrected for dominant data) (McGlaughlin 1999). Also, the log of heterozygosity of polymorphic loci was positively correlated with population size.

Pollination and breeding system

Pink sand-verbena produces 8-20 (average 14-15) flowers in hemispheric clusters. An individual plant may produce from one to thousands of these clusters, depending on growing conditions. The flower tubes are approximately 6-7 mm deep, and long-tongued insects such as bumblebees, skippers and other butterflies visit the unscented flowers and probe for small amounts of nectar (Kaye pers. obs.). Some observers (Tillet 1967) have noted nocturnal pollinators like noctuid and sphingid moths on ssp. *umbellata*, but these have not been documented for ssp. *breviflora* in Oregon, despite dusk and night time observations (Kaye pers. obs). Also, in Oregon pink sand-verbena is fully self-compatible and will self-pollinate in the absence of insect visitors, suggesting that the taxon has a mixed-mating system. This observation is in contrast to Tillet's (1967) conclusion that *A. umbellata* ssp. *umbellata* is self-sterile, producing neither fruit nor seed from self pollination. This difference in breeding system between the southern and northern subspecies may be an important factor in their evolutionary divergence, and may also partly explain the low frequency of observed interspecific hybrids in Oregon.

Fruits and seeds

Each pink sand-verbena flower produces a single-seeded fruit (achene), which is broadly 3 to 5-winged, presumably to promote dispersal by wind (Wilson 1976). These wings may also facilitate long-distance dispersal by ocean waves and currents. Fruit set is generally very high in pink sand-verbena; observations from Port Orford, Oregon in 1998 found that 13 out of an average 14 flowers per flower-cluster formed fruits, and plants grown in a garden setting in 2001 yielded 13 out of an average 15 flowers, for a fruit-set rate of approximately 85% to 95% (Kaye unpubl. data). Typically, 80% to 90% of the fruits contain a seed (Kaye unpub. data).

Seed bank

Long-term persistence of pink sand-verbena populations may depend on the development and maintenance of a long-lived persistent seed bank. 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, and even seeds stored for ten years retained over 90% viability (Kaye 2001; Figure 3). Although environmental conditions of seeds stored in paper sacks are not the same as those buried in sand in a wild state, these results are consistent with the hypothesis that pink sand-verbena seeds are capable of persisting in the sand for extended periods of time.

Furthermore, the appearance of some populations of pink sand-verbena long distances from natural populations, such as at Tenmile Creek, Oregon in 1995, Gearhart, Oregon in 1993, and Vancouver Island in 2000 (after over 70 years of absence), suggest that some populations may establish from seed many years after their presence as adult plants.

And finally, the stochastic behavior of natural populations, such as Otter Point, Oregon, can result in a decline to zero plants in some years, followed by the re-emergence of the species the following year, which suggests that the species can re-colonize sites from a local seed pool. Taken together, these lines of evidence provide strong support for the notion that pink sand-verbena is capable of maintaining a persistent seed bank, and that buried seeds may play an important role in the population dynamics of this species and should be fostered in reintroduction attempts.

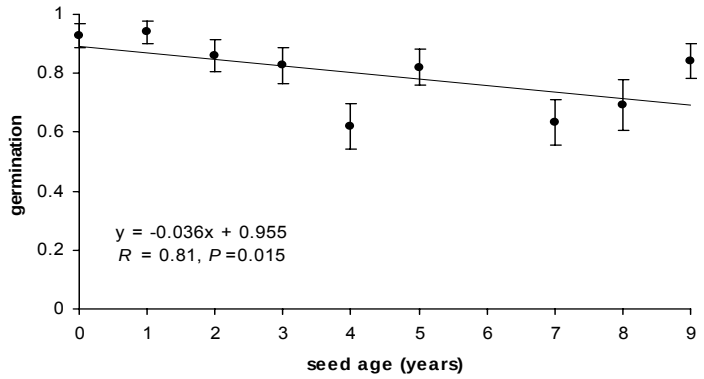

Figure 3. Germination of pink sand-verbena seeds after storage in paper packets at room temperature for different numbers of years.

Limiting Factors and Threats

Invasive species: European beachgrass

Due to the invasion and subsequent stabilization of foredune systems by European beachgrass (Wiedemann 1984, Rittenhouse 1994) and disturbance by off-road vehicles, pink sand-verbena is now restricted to 3 to 5 (depending on the year) wild populations on the southern Oregon Coast and perhaps a dozen in California (Kaye 1995a). The introduction of European beachgrass has resulted in the loss of a low, hummocky, discontinuous foredune which once characterized beaches throughout the range of pink sand-verbena, and provided habitat for many native plants and animals. This topographic feature has been widely replaced by a high, steep, primary foredune

dominated by a thick growth of European beachgrass (Pickart and Sawyer 1998).

Recreation: Off-road vehicles and trampling

Off-road vehicles are popular on the Oregon coast at many locations, including the Oregon Dunes National Recreation Area. These vehicles drive over the uneven and often steep terrain of coastal dune systems and beaches, and are capable of damaging native vegetation. Their use in areas occupied by pink sand-verbena represents a threat to the species at these locations, especially if this use occurs during the plant's growing season (May through November).

Trampling by beach users may also represent a threat to pink sand-verbena. High use areas are most vulnerable because trampling can result in extreme disturbance of the loose sand habitat, including crushing or burial of plants. Bonfires and cooking fires can kill plants and buried seeds through direct heat and by concentrating human-trampling around a small area.

Strong winter storms

Winter storms are capable of scouring and building beaches and foredunes on the Pacific Coast in the range of pink sand-verbena (Komar 1997). These storms can directly alter beach topography through wave action and indirectly through flooding of creeks and rivers. High tides combined with high water levels in streams may result in the shifting of the mouths of these waterways, which alters the position of foredunes and causes large scale re-working of beach sand. In addition, high tides and strong winds during winter months can result in substantial beach erosion and breaching of sand spits, especially in areas where rip current embayments develop, which allow high energy waves to reach the upper beach and foredune (Komar 1997). During such storm events, beach vegetation, including pink sand-verbena, is typically destroyed, and this process contributes to the strong swings in populations of this species. However, strong winter storms and shifting creeks and rivers may also unearth buried seeds of pink sand-verbena, thus creating areas of open sand with little competition, which may result in the re-appearance of plants and populations in areas where they had not been reported for some years or reinvigorate existing populations (see Population Dynamics, above).

Herbivory by mammals and invertebrates

Animals are known to eat portions of pink sand-verbena in some instances. Deer may eat leaves and growing tips, slugs and snails have been observed consuming leaves and outer portions of stems, and insect larvae (moths and beetles) appear to bore into the stems and eat the leaves. The most common insects observed eating pink sand-verbena are larvae of noctuid moths (*Lasionycta wyatti*, personal communication from George Poinar, OSU entomologist). Damage from these animals may reduce the size and seed-production of individual plants. However, herbivory by animals appears to

pose a small threat to the species overall. The noctuid moth that has been observed feeding on pink sand-verbena in Oregon (Kaye, pers. obs.) has been reported as a rare invertebrate, at least in British Colombia, where it has been seen to feed on silver burrsage (*Ambrosia chamissonis*) (Dojillo et al. 1999).

Collecting – Scientific and casual

Biologists have collected scientific specimens of pink sand-verbena for many years. In some cases, especially in the historic past, botanists collected large numbers of individuals from some populations at one time, and these collections may have had locally significant impacts. However, this species has been little collected in recent years (since 1970), so scientific collections appear to represent an insignificant threat to the species. Since most populations occur on state or federally managed lands and the species is considered sensitive or endangered (depending on the authority), collecting activities require a permit; collection of this species for scientific purposes is not likely to contribute to its decline.

Casual collection of plants, especially flowers, has been reported and may impact some populations locally, especially where recreational use of beaches is high. Beach users may be attracted by the showy flowers of the plants, and incidents of collection of small floral bouquets from pink sand-verbena have been reported.

Hybridization with related species

Hybridization between endangered plants and close relatives, both native and introduced, has been identified as a potential threat to some species (e.g., Imper 1997, McGranahan et al. 1988). Pink sand-verbena often co-occurs with yellow sand-verbena (*A. latifolia*) and red sand-verbena (*A. maritima*) (Tillet 1967), and hybrids of *A. umbellata* ssp. *breviflora* x *A. latifolia* have been observed in wild populations, such as at Port Orford in Oregon (Kaye, pers. obs.). Although hybridization among species of *Abronia* has been documented in various locations, the species appear to maintain their morphological isolation in many populations especially in Oregon. Further, most populations of pink sand-verbena appear to be largely unaltered by hybridization with yellow sand-verbena, despite the frequent co-occurrence of these species. Pink sand-verbena does not appear to be threatened by hybridization at this time.

Propagation and Reintroduction

Plant conservationists generally agree that the most effective way to protect rare species and their habitats is to maintain and foster surviving wild populations. Current laws protect populations of endangered plants *in situ*, at least on public lands. Creating new populations to compensate for losses caused by development or habitat alteration is controversial because it may be seen as condoning the loss of habitat in return for an artificial replacement that does not adequately reproduce wild populations. Further, the success of mitigation projects is often uncertain.

There are some species, however, for which introduction back into former habitat or into new sites may be appropriate, and even urgent (Kaye et al. 1998). Plants that are extinct from the wild are obvious candidates, and so too are endangered species that occur in only a few remaining locations or have suffered dramatic declines in population numbers. In addition, rare species experiencing population losses on private lands, where they are not legally protected, may especially benefit from population establishment on public lands. There is a growing awareness among plant conservation biologists that reintroduction (often called translocation) is a worthwhile measure in some situations, yet the methods of reintroduction are largely untried and experimental. Establishing new populations or enhancing existing ones (augmentation), by seeding or adding new plants, is an area of research where elements of ecology and horticulture meet.

Guidelines for reintroduction projects have been developed, but these tend to deal with general issues such as appropriateness of reintroduction, site selection, protection against genetic problems, damage to other rare species, and loss of irreplaceable propagation stock (e.g., Kaye 1992, Falk et al. 1996). Of course, this generality is due to necessity, since very little information is available on how to establish a self-sustaining population for most species. What is more, plants and habitats vary in their needs and limitations, and there is no single recipe for reintroduction. The tools required, including propagation techniques and site selection criteria, must be developed on a species by species basis. Although re-introduction is underway for some plant species, the field is in its infancy. In a bibliography of 600 published accounts and grey literature on plant re-introduction and restoration (Atkinson, Maunder, and Walter 1996), only about 10% were detailed re-introduction case histories (Kaye, Kirkland, and Testa 1999). Descriptions of effective procedures for rare plant propagation and establishment in the field are crucial for advancing the practice of species re-establishment.

Many sand-verbenas (*Abronia* spp.) are rare and prone to extinction, a characteristic that lead Wilson (1972) to call them “disappearing species.” Their conservation may rely on restoration of habitat and re-establishment of populations, which in turn, requires information on the behavior of natural populations (Pavlik 1996). Sowing seeds directly on beaches and out-planting greenhouse-grown stock both appear to be options for pink sand-verbena population re-establishment and augmentation. A series of transplanting and seeding experiments have documented the potential success of each of these techniques for short-term population establishment.

Transplanting

An out-planting experiment with pink sand-verbena conducted in 1995 examined the survival and growth of plants on 10 beaches on the Oregon coast, and evaluated the importance of fertilizing transplants (Kaye 1995b). Potted plants were grown in a heated greenhouse following seed germination procedures outlined in Kaye (1999a).

On average, 45% of the transplants survived from May to August. Fertilizer had only a weak effect on transplant survival (42% survival without fertilizer, 51% with fertilizer), but it substantially and significantly increased plant size, and more than doubled reproduction (flowering increased from 13 to 29 inflorescences per plant).

Continued out-planting efforts on beaches since that time have adopted the use of fertilizer as standard procedure and documented a similar overall survival rate of 47% (Kaye 2001). Environmental factors that appear to affect survival of transplants at any given site include the 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.

Depending on these conditions, results to date suggest that it is possible to establish pink sand-verbena plants on natural beaches and in restored dune habitat, at least in the short-term. In 2001, for example, transplants at Tahkenitch Creek, Oregon, did relatively well (76% survival), especially those near the shore and those that did not show evidence of intense wind (Kaye 2001). In contrast, transplants at Siltcoos Creek, Oregon, were clearly damaged by wind that excavated their root systems and relatively few (16%) survived.

Since most pink sand-verbena plants on beaches are short-lived (annual), the viability of out-plant-reintroduced populations 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 transplanting in 1997 at Siltcoos Creek, which produced abundant plants the following year, but not the year after that (Kaye 2000).

Seeding

Population models suggest that planting small transplants will produce more vigorous populations than sowing an equal number of seeds (Guerrant 1996). However, seeds are much easier to sow than plants are to propagate and out-plant. Because large numbers of pink sand-verbena seeds are available from some populations, these can be used in direct-seeding, possibly outweighing any transplant advantage. Research to date suggests that pink sand-verbena may, in some cases, be successfully reintroduced to appropriate habitat through direct seeding.

Seeding experiments on 13 beaches on the Oregon Coast in 1995 (Kaye 1998) resulted in establishment of at least one plant at six locations. However, the establishment rate was so low, on average 0.07%, that this work was followed up with seedings of 50,000 seeds per beach location. Efforts with this larger number of seeds produced an average of 254 plants per site (0.52% establishment rate) within one year of seeding, and at least some plants in 26 of 27 attempts between 1997 and 2003 (Figure 4, Kaye 2003).

Unfortunately, most of these seeding attempts have failed to produce self-perpetuating populations. One notable exception is the now-thriving population at North Spit near Coos Bay, Oregon. This site is relatively unique among the direct-seeding sites in that the habitat is completely protected from winter storm events; the seeds produced on-site remain there, and are not buried by wave-moved sand or swept off-shore. The reintroduction site is located in the interior of the spit, in an area formerly dominated by European beachgrass but which has been successfully cleared of this invasive species in an effort to restore habitat for the western snowy plover (*Charadrias alexandrinus nivosus*) and pink sand-verbena (Kaye 1998, Pickart and Sawyer1998). The site was seeded in 1997 in five plots with various residual infestations of European beachgrass. The abundance of beachgrass and other weedy plants was negatively correlated with the growth and reproduction of pink sand-verbena (Figure 4, Kaye 1998), showing a clear connection between the success of a rare species and the destruction of an invasive exotic.

In 1997, the Coos Bay population numbered about 1,700 plants, then climbed to over 4,100 plants in 1998. Since that time, the population has increased to the point that it is now the largest population of pink sand-verbena in the world, topping 111,000 flowering individuals in 2003. The habitat has been disced each year in the winter to keep competing vegetation from invading the open sandy habitat, and this continued management is likely the main reason the population has done so well.

Recent observations at sites that have been seeded and in some cases transplanted multiple times have produced positive signs that repeated introductions may result in populations that return from seed in later years. For example, 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. Also, observation at Floras Lake indicate that an area that received transplants in 1995 (Kaye 1996) still had plants in 2000, and recent observations in June of 2004 located over 200 plants, some of them quite large (R. Meinke, pers. comm.). These observations suggest that the species can re-colonize sites from a local seed pool after reintroduction.

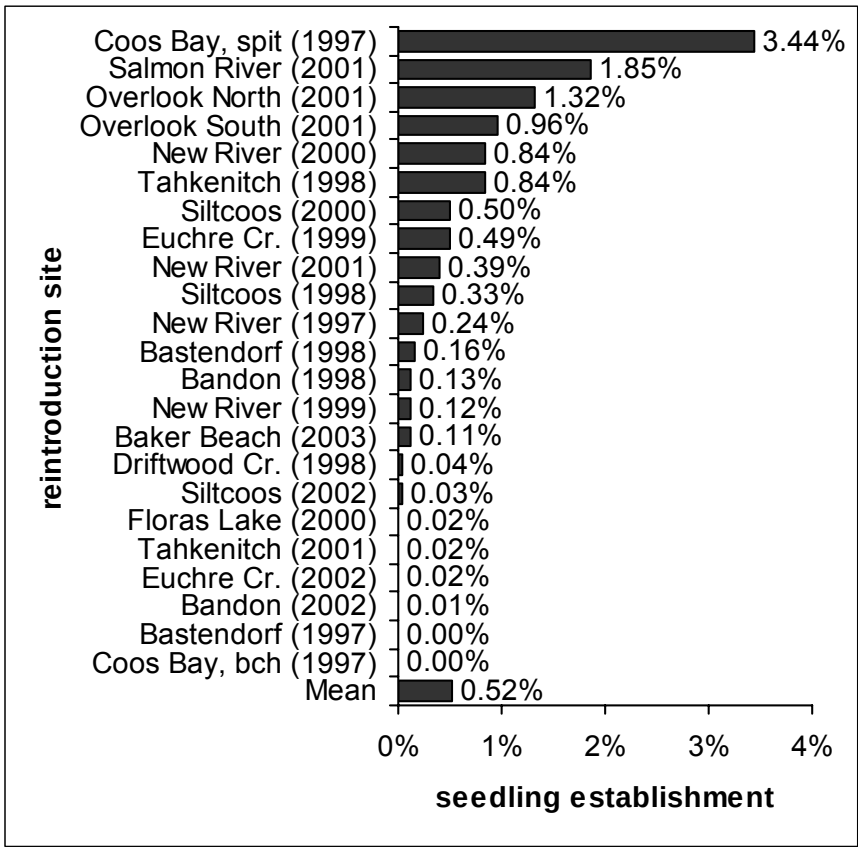

Figure 4. Plant establishment rates within one year of seed-sowing on beaches and restored dunes. Bar length and the value to the right indicate the percentage of seeds establishing as vegetative or reproductive plants. Only sites that were seeded at least two years after an earlier seeding attempt are shown. The year of seed sowing is indicated in parentheses after each location name.

Genetic issues

Recent research by McGlaughlin, Karoly and Kaye (2002) and McGlaughlin (1999) showed that reintroduced populations of pink sand-verbena could mimic the genetic variability of natural populations if population size was large enough. They found a strong positive correlation between the population size of created populations and log of genetic diversity. Based on this research, they estimated that a reintroduced population must have 600-1,250 individuals (depending on the method of estimation) to maintain 90% of the genetic variability found in the wild source population (in their case, the population at Port Orford, Oregon). The created population at Coos Bay, North Spit, which contained nearly 4,100 plants when sampled in 1998, had genetic variability equal to that found at its seed source in Port Orford. But even a reintroduced population two orders of magnitude smaller than the source population maintained over half of the genetic variability. These results suggest that it is possible to create new

populations of pink sand-verbena that successfully reproduce the genetic diversity of wild populations, but the created populations may need to be fairly large to capture most of the genetic variation of their seed source.

Population Descriptions

See Appendix A for map of natural and reintroduced populations of pink sand-verbena in Oregon. Specific location details for each site are maintained in agency files.

Oregon

Recent natural populations (observed within five years)

These descriptions include only naturally occurring populations that have been observed since 1998. Some restoration work has occurred at a subset of these sites, as noted, but most have been unmanipulated in recent years. Many populations have been observed only in one or a few recent years, reflecting the highly variable nature of pink sand-verbena population size and persistence. The populations are listed in geographic order from north to south.

Ona Beach – This is currently the most northern natural population of pink sand-verbena on the Oregon coast. It was observed only in 2000, at which time two reproductive plants were found. Subsequent visits to the site failed to document the populations (Kaye 2002). The plants grew at Ona Beach State Park on either side of Beaver Creek, Lincoln County.

Tenmile Creek – This natural population of pink sand-verbena occurs at the mouth of Tenmile Creek, Coos County. Plants were observed at this site in 1995 and 1996, but not in subsequent years. In 1999, 150 greenhouse-starts grown from seed collected from the 1996 population were outplanted to the site to augment the natural population. Since that time, no plants have been observed (Kaye 2003). The site is managed by the Siuslaw National Forest.

Cape Blanco – The small population at Cape Blanco State Park in Curry County has been observed intermittently since 1984. In recent years, one plant was found in 1999 and two were located in 2000. The plants were observed growing on the upper beach just below the foredune south of the main access road to the beach from the campground.

Port Orford – Consistently the largest natural population of pink sand-verbena in Oregon in recent years, the plants at Port Orford, Curry County, have been the subject of active research and conservation since 1992. In 2003, the population stood at 552 plants (159 flowering and 393 vegetative), which was the lowest size observed since 1996 (Kaye 2003). One reason for the large population

sizes observed at Port Orford is the active restoration and research that took place at this site from 1992-1999, which resulted in substantial expansion of habitat for pink sand-verbena as European beachgrass was buried with sand on the foredune. This activity was associated with dredging of the adjacent harbor by the Army Corps of Engineers, who largely supported the research and population augmentations at this site. This work was concluded in 1999, and the population appears to have declined since then due to encroachment of competing vegetation onto the areas previously made open. The site is managed by the Oregon Parks and Recreation Department.

Otter Point – The population of pink sand-verbena at Otter Point, Curry County, has been relatively stable compared to other natural populations on the Oregon coast. It was observed every year from 1993 through 2002, with the exception of 2000 when no plants were observed (Figure 2). Although generally small (fewer than 20 plants), the population was relatively large (>100) in 1997 and 1998. The plants have occurred strictly on the upper beach, and in most years have been concentrated south of the trail that leads from the headland to the beach. The site is managed by the Oregon Parks and Recreation Department.

Winchuck River – First discovered in 2000, the population at Winchuck River, Curry County, occurs approximately ½ mile north of the Oregon-California border. The population numbered five plants in 2000 and six in 2002. The individuals occurred on the beach on both the north and south sides of the mouth of the Winchuck River. Although recently found, this population probably has occurred here for many years, but may have been sporadic and of variable size.

Reintroduced populations

The populations listed here are the result of intentional population reintroductions aimed at establishing new populations of pink sand-verbena to promote the species' recovery. They have utilized direct seeding and/or outplanting of greenhouse-grown starts. Several of these attempts do not appear to have produced self-sustaining populations, but some have been present for multiple years. Only sites at which some population persistence has been detected are reported here. The populations are listed in geographic order from north to south. Each is described separately.

Baker Beach – This population in Lane County (Siuslaw National Forest) was initiated in winter of 2003 through direct seeding of 50,000 seeds. In summer of 2003 a total of 55 plants were observed, approximately half of which were flowering.

Siltcoos Creek – Habitat at the mouth of Siltcoos Creek, Lane County (Siuslaw National Forest), has received a combination of direct seeding and outplanting of greenhouse-grown starts since 1998. The population size has varied from a high of 249 plants in 2000 to a low of 7 in 2001. The population has been present for

at least the last four years, but appears to vary substantially with beach disturbance from winter weather patterns and with reintroduction effort.

Overlook sites – The Overlook sites are located in Douglas County north of Tahkenitch Creek (Siuslaw National Forest) on foredunes subjected to bulldozing to reduce abundance of European beachgrass. This work is being coordinated by the Siuslaw National Forest. Two tracts of foredune approximately 10 acres each have been treated and then seeded with pink sand-verbena in 2001 and 2002. The North Overlook site was also planted with greenhouse-grown starts in 2000. Since 2000, the combined population sizes for both the North and South sites have been 1,140 (2001), 2,817 (2002), and 3,585 (2003). Beachgrass is re-invading the habitat but additional treatment efforts will likely result in better control and invigoration of the pink sand-verbena population.

Tahkenitch Creek – Tahkenitch Creek, Douglas County (Siuslaw National Forest), has been seeded and planted with pink sand-verbena multiple times since 1996. In recent years the site has supported between 22 and 32 plants on both sides of the mouth of the creek combined. The habitat is subject to natural disturbances associated with winter weather events and it has received beachgrass control efforts in the recent past.

Tenmile Creek (augmentation) – The natural population at Tenmile Creek, Coos County (Siuslaw National Forest), received population augmentation through outplanting of greenhouse-grown starts in 1999 on the south side of the creek. However, no plants were observed in following years until 2003. At that time, one plant was discovered during surveys of the site by US Forest Service biologists in the area on the north side of the creek where the natural population had previously been located.

Coos Bay, North Spit – The Coos Bay area was host to at least one documented historic population of pink sand-verbena. In 1999, the 1994 Western Snowy Plover Habitat Restoration Area (HRA) received experimental control measures for European beachgrass and was seeded at that time with 50,000 pink sand-verbena seeds. Since then, a population of pink sand-verbena has become well established and grown steadily in size and area and represents the most successful reintroduction effort with this species to date. The population has exceeded 40,000 individuals for the last four years (with over 111,000 reproductive plants in 2003), making it the largest known population of pink sand-verbena. The 1994 HRA is on US Army Corps of Engineers (ACOE) land. The plants have spread beyond the boundaries of the HRA to BLM lands in the adjacent North Spit Area of Critical Environmental Concern (ACEC).

Greggs Creek (adjacent to Euchre Creek) – Two sites are closely adjacent, one at Greggs Creek (Coos Bay District, BLM and The Nature Conservancy), and one at Euchre Creek (Oregon Parks and Recreation Department). Both are

in Curry County. No plants are currently known from BLM-managed lands at Greggs Creek, but past reintroduction activities here and on adjacent lands at Euchre Creek have shown promise. The Euchre Creek site occupies beach and foredune habitat. Beginning in 1995, Euchre Creek has been seeded and received transplants multiple times. Population sizes have typically been small, ranging from 1 to 9 plants since 2000. The individual plants typically have occupied the beach as well as occasionally some unvegetated, low foredune areas.

Bandon Beach – Reintroduction attempts at Bandon Beach, Coos County (Oregon Dept. Parks and Recreation), were initiated through direct seeding in 1998 and seeding was repeated in 2002. Few plants were located until 2003, when the population grew to 127 individuals, all of which occurred in beach habitat north and (primarily) south of Bradley Creek, as well as around the mouth of the creek. In 2005, additional seeding was conducted in a beachgrass control area about one mile south of Bradley Creek, and a total of 139 plants emerged that year. Restoration is ongoing at this site.

New River – Due to aggressive efforts to control European beachgrass at the New River ACEC site, Coos and Curry Counties (Coos Bay District BLM) for beach habitat and the Western Snowy Plover, this site has received extensive and repeated seedings with pink sand-verbena in an effort to establish a strong population on open sand on its extensive beaches and foredunes. The site has been seeded six times since 1997 with 50,000 to 100,000 seeds per year. The population appears to be responding to this constant effort with total sizes ranging from 145 to 917 since 2000 (Kaye 2003). Active management of this site is conducted under the Final New River ACEC Management Plan (USDI 1995b).

Floras Lake – This site west of Floras Lake, Curry County, appears to be managed by BLM but may also be partly on lands managed by the Oregon Parks and Recreation Department. The habitat is open beach and partially protected upper beach away from active tide effects. This site received 12 transplants in 1995 (Kaye 1995), and the beach adjacent was seeded with 5,000 seeds in winter of 1995 (Kaye 1996). Plants were observed in 1995 and 1996 (Kaye 1995 and 1996), then again in 2000 (by Bruce Rittenhouse, BLM). In 2004, approximately 200 plants were observed (R. Meinke, pers. comm..). No off-site transplanting or seeding was conducted after 1995 at this site.

British Columbia

Recent natural populations (observed within five years)

Pacific Rim National Park – This is the only known population of pink sand-verbena in British Columbia, and represents the furthest north population known. A description of the history of this population is described below in material

quoted from Douglas (2000). Several (30 to 40) plants grown from seed from this population were outplanted in 2001 by a local resident, and these plants grew well through that year. However, the species has not been detected at this site since then (Douglas, pers. comm.).

This plant has an interesting history in British Columbia. It was first reported by J.K. Henry from Pachena Bay (near Bamfield) prior to 1915 (Henry 1915) and was later collected there in 1927. A second collection, from Ahousat (near Tofino) was made in 1915. Officially, it was not seen again until the summer of 2000 by Jim Hamilton, who lives along the Pacific Coast Trail in Pacific Rim National Park. Mr. Hamilton reported that a previous neighbour in the Park saw this species in 1941 on the same beach where he located the plant. Although Mr. Hamilton has lived near this beach since 1954 and explores it often every summer, this is the first time he has seen it.

On September 11, 2000 a Conservation Data Centre field team (George W. Douglas, Jennifer Penny, and Beth Rogers) visited the site. Two *Abronia umbellata* ssp. *acutalata* plants were examined on the upper beach, just below the driftwood zone. The plants were growing in fine sand in a plant community comprised almost solely of scattered *Cakile maritima*, a European introduction. The plants measured 2 x 1.5 and 1 x 0.75 metres in diameter. The larger plant had about 200 flower/seed heads while the smaller had about 100 heads. About 20 seed heads were collected for propagation and further research. A search of about 2 km of beach on foot and a quick aerial reconnaissance by helicopter over about 30 km of coastline did not reveal additional *Abronia* plants.

Proposed Management Actions

Management Goals and Objectives

The objective of the management actions presented in this Conservation Strategy is to maintain or increase the numbers and stability of pink sand-verbena by maintaining and restoring habitat in each of the populations. The ultimate goal is to remove the need to list the species as threatened or endangered.

This will be accomplished by protecting all known populations of the species on public lands included in this Conservation Strategy. These populations will not knowingly be subjected to development or habitat degradation through land management actions. Efforts will be made to limit the impacts of recreational use (such as from off road vehicles), as appropriate to the anticipated use and site characteristics. The habitat associated with the populations will be considered for potential European beachgrass control. Any new populations discovered on lands included in this strategy will

automatically be covered. Due to the small size of most pink sand-verbena populations and their restriction to the immediate coast (beaches), the impact of their protection on other resource utilization activities is expected to be low.

Monitoring is a crucial part of this Conservation Strategy. Monitoring will be scheduled and conducted at each population or subpopulation as resources permit. Data will be gathered at each population as time and resources permit to document overall population trends and the impact of protection and restoration activities on the species.

Management Actions

The following activities have been identified as management tools available to address some of the human-caused or human-controllable threats to the species on public lands covered by this Conservation Strategy. If a population is threatened, one or more of these activities will be employed to protect the species.

Reduce competition from European beachgrass and other plant species:

- Develop habitat restoration plans to restore habitat and control competing vegetation, including, but not limited to, aggressive non-native species such as European beachgrass (and possibly sea-rocket species).
- Restore natural processes that maintain the habitat (e.g., breach or lower foredunes to allow the penetration of winter storm waves, etc.).
- Control vegetation with mechanical equipment, manual removal, or herbicides.

Conduct periodic monitoring of populations:

- See Monitoring section (below) for guidelines.
- Monitor plants in selected populations on public land to determine population trends and effects of management treatments and practices.
- Consider using a single individual or group to conduct monitoring across ownership boundaries for consistency. Alternatively, conduct joint training of monitoring staff.

Augment existing populations:

- Place seeds of pink sand-verbena within suitable habitat during winter to promote establishment of new plants and increase local population size.
- Out-plant greenhouse-grown individuals to suitable habitat.
- Document dates and types of activities at each site.

Restore habitat and reintroduce pink sand-verbena:

- Conduct beachgrass control measures to reduce or eliminate competition with pink sand-verbena.

- Place seeds of pink sand-verbena within suitable habitat during winter to promote establishment of new plants and increase local population size.
- Out-plant greenhouse-grown individuals to suitable habitat.
- Monitor planting results to document project success.
- Document dates and types of restoration activities at each site.

Develop opportunities for collaborative habitat management on public land to increase the amount of habitat suitable for the species and to link isolated populations with one another.

- Coordinate pink sand-verbena conservation activities with management of Western Snowy Plover.
- Implement beach and dune ecosystem restoration for pink sand-verbena and other animal and plant species of the same habitat through beachgrass control and multiple species reintroduction or augmentation.

Educate members of the public to reduce impacts from recreation and increase conservation opportunities:

- Develop management plans in high-use recreation areas to limit human-caused disturbance of plants and habitat during critical parts of the growing season, especially June through September.
- Conduct outreach activities to educate the public about pink sand-verbena. Examples of such activities include:

    - Distribute the informational video ("Ecoregion DVD") on coastal habitat conservation featuring pink sand-verbena (produced by BLM and other partners) targeting the general public and school groups.
    - Host a web site featuring pink sand-verbena and providing information on coastal dune ecosystem conservation and research needs.
    - Post interpretive signs at popular trailheads.
    - Prepare a brochure on beach and dune conservation featuring pink sand-verbena and other sensitive coastal species.
    - Distribute information and make presentations to beach conservation groups, such as those involved in annual beach cleanup activities (e.g., SOLV's Great Oregon Beach Cleanup).
    - Conduct habitat restoration actions such as invasive grass pulling as part of National Public Lands Day.
    - Conduct hikes and field trips to view pink sand-verbena and discuss conservation challenges and opportunities for public involvement.
    - Recruit schools and other groups to assist with restoration and conservation activities.

- Collect seeds:
    - Collect seeds from large populations to support population augmentation and reintroduction at other sites.

- Collect seed from a variety of populations throughout the range of pink sand-verbena for storage at the Berry Botanic Garden seed bank or other repository. A total of eleven seed collections of pink sand-verbena from only three populations in Oregon are housed at the Garden at this time (E. Guerrant, pers. comm. to T.N. Kaye). These collections are all very small and underscore the need for additional seed collection to support restoration and recovery of this species. In October 2003, a seed collection of over 10,000 pink sand-verbena from the Coos Bay, North Spit site was sent to the Royal Botanic Gardens (RBG), Kew as part of the "Seeds of Success" project. The purpose of the "Seeds of Success" project in the United States on public lands administered by the BLM is to establish a high quality, accurately identified and well documented native species seed collection at the population level in cooperation with the RBG's Millennium Seed Bank project.

Acquisition of Additional Information

Additional information that is needed to improve management and conservation of pink sand-verbena is listed below. These projects will be proposed as administrative studies or research and accomplished by Bureau of Land Management, Forest Service, National Park Service, and U.S. Fish and Wildlife Service personnel or state agencies, through challenge cost share, or by contract with a research organization as appropriate and as funding is available.

- **Continued surveys**. Conduct systematic inventory for potential habitat and undiscovered populations.

- **Pathogens and herbivores**. Identify all pathogens (e.g., insects, fungi, viruses) that affect the growth and reproduction of pink sand-verbena in natural populations.

- **Plant taxonomy**. Conduct and publish studies resolving the taxonomic issues regarding *Abronia umbellata* and its subspecies and documenting the genetic relationship of Oregon and California plants to those from Washington and British Columbia.

- **European beachgrass control**. Develop additional methods or improve the efficiency of existing methods for controlling European beachgrass.

- **Population augmentation and reintroduction**. Continue with studies that yield information improving the success pink sand-verbena population augmentation and reintroduction. The current average seeding success of approximately ½% is very low, but the range of seedling establishment rates to date has been very wide. Some seeding attempts have been very successful. Research is needed to identify which habitat or climatic factors affect seeding success. In addition, more information is needed to improve the survival and seed production of out-planted pink sand-verbena.

- **Population modeling: Assessing recovery objectives**. Recovery objectives for pink sand-verbena need to be developed that take into account our ability to establish successful reintroduced populations of the species. Information on natural population dynamics, population establishment success, and interactions between populations and unoccupied suitable habitat can be combined in computer models that simulate population dynamics over time. For example, through the use of matrix models, the viability of individual populations may be estimated based on observations of individuals in populations through time. And groups of populations, or meta-populations, can be modeled to determine the chance of extinction of the entire group through time. As yet, we have no estimate of the number of populations needed to establish a successful pink sand-verbena meta-population. A meta-population model for the species, using the information we have from population monitoring, additional population studies, and estimates of dispersal rates to drive the model, should be developed. 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 just one of several beach species in decline on the Pacific 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). Wildlife such as the plover thrive in this open habitat, and tolerate small amounts of open vegetation, such as the types of habitat that were plentiful prior to European beachgrass introduction. Therefore, establishment of limited additional beach and dune plant species is compatible with plover and sand-verbena habitat management. Unfortunately, propagation methods for many beach species have not been developed and are badly needed. A list of 17 native plant species that could be useful in restoration projects of beach ecosystems is provided below (Table 1), and more information is available in Pickart and Sawyer (1998).

Table 1. 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[1]	*Abronia latifolia*
silver bursage	*Ambrosia chamissonis*
beach morning-glory	*Calystegia soldanella*
coastal cryptantha[1]	*Cryptantha leicarpa*
American dunegrass	*Leymus mollis*
many-leaf gily flower[1]	*Gilia millefoliata*
American glehnia	*Glehnia leiocarpa*
beach pea	*Lathyrus littoralis*
maritime pea	*Lathyrus japonicus*
Wolf's evening primrose[2]	*Oenothera wolfii*
silvery phacelia[2]	*Phacelia argentea*
seashore bluegrass	*Poa macrantha*
dune bluegrass	*Poa confinis*
black knotweed	*Polygonum paronychia*
seaside dock	*Rumex maritimus*
swaying bulrush[1]	*Schoenoplectus subterminalis*
dune tansey	*Tanacetum camphoratum*

[1]Bureau of Land Management Assessment and Tracking species
[2]Listed as Threatened with the Oregon Dept. of Agriculture; Species of Concern with the U.S. Fish and Wildlife Service.

Proposed Management Actions by Population

The following management actions are designed to meet the management objectives for pink sand-verbena outlined above under Management Goals and Objectives. The suggested management actions listed below do not identify specific methods or techniques. Instead, to make this Conservation Strategy as flexible as possible, these are only briefly summarized above (see Management Actions), and specific actions are left to each management agency to identify and implement.

- Conduct control activities for European beachgrass to maintain open beach and foredune conditions. Develop a habitat management plan to document the effectiveness of beachgrass control efforts and schedule additional treatments.

- Continue with population reintroduction efforts through direct seeding at annual or biennial intervals to develop a viable population with a resident persistent seed bank.

- Collect seed for storage at the Berry Botanic Garden's Cryogenic Seed Bank.
- Monitor plants to determine population trends and effects of management treatments and practices.
- Conduct additional inventory for potential habitat and undiscovered populations (mostly as part of project surveys).
- Reduce impacts of recreation.
- Coordinate pink sand-verbena conservation activities with management of Western Snowy Plover and implement beach and dune ecosystem restoration for multiple species.
- Develop opportunities for collaborative habitat management on public and private land to increase the amount of habitat suitable for the species and to link isolated populations with one another.

USDA Forest Service, Siuslaw National Forest

Tenmile Creek

- Conduct control activities for European beachgrass to maintain open beach and foredune conditions. Develop a habitat management plan to document the effectiveness of beachgrass control efforts and schedule additional treatments.
- Augment the population through outplanting of greenhouse-propagated plants grown from seed collected at this site.
- Develop a grow-out plan to increase the availability of seed from this site.
- Collect seed for storage at the Berry Botanic Garden's Cryogenic Seed Bank.
- Monitor plants to determine population trends and effects of management treatments and practices.
- Conduct additional inventory for potential habitat and undiscovered populations (mostly as part of project surveys).
- Coordinate pink sand-verbena conservation activities with management of Western Snowy Plover and implement beach and dune ecosystem restoration for multiple species.

Tahkenitch Creek

- Conduct control activities for European beachgrass to maintain open beach and foredune conditions. Develop a habitat management plan to document the effectiveness of beachgrass control efforts and schedule additional treatments.

- Continue with pink sand-verbena population reintroduction efforts through direct seeding at annual or biennial intervals to develop a viable population with a resident persistent seed bank.

- Monitor plants to determine population trends and effects of management treatments and practices.

- Conduct additional inventory for potential habitat and undiscovered populations, (mostly as part of project surveys).

- Coordinate pink sand-verbena conservation activities with management of Western Snowy Plover and implement beach and dune ecosystem restoration for multiple species.

Siltcoos Creek

- Conduct control activities for European beachgrass to maintain open beach and foredune conditions. Develop a habitat management plan to document the effectiveness of beachgrass control efforts and schedule additional treatments.

- Continue with pink sand-verbena population reintroduction efforts through direct seeding at annual or biennial intervals to develop a viable population with a resident persistent seed bank.

- Monitor plants to determine population trends and effects of management treatments and practices.

- Conduct additional inventory for potential habitat and undiscovered populations, (mostly as part of project surveys).

- Coordinate pink sand-verbena conservation activities with management of Western Snowy Plover and implement beach and dune ecosystem restoration for multiple species.

Overlook sites

- Continue with control activities for European beachgrass to maintain open beach

and foredune conditions. Develop a habitat management plan to document the effectiveness of beachgrass control efforts and schedule additional treatments.

- Continue with population reintroduction efforts through direct seeding at annual or biennial intervals to develop a viable population with a resident persistent seed bank.
- Collect seed for storage at the Berry Botanic Garden's Cryogenic Seed Bank at times when this population produces large amounts of seed.
- Monitor plants to determine population trends and effects of management treatments and practices.
- Conduct additional inventory for potential habitat and undiscovered populations (mostly as part of project surveys).
- Coordinate pink sand-verbena conservation activities with management of Western Snowy Plover and implement beach and dune ecosystem restoration for multiple species.
- Develop opportunities for collaborative habitat management on public and private land to increase the amount of habitat suitable for the species and to link isolated populations with one another.

Baker Beach/Berry Creek

- Continue with control activities for European beachgrass to maintain open beach and foredune conditions. Develop a habitat management plan to document the effectiveness of beachgrass control efforts and schedule additional treatments.
- Continue with population reintroduction efforts through direct seeding at annual or biennial intervals to develop a viable population with a resident persistent seed bank.
- Collect seed for storage at the Berry Botanic Garden's Cryogenic Seed Bank at times when this population produces large amounts of seed.
- Monitor plants to determine population trends and effects of management treatments and practices.
- Conduct additional inventory for potential habitat and undiscovered populations (mostly as part of project surveys).
- Reduce impacts of recreation.
- Coordinate pink sand-verbena conservation activities with management of Western

Snowy Plover and implement beach and dune ecosystem restoration for multiple species.

- Develop opportunities for collaborative habitat management on public and private land to increase the amount of habitat suitable for the species and to link isolated populations with one another.

USDI–BLM Coos Bay District

New River ACEC

- Continue with large-scale control activities for European beachgrass to increase open foredune conditions, maintain treated areas, and facilitate over-washing of the sand spit by winter storms and tidal events. Develop a habitat management plan to document the effectiveness of beachgrass control efforts and schedule additional treatments.

- Coordinate pink sand-verbena conservation activities with management of Western Snowy Plover and implement beach and dune ecosystem restoration for multiple species.

- Continue with population reintroduction efforts through direct seeding at annual or biennial intervals to develop a viable population with a resident persistent seed bank.

- Collect seed for storage at the Berry Botanic Garden's Cryogenic Seed Bank.

- Monitor plants to determine population trends and effects of management treatments and practices.

- Develop opportunities for collaborative habitat management on public and private land to increase the amount of habitat suitable for the species and to link isolated populations with one another.

Coos Bay, North Spit ACEC

- Coordinate with Oregon Department of Fish and Wildlife and Army Corps of Engineers to maintain large areas of open sand in the interior of the sand spit.

- Develop a habitat management plan to document the effectiveness of beachgrass control efforts and schedule additional treatments.

- Determine the feasibility of extending European beachgrass control efforts west to

develop beachfront habitat for pink sand-verbena. Initiate pink sand-verbena reintroduction in beach habitat.

- Collect seed for storage at the Berry Botanic Garden's Cryogenic Seed Bank (noting that the seed from this site is produced by plants originally reintroduced from Port Orford, Oregon).

- Monitor plants to determine population trends and effects of management treatments and practices.

- Conduct additional inventory for potential habitat and new pink sand-verbena colonies establishing themselves in habitat openings on the spit.

- Coordinate pink sand-verbena conservation activities with management of Western Snowy Plover and implement beach and dune ecosystem restoration for multiple species.

- Develop opportunities for collaborative habitat management on public and private land to increase the amount of habitat suitable for the species and to link isolated populations with one another.

Floras Lake

- Coordinate with Oregon Parks and Recreation Department maintain open sand habitat. All such activities should be compatible with maintaining habitat for many-leaf gilia (*Gilia millefoliata*) and silvery Phacelia (*Phacelia argentea*), which occur on nearby BLM lands.

- Monitor plants to determine population trends and effects of management treatments and practices.

- Conduct additional inventory for potential habitat and new pink sand-verbena colonies establishing themselves in habitat openings on the adjacent beach.

- Coordinate pink sand-verbena conservation activities with management of Western Snowy Plover and implement beach and dune ecosystem restoration for multiple species.

- Develop a management plan for the site that may include additional reintroductions to increase genetic diversity in the population.

Greggs Creek (adjacent to Euchre Creek)

No plants are currently known from BLM-managed lands at this site, but past reintroduction activities here and on adjacent lands (Euchre Creek, see population descriptions above) have shown promise. Therefore, this site is included as a location at which additional reintroduction and conservation work with pink sand-verbena may be warranted. Any activities conducted at this site must be compatible with archeological resources and other sensitive plants known to occur here.

- Develop opportunities for collaborative habitat management on public and private land (e.g., The Nature Conservancy preserve at Ophir Dunes, Oregon Parks and Recreation Department) to increase the amount of habitat suitable for the species, connect and expand adjacent populations, and link isolated populations with one another.

- Conduct control activities for European beachgrass where compatible with archeological resources and other sensitive plant species (such as silvery phacelia) to maintain open beach and foredune conditions. Develop a habitat management plan to document the effectiveness of beachgrass control efforts and schedule additional treatments.

- Increase population reintroduction efforts through direct seeding at annual or biennial intervals to develop a viable population with a resident persistent seed bank.

- Monitor pink sand-verbena and silvery phacelia plants to determine population trends and effects of management treatments and practices.

- Conduct additional inventory for potential habitat and undiscovered populations (mostly as part of project surveys).

- Reduce impacts of recreation.

- Coordinate pink sand-verbena conservation activities with management of Western Snowy Plover and implement beach and dune ecosystem restoration for multiple species.

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Bandon Beach (experimental reintroduction site)

- Conduct control activities for European beachgrass to maintain open beach and foredune conditions within the current habitat enhancement area. Develop a habitat management plan to document the effectiveness of beachgrass control efforts and schedule additional treatments.

- Continue with population reintroduction efforts through direct seeding at annual or

biennial intervals to develop a viable population with a resident persistent seed bank. Seeding schedule may be interrupted when intensive foredune and/or European beachgrass treatment is necessary.

- Monitor plants to determine population trends and effects of management treatments and practices.

- Limit impacts of recreation.

- Coordinate pink sand-verbena conservation activities with management of Western Snowy Plover and implement beach and dune ecosystem restoration for multiple species.

Port Orford

- Pursue pink sand-verbena conservation activities and consider implementation of beach and dune ecosystem restoration for multiple species. Any restoration activities should be compatible with and have mutual benefit for Wolf's evening primrose (*Oenothera wolfii*), which also occurs at this site and grows with pink sandverbena, as well as on adjacent banks and bluffs.

- Permit seed collection for reintroduction efforts elsewhere and for storage at the Berry Botanic Garden's Cryogenic Seed Bank.

- Monitor plants to determine population trends and effects of management treatments and practices.

- Develop opportunities for collaborative habitat management with the Port of Port Orford and Army Corps of Engineers.

Otter Beach

- Monitor plants to determine population trends and effects of any future management treatments and practices.

- Conduct additional inventory for potential habitat and new pink sand-verbena colonies establishing themselves in habitat openings on adjacent beaches.

- Coordinate pink sand-verbena conservation activities with management of Western Snowy Plover and implement beach and dune ecosystem restoration for multiple species.

- Consider development of a management plan for the site that may include seed

augmentations to increase genetic diversity and size of the population.

Ona Beach

- Monitor the site for natural re-establishment of this population (which is currently has no above-ground plants).
- Conduct additional inventory for potential habitat and new pink sand-verbena colonies establishing themselves in habitat openings on adjacent beaches.
- Coordinate pink sand-verbena conservation activities with management of Western Snowy Plover and implement beach and dune ecosystem restoration for multiple species.
- Consider development of a management plan for the site that may include additional reintroductions to increase genetic diversity in the population.

Floras Lake

- Coordinate with Coos Bay District, BLM to maintain open sand habitat. All such activities should be compatible with maintaining habitat for many-leaf gilia (*Gilia millefoliata*) and silvery Phacelia (*Phacelia argentea*), which occur on nearby BLM lands.
- Monitor plants to determine population trends and effects of management treatments and practices.
- Conduct additional inventory for potential habitat and new pink sand-verbena colonies establishing themselves in habitat openings on the adjacent beach.
- Coordinate pink sand-verbena conservation activities with management of Western Snowy Plover and implement beach and dune ecosystem restoration for multiple species.
- Consider development of a management plan for the site that may include additional reintroductions to increase genetic diversity in the population.

Cape Blanco

- Monitor plants to determine population trends and effects of management treatments and practices.

- Conduct additional inventory for potential habitat and new pink sand-verbena colonies establishing themselves in habitat openings on the adjacent beach.

- Coordinate pink sand-verbena conservation activities with management of Western Snowy Plover and implement beach and dune ecosystem restoration for multiple species.

- Develop a management plan (in process) for the site that may include additional reintroductions and/or augmentations to increase genetic diversity and size of the population.

Other areas managed by Oregon Parks and Recreation Department not currently containing populations of the species

- Coordinate with adjacent landowners to accommodate or enhance their species and habitat management efforts when the species occurs on adjacent lands.

- Consider opportunities for collaborative habitat management on public and private land to increase the amount of habitat suitable for the species, connect and expand adjacent populations, and link isolated populations with one another.

- Conduct control activities for European beachgrass (where feasible, reasonable, and compatible with other resource needs) in order to maintain open beach and foredune conditions and facilitate over-washing of the sand spit by winter storms and tidal events. Document the effectiveness of beachgrass control and habitat enhancement value.

- Monitor pink sand-verbena plants to determine population trends and effects of management treatments and practices.

- In areas where European beachgrass is treated to produce an approximation of historic beach conditions, consider reintroduction of pink sandverbena and/or a natural (historic) dune and beach native plant community consistent with the species outlined in Table 1.

Updates and amendments

Additional populations of different ownership or management responsibility and in different states or provinces will be added to this document as assistance from these various regional partners permits. A Recovery Strategy for the species in British Columbia is in draft form (Fairbarns 2006) at this time, and its implementation may make inclusion of Canadian populations in this Conservation Strategy unnecessary.

Conservation Strategy Duration and Review Schedule

The life of this Conservation Strategy will be ten years, after which time the status of pink sand-verbena, along with the objectives and methods included in the strategy, will be re-evaluated, and if necessary, extended. At three year intervals the participating parties will review progress achieved at each managed population, and amendments to the plan may be made as needed to address new information and any discoveries of additional populations.

Monitoring

Monitoring is a key component of this conservation strategy. It will be necessary to determine the effectiveness of the proposed management actions and whether the management objective of the conservation strategy is being achieved. Proposed management actions are intended to be flexible. As monitoring data are collected, management actions will be modified and the conservation strategy amended, as necessary, to ensure that the management objective is achieved. Amendments will be implemented only with full consent of the signatories of this plan.

Two types of monitoring are proposed, ecological status monitoring and management treatment monitoring. The purpose of ecological status monitoring is to determine trend by tracking over time the numbers of individuals in populations and subpopulations. Management treatment monitoring is intended to evaluate the response of populations and subpopulations to selected management treatments.

Ecological Status Monitoring

Monitoring Objective. The objective for ecological status monitoring is to detect a 30% change in population or subpopulation numbers (and reproductive output) over a five year period with a 10% chance of a false change error (Type I) and a 10% chance of a missed change error (Type II). Monitoring should be conducted annually for the first five years to document a reliable baseline, then every three years. If populations typically contain fewer than 1,000 individual plants, an annual census may be preferable to a sampling procedure.

Monitoring Locations. Monitoring will be conducted annually on federally managed land at the following populations, or as resources permit:

Monitoring Methods. Ecological status monitoring will be conducted by BLM, Forest Service, Park Service, U.S. Fish and Wildlife Service, or state agency personnel, through challenge cost share, or by contract. Monitoring will be conducted according to the following procedures, depending on population size and plant growth form:

A. Populations with 1,000 or fewer individuals: direct census

Small populations may be monitored effectively and efficiently through direct census. Note, however, that small populations may occasionally become too large for a direct census in just one year. Therefore, field investigators should be prepared to perform a subsample (see B below) each year that monitoring is conducted, in the event that the population has increased unexpectedly.

1. Count the number of vegetative and flowering plants, and record on a standard sighting report form.

B. Populations with 1,000 to 10,000 individuals: random subsample

1. Map population or subpopulation location carefully onto aerial photographs and large scale topographic maps. Locate population perimeter with GIS equipment (1 to 5 meter minimum accuracy), if available. Flag surrounding vegetation and draw a sketch map of the area.

2. Randomly select plots within the population. Begin with at least six plots per population, subpopulation, or stratum. Follow procedures recommended in Elzinga, Salzer, and Willoughby (1998).

3. Conduct sampling when plants are in flower or early fruit; count the number of vegetative and reproductive plants and record them on a data form (September will generally be a good month for sampling, but this may be delayed until October or conducted as early as August, depending on the year and location).

4. Use plot data to estimate total population or subpopulation size (number of individuals), as well as standard deviations and confidence intervals.

If populations or subpopulations decrease more than 30% in a consistent trend over a five year period, then the cause of the decrease should be identified and appropriate management actions recommended.

C. Populations with more than 10,000 individuals: perimeter mapping.

Survey the perimeter of the population with a Geographic Positioning System

(GPS) and provide a rough estimate of total population size (or reproductive plants only). This situation currently applies only to one known population in Oregon at Coos Bay, North Spit, at which the population exceeds (as of 2003) 100,000 reproductive individuals and covers several acres.

Management Treatment Monitoring

Monitoring Objective. Management treatment monitoring is an optional tool for determining the effectiveness of trial management practices, such as beachgrass removal (see Acquisition of Additional Information, above). The objective for management treatment monitoring is to detect if there is a 30% change in the number of plants in control (untreated) versus treated plots with a 10% chance of a missed change error and a 10% chance of a false change error.

Monitoring Locations. Sites where management treatment monitoring will be implemented shall be determined on an as needed basis, but shall include all sites where management treatments are conducted on a trial basis, or as resources permit.

Monitoring Methods. Management treatment monitoring will be proposed as administrative studies or research and accomplished by Bureau of Land Management, Forest Service, U.S. Fish and Wildlife Service, or state agency personnel, through challenge cost share, or by contract with an appropriate research organization. Monitoring will be conducted according to methods proposed at the time of the administrative study or research.

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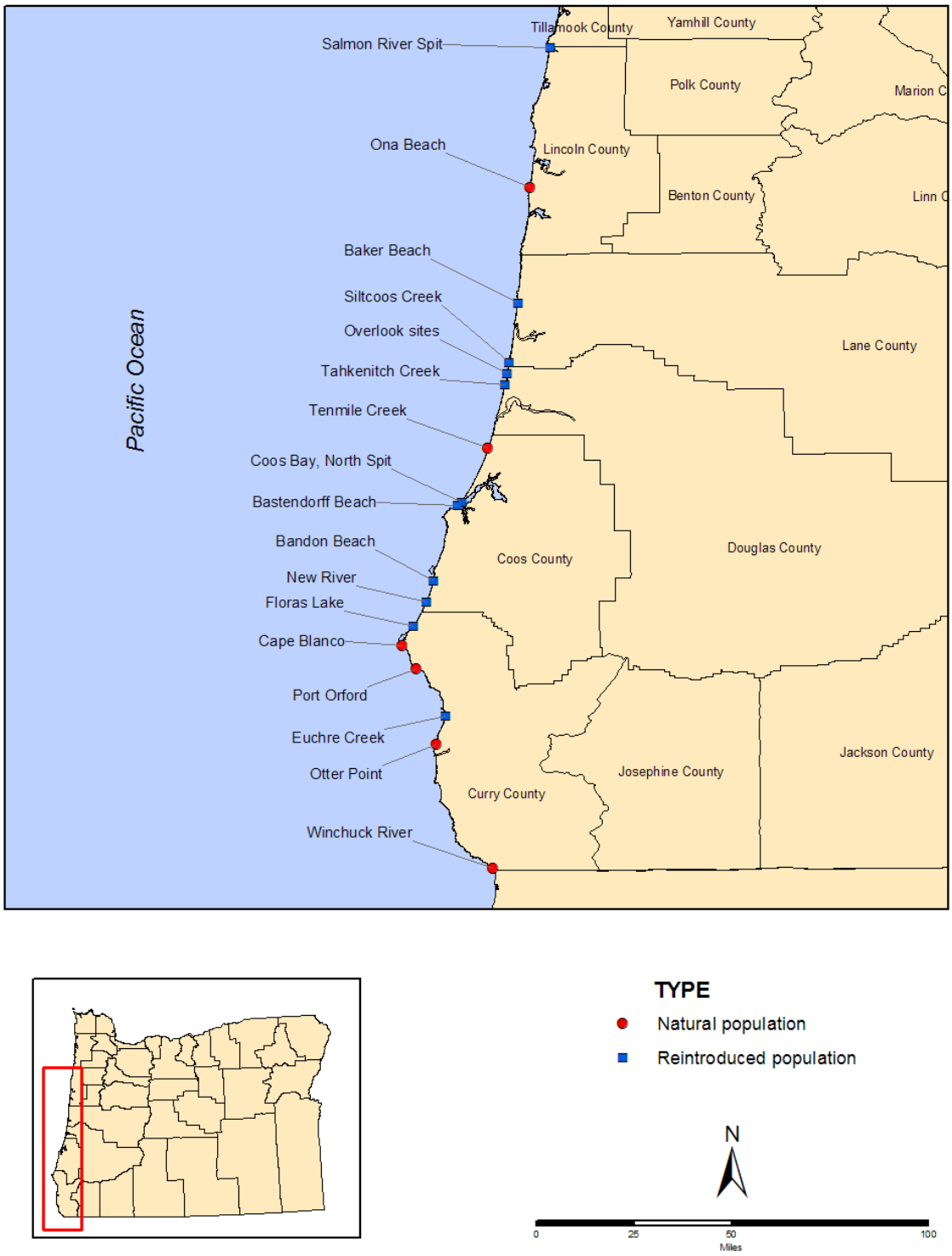
Appendix A. Range map for pink sand-verbena in Oregon. Dots represent currently known (within 5 years) populations.



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