

**Large-fruited Sand-verbena  
(*Abronia macrocarpa*)  
Recovery Plan**



**U.S. FISH AND WILDLIFE SERVICE  
REGION 2, ALBUQUERQUE, NEW MEXICO  
1992**

# **LARGE-FRUITED SAND-VERBENA**

**Abronia macrocarpa**

## **RECOVERY PLAN**

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Date:

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## Disclaimer

Recovery plans delineate reasonable actions that are believed to be required to recover and/or protect listed species. Plans are published by the U.S. Fish and Wildlife Service, sometimes prepared with the assistance of recovery teams, contractors, State agencies, and others. Objectives will be attained and any necessary funds made available subject to budgetary and other constraints affecting the parties involved, as well as the need to address other priorities. Total recovery costs and dates for meeting objectives are estimates and are uncertain because the feasibility of several tasks in the plan are dependant on the results of other tasks. Recovery plans do not necessarily represent the views nor the official positions or approval of any individuals or agencies involved in the plan formulation, other than the U.S. Fish and Wildlife Service. They represent the official position of the U.S. Fish and Wildlife Service only after they have been signed by the Regional Director or Director as approved. Approved recovery plans are subject to modification as dictated by new findings, changes in species' status, and the completion of recovery tasks.

## LITERATURE CITATIONS

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### **Acknowledgements**

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## EXECUTIVE SUMMARY OF THE LARGE-FRUITED SAND VERBENA RECOVERY PLAN

**Current Status:** The large-fruited sand-verbena is listed as endangered. It is known from three sites in east-central Texas. The number of plants totals less than 3,000.

**Habitat Requirements and Limiting Factors:** The large-fruited sand-verbena grows in deep sandy soils in openings and disturbed areas of post oak woodlands. The species is threatened by habitat destruction from the development activities of a resort/residential community where one population occurs, and habitat modification from small scale clearing, fire suppression, and introduction of non-native plant species.

**Recovery Objective:** Delisting.

**Recovery Criteria:** Develop and implement management plans that insure the continued protection and stability of at least 20 viable populations, each with a habitat area of at least 25 acres and a stable population of at least 600 plants.

**Major Actions Needed:**

1. Protect existing populations from present and future threats.
2. Establish a reserve seed bank and cultivated population.
3. Gather biological information necessary to make management decisions.
4. Search for new populations.
5. Develop plans for reintroducing plants into suitable habitat.

**Estimated Total Cost of Recovery (\$000's):**

<u>Year</u>	<u>Need 1</u>	<u>Need 2</u>	<u>Need 3</u>	<u>Need 4</u>	<u>Need 5</u>	<u>Total</u>
1993	30.0	11.5	54.5	10.0	18.0	124.0
1994	31.8	6.0	45.5	10.0	7.0	100.3
1995	18.0	3.5	35.5	7.0	7.0	71.0
1996	21.8	3.5	11.0	0.0	7.0	43.3
1997	18.0	3.5	11.0	0.0	7.0	39.5
1998	18.8	3.0	0.0	0.0	7.0	28.8
1999-2015 (ea.)	15.0	3.0	0.0	0.0	7.0	25.0

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<b><u>Recovery Cost</u></b>	393.4	82.0	157.5	27.0	172.0	831.9
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**Date of Recovery:** If continuous progress is made, delisting may be possible by 2015.

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## PART I. INTRODUCTION

### Brief Overview

The large-fruited sand-verbena (Abronia macrocarpa) was Federally listed as endangered on September 28, 1988 (U.S. Fish and Wildlife Service 1988). No critical habitat was designated. Abronia macrocarpa is also listed as endangered by the State of Texas (Texas Parks and Wildlife Department, Executive Order No. 88-003, on Dec. 30, 1988). Abronia macrocarpa has a recovery priority of two. Recovery priorities for listed species range from 1 to 18, with species ranking 1 having the highest recovery priority. A recovery priority of two indicates that this is a full species with a high degree of threat and a high recovery potential (U.S. Fish and Wildlife Service 1983a, 1983b).

Abronia macrocarpa is a member of the Four-o'clock (Nyctaginaceae) family, and was described as a distinct species by Galloway (1972). It is known from only three East Texas counties (Freestone, Leon, and Robertson) and is apparently endemic to the sandy soil regions of eastern Texas (Figure 1). It occurs in a relatively restricted area and has never been described as abundant. Little is known about the biology of the species (Kennedy, et al. 1990).

### Taxonomy

Donovan S. Correll and Helen B. Correll first collected the species in Leon County, Texas in 1968. Dr. Correll recognized that it was likely a species new to science and called it to the attention of Dr. Leo A. Galloway who was working on a monograph of the genus at the time. Dr. Galloway (1972) described the species, designating a type from collections he personally made at the same locality as the collection made by the Corrells. At the time he named and described the species, he noted it appeared in danger of extinction. In 1975 Galloway discussed the genus Abronia in its traditional sense and demonstrated characters that justified the separation of two genera, Abronia and Tripterocalyx, from the group. He places Abronia macrocarpa definitively within the genus Abronia (Galloway 1975).

### Morphology

This species is a broad-leaved, tap-rooted, herbaceous perennial growing to 20 inches (50 centimeters). The foliage is sticky from glandular hairs. The leaves are usually rounded, and about 0.75-2.0 inches (2-5 centimeters) long and 0.6-1.4 inches (1.5-3.5 centimeters) wide. The magenta flowers are grouped into rounded heads composed of 20-75 individual flowers. These flower heads are quite striking, and each has bracts at the base that

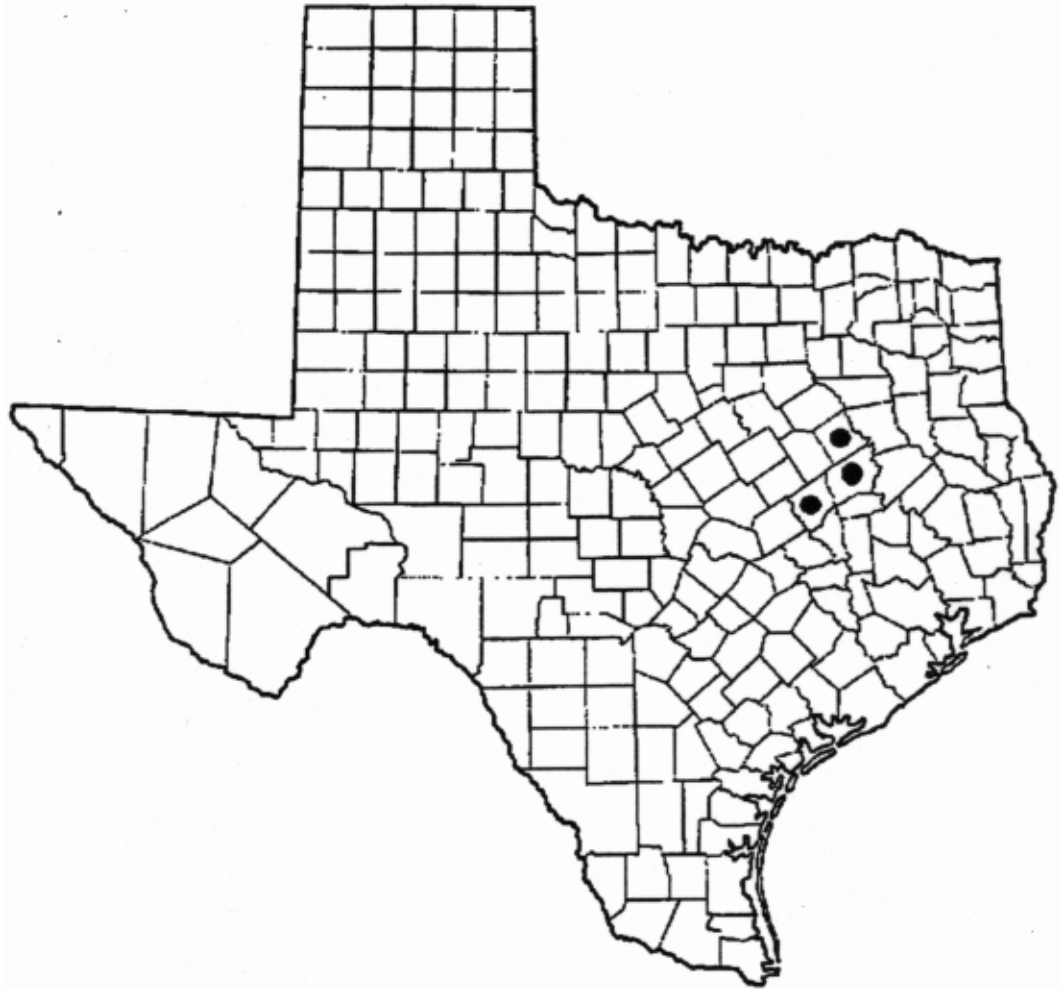


Figure 1. Distribution of Abronia macrocarpa.

are nearly oval and about 0.25-0.5 inches (0.6-1.3 centimeters) long and 0.13-0.38 inch (0.3-1.0 centimeter) wide. The species flowers in March or April and occasionally again in the fall following periods of high rainfall. Each flower has a tube about 0.7-1.3 inches (1.8-3.3 centimeters) long that widens at the top into five nearly divided lobes 0.3-0.4 inch (0.8-1.0 centimeter) wide. The fruits are 0.3-0.6 inch (0.8-1.6 centimeters) long and 0.2-0.5 inch (0.5-1.3 centimeters) wide and papery with five often somewhat twisted wings. The seeds (achenes) are from 0.06-0.19 inch (1.5-4.8 millimeters) long and brown. The species is most easily characterized by its large, thin-walled fruits (anthocarps), which are thinner and more papery than any other species of Abronia and among the largest in the genus. This description is adapted from Galloway (1972, 1975) and Turner (1983).

### Life History

Field observations during a reproductive biology study by Corlies (1991) indicate that the plant is a tap-rooted perennial, forming rosettes in the fall that overwinter. In spring, plants produce shoot material and bloom. Plants die back during the hot summer months, and send up new rosettes each fall.

The Corlies study (1991) of pollination indicated that the flowers have the characteristics of a moth pollinated flower (light color with long floral tube, evening blooming, intense fragrance after 6 p.m), but no moths or butterflies were observed pollinating the flowers. The flowers were visited by hummingbirds, members of the hymenoptera, small bees, and bumble bees. Cross-pollinated flowers do set seed.

### Habitat

Abronia macrocarpa occurs in a subtropical, humid climatic region characterized by warm summers (Larkin and Bomar 1983). The frost-free period averages 267 days over the three county area, with a first freeze date of November 29 to December 1 and an average last freeze date of March 6-11. The average number of days of temperatures above 32.2° C (90° F) is 97, and the average number of days with temperatures below 0° C (32° F) is 37. The three county area has an average annual precipitation of 38-39.3 inches or 96.5-99.8 centimeters (Natural Fibers Information Center 1987). The wettest months of the year are April, May, and September. The driest months are March, July, and August.

Abronia macrocarpa occurs on nearly level to gently sloping terrain. Elevations of known occurrences are from 360-450 feet (110-137 meters). The Bureau of Economic Geology (1968, 1970) designates the area as a broad upland with deep sands of Eocene age (Sparta sands and Queens City sand). Observers note

instability of the sands with some sites forming dunes and active blow-outs (barren wind-eroded topographic features). In addition, botanists conducting surveys for the species noted a possible trend of secondary deposition of sandy material over Arenosa soils (Steve Orzell, Florida Natural Areas Inventory, pers. comm. 1990). Expert soil description and classification are needed. A detailed U.S. Soil Conservation Service soil survey is available only for Leon County. It places the Leon County site in an Arenosa Fine Sand soil type, within the Padina-Arenosa soil association (Neitsch, et al. 1989). A Soil Conservation Service general soil map is available for Robertson County (U. S. Soil Conservation Service 1979). These references give a broad estimate of soil types in the area. The Robertson County site appears to be within the Silsted-Padina soil association. All of these soils are deep sands.

The microclimatic conditions where Abronia macrocarpa occurs are particularly rigorous. The plant occurs in sandy openings in a savannah-like woodland. Exposure is great; the soils are relatively infertile and unstable; water availability is low and unreliable; and temperatures are extreme and variable both diurnally and seasonally (Kennedy, et al. 1990).

Kuchler (1964) classified the area vegetation as a part of the Oak-Hickory Forest (Quercus-Carya Series). Gould (1975) classifies the area as Post Oak Savannah. McMahan (1974) maps the area as Post Oak Woods/Forest using generalized Landsat imagery. The area can generally be characterized as scattered deciduous trees with an understory of grasses and herbs. Abronia macrocarpa occurs on sandy soils in openings and disturbed areas of the woodlands, apparently along drainages (Bridges 1988; Turner 1983; Orzell 1988a, 1988b). The species appears in areas with no or very light vegetative cover of grasses and colonizing herbaceous species (Poole 1985, Orzell 1988b; Yantis 1990). It appears to colonize openings in the Post Oak Savannah and may well be a component of early to mid-successional stages of the mature grassland savannah, though its seral nature is not yet clearly documented.

#### Associated Species

Dominants in the overstory include post oak (Quercus stellata) and blue jack oak (Quercus incana). Dominants in the shrub cover include yaupon (Ilex vomitoria) and sparkleberry (Vaccinium arboreum). Both overstory and shrubby species in the areas where Abronia macrocarpa occur are present in very low numbers.

The herbaceous understory may include three-awn grass (Aristida longespica) or little bluestem (Schizachyrium scoparium) as dominant grasses. Other grasses present include three-awn grass (Aristida desmantha), Tridens sp., and Paspalum

sp. Consistent dominant forbs include bigpod bonamia (Stylisma pickeringii), woolly-white (Hymenopappus carrizoanus), jointweed (Polygonella parksii), and beard-tongue (Penstemon murrayanus). A variety of other herbs have been found with Abronia macrocarpa, and while not dominant, they are notable because of their endemic status and habitat restrictions. These include Brazoria pulcherrima, angled hedeoma (Rhododon ciliatus), Paronychia drummondii, Psoralea digitata var. parviflora, and silver evax (Evax candida).

Additional psammophilic (sand loving) species that may be significant in characterizing the community include Cyperus grayioides, longbract prairie clover (Dalea phleoides) var. microphylla, Reverchon spiderwort (Tradescantia reverchonii), Drummond's phlox (Phlox drummondii), silver croton (Croton argyranthemus), varileaf evening primrose (Oenothera heterophylla), false aloe (Manfreda virginica), Georgia sandrose (Helianthemum georgianum), and large clammyweed (Polanisia erosa var. erosa).

Observers have also noted a number of wide-ranging species common in disturbed areas including Indian blanket (Gaillardia pulchella), plantain (Plantago wrightii), prickly-pear (Opuntia compressa), Paspalum sp., Cassia sp., and Baptisia sp. (adapted from Turner 1983, Poole 1985, Orzell 1988a, 1988b, and Bridges 1988).

Polygonella parksii (Federal category 3C, Texas Natural Heritage Program Special Plant) List and Cyperus grayioides (Federal candidate category 2, Texas Natural Heritage Program Special Plant List) have been found in the same locality with Abronia macrocarpa (Orzell 1988a).

#### Distribution, Abundance, and Land Ownership

Distribution: Only three populations of Abronia macrocarpa are known, one each in Freestone, Leon, and Robertson counties (Figure 1). They occur within 60 miles of one another. Orzell conducted intensive surveys in 1988 and 1989 (Kennedy, et al. 1990), but a hard freeze in the late spring of 1989 killed back plants in one known locality and perhaps over the species' entire range (Orzell, pers. comm. 1990). Additional surveys are advisable in quality habitat areas. Intensive, quantitative studies of exact physical habitat requirements have not been done. Because of the limited number of known populations observed, and lack of quantitative habitat characterization, present concepts of habitat may be inaccurate. Consequently, the geographic extent of suitable habitat, and therefore potential range, is not specifically known. Habitat characterization followed by more intensive surveys of possible habitats might yield more populations.

Abundance: The number of individuals in the three populations are: two (Robertson County), several hundred (Leon County), and several thousand (Freestone County). The areal extent of the latter population is unknown, as it is a recent discovery that has not yet been assessed by botanists. The population with several hundred plants covers an area of about 25 acres, while only a point location can be delimited for the population with only two known plants.

The relative importance of land area and abundance of individuals in sustaining the population is unknown. Minimum population levels and characteristics necessary for sustaining the species are not understood. Most of the population biology of the species is unknown, and where data exists it is chiefly from characterization of a single population in Leon County (Poole 1985).

Land Ownership: All three of the populations known are on privately owned lands. Two of the landowners are aware of the existence of the plants, and one is voluntarily protecting the site. Attempts to locate and contact landowners continue for the third site, which was most recently discovered.

#### Impacts and Threats

The existing populations of Abronia macrocarpa are exposed to a variety of threats and are considered extremely vulnerable (Kennedy, et al. 1990).

Human habitat modification and destruction constitute the greatest threats to the species at present. Unstable openings in the Post Oak Savannah seem to be the main habitat for the species (Bridges 1988, Orzell 1988b). Apparently human activities have suppressed the forces creating these openings and accelerated and changed the successional sequence of events in the openings that do occur.

Historically, habitats in this area have been modified by the introduction of grass species including coastal bermuda (Cynodon dactylon), and weeping lovegrass (Eragrostis curvula), for range improvement and soil stabilization. Habitat destruction and modification has also been brought about through clearing of vegetation for agricultural and other uses, and through fire suppression.

The habitat at one site has been degraded in the past by the construction of an oil well on the site and by the development of a resort/residential community with attendant road building, a man-made lake, power station, and residential construction. These uses have introduced additional threats from associated activities including roadway maintenance and improvements, oil well maintenance, accidental oil spills, off-road vehicles,

horseback riding, and possible overcollection through wildflower picking (Turner 1983, Poole 1985, Orzell 1988a). The owner's plans regarding possible expansion of this development are unknown. All of the above activities continue in the area.

Browsing, possibly by wildlife, cattle, or exotic game species has been noted at one locality and constitutes a threat to the species. Insect predation may also be damaging the plants (Kennedy, et al. 1990).

While the impact of wildflower picking/collecting on the species is presently unknown, the genus is noted for its aesthetic and horticultural appeal. Any collecting would be a serious threat to the species, as the number of known individuals is so low. If the plant becomes known and desired by collectors, taking could cause the extinction of the known populations.

### Conservation and Research Efforts

Conservation: One site (with two individuals of the species) is voluntarily protected by the landowner though no formal agreement has been established and no management plan has been developed for the site.

Research: Little is known about the population biology and ecology of Abronia macrocarpa. This is a severe handicap in efforts to devise management plans for existing populations and recovery strategies for the species as a whole.

Corlies (1991) investigated reproductive biology during a single field season. The pollinator(s) were not determined. Some bagged buds (excluding pollinators) did attain low fruit set (about 19%); this may have been due to field error (Corlies, Texas Parks and Wildlife Department, pers. comm). Flowers that were greenhouse grown did not set fruit without cross pollination, even though selfing pollen was in contact with the stigma. Fruit set in the field relative to number of flowers or inflorescences produced was not monitored, but 50.9 to 68.6% of anthocarps (fruiting bodies) examined contained mature fruits. Seed viability is low (27%), even though pollen viability is high (91.6%).

Dr. Paula Williamson and other investigators at Southwest Texas State University are continuing studies on the community structure, habitat requirements, population dynamics, reproductive biology and cultivation requirements of Abronia macrocarpa that are expected to produce information necessary to develop good management plans.

Mercer Arboretum has also begun attempts to cultivate the species, but has not yet published any reports.

## PART II - RECOVERY

### Objectives and Recovery Criteria

Objectives: The short-term objective in a strategy for the recovery of Abronia macrocarpa is to prevent extinction. Meeting this objective requires protection from immediate threats. All existing wild populations found should be protected from destruction or damage. To prevent extinction they must also be monitored and managed in a manner that will restore the populations to normal, biologically viable, and demographically stable conditions and then maintained in this condition.

With only three known sites (one of which may not be viable) located in such close proximity, protection and stabilization alone will not be sufficient for down- or de-listing. More populations will be needed. The goal of delisting is especially challenging since all known populations are on private lands. It is likely that any anticipated new populations would be on private lands as well. Private lands provide less assured protection due to the possibility of property transfers and changes in land use.

The long-term objective, full recovery of the species, would require the location of suitable natural habitat in Abronia macrocarpa's likely area of distribution and the establishment of additional populations. Based on surveys and knowledge of the species and habitat to date (Kennedy, et al. 1990), it does not appear likely that many additional wild populations will be located, and it is unclear if there is sufficient habitat available for recovery through reintroduction.

Recovery Criteria: If restoration proves feasible for Abronia macrocarpa, to consider the species for downlisting (from endangered to threatened) there would need to be enough populations established over a wide enough area that the threat of loss from a single catastrophic event is minimal. The populations should contain a sufficient number of individuals and variability to assure regeneration and viability. The age-classes present and overall vigor and maturity of the plants should be sufficient to keep the population stable enough to survive a variety of seasonal conditions (wet and dry, high and low levels of pollinators and predators, and seasons with low fruiting success) and still maintain a reproductively vigorous and self-regenerating population. No suitable habitat is known to exist on public lands or private refuges. The habitat supporting Abronia macrocarpa may be a dynamic mosaic that would appear sporadically over the landscape under natural conditions, and consists of relatively small areas. Virtually all of the populations recommended are expected to be on private lands, with less assurance of long-term cooperation and protection. Initial estimates of numbers of populations needed will necessarily be on

the high side to compensate for inevitable losses due to changes in ownership or habitat management. For downlisting from endangered to threatened status at least 20 healthy, stable populations with a minimum of 600 plants in each should be located or established. A healthy population would be considered to be one with a habitat area of at least 25 acres, demographically stable, and genetically viable. These populations should be distributed throughout the natural, potential geographic range of the species, as determined by recovery research activities.

Abronia macrocarpa could be considered for delisting when the 20 populations described above have maintained needed population structure and viability for at least 10 years. In addition, long-term agreements and management plans should be in place that will insure their continued protection.

Based on the above criteria, if steady progress is made, it would be anticipated that Abronia macrocarpa might be recovered in the year 2015.

Downlisting and delisting criteria are preliminary and as more information about the species is accumulated, and recovery tasks are accomplished, the criteria will be reevaluated and may be revised.

## Recovery Outline

The following is an outline of the recovery tasks needed to attain the objectives of this plan. The following section includes more detailed information on the tasks.

1. Protect *Abronia macrocarpa* populations from existing and future threats and develop management plans
  11. Contact private landowners offering assistance and advice and enlist interested landowners in a cooperative program
    111. Establish protected sites
    112. Work cooperatively with landowners to establish short-term management practices adequate to protect the species
    113. Develop and implement a long-term management plan for each site
  12. Enforce applicable Federal and State laws and regulations
  13. Monitor populations for general condition, reproductive success, and to elucidate any needed revisions to the management plans
  14. Assess and revise management plans regularly to address species needs
2. Maintain a reserve germ bank/cultivated population with a responsible agency/institution
  21. Include maximum genetic diversity
  22. Establish a monitoring and management plan
  23. Coordinate cultivation program with restoration research efforts, giving support, and incorporating results
3. Initiate studies to gather information necessary for protective management and restoration
  31. Determine exact habitat requirements
    311. Geologic, edaphic (soil conditions), and microclimate profiles
      3111. Geology
      3112. Soils
      3113. Microclimate

- 312. Community structure
- 313. Community dynamics/ecology
  - 3131. Necessary natural phenomena
  - 3132. Seral stage
  - 3133. Response to disturbance, agricultural practices, and other land uses
  - 3134. Beneficial, neutral, and negative interactions with other species
- 32. Study population biology
  - 321. Determine present conditions and determine stability requirements for populations
    - 3211. Assess present demographic conditions, evaluate needs to achieve stability, and develop recommendations for any needed augmentation
    - 3212. Assess present genetic viability, evaluate requirements for stability, and develop recommendations for augmentation
  - 322. Characterize phenology and assess most vulnerable stages of the life cycle
  - 323. Determine reproductive biology
    - 3231. Determine types of reproduction and contribution to the population
    - 3232. Investigate pollination biology
    - 3233. Investigate seed production and dispersal
    - 3234. Seedling recruitment
- 33. Study cultivation requirements
  - 331. Seed biology
  - 332. Germination requirements
  - 333. Seedling biology
  - 334. Investigate other propagation techniques
- 4. Search/inventory potential habitat
  - 41. Search for existing populations
  - 42. Search/inventory for potential restoration sites
- 5. Assess restoration feasibility
  - 51. Examine reintroduction techniques available
  - 52. Establish a pilot program
  - 53. Assess feasibility of reintroduction program
- 6. Develop and implement a reintroduction plan, if feasible

7. Develop public concern and support for the preservation and study of *Abronia macrocarpa*
8. Develop a post-recovery monitoring plan

## Narrative Outline of Recovery Actions

1. Protect *Abronia macrocarpa* populations from existing and future threats and develop management plans. Given the small number of populations and individuals known to exist, and the relatively small geographic area of known occurrence, *Abronia macrocarpa* appears to be extremely vulnerable. The habitat may be a successional phase and therefore somewhat ephemeral, which would require specific management techniques to maintain favorable conditions. The populations face a variety of threats. All known populations of *Abronia macrocarpa* are on private property. Immediate, proactive, coordinated measures are needed to prevent extinction of the species. Landowner cooperation is essential to realizing the goal of preservation of *Abronia macrocarpa*.
11. Contact private landowners offering assistance and advice and enlist interested landowners in a cooperative program. Landowners of all existing natural populations need to be informed of the presence and importance of the species and the legal requirements of Federal and State law. They should be informed about the biology of the species and its apparent fragility, along with recommended steps for its protection. There should be a continuous dialogue with landowners, keeping them informed of new information obtained about the species and the condition of other populations.
  111. Establish protected sites. Working with private landowners and using whatever mechanisms are appropriate, natural sites of occurrence of *Abronia macrocarpa* should be effectively protected from known threats as soon as possible. Specific areas, including buffer zones, should be identified and protected from inappropriate uses through whatever means are possible (physical barriers, limiting access, special designations, etc.). Landowners should be provided assistance in implementing these measures.
  112. Work cooperatively with landowners to establish short-term management practices adequate to protect the species. A thorough assessment of the condition of each site should be made (e.g. location, size, overall condition of the plants, evidence of browsing, insect infestation, damaged plants, exposed roots, disease, etc). Actions that could be taken to avert decline (e.g. care of damaged plants and any exposed roots, control

of insects) should be identified. Based on this evaluation, recommendations and assistance should be provided to the landowner for specific management activities needed to protect and maintain the species until long-term management and recovery activities can be developed.

113. Develop and implement a long-term management plan for each site. In addition to immediate steps to remove threats and preserve Abronia macrocarpa, a long term management plan should be generated for each site, with the goal of insuring that the populations become demographically stable and genetically viable, and are maintained in stable condition. This plan should be provided to landowners along with as much help as possible in implementing management prescriptions and monitoring their effectiveness (see task 13).
12. Enforce applicable Federal and State laws and regulations. Federal and state laws regarding commercial trade, permits, collecting, and habitat destruction should be enforced. Landowners should be encouraged to enforce trespassing laws in areas where this will help protect populations.
13. Monitor populations for general condition, reproductive success, and to elucidate any needed revisions to the management plans. Periodic monitoring of individual populations should occur frequently (at least three times annually) in the initial stages of research and recovery management and possibly less frequently as stability and recovery are achieved. Monitoring methods for all populations should be coordinated, and comparisons should be made between populations to help differentiate normal fluctuation from conditions revealing stress or decline.
14. Assess and revise management plans regularly to address species needs. As information about Abronia macrocarpa's biology becomes available, it should be incorporated into management strategies. Evaluation and revision of plans should be coordinated among all responsible parties to take advantage of all available information and expertise. If monitoring shows unacceptable decline in the condition of populations, this should be brought to the attention of all parties involved in conservation planning. Coordinated, well thought out management strategies should be developed for a quick and effective response.

2. Maintain a reserve germ bank/cultivated population with a responsible agency/institution. Preservation of Abronia macrocarpa in its natural environment is absolutely of first priority. Natural populations appear to be at critically low levels (Galloway 1972, Turner 1983) and catastrophic conditions in the area could force it to extinction. To prevent total loss of the species, a germ bank and cultivated population maintained in more controlled and protected conditions is advised. It should also serve as a non-destructive source of material for research, restoration, education, and possible horticultural development. It is essential that the cultivation program proceed responsibly and in a manner that does not threaten the reproductive capacity of existing populations. The Mercer Arboretum, in cooperation with the Center for Plant Conservation, has done some promising work in cultivating the species (Young 1990). Abronia macrocarpa is also under cultivation at Southwest Texas State University. This program needs to be expanded and questions regarding genetic variability and viability of collections need to be addressed.
21. Include maximum genetic diversity. Reserve materials should be collected and maintained in a manner that will represent and maintain the maximum possible genetic diversity to preserve the viability of the species and its ability to respond to natural environmental changes.
22. Establish a monitoring and management plan. Cultivated and reserve material should be periodically monitored and assessed and this program should be guided by a formal management plan coordinated among all growers. This plan should address such issues as collection guidelines (for documentation, genetic representation, and minimal impacts on wild populations), seed storage and propagation responsibilities and targets, data collection and sharing, and the proper distribution and disposal of plant materials as collections and plant stocks are started or closed down.
23. Coordinate cultivation program with restoration research efforts, giving support, and incorporating results. Abronia macrocarpa has been grown successfully from seed under greenhouse conditions (Galloway 1975, Young 1990, Corlies 1991) in small quantities. Successful cultivation will require additional quantitative studies of cultivation and propagation. The cultivation program should coordinate with research studies in reproductive biology and cultivation (contributing materials, incorporating

findings into the cultivation program, and collecting compatible data). This coordination should yield the maximum useful biological information for the effort expended.

3. Initiate studies to gather information necessary for protective management and restoration. Our scientific understanding of the biology of Abronia macrocarpa is minimal, based predominately on qualitative observations. This has limited efforts to define habitat and management needs for the species. Additional studies are necessary to identify the critical parameters of habitat, growth, and reproduction for Abronia macrocarpa.
31. Determine exact habitat requirements. This information is essential to predictive efforts to locate any additional existing populations and appropriate areas for any necessary reintroduction efforts.
  311. Geologic, edaphic (soil conditions), and microclimate profiles. The basic physical factors of Abronia macrocarpa's environment remain undocumented in a detailed and quantitative manner.
    3111. Geology. Abronia macrocarpa is found in openings in Post Oak Savannah (Bridges 1988, Orzell 1988a, 1988b). The origin of these openings is unclear. There is speculation that the species is associated in some way with stream drainages (Turner 1983). Orzell (pers. comm. 1990) notes that the plant occurs on Arenosa soils with a sandy layer deposited secondarily on top, perhaps riparian sands blown up out of river valleys in the Pleistocene. It is likely that the species is found associated with some geological feature that is not apparent from general maps and descriptions of the area. The type of landform, drainage pattern, and dynamic geological processes occurring where the species is found need further analysis and documentation. For example, piping (the formation of small underground channels from below-grade drainage) may play a critical role in the instability of soils on these sites.

3112. Soils. Detailed U.S. Soil Conservation Service soil surveys are available only for Leon County. Soils need to be classified and described in detail for all known localities of Abronia macrocarpa, to assist in the search for new populations or reintroduction sites. Soils should also be analyzed for parameters affecting plant growth. Soil pH and chemical nutrient levels have been examined by Corlies (1991). Additional factors affecting growth such as porosity, soil water potential, texture, and parent material should be determined to identify needs for cultivation and to help in identifying critical factors in potential reintroduction sites.
3113. Microclimate. Abronia macrocarpa appears to grow in an extremely rigorous environment. The characteristics of microclimate in the habitat of Abronia macrocarpa are not documented. A microclimatic profile should be prepared, especially for those factors critical to plant growth such as insolation, surface and subsurface temperature profiles and extremes, and water availability (Rosenberg 1974). These factors governing plant stress and photosynthesis rates need to be understood before proper management techniques to insure population health can be selected. These factors will be critical in providing for the needs of plants in any attempts at cultivation or reintroduction.
312. Community structure. Detailed, quantitative characterization of the community structure in areas where Abronia macrocarpa occurs has never been done. Associated species should be documented for all known populations, including quantitative measures of dominance, density, frequency, and especially constancy, so that a profile of diagnostic species can be obtained (Daubenmire 1968). This information is necessary for refining the search for new populations, understanding the dynamics and management needs of the populations, and evaluating the potential for reintroduction efforts. This is also essential baseline data in evaluating the

condition of the populations and formulating management needs over time.

313. Community dynamics/ecology. Little is known about factors critical to the habitat of Abronia macrocarpa, including the cause and dynamics of the relatively open areas where it is found, successional stage of the community in which it occurs, and interactions with other species. A knowledge of these processes is important for the formulation of management plans for maintenance and restoration, as well as assessment of the feasibility of reintroduction.
3131. Necessary natural phenomena. The formative factors of the environment of Abronia macrocarpa need to be established, including the nature of the openings (edaphic changes, processes such as piping, fire, flood, erosion, frost), degree of disturbance, relative frequency of disturbance, and longevity of such sites.
3132. Seral stage. While it appears likely that the community in which Abronia macrocarpa occurs is successional, this has never been clearly documented. Information about successional status of the community, its relative seral stage, and expected longevity of vegetation phases is needed.
3133. Response to disturbance, agricultural practices, and other land uses. In designing maintenance and long-term management strategies for the species, it is necessary to anticipate the response of the plant to various management actions. Comparative observation of the three known populations and their history of land use and management would be helpful, providing at least preliminary indications of the effects of different disturbances and land use practices.
3134. Beneficial, neutral, and negative interactions with other species. It is possible that some species have a positive interaction with Abronia macrocarpa (such as serving as shelter for germinating seedlings), while negative impacts from

other species have been reported (insect predation, Poole 1985 and Turner 1983). The positive, negative, or neutral impacts of other species in the community need study. Provision for these influences needs to be made in management plans.

32. Study population biology. The current status of populations in terms of stability, demographic and genetic viability, simple phenology (the relationship of climate and seasonality to the stages of the plant's life cycle), and reproductive biology are unknown.
321. Determine present conditions and determine stability requirements for populations. The relative stability of known populations in terms of demographic structure and genetic diversity should be determined. This information is needed to determine if habitat manipulation or augmentation (such as the addition of plants or pollination manipulations) is needed.
3211. Assess present demographic conditions, evaluate needs to achieve stability, and develop recommendations for any needed augmentation. The distribution of different life cycle phases (Harper 1977) in existing populations, and the relative contribution of each to regeneration, is unknown and needs to be established. The survivorship curve of the species is not known. Because of these gaps in knowledge, assessment of the demographic stability of populations and targets for numbers of individuals of various stages needed to maintain the population are difficult to establish. This study should obtain necessary information and develop recommendations for management.
3212. Assess present genetic viability, evaluate requirements for stability, and develop recommendations for augmentation. The genetic vitality of populations of Abronia macrocarpa is also unknown. Reliance on a few geographically isolated populations with low numbers of individuals may lead to a loss of fertility and genetic variability (Futuyma 1986). Lowered fertility and variability result in reduced vigor and ability to respond to environmental fluctuation. Populations

should be sampled to determine degree of homogeneity, and assess the implications for viability in this species. This study should produce recommendations for any needed augmentation.

322. Characterize phenology and assess most vulnerable stages of the life cycle. Corlies (1991) has recorded developmental observations for several aspects of phenology over one field season. This study should be expanded, taking periodic phenological observations several times during the growing season. This should be done for several seasons covering the spectrum of climatic variation. The resulting record should be compared to local climatic data (such as rainfall and temperature) for correspondence. With a record of phenology, corrected for climatic fluctuations, an evaluation should be made of any stages in the life cycle that are critical and consistently impaired, any known causes, and advisable management.

323. Determine reproductive biology. The reproduction of Abronia macrocarpa, from flowering to the germination and establishment of new plants (including mechanisms, processes, and necessary agents), needs to be understood for cultivation, successful management, and restoration.

3231. Determine types of reproduction and contribution to the population. Sexual reproduction has been demonstrated (Galloway 1975), and Corlies (1991) has shown the plants to be primarily outcrossing. However, other breeding strategies may also be involved. The actual capability for (and incidence of) self-pollination, insect-mediated self-pollination, and other possible breeding scenarios need to be determined, as well as the potential for asexual reproduction.

3232. Investigate pollination biology. Several insect visitors and one potential pollen predator have been identified (Turner 1983, Corlies 1991), but the pollinator for the species has not been documented. Pollen viability has been established as being high (Corlies 1991). A more detailed study of insect visitation,

pollination, pollinator sufficiency, pollen predation, and other aspects of pollination biology is needed to determine if any of these factors is reducing normal fruiting.

3233. Investigate seed production and dispersal. Seed production and viability of Abronia macrocarpa need to be determined, as well as the mechanism(s) and distance of dispersal. Corlies (1991) has demonstrated moderate fruit production, but low viability in the seed of Abronia macrocarpa in a single field season. Factors influencing fruit set, abortion, and maturation have not been established. This work should continue for a few additional seasons (through a variety of conditions), and be expanded to examine dispersal mechanisms and distances.
3234. Seedling recruitment. The relationship between seed production, seed reserves, and rates of seedling recruitment should be established. The percentage of seed crops lost to disease and predation should be monitored. Changes in rates of recruitment with seral age/stage of the community and the degree of disturbance should also be investigated. This information is needed to determine optimum conditions for regeneration of populations and management needed.
33. Study cultivation requirements. While the species has been successfully cultivated from seed for scientific study, additional studies are needed for the establishment of a successful management program for both natural and cultivated populations.
331. Seed biology. Attributes such as average seed production per plant, viability, longevity, degree of dormancy, and factors inducing and breaking dormancy need to be determined, both for horticultural cultivation and for field conditions.
332. Germination requirements. Corlies (1991) conducted germination trials but they were largely destroyed by fungal infections. Optimum germination achieved was 25%. Additional work is needed to determine optimum conditions and range

of tolerance for germination in the field and in cultivation (including seasonality, soil depth, temperature and moisture, necessary pretreatments, light, etc.).

333. Seedling biology. Light, temperature, moisture, and nutrient requirements for seedling establishment (attaining independence from seed reserves and making the transition to independent nutrition and growth) need to be better understood. Threats to seedling establishment after germination (disease, predation) need to be evaluated and addressed for successful cultivation and restoration techniques to be developed.

334. Investigate other propagation techniques. Cultivation from seed has been demonstrated (Kennedy, et al. 1990), but production of seed for large-scale cultivation may be laborious. Other techniques should be investigated. Propagation, if properly handled, may be used for the multiplication of selected genotypes to meet reintroduction program needs. Propagation methods may also be helpful in the event a horticultural demand develops, because providing a means for propagation often reduces collecting threats.

4. Search/inventory potential habitat. Additional inventory work for existing populations is needed, and as information about habitat requirements becomes more refined, a search should be done for suitable sites for potential reintroduction.

41. Search for existing populations. While surveys for the species have been conducted, the results of one season's work may be questionable due to a late spring freeze that destroyed plants in the area (Orzell, pers. comm. 1990). Refining our understanding of the habitat may also enable investigators to locate additional populations. Landsat imagery may be helpful in locating potential habitat. The Service and Texas Department of Parks and Wildlife should continue to search for and verify the occurrence of new populations of Abronia macrocarpa.

Other federal, state, and local agencies can be helpful in this effort. Many agencies have field staff who should be educated about the appearance and importance of Abronia macrocarpa. Knowledgeable agency employees working in suitable habitat may recognize new

populations of the species. Field staff that discover new populations should be requested to encourage landowners to bring them to the attention of the State and the Service and cooperate in recovery. It would be helpful for agency staff to make private landowners aware that State and Service conservation biologists are available to provide assistance of many kinds in developing and implementing the best possible measures for the conservation of the species.

42. Search/inventory for potential restoration sites. In the event that an attempt at reintroduction is made, a search will be needed identifying suitable locations that meet natural habitat and likely distribution criteria.
5. Assess restoration feasibility. An evaluation of the need and potential for reintroduction of the species can be made when more information is available about the possibility of overlooked populations, genetic vitality, population stability, habitat availability, long-term management requirements of the community, and success of cultivation. In the event that reintroduction is to be attempted the following recovery actions (tasks 51-53) should be implemented.
  51. Examine reintroduction techniques available. Evaluate the relative success of different cultivation, site preparation, planting, and management techniques available, based on past research and monitoring. Assess any additional information needs and readiness to attempt reintroduction. Develop initial reintroduction guidelines.
  52. Establish a pilot program. Using the guidelines derived above, design and implement a pilot program to meet information needs and test methods.
  53. Assess feasibility of reintroduction program. Assess results of above program and determine potential for reintroduction.
6. Develop and implement a reintroduction plan, if feasible. Based on the assessment of the pilot program, a reintroduction plan should be developed and implemented that provides for all phases, including plant propagation, site selection, site preparation, introduction, establishment (to independent living), monitoring, and short- and long-term management strategies.
7. Develop public concern and support for the preservation and study of *Abronia macrocarpa*. A broad-based awareness of the

species, and support for efforts to recover it, need to be developed. This is particularly important among local landowners whose support is critical to maintaining existing populations and in attempts to locate or introduce additional populations. However, because of the aesthetic appeal of the plant, greater awareness is expected to create a demand for it, and therefore dangerous collection pressures. Public education efforts should occur only after a provision to meet horticultural demand is in place. Environmental groups, native and endangered species organizations, garden clubs, and horticultural enthusiasts may all have a role to play encouraging and facilitating preservation of the species. Local and regional appreciation can be furthered through the use of personal meetings, as well as presentations before groups and in the local media. Larger audiences are best reached through the educational systems and printed and visual media with national distribution.

8. Develop a post-recovery monitoring plan. If recovery is determined to be feasible, a coordinated monitoring plan should be developed that will track the condition of natural and introduced populations for at least 5 years after delisting, as required by the 1988 amendments to the E.S.A. Responsibilities for implementation and reporting should be clear. This plan should specify types and levels of decline that should trigger intervention.

## References Cited

- Bridges, E. 1988. Endangered Species Information System Species Workbook on the large-fruited sand-verbena (Abronia macrocarpa). U.S. Fish and Wildlife Service, Division of Endangered Species, Washington, D.C.
- Bureau of Economic Geology. 1968. Geologic atlas of Texas: Palestine Sheet. University of Texas, Austin.
- Bureau of Economic Geology. 1970. Geologic atlas of Texas: Waco Sheet. University of Texas, Austin.
- Corlies, G. 1991. Reproductive biology and leaf structure of Abronia macrocarpa Galloway (Nyctaginaceae), an endangered East Texas endemic. Masters thesis. Southwest Texas State University, San Marcos.
- Daubenmire, R. 1968. Plant Communities: A Textbook of Plant Synecology. Harper and Row, New York.
- Futuyma, D. J. 1986. Evolutionary Biology. Sinauer Assoc., Inc. Sunderland, Massachusetts.
- Galloway, L. A. 1972. Abronia macrocarpa (Nyctaginaceae): A new species from Texas. Brittonia 24:148-149.
- Galloway, L. A. 1975. Systematics of the North American desert species of Abronia and Tripterocalyx (Nyctaginaceae). Brittonia 27:328-347.
- Gould, F. W. 1975. Texas Plants--A Checklist and Ecological Summary. Texas A&M University System, Texas Agricultural Experiment Station, College Station.
- Harper, J. L. 1977. Population Biology of Plants. Academic Press, New York.
- Kennedy, K. L., J. M. Poole, and S. L. Orzell. 1990. Revised status report on Abronia macrocarpa. U. S. Fish and Wildlife Service, Region 2, Albuquerque, New Mexico.
- Kuchler, A. W. 1964. Potential vegetation of the conterminous United States and Canada. American Geographical Society, New York.
- Larkin, T. J. and G.W. Bomar 1983. Climatic atlas of Texas. Texas Department of Water Resources, Austin.
- McMahan, C. A., R. G. Frye, and K. L. Brown. 1984. The vegetation types of Texas. Texas Parks and Wildlife Dept. Bulletin 7000-120. Austin.

- Natural Fibers Information Center. 1987. The Climates of Texas Counties. University of Texas Bureau of Business Research, Graduate School of Business, Austin.
- Neitsch, C. L., J. J. Castille, and M. R. Jurena. 1989. Soil survey of Leon County, Texas. U. S. Soil Conservation Service.
- Orzell, S. L. 1988a. Field survey of East-Central Texas of 2-6 May, 1988. Texas Natural Heritage Program, Texas Parks and Wildlife Department, Austin.
- Orzell, S. L. 1988b. Field survey of northern East Texas of 5-7 October 1988. Texas Natural Heritage Program, Texas Parks and Wildlife Department, Austin.
- Poole, J. M. 1985. Field survey to Cherokee Lake Sand Dunes of 5 June 1985. Texas Natural Heritage Program, Texas Parks and Wildlife Department, Austin.
- Rosenberg, N. J. 1974. Microclimate, the Biological Environment. John Wiley and Sons, Inc., New York.
- Turner, B. L. 1983. Status report on Abronia macrocarpa. U.S. Fish and Wildlife Service, Albuquerque, N.M.
- U.S. Fish and Wildlife Service. 1983a. Endangered and threatened species listing and recovery priority guidelines. Fed. Reg. 48(184):43098.
- U.S. Fish and Wildlife Service. 1983b. Endangered and threatened species listing and recovery priority guidelines, Correction. Fed. Reg. 48(221):51985.
- U.S. Fish and Wildlife Service. 1988. Endangered and threatened wildlife and plants; Determination of endangered status for Abronia macrocarpa (Large-fruited sand-verbena). Fed. Reg. 53(188):37975.
- U. S. Soil Conservation Service. 1979. General Soil Map Robertson County Texas. U. S. Department of Agriculture.
- Young, S. 1990. Unpublished report on Abronia macrocarpa. Mercer Arboretum, Houston.

### PART III. IMPLEMENTATION SCHEDULE

The following implementation schedule outlines actions and estimated costs for the large-fruited sand-verbena recovery program. It is a guide for meeting the objectives discussed in Part II of this Plan. The schedule indicates task priorities, task numbers, task descriptions, duration of tasks, responsible agencies, and estimated costs. These actions, when accomplished, should bring about the recovery of large-fruited sand-verbena and protect its habitat. It should be noted that the estimated monetary needs for all parties involved in recovery are identified for the first 3 years only. The costs estimated are intended to assist in long-range planning. This recovery plan does not obligate any involved agency to expend the estimated funds. Though work with private landowners is called for in the recovery plan, private landowners are also not obligated to expend any funds.

#### Task Priorities

- Priority 1 - An action that must be taken to prevent extinction or to prevent the species from declining irreversibly in the foreseeable future.
- Priority 2 - An action that must be taken to prevent a significant decline in species population/habitat quality, or some other significant negative impacts short of extinction.
- Priority 3 - All other actions necessary to meet the recovery objectives.

#### Abbreviations Used

CoEx - County Agricultural Extension Service(s)  
FWS - U.S. Fish and Wildlife Service  
ES - Ecological Services  
LE - Law Enforcement  
SCS - U.S. Soil Conservation Service  
TDA - Texas Department of Agriculture  
TNC - Texas Nature Conservancy  
TPWD - Texas Parks and Wildlife Department

**LARGE-FRUITED SAND-VERBENA RECOVERY PLAN IMPLEMENTATION SCHEDULE**

PRIOR- ITY #	TASK #	TASK DESCRIPTION	TASK DURATION (YRS)	RESPONSIBLE PARTY			COST ESTIMATE (\$000)			COMMENTS
				FWS		OTHER	YEAR 1	YEAR 2	YEAR 3	
				REGION	PROGRAM					
1	111	Establish protected sites by appropriate mechanism	5	2	ES	TPWD	5.0	10.0	3.0	Year 4 & 5 also three thousand
1	112	Work with landowners to establish short-term management practices	2	2	ES	TPWD TNC	5.0 1.0	3.0 .5		landowner liaison for TNC
1	12	Enforce Federal & State Laws	ongoing	2	ES LE	TPWD	2.0 1.0 2.0	2.0 1.0 2.0	2.0 1.0 2.0	
1	21	Establish & maintain a cultivated population and seed bank w/maximum genetic diversity	ongoing	2	ES	SCS	10.0	5.0	2.5	necessary to 111, 52, 62 technical assistance (SCS)
1	3131	Determine necessary natural phenomena in the community	5	2	ES		5.0	3.0.	3.0	necessary to tasks 113, 41, 42, 52, and 62 Year 4 & 5 also three thousand
1	3132	Determine seral stage of community	3	2	ES		2.5	2.5	2.5	necessary to tasks 113, 41, 42, 52, and 62
1	3133	Determine response to disturbance, agricultural practices, & other land uses	5	2	ES		5.0	4.0	4.0	necessary to tasks 113, 41, 42, 52, and 62 Year 4 & 5 also three thousand
1	3134	Determine species interactions	5	2	ES		5.0	3.0	3.0	necessary to 113, 52, 62 Year 4 & 5 also three thousand

LARGE-FRUITED SAND-VERBENA RECOVERY PLAN IMPLEMENTATION SCHEDULE										
PRIOR- ITY #	TASK #	TASK DESCRIPTION	TASK DURATION (YRS)	RESPONSIBLE PARTY			COST ESTIMATE (\$000)			COMMENTS
				FWS		OTHER	YEAR 1	YEAR 2	YEAR 3	
				REGION	PROGRAM					
1	3211	Assess demographic conditions and needs	3	2	ES		5.0	5.0	5.0	necessary to 113, 52, 62 and 8
1	41	Search potential habitat for new populations	3	2	ES	TPWD SCS CoEX TDA	5.0 2.0 .5 .5	5.0 1.0	5.0 1.0	necessary to 111  SCS, CoEX, TDA liaison to landowners. See paragraph 2 of task 41
2	42	Search potential habitat for potential restoration sites	3	2	ES	TPWD	5.0 2.0	5.0 2.0	2.0 1.0	May reduce cost if able to do synchronously with 41 needed for 52, 53, and 62
2	113	Develop & implement long-term management plans	ongoing	2	ES	TPWD SCS	10.0 1.0 1.0	5.0 1.0 1.0	5.0 1.0 1.0	technical assistance/landowner liaison
2	13	Monitor wild populations	ongoing	2	ES	TPWD	5.0 5.0	5.0 5.0	5.0 5.0	necessary to 113, 14, 51, 52, 53 & 6; helpful to task 3
2	14	Assess & revise management plans regularly	ongoing	2	ES	TPWD	0 0	3.0 0.75	0 0	Every other year during the first few years
2	22	Establish a cultivation collection monitoring and management plan	ongoing	2	ES	TPWD	1.0 0.5	0.5 0.25	0.5 0.25	necessary to 21
2	23	Coordinate cultivation program with research efforts providing support and incorporating results	5	2	ES	TPWD	0.5 0.25	0.5 0.25	0.5 0.25	necessary to 21 helpful to 331, 332, 333, 334, 3212

**LARGE-FRUITED SAND-VERBENA RECOVERY PLAN IMPLEMENTATION SCHEDULE**

PRIOR- ITY #	TASK #	TASK DESCRIPTION	TASK DURATION (YRS)	RESPONSIBLE PARTY			COST ESTIMATE (\$000)			COMMENTS
				FWS		OTHER	YEAR 1	YEAR 2	YEAR 3	
				REGION	PROGRAM					
2	3111	Study geology and dynamic processes	2	2	ES		1.0	0.5		necessary to 113, 41, 42, 51, 52, and 62
2	3112	Study soils-classification and growth parameters	1	2	ES	SCS	1.0 1.0	0.5 0.5		necessary to 113, 41, 42, 51, 52, and 62 soils classification & assessment of potential habitat available
2	3113	Study microclimate	3	2	ES		3.0	2.0	1.0	May be less expensive if conducted in cooperation with other studies necessary to 113, 41, 42, 51, 52, and 62
2	312	Community structure: Study diagnostic/ associated species	2	2	ES		1.0	0.5		necessary to 113, 41, 42, 51, 52, and 62
2	3212	Assess genetic viability	3	2	ES		5.0	5.0	5.0	necessary to 113, 52, and 62
2	322	Characterize phenology	2	2	ES		3.0	2.0		necessary to 113, 52, and 62
2	3231	Determine types of reproduction	2	2	ES		2.0	2.0		necessary to 113, 52, and 62
2	3232	Study pollination biology	2	2	ES		1.0	1.0		necessary to 113, 52, and 62
2	3233	Study seed production & dispersal	3	2	ES		2.0	2.0	2.0	necessary to 113, 52, and 62 helpful to 41 and 42
2	3234	Study seedling recruitment	3-5	2	ES		1.0	1.0	1.0	Years 4 & 5 also one thousand necessary to 113, 52, and 62

LARGE-FRUITED SAND-VERBENA RECOVERY PLAN IMPLEMENTATION SCHEDULE										
PRIOR- ITY #	TASK #	TASK DESCRIPTION	TASK DURATION (YRS)	RESPONSIBLE PARTY			COST ESTIMATE (\$000)			COMMENTS
				FWS		OTHER	YEAR 1	YEAR 2	YEAR 3	
				REGION	PROGRAM					
2	331	Study seed biology (viability, longevity, etc.)	5	2	ES		2.0	1.0	1.0	necessary to 113, 21, 52, and 62
2	332	Study germination requirements	2	2	ES		2.0	1.0		necessary to 113, 21, 52, and 62
2	333	Study seedling biology	3	2	ES		2.0	2.0	2.0	necessary to 113, 21, 52, and 62
2	334	Study propagation techniques	3	2	ES		3.0	3.0	3.0	necessary to 21, 52, and 62
2	51	Assess reintroduction techniques		2	ES		2.0			
2	52	Establish pilot reintroduc- tion program, if feasible	5	2	ES		5.0	2.0	2.0	Depends on study results and outcome of task 5.1
2	7	Develop public concern & support	ongoing	2	ES	TPWD	4.0 1.0	2.0 0.5	2.0 0.5	
3	53	Assess feasibility of reintroduction program	15	2	ES		1.0			Depends on pilot results
3	62	Develop a reintroduction program	ongoing	2	ES		10.0	5.0	5.0	Depends on assessment of feasibility

## Appendix

### Summary of Comments Received On The Large-fruited Sand-verbena Technical/Agency Draft Recovery Plan

This recovery plan was sent out for technical review to the advisors on the Texas Plant Recovery Team in January of 1992. No substantive changes were recommended. In July and August the Service distributed 62 copies of the draft recovery plan to agencies and individuals, as well as 15 letters notifying county judges, and local and national organizations that the plan was available for public review and comment. Comments were received from the five individuals or agencies listed below:

Ms. Jackie Poole, Montana Natural Heritage Program  
Dr. Hugh Wilson, Department of Biology, Texas A&M University  
Dr. Michael J. Warnock, Department of Biological Sciences,  
Sam Houston State University  
U. S. Soil Conservation Service  
Texas Wildlife Association

All comments were considered when revising the draft plan. The Service appreciates the time that each of the commenters took to review the draft and to submit their comments.

The comments discussed below represent a composite of those received prior to the close of the public comment period. Comments of a similar nature are grouped together. Substantive comments that question approach, methodology, or financial needs called for in the draft plan, or suggest changes to the plan are discussed here. Comments received that related to the original listing decision or general comments about the Endangered Species Act that did not relate to the large-fruited sand-verbena are not discussed here. Comments regarding simple editorial suggestions such as better wording or spelling and punctuation changes, were incorporated as appropriate without discussion here. Favorable, supportive comments were also received, but are not summarized here.

All comments received are retained as a part of the Administrative Record of recovery plan development in the Austin, Texas, Ecological Services office.

Comment: If this plant has never been abundant, and the soils that support it are restricted, it may not be recoverable.

Service response: The recovery plan states that it is unclear if sufficient habitat is available for recovery of the species, mainly because the habitat requirements of the species are so

poorly understood (including soil requirements). The recovery plan addresses the need for more information to determine if recovery can be achieved. The Service has no reason to believe that recovery is not achievable, as the plant can be cultivated and additional suitable habitat is believed to be available. Recovery would be achieved when there were a sufficient number of unthreatened stable populations in the wild to prevent its extinction (now estimated as only 20 populations in a three county area).

Comment: It should be easy to alleviate threats to the species by enlisting the aid of landowners. Landowner information should really be provided for the entire community of landowners through providing an overview of the situation in a group meeting or mailing.

Service response: The Service feels that successful recovery of this species will be dependant on working cooperatively with local landowners (see tasks 1 and 7). Good communication will be necessary to develop the needed understanding and cooperation of all parties working for recovery. Task 7 calls for an initiative to develop public awareness, concern, and support through a variety of methods, including the use of meetings. The wording of task 7 has been modified to stress the importance of area landowners in this task.

Comment: The protection of habitat could be a significant task for a landowner, and they should be compensated for their efforts.

Service response: The Service is deeply appreciative of landowners who are cooperating in recovery activities to preserve the Nation's resources, and wishes to support and assist their effort as much as possible. For the large-fruited sand-verbena, the Service believes the simple protection and management strategies that appear to be needed for recovery will not require a great commitment of time and resources on the part of the landowner. Tasks 111, 112, & 113 call for providing as much assistance and support as possible to landowners in implementing any needed management activities. The exact nature of this support will vary with individual site needs, landowners, and agency budget constraints.

Comment: If reproductive biology studies are needed to achieve recovery (as in task 323) why are these studies given only a priority two?

Service response: As noted in the introduction to the implementation schedule, priority one tasks are those that must be taken to prevent extinction or irreversible decline in the foreseeable future. For this species, these high priority items are those that will locate, protect and preserve the plants

physically (on and off site), identify and meet their habitat requirements on the site, and preserve the population structure to prevent continued decline. Examination of the reproductive biology is needed to evaluate the need for augmentation to improve population viability and to assist in designing reintroduction strategies. This information, while necessary for recovery, is not felt to be critical to prevent immediate extinction and is more appropriately a priority two task.

Comment: The discussion on reproductive biology avoids a central question regarding the relationship between vegetative and sexual reproduction in the natural populations. Entities described as single plants could be shoots produced by a single plant. This should be an initial element of the data-taking.

Service response: Task 3231 calls for determining the different types of reproduction and their contribution to the population. Herbarium specimens of Abronia macrocarpa as well as field observations by Corlies (1991) describe the plants as taprooted perennials without rhizomatous or stoloniferous shoots.

Comment: Additional searches may well reveal more existing populations. Sandy, open areas occupied by this plant might provide a good search signal for satellite imagery. Landsat photos might facilitate selection of potential sites to be surveyed.

Service response: The recovery plan states that surveys should continue for additional existing populations (see task 41) as habitat requirements are better understood. Landsat imagery may well prove to be useful. A comment mentioning the technique has been added to task 41.

Comment: There seems to be no reason to assume that this species is part of a seral community, the habitat is unusual with a high frequency of rare and endemic taxa, and the plant community could be quite stable.

Service response: While several investigators have speculated that the openings where the species occurs may be successional, the recovery plan notes that this has never been clearly documented (see the introduction and task 3132), and that the formative factors of these openings and exact habitat requirements need further investigation.

Comment: Local sandy prairies near College Station might provide possible introduction sites for this species.

Service response: While the Service will attempt reintroduction of a species within its historic range, it is against Service policy to transplant listed species outside their historic range. The historic range for Abronia macrocarpa is Freestone, Leon, and

Robertson counties, in openings in Post Oak Woodlands. It is most appropriate for the Service to concentrate reintroduction efforts in this area.

Comment: Although cultivation has been started at Mercer Arboretum and Southwest Texas State University, it would seem that the cultivation program still deserves a priority 1 status in the implementation schedule, given the vulnerability of the populations to extinction and the possibility of changing levels of protection in the future on the part of private landowners.

Service response: The Service agrees and the change has been made in the final plan.

Comment: The U.S.D.A. Soil Conservation Service wants to cooperate with the Service and agricultural producers in the conservation of endangered species and could provide some assistance in the delineation of soils, recommendations of possible management techniques, liaison to landowners, and technical assistance with any propagation problems.

Service response: The Service is delighted to have these offers of assistance and has noted a role for the SCS in tasks 113, 21, 3112, and 41 on the implementation schedule.

Comment: Why aren't these necessary studies already done?

Service response: The species has been monitored regularly for many years and research studies on the species have been conducted since 1990. One site has too few plants to allow extensive study. Another site has only been known since mid-1990; landowners have been difficult to locate, and it is the Service's understanding that investigators have not yet obtained access for studies. While frustrating, it is not unusual for conservation agencies to be forced to delay research and recovery activities due to budget constraints that limit our ability to fund all of the necessary work to be done.

Comment: We are not familiar with the blue jack oak mentioned in the plan. Could this be an error, and was the intended species the black jack oak?

Service Response: Blue jack oak is one of many common names for Quercus incana, the species noted in the plan. It may be more readily recognized in some areas by one of its many other common names, including sandjack oak, upland willow oak, cinnamon oak, shin oak, and turkey oak.

Comment: Costs estimated for recovery are not sufficient to acquire the 500 acres or more of habitat that would be needed for the 20 populations of 25 acres each mentioned in the recovery criteria.

Service response: No property acquisition is recommended. The Service does not anticipate property acquisition to be required for recovery. Cooperation with private landowners in protection and management for the species is recommended to alleviate threats and meet recovery objectives.

Comment: Planning and monitoring costs appear to be too low, especially for 20 sites.

Service response: Costs detailed in the implementation schedule are outlined only for the first 3 years of recovery activity. The noted costs for the Service during this time period are believed to be reasonable. Two necessary changes to the plan were found as a result of re-examining these costs, however. The role of the Texas Parks and Wildlife Department in assisting in planning and monitoring of the species was inadvertently omitted and they have been added to the implementation schedule with appropriate costs incurred. The SCS has also been added in light of their comment discussed above. These changes have raised costs listed for these tasks slightly. In addition, inaccurate wording in the draft introduction to the implementation schedule, which stated that schedule costs represent total estimated costs for recovery, has been changed to reflect the fact that costs are estimated for only the first 3 years.

Comment: Projected dates for recovery and delisting are unreliable, as they are based on tasks whose results and recommendations cannot be predicted.

Service response: Dates given for recovery and delisting objectives are intended only as estimates to assist in planning, as noted in the plan. To clarify this, additional language has been added to the disclaimer at the beginning of the recovery plan.