

RECOVERY PLAN

Nineteen Florida Scrub and High Pineland Plant Species



U.S. Fish and Wildlife Service
Southeast Region
Atlanta, Georgia

**RECOVERY PLAN FOR NINETEEN
FLORIDA SCRUB AND HIGH PINELAND
PLANT SPECIES**

(Revision and expansion of
Recovery Plan for Eleven Florida Scrub Plant Species,
approved January 29, 1990)

prepared by

Jacksonville, Florida Field Office
U.S. Fish and Wildlife Service

for

Southeast Region
U.S. Fish and Wildlife Service
Atlanta, Georgia



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Several biologists commented on the draft of the second edition of this plan, as noted in the text and the mailing list. In addition, it has been possible to incorporate biological information presented at a recovery team meeting organized by the Fish and Wildlife Service's South Florida Ecosystem Office, Vero Beach. Such information is usually noted as (pers. comm. 1995). Errors and misrepresentations are, of course, the responsibility of the Fish and Wildlife Service.

The U.S. Fish and Wildlife Service thanks Gail Tikkanen from MASCO Corporation in Detroit, Michigan, for the cover sketch.

EXECUTIVE SUMMARY

CURRENT STATUS, HABITAT REQUIREMENTS, AND LIMITING FACTORS: The 19 plant species occur in central peninsular Florida, especially on a long strip of hills southwest of Orlando known as the Lake Wales Ridge. A few species have wider distributions, especially the lichen *Cladonia perforata*. Most of these plants inhabit Florida scrub vegetation dominated by shrubby evergreen oaks and ericoid shrubs, with sand pine. Several species occur entirely or partly in high pineland, with longleaf pine, deciduous oaks, and a grassy understory. Only about 15% of the original upland vegetation remains; the rest has been converted to citrus groves, pasture, and residential areas. The first edition of this plan, published in 1990, emphasized that public land acquisition was urgently needed to avert the extinction of several species and make recovery possible for others. Less costly alternatives would not suffice. Today, public land acquisition is underway that is likely to meet the needs of most of these plants. The species, arranged in groups in order of increasing threat are:

1. Threatened (T) and endangered (E) species whose reclassification and/or delisting are clearly feasible when habitat protection is complete and management measures are taken:

Clitoria fragrans (T) (pigeon wings)
Bonamia grandiflora (T) (Florida bonamia)
Eriogonum longifolium var. *gnaphalifolium* (T) (scrub buckwheat)
Paronychia chartacea (T) (papery whitlow-wort)
Chionanthus pygmaeus (E) (pygmy fringe tree)
Liatris ohlingerae (E) (scrub blazing star)
Nolina brittoniana (E) (scrub beargrass)
Polygonella basiramia (E) (a wireweed)
Polygonella myriophylla (E) (sandlace)
Prunus geniculata (E) (scrub plum)

2. Endangered species with obstacles to delisting of varying severity:

- *Cladonia perforata* (E) (Florida perforate cladonia). This lichen occurs at very few sites. Opportunities for conservation through land acquisition are limited, and learning about the ecology of this ground-dwelling lichen will be essential.
- *Conradina brevifolia* (E) (short-leaved rosemary), *Crotalaria avonensis* (E) (Avon Park harebells), *Eryngium cuneifolium* (E) (a snakeroot), and *Hypericum cumulicola* (E) (Highlands scrub hypericum). These species have limited geographic distributions, so protection through land acquisition requires purchase of specific tracts. Because of their narrow distributions, these species may have to remain listed indefinitely as threatened species.

- *Liatrix ohlingerae* (E), an obligately outbreeding species, needs genetic monitoring to assure that populations at preserves are genetically diverse to produce viable seed.
- *Polygala lewtonii* (E) (Lewton's polygala) is easily overlooked and often confused with *P. polygama*, so it requires extra inventory of likely sites. Prospects for its recovery appear good.
- *Warea carteri* (E) (Carter's mustard) is an annual that germinates and flowers after fire, remaining dormant in the seed bank between fires. Fire management is particularly important.

3. Critically endangered species with limited conservation opportunities:

- *Lupinus aridorum* (E) (scrub lupine) is restricted to areas where few opportunities exist to conserve scrub vegetation (e.g., metropolitan Orlando). A few small sites are protected or likely to be protected. The plant is very difficult to propagate, and susceptible to disease in the wild. It may become extinct in a few years.
- *Ziziphus celata* (E) (Florida ziziphus). Only a few populations are known, the largest in pastures where it probably cannot be permanently protected. Extinction of this species can be averted because it is readily propagated, and new populations can be established. However, it may take many years to determine whether new populations are self sustaining. As a result, this species may retain endangered or threatened status indefinitely.

RECOVERY OBJECTIVES:

Species group 1: reclassification to threatened status.

Species group 2: reclassification and eventual delisting; these species have to be conserved on relatively few or relatively small preserves. Surveys, monitoring, or specially-targeted land acquisition will be necessary.

Species group 3: avert extinction; protect existing populations; establish new populations.

Secondary objective: to conserve other listed plants and animals of the central Florida scrub (including two mints, scrub jays, two lizards); also to conserve many other endemic invertebrate and plant species.

RECOVERY CRITERIA: The nineteen species have different life histories and require different population sizes to be secure: short-lived plants need more individuals than long-lived ones. All species need to be represented at enough sites to assure against losses from disaster or management mistakes. Research and monitoring are leading biologists to recommend more stringent recovery criteria than were adopted in the first edition of this plan or in the draft of the revised plan. Generally, a species can be considered recovered, and be delisted when about 20 distinct, viable populations are protected at more than five separate, secure properties representing the range of the species (more sites for widely distributed species to assure representation throughout their geographic ranges). *Nolina brittoniana* (p. 60) is used as an example of how recovery criteria might be tightened in future recovery plans.

MAJOR ACTIONS NEEDED:

1. Protect habitat through purchase and other means (including the Habitat Conservation Plan process for threatened animals in the Florida scrub habitat).
2. Manage protected habitats.
- 3/4. Conserve germplasm and establish new populations of *Ziziphus celata* and (if possible) *Lupinus aridorum*
5. Assess progress and plan post-recovery monitoring

ESTIMATED COST OF RECOVERY, apportioned among the major actions, in dollars:

<u>Year</u>	<u>Action 1</u>	<u>Action 2</u>	<u>Actions 3&4</u>	<u>Action 5</u>	<u>Total</u>
1996	2,400	32,000	38,000	8,000	70,400
1997	2,900	43,000	48,000	0	83,900
1998	8,400	33,000	34,000	0	65,400
Total	13,700	108,000	120,000	8,000	219,700

The table shows identifiable plant conservation costs excluding funds spent to buy land. For fiscal years 1994 and 1995, Congress appropriated nearly \$3 million for the Lake Wales Ridge National Wildlife Refuge. By the end of 1994, the State of Florida had spent more than \$38 million for land in the Lake Wales Ridge region. Polk County and Palm Beach County passed bond issues to purchase land in cooperation with the State. The Nature Conservancy is acquiring smaller tracts, and Archbold Biological Station is expanding its boundaries. Total land acquisition costs for tracts with these plants will approach \$70 million. The State estimates that the total cost of managing its network of scrub preserves will approach \$1 million/year.

DATE OF RECOVERY: Scrub and other dry upland habitats occupied by these species have to be conserved promptly. The 1990 edition of this plan assumed that land protection had to be substantially complete within 5 years; now, 7 to 10 years appears more likely. Genetic and demographic research on these plants is underway. Delisting or reclassification of the group 1 species will be feasible when land acquisitions are made, site management is assured, and ecological studies are completed (perhaps by 1998). Group 2 species will mostly take longer because of individual needs. It should be clear whether conservation measures are working by 2000. For *Lupinus aridorum* and *Ziziphus celata*, the recovery plan will be successful in the short term if habitat is protected and extinction averted. Reclassification to threatened status cannot be predicted at the present time.

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PART I. INTRODUCTION

BACKGROUND

The nineteen plant species covered by this recovery plan are:

<i>Bonamia grandiflora</i>	Florida bonamia	threatened
<i>Chionanthus pygmaeus</i>	pygmy fringe tree	endangered
<i>Cladonia perforata</i>	Florida perforate cladonia	endangered
<i>Clitoria fragrans</i>	pigeon wings	threatened
<i>Conradina brevifolia</i>	short-leaved rosemary	endangered
<i>Crotalaria avonensis</i>	Avon Park harebells	endangered
<i>Eriogonum longifolium</i> var. <i>gnaphalifolium</i>	scrub buckwheat	threatened
<i>Eryngium cuneifolium</i>	a snakeroot, scrub celery	endangered
<i>Hypericum cumulicola</i>	Highlands scrub hypericum	endangered
<i>Liatris ohlingerae</i>	scrub blazing star	endangered
<i>Lupinus aridorum</i>	scrub lupine	endangered
<i>Nolina brittoniana</i>	scrub beargrass	endangered
<i>Paronychia chartacea</i>	papery whitlow-wort	threatened
<i>Polygala lewtonii</i>	Lewton's polygala	endangered
<i>Polygonella basiramia</i>	a wireweed	endangered
<i>Polygonella myriophylla</i>	sandlace	endangered
<i>Prunus geniculata</i>	scrub plum	endangered
<i>Warea carteri</i>	Carter's mustard	endangered
<i>Ziziphus celata</i>	Florida ziziphus	endangered

These plants occur on dry, nutrient-poor sand soils; most occur primarily in Florida scrub vegetation dominated by shrubby evergreen oaks (*Quercus* spp.), sand pine (*Pinus clausa*), and/or Florida rosemary (*Ceratiola ericoides*). Several species occur in high pineland (or "sandhill") vegetation dominated by wiregrass (*Aristida stricta*), longleaf pine (*Pinus palustris*), and turkey oak (*Quercus laevis*) or, less commonly, by scrub hickory (*Carya floridana*) (Abrahamson et al. 1984) (Christman 1988c). All but one of this plan's species occur on the Lake Wales Ridge, the southernmost major upland in the Florida peninsula (see map 1). Eighteen of the species are in Highlands County (the exception is *Lupinus aridorum*) and eighteen in Polk County (the exception is *Eryngium cuneifolium*); the distributions of thirteen species extend into other counties, two as far away as the Panhandle and the southeastern coast.

Although stands of Florida scrub are varied in their floristic compositions and dominant species, scrub is a reasonably distinct vegetation type (Richardson 1989), and can readily be mapped (Abrahamson et al. 1984, Christman 1988c, Fernald 1989, Richardson 1977).

High pineland once covered vast areas on sandhills and clayhills in the Coastal Plain from Virginia to Louisiana. In Florida, large areas of sandhills with deep, excessively drained, infertile sand soils are

in the Panhandle and the northern and central peninsula, as far south as the Lake Wales Ridge, where almost all of the high pineland was cleared to become Florida's prime citrus land. There is little high pineland south of the Ridge.

Scrub and high pineland occur in close proximity, so managers of biological preserves often have to deal with both types of vegetation. This recovery plan emphasizes scrub because more endemic plants occur in scrub than in high pineland, and because scrub may be more difficult to manage.

This recovery plan overlaps with recovery plans for the following species:

- **Scrub mint** (*Dicerandra frutescens*) and **Garrett's/Christman's mint** (*D. christmanii*). The recovery plan for endangered species of *Dicerandra* (U.S. Fish and Wildlife Service 1987a) was prepared before *Dicerandra christmanii* was recognized as a distinct species from *D. frutescens* (U.S. Fish and Wildlife Service 1989). These two woody mints occupy tiny geographic ranges, the first near Lake Placid, the second in the Flamingo Villas area near Sebring airport. Dr. Robin Huck, the expert on the genus, will prepare a treatment of *Dicerandra* for the Flora of North America that will take into account recently-discovered populations in Polk and Brevard counties (mentioned in McCormick et al. 1993) (also N. Bissett, pers. comm. 1994).
- The **Florida scrub jay** (*Aphelocoma coerulescens coerulescens*), a threatened species (U.S. Fish and Wildlife Service 1990b). Although conservation of the scrub jay requires protecting a much larger area of habitat than the listed plants require, the jay's relatively wide geographic distribution allows more flexibility with respect to habitat conservation than is possible for plants with narrow distributions.
- **Sand skink**, (*Neoseps reynoldsi*) and **blue-tailed mole skink** (*Eumeces egregius lividus*), both threatened scrub species (U.S. Fish and Wildlife Service 1993a).
- The **clasping warea** (*Warea amplexifolia*), endangered, which is restricted to high pineland in central Florida. It shares habitat with *Chionanthus pygmaeus*, *Eriogonum longifolium* var. *gnaphalifolium*, *Polygala lewtonii*, and *Prunus geniculata* (Wallace 1993).
- **Eastern indigo snake** (*Drymarchon corais couperi*) occurs in dry habitats and could benefit from measures prescribed in this recovery plan. (Speake et al. 1982).
- **Florida golden aster** (*Chrysopsis floridana*), long believed to be restricted to the Tampa Bay area (U.S. Fish and Wildlife Service 1988), occurs farther inland, apparently even on the Lake Wales Ridge at Highlands Hammock State Park (Florida Department of Environmental Protection, Division of State Lands 1994, data provided by Florida Natural Areas Inventory, undoubtedly based on field work by K. DeLaney).

This plan is intended to benefit other species native to scrub and high pineland in central Florida, some of which may qualify for Federal listing. For example, the bluestem grass *Schizachyrium niveum* and Ashe's savory, *Calamintha ashei*, are restricted to scrub. The native lantana, *Lantana depressa* var. *floridana*, is severely threatened by hybridization with *Lantana camara* (Sanders 1987), a cultivated species turned weed that invades neglected citrus groves. Perhaps the native lantana can persist in the largest natural areas, distant from human activities. Cutthroat grass (*Panicum abscissum*) has a very

narrow distribution in central Florida, where it carpets seepage areas on gentle slopes, usually near scrub or high pineland. Mark Deyrup (Archbold Biological Station, in litt. 1989) prepared a draft list of 15 threatened arthropods on the Lake Wales Ridge of central Florida and an additional 14 species known only from the Lake Wales Ridge. About 46 arthropod species are believed to be endemic to Florida scrub (Deyrup 1989). The Highlands tiger beetle, *Cicindela highlandensis* appears to merit protection under the Endangered Species Act. The best sites for this beetle are Catfish Creek and the Flaming Arrow Boy Scout ranch (Knisley et al. 1994).

BACKGROUND: SCRUB VEGETATION AND SOILS

Scrub vegetation occurs on dunes along or near the present-day coastlines and inland on sand soils that are typically associated with ancient shorelines (Laessle 1958, White 1958). These soils are classified as Psammments—soils that are almost entirely sand, and are nearly featureless in terms of soil morphology. They have little capacity to hold water and lack nutrients. Scrub is usually on white sand soils, and occasionally on yellow sand. Yellow sand scrub and/or scrubby high pineland on the Lake Wales Ridge is of special interest (Christman 1988c, 1995). Usually, yellow sands were occupied by high pineland vegetation. Yellow iron oxide and organic stains on sand grains are leached by the action of organic acids from the oak leaf litter that is typical of scrub; scrub sites with deep white sand soils presumably have been occupied by scrub for a long time while high pineland maintains the yellow stains from a combination of the actions of abundant grass roots and from soil mixing by burrowing animals, including gopher tortoises. Lack of perfect correlation between present vegetation and soil color indicates that vegetation boundaries have changed faster than soils develop (Myers 1990, summarizing papers including Kalisz and Stone [1984] and Myers [1985]).

Table 1 shows soil survey map units for well-drained soils in Highlands County, and the predominant vegetation of map units at Archbold Biological Station. Soil survey sheets are very useful for locating stands of scrub. The county's previous soil survey (published in 1957) is also valuable because its map units coincide more closely with the boundaries of scrub vegetation than the new soil survey (Kris DeLaney, Environmental Research Consultants Inc., Sebring, Fla., pers. comm. 1989). Similar soil information is available for Polk (U.S. Dept. of Agriculture 1990) and other counties. At Archbold Biological Station, Abrahamson et al. (1984) provided evidence that soil drainage, rather than soil nutrient levels, was the primary determinant of vegetation patterns.

Scrub vegetation usually has sand pine (*Pinus clausa*). Some scrub stands, especially north of the Lake Wales Ridge, are dense forests of this pine. Three scrubby evergreen oaks are ubiquitous and usually dominant, at least as understory beneath the pines:

- sand live oak (*Quercus geminata*)
- Chapman oak (*Quercus chapmanii*)
- myrtle oak (*Quercus myrtifolia*)

Scrub hickory (*Carya floridana*) is the predominant shrub/small tree in some stands of scrub vegetation.

Table 1. Excessively drained soils in Highlands County, Florida.

Map unit	Soil(s)	Drainage class	Seasonal high water table	Soil color; major vegetation at Archbold Biological Station
1	Paola	Excessively well-drained	76 in.	White to yellow sand; oak phase of sand pine scrub
2	St. Lucie	Excessively well-drained	76 in.	White sand; rosemary phase of sand pine scrub
4	Duette	Moderately well-drained	4-6 ft.	(Has hardpan); scrubby flatwoods
6	Tavares	Moderately well-drained	3.5-6 ft.	Yellow to lighter sand; hickory phase of high pineland
9	Astatula	Excessively well-drained	> 6 ft.	Yellow sand; high pineland (some scrub)
11	Orsino	Moderately well-drained	3.5-6 ft.	Hickory phase, high pinelands
14	Satellite	Somewhat poorly-drained	1-3.5 ft.	White sand; scrubby flatwoods
28	Archbold	Moderately well-drained	3.5-6 ft.	White sand; rosemary scrub, scrubby flatwoods
32	Arents	Excessively well-drained	> 6 ft.	

Sources: U.S. Dept. Agric, Soil Conservation Service 1989; Abrahamson et al. 1984

Florida rosemary (*Ceratiola ericoides*) is the dominant or only shrub in open, usually hilltop stands called "rosemary balds." Several endangered or threatened plant species occur mostly or entirely in the open spaces between rosemary bushes, especially *Eryngium cuneifolium*, *Hypericum cumulicola*, and *Cladonia perforata* (R. Yahr, Archbold Biological Station, in litt. 1995, Menges and Kohfeldt 1995). A fourth scrub oak, Archbold oak (*Quercus inopina*), has a limited geographic range in central and southeastern Florida but is abundant where it occurs (Johnson and Abrahamson 1982, Hardin 1985). Archbold oak is most abundant in scrubby flatwoods (Abrahamson et al. 1984) that are transitional from scrub to flatwoods, and occur on moderately well drained soils (Table 1).

Natural intermediates exist between scrub and high pineland vegetation (Christman 1995, also 1988c, citing Christman 1988d and Myers and Boettcher 1987). The intermediate vegetation occurs in areas with an irregular topography of hills, swales, and ponds "recognizable on the [topographic] map by the complex pattern of contour lines" (Christman 1988c), or as an ecotone on slopes between high pineland and wetlands. This "scrubby high pine" was previously called "yellow sand scrub" (Christman 1988c), "natural turkey oak barrens," (Christman and Judd 1990), "southern ridge sandhills" (Abrahamson et al. 1984), or "blackjack ridges" by land surveyors cited in Myers (1990). Christman reserves the term "turkey oak barren" for degraded high pineland. Scrubby high pine has variable amounts of wiregrass, abundant turkey oak and bluejack oak (*Quercus incana*), mingled with species typical of evergreen oak scrub such as *Garberia fruticosa* and rosemary. Such natural turkey oak scrub is distinct from high pinelands degraded by fire suppression and cutting of longleaf pines. Several endangered or threatened plants occur in scrubby high pineland, notably *Chionanthus pygmaeus*, *Clitoria fragrans*, *Warea carteri*, *Eriogonum longifolium* var. *gnaphalifolium*, and *Polygala lewtonii* (Christman 1992). A good example of scrubby high pine is in the southern Carter Creek area. Near Clermont in

Lake County, remnants of high pineland on the high hills also have "scrub" species, plus the endangered *Warea amplexifolia*. Eric Menges (Archbold Biological Station, in litt. 1995) notes that species listed as occurring in scrubby high pine are in fact more typical of scrub hickory-dominated scrub (hickory phase of high pineland), especially *Warea carteri*, *Clitoria fragrans*, and *Eriogonum longifolium*. This apparent disagreement between Christman and Menges indicates that more information is needed on the distributions of these plants, and perhaps also that there are limits to developing and applying consistent terminology to describe a complex mosaic of vegetation.

BACKGROUND: FIRE ECOLOGY OF SCRUB

Most of Florida's natural vegetation is subject to, and dependent on, fire. For upland vegetation, the fire regimes are:

- Rosemary scrub: very infrequent, due to discontinuous fuel because of the vegetation's low density, with gaps between shrubs (A. Herndon, Florida International Univ., in litt. 1995). Should fire occur at intervals of less than about 10 years, rosemary would be eliminated (Johnson and Abrahamson 1990).
- Sand pine scrub: infrequent/high intensity, because sand pines support crown fires and usually reseed from serotinous cones. Evidence that fires can eliminate sand pine, leaving oak scrub, comes from a spring fire in coastal scrub near Juno Beach, Palm Beach County, in the 1970's (Steve Farnsworth, Palm Beach County Environmental Resources Management, pers. comm. 1995. Eugene Kelly, Southwest Florida Water Management District, in litt. 1995). Coastal sand pine scrub in the Florida panhandle is apparently affected more by hurricanes than by fire (Doyle et al. 1992); the scarcity of serious hurricanes in the peninsula in recent decades, up to 1995, may have obscured the importance of hurricane effects.
- Scrubby flatwoods: moderate frequency/relatively high intensity, because ample fuel is provided by dense evergreen scrub oaks.
- Flatwoods: frequent/moderate intensity. To the extent that flatwoods have more pine trees than scrubby flatwoods, the extra pine needles promote the spread of fire. Flatwoods shrubs are not inherently more flammable than those of scrub, but there are fewer gaps in the understory vegetation, so fire spreads more readily (Herndon, in litt. 1995).
- High pinelands: very frequent/low intensity, due to a grass-carpeted understory and dry pine needles that propagate fire (Christman 1988c; Platt et al. 1988; summary in Myers 1990, pp. 189-193).

Most scrubs appear to be in locations sheltered from the spread of fire by lakes, hardwood swamps, or other wetlands and aquatic habitats (Myers 1985, 1990; Christman 1995). Scrub vegetation has few flammable grasses, in part because woody plants inhibit the germination of grass seed and growth of grass plants (Richardson and Williamson 1988) (an exception is the scrub bluestem [*Schizachyrium niveum*]). Evergreen oaks and sand pines are most flammable during droughts in spring or early summer, when they become dry enough to support crown fires that, at least in patches, kill all aboveground vegetation. Evergreen oaks, scrub hickory, and most of the other shrubs have massive underground root systems from which the modest aboveground portions of the plants regenerate rapidly following a fire

(Johnson et al. 1986). *Chionanthus pygmaeus* and *Prunus geniculata* behave this way (Harper 1911, Kral 1983), as does *Bonamia grandiflora*, which has sprawling aboveground stems that arise from a tap root (Ward 1979, Hartnett and Richardson 1989). Sand pine is an exception: it is killed by fire, after which the tree's closed cones open, shedding seed that produces a new even-aged stand of pines. In the Ocala National Forest, even-aged stand management substitutes for fire. The resulting sand pine forests are similar to the extensive, thick stands of sand pine that existed before the area was set aside as a National Forest (Hill 1916). Sand pines in central Florida often have open cones and shed seed every year, so while fire is a stimulus for reproduction by these trees, it is not essential (Christman 1988c). In the absence of fire, sand pine may encroach into oak or rosemary scrub, as has been observed at the Starkey Wilderness Preserve operated by the Southwest Florida Water Management District in Pasco County. Extremely dense flushes of young sand pine have invaded canopy gaps in a stand from which fire has been excluded for many years. At another stand several hundred acres in size, scrub oaks, rosemary, and other typical understory species have been virtually eliminated from all but the stand's fringes (Eugene Kelly, Southwest Florida Water Management District, in litt. 1995). This case history shows that fire may be as critical in the long-term management of nonserotinous stands as in serotinous stands if the management objective is to maintain an open canopy and a healthy, diverse scrub community. Open canopies are essential to the conservation of the plants covered by this recovery plan.

Florida rosemary (*Ceratiola ericoides*) has reproductive behavior similar to sand pine. This long-lived shrub perishes when burned. Seeds stored in the soil germinate only after the parent plant dies (Johnson 1982). Stands of scrub dominated by rosemary are open and easy to walk through, with areas between the shrubs occupied by spike moss, lichens, and herbs. The openness may be the result of allelopathy by rosemary (Richardson and Williamson 1979, 1988; Richardson 1985a,b). Allelopathy is the inhibition of one plant "by another via the release of metabolic by-products into the environment" (definition adapted from Barbour et al. 1980, p. 94). Such interactions appear to be common in nature, but are not easy to demonstrate. Most of the herbs covered by this recovery plan are associated with Florida rosemary, so there is obvious scope for further research. Allelopathy within the rosemary scrub community is probably not restricted to *Ceratiola*. Many lichens, including some *Cladonia* species, contain allelopathic chemicals (Lawrey 1986), and lichen allelopathy may be a force in shaping the characteristic openings in scrub, although this process has not yet been documented in scrub. Open space is important to at least some of the plants covered by this recovery plan, as shown for *Polygonella basiramia* by Hawkes and Menges (1995).

Intense, fast-moving lightning or arson fires that are typical of Florida scrub (especially dense sand pine) present a hazard to nearby buildings, to traffic on nearby roads, and to people with breathing problems. The Ocala National Forest has warned local residents of the fire hazard. In Highlands and Polk Counties, the small sizes of most stands of scrub limits the fire hazard, and rosemary-dominated sites may burn rarely, if at all. Before a tract of scrub is set aside as a preserve, an assessment should be made of the fire hazard and whether the tract is adequately buffered against the spread of fire into residential areas by a road, citrus groves, or other non-residential land use. Zoning or other planning procedures may help ensure buffering.

Experience with fire management in other kinds of shrubby vegetation can be applied to scrub. Schmalzer and Hinkle (1987) note that the responses to fire of oak scrub at Cape Canaveral and of scrubby flatwoods at Archbold Biological Station (Abrahamson et al. 1984) are similar to fire responses in other vegetation dominated by root-sprouting shrubs, including North Carolina pocosins (evergreen shrub bogs) and New Jersey pinelands. A physical model for fire behavior of California chaparral proved useful for planning a prescribed burn in scrub in Boca Raton (Doren et al. 1987). The Boca Raton experience helped in developing a prescribed fire plan for Jonathan Dickinson State Park. Some protected tracts of scrub vegetation are so closely bordered by buildings or roads that prescribed fire is difficult; a project at Jonathan Dickinson State Park is investigating burning methods and alternatives.

BACKGROUND: GEOGRAPHY AND BIOGEOGRAPHY OF SCRUB

Florida scrub vegetation occurs in peninsular Florida and the Gulf coast of the Florida Panhandle, with the westernmost stands near Mobile Bay in Alabama (I. Jack Stout, University of Central Florida, pers. comm. 1988; Stout and Marion 1993; Myers 1990). Evergreen oak scrub without sand pine occurs in southeastern Georgia (Wharton 1978), and several species typical of scrub (including rosemary) occur well to the north. The geographic distribution of sand pine approximates the distribution of Florida scrub. Although the largest area of scrub vegetation is in the Ocala National Forest, most of the plant species endemic to scrub are found farther south on the Lake Wales Ridge, a series of hills interrupted by sinkhole lakes about 100 miles long and 4 to 13 miles wide (map 1; Christman 1988c, White 1970). The Ridge was never blanketed by scrub vegetation, but rather has "over 200 isolated, recognizable scrub islands imbedded in high pine, turkey oak, flatwoods, and bayhead habitats" (Christman 1988b). The historic extent of scrub on the Lake Wales Ridge can be mapped from older aerial photographs and soil surveys. With the help of such resources, researchers at Archbold Biological Station have mapped former and present scrub jay habitat. Few existing scrubs on the Lake Wales Ridge are larger than a few hundred acres (the largest, by Christman's measurement, is 2,866 acres), and no site contains all of the Ridge's endemic species. Conserving plant species requires protection of over a dozen sites in Polk and Highlands counties, and conservation of a number of small or medium-sized tracts rather than just a few big ones. Destruction of sites has proceeded to such an extent that establishing new populations of a few species will be necessary (Christman 1988a).

The Lake Wales and neighboring high ridges constitute one of Florida's three main regions of plant endemism. The two others are the Apalachicola lowlands in the Panhandle and tropical south Florida. The Apalachicola lowlands have about the same number of endemic species as the high ridges; southern Florida has fewer full species, but many more subspecies and varieties (Muller et al. 1989). The plant endemism of the Lake Wales and nearby ridges is concentrated in scrub vegetation. Christman (1988c) notes that the degree of plant endemism in the Florida scrub is very high by continental standards (islands such as Hawaii have the highest percentages of endemics in their floras).

Christman (1988c) attempted to rank scrubs by size to see whether larger scrubs have more species than small ones. Neither this study nor one by Connery (1984) showed a correlation between the size of

a scrub and the number of species present, nor between size and number of endemic species. Connery noted that most plant species that occur in scrub also occur in other habitats, so for most plants, scrub sites do not form “islands” of suitable habitat surrounded by a “sea” of uninhabitable vegetation—rendering island biogeography theory irrelevant (summarized in Fernald 1989, p. 55). Nevertheless, many of this recovery plan’s species are restricted to scrub, and their limited, spotty distributions indicate that they disperse poorly across non-scrub and/or undergo local extinctions and recolonizations, so, for these species, unoccupied scrub may represent suitable habitat that hasn’t been colonized. If so, prospects may be good for establishing new populations of the most narrowly-distributed species. Christman’s analysis did not deal with the patchiness of scrub habitat; for the species in this recovery plan, a tract of “scrub” usually represents a mosaic of suitable and unsuitable/occupied and unoccupied habitat (see the discussion of patchiness, below).

Christman (1988c) pointed out that scrub in Highlands and Polk counties that is rich in endemic species is ancient in the geologic sense, and is distinct from endemic-poor “pioneer” scrub. Most Florida scrub vegetation is pioneer scrub (including most of the Ocala National Forest’s 200,000 acres of scrub, and coastal scrub on both coasts). Christman hypothesized that the pioneer scrubs were colonized by plants that migrated from ancient scrubs, accounting for their smaller floras.

Ancient scrubs are largely restricted to three interior ridges: the Lake Wales, Winter Haven, and Lake Henry (map 1). The Lake Wales Ridge is by far the largest, and longest, of the three. The ridges were formed as the slender southern tip of a much smaller Florida peninsula. McCartan (1992) dates the beach and dunes complex of the Lake Wales Ridge at 2.5 million years old, with fresh erosion of the east margin of the Ridge about 1.8 million, 1.0 to 0.7 million, and 0.2 million years ago. Further information on the dates of former shorelines is in Haq et al. (1987), and on warping (i.e., upward bending) of the Florida peninsula is in Winkler and Howard (1977), Opdyke et al. (1984), and Walker and Coleman (1987). Sand on the Lake Wales Ridge formed active dunes during periods of a dry climate (an example is the washboard terrain of “turkey oak scrub” near Carter Creek). Further information and references on the geologic history of Florida can be found in Christman (1988c), Myers (1985), and Schmalzer and Hinkle (1987).

Webb (1992) presented indirect evidence of open, dry savanna-like habitats in Florida as long ago as the early Miocene, with a “protosandhill biota.” Watts and Hansen (1994), reviewing evidence from pollen analysis of lakes on the Lake Wales Ridge, suggest that sand-dune and xeric shrubby vegetation has been present for the past 50,000 years, with alternating peaks of pine and oak-dominated vegetation, with pine (which has dominated for the past 5,000 years) being characteristic of periods with wet climate due to warm Gulf of Mexico waters. The Florida climate appears to have been dry from 12,000 to 6,000 years before the present, when central Florida pollen records were rich in forb pollen typical of prairies. There is no evidence that tropical plants nor mesic hardwoods were important during the past 50,000 years. Neither is there evidence that Florida had much cooler winters than it does now (summary of earlier data in Jacobson et al. 1987). Florida scrub, having been present for tens of thousands of years, with a flora and fauna possibly going back millions of years in the same geographic area, is ancient compared with vegetation elsewhere in eastern North America, and is relictual in the sense that shrubby

vegetation and its biota have evolved in the same place for a long time, with shrinkage and expansion as the climate became wet or dry and as sea level fluctuated. The ebb and flow of scrub with changing climate may have created the opportunity for speciation in isolated patches of scrub, resulting in the patterns of endemism seen today, particularly among short-lived plants and those lined to disturbance (Eric Menges, Archbold Biological Station, in litt. 1995).

Some endemism in Florida scrub is almost certainly due to geographical isolation of taxa that migrated from shrubby vegetation of the Southwest into Florida during periods of dry climate. Examples include the Florida ziziphus (*Ziziphus celata*), scrub hickory (*Carya floridana*), scrub beargrass (*Nolina brittoniana*), scrub buckwheat (*Eriogonum longifolium* var. *gnaphalifolium*), and the Florida scrub jay (*Aphelocoma coerulescens coerulescens*) (Christman 1988c). Other scrub endemics are closely related to widespread Eastern plants, such as the following pairs (Judd and Hall 1984):

scrub taxon

Persea borbonia var. *humilis* (silk bay)
Ilex opaca var. *arenicola* (sand holly)
Chionanthus pygmaeus (pygmy fringe tree)

widespread taxon

Persea borbonia var. *borbonia* (red bay)
Ilex opaca var. *opaca* (American holly)
Chionanthus virginicus (fringe tree)

Some scrub endemics originated recently within Florida, including Florida golden aster (*Chrysopsis floridana*), the four-petal pawpaw (*Asimina tetramera*), and the woody species of *Dicerandra* (R. P. Wunderlin, University of South Florida, pers. comm. 1988). Each woody species of *Dicerandra* appears to be native to a small, discrete geographic area—even though two of the *Dicerandra* species are separated from each other by only about 8 miles. Speciation in *Dicerandra* may have been promoted by the large number of small tracts of scrub, the inability of pollinators to move between stands, or of seed to disperse between stands (Huck 1987; Huck et al. 1989). In the genus *Polygonella*, which consists of narrowly-distributed species in central Florida and a few widely-distributed species, the narrowly-distributed species have as much or more genetic diversity than the widespread ones (Lewis and Crawford 1995).

Several scrub species or pairs of closely related species have disjunct distributions in central and panhandle Florida. They include the lichen *Cladonia perforata*, *Lupinus aridorum* and *Lupinus westianus*, *Paronychia chartacea* subsp. *chartacea* and *P. chartacea* subsp. *minima* (see map, page 94), and *Conradina brevifolia* and *Conradina canescens* (Anderson 1991, Isely 1990).

The variability in floristic composition among scrub at different sites, including those richest in species, requires that conservation measures focus, not on an idealized plant community, but on many individual sites. To recover all of the plant species, at least a dozen sites must be protected, including some small or medium-sized tracts. Destruction of sites has already proceeded to such an extent that establishing new populations of some species will be necessary (Christman 1988a).

BACKGROUND: PATCHINESS OF SCRUB VEGETATION

Christman and his predecessors, as well as preserve designers for the State and Federal governments analyzed scrub on a large scale. Now, Eric Menges and others at Archbold Biological Station are examining patch-level incidence of Florida scrub plants and their responses to fire to infer metapopulation dynamics. They are working at the scale of the rosemary scrub patches at Archbold Biological Station, all smaller than 3 hectares (7 acres). While the rosemary patches themselves are relatively permanent, their vegetation changes with time, and different species occur in different patches. A particular species may not permanently inhabit any one patch, but undergo periodic patch-scale extinctions and colonizations. In technical terms, such a species that comes and goes from patches behaves as a metapopulation.

Fires are probably the major creators/maintainers of open areas in scrub; a discussion, with references, can be found in Hawkes and Menges (1995), who point out that local disturbances such as gopher tortoise burrows and sand movement have not been studied in scrub, but the effects of burrowing may be important, based on the results of a study by Kaczor and Hartnett (1990), that showed that cover of short-lived herbaceous species were greater on tortoise mounds than in undisturbed areas.

Plants have several means of responding to fire. Menges and Kohfeldt (1995) classified 98 species of scrubby flatwoods and rosemary scrub into guilds based on method of recovery and post-fire abundance patterns. The major guilds (from their Table 1) are:

mode	%	examples
obligate seeders/sporers (soil)	27	rosemary, <i>Paronychia chartacea</i> , <i>Polygonella basiramia</i>
resprouters	25	silk bay
resprouters and seeders	25	saw palmetto, wiregrass, <i>Eryngium cuneifolium</i>
resprouters and clonal spreaders	14	oaks, blueberries, <i>Lyonia</i>

They distinguished between “resprouters” and “clonal spreaders” because clonal spread appears to be an important means by which plants occupy post-fire gaps. All of the plants practicing clonal spread also resprouted. Seeders (especially rosemary) were much more predominant in rosemary scrub, while scrubby flatwoods are dominated by shrubs that are resprouters and clonal spreaders. As a result, scrubby flatwoods have a nearly continuous shrub layer that supports continuous fires, while the patchy shrub layer of rosemary scrub seldom burns all at once. Reproduction in common shrubs of the scrub seems not to be tightly scheduled with respect to the time since the last fire (Ostertag and Menges 1994).

There is evidence of microsuccession of dominant herbs in the sandy patches, starting with *Eryngium cuneifolium* and continuing to *Hypericum cumulicola* and *Polygonella basiramia* (Pedro Quintana-Ascencio, Archbold Biological Station, unpublished data, Menges 1992, Hawkes and Menges 1995). Some species increase with time after fire, some decline after a few years, and some (including *Cladonia perforata*) increase for a number of years, then decline (Menges and Kohfeldt 1995). Some other vascular plants that utilize gaps are: *Calamintha ashei*, *Cnidocolus stimulosus*, *Dicerandra frutescens*, *D. christmanii*, *Euphorbia floridana*, *Lechea cernua*, *L. deckertii*, *Licania michauxii*, *Paronychia*

chartacea, *Polanisia tenuifolia*, *Polygonella polygama*, *P. robusta*, *Selaginella arenicola*, and *Stipulicida setacea* (U.S. Fish and Wildlife Service 1995).

A recent study (Quintana-Ascencio and Menges, submitted) showed that the occupancy of these rosemary patches by the small scrub endemic plants was related to time-since-fire, patch size, patch isolation, and interactions of these variables for two-thirds of the species examined. The species whose presence was related to the interaction of patch size and patch isolation were primarily specialists of rosemary scrub and herbs. These species' minimum patch sizes were well-fit by metapopulation models, which suggests that some species in this recovery plan do function as metapopulations. For species that behave as metapopulations, suitable unoccupied habitat is probably available for future colonization. To conserve such species, it may be necessary to protect a viable but dynamic metapopulation by ensuring that there will be many patches of suitable habitat, including patches not currently occupied.

Ensuring that there are gaps in the shrub cover suitable for smaller shrubs, herbs, and lichens is a primary concern in the management of scrub preserves. Research that is underway is highly relevant to future management (see the species accounts for *Eryngium cuneifolium*, *Hypericum cumulicola*, and *Polygonella basiramia*). The propensity of these and other plants to colonize fire lanes and edges of sand roads means that some species are probably more abundant in artificially disturbed habitat than they are within undisturbed scrub. There is a danger that land managers, seeing that the plants are abundant in fire lanes, will see little reason to implement prescribed fire plans (Dennis Hardin, Florida Dept. of Agriculture and Consumer Services, Division of Forestry, pers. comm. 1995).

A different kind of gap may have been important for *Lupinus aridorum*. Jack Stout (University of Central Florida, unpubl. observation) saw lupines flowering along recently-built residential streets in a solid forest of sand pine whose understory was almost entirely rosemary. There were no lupines in undisturbed vegetation. His interpretation is that virtually the entire existing stand of vegetation came from seed banks: sand pine seeds from closed cones on the trees and rosemary and lupine seeds from the soil. The young sand pine-rosemary stand would have had gaps suitable for *Lupinus aridorum*, which presumably thrived for a few years and remained present in the seed bank until the bulldozers arrived.

BACKGROUND: HIGH PINELAND

Myers (1990, pp. 174-193) reviewed the ecological literature on high pine, which was found on sandhills and clayhills in the southeastern United States, noting that "of the estimated 25 million hectares of longleaf pine forests that existed in the Coastal Plain just before European settlement, roughly 3 percent of the upland support high pine vegetation today" (p. 178). Because of logging and fire exclusion, most sandhills are now dominated by turkey oak; Myers prefers to classify such degraded sites as turkey oak barrens or turkey oak sandhills rather than high pine (p. 179). Alan Herndon (Florida International Univ., in litt. 1995) commented that the "turkey oak barrens" could well represent a transient response to human activities. If so, efforts to maintain this vegetation type would be very difficult to justify from a conservation standpoint since it would be based on single species management.

The high pinelands of the Lake Wales Ridge, even before logging and fire suppression, had substantial amounts of turkey oak and plant species typical of scrub. Christman (1995) calls such areas "scrubby high pine," noting that such areas had been called "yellow sand scrub" (Christman and Judd 1990, "southern ridge sandhills" (Abrahamson et al. 1984), and "blackjack lands" by nineteenth-century surveyors (Myers 1990).

The high pinelands on the northern Lake Wales Ridge west of Lake Apopka were apparently impressive before they were cleared to make way for citrus groves. Harper (1911) stated that "the vegetation of these hills is uniformly of the 'high pine land' type . . . with the addition of a few species more characteristic of the 'scrub,' such as *Ceratiola* [Florida rosemary] and *Selaginella*, and a few very local species such as *Polygala Lewtonii* [sic] and the shrub presently to be described [*Prunus geniculata*]." *Chionanthus pygmaeus* and *Warea amplexifolia* occur in the same area, where remnants of the high pinelands are now small and scattered. Harper provides several references that describe the area in the late nineteenth century.

Scrub hickory-dominated vegetation on yellow sand soils has gone by a variety of names, much like turkey oak vegetation. Abrahamson et al. (1984) considered this vegetation at Archbold to be high pineland), but it's also possible to think of it as hickory-dominated scrub. Several endangered and threatened species are typical of scrub dominated by scrub hickory-dominated scrub, especially *Warea carteri*, *Clitoria fragrans*, and *Eriogonum longifolium* (called *E. floridanum* in Myers 1990), and *Polygala lewtonii* (Eric Menges, Archbold Biological Station, in litt. 1995).

The reproduction of wiregrass (*Aristida stricta*), the dominant grass of high pinelands, is coming to be understood. The Florida Division of Recreation and Parks is planting wiregrass propagated by the Florida Division of Forestry at Lake Griffin State Recreation Area to benefit the endangered plant *Warea amplexifolia*, and The Nature Conservancy is experimenting with re-establishing the species in degraded sandhills on the Apalachicola bluffs. These experiments will be relevant to similar efforts in the Lake Wales Ridge, where high pineland restoration would be very desirable to protect *Ziziphus celata* and other species at several sites (Seamon et al. 1989).

The low-intensity fires typical of high pineland are, as Myers points out, are relatively easy to prescribe and conduct. The high pineland "islands" in Ocala National Forest show that appropriate fire management is feasible. The Ocala "islands," apart from being important for *Eriogonum longifolium* var. *gnaphalifolium* and *Polygala lewtonii*, are occupied by endangered red-cockaded woodpeckers (*Picoides borealis*). The Forest Service plans to manage the longleaf pines so that there are enough trees old enough for woodpecker nest cavities. Woodpecker-oriented management will almost certainly benefit the entire high pineland flora, but it is important to obtain site-specific analyses of the effects of logging and other management activities, at least if such management affects the ground flora.

THE SPECIES AND THEIR LISTING HISTORY

The nineteen plants addressed in this recovery plan are described in Table 2 (p. 36). They were added to the Federal List of Endangered and Threatened Plants as follows: *Chionanthus pygmaeus*, *Eryngium cuneifolium*, *Hypericum cumulicola*, *Polygonella basiramia*, *Prunus geniculata*, and *Warea carteri* (endangered) and *Paronychia chartacea* (threatened) on January 21, 1987 (52 FR 2227, U. S. Fish and Wildlife Service 1987c). *Lupinus aridorum* (endangered) on April 7, 1987 (52 FR 11172, U. S. Fish and Wildlife Service 1987d). *Bonamia grandiflora* (threatened) on November 2, 1987 (52 FR 42068, U. S. Fish and Wildlife Service 1987b). *Liatris ohlingerae* and *Ziziphus celata* (endangered) on July 27, 1989, (54 FR 31190, U. S. Fish and Wildlife Service 1989). *Cladonia perforata*, *Crotalaria avonensis*, *Nolina brittoniana*, *Polygala lewtonii*, *Polygonella myriophylla* (endangered) and *Clitoria fragrans* and *Eriogonum longifolium* var. *gnaphalifolium* (threatened) on April 27, 1993 (58 FR 25746, U. S. Fish and Wildlife Service 1993c). *Conradina brevifolia* (endangered) on July 12, 1993 (58 FR 37432, U. S. Fish and Wildlife Service 1993d).

PRESENT STATUS OF EACH SPECIES

Christman's (1988c) report is the primary source for information on distributions and habitats of the plants in this recovery plan. Christman's report combines his own extensive field work and evaluations of aerial photographs with data gathered by other researchers, including Johnson (1981), Stout (1982), and Gary Schultz (for the Florida Natural Areas Inventory, 1983). Other information came from status surveys funded by the U.S. Fish and Wildlife Service (summarized in U.S. Fish and Wildlife Service 1987b, 1987c). Christman's data have been incorporated into the Florida Natural Areas Inventory. Since Christman's report, substantial new information has come from field work by scientific staff at Archbold Biological Station and by others (including Nancy Bissett and Susan Wallace). The available data on plants of central Florida scrub provide a basis for site-specific planning and execution of recovery activities, although users of the data must be aware of occasional errors due to misidentifications and/or lack of voucher specimens, and to the inability of biologists to visit every site. Field checking of information is advisable. The known distributions of these plants, based largely on Christman's maps, are summarized in maps 3-21 (pp. 95-113). Because field work has been concentrated in the Lake Wales Ridge area, it is possible that important new populations of some species will be found, especially in Hardee, Manatee, and perhaps Hernando and Citrus counties (D. Richardson, K. DeLaney, pers. comm. 1995; E. Kelly, Southwest Florida Water Management District, in litt. 1995). Our understanding of how to conserve these habitats and their plants is improving due to research and monitoring by scientists and managers. Further information on measures to improve the status of these plants is in "Existing Conservation Measures," page 44.

Bonamia grandiflora – Florida bonamia, map 3, p. 95; drawing 1, p. 114

This large-flowered morning-glory vine, the only member of its genus in Florida, occurs mainly in scrub, but occasionally occurs in high pinelands in the Ocala National Forest (Miller 1989) in Marion County, the only place where this plant is really abundant. *Bonamia grandiflora* was listed as a threatened species because it was relatively secure in the National Forest, but not elsewhere in its range (U.S. Fish and Wildlife Service 1987b).

Bonamia grandiflora formerly occurred in central Florida from Volusia and Marion Counties south to Highlands and Charlotte Counties (Wunderlin et al. 1980). The plant was collected in Sarasota, Manatee, and Volusia Counties in 1878, 1916, and 1900, respectively (Wunderlin et al. 1980a).

State land acquisitions and other actions are increasing the number of protected sites even as many sites are being destroyed. The current situation by county:

- Charlotte County: There is a recent report by D. Darden (cited by Christman [1988c]), and I. J. Stout (in litt. 1989) has seen the plant.
- Manatee County: Protected at Wingate Creek State Preserve (Jeff Webber, Florida Division of Recreation and Parks, pers. comm. 1991).
- Hardee County: Johnson (1981) reported one small site, but there seems to be some question about the location or the identification. In the Florida Natural Areas Inventory database, a report the Myakka Head quadrangle, Hardee County, has a note of "questionable identification."
- Lake and Orange counties: Protected at Lake Louisa State Park in southern Lake County and a property at Crooked Creek owned by the Lake County Water Authority (Race and Orzell 1995). In 1992, Gabriela Romano (University of Florida, in litt.; data at FNAI) checked nearly 20 sites where the plant had been reported, and found populations at only 2 sites: one in Lake County, south of Lakes Minnehaha and Susan on Hull Road, the other in Orange County at Big Sand Lake on Fenton Road, off the Apopka-Vineland Road. In Orange County, the bonamia is restricted to remnants of scrub (along with *Lupinus aridorum*), including Turkey Lake Park (City of Orlando) and Lakes Cane and Marsha Park (Orange County).
- Osceola County: Present immediately north of the county line, southeast of Interstate 4.
- Polk County: Protected at The Nature Conservancy's Tiger Creek Preserve (a dozen or fewer plants in a small tract of scrub) (The Nature Conservancy 1986; Christman 1988a), at the Saddle Blanket Lakes (a State/Nature Conservancy project), and at the Livingston Creek scrub in the Lake Arbuckle tract of Lake Wales Ridge State Forest.
- Highlands County: Protected at the Flamingo Villas tract of Lake Wales Ridge National Wildlife Refuge. Archbold Biological Station's plant list reported the bonamia, but the plant does not currently occur there (Christman 1988c). The bonamia is not known to occur at the state-owned Placid Lakes property, although it is present on nearby private land (comment made at recovery meeting, Archbold Biological Station, December 1995).
- In Hardee and Manatee counties, scrub sites have not been adequately searched for *Bonamia grandiflora* or other listed species (K. DeLaney, pers. comm. 1995).
- Marion County: In Ocala National Forest, the bonamia is known from 52 sites, and its range extends from Lake Kerr, north of County Road 314, to State Road 42 covering approximately 23 miles from north to south and six miles from east to west. The bonamia's range overlaps the ranges of both

scrub buckwheat and Lewton's polygala. The bonamia is abundant along roadsides and rights-of-way in the Forest and it probably occurs in Pinecastle Bombing Range (a U.S. Naval Reservation surrounded by the Forest) (J. L. Clutts, Lake George Ranger District, in litt. 1995).

In Ocala National Forest, the bonamia has been observed in the following stand condition classes of sand pine: regeneration, seedling and sapling, immature poletimber, mature poletimber. The plants flower profusely in the open, sunny conditions of regeneration stands, and sparsely if at all in older stands. The bonamia is not found on the clay applied to logging roads (Miller 1989).

Susan Wallace (then at Bok Tower Gardens, Lake Wales, Fla.) propagated *Bonamia grandiflora* from seed. Cultivated plants at Bok grew away from the partial shade of a live oak into full sun, invading a path covered with black anti-weed plastic mesh. Wallace partially excavated around several plants and found that the taproot is relatively slender, and produces several below-ground stems. One cannot readily determine from the surface whether stems are connected below-ground. Hartnett and Richardson (1989) excavated several plants and found that the clumps of prostrate stems seen at the surface are all connected to a "large central and somewhat woody rootstock." They had no difficulty distinguishing such well-established older individuals from young single-stem plants that had grown from seed. Hartnett and Richardson observed that populations of this species have large seed banks of dormant seeds, mostly in the top centimeter of the soil, distributed rather homogeneously, with no relation to the distribution of mature plants. Fire in the habitat stimulates flowering and seed production of mature plants, stimulates germination of seed, and causes turnover of the seed bank due in part to heavy seed mortality during the fire, followed by replenishment by seed falling from mature plants.

*Chionanthus pygmaeus*¹ – pygmy fringe tree, map 4, p. 96; drawing 2, p. 115

This large shrub occurs in scrub as well as high pineland, dry hammocks, and transitional habitats.

Chionanthus pygmaeus is similar to the widespread *Chionanthus virginicus*, whose range extends into central Florida, and the two species appear to hybridize in habitats other than scrub (Elfers 1989). Plants that had been thought to be *C. pygmaeus* at Fort Cooper State Park south of Inverness, Citrus County (Fla. Natural Areas Inventory data) were assigned by Elfers to *Chionanthus virginicus*. Fort Cooper State Park has no scrub; it is mostly live oak hammock or high pineland (Ann Johnson, Florida Natural Areas Inventory, pers. comm. 1989). Both species of *Chionanthus* occur at Little Manatee River State Recreation Area. A population of *Chionanthus* at O'Leno State Park (Columbia/Alachua counties) is hybrid, while a population of *Chionanthus* in western Hillsborough County was probably *C. virginicus* (R. Currie, Fish and Wildlife Service, Asheville, N.C., pers. comm. 1985).

Chionanthus pygmaeus is known from:

- Lake County: a scrub adjacent to the Lake Apopka Marsh in Lake County, (near Astatula) where *Prunus geniculata*, *Warea carteri*, and other rare plants might be present (M. Spontak, Director, Div. of Policy and Planning, St. Johns Water Mgt. District, in litt. 1995). This tract is in the area

¹ Small (1933) used the Greek feminine form of the specific epithet, *C. pygmaea*. Every author since, including Little (1953), Hardin (1974), Currie, and Larry Morse (The Nature Conservancy, Arlington, VA, letter to Suzanne Cooper, Florida Natural Areas Inventory) has used the masculine form, *C. pygmaeus*.

where the state is planning land acquisition for the "Warea archipelago" portion of the Lake Wales Ridge project. *Chionanthus* may also be in the Sugarloaf Mountain area west of Lake Apopka.

- northwestern Osceola County
- Polk County: *Chionanthus pygmaeus* is protected at Saddle Blanket Lakes, Lake Wales Ridge State Forest (Arbuckle and Walk-in-the-Water tracts) and Lake Arbuckle Preserve, Tiger Creek Preserve, and the Catfish Creek Preserve². Flamingo Villas (acquisition area for Lake Wales Ridge National Wildlife Refuge) has a large population (Eric Menges, Archbold Biological Station, in litt. 1995). *Chionanthus pygmaeus* is present at two sites where acquisition is likely: Horse Creek and Snell Creek (N. Bissett, pers. comm. 1995).
- Highlands County: Protected at Placid Lakes. Purchase of the Gould Road site protected more than 100 individuals (M. Deyrup, Archbold Biological Station, pers. comm. 1995).

At The Nature Conservancy's Tiger Creek Preserve (Possum Creek Trail Scrub), Dr. Jack Stout of the University of Central Florida tagged 100 individuals, and is continuing to monitor them. He has found one seedling and many root sprouts, (I. J. Stout, in litt. 1989; report submitted to The Nature Conservancy, Winter Park, Florida). Doria Gordon of The Nature Conservancy suggests that further research is needed on recruitment in this species.

Although both native species of *Chionanthus* are valuable ornamentals, their availability is limited by the difficulty of propagation from cuttings (Dirr 1990).

Cladonia perforata – Florida perforate cladonia, map 5, p. 97

This lichen inhabits otherwise bare sand in scrub vegetation, often near rosemary bushes. It may require some degree of shade to survive, but how much is uncertain (A. Herndon, Florida International Univ., in litt. 1995), and it is in full sun in coastal dune vegetation of the Florida panhandle (Florida Natural Areas Inventory element occurrence sheets).

Cladonia perforata was first collected by George Llano in 1945 on Santa Rosa Island, and was named by Evans (1952). Although both Llano and Evans stated that the site was in Escambia County, it was actually in Okaloosa County (Wilhelm and Burkhalter 1990) and was paved by the time Llano revisited in the mid 1950's. The lichen was next collected by Moore (1968), who found it in Highlands County during her massive survey of Florida lichens. Buckley and Hendrickson (1988) relocated the remnants of Moore's population, and searched the surrounding area, including Archbold Biological Station, where blankets of lichens occur on 84 "rosemary balds," small hills of excessively drained sand (Archbold soil series) occupied by Florida rosemary and small vascular plants (including *Hypericum cumulicola* and *Eryngium cuneifolium*). Buckley and Hendrickson (1988) found *Cladonia perforata* on only six of the rosemary balds, and they reported that ecologist Ann Johnson found the lichen on a seventh bald. They extended the search beyond Archbold Biological Station, finding *Cladonia perforata* only in a 6 square mile area south and west of the Station.

² A "Natural Areas Protection Plan for the Allan David Broussard Memorial/Catfish Creek Preserve" was prepared for The Nature Conservancy during its ownership of this property. A similar plan was prepared for Saddle Blanket Lakes (Eugene Kelly, Southwest Florida Water Management District, in litt. 1995).

Wilhelm and Burkhalter (1990) found the lichen near its original locality on Santa Rosa Island (Eglin Air Force Base, Okaloosa County) but nowhere else on the Gulf barrier islands, despite searching from Gulf Shores, Alabama to Grayton Beach, Florida.

The Florida Natural Areas Inventory (FNAI) surveyed for *Cladonia perforata* in rosemary scrub at 111 sites throughout Florida (Hilsenbeck and Muller 1991). They enlisted James Allison and Thomas Patrick (Georgia Freshwater Wetlands and Heritage Inventory) to search similar areas in southeast Georgia (15 sites in 8 counties). Separately, Ann Johnson and FNAI collaborators searched coastal scrubs in southeast Florida (Martin, Palm Beach, and St. Lucie Counties). Hilsenbeck and Muller assembled the data to show that the lichen had been found at only 12 sites (including the 6 on Archbold Biological Station). In Okaloosa County, they confirmed the two known sites on Santa Rosa Island. In Highlands County, they found that one site had recently been destroyed, and failed to find any new sites. They concluded that the lichen is rare, with an estimated total of at least 26,000 individuals: 17,000 on one private site, 3,000 on another, 4,400 on Archbold Biological Station, and only 1,300 individuals on Santa Rosa Island.

Subsequent field work at Eglin Air Force Base found that the known *Cladonia perforata* site at the eastern end of Santa Rosa Island (also called Okaloosa Island) extended 1.3 miles west starting at the Coast Guard station. The lichen covered hundreds of square meters. Two much smaller sites are roughly 9-10 miles west of the inlet, in an area closed to the public. *Cladonia perforata* occurs in full sun, associated with other lichens including *Cladonia leporina*, *C. prostrata*, and *C. subsecta*. Herbs on the dunes include *Balduina angustifolia*, *Paronychia erecta*, *Polygonella polygama*, *Helianthemum arenicola*. Woody plants are sand pine trimmed by salt spray, myrtle oak, live oak, and rosemary (Florida Natural Areas Inventory element occurrence record, 1995, provided by Richard McWhite, Eglin Air Force Base; also A. Schotz, Alabama Natural Heritage Program, in litt. 1995).

The current situation, by county, is:

- Okaloosa: Eglin Air Force Base suffered a direct hit from Hurricane "Opal" in October 1995. The lichens were destroyed or stranded in vegetation. Salvage and reintroduction from surviving material is being attempted (Paula T. DePriest, Department of Botany, National Museum of Natural History, Smithsonian Institution).
- Highlands: The largest private site is protected by its owner; neither State nor Federal acquisition is contemplated. The lichen is also protected at Archbold Biological Station. Since the FNAI survey, *Cladonia perforata* was found at the Lake Apthorpe Preserve in Highlands County (G. Babb, The Nature Conservancy, pers. comm. 1991; voucher specimen by Eric Menges at Archbold Biological Station). It is also on the South Florida Community College campus (R. Yahr, Archbold Biological Station, in litt. 1995).
- Polk: The lichen has been found at the Trout Lake North site, which might be purchased (R. Yahr 1995), and Kris DeLaney (in litt. 1995) has found other populations of *Cladonia perforata* here and in northern Highlands County. Sites are in all likelihood being lost to development faster than they are being found. He emphasizes the need to carefully search rosemary scrub.
- Martin and Palm Beach: *Cladonia perforata* has been found on the Atlantic coastal ridge at Jonathan Dickinson State Park in Martin County and at Jupiter Ridge Natural Area and Jupiter Lighthouse in northern Palm Beach County. The lichen populations at Dickinson Park are as large as any known to exist (R. Roberts, Jonathan Dickinson Park, pers. comm., August and November 1994; Bureau of

Land Management 1996). Identification of the lichen at Jupiter Lighthouse was confirmed by Roberts and collaborators, Feb. 1995). At these coastal sites, *Cladonia perforata* occurs near but not adjacent to the endangered *Asimina tetramera*. A report of *Jacquemontia reclinata* at the lighthouse has proven incorrect; the plant is *Stylisma villosa* (K. DeLaney, pers. comm. 1995).

• Manatee: Kris DeLaney (in litt. 1995) reports that he is finding populations.

The conservation biology of *Cladonia perforata* became an urgent concern after hurricane Opal struck the Gulf Coast lichen populations in October 1995. Paula T. DePriest (National Museum of Natural History, Smithsonian Institution) was immediately recruited by the Air Force to suggest how to reintroduce the lichen. She has suggested a course of action and has visited *Cladonia perforata* sites both on the Gulf and at Archbold Biological Station.

The need for lichen conservation probably extends beyond *Cladonia perforata*. Masses of *Cladonia* lichens covering the ground in dry forests and scrub are a feature of the Florida landscape, and Florida apparently has several endemic species of *Cladonia*. *Cladonia evansii* and *C. subtenuis* are collected to serve as miniature trees and shrubbery for architectural and other models. No assessment has been made of potential threats to lichens from collecting or from pedestrian or off-road vehicle traffic. Little seems to be known about *Cladonia* ecology, especially their relation to fire. At Lake Apthorpe, the Nature Conservancy is monitoring the results of a prescribed fire that unintentionally burned into a *C. perforata* population. The Jupiter Ridge Natural Area and Trout Lake, North sites may offer opportunities to observe lichens invading areas disturbed by off-road vehicles (R. Yahr, in litt. 1995). *Cladonia perforata* in rosemary scrub at Archbold Biological Station increased in abundance from 4 to 20 years after fire but not afterward. Other ground lichens at Archbold continued increasing (Menges and Kohfeldt 1995).

It is possible to study the population structure of lichens and their genetic variation, using morphological, chemical, and genetic characters and markers, and these methods may prove very helpful in restoring damaged lichen populations such as those at Eglin Air Force Base (Paula DePriest, National Museum of Natural History, pers. comm. 1995). Apparently the only American paper on lichen succession is Robinson (1959, summarized in Hale 1967).

Clitoria fragrans – pigeon wings, map 6, p.98; drawing 3, p. 116

This herb whose common name of “pigeon wings” comes from Fanz (1979) is one of three species of the genus occurring in the southeastern states. The others are the native butterfly pea, *Clitoria mariana*, and a butterfly pea escaped from cultivation, *Clitoria ternata*.

Clitoria fragrans occurs in scrub, scrubby high pineland, and at least at the edges of high pineland (Christman and Judd 1990); it appears to have habitat preferences similar to *Eriogonum longifolium* var. *gnaphalifolium* and *Polygala lewtonii*, although its range does not extend as far north as these species. Fanz (1979) considered it a species of white sand soils, while the *Eriogonum* and *Polygala* tend to occur on yellow sand. Christman (pers. comm. 1992), Margaret Evans (Archbold Biological Station, pers. comm. 1995) and Kris DeLaney (pers. comm. 1995) emphasize that this is primarily a species of yellow sand turkey oak or hickory areas, but DeLaney has seen it in white sand scrub at Carter Creek and other sites.

The distribution of *Clitoria fragrans* is on the Lake Wales Ridge, except as noted (Fanz 1977, Wunderlin et al. 1980a, Christman 1988c). By county:

- Highlands: Protected at the State's Placid Lakes tract, Archbold Biological Station, and Lake Apthorpe. It is also present at several sites where land acquisition is beginning, including Carter Creek (Sebring Highlands subdivision). It may be present on land owned by the Southwest Florida Water Management District at Henscratch/Jack Creek (Eugene Kelly, SWFWMD, in litt. 1995).
- Polk: Protected at Arbuckle State Preserve, the Arbuckle and Lake Walk-in-the Water tracts of Lake Wales Ridge State Forest, Catfish Creek, Tiger Creek (The Nature Conservancy), Saddle Blanket Lakes, and the Pine Ridge Nature Preserve at Bok Tower Gardens (Tammera Race, Bok Tower Gardens, in litt. 1995). *Clitoria fragrans* is protected on Avon Park Air Force Range (Bombing Range Ridge) (Florida Natural Areas Inventory, confirmed by a recent Defense Department survey).
- Lake: Collected at Leesburg, north of the Lake Wales Ridge, in 1910 (Fanz 1977).
- Osceola: 12 miles south of Holopaw via US 441. This site is on one of a series of low ridges east of the Lake Wales Ridge, with scrub vegetation, in ranching country (Fanz 1977). These ridges have obviously not been carefully searched for this or other endemic plants.

Studies at Archbold Biological Station have documented positive post-fire responses in flowering and vegetative growth (Eric Menges, Archbold, in litt. 1995). Monitoring of *Clitoria fragrans* at Archbold is being done with the help of school children (Mark Deyrup, Archbold, pers. comm. 1995). This plant has been observed to appear, and flower at a site that had not been burned for 30 years, so it evidently persists despite shade and litter, maintaining reserves in its substantial roots. The spurt of flowering is nearly finished one year after the fire. It appears that lack of fire and canopy closure suppress this plant, resulting in reduced vegetative vigor and reproduction. Prescribed fire is therefore crucial to the recovery of this species (R. Yahr, E. Menges, Archbold Biological Station, in litt. 1995).

Donald Richardson (pers. comm. 1995) noted that this species never occurs in dense populations. He has never seen more than 20 to 30 plants per site. Avon Park Air Force Range is developing a rare plant monitoring protocol for this species under contract with The Nature Conservancy (P. Ebersbach, Avon Park, in litt. 1995).

Conradina brevifolia - short-leaved rosemary, map 7, page 99; drawing 4, p. 117

This is one of five shrubby mints in the interior central Florida scrub. The others are *Calamintha ashei* (a species that might qualify for Federal listing), *Dicerandra frutescens*, *D. christmanii*, and a *Dicerandra* population whose taxonomic status is unresolved. *Conradina brevifolia* was described as a new species by Shinnars (1962). It is very similar to the relatively widespread, and quite variable *Conradina canescens* of the Florida panhandle, Alabama, and Mississippi, and it is similar to the endangered *Conradina glabra* of the Apalachicola bluffs (Gray 1965, U.S. Fish and Wildlife Service 1994). As its name implies, *Conradina brevifolia* has shorter leaves than the other species: the larger leaves on well-developed flowering branches are 6.0-8.2 mm long, and mostly shorter than the internodes. *Conradina brevifolia* was upheld as a distinct species in careful taxonomic reviews by Gray (1965) and Kral and McCartney (1991), as well as in Wunderlin et al. (1980d) and Kral (1983). However, Wunderlin (1982) included *C. brevifolia* in *Conradina canescens*, without noting *C. brevifolia* as a synonym, as did DeLaney and Wunderlin (1989).

Conradina brevifolia inhabits sand pine scrub vegetation on the Lake Wales Ridge, where it occurs only in about 30 scrubs whose combined areas total less than 6,000 acres (Christman 1988c). Although it is narrowly distributed, it is nevertheless more widespread *Eryngium cuneifolium* or *Hypericum cumulicola* (Kris DeLaney, in litt. 1995). Its distribution by county:

- Polk: Protected at Lake Arbuckle State Preserve and the Arbuckle tract of Lake Wales Ridge State Forest, and at Saddle Blanket Lakes.
- Highlands: The State is attempting to acquire the best available habitat, at Carter Creek.

Recent research on *Dicerandra* (McCormick et al. 1993, Menges 1992, and Menges 1995) is likely to be relevant to *Conradina brevifolia*. Menges found that plants that are burned, clipped, or defoliated, die. The plants are unable to regrow from their underground parts. Anecdotal reports that *Dicerandra* has spread into areas that are disced regularly (probably annually) at Horse Creek and along Interstate 75 (Steven Tonjes, Florida Dept. of Transportation and Michael Goralski, pers. comm. 1995) indicate that similar treatments may work for *Conradina*. Experience with managing *Conradina glabra* in and near The Nature Conservancy's Apalachicola Bluffs and Ravines Preserve should also prove relevant to managing the short-leaved rosemary. Reed Crook, a graduate student at the University of Georgia, is studying the genus *Conradina*, including *C. brevifolia*.

Crotalaria avonensis – Avon Park harebells, Avon Park rabbit bells, map 8, p. 100; drawing 5, p. 118

This small herb with large seed pods was not named until 1989, evidently because very few specimens had ever been collected and they had not been examined by taxonomists, such as Windler (1974). This species is most closely related to *Crotalaria rotundifolia*, a variable species that ranges from Virginia to Panama (DeLaney and Wunderlin 1989). *Crotalaria avonensis* inhabits scrub, where it typically grows in full sun on bare white sand or in association with clumps of *Cladonia* lichens. Many individuals occur in partial shade of other plants (DeLaney and Wunderlin 1989). It is a perennial with a substantial taproot that presumably enables it to resprout after fire. It appears to depend on bare patches in scrub, like the other small scrub endemics. It seems immune to allelopathic effects from shrubs, and it invades disturbed areas (K. DeLaney, pers. comm. 1995). There is no similarity in population biology between this species and the species of *Crotalaria* that are robust annual weeds.

Crotalaria avonensis is one of the most narrowly distributed of the Lake Wales Ridge endemics. Its distribution (K. DeLaney, in litt. 1991):

- Polk: Avon Park Lakes acquisition area and Saddle Blanket Lakes State Preserve.
- Highlands: Carter Creek acquisition area.

At the protected Saddle Blanket Lakes site, the *Crotalaria avonensis* population is estimated by Doria Gordon (The Nature Conservancy, pers. comm. 1995) at 200 plants. Avon Park Lakes, which is platted, is developing fast enough to make land acquisition difficult (the area was excluded from plans for the Lake Wales Ridge National Wildlife Refuge for this reason), and the area has infestations of cogon grass in yellow sand areas (E. Menges, Archbold Biological Station, pers. comm. 1995). At Carter Creek, Florida government is having difficulties with land acquisition. *Crotalaria avonensis* is threatened both by incipient development, by placement of shell along roads (altering the soil in areas that might be invaded by *Crotalaria*), and by proliferation of Bahia grass along those roads. Dumping is also a problem.

Eriogonum longifolium var. *gnaphalifolium* – scrub buckwheat, map 9, page 101

Eriogonum is a genus of about 150 species, most of them in western North America. Florida has only two species, both native to high pineland: *Eriogonum tomentosum* is common throughout the northern part of the state, as far south as Highlands County. The second species, scrub buckwheat, was named *Eriogonum floridanum* by J.K. Small (1903). Subsequent publications on Florida's flora consistently adopted Small's treatment of *E. floridanum* as a full species (Small 1933, p. 445; Kral 1983, p. 326; Ward 1979, p. 86; Wunderlin 1982, p. 169), but James Reveal (1968), the expert on the genus, treats the Florida plants as a variety of *Eriogonum longifolium*, a widespread species of the Great Plains that is represented east of the Mississippi by var. *harperi* in northern Alabama, Tennessee, and Kentucky (Kral 1983 and Kentucky heritage program data), and by var. *gnaphalifolium* in Florida.

Scrub buckwheat "occurs in habitats intermediate between scrub and sandhills [i.e., in scrubby high pineland] . . . from Marion County to Highlands County" (Christman 1988c). Its historic distribution is as follows:

- Marion: The northern range limits for scrub buckwheat are in Ocala National Forest and in areas of mixed scrub and high pine south of Ocala. It is abundant in the National Forest.
- Sumter: No records, but suitable habitat—and possibly the plant—extends south from Marion into Sumter County.
- Pasco County: Sandhill area within the Green Swamp property owned by the Southwest Florida Water Management District (Eugene Kelly, SWFWMD, in litt. 1995). Apparently not present on Withlacoochee State Forest in Hernando County, where personnel are familiar with *E. tomentosum*.
- Hillsborough County: Scrub buckwheat may have occurred in the Tampa area, if a specimen cited by Gandoger (1906) as the type of "*E. longifolium* var. *floridana*" belongs to this variety.
- Lake County: collected near Eustis around the turn of the century, and it still occurs near Clermont in remnants of high pine with *Polygala lewtonii* and several other endangered plant species.
- Orange County, southwest corner.
- Osceola County, northwest corner.
- Polk and Highlands counties, on the Lake Wales Ridge as far south as Archbold Biological Station, south of Lake Placid. Most of the recent records for the species are from Polk and Highlands Counties, partly because intensive biological surveys of scrub vegetation have been conducted in those counties (Christman 1988c; pers. comm. by K. DeLaney and E. Menges, 1991). It is protected at Lake Arbuckle State Preserve, the Arbuckle and Lake Walk-in-the-Water tracts of Lake Wales Ridge State Forest, Catfish Creek State Preserve, the Lake Aphorpe preserve, the Nature Conservancy preserve at Tiger Creek, and Archbold Biological Station. More sites will be protected as State or Federal land acquisition proceeds.

Other listed plants, including *Polygala lewtonii*, *Chionanthus pygmaeus*, and *Prunus geniculata*, occur in the same places. In Ocala National Forest, scrub buckwheat occupies 71 areas (*Bonamia grandiflora* is in 52, *Polygala lewtonii* in 48), extending through the westerly part of the Forest from Fore Lake south along county Road 314 to the area between Big Bass and Nicotoon Lakes along State Road 42 at the Forest's southern boundary, an area of about 23 miles from north to south and six miles east to west (J. L. Clutts, Lake George Ranger District, in litt. 1995).

A Forest Service survey (Brandt 1992) and subsequent surveys in 1994 and 1995, located 976 scrub buckwheat plants in longleaf pine with wiregrass and turkey oak; 20 plants in areas where slash pine had been planted in high pineland, and 400 plants in sand pine scrub. The forest stands represented a variety of condition classes, from in-regeneration to mature poletimber, and the scrub buckwheat plants were well within stands, flowering in filtered light situations, not just along roadsides. Forest Service biologists conclude that the plant persists without regard to site preparation practices. The longleaf pine sites had some combination of mowing, single chopping, herbicide application (Arsenal[®] mixed with Accord[®] or Velpar[®], releasing by chain saw, prescription burning, and machine planting. Sand pine scrub was either not site-prepared or site-prepared by either single-chopping or burning, and seeded by either broadcast seeding, row seeding, or row-bracke seeding. The apparent tolerance of scrub buckwheat for these various practices may be due to its woody taproot.

Scrub buckwheat's recovery from a site-preparation burn at a recently-clearcut site in Ocala National Forest was observed by Carrington (1993), a graduate student in botany at the University of Florida. The resprouting plants flowered within a month of the July fire, and seedlings were observed three months later.

There was a different response among scrub buckwheat plants in a relict longleaf pine site encroached by sand pine, after the 50-year old sand pine was logged on March 9, 1995, followed by a prescribed burn in May. The fire was fast-moving and unexpectedly intense, even jumping a plowline. Thirty scrub buckwheat plants were selected before the logging and prescribed burn. Twenty plants with live basal rosettes were relocated afterward; ten had apparently died. Of the 20 live plants, 15 flowered. There may be a correlation between pre-fire flowering and post-fire mortality or flowering. Some of the plants that died had produced four flower stalks before the fire, while plants that had produced only one flower stalk before the fire sent up six stalks afterward. Possibly, plants that recently flowered heavily lacked reserves to recover from the disturbance. Partial excavation around the roots of several dead plants showed that most of them had tap roots as large as those of plants that survived the fire. Another possibility is that the abrupt change from partial shade to direct sun stressed the plants. Rainfall, or more accurately, soil moisture, may have been a factor. Rainfall in May was close to the ten-year average, but local conditions were dry, as shown by the intensity of the fire (in northern Florida, plants often suffer water stress in spring as their rapidly increasing evapotranspiration outpaces the seasonal increase in rainfall). Rainfall in the wet months of June, July, and August was higher than the ten-year average. The Forest Service will continue monitoring scrub buckwheat (J. L. Clutts, Lake George Ranger District, in litt. 1995).

Open, grassy high pinelands are attractive to recreational off-road vehicle users. Recreational use in protected areas must be assessed to ensure that this species is not harmed.

Eryngium cuneifolium – a **snakeroot**, map 10, p. 102; drawing 6, p. 119

Eryngium cuneifolium occurs only on bare white sand in scrub, usually with rosemary. It occurs only on the southern Lake Wales Ridge in Highlands County. The northernmost site is on a dune on the south side of Lake Jackson in Sebring (K. DeLaney, in litt. 1989). All other sites are in an area about 24 miles long from the southern side of Josephine Creek to the southern tip of the Lake Wales Ridge (K. DeLaney, in litt. 1995). Christman (1988c) reports only about 20 localities, but even this number is

misleadingly large because he divided several large sites. Johnson (1981) and Abrahamson et al. (1984) showed that Archbold Biological Station has about 90 rosemary balds. Only about 12 of them have *Eryngium cuneifolium* and 30 have *Hypericum cumulicola*. Most balds have *Polygonella basiramia*, and all have *Paronychia chartacea* (Eric Menges, Archbold Biological Station, pers. comm. 1989). A recent 40-acre addition to the Archbold property (acquired through a habitat conservation plan for Florida scrub jay) has abundant *Eryngium cuneifolium*, which apparently proliferated after the former owner root-raked the area. *Eryngium cuneifolium* is reported to occur at the site that is being acquired as a State Park on the west side of Lake June in Winter (R. Burns, The Nature Conservancy/M. Deyrup, Archbold Biological Station, pers. comm. 1994). Ann Johnson (in litt. 1988) thinks her report of outlying populations in Collier and Putnam counties (Johnson 1981) is mistaken: she did not distinguish *Eryngium cuneifolium* from the more widespread *Eryngium aromaticum*.

Eryngium cuneifolium is currently protected at Archbold and the State's Placid Lakes and Lake Apthorpe preserves (Robert Burns, The Nature Conservancy, pers. comm. October 1989). Acquisition of the Holmes Avenue tract for the State preserve system is proceeding. The plant is present on a right of way managed by Florida Power (N. Bissett, pers. comm. 1995).

Microhabitat of *Eryngium cuneifolium* significantly affected survival, growth, and fecundity over a 4-year period. This species is most abundant in gaps at larger distances from shrubs, particularly *Ceratiola ericoides* and *Calamintha*, both putative allelopathic species. As time-since-fire increases, open patches in rosemary scrub tended to close, and *Eryngium* underwent a rapid decline. Pedro Quintana-Ascencio's current studies on rosemary scrub may demonstrate that *Eryngium* is particularly sensitive to gap closure, even compared with other gap species such as *Hypericum cumulicola* and *Polygonella basiramia* (Menges and Kimmich 1995). The exacting habitat requirements of *Eryngium cuneifolium* mean that, despite large populations at several sites (possibly millions of individual plants in its range), its habitats must be managed aggressively to maintain the gaps that *Eryngium* needs. Eric Menges and his associates are experimenting with fire at Archbold Biological Station and Lake Apthorpe. *Eryngium cuneifolium* recovers from fire by resprouting and by seedling recruitment from the seed bank (Menges and Kimmich 1996). This fire-recovery strategy is similar to that of *Bonamia grandiflora*.

Hypericum cumulicola – **Highlands scrub hypericum**, map 11, p. 103; drawing 7, p. 120

This herb is restricted to scrub in Polk and Highlands Counties, from the 27 Truck Stop just north of Sunray, Polk County (K. DeLaney, pers. comm. 1989) to the south end of the Lake Wales Ridge (Judd 1980b). *Hypericum cumulicola* is protected at:

- Highlands County: Archbold Biological Station and the Placid Lakes and Lake Apthorpe preserves.
- Polk County: Lake Arbuckle State Preserve, the Arbuckle tract of Lake Wales Ridge State Forest, and Saddle Blanket Lakes.

Like *Eryngium cuneifolium*, *Hypericum cumulicola* is almost exclusively limited to rosemary scrub; it occurs occasionally in adjacent openings in well-drained scrubby flatwoods. It was present at only 69 of the 254 scrub sites surveyed by Christman (1988c), but within those sites, it is locally common (R. Yahr, Archbold, in litt. 1995). Fire suppression hurts this species, just as it does *Eryngium*, although too much fire can be harmful. Patchiness is best, and fire in preserves needs to be carefully planned but flexible (Pedro Ascencio-Quintana, Archbold Biological Station, pers. comm. 1995).

The demography and competitive relationships of *Hypericum cumulicola* are being studied by Pedro Quintana-Ascencio at Archbold Biological Station, in work related to similar studies of *Eryngium*. So far he has followed 15 populations for a year. This species has a flexible life span, reaching full size in as little as a year.

Margaret Evans (in litt. 1995) recently completed a study of the breeding system of *Hypericum cumulicola* at Archbold. The results of this experiment, although not analyzed formally, indicate that *H. cumulicola* is fully self-compatible, not apomictic, and autogamous at only a low rate (10% fruit set). At Archbold it is pollinated by small solitary bees such as *Augochloropsis* sp. and *Dialictus* sp., and is visited by native bumblebees (*Bombus* sp., *Geron* sp., and *Copetiliium nigrum*). These bees are only active in the morning, so this plant has relatively specialized pollination. This plant has a very long flowering season, from March to December (peaking from April to October [Menges and Salzman 1992]), and although only on a given day only a single flower may be open, a single plant may produce up to 4,000 fruits (M. Evans, Archbold Biological Station, pers. comm. 1995). This species maintains a substantial seed bank, from which there is vigorous recruitment after a fire. Burned plants do not resprout (P. Quintana-Ascencio, pers. comm. 1995).

Liatris ohlingerae – scrub blazing star, map 12, p. 104; drawing 8, p. 121

Liatris is an eastern North American genus of perennial herbs (Gaiser 1946), of herbs of open, usually fire-maintained habitats, with two species and one variety endemic to Florida, and one species endemic to Florida and the Bahamas (Muller et al. 1988). At least one other endemic, *Liatris provincialis* of the Gulf coast in northwestern Florida, is of conservation concern. The genus *Liatris*, especially *L. spicata*, is economically important as a source of garden perennials and cut flowers. *Liatris ohlingerae* is entirely distinct from other members of the genus.

As of 1990, *Liatris ohlingerae* was found at 93 localities, 71 of them in Highlands County (Christman 1988c), the rest in Polk. Its geographic distribution is:

- Polk County, southward from a line extending from near Lake Blue and Auburndale to Catfish Creek (north of Highway 60 east of Lake Wales) (Nancy Bissett, The Natives nursery, Davenport, Fla., in litt. 1988). It is protected at Saddle Blanket Lakes, Lake Arbuckle State Preserve, the Arbuckle tract of Lake Wales Ridge State Forest, and Catfish Creek Preserve.
- Highlands County from the Polk county line south along the Lake Wales Ridge through Sebring to Archbold Biological Station at the south end of the Ridge. Sites are protected at Archbold Biological Station, Placid Lakes, and Lake Apthorpe; another site may become protected as Highlands Hammock State Park is expanded.

Liatris ohlingerae is restricted to scrub, particularly the edges of rosemary balds. It grows under rosemary bushes, so it is evidently not affected by allelopathic chemicals produced by rosemary (Herndon 1995).

Alan Herndon (1995) of Florida International University is studying the life history of this species, with emphasis on the level of seed production (difficult because many full-sized fruits lack seed, and the fertile and sterile fruits cannot be distinguished visually). He is also examining recruitment into populations and small-scale environmental features associated with *Liatris ohlingerae*. He is comparing *L. ohlingerae* to *L. laevigata*, a species that occurs both in scrub and flatwoods. Herndon has reviewed

the substantial literature on the ecology of other species of *Liatris*, which includes work on pollination and mycorrhizal associations. Margaret Evans of Archbold Biological Station (in litt. 1995) is finishing research on the reproductive biology (breeding system and pollination) and ecology of *Liatris ohlingerae*. The results are preliminary, but she believes they indicate *L. ohlingerae* is self-incompatible, not autogamous, and not apomictic. *L. ohlingerae* is primarily pollinated by lepidopterans, especially “skippers” (at least at Archbold).

Lupinus aridorum – scrub lupine, map 13, p. 105

Isely (1986) evaluated the systematics of *Lupinus aridorum* for his floristic treatment of the pea family in the Southeast (Isely 1990), concluding that the pink-flowered *Lupinus aridorum* belongs to the same species as *Lupinus westianus* of the Gulf Coast of northwest Florida, which differs mainly in flower color (blue). Isely treats the central Florida plant as *Lupinus westianus* var. *aridorum* (McFarlin ex Beckner) Isely. The Service is continuing to use the older name to avoid confusion, perhaps until the forthcoming Flora of North America treatment is published. *Lupinus westianus* is of conservation concern because of development in its coastal habitat. The Florida Natural Areas Inventory is developing site-specific management guidelines for it. These guidelines may prove helpful for working with *L. aridorum*.

There are probably fewer than 1,000 plants of *Lupinus aridorum* in existence (not counting viable seeds in the soil) (Stout and Charba 1992), and land values are high, so it is essential to take advantage of any opportunities to conserve habitat. It is this recovery plan's only species that is absent from the Lake Wales Ridge. It is known from two distinct areas:

- Western Orange County (Orlando area) on the southern Mount Dora Ridge from the Apopka-Plymouth area south through Ocoee, Turkey Lake, Lakes Cain and Marsha, Big Sand Lake, and Interstate 4 from the Bee Line Expressway south past Lake Buena Vista. These sites totaled about 2,400 acres (Christman 1988c), although the lupine did not occupy any site in its entirety. The lupine occurs with *Bonamia grandiflora*, *Paronychia chartacea*, *Polygonella myriophylla*, and *Prunus geniculata* (U.S. Fish and Wildlife Service 1987d; Wunderlin 1984a). In this first area, the plant occurs at Lakes Cane and Marsha Park, belonging to Orange County (I. J. Stout, in litt. 1989), Turkey Lake Park (City of Orlando), the Florida Turnpike right-of-way near the East-West Expressway, and (at least formerly) the Interstate 4 right-of-way near Vineland.
- North-central Polk County on the Winter Haven Ridge near Auburndale and Winter Haven, on sites that total only about 540 acres. A reported locality for the lupine from the vicinity of Lake Arbuckle is actually *Lupinus diffusus* (K. DeLaney, pers. comm. 1989, Christman 1988c).

Lupinus aridorum is a short-lived perennial that declines after the first season of flowering (Beckner 1982; I. J. Stout, Univ. of Central Florida, pers. comm. 1992). This reproductive cycle, combined with the susceptibility of the plant to root rot both in the wild and when cultivation is attempted, creates severe problems for conservation (S. Wallace, Bok Tower Gardens, pers. comm. 1989). Similarly, the more abundant *Lupinus diffusus*, also native to central Florida, falls victim to fungus under nursery conditions. The species also does not transplant well, even when very young (N. Bissett, in litt. 1986). The best approach for augmenting existing populations of lupines or establishing new ones is almost certainly to directly sow seed at the site.

Site visits and more formal monitoring have improved our understanding of this species. Bissett (in litt. 1989) visited six populations of *Lupinus aridorum* near Winter Haven in spring of 1989. She found only five living plants, four of them at one site. Another site near Eagle Lake had 20 plants. The plants may have been damaged by a March freeze that had followed a very warm winter that had stimulated *L. diffusus* to flower in February. Stout and Charba have visited some of these sites since then. Stout has pointed out that in the Orlando suburbs, clearing of sand pine forests for construction causes scrub lupine seeds to germinate in the newly-cleared areas. One such forest was dense sand pine with an understory mostly of rosemary. The stand was evidently even-aged, and had grown up after a stand-replacing fire. Presumably *Lupinus aridorum* had thrived for the first few years after the fire, then persisted as a seed bank until the next disturbance.

Nolina brittoniana – scrub beargrass, map 14, p. 106; drawing 9, p. 122

The genus *Nolina*, which belongs to the agave family, is centered in western North America (Mabberley 1987), so the three species in the Southeast represent a western element in the flora, as does *Ziziphus*. Florida has two species of *Nolina*. The other species, *Nolina atopocarpa* (Bartlett 1909) occurs in Franklin and Liberty counties west of the Suwannee River and in a few counties on the east coast and in central Florida, including St. Johns, Marion (Ocala National Forest, collected by R. Simons and D. Hall, 1988), Osceola (R. Schultz, Osceola County pers. comm. 1990), Brevard (M. Hames, pers. comm. 1988), and Charlotte (Burnt Store Road south of Punta Gorda [R. McCartney, Woodlanders Inc., pers. comm. 1990]). *Nolina atopocarpa*, a flatwoods species, may occur near *Nolina brittoniana*; it can be distinguished by its shorter leaves, flowers that are greenish rather than white, and fruits that are asymmetric. The third southern species of *Nolina*, *N. georgiana*, is restricted to Georgia and South Carolina (Jones and Coile 1988, Ward 1968).

Nolina brittoniana has symmetrical fruits, triangular in cross section. Its long, narrow leaves probably live several years; flower stalks may be produced annually. A large population of *N. brittoniana* occurs at The Nature Conservancy's Lake Apthorpe Preserve, where the number of individuals is somewhere in the hundreds, probably about 500, so the impression that this species occurs as scattered individuals is not always correct. A taxonomic treatment of the three southeastern species of *Nolina* was completed by Thorne (1965); he presented results of work on its ecology, morphology, and cytology, as well as information on the reproductive biology of all three species (M. Evans, Archbold Biological Station, in litt. 1995).

Nolina brittoniana occurs in scrub, high pineland, and even occasionally in hammocks (Christman 1988c). It ranges from the south end of the Lake Wales Ridge in Highlands County north to Orange County (Orlando) and northern Lake County. The plant was collected in Hernando County, north of Tampa, in scrub, in 1961 (Wunderlin et al. 1980b), and in 1994 there was a report, not yet confirmed, from Brevard County on the east coast. The known distribution is:

- Marion County: Collected near Belleview in 1928, on "low ground." Christman (1988c) doubts this locality. Robert McCartney (pers. comm. 1990), a knowledgeable field worker, considers the northern range limit for *Nolina brittoniana* to be northern Lake County.
- Hernando County: Collected in a "much disturbed, old white sand scrub with hardwood intrusion" in 1961 (herbarium specimen cited in Wunderlin et al. 1980b). The presence of *Dicerandra*

cornutissima near Dunellon and *Persea humilis* at the Southwest Florida Water Management District's Potts Preserve in eastern Citrus County indicates that it would be worthwhile to conduct a comprehensive survey of scrub in Citrus, Hernando, and western Marion counties (Eugene Kelly, Southwest Florida Water Management District, in litt. 1995).

- Lake County: In remnants of high pineland on hills west of Lake Apopka, near Clermont. A recent survey (Race and Orzell 1995) may suggest other areas to search. The type specimens of *Nolina brittoniana* were collected near Eustis in 1894 (Nash 1895), and it was collected near Tavares in 1941.
- Osceola County: Northwest corner, adjacent to Interstate 4 (sighting, apparently not documented).
- Orange County: Protected by a conservation easement on a private 35 acre tract in western Orange County, along with *Lupinus aridorum*, *Polygonella myriophylla*, *Bonamia grandiflora*, and other species. It may be present in parks (such as Turkey Lake), but this is not confirmed.
- Highlands and Polk Counties: *Nolina brittoniana* occurs in more or less dense colonies in several locations, including Trout Lake, North; Henscratch; and Lake Apthorpe, among others (R. Yahr, in litt. 1995). Both the Lake Walk-in-the-Water and Arbuckle units of Lake Wales Ridge State Forest have substantial populations (C. Weekly, Division of Forestry, pers. comm. 1996). It is present in most of the tracts targeted for acquisition by the State or by the Fish and Wildlife Service. A high pineland site for the species is at the Pine Ridge Nature Preserve at Bok Tower Gardens (Tammera Race, Bok Tower Gardens, in litt. 1995).

Nolina brittoniana is clonal, producing new rosettes at the end of short runners (E. Menges, Archbold Biological Station, in litt. 1995), but genetic data on *N. brittoniana* populations indicate normal variability. The southwestern species of *Nolina* are much more clumped/clonal, so their population genetics are probably quite different (Menges, pers. comm. 1995). The tendency of plants to have male or female flowers helps mark clones, making crude clone mapping possible during the flowering/fruitletting season.

The demography of *Nolina brittoniana* is being monitored at Tiger Creek Preserve by The Nature Conservancy. Margaret Evans has studied its breeding system and pollination. It is effectively dioecious, meaning that it has separate male and female plants (with a few exceptions). Seed is produced only through pollination, not apomictically (Thorne 1965, M. Evans, Archbold Biological Station, in prep.). It exhibits a generalist pollination syndrome, being pollinated throughout the day by a variety of floral visitors. *Nolina brittoniana* resprouts and flowers quickly after a fire (staff at The Nature Conservancy's Lake Wales office have data from their Tiger Creek Preserve; Margaret Evans at Archbold also has data). This is important in that it represents a pulse of reproduction and potentially, subsequent recruitment of new individuals to the population. This strongly suggests it is adapted to fire, although Evans doubts that adequate data are available to prove this. Because the other two southeastern species of *Nolina* occur in longleaf pine habitats, they are probably adapted to fire.

Nolina brittoniana is easily propagated from seed and is available in the trade (Association of Florida Native Nurseries 1995). It and other members of the genus have potential as ornamentals.

Paronychia chartacea – papery whitlow-wort, map 15, p. 107; drawing 10, p. 123

There are two geographically isolated subspecies of this small herb: subsp. *chartacea* in central Florida and subsp. *minima* L. Anderson in the Florida panhandle. Subspecies *minima* was described by Anderson (1991), several years after *Paronychia chartacea* had been listed as a threatened species. Because the entire species had been listed as threatened, the newly described subspecies Panhandle subspecies shares the threatened status of the Peninsula subspecies, so its status and conservation needs are addressed in this recovery plan. The Service anticipates taking a much more site-specific approach to the conservation of subspecies *minima* in the future.

Paronychia chartacea subsp. *minima* occupies “coarse sands along margins of karst lakes, often in nearly pure stands.” Its known distribution:

- Bay County: River Lake, Shirt Tail Lake, and White Western Lake.
- Washington County: Crystal Lake, Sand Lake, Gully Lake, a small pond adjacent to Gully Lake, Whitewater Lakes, and Boat Lake.

It is associated with *Xyris longisepala*, which is nearly endemic to these counties, and occurs in close proximity to the narrowly-distributed plants *Hypericum lissophloeus*, *Xyris isoetifolia*, and *Rhexia salicifolia* (Anderson 1991). These endemics have been under consideration for Federal listing and are the subjects of ongoing status surveys. These pond margins are being developed for homesites; in 1994, one landowner drastically reshaped much of the shoreline of one such lake without obtaining a dredge and fill permit from the U.S. Army Corps of Engineers.

Paronychia chartacea subsp. *chartacea* is restricted to scrub and man-made sandy habitats such as road rights-of-way and recently-cleared high pineland. The range of *Paronychia chartacea* subsp. *chartacea* is in the following counties:

- Lake: Known at the Crooked Lake site near Lake Louisa owned by the Southwest Florida Water Management District (N. Bissett, The Natives nursery, Davenport, Fla., pers. comm. 1995). There are also old collections.
- Orange: It is protected at Lakes Cain and Marsha Park in the southwest Orlando area.
- Polk and Highlands: It is ubiquitous in scrub on the Lake Wales Ridge in both counties, and is protected in all of the biological preserves.

On the Lake Wales Ridge, *Paronychia chartacea* subsp. *chartacea* can become very abundant, carpeting the ground in rosemary scrub after a fire. It is otherwise restricted to paths or openings in scrub (A. Johnson, pers. comm. 1989, based on observations at Archbold). Susan Wallace (Bok Tower Gardens) observed that this plant behaves, both in the garden and in the wild, as a short-lived perennial; Mark Deyrup (Archbold Biological Station) has studied the pollination biology of this plant. He found that the plants are dioecious (male and female flowers on separate plants), and that they are annual. Anderson (1991) notes that subsp. *chartacea* has repeatedly been described as annual in the scientific literature, but that it is often a short-lived perennial: “Many specimens exhibit dead tops with green, new branches developed toward the base of the plant.”

Because this plant thrives in fire lanes and along sand roads, it is the last of the small endemic plants of Lake Wales scrub to disappear from fire-protected areas. It is probably far more abundant in such artificial habitats than it is in its natural habitat, which apparently is rosemary balds. Archbold Biological Station has not monitored this plant because it thrives in fire lanes that usually do not have exotic plant

problems. The status of this species could be assessed by examining it in many fire lanes over one or two years (Eric Menges and Mark Deyrup, Archbold Biological Station, pers. comm. 1995).

Polygala lewtonii – Lewton's polygala, map 16, p. 108; drawing 11, p. 124

This small herb was first collected near Frostproof, Florida by F. L. Lewton in 1894, and was promptly named by J. K. Small (1898). *Polygala lewtonii* occurs most frequently in habitats intermediate between high pine and scrub (scrubby high pineland), as well as in both habitats (Christman 1988c, Wunderlin et al. 1981). Its distribution by county:

- Marion: *Polygala lewtonii* was collected from Ocala National Forest (Marion County) in firebreaks near Juniper Springs, 1949. Walter Judd of the University of Florida found it to be locally common on Hughes Island, one of the Forest's "islands" of longleaf pine, in 1980. Paul Kalisz found the plant in a soil/vegetation plot for his doctoral dissertation (Kalisz and Stone 1984). Careful surveys for the plant began in 1991 (C. Greenberg, Univ. of Fla., pers. comm. 1992). It is now known from 48 areas in the Forest, in an area that extends about 16 miles from north to south and six miles from east to west, from Salt Springs Island, south of county road 314, to one mile south of the Bombing Range, then jumping south for another five miles to State Road 42, west of Big Bass Lake at the Forest's southern boundary. The Kalisz site, where the plant has not yet been relocated, was seven miles north of the known range (J. L. Clutts, Lake George Ranger District, in litt. 1995).
- Lake: *Polygala lewtonii* was collected once near Eustis (James 1957, cited in Wunderlin et al. 1981). Collected in scrub four miles north of Astatula and from at least five sites in the hills between Lake Apopka and Clermont. These hills were once covered with high pine that had a number of endangered plants, including *Prunus geniculata* (scrub plum), *Nolina brittoniana* (scrub beargrass) (Wunderlin et al. 1981), and *Warea amplexifolia* (wide-leaf mustard or clasping warea) (Judd 1980a). These habitats are nearly gone.
- Osceola: Collected at the county's northwest corner, on a dry prairie above Lake Davenport, in 1974.
- Polk: *Polygala lewtonii* occurs in the Lake Walk-in-the-Water and Arbuckle tracts of Lake Wales Ridge State Forest (C. Weekly, Division of Forestry, pers. comm. 1996), Arbuckle State Preserve, Catfish Creek State Preserve (G. Babb, The Nature Conservancy, in litt. 1991), The Nature Conservancy's Tiger Creek Preserve (Wunderlin et al. 1981), at a site near Davenport that was partly bulldozed in 1991, and in the Poinciana residential development, which is mostly in Polk County, on the border with Osceola (N. Bissett, in litt. 1991). Bok Tower Gardens has a few plants on the slope of their hill (K. DeLaney, in litt. 1995).
- Highlands: Collected near Sebring in 1945 and 1955, but not seen again (Wunderlin et al. 1981) until recently, when it was found in abundance in turkey oak barrens/scrub in the southern portion of the Carter Creek area, northeast of Sebring (J. Fitzpatrick, Archbold Biological Station, pers. comm. 1992). It is apparently at Highlands Hammock State Park. Ancient dunefields on the east side of the Lake Wales Ridge in Polk and Highlands counties need to be searched (K. DeLaney, pers. comm. 1995).

At Hughes Island in Ocala National Forest, starting in the mid 1980's, the burning regime was changed from winter the growing season, about every three years. A reportedly cool summer burn covered the entire island in 1988. At that time, wiregrass was very patchy, but its cover is increasing

with continued summer burns. *Polygala lewtonii* has been observed at Stand 5 on Hughes Island before and during planting of longleaf pine. The stand was burned in winter of 1993-1994; planting was done in February and March 1994. A prescribed fire on July 23, 1995 burned only 45-50% of Stand 5 due to patches of bare sand. On August 28, *Polygala lewtonii* plants near wiregrass that had carried the fire well were already resprouting. On September 20, these plants were producing underground shoots with cleistogamous flowers. Plants outside the fire area in a scrub plowline were behaving similarly at the same time, so it is not clear whether the fire affected the plants' behavior; at least the fire did not prevent the plants from growing (J. L. Clutts, Lake George Ranger District, in litt. 1995).

Elsewhere in Ocala National Forest, 14 *Polygala lewtonii* plants were found along an old woods road that was about to be C-framed to provide a fireline. The plants were burned in a March 1993 wildfire from a mature sand pine stand that bordered the road. In late April, most of the *Polygala* plants had resprouted and two were flowering. When the area was resurveyed on September 28, 1995, the *Polygala* population had increased to about 150 clumps of plants spread over three times the area of the original population. Individuals that were partially excavated had cleistogamous flowers. Another group of 75 plants were located about 50 yards from the road in the burned stand (Boyle 1993, J. L. Clutts, Lake George Ranger District, in litt. 1995).

Forest Service personnel are not sure whether fire outside of the usual late spring/early summer flowering season of *Polygala lewtonii* stimulates this plant to flower chasmogamously. They wonder whether the expansion of wiregrass cover with summer fire will reduce the amount of bare sand patches that provide suitable habitat for *Polygala lewtonii*. This could have happened on Riverside Island, where wiregrass has become very thick under a summer burn regime; an older element occurrence record for the plant has not been relocated. They wonder whether the practice of winter burning may have allowed *Polygala lewtonii* to expand its distribution from scrub vegetation into high pineland. They will set up monitoring plots to address such questions (J. L. Clutts, Lake George Ranger District, in litt. 1995).

Polygonella basiramia - a wireweed, map 17, p. 109; drawing 12, p. 125

The Lake Wales Ridge is the center of diversity for the genus *Polygonella*, whose species have remarkably diverse growth habits ranging from tall and leafy to upright and virtually leafless (wireweeds) to prostrate (Horton 1963). Susan Wallace (Bok Tower Gardens) has observed that *Polygonella basiramia* is a short-lived perennial (it was incorrectly reported to be annual by Lewis and Crawford [1995]).

Polygonella basiramia was originally described as a variety of *Polygonella ciliata*, which is distributed on inland ridges north of the range of *Polygonella basiramia* and along the Gulf and Atlantic coasts of the Florida peninsula (Nesom and Bates 1984). Lewis and Crawford (1995) report that *P. basiramia* and *P. ciliata* both originated from *Polygonella gracilis*, a species that ranges from Louisiana to South Carolina. Christman (1988c) reports that populations intermediate between *P. basiramia* and *P. ciliata* occur in scrubs near Lake Pierce and Lake Weohyakapka in Polk County, that populations of *P. ciliata* occur in the same area, and that specimens from a Highlands County site have been tentatively assigned to *Polygonella ciliata*. DeLaney (pers comm. 1989) cautions that in his experience, *P. basiramia* is a very distinctive species whose habitat does not overlap with that of *P. ciliata*, and that *P. gracilis* is easily misidentified as *P. ciliata* during its leafless phase.

Christman (1988c) found *Polygonella basiramia* at 123 scrub sites. Its distribution is:

- Polk County. Winter Haven Ridge from Auburndale south; common in scrubs on the Bombing Range Ridge on Avon Park Air Force Range (Christman 1988c); Lake Wales Ridge from Catfish Creek (about 5 miles east of the town of Lake Wales) southward. Protected at Catfish Creek, Lake Arbuckle State Preserve, and Saddle Blanket Lakes. Present at the Flaming Arrow site where acquisition/conservation with the Lake Wales Ridge National Wildlife Refuge is possible. Also Polk #52 (this is Christman's identifying number for the site), and Sun Ray. It should be searched for at the Lake Walk-in-the-Water tract of Lake Wales Ridge State Forest.
- Highlands County. Lake Wales Ridge south to Venus (south tip of Ridge). Protected at Highlands Hammock State Park, Flamingo Villas, Placid Lakes, Archbold Biological Station, Lake Apthorpe, and the west side of Lake June in Winter (purchased for a state park). It is present at acquisition sites including Holmes Avenue (East), Avon Park Lakes, Carter Creek, and Eagle Lake.

Polygonella basiramia is a plant of sandy gaps in the shrub matrix, associated with lichens and herbs such as *Hypericum cumulicola*. Because gaps between shrubs are more persistent in rosemary scrub than among oaks (Hawkes and Menges 1995; Menges and Hawkes, submitted), *P. basiramia* is, or was, largely a plant of rosemary scrub. It has spread into sandy firelanes that provide similar habitat. Open space (i.e., bare sand) was found (by Hawkes and Menges 1995) to be a good indicator of *P. basiramia* density, with greater amounts of open space at a site associated with higher plant densities. In rosemary scrub sites at Archbold Biological Station, density of *P. basiramia* ranged from nil to 0.085 plants per m². Along firelanes with open sand, densities were an order of magnitude higher, with a mean of 8.1 plants per m² (Hawkes and Menges 1995). Compared to other herbs of sandy gaps, *P. -basiramia* persists in smaller gaps and often occupies small, ephemeral gaps of scrubby flatwoods that border rosemary scrub (Hawkes, pers. obs.). As gaps begin to close there may be a microsuccession of dominant herbs, from *Eryngium cuneifolium* to *Hypericum cumulicola* to *P. basiramia* (Quintana-Ascencio, unpublished data). *Polygonella basiramia* is killed by fire, and the species reoccupies burned areas from seed (Menges and Kohfeldt 1995).

Polygonella basiramia is gynodioecious, with individual plants producing either pistillate (female) flowers or perfect (both sexes) flowers. The ratio of female to perfect plants is 1:1 at Archbold Biological Station (Hawkes and Menges 1995). Pollinators of *P. basiramia* include small halictid bees, *Perdita polygonellae* (a bee specific to the genus *Polygonella*), Eumenidae wasps, and potentially *Glabellula* spp. (Bombyliidae) (Mark Deyrup, Archbold Biological Station, pers. comm. 1995). Seed production by female plants greatly exceeds that of perfect plants, with mean number of seeds per stem of 217.8 for females but only 32.1 for perfect plants. *Polygonella basiramia* is an obligate seeder; because the seeds are not specialized for long-distance dispersal, most recruitment of new plants after a fire is probably from the seed bank. *Polygonella basiramia* seedlings require about three years to mature and set seed, so populations would probably not recover if fires occur at more frequent intervals (Hawkes and Menges 1995).

Density and seed production of *Polygonella basiramia*, in relation to open sand and time-since-fire was studied by Hawkes and Menges (1995). Their multivariate analysis showed that *Polygonella basiramia* density and time-since-fire were not related, so it appears that *P. basiramia* can persist indefinitely without fire in the long-lasting sandy areas of rosemary balds. Density and seed production of *Polygonella basiramia* both increased with the area of open sand. Large areas of open sand have

especially dense populations of the plant, and seed production is greater on high-density than low-density sites. They suggest that *Polygonella basiramia* plants are sensitive to competition from shrubs, and only slightly sensitive to competition from each other. The lack of interspecific competition probably is due to *Polygonella basiramia* plants having shallow root systems bearing their leaves at ground level. Dense *Polygonella* populations may also be especially attractive to pollinators that may also account for the high seed production.

Polygonella myriophylla – sandlace, map 18, p. 110; drawing 13, p. 126

The common name, “sandlace,” comes from Christman (1988c); other names are Small’s jointweed (Florida Natural Areas Inventory) because it was named by John Kunkel Small (1924) or woody wireweed (Wunderlin 1982). As G. L. Webster noted on a herbarium specimen, this sprawling shrub has the habit of a popular landscaping plant, creeping juniper, *Juniperus horizontalis* (cited in Wunderlin et al. 1980c), albeit with clusters of white or cream flowers (R. Yahr, in litt. 1995). Because it is one of the most distinctive and easily-recognized plants of the Florida scrub, information on its distribution and abundance is particularly complete and accurate. *Polygonella myriophylla* occurs within scrubs that covered about 25,000 acres when inventoried by Christman (1988c).

The distribution of *Polygonella myriophylla* is:

- Western Orange County, at three sites where it occurs with the endangered scrub lupine *Lupinus aridorum* (Wunderlin 1984a). The sites are near Vineland, an intensely developed portion of the Orlando metro area with theme parks and resorts.
- Osceola County, one site near Interstate 4.
- Polk County: on the Lake Wales Ridge from the Davenport-Poinciana area in Polk, south to the Highlands county line. It was found well west of the Lake Wales ridge just SE of Bartow. This area is now mostly developed (K. DeLaney, in litt. 1995). It is protected at Saddle Blanket Lakes and Catfish Creek.
- Highlands County on the Lake Wales Ridge south to Archbold Biological Station. Archbold has very few plants, but it is more abundant, and protected, at Lake Apthorpe, Flamingo Villas, and (pending acquisition) Gould Road. It is present at Henscratch/Jack Creek (Eugene Kelly, Southwest Florida Water Management District, in litt. 1995). Large populations exist at Carter Creek, where the state is attempting land acquisition.

A report of *Polygonella myriophylla* from Lake County was based on a misidentification (Wunderlin et al. 1980c, Christman 1988c, citing a pers. comm. by B. Hansen, Univ. of South Florida). Kral’s (1983) distribution map places this plant in DeSoto County, based on a specimen collected by J. K. Small and J. B. DeWinkler in 1919, before Highlands County was created in 1921 (the specimen is cited in Wunderlin et al. 1980c).

A doctoral dissertation on this species by J. Weidenheimer focuses on chemical variation with emphasis on allelopathy. Don Richardson considers this species allelopathic. It may become established in bare spots in scrub created (and nearly sterilized) by intense heat from burning sand pines. It is not known whether regular fires are needed to maintain bare habitat for this species, nor has its recruitment or mortality been studied.

Prunus geniculata – scrub plum, map 19, p. 111

This shrub with zigzag branches cannot be mistaken for any of Florida's other native plums. It is found in both scrub and high pineland. It should probably be sought in ecotones or scrubby high pineland. The distribution of *Prunus geniculata* (Johnson 1981, Stout 1982) is:

- Orange County: Apopka-Vineland Road area, southwest part of the county (The Nature Conservancy, 1990). Sites in this area were being destroyed rapidly, so the species might be extirpated.
- Osceola County: Reported from the northwest corner of the county.
- Lake County: Lake Wales Ridge west of Lake Apopka; the Lake County Water Authority owns one site (Race and Orzell 1995). *Prunus geniculata* occurred in high pineland, along with *Chionanthus pygmaeus* and the endangered *Warea amplexifolia* from Lake Apopka to Lake Eustis (Harper 1911, Kral 1983). Harper saw the area shortly before nearly all the native vegetation was converted to citrus groves, which in turn were abandoned after freezes in the 1980's.
- Polk County: Protected at the Arbuckle and Lake Walk-in-the-Water tracts of Lake Wales Ridge State Forest, in the Pine Ridge Nature Preserve of Bok Tower Gardens near Lake Wales (Jonathan Shaw, Bok Tower Gardens, pers. comm. 1986), Catfish Creek, Tiger Creek, and possibly at Saddle Blanket Lakes (Doria Gordon of The Nature Conservancy doubts that it is confirmed at this site). Babson Park Audubon Nature Park has a few plants.
- Highlands County: Locally easy to find and protected at Placid Lakes (only a few plants) and at Lake June in Winter. Soon to be protected at Gould Road. Present at two separate sites at Archbold Biological Station (R. Yahr, in litt. 1995).

Scrub plum persists in roadcuts and fire lanes, indicating tolerance for disturbance or the germination of its seeds on disturbed sites. Nancy Bissett (The Natives nursery, Davenport, Fla., pers. comm. 1995) has germinated seed and doubts that this species maintains a seed bank. No one has observed a seedling in the wild (M. Deyrup, Archbold Biological Station, pers. comm. 1995). No data are available to confirm that these shrubs are long-lived. The largest known populations may have only about 100 stems, so the conservation of this species may require investigation of its population biology.

Warea carteri – Carter's mustard, map 20, p. 112; drawing 14, p. 127

This annual maintains seed banks in the soil (N. Bissett, pers. comm., cited by Christman 1988c). It occurs in dry oak sites where other scrub endemics are scarce (K. DeLaney, pers. comm. 1989) and at the ecotone between scrub and high pineland with *Eriogonum longifolium* var. *gnaphalifolium* and *Prunus geniculata* (K. DeLaney, in litt. 1995). The distribution of *Warea carteri*:

- Dade County: *Warea carteri* formerly occurred in pine rockland vegetation and sand pine scrub in what is now Miami, where at least a dozen herbarium specimens were collected from 1878 to 1934 (Nauman 1980). It has not been seen since then, despite intensive biological inventories.
- Brevard County: a specimen from Brevard County (Kral 1983) was confirmed by a specimen collected at the Spessard Holland Recreation Area in Melbourne Beach, where it was found in scrub with Florida scrub jays (M. Hames, Melbourne, Fla., pers. comm. 1988. The Hames specimen, collected after the plant had shed its seeds, is at the University of Florida herbarium).

- Polk County: The largest and healthiest metapopulation on protected land is at The Nature Conservancy's Tiger Creek Preserve (E. Menges, Archbold Biological Station, in litt. 1995). It is present at several locations in the Lake Walk-in-the-Water (C. Weekly, Division of Forestry, pers. comm. 1996) and Lake Arbuckle (K. DeLaney, pers. comm. 1989) tracts of Lake Wales Ridge State Forest, and it is present at possible acquisition areas at Snell Creek and Horse/Reedy Creek.
- Highlands County: *Warea carteri* was known for some years only from Archbold Biological Station, where populations have been observed near Lake Annie, in Section 30, and near Station headquarters. It is not in evidence during some years (for example, 1987-88). It is present in the adjacent State-owned Placid Lakes tract (E. Menges, pers. comm. 1989; manuscript species list for Placid Lakes tract prepared by Archbold Biological Station, 1989).

Warea carteri has been seen at a few other sites on the Ridge by Steven Christman (Florida Museum of Natural History, pers. comm. 1988) and Nancy Bissett. They are sure the present distributional records are incomplete. The annual habit of *Warea carteri*, its widely separated known localities, and its tendency to flower only after fire makes appraisal of its status or planning its conservation more difficult than is the case for perennial herbs or shrubs.

Eric Menges is studying the demography of *Warea carteri* at Archbold, Tiger Creek Preserve, and the Lake Placid Scrub. Dozens of local patches are known from Archbold and Tiger Creek, although not all patches have aboveground plants in any given year. At both Archbold and Tiger Creek, many *Warea* populations have behaved fairly predictably in response to fire. Populations either appear or boom the year following fire (11 of 16 instances of population doubling at Tiger Creek occurred the year after a fire). Population crashes occur in the second year (18 of 26 populations at Tiger Creek lost >50% two years post fire) (Menges et al. 1994; Menges and Gordon 1996). Populations in sites that have experienced prolonged fire suppression usually persist only in very low above-ground densities.

Fire-related cues such as heat do not stimulate germination, but germination does require light and seeds may remain dormant for more than 2 years (E. Menges and N. Kohfeldt, unpublished data). Breeding system experiments have demonstrated that *Warea carteri* is autogamous and self-compatible but that pollinators may still limit fruit and seed production (Margaret Evans et al. in prep.). Because aboveground populations fluctuate wildly, autogamy helps ensure fecundity and may be a key life history trait (E. Menges, in litt. 1995).

Ziziphus celata – Florida ziziphus, Garrett's ziziphus, or a lotebush, map. 21, p. 113

One of the rarest shrubs in North America, *Ziziphus celata* was first collected in 1948 on sand dunes in or near Sebring, but it has not been found there since. The Sebring specimen went unidentified until Judd and Hall (1984) found that it represented an undescribed species whose nearest relatives are in the Southwest and Mexico. In 1987, Kris DeLaney rediscovered *Ziziphus celata* in the wild. He and Tammera Race of Bok Tower Gardens are responsible for the information on its distribution:

- Polk County: DeLaney found several plants at a site that has since been added to the Arbuckle tract of Lake Wales Ridge State Forest. Another DeLaney site is in an improved pasture west of the Lake Arbuckle area, consisting of one large clump or cluster of plants (K. DeLaney, in litt. 1995). Tammera Race (in litt. 1995) found 2 sites in Polk County, one north of Bok Tower Gardens in high pineland, the second near Lake Wales in an improved pasture south of Hwy. 60. This site is sloping, with scattered longleaf pine, turkey oak, and *Lupinus diffusus*.
- Highlands County: A large number of plants are in "partially improved pasture on a former scrub site" nearly a mile long southeast of Avon Park (K. DeLaney, in litt. 1995).

Ziziphus plants in pastures are mowed occasionally. The DeLaney sites are, or were, dominated by oaks including turkey oak (*Quercus laevis*) and bluejack oak (*Quercus incana*) that indicate a transition from scrub to high pineland vegetation. The Highlands County population seems vigorous, perhaps because of having been disturbed. The Polk County population, on an undisturbed, unburned site, appears to be declining. DeLaney observed only one mature fruit in the wild. The low seed set raised the possibility that the plants may form large clones by spreading from underground stems or root sprouts, and that each clone might be self-incompatible (DeLaney et al. 1989). In February 1995, Tammera Race of Bok Tower Gardens reported a new wild population on private land near Lake Wales. About a dozen *Ziziphus* plants are in a remnant of high pineland, with longleaf pine, bluejack oak, and a carpet of wiregrass. The plants fruited vigorously in 1995. Cultivated specimens at Bok Tower Garden produce fruit abundantly. Because the species is easily propagated, it appears feasible to establish new populations at Lake Arbuckle and perhaps other sites. The distribution map shows what may be this plant's potential range, from Lake Wales to Sebring.

At the two relatively undisturbed sites, *Ziziphus celata* is threatened by habitat alteration and, probably, by changes in the fire regime. The Lake Wales site, with *Ziziphus* growing among wiregrass, indicates that *Ziziphus* may be a high pineland species adapted to frequent fires, and whose above-ground stems may become senescent after many years or in the presence of too many other competing shrubs (a healthy-looking plant over 6 feet tall, near Lake Wales, shows that these slow-growing shrubs can achieve a respectable size in nature). The Lake Wales site is, at present, a grassy opening surrounded by laurel cherries, evergreen oaks, camphor trees, and even bamboo. Lantana is present, and a camphor tree is growing rapidly in the midst of a cluster of ziziphus. The site can presumably be restored if the landowners are interested, but the cost of restoration will probably be high, and conducting a prescribed fire seems out of the question unless many large trees are removed. Ecologists working with ziziphus should review the literature on the fire ecology of southwestern shrublands inhabited by *Ziziphus parryi* and other close relatives.

Table 2. Descriptions and geographic ranges of the species.

NAME & FAMILY	DESCRIPTION	DISTRIBUTION (by county)
<p><i>Bonamia grandiflora</i> Florida bonamia morning glory family (Convolvulaceae)</p>	<p>Perennial vine with taproot and underground stems with (usually) prostrate aboveground stems about 1 m [3 ft] long (up to 3 m or longer). Leaves are leathery, oval or ovate, upright or spreading. Funnel-shaped flower up to 10 cm [4 in] long, 10 cm across; pale but vivid blue.</p>	<p>Highlands, Polk, Osceola, Orange, Volusia, Marion, Lake, Hardee, Charlotte (p. 14).</p>
<p><i>Chionanthus pygmaeus</i> pygmy fringe tree olive family (Oleaceae)</p>	<p>Deciduous shrub with simple, opposite leaves. White flowers with 4 narrow corolla lobes, each 1 cm [0.4 in] long, in showy panicles. Flowering in March. Fruit a fleshy purple drupe, 2.0-2.5 cm [0.8-1 in] long. Similar to the widespread <i>Chionanthus virginicus</i>, which has longer corolla lobes and smaller fruits.</p>	<p>Highlands, Polk, Lake, Manatee, possibly Hillsborough (p. 15).</p>
<p><i>Cladonia perforata</i> Florida perforate cladonia "reindeer moss" family (Cladoniaceae)</p>	<p>A ground-dwelling lichen. The branches of <i>Cladonia</i> are different from those of other lichens and are called "podetia". Several podetial characters of <i>C. perforata</i> differ from those of other <i>Cladonia</i>, including color, shape, and texture. It has rather wide (up to 6 mm), pale, yellowish gray-green podetia, punctuated where the branches meet by perforations 1-1.5 mm wide. This is the only <i>Cladonia</i> in Florida with perforations at every branch. The podetia have a complex branching pattern, with roughly equal forking branches near the tips. Below, there are unequal branches with the smaller branch of a pair forking to one side (Evans 1952). Individual podetia are usually 4-6cm long, although some are as long as 8 cm and several cm tall. The oldest parts of the podetia degenerate, so there is no means of determining ages.</p> <p>No studies have been conducted of growth rates in <i>C. perforata</i>, but in boreal climates, growth studies of <i>Cladonia</i> species suggest that one branching occurs each year (Thomson 1967); however, in tropical areas, more than one branching per year may be possible. <i>C. perforata</i> may reproduce only by vegetative fragmentation; no spore-producing organs have been observed (Thomson 1967), and the lack of sporing structures (such as red tips on the podetia) helps identify this species.</p>	<p>Highlands, Okaloosa, Martin, Palm Beach, Polk, Manatee (p. 16).</p>
<p><i>Clitoria fragrans</i> pigeon wings pea family (Fabaceae/ Leguminosae)</p>	<p>Erect perennial herb, 15-50 cm [6-20 inches] tall, with one or a few stems growing from a thick horizontal root. The stems are wiry (1-2 mm [0.04-0.08 in] thick) and somewhat zigzag. The leaves have 3 leaflets. The flowers are inverted so that the anthers and stigma touch the backs of visiting insects (the only other legume genus with inverted flowers is <i>Centrosema</i>, with two species in central Florida). The corolla is arranged like a typical pea (5 petals, 2 fused into a single "keel," 2 wings, and a banner, or standard. The banner is large, 4-5 cm [1.5-2 in] long, colored lilac.</p>	<p>Highlands and Polk, including Avon Park Air Force Range. Osceola. Collected in Lake in 1910 (p. 18).</p>

NAME & FAMILY	DESCRIPTION	DISTRIBUTION (by county)
<p><i>Conradina brevifolia</i> Short-leaved rosemary mint family (Lamiaceae/ Labiatae)</p>	<p>This "profusely branched mint-smelling shrub to about 1 meter [3 ft] tall" (Kral 1983) has short, narrow leaves and lavender flowers about ½ inch long that are bilaterally symmetric (with upper and lower lips). It is similar to <i>Conradina canescens</i>, but <i>C. brevifolia</i> has (as its name implies) shorter leaves: the larger leaves on well-developed flowering branches are 6.0-8.2 mm [roughly ¼ inch] long, mostly shorter than the internodes, versus 7.0-20 mm long, mostly longer than the internodes for <i>C. canescens</i>. <i>Conradina brevifolia</i> also tends to have more flowers per axil than <i>C. canescens</i>: 1 to 6 per axil versus 1 to 3. Gray (1965) showed that <i>C. brevifolia</i>, like <i>C. glabra</i>, is morphologically not strongly differentiated from, and is less variable than, <i>C. canescens</i>. Kral and McCartney (1991) upheld <i>C. brevifolia</i> as a distinct species.</p>	<p>Saddle Blanket Lakes and Carter Creek in Highlands and Polk. Closest relatives are <i>Conradina glabra</i> (Liberty Co., Fla. panhandle) and <i>C. canescens</i> (Fla. panhandle and adjacent Ala. and Miss. (p. 19).</p>
<p><i>Crotalaria avonensis</i> Avon Park harebells pea family (Fabaceae/ Leguminosae)</p>	<p>Perennial herb. A tap root produces flowering stems that grow above the surface for 2 inches or slightly more, and terminate in flowering racemes. The leaves are mostly 8-19 mm [0.3-0.8 in] long, coated with white or yellowish-white hairs. The general appearance of the plant is of clusters of fuzzy grayish leaves hugging the ground. The flower, shaped like a typical pea flower, has a yellow corolla 8-9 mm [0.3-0.4 in] long. The seed pods are inflated, 14-25 mm [0.56-1.0 in] long. The pods can be nearly as long as the upright stems that hold them in place. Flowering begins in mid-March and continues profusely until June. After flowering, the plants enter a vegetative phase, forming clusters of stems that give a clumped or rosette appearance. The plants are dormant from late fall or early winter until March.</p>	<p>Saddle Blanket Lakes and Carter Creek areas, Highlands and Polk (p. 20).</p>
<p><i>Eriogonum longifolium</i> var. <i>gnaphalifolium</i> Scrub buckwheat buckwheat family (Polygonaceae)</p>	<p>Perennial herb; taproot and a basal rosette of leaves that are 6-8 inches long, narrow, and white-wooly on the underside. Each plant usually has from 0 to 3 flowering stems, but upwards of 10 in vigorous specimens, especially post-fire. Stem leaves are smaller than rosette leaves. The stem terminates in a panicle, with each branch of the panicle ending in a cup-shaped involucre that holds a cluster of 15-20 small flowers, with each flower hanging on its stalk down below the involucre. The involucre and flowers are silvery, silky-pubescent. There is only other species of <i>Eriogonum</i> in Florida.</p>	<p>Marion (including Ocala National Forest), perhaps n. Sumter, Lake (near Clermont, formerly near Eustis), Orange, n.w. Osceola, Polk, and Highlands (p. 21).</p>
<p><i>Eryngium cuneifolium</i> a snakeroot carrot family (Umbelliferae/ Apiaceae)</p>	<p>Perennial herb; long taproot; basal rosette of wedge-shaped, thick but not succulent leaves. Flowering stems up to 0.5 m (1 ½ ft) tall. Small flowers with white petals, filaments, styles and stigmas but powdery blue anthers form small heads, with bristly bracts. Flowering is from August-October (other <i>Eryngium</i> species, including <i>E. aromaticum</i> and <i>E. baldwinii</i> have blue flowers).</p>	<p>southern Lake Wales Ridge, Highlands; range is only about 24 miles long (p. 22).</p>

NAME & FAMILY	DESCRIPTION	DISTRIBUTION (by county)
<p><i>Hypericum cumulicola</i> Highlands scrub hypericum St. Johns wort fami- ly (Hypericaceae) or Clusiaceae/Guttiferae</p>	<p>Herb with a flexible life span; individuals may reach full size in as little as 1 year and live several years. Root is woody, not a taproot. Plants bearing flowers are 20-70 cm [8-28 in] tall. Stems are shorter in winter and spring before reproductive stalks are differentiated. Stems are slender, branched, upright, with 1-17 stems per plant and a mean of 3 per plant (based on n = 1000 plants measured at Archbold). Leaves are opposite, simple, small and needle-like. Flowers are arranged in cymes at the tops of stems. The calyx consists of 5 distinct sepals (mean sepal length 3.0 mm). The corolla consists of 5 bright yellow petals (mean length 6.6 ± 0.2 mm, n = 14 flowers). The petals are asymmetrical and borne at an angle, so that the flower looks much like a small window fan. Stamens are numerous (27 ± 3 per flower, n = 13). The gynoecium has 3 (sometimes 4) locules, and the ovary is superior. There are numerous (22 ± 5, n = 13) ovules. The style has 3 (sometimes 4) white lobes, and the fruits are small capsules (6.0 ± 1.0 mm fruit length), red when immature and dark purple when they open. Mature seeds (19 ± 4 per fruit, n = 60) are 0.5 mm long and dark brown. Flowering from March to Dec.</p>	<p>Lake Wales Ridge, Highlands and southern Polk (p. 23).</p>
<p><i>Liatris ohlingerae</i> scrub blazing star aster family (Compositae/ Asteraceae)</p>	<p>Perennial herb with a corm-like thickened, cylindric root. Stems are erect, usually unbranched, up to 1 m [3 ft] tall. Leaves narrow, only 1-2.5 mm wide, mostly 3-8 cm (1-3 in) long. Flower heads are well separated on the stem, up to 2 cm [0.8 in] broad, with disc flowers only; bright purplish pink. Flowering July-Oct. The flower heads are broad and the leaves narrow compared to the 8 other <i>Liatris</i> species in central Florida.</p>	<p>Highlands, Polk (p. 24).</p>
<p><i>Lupinus aridorum</i> scrub lupine pea family (Leguminosae/ Fabaceae)</p>	<p>Short-lived perennial herb. Forms large clumps. Stems up to 1 m [3 ft] tall. Leaves are simple, silvery, without stipules. Pink pea-like flowers are 11-14 mm [about ½ in] long, borne in racemes, flowering in late March-April. <i>Lupinus diffusus</i>, with sky blue flowers, is much more abundant in central Florida.</p>	<p>northern Polk, western Orange (p. 25).</p>
<p><i>Nolina brittoniana</i> scrub beargrass agave family (Agavaceae)</p>	<p>Perennial herb with thick underground rhizomes (stems). The long-lived, slender, arching leaves are 1-2 m [3-6 ft] long, 6-13 mm [0.2-0.5 in] wide, forming a rosette. The flowering stem grows at least 2 m [6 ft] high in April. The branches of its panicle are covered with many small white six-parted flowers. Plants are subdioecious (i.e. male and female flowers on separate plants). The plant is conspicuous when in flower. The fruits are triangular in cross section and are symmetrical. <i>Nolina atopocarpa</i>, a species of dry flatwoods, may occur in the vicinity of <i>Nolina brittoniana</i>; this species has shorter leaves and asymmetric fruits.</p>	<p>Highlands, Polk, (probably northwest corner of Osceola), Orange, and northern Lake County. Reported once from Hernando County (p. 26).</p>

NAME & FAMILY	DESCRIPTION	DISTRIBUTION (by county)
<p><i>Paronychia chartacea</i> papery whitlow-wort pink family (Caryophyllaceae)</p>	<p>Short-lived dioecious herb. The Panhandle subspecies is strictly annual, the peninsular subspecies may behave as a short-lived perennial. Forming small mats with numerous bright yellowish-green forking branches and tiny, opposite leaves. Numerous small cream-colored to greenish flowers. Flowering and fruiting in late summer/fall. This species may be mistaken for <i>Paronychia americana</i>.</p>	<p>ssp. <i>chartacea</i>: Highlands, Polk, Osceola, Orange, Lake; ssp. <i>minima</i>: Bay, Washington (p. 28)</p>
<p><i>Polygala lewtonii</i> Lewton's polygala milkwort family (Polygalaceae)</p>	<p>Perennial herb with one to several annual stems, which are spreading, upward-curving, or erect, and often branched. The small, sessile leaves overlap along the stem like shingles. The visible flowers are in erect, loosely flowered racemes up to 5 cm [2 in] long. They are bright pink or purplish-red, and are about 3.5 mm [0.14 in] long. Two of the 5 sepals are enlarged and wing-like; between them, the largest of the three petals forms a keel that ends in a tuft of finger-like projections. The plant also produces small, non-sexual (cleistogamous) flowers. This species is closely related to the widespread <i>Polygala polygama</i>, which forms larger clumps and has a longer root, narrower leaves, and differently-shaped wing sepals.</p>	<p>Highlands, Polk, Osceola, Lake, and Marion Counties (including Ocala National Forest) (p. 29).</p>
<p><i>Polygonella basiramia</i> a wireweed buckwheat family (Polygonaceae)</p>	<p>Short-lived perennial herb that branches at ground level. 7 to 30 erect stems up to 0.8 m [nearly 3 ft] tall. Leaves are hairlike, 2 cm [0.8 in] long, and have the sheathing stipules (ocreae) typical of the family; the ocreae are ciliated. Stems and leaves range in color from red to dark green. Red coloration is associated with individuals more exposed to sunlight and with older vegetative parts (although even seedlings are often red). As the stems elongate, plants develop 1 to 46 slender, spike-like panicles as tall as 0.8 m [3 ft]. Plants are gynodioecious. Individual flowers are small, white to slightly pink with 5 sepals and no petals. Flowering begins in September and achenes are produced in late November and early December. Because flowering begins at the top of each panicle and moves down the plant, both flowers and achenes will be present in mid-autumn. Most achenes fall by mid-January. This species is similar to <i>Polygonella ciliata</i>, which has only one main stem at ground level and branches only 10-50 cm above ground. Both species have anthers with basally dilated filaments with an additional basal, bilateral flange. In <i>P. basiramia</i>, the short, interwoven trichomes of the flange on each filament surround the ovary in an undefined mass. In <i>P. ciliata</i>, the flanges are sharply defined and appear as flat sheets of tissue.</p>	<p>Highlands, Polk (p. 30).</p>

NAME & FAMILY	DESCRIPTION	DISTRIBUTION (by county)
<i>Polygonella myriophylla</i> sandlance buckwheat family (Polygonaceae)	Sprawling shrub that looks roughly like a creeping juniper. The shrub's many branches zigzag along the ground and root at the nodes, forming low mats. The lower parts of the creeping branches have bark that cracks and partly separates in long, flat, interlacing strips. The short lateral branches end in flowering racemes. <i>Polygonella myriophylla</i> has the sheathing leaf stipules (ocreae and ocreolae) typical of the jointweed family. The leaves are needle-like, 0.3-10 mm [0.1-0.4 in] long. The small flowers have white petal-like sepals up to 3.4 mm [0.1 in] long.	Lake Wales Ridge in Highlands, Polk; Osceola, western Orange (p. 32).
<i>Prunus geniculata</i> scrub plum rose family (Rosaceae)	Deciduous shrub with toothed leaves. Heavily branched. Branches are zigzag (unlike any other plum in Florida) and thorny. Flowers with 5 white petals, 11-13 mm (up to about 0.5 inch) across when open late winter, early spring. Fruit a dull reddish, bitter plum up to 2.5 cm [1 in] long, ripe in April. This is one of several scrub plants with zigzag stems, the others being <i>Bumelia lacuum</i> , <i>Ximenesia americana</i> , <i>Ziziphus celata</i> , and a local variant of <i>Crataegus flava</i> .	Highlands, Polk, western Orange; high pinelands, southern Lake. (p. 33).
<i>Warea carteri</i> Carter's mustard mustard family Cruciferae/ Brassicaceae)	Annual herb with a single main stem, usually branched near the top. Smaller plants may be unbranched. Up to 1 m tall, with simple, alternate leaves up to 1 cm [0.5 in] long. Stem is topped by a tight raceme of white, 4-petaled flowers. Slender seed pods are 4-6 cm [1.5-2.5 in] long.	Highlands, Polk; barrier island in Brevard; formerly rock pinelands in Dade (p. 33).
<i>Ziziphus celata</i> Florida ziziphus buckthorn family (Rhamnaceae)	Shrub up to 2 m [6 ft] tall, usually shorter. Stems always occur in groups, evidently connected by underground stems or roots, but the species may reproduce by seed. Branches are zigzag and bear short, spiny branchlets. Leaves are entire, deciduous, dark, glossy green, 4.5-21 mm [0.2-0.8 in] long. Fruit is a yellowish drupe. Best time to search for this shrub is while flowering in the winter, December-February; the distinctive fragrance carries well.	Highlands, Polk (only 4 populations known). Historic range possibly from Sebring to north of Lake Wales (p. 35).

References for Table 2. *Bonamia*: Ward 1979, Wunderlin et al. 1980a. *Chionanthus*: Elfers 1989, Hardin 1974, Langdon 1984, Wunderlin et al. 1980e. *Cladonia*: Yahr 1995, Evans 1982, Hale 1983 (illustration). *Clitoria*: Fanz 1977, 1979. *Conradina*: Gray 1965, Kral 1983, Kral and McCartney 1991. *Crotalaria*: DeLaney and Wunderlin 1989. *Eriogonum*: Rickett 1967 (illus.). *Eryngium*: Bell 1963, Kral 1983, Wunderlin 1980f, M. Evans and R. Yahr, Archbold Biol. Station, in litt. 1995. *Hypericum*: Judd 1980, Kral 1983, comments by P. Quintana-Ascencio and M. Evans, Archbold Biological Station, 1995. *Liatris*: Kral 1983, Wunderlin et al. 1980g, Cronquist 1980. *Lupinus*: Beckner 1982, Isely 1986, Wunderlin 1984b. *Nolina*: Wunderlin et al. 1980b. *Paronychia*: Anderson 1991, K. DeLaney, pers. comm. 1995, R. Yahr, Archbold, in litt. 1995. *Polygala*: Blake 1924, Wunderlin et al. 1981, R. Yahr, Archbold, in litt. 1995. *Polygonella basiramia*: Kral 1983, Nesom and Bates 1984, Wunderlin et al. 1980h. *Polygonella myriophylla*: Kral 1983, Wunderlin et al. 1980c. *Prunus*: Kral 1983, Judd and Hall 1984, N. Bissett, pers. comm. 1995. *Warea*: Nauman 1980, M. Evans, Archbold, in litt. 1995. *Ziziphus*: DeLaney et al. 1989, Judd and Hall 1984, T. Race, Bok Tower Gardens, in litt. 1995.

REASONS FOR DECLINE

The principal cause of decline of central Florida's upland vegetation and its plants is conversion of high pineland and scrub for agricultural purposes (principally citrus groves), and for commercial, residential, and recreational purposes. Peroni and Abrahamson (1985) used aerial photography to determine that in Highlands County, 64.2 percent of the xeric vegetation (scrub, scrubby flatwoods, and southern ridge sandhills [high pineland]) present before settlement was destroyed by 1981. An additional 10.3 percent of the xeric vegetation was moderately disturbed, primarily by building roads to create housing subdivisions. This left about 24,000 acres. The situation appeared similar in Polk County. Christman (1988c) prepared a statistically valid estimate of habitat loss by examining a 10 percent random sample of all land sections containing scrub on the Lake Wales, Lake Henry and Winter Haven Ridges. Present-day scrub was mapped using aerial photography taken November 1984 to January 1987, supplemented by more recent site visit data, where available. His results:

- Original area of scrub: 76,600 acres (0.95 confidence interval: \pm 13,400 acres)
- Present area of scrub: 27,500 acres (0.95 confidence interval: \pm 10,500 acres)

Christman's report also estimates the acreage of each tract of scrub vegetation known to be inhabited by endangered plants. Because no species inhabits an entire tract, Christman's estimates place upper limits on the acreage that might be occupied by each species; as scrub continues to be destroyed, Christman's acreages become useful as historic information. Since then, researchers at Archbold Biological Station have mapped scrub using a geographic information system (Fitzpatrick et al. 1994).

Agricultural development was restricted to high pineland until the early 1980's, when it was nearly all developed. Then development spread into scrub (Christman 1988c; K. Delaney, F. Lohrer, pers. comm. 1988). Freezes of the 1980's that destroyed citrus groves farther north made the southern Lake Wales Ridge particularly attractive for new groves. The populations of Polk and Highlands counties are growing and, especially in Highlands County, most new real estate development is along the U.S. Highway 27 corridor on the Lake Wales Ridge, where a great deal of scrub was developed for commercial and residential purposes during 1987-1988 (K. DeLaney, pers. comm. 1989) because scrub land was less expensive than existing citrus groves. Another incentive for destruction of scrub comes from property tax rates that, in some counties, are lower for agricultural land than for "raw" land or residential areas.

The State of Florida requires counties to prepare and implement comprehensive plans that include conservation measures to discourage indiscriminate land clearing. Polk County is encouraging preservation and management of native vegetation on private land; Highlands County is not. Orange County has a "tree ordinance" intended to encourage protection of scrub and other native vegetation in developments, although county landscaping requirements may conflict with the tree ordinance (fide Devorah Levy, City of Orlando Recreation Bureau). Lake County has a tree protection ordinance and land development regulations encouraging the protection of native vegetation communities (Gary Race,

Lake County Environmental Management Division, pers. comm. to Tammera Race, Bok Tower Gardens 1995).

The distribution of *Lupinus aridorum* made it especially vulnerable to loss of habitat. The portion of its range in western Orange County is largely urbanized, including residential areas and Orlando's cluster of theme parks and hotels. The remaining Orange County sites for scrub lupine are small remnants of the original scrub, including empty lots and the Florida Turnpike right-of-way. Much the same situation prevails in the lupine's range near Auburndale, Polk County. The area is semi-rural, with many houses and only small tracts of scrub available for purchase.

Scrub is degraded by trash dumping, recreational use of off-road vehicles, and other practices (perhaps including harvesting of rusty lyonia [*Lyonia ferruginea*] stems for the silk-plant industry). In publicly-owned high pinelands, all-terrain vehicles and motorcycles severely impacted several species, including *Dicerandra christmanii*, *Crotalaria avonensis*, *Eriogonum longifolium* var. *gnaphalifolium*, and *Polygala lewtonii*. The only large site for *Dicerandra christmanii* has been severely impacted by off-road vehicles, which have caused severe erosion problems (K. DeLaney, in litt. 1995). These miscellaneous threats are likely to eventually destroy tracts of scrub that are not protected from trespassers. Scrub in unbuilt subdivisions is particularly vulnerable. Even when a tract has been purchased for conservation purposes, it is difficult to exclude vehicles and prevent trash dumping, potentially requiring extensive efforts in community relations/education and/or enforcement. For example, it has proven difficult to keep small "four wheeler" vehicles out of scrub at Hobe Sound National Wildlife Refuge. Some tracts of publicly-owned scrub that might be valuable for conservation may well have to be reserved for recreational purposes. Recreational vehicle use need not be incompatible with plant conservation; in scrubs where fire suppression has caused large shrubs to crowd out the small scrub endemic plants, the small endemics have persisted on firebreaks, road edges, and other disturbed areas (M. Evans, Archbold Biological Station, in litt. 1995).

Until now, fire suppression (including reduced fire frequency due to the firebreak effects of roads and agricultural land uses) has seemed a secondary threat to scrub and high pineland compared to outright habitat destruction. Research is making it clear that fire stimulates growth and flowering (and sometimes seed germination) in high pinelands and some scrub species (such as *Warea carteri*). The need to restore fire to unburned high pinelands has been more or less obvious. It was not obvious excluding fire from scrub may cause local extinctions of endangered plants. Work on plant demography, largely conducted out of Archbold, is showing that fire at proper intervals is essential for most of these plants. Fire regimes intended to conserve scrub jay populations are likely to be satisfactory for plant, but this must not be taken for granted.

Scrub is vulnerable to invasion by weeds wherever fill dirt is brought in (as for roadbeds or shoulders). In Hillsborough County, and probably elsewhere, bahia grass (*Paspalum notatum*) has become established in scrubs. Cogon grass (*Imperata* spp.) is a menace to dry habitats throughout central Florida, including Ocala National Forest, which has an extirpation program. Other problems include

Centipede grass (*Eremochloa ophiuroides*), Natal grass (*Rhynchelytrum repens*), and tanglehead (*Heteropogon melanocarpus*). *Neyraudia reynaudiana* (Burma reed) has spread into Highlands County (possibly in limestone from southeast Florida) and is invading scrub. Lantana (*Lantana camara*, an ornamental plant turned pest) is abundant in neglected or abandoned citrus groves; it threatens the native *Lantana depressa*³. Fortunately, the exotics problems so far are mostly outside of preserves (Eric Menges, Archbold, pers. comm. 1995). Scrub may be somewhat less vulnerable to invasion by weeds than other Florida vegetation due to the lack of nutrients and water, and allelopathy by scrub plants (Richardson 1985a,b). Although relatively small tracts of scrub may maintain their integrity for many years despite being surrounded by agricultural or residential areas, the best hope for long-term protection of the vegetation is in large tracts.

There has been no overall assessment of exotic pest plant and weed problems in high pineland. Small tracts of high pineland such as those targeted for State purchase in the northern part of the Lake Wales Ridge project (formerly the *Warea [amplexifolia]* Archipelago project) are probably vulnerable to invasion by *Lantana camara*. Near Lake Wales, a high pineland remnant with *Ziziphus celata* is seriously threatened by camphor trees (*Cinnamomum camphora*) growing among the ziziphus. The experience of the U.S. Forest Service should be relevant to other land managers. Ocala National Forest is dealing with cogon grass, air potato (*Dioscorea bulbifera*), kudzu (*Pueraria lobata*), Japanese climbing fern (*Lygodium japonicum*), Chinese wisteria (*Wisteria sinensis*), mimosa (*Albizia julibrissin* and possibly *A. lebbekii*), camphor (*Cinnamomum camphora*), and tallow tree (*Sapium sebiferum*). The principal source of undesirable plant species in the Forest has been from county stockpiles of infested soil along roads in the Forest. Other sources are from adjacent private properties and from illegal dumping in the Forest (J. L. Clutts, Lake George Ranger District, in litt. 1995).

At least one local extinction of a scrub plant appears to have occurred: *Bonamia grandiflora* disappeared from Archbold Biological Station. *Liatris ohlingerae* has not been seen at Tiger Creek Preserve since 1992 (Doria Gordon, The Nature Conservancy, in litt. 1995). Other local extinctions have undoubtedly occurred without the scientific community taking notice.

³*Lantana depressa*, a native Florida species listed as endangered by the State, is restricted to the Florida peninsula. The species consists of three geographical varieties, one in the Miami pinelands, one on the west coast and southwest Florida, and the third, var. *floridana*, on sand dunes of the east coast and the interior, including the Lake Wales Ridge. The survival of this species is doubtful due to destruction of its habitats and hybridization with *Lantana camara*, a horticultural hybrid that has become a serious weed (Sanders 1987), abundant around towns and in abandoned citrus groves.

EXISTING CONSERVATION MEASURES

A series of studies of central Florida's scrub flora (see the Present Status section, p. 13) culminated in Christman's (1988a, 1988c) three-year inventory of the scrub biota that provided a basis for preserve design by the Florida Department of Environmental Protection (formerly Natural Resources) and the Fish and Wildlife Service. The Nature Conservancy, the Southwest Florida Water Management District, and Polk County also have conservation strategies.

The main recovery task of the first edition of this plan was to acquire land for a series of biological preserves. Land acquisition is being accomplished mainly by the State of Florida, augmented county and private purchases, and by Federal purchases for the Lake Wales Ridge National Wildlife Refuge. The State's number-one priority land acquisition project for 1996 is the Lake Wales Ecosystems, at an estimated cost of over \$30 million; it is also the top-priority "mega-multiparcel" project. Catfish Creek, a separate project with scrub, is 18th on the priority list (Florida Department of Environmental Protection 1995, 1996). Florida's water management districts have their own plans, coordinated with the State, as will Polk County. Highlands County has acquired a tract and will manage it. The U.S. Fish and Wildlife Service (1993) has, at the time of writing, purchased over 400 individual lots for the Lake Wales Ridge National Wildlife Refuge. If public funding is sustained (and private landowners are willing to sell), nearly all of these plants will probably be conserved in Highlands and Polk counties. On a much smaller scale, a habitat conservation plan for the Florida scrub jay, approved by the Fish and Wildlife Service, protected a 40-acre, high quality tract with endangered plants.

The public has become more aware of the Florida scrub biota due to efforts by the Florida Native Plant Society and its members (notably Nancy Bissett, whose nursery specializes in scrub and high pineland plants), by the City of Orlando Recreation Bureau (Devorah Levy), by University of Florida extension services, and by Archbold Biological Station (led by then-director John Fitzpatrick) that promotes scrub conservation at the local level, produced a 20-minute video "Islands in Time," and initiated national press coverage, starting with a news story in "Science". This and a story in the New York Times led to general-interest stories in "Defenders" (Defenders of Wildlife), "Audubon," "Natural History," and "Smithsonian." The Florida Audubon Society devoted an issue of its magazine "Florida Naturalist" to scrub (Fitzpatrick 1992). "Florida Wildlife" (vol. 48, 1994) has an excellent series of four articles.

Monitoring and research on these plants is underway. For example, on sites that they manage, The Nature Conservancy is monitoring several species: *Bonamia grandiflora*, *Nolina brittoniana*, *Polygonella myriophylla*, *Prunus geniculata*, *Polygala lewtonii*, *Conradina brevifolia*, *Crotalaria avonensis*, *Chionanthus pygmaeus* [by J. Stout], and *Warea carteri*, and the Conservancy is ascertaining the presence or absence of populations of *Clitoria fragrans*, *Eriogonum longifolium* var. *gnaphalifolium*, and *Paronychia chartacea*. The Florida Division of Forestry established a monitoring program for its preserves in 1995. At Archbold Biological Station, research into the conservation biology of these plants

is integrated with monitoring. For example, Eric Menges, Rebecca Dolan and Doria Gordon are working on the breeding system, pollinators, demographic patterns, and genetic variability (through enzyme electrophoresis) of the following scrub endemics: *Liatrix ohlingerae*, *Warea carteri*, *Dicerandra christmanii*, *D. frutescens*, *Hypericum cumulicola*, *Nolina brittoniana*, and *Eryngium cuneifolium*. The data will be useful for conservation planning for these species (D. Gordon, The Nature Conservancy, in litt. 1995). Other projects are noted in the "present status" section of this recovery plan. The amount of work in progress or in publication makes it premature to synthesize the results and interpret their meaning for conservation. Virtually all of the research on the conservation biology of these plants (other than work on propagation) has been done since the first edition of this recovery plan was prepared in 1989.

Propagation of selected scrub and high pineland plants for conservation purposes has been pioneered by Bok Tower Gardens, as part of the national program of the Center for Plant Conservation. The program has been vital for producing material of *Ziziphus celata* for reintroduction, and has yielded a great deal of practical information on other species that helped research biologists ask intelligent questions about the population biologies of these species. Separately, the Plant Biotechnology section at Disney World's EPCOT Center has worked at cloning several rare scrub species for conservation purposes.

Appreciation of the importance of exotic pest plant control is increasing. Cogon grass is being controlled in the Ocala National Forest. The Florida Department of Transportation spent more than \$7 million in fiscal year 1993-94 to control invasive exotic vegetation. This major effort is continuing (J. Caster, Fla. Dept. of Transportation, in litt. 1995). Partly because Florida has severe exotic pest plant problems concentrated in wetlands, scientists in Florida have organized an effective Exotic Pest Plant Council.

The larger properties with these plants in public ownership (or coming into public ownership) arranged roughly from north to south, are:

Ocala National Forest has the greatest area of Florida scrub, most of it managed to produce sand pine pulpwood with concern for wildlife including Florida scrub jays. The Forest's high pineland is also significant, partly because it provides a model for management of new State preserves. Three listed plants occur in the Forest: *Bonamia grandiflora*, *Eriogonum longifolium* var. *gnaphalifolium*, and *Polygala lewtonii*.

Miller (1989) mapped the bonamia's distribution in the Forest, and found that it occupies a roughly oval area about 6 miles wide and at least 17 miles long from Lake Kerr south to at least the Naval bombing range. This is a single, very large population. The bonamia survives through the pulpwood rotation, and thrives on some road edges and other rights-of-way. *Polygala lewtonii* appears to be less widely distributed. Although scrub buckwheat (*Eriogonum*) is relatively easy to recognize, finding it is difficult, especially when in the vegetative condition, so mapping this species is not necessarily easy.

The Forest Service, Lake George Ranger District, has developed bonamia management recommendations incorporated in this recovery plan's narrative outline. The conservation measures

concentrate on maintaining a reasonable amount of open, sunny habitat and preventing the invasion of such habitats by cogon grass (*Imperata* spp.), an exotic pest that has the potential to destroy scrub and high pineland habitats. The only available method to control cogon grass is by spot herbicide treatment, which may unavoidably kill a few bonamia plants. The benefit of pest control is far greater than the risk to the locally abundant bonamia.

Road rights-of-way: The Florida Department of Transportation [FDOT] has a program to protect native plants, especially endangered ones. Long-term prospects for maintaining endangered and threatened plants on rights-of-way are severely limited by the likelihood of road widening and changes in land use adjoining the roads. Road widening, in particular, is usually far less costly and environmentally damaging than creating new road corridors, so along many roads it should be assumed that remnants of the native vegetation will eventually be destroyed by maintenance or construction. Measures developed by the Department to protect, restore, or maintain habitat on the rights-of-way may prove useful to other parties managing protected sites, either as workable procedures or as starting points for designing their own measures. The Department has an Environmental Policy for State Transportation Facilities (J. Caster, FDOT, in litt. 1995). The presence of exotic plant species (such as bahia grass) near roadside scrub remnants increases the likelihood of their being overrun. Routine maintenance (including replacement or repair of right-of-way fences) can destroy native plants. The Florida Turnpike is carefully maintaining known localities for the scrub lupine (*Lupinus aridorum*), and the FDOT Environmental Management Office will request funding for the research necessary to identify all listed scrub and high pineland species along the Turnpike and to develop site specific plans (J. Caster, Florida Dept. of Transportation, in litt. 1995). *Bonamia grandiflora* is probably also present on the right of way at Turkey Lake, since it is present at a nearby Orlando park (below). The Turnpike passes through an area near Clermont where *Prunus geniculata*, *Polygala lewtonii*, and *Warea amplexifolia*⁴ are known to have existed. *Eryngium cuneifolium* and *Dicerandra frutescens* occur on the right-of-way of U.S. Highway 27 in Highlands County (Christman 1988a).

Scrub lupine sites in Orange County: Lakes Cane and Marsha Park (Orange County) and Turkey Lake Park (City of Orlando) contain *Lupinus aridorum* and *Bonamia grandiflora*. J. Charba and J. Stout of the University of Central Florida have been studying the lupine at the county park. The County and City governments have entered into non-binding registry agreements with The Nature Conservancy to protect the lupine at these sites. A 2-acre site with *Lupinus aridorum* was set aside as mitigation in a real estate development (I. J. Stout, pers. comm. 1988), but it faces an uncertain future.

Bok Tower Gardens: The Garden's 75 acres of natural areas include the 25-acre Pine Ridge Nature Reserve and 50 acres of high pineland buffer areas that are included in their prescribed burn program (T. Race, Bok Tower Gardens, in litt. 1995). The prescribed burn program to rehabilitate the natural areas is being conducted with technical assistance from The Nature Conservancy. The

⁴*Warea amplexifolia* and *Dicerandra frutescens* have separate recovery plans.

natural areas have *Nolina brittoniana*, several wild individuals of *Prunus geniculata*, *Polygala lewtonii*, and a small population of *Warea amplexifolia*, an endangered plant not covered in this plan. The Gardens are hoping to expand their natural areas by planting pineland species in former citrus groves.

The Tiger Creek Preserve: Owned by The Nature Conservancy, this 4,718 acre Polk County preserve is centered on Tiger Creek and its wetlands, but upland habitats contain the following listed plants: *Bonamia grandiflora*, *Chionanthus pygmaeus*, *Clitoria fragrans*, *Eriogonum longifolium* var. *gnaphalifolium*, *Liatris ohlingerae*, *Nolina brittoniana*, *Paronychia chartacea*, *Polygala lewtonii*, *Prunus geniculata*, and the largest protected population of *Warea carteri*. A proposal to develop a sand quarry adjacent to the property was turned down in April 1988 when the County Commission denied a Conditional Use Permit.

Avon Park Air Force Range on the Polk-Highlands County boundary has a large acreage of scrub on Bombing Range Ridge, 10 miles east of the Lake Wales Ridge but with only three of the listed plants: *Clitoria fragrans*, *Polygonella basiramia*, and *Eriogonum longifolium* var. *gnaphalifolium*. The Range's natural resource management staff works with endangered and threatened animals, including the Florida scrub jay, Audubon's crested caracara, and the Florida grasshopper sparrow.

Catfish Creek: The State owned 3,966 acres here as of 1994, with 2,458 acres remaining to be acquired (the preserve grew to 4,404 acres by early 1996). The area has *Chionanthus pygmaeus*, *Liatris ohlingerae*, *Nolina brittoniana*, *Paronychia chartacea*, *Polygala lewtonii*, *Polygonella basiramia*, *Polygonella myriophylla*, and *Prunus geniculata*. Catfish Creek has a wide variety of vegetation, and is managed by the Division of Recreation and Parks.

Saddle Blanket Lakes: The Nature Conservancy acquired 642 acres and the State 722 acres of a what has been planned to be a State Scrub Preserve managed by the Division of Recreation and Parks, but it now appears that The Nature Conservancy will retain ownership of its property. Managers have to be concerned over adjoining land uses: residential development around the boundaries is possible (as shown by a zoning case in 1987), and undesirable, partly because houses on the borders complicate fire management. Saddle Blanket Lakes has *Bonamia grandiflora*, *Chionanthus pygmaeus*, *Conradina brevifolia*, *Crotalaria avonensis*, *Hypericum cumulicola*, *Liatris ohlingerae*, *Nolina brittoniana*, *Paronychia chartacea*, *Polygonella basiramia*, and *Prunus geniculata*. The site is crucial for the conservation of *Conradina* and *Crotalaria*.

Lake Walk-in-the-Water tract of the Lake Wales Ridge State Forest. The eastern part of this tract has *Polygala lewtonii* (at least 130 plants), *Bonamia grandiflora*, *Clitoria fragrans*, *Eriogonum longifolium* var. *gnaphalifolium*, abundant *Nolina brittoniana*, and a few *Prunus geniculata* (Carl Weekly, Florida Division of Forestry, pers. comm. 1996). The area is on record as having *Chionanthus pygmaeus* (Florida Natural Areas Inventory). This 5,801 acre tract is managed by the Florida Department of Agriculture and Consumer Services, Division of Forestry.

Lake Arbuckle tract of the Lake Wales Ridge State Forest and Lake Arbuckle State Preserve: This 13,746 acre tract in Polk County is adjacent to the Avon Park Air Force Range and is partly on the Lake Wales Ridge. It was purchased by the State for \$8,849,820. At the time of writing, discussions are underway about merging into the State Forest the strip of land along the lake that is managed as a preserve by the Florida Department of Environmental Protection, Division of Recreation and Parks. The State Forest has *Bonamia grandiflora*, *Chionanthus pygmaeus*, *Eriogonum longifolium* var. *gnaphalifolium*, *Hypericum cumulicola*, *Liatris ohlingerae*, *Nolina brittoniana*, *Paronychia chartacea*, *Polygala lewtonii*, *Polygonella basiramia*, *Polygonella myriophylla*, *Warea carteri*, *Ziziphus celata*, and a large population of *Prunus geniculata* (Christman 1988c). The Preserve has nearly all of the same species. The Division of Forestry entered into a memorandum of understanding with The Nature Conservancy in October, 1988, for the Conservancy to identify and locate scrub areas in the State Forest for an overall management plan. Because the State Forest is close to populations of *Ziziphus celata*, it is an excellent location for establishing new population(s) of this shrub.

Carter Creek (Sebring Highlands): The northern part of this area is a cornerstone preserve designs by the State and the Fish and Wildlife Service because of its rich scrub flora (including *Conradina brevifolia* and *Crotalaria avonensis*). Turkey oak scrub at the south end of the area has abundant *Polygala lewtonii* and perhaps other species. The State had approximately 143 acres of the site under contract for purchase in 1993, and by the end of 1994 the State had over 400 lots under contract. There are very serious obstacles to negotiating the purchase of much of rest of this area. Landowners in Carter Creek have been assessed over a number of years to pay for road improvements. The fund became large enough to pave the main road through the area in 1993, and the county did some paving work in 1995.

Highlands Hammock State Park Addition, had 1,094 acres by 1996. The addition mainly protects a creek that runs through the park, but *Chrysopsis floridana* (Florida golden aster) occurs, or did occur, just west of the Park (K. DeLaney, in litt. 1995). This endangered species had been thought endemic to Gulf coastal counties around Tampa, but Kris DeLaney (in litt. 1995) has extended its range east into Hardee County, with one population on the Lake Wales Ridge. Taxonomic reexamination of the relation of *C. floridana* to the widespread *Chrysopsis scabrella* is probably warranted, and biologists should look for *C. floridana* in areas outside of Hillsborough and coastal Manatee counties. At least two plants in this recovery plan, *Polygonella basiramia* and *Liatris ohlingerae*, occur at Highlands Hammock, along with the threatened sand skink. Highlands Hammock is managed by the Division of Recreation and Parks.

Henscratch Road/Jack Creek: The Southwest Florida Water Management District (SWFWMD) has purchased 2,148 acres, largely swamp forest, for watershed protection. The tract contains scrub with *Asclepias curtissii*, *Clitoria fragrans*, *Lechea cernua*, *Liatris ohlingerae*, *Nolina brittoniana*, *Polygonella basiramia*, *Polygonella myriophylla*, and *Paronychia chartacea* (E. Kelly, Southwest Fla. Water Mgt. District, in litt. 1995 and K. DeLaney, in litt. 1995) and other species of special

interest. The tract has cutthroat grass seeps. The State's Conservation and Recreation Lands (CARL) bargain/shared project with the Water Management District proposes to expand this preserve from the existing tract to 3,985 acres. It is managed by SWFWMD and the Florida Game and Fresh Water Fish Commission.

Flamingo Villas: This unbuilt subdivision adjacent to Sebring Airport is the best surviving example of scrub on yellow sand; it is the principal site for *Dicerandra christmanii* and has a large population of *Chionanthus pygmaeus*. It is the first acquisition area for the Lake Wales Ridge National Wildlife Refuge. Because it is an unbuilt subdivision, acquiring the multitude of lots is time consuming. As of November 1995, the Fish and Wildlife Service had arrived at contracts on 698 of 1,028 interior subdivided lots (434 ownerships out of 559), 14 of 30 lots facing State Road 623, and 354.2 acres out of 400 in Section 11. Establishing management is an urgent priority due to rapidly-increasing off-road vehicle use and trash dumping (K. DeLaney, in litt. 1995).

Lake June West: This 846 acre tract will be managed as a state park by the Division of Recreation and Parks. Its flora is very similar to the Lake Apthorpe site (below), and it is one of only 6 sites where *Eryngium cuneifolium* is protected.

Lake Apthorpe: The Nature Conservancy purchased 292 acres in this unbuilt subdivision southeast of Sebring, often on a lot-by-lot basis, and sold it to the State. The tract is very rich in endemic plants, including *Bonamia grandiflora*, *Eryngium cuneifolium*, *Hypericum cumulicola*, *Paronychia chartacea*, and *Polygonella basiramia* (Robert Burns, The Nature Conservancy, Winter Park, pers. comm. 1989; Christman 1988c). The area also has *Nolina brittoniana* (Margaret Evans, Archbold Biological Station, in litt. 1995), *Liatris ohlingerae*, and *Polygonella myriophylla* (K. DeLaney, in litt. 1995). Management is by the Florida Game and Fresh Water Fish Commission.

Holmes Avenue: The State has 318 acres and The Nature Conservancy 10 at this unbuilt subdivision south of Lake Apthorpe, with nearly the same plants.

Placid Lakes: This 3,189 acre tract adjacent to Lake Placid and Archbold Biological Station was acquired by the State for \$6,618,000 in November 1993. Placid Lakes has most of the species at Archbold, including *Dicerandra frutescens*, *Eryngium cuneifolium* and *Hypericum cumulicola*. It has two species absent at Archbold: *Bonamia grandiflora* and *Chionanthus pygmaeus*. Placid Lakes is managed by the Florida Game and Fresh Water Fish Commission with assistance from Archbold Biological Station.

Archbold Biological Station: A nonprofit biological research institution with its own 4,300 acre preserve immediately south of Placid Lakes. Part of the preserve is a hill with high pineland and scrub with dense stands of sand pine, scrub hickory, and oaks. The rest of the property is relatively level, with scrubby flatwoods on moderately well drained soils and, on hillocks, rosemary balds. The Station has two large populations of *Dicerandra frutescens*. Some rosemary balds have

Cladonia perforata (present on 8 of the more than 100 balds) (Yahr 1995), *Eryngium cuneifolium* (on about 12 balds), *Hypericum cumulicola*, *Paronychia chartacea*, *Polygonella basiramia*, *Prunus geniculata* (Yahr, in litt. 1995), and *Liatris ohlingerae*. *Warea carteri* occurs mostly in scrubby flatwoods with Archbold oak (whose common name comes from the station).

Gould Road: This 157 acre tract will be managed by the Florida Game and Fresh Water Fish Commission. It is notable for having *Chionanthus pygmaeus* (which is absent from the nearby Archbold Biological Station, and it is one of the six sites where *Eryngium cuneifolium* is protected.

Footnotes to Table 3.

Plant occurrences marked by X are from Christman (1988), except for Lake McLeod (see footnote 13). Occurrences provided by other sources are shown using footnote numbers:

- 1 Data for Flamingo Villas is from Christman (1988).
- 2 *Ziziphus celata* was discovered just outside the boundary of the Lake Arbuckle unit of Lake Wales Ridge State Forest, and the site has since been purchased for the Forest. The Florida Division of Forestry is working on (re)introducing *Ziziphus* to more sites in the Lake Arbuckle unit.
- 3 Eric Menges, Archbold Biological Station, letter and personal communication, Feb. 1991. Information on Archbold, Gould Road, Flamingo Villas, Lake June West, Placid Lakes, Tiger Creek. He notes that the metapopulation of *Warea carteri* at Tiger Creek is the largest and healthiest on public land (letter, Sept. 1995). As of 1995, *Bonamia grandiflora* is not known from protected land at Placid Lakes, although it is present in an adjacent real estate development.
- 4 Acreages, except for Lake McLeod, are from Christman (1988).
- 5 Deborah White, Florida Natural Areas Inventory, personal communication 1990.
- 6 Christman (1988) shows *P. myriophylla* at his site HIGH 92, but not other Hendrie Ranch scrubs.
- 7 Kris DeLaney, Environmental Research Consultants, Inc., letter, Jan. 1991.
- 8 Robert Burns, personal communication, with Mark Deyrup, 1994.
- 9 Eagle Lake data from Nancy Bissett, The Natives, letter, Feb. 1991.
- 10 Data for Placid Lakes: Archbold Biological Station staff and Steven Christman (1988) Lake Placid S. Shore Scrub (HIGH 28).
- 11 *Bonamia grandiflora* was included on the Archbold Biological Station plant list, but is not currently known to occur there.
- 12 *Cladonia perforata* discovered Dec. 1990.
- 13 Lake McLeod site data from Nancy Bissett and Steve Riefler, April 1990. Name of site was changed from Gerber Dairy Road to Lake McLeod by Bissett.
- 14 Geoff Babb, The Nature Conservancy, letter, Feb. 1991.
- 15 U.S. Forest Service, Lake George Ranger District [Ocala National Forest], letter, Oct. 5, 1995.
- 16 Kris DeLaney in litt. Nov. 1995 (*Nolina brittoniana* at Placid Lakes).
- 17 Rebecca Yahr, Archbold Biological Station, in litt. 1995 (*Prunus geniculata* at Archbold).
- 18 Carl Weekly, Florida Division of Forestry, pers. comm. Feb. 29, 1996.
- 19 The Fish and Wildlife Service is concentrating its acquisition activities at Flamingo Villas and Lake McLeod.

Table 3. Scrub plant species, by site

Species	Federal Status	Hendrie Ranch	Gould Road	Archbold Biol. Sta.	Placid Lakes ¹⁰	Lake June W. (S.)	Holmes Avenue	Highlands Park	Lake Apthorpe	Flamingo Villas ¹	Carter Creek	Avon Park Lakes	Saddle Blanket Lks.	Sun Ray	Lake Arbuckle	Catfish Creek	Tiger Creek	Sun & Lakes North	Trout Lake North	Polk #52	Flaming Arrow	Snell Creek	Horse (Reedy)	Eagle Lake ⁹	Lake McLeod ¹³	Lake Blue	College	Lk. Walk in Water	Avon Park A.F.	Ocala Natl. Forest	
<i>Asclepias curtissii</i>	T			3			X			3	X	X	X	X	X	X	14								X					15	
<i>Bonania grandiflora</i>	T	X	3	11			X				X	X	X	X	X	X	X	X	X			X	X			X				X	
<i>Calamtha ashei</i>	E	X	X	X	X	3					X	X	X	X	X	X	14					X	X			X				X	
<i>Chionanthus pygmaeus</i>	E	X	3		3						X	X	X	X	X	X	X					X	X			X				X	
<i>Cladonia perforata</i>	E	X		X																											
<i>Cillaria fragrans</i>	T			3		3																									
<i>Conoclinium brevifolia</i>	E																														
<i>Crotalaria avonensis</i>	E																														
<i>Dicerandra christmanii</i>	E																														
<i>Dicerandra frutescens</i>	E																														
<i>Dicerandra sp.</i>	E																														
<i>Eriogonum longifolium</i>	T																														
<i>Eriogonum longifolium</i> var. <i>graphifolium</i>	E																														
<i>Eriogonum cuneifolium</i>	E	X	X	X	X	8	X				X	X	X	X	X	X															
<i>Hypericum cummicola</i>	E	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X
<i>Hypericum edisonianum</i>	E																														
<i>Ilex opaca</i> var. <i>ericicola</i>	E																														
<i>Lechea cernua</i>	E	3		X	X	3	X				X	X	X	X	X	X															
<i>Liatris ahingeriae</i>	E	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	3													
<i>Lupinus aridorum</i>	E																														
<i>Nothia brittoniana</i>	E	1																													
<i>Paronychia charitacea</i>	T	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X
<i>Polygala lewtonii</i>	E																														
<i>Polygonella basiramia</i>	E	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X
<i>Polygonella myriophylla</i>	E	6	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X
<i>Prunus geniculata</i>	E	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X
<i>Schizachyrium niveum</i>	E																														
<i>Wreca carteri</i>	E																														
<i>Zitiphus celata</i>	E																														
State of Florida purchase?			X		X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X
Fish and Wildlife Service					X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X
Approximate acres of scrub ⁴		95	305	800	800	886	886	886	61	682	87	353	252	229	194	32	20					186	26			20 ¹³	90	151	670		

STRATEGY FOR RECOVERY

For most of these plants, the first priority is to purchase the best available habitat in the Lake Wales Ridge area, principally in Highlands and Polk counties, Florida. Land purchases were beginning when the first edition of this plan was published in 1990. So far, the State has spent over \$38 million for land in the Lake Wales Ridge region. Congress has appropriated nearly \$3 million for the Lake Wales Ridge National Wildlife Refuge. Much more land acquisition still needs to be done, and while it is underway, it is essential to discourage or delay government-sponsored actions that would degrade sites where acquisition is planned.

As land is acquired, management has to be established. Fortunately, exotic pest plants are not yet a critical problem; and in scrub, fires are naturally infrequent, so prescribed fire need not be arranged immediately. Most of the high pineland sites will require restoration of the grassy understory through prescribed fire and planting of grass and/or pine trees. There is already a body of experience in restoring high pinelands. Cleaning up debris and establishing control over access by vehicles may present the most serious early challenge to managers. Land managers in the Lake Wales Ridge area already cooperate with each other through an Arbuckle Working Group.

Although prescribed fire in scrub need not be implemented immediately in new preserves, it is nevertheless essential. Many of the endemic herbaceous plants and small shrubs suffer decreased flowering or vegetative vigor, or lack of seedling recruitment due to canopy closure in unburned scrub (R. Yahr, Archbold Biological Station, in litt. 1995). Similar concerns also apply to the Florida scrub jay. Managers cannot dismiss the need for prescribed fires because the endemic plants are abundant along sand roads and firebreaks (Dennis Hardin, Florida Division of Forestry, pers. comm. 1995).

Managers must obtain feedback from the biological and other resources being managed. Biological monitoring is the principal means to determine whether management actions produce the desired effects. The presence of Archbold Biological Station and a field office of The Nature Conservancy ensure that expert conservation biologists and scientific facilities are available.

Conservation measures beyond land acquisition and management are needed to conserve particular species with special threats. Protecting *Lupinus aridorum*, whose range is largely in the Orlando urban area, will be difficult, and will require conservation efforts on small remnant sites in public and (to the extent possible) in private ownership. Garden propagation and reintroduction of several species will be necessary or useful (e.g. *Ziziphus celata*). We know little about the conservation biology of the lichen *Cladonia perforata*. Ocala National Forest's three species (*Bonamia grandiflora*, *Eriogonum longifolium* var. *gnaphalifolium*, and *Polygala lewtonii*) are probably thriving under current management practices, but it is important to periodically evaluate their status. Finally, existing botanical inventories on the Lake Wales Ridge are very good, although new finds can still be expected). Opportunities will arise for botanical inventories in more poorly-known parts of central Florida as the State and counties purchase land for conservation purposes. Such inventories may considerably increase our knowledge of the more widely-distributed species.

PART II. RECOVERY

A. RECOVERY OBJECTIVES AND CRITERIA

The 1988 amendments to the Endangered Species Act specify that recovery plans shall incorporate “objective, measurable criteria which, when met, would result in a determination . . . that the species be removed from the list” (section 4(f)(1)(B)(ii)). The Endangered Species Act is intended to provide “a means whereby the ecosystems upon which endangered species and threatened species depend may be conserved” (section 2(b)), and the policy of the Fish and Wildlife Service is to develop recovery plans on an ecosystem basis wherever possible.

This recovery plan coordinates the recoveries of 19 species, each with its own geographic distribution, life history, and habitat requirements. The plan attempts to balance the recovery objectives for each species with the overall objective of conserving the most endemic-rich examples of the scrub and high pineland ecosystems. The plan’s approach is as follows:

- **first**, conserve the plants’ habitats, mainly through purchase. The State and the Fish and Wildlife Service have already planned biological preserves and land acquisition is underway. This recovery plan reviews preserve designs, and points out gaps in protection, mainly for plants that occur off the Lake Wales Ridge or in vegetation other than scrub.
- **second**, ensure effective management of biological preserves. Most of the listed species require demographic monitoring and experimentation with management practices. A few need genetic monitoring, too (see *Liatris ohlingerae* and *Ziziphus celata*) Such monitoring is inexpensive compared with the cost of land acquisition and to some other management costs, such as fire services.
- **third**, several species (especially *Lupinus aridorum* and *Ziziphus celata*) require special recovery measures because of their life histories, rarity, or restricted geographic distributions. Research and monitoring programs must be tailored to these species.
- **fourth**, for the Service to reclassify or delist these species, it must show that goals set in the approved recovery plan have been met. A reclassification/delisting proposal must discuss the expected effects of the action. For example, what protection will still be afforded at State and Federal levels and what future monitoring and management will be conducted if the species is delisted? The Endangered Species Act requires that the Service, in cooperation with the State, provide at least five years of monitoring for all delisted species.

The species, grouped in order of increasing difficulty of recovery, are:

1. Relatively widespread species; the main threat is habitat loss or degradation. **Reclassification and/or delisting is clearly feasible** with additional habitat protection and demographic monitoring. Conservation measures for more seriously threatened species will greatly benefit these species:
 - Bonamia grandiflora* (T)
 - Clitoria fragrans* (T) (prescribed fire is essential for this species)
 - Eriogonum longifolium* var. *gnaphalifolium* (T) (prescribed fire is essential)
 - Nolina brittoniana* (E)

Paronychia chartacea (T) (both subspecies)
Polygonella basiramia (E)
Polygonella myriophylla (E)

2. Species with obstacles to recovery:

Chionanthus pygmaeus (E) Biologists at Archbold Biological Station have expressed concern about population size and recruitment. Little is known about recruitment, although Jack Stout has made a start on long-term monitoring at one site.

Cladonia perforata (E). This lichen occurs at a moderate number of sites, but they are usually small and are widely scattered. Several opportunities exist to protect its habitat in Highlands, Polk, and Manatee counties (K. DeLaney, in litt. 1995), but land acquisition prospects are not as promising as they are for most of the other species in the plan. Fire may pose a severe threat to this species, and special site management may prove necessary to cope with the fire problem. It will be essential to study the ecology of this ground-dwelling lichen, a long though probably not costly project. Lichen conservation is a relatively new, promising, field.

Conradina brevifolia (E) has a restricted range in the middle of the Lake Wales Ridge. Scrub sites at Avon Park Lakes, Carter Creek, and Saddle Blanket Lakes are critical for its conservation. Land acquisition is planned for all three sites, although residential development at Avon Park Lakes limits preserve options there.

Crotalaria avonensis (E) has a narrower distribution, in the same part of the Lake Wales Ridge, as *Conradina brevifolia*. Its prospects for recovery depend on successful land acquisition at Carter Creek and on understanding its demography at least as well as *Eryngium cuneifolium* has been elucidated.

Eryngium cuneifolium (E) and *Hypericum cumulicola* (E). Large populations of both species are already protected, but both have narrow geographic distributions, and are absent from much seemingly suitable habitat, probably due to their dependence on rather temporary gaps between shrubs. Land acquisition must be carefully targeted. Establishment of new populations may be needed if land acquisition is not fully successful.

Liatris ohlingerae (E) has an obligate outcrossing breeding system, which means that for a protected population to persist, it must contain enough genetic diversity for outcrossing to work. This is a rare case where genetic diversity may be crucial to the viability of plant populations. The species is reasonably widespread in preserves and potential preserves, so its full recovery is possible.

Polygala lewtonii (E) is easily overlooked, so its distribution may prove to be less spotty than it seems. Because it is present and rather abundant in Ocala National Forest, prospects for conserving this species are good. The south portion of Carter Creek has the largest known population on the Lake Wales Ridge, so protection of this area is important. Other areas (such as Hesperides) with large areas of turkey oak should be searched for *Polygala*.

Prunus geniculata (E) shares the same concerns about population size and recruitment as *Chionanthus pygmaeus*.

Warea carteri (E) is a locally abundant annual that may remain dormant as seed for several years, so a population may have a substantial number of growing, flowering plants only in the first year after a fire. Because this species is conspicuous only when in flower, monitoring it and

finding populations is difficult. Studying or setting recovery goals for this plant will be difficult. Fire management is a critical concern for this species. Long intervals between fires are likely to result in loss of viable seeds from the seed bank and declines in population sizes. Extinction risk is likely to be higher without proper fire management (Eric Menges, Archbold Biological Station, in litt. 1995).

3. Critically endangered species with **limited opportunities for recovery:**

Lupinus aridorum (E) is suffering severe habitat loss because its range is entirely in urbanizing areas (including the theme park/resort area south of Orlando). This species is short-lived and susceptible to disease both in cultivation and in the wild. It can be propagated only from seed sown *in situ*; transplanting is impossible. This makes establishment of new populations or augmentation of existing ones difficult. There has apparently been private experimentation with propagation from tissue culture. Wild populations apparently suffered a severe loss of mature individuals and seeds due to a very late freeze in 1989 that followed an unusually warm late winter (N. Bissett, in litt. 1989). This species may become extinct in a few years.

Ziziphus celata (E) is extremely rare. Only five small populations are known, two in pastures where the species survived land clearing. Each "population" may consist of only a single genetic individual (a genet, as defined in Harper [1977, p. 26]) (DeLaney et al. 1989). As a result, full recovery of this species may be impossible for lack of enough genetic material for a minimum viable population. Nevertheless, garden propagation of this plant has been successful, and it is worthwhile to try to establish new populations. Plants are probably very long-lived (assuming that individuals resprout from the roots after fire), so an artificial population in a wild setting might persist for many decades.

The concept of minimum viable population (MVP) (Menges 1991) is helpful for recovery planning. For species with few genetically distinct individuals, careful captive breeding to prevent further loss of genetic variability may be essential. For plants, this is seldom necessary because most endangered plant species are locally abundant (an exception is *Ziziphus celata*, and Margaret Evans at Archbold has expressed concern over *Liatris ohlingerae*). MVP is usually a matter of having enough individuals (including viable seeds stored in the soil) for a species to survive 1) mass mortality or massive failure of reproduction due to calamities caused by drought, fire, trampling, disease, or predators; 2) long periods of low seed production between bursts of fire-stimulated reproduction (e.g. *Warea carteri*); or 3) changes in the habitat, such as shrub encroachment, that reduce patches of suitable microhabitat or cause them to move (e.g. *Eryngium cuneifolium*). Some of the species in this plan have very large populations (especially *Paronychia chartacea*), so the first task for recovery is to provide enough appropriately managed preserves to protect each species throughout most of its range. Research underway by Eric Menges (Archbold Biological Station), Doria Gordon (The Nature Conservancy), and others is expected to clarify the minimum populations needed to conserve most of these species. The four woody endangered plants (*Chionanthus pygmaeus*, *Polygonella myriophylla*, *Prunus geniculata*, and *Ziziphus celata*) probably require fewer mature genetically distinct individuals to be reclassified to threatened status because the long life spans of individuals provide a buffer against changes in population size. These important life history characteristics are noted below.

This plan makes assumptions that affect the recovery objectives and tasks:

- Because central Florida's natural landscape is fragmented, and becoming more so, a **population** of a species is most likely to consist of the plants in a protected tract. Possible exceptions are noted.
- Generally, land with these plants that isn't protected (mostly by purchase) will be lost or degraded. The first edition of this plan concluded that it would waste time to pursue conservation agreements and other non-acquisition measures in the face of the urgent need to purchase habitat.
- The first edition of this plan also concluded that **Habitat Conservation Plans⁵** for Florida scrub jays and other animals were unlikely to contribute much to the conservation of these plants.
- Most of the populations of these plants on protected sites are **viable**. Most of the plants are locally abundant and they are likely to persist in preserves, even with suboptimal management. Known exceptions are mentioned in the text, and it is important to look for other exceptions.
- Most of the **preserve design** in central Florida has already been done. Water management districts, counties, and other parties may still identify new opportunities to acquire or otherwise protect important habitats (especially in counties other than Highlands and Polk). In Highlands and Polk counties, acquisition plans by government agencies appear to be as ambitious as is possible, within the restraints of availability of good sites and willing sellers. It is rarely possible to protect a species at all the sites where it currently exists.
- **Creation of new scrub or high pineland** out of orange groves, phosphate mines, or other disturbed areas for endangered plant conservation is not feasible, or at least much more costly than purchasing existing intact habitat. Exceptions may occur at the borders of native vegetation in preserves.
- **Land managers** for public lands are likely to be preoccupied by issues other than the recovery of these plants. Turnover of management personnel is also likely to cause problems with continuity in monitoring.
- The amount, quality, and apparently reasonable cost of current **monitoring and research** bode well for improving the recovery objectives and guiding management. The situation is vastly better than anticipated by the first edition of this plan.
- Species that have **recovered** will be **monitored** (in cooperation with the State of Florida) for at least five years as required by the Endangered Species Act. "Significant risk to the well being of any such recovered species" will be addressed through the emergency listing provisions of the Endangered Species Act. Species will not be abandoned when they are delisted.

Several biologists commented that the recovery criteria in the draft of this recovery plan seemed low, considering what is being learned about microsite specialization, population fluctuations, and other features that may make certain species vulnerable in small, isolated, or mismanaged populations (E.

⁵ The Endangered Species Act protects endangered and threatened animals, but not plants, against "take." Permits to take listed animals may be granted under Section 10(a)(1)(B) of the Act "if such taking is incidental to, and not the purpose of the carrying out of an otherwise lawful activity." A permit may be issued only if the applicant submits a conservation plan for the affected animal species. Such Habitat Conservation Plans (HCP's) must conserve endangered or threatened plants that would be affected along with the animal(s). For example, an HCP developed for scrub inhabited by Florida scrub jays and *Eryngium cuneifolium* must conserve *Eryngium* as well as the jays.

Menges, Archbold Biological Station, in litt. 1995). In response to these concerns, recovery criteria have been modestly tightened in the final version of the plan.

After the public comment period on this plan closed, the Service's South Florida Ecosystem Office (Vero Beach) convened a recovery meeting on these and other plants. Recovery criteria for all the species were discussed, with *Nolina brittoniana* getting the most detailed treatment. It was also noted at the meeting that substantial progress has been made at conserving Florida scrub, and the present situation is much better it would have been without the past decade's concerted conservation actions.

Because the recovery meeting was held after the public comment period for this plan closed, it would be inappropriate to incorporate suggestions made at the meeting into a final recovery plan without reopening the comment period to allow review by other parties. Delaying this recovery plan for a second comment period is undesirable because 1) the Service is expected to produce recovery plans in a timely manner, and several species do not yet have a recovery plan; 2) a second comment period would be burdensome to reviewers; 3) scientific work on these plants is progressing fast enough that better recovery objectives can be developed in just a few years; 4) altering the recovery criteria would not greatly affect the progress of recovery of these plants through land acquisition and management, which is already a high state and national priority; and 5) the South Florida Ecosystem Office is preparing additional material. Possible future recovery criteria are discussed under *Nolina brittoniana*, on page 60.

Recovery objectives, and the reasons for them, are as follows (the species are in alphabetical order):

***Bonamia grandiflora* – Florida bonamia (T)**

Life history: Long-lived perennial herb, recovering from fire by resprouting and by germination from the seed bank. Occurs mostly in sunny gaps in the shrub layer of scrub.

Objective: Delist.

Criteria: 1) The species is secure in Ocala National Forest (Marion County). Low-intensity monitoring must continue after delisting.
 2) Secure and monitor at least three sites in Highlands, at least three in Polk, and at least two in other counties (The 1990 edition of this plan called for one site in Highlands, one in Polk, and one elsewhere).
 3) Provide at least 5 years of demographic monitoring for each site, coupled with prescribed fire (not provided for in the 1990 edition of the plan).

Reasons: *Bonamia grandiflora* is abundant in much of the Ocala National Forest, but when it was listed, it was secure nowhere else. One commenter on the draft of this recovery plan (R. Yahr, Archbold Biological Station) noted the need for multiple protected sites for *Bonamia* on the Lake Wales Ridge, where the species had locally gone extinct at Archbold Biological Station. Progress is being made toward habitat protection on the Ridge; appropriate fire management is also essential. The two units of Lake Wales Ridge State Forest offer an excellent opportunity to manage and monitor this species on large tracts. Nothing has yet been done to protect *Bonamia* in Hardee, Manatee, and Hillsborough counties.

Chionanthus pygmaeus – **pygmy fringe tree** (E)

Life history: Long-lived shrub, presumably resprouting from base of stem after fire. It occurs in high pineland, scrubby high pineland, and scrub.

Objective: Reclassify to threatened, then delist.

Criteria: Reclassify: Eight populations at four sites in Highlands, Polk, and Lake counties; with at least 10 years of demographic monitoring of at least one site (and demographic monitoring established at all sites).

Delist: 20 populations at five sites, with 10 additional years of monitoring.

Reasons: The criteria are the same as for *Prunus geniculata* and are changed from the 1990 edition of this plan by the addition of demographic monitoring. It is uncertain that there are any really large populations of this species. Assuming it is pollinated by wide-ranging insects, even a large protected area like Lake Arbuckle may prove to have only a single population. Demographic monitoring (already underway) needs to continue for a number of years. Although the State is planning land acquisition in Lake County, no purchases have been made yet.

Cladonia perforata – **Florida perforate cladonia** (E)

Life history: Ground-dwelling lichen, destroyed by fire. Occupies gaps in scrub, increasing with time-since fire.

Objective: Reclassify to threatened

Criteria: 1) Sites at Eglin Air Force Base recover from Hurricane Opal
2) Experts concur on fire prescriptions for this species.
3) The largest site on the Lake Wales Ridge is protected (probably in private ownership)
4) Monitoring at all protected sites

Reasons: This lichen requires many years between fires or other disturbance, so there may be a special threat from off-road vehicles or other disturbance. The science of lichen conservation is likely to develop rapidly, so recovery criteria are almost certain to be rewritten. The prospects for finding more sites for this lichen are good, so further opportunities for habitat conservation are possible.

Clitoria fragrans – **pigeon wings** (T)

Life history: Long-lived herb of high pineland. Fire stimulates new growth and flowering. Plants usually occur sparsely, never in dense populations.

Objective: Delist

Criteria: Protect six or more sites in Highlands and Polk counties, plus 1 or more in other counties. Five years of demographic monitoring in conjunction with prescribed fire.

Reasons: Recovery depends upon protecting and managing enough high pineland. This species appears to pose no special management problems, although monitoring may be difficult due to the need to search for plants. Opportunities may occur to conserve this species on privately owned land that can be expected to remain in use as ranchland, perhaps in connection with Habitat Conservation Plans for listed animals.

Conradina brevifolia – **short-leaved rosemary** (E)

Life history: An apparently short-lived small shrub of scrub, destroyed by fire, reproducing entirely by seed.

Objective: Reclassify to threatened; eventually delist.

Criteria: Protect Carter Creek and at least one other site (to make a total of four or more protected sites). Conduct demographic monitoring at the protected sites for at least 10 years.

Reasons: This species occurs only in about 30 scrubs whose combined areas total less than 6,000 acres (Christman 1988c). It is one of the more narrowly distributed species in this plan, although more widespread than *Eryngium cuneifolium* and *Hypericum cumulicola* (Kris DeLaney, in litt. 1995). The plant is protected at the Lake Arbuckle tract of Lake Wales Ridge State Forest, at Lake Arbuckle State Preserve, and at Saddle Blanket Lakes. The Carter Creek area offers the best opportunity to protect more habitat.

Crotalaria avonensis – Avon Park harebells (E)

Life history: Herb from a taproot, dormant in winter. Occupies gaps in scrub. Presumably resprouts after fire.

Objective: Reclassify to threatened.

Criteria: Protect the Carter Creek area. Monitor the species here and at the only other site for 10 years. Ensure that the plant is viable within scrub vegetation, not just on road edges and firelanes.

Reasons: This species occurs at only three sites where protection is feasible. One site (Saddle Blanket Lakes) is protected and the two others are targeted for land acquisition. Carter Creek is by far the better of the two. The demography and micro-habitats of this species are not yet well understood. It is probably a species of temporary gaps in the shrubby vegetation, much like *Eryngium cuneifolium*.

Eriogonum longifolium var. *gnaphalifolium* (scrub buckwheat) (T)

Life history: Perennial herb with a rosette and flowering stems. Stimulated to flower by fire. Occurs mostly in high pineland, also in scrub.

Objective: Delist.

Criteria: Complete planned land acquisitions; protect at least one more site in Lake and/or Pasco counties (one site is protected in Pasco). Demographic monitoring in conjunction with habitat manipulation (prescribed fire or other measures) appears essential, so monitoring is needed for at least five years.

Reasons: Monitoring is necessary because most sites that may be protected must be restored to a condition of having a grassy understory with longleaf pine. This means applying prescribed fire and perhaps cutting oaks. Each individual site will need its own restoration plan. At Ocala National Forest, where the high pineland vegetation is intact, monitoring is providing information on the response of this species to fire.

Eryngium cuneifolium – a snakeroot (E)

Hypericum cumulicola (Highlands scrub hypericum) (E)

Liatris ohlingerae (scrub blazing star) (E)

Life histories: *Eryngium* and *Hypericum* are herbs with life spans of one to several years. *Eryngium* recovers from fire by resprouting and by seedlings from the seed bank (Menges and Kohfeldt 1995). *Hypericum* apparently does not resprout, maintaining its populations entirely by seed. Both species are restricted to sunny gaps between the shrubs that are apparently usually created by fire and relatively

short-lived. Populations of *Eryngium cuneifolium* are very large but highly localized. These species needs not merely gaps, but fresh gaps. It disappears after a few years, even if open, sunny conditions persist. *Liatris*, an apparently longer-lived plant that resprouts after fire from a corm, occurs at nearly the same list of sites, but does not depend on gaps. Populations consist of scattered plants. The dependence of *Eryngium* and *Hypericum* on temporary gaps means that local populations are temporary, and function as parts of metapopulations. Research on the population biology of these species will be very important to future review of the recovery criteria.

Objective: Reclassify to threatened; eventually delist.

Criteria: Protect at least five sites, with intensive demographic monitoring and prescribed fire planning for *Eryngium* and *Hypericum*; demographic and genetic monitoring for *Liatris*.

Reasons: These species have similar, restricted geographic ranges. Biologists are not persuaded that enough sites can be protected to allow delisting of these species, especially *Eryngium cuneifolium*. *Eryngium* and *Hypericum* require active management of preserves to create a mosaic of different-aged gaps. *Liatris* does not depend on gaps, but occurs sparsely. Because its geographic range is slightly broader than *Hypericum*'s, it appears nearly certain that land acquisition and management undertaken for the first two species will be adequate for *Liatris*. The obligate outbreeding system of *Liatris ohlingerae* means that for a population to be viable, it must include enough genetic diversity for the breeding system to function. Methods to assess genetic diversity are available. If a population is found to be excessively uniform, population augmentation can be considered.

The 1990 edition of this plan supposed that a single site could support several populations of *Eryngium* or *Hypericum*. This does not seem plausible now that Eric Menges and others are examining metapopulation dynamics. The 1990 edition noted the similarity of the distribution of *Liatris ohlingerae* to the two other species, and assumed that *Liatris* needed the same number of protected sites.

Lupinus aridorum – scrub lupine (E)

Life history: Short-lived herb (one to several years) whose seed remains dormant in seed bank perhaps as long as 50 years. Populations may be in evidence for only a few years after a fire.

Objective: Prevent extinction.

Criteria: Protect sites in Polk and Highlands counties, and establish a disturbance regime to create bare, sunny openings. Conduct demographic monitoring for the foreseeable future.

Manage and rehabilitate publicly-owned habitats in Orange County.

Reasons: Not only is habitat loss and modification severe (due to growth of the Orlando urban area and semi-rural development in northern Polk County) but this plant's life history makes protection and monitoring difficult. The plant's vulnerability to disease makes garden propagation and reintroduction difficult if not impossible. Conservation of this species seems as difficult now as it did in the 1990 edition of this plan.

Notina brittoniana – scrub beargrass (E)

Life history: Long-lived relative of the yuccas that resprouts from substantial underground stems after fire. The plants spread vegetatively, so a group of rosettes may represent only a single genetic individual.

Objective: Reclassify to threatened, then delist

Criteria: For reclassification, protect eight populations at four or more sites, with simple genetic assessment of number of individuals and demographic monitoring for five years. For delisting, 20 viable populations at five or more sites, with sites in each of Highlands, Polk, Orange/Osceola, and Lake counties.

- At a recovery meeting held after the comment period for this plan, the most expert biologists agreed that recovery criteria should be more conservative. Their tentative criteria for reclassifying *Nolina brittoniana* to threatened status: Protection of 25 sites for 20 years [eight to ten sites are currently protected], with half of the sites larger than 500 acres, the rest at least 10 acres. The sites must represent the plant's entire geographic range. Appropriate fire management is essential, as is demographic monitoring. Better information is needed on seedling recruitment. Delisting might not require the protection of more sites, just confirmation that the sites are safe.

Reasons: Because of *Nolina brittoniana* has a long life span, recovery criteria for this species should be similar to those for *Chionanthus pygmaeus* and *Prunus geniculata*. Researchers have learned a great deal about this plant's population biology over the past several years, aided in part by the tendency of plants to have either male or female flowers, which makes it easy to crudely map clones.

Paronychia chartacea subsp. *chartacea* (papery whitlow-wort) (T)

Life history: Dioecious herb that may live from one to several years. It is destroyed by fire and maintains its populations strictly by seed.

Objective: Delist.

Criteria: The first edition of this recovery plan called for delisting this species when it is protected at 10 sites, including at least one in Orange and/or Osceola Counties and at least three each in Polk and Highlands counties. These criteria are likely to be substantially exceeded as recovery measures are implemented for the other species.

Reasons: This is one of the most widely-distributed of the listed scrub species, and it is usually abundant in disturbed areas such as fire lanes. Enough sites are protected or nearing protection (including one small privately-owned site in Orange County), that the delisting process can be started as soon as land acquisition is complete and prescribed fire plans are implemented. This plant is so abundant that demographic monitoring is not needed. Mark Deyrup of Archbold Biological Station (pers. comm. 1995) notes that until land acquisition programs were implemented, this plant was genuinely threatened and that conserving its habitat has been a difficult and worthwhile enterprise.

Paronychia chartacea subsp. *minima* – papery whitlow-wort (T)

Life history: Annual herb.

Objective: Delist.

Criteria: Conservation of its habitat: margins of karst ponds. The exact number of sites needing conservation cannot yet be determined.

Reasons: Further work is needed to map this plant's distribution on shores of karst ponds north of Panama City in the Florida panhandle. Several other endemic plants occur in the same habitat, and botanical survey work has been progressing, although the Service has yet not begun the listing process for these plants. These pond margins are definitely threatened by residential development and perhaps

by off-road vehicles, so it is appropriate to develop conservation measures and to encourage land acquisition that is already planned by the State and the Northwest Florida Water Management District.

Polygala lewtonii – **Lewton's polygala (E)**

Life history: Lives several years, survives fires. Occupies scrub, high pineland, and, especially, intermediate habitats (like *Eriogonum longifolium* var. *gnaphalifolium*).

Objective: Reclassify, then delist.

Criteria: For reclassification, the species must be conserved in Highlands, Polk, and Marion Counties, plus at least one other county (Lake or Orange). It must be present at 20 or more protected sites, each with demographic monitoring for at least 5 years. Surveys are needed to determine the extent of populations on protected or likely-to-be-protected sites. Limited experimentation (or careful examination of the results of natural experiments) with habitat management is needed. This can probably be accomplished at Ocala National Forest and perhaps one or two sites elsewhere.

Reasons: This small plant, which can be mistaken for other species of *Polygala*, may prove to be somewhat more widespread than indicated by existing surveys. It appears likely that an adequate number of sites will be protected, so measures to recover *Polygala lewtonii* can concentrate on assuring good management of protected sites.

Polygonella basiramia – **a wireweed (E)**

Life history: Short-lived perennial herb that does not resprout after fire; it maintains its populations by seed (Menges and Kohfeldt 1995).

Objective: Reclassify to threatened, then delist.

Criteria: Reclassify: The 1990 edition of this plan stated that the species could be reclassified when adequate management was assured at the five sites that were already protected (and the accuracy of identification of this species had been confirmed), and delisted when one more site in Highlands County was protected. This objective has been met.

Biologists who work with scrub conservation now prefer to see more sites protected (20 to 25 representing the entire range of the species), with adequate fire management and monitoring for at least 10 years. Some of the larger protected tracts have more than one distinct area of scrub, and by counting these areas, it is likely that present acquisition plans suffice to protect at least 20 sites.

3) The distribution of this species needs to be confirmed by an examination of herbarium material by an expert systematist.

Reasons: *Polygonella basiramia* can be confused with the more widespread *P. ciliata*, so it is essential to have herbarium voucher specimens from protected sites, and to review those specimens before delisting. The species is locally abundant, so there is no biological reason not to take specimens. Adequate habitat protection for *Polygonella basiramia* seems assured. It was found at Avon Park Air Force Range after it had been listed, and it is present at most of the land acquisition sites in the Lake Wales Ridge. Eleven of the sites are already protected. This species is nearly ubiquitous in firebreaks, animal or human trails, or other disturbed areas, so it is essential to ensure that it is not being confined to artificially-disturbed areas while natural gaps in the vegetation disappear (see comment on *Polygonella myriophylla* about the necessity of prescribed fire). *Polygonella basiramia* almost certainly

does not need to be monitored at sites with more seriously endangered gap plants, such as *Hypericum cumulicola*.

The 1990 edition of this plan noted that the species had been found at Avon Park Air Force Range, and protected at 4 other sites since it was listed, so reclassification to threatened status could be considered as soon as herbarium specimens were reviewed and appropriate management established at the protected sites. Delisting required protection of one more site in Highlands County.

Polygonella myriophylla – sandlace (E)

Life history: A low, spreading shrub that occupies areas of bare sand created by disturbance in scrub.

It may resprout after fire.

Objective: Reclassify to threatened status, then delist.

Criteria: Reclassify: Protect 10 sites in Highlands and Polk counties. Demographic monitoring is needed to ensure that populations are being maintained in the vegetation proper, not just in fire lanes and road edges;

Delist: protect 20 sites (including at least 1 site in Orange or Osceola counties; the count can include multiple sites on large protected tracts) and have 10 years of demographic monitoring results from 10 or more protected sites showing that the plant is not being restricted to artificially disturbed areas.

Reasons: This conspicuous plant occurs with *Eryngium cuneifolium*, *Hypericum cumulicola*, *Paronychia chartacea*, and *Polygonella basiramia*. There is a serious danger that land managers, seeing the plants in these artificially-disturbed sites, will see little reason to provide prescribed fires to simulate the natural fire regime. Demographic monitoring of *Polygonella myriophylla* is also needed because it is not clear whether fire is essential for this species (which readily moves into bare areas created by fires). It is possible that this species maintains its own openings through allelopathy.

Prunus geniculata – scrub plum (E)

Life history: Shrub that resprouts after fire but apparently does not spread clonally, so every clump of stems is a distinct individual. Occurs in high pineland, scrub, and scrubby high pineland.

Its habitat and range are similar to those of *Chionanthus pygmaeus*.

Objective: Reclassify to threatened, then delist.

Criteria: Reclassify: 8 populations at 4 sites, with at least 10 years of demographic monitoring of at least one site (and monitoring established at all sites). Sites must be protected in Highlands, Polk, and Lake counties.

Delist: 20 populations at 5 sites, with 10 further years of monitoring.

Reasons: The objective and criteria are the same as for *Chionanthus pygmaeus*, and are the same as for the 1990 edition of this plan, with the addition of demographic monitoring.

It is uncertain that there are any really large populations of this shrub. Assuming it is insect pollinated, even a large protected area like Lake Arbuckle may prove to have only a single population. Demographic monitoring (already underway) needs to continue for a number of years.

Although the State is planning land acquisition in Lake County, no purchases have been made yet. In Highlands and Polk counties, the two shrubs are gaining habitat as land acquisition proceeds.

Warea carteri – Carter's mustard (E)

Life history: An annual whose seeds germinate mostly the year after fire. Plants that grow the first year after fire are more vigorous than the plants that germinate in following years.

Objective: Reclassify to threatened, eventually delist.

Criteria: Reclassification: tentatively, protect at least 10 sites with viable populations. The same delisting objective as for *Paronychia chartacea* subsp. *chartacea* would be appropriate, but the fugitive nature of *Warea carteri*, with seed germinating only under the right conditions, makes it harder to be sure that the latter species is secure. It will probably take at least 10 years of searching for *Warea* populations in burned or disturbed areas to understand its real abundance and distribution, and the extent of its seed banks. If sites in scrubby high pineland, with their higher fire frequencies, turn out to have significant populations, the recovery process might be speeded up. It is essential to search for this species on the Florida east coast, especially Brevard County.
Delisting: may depend primarily on understanding this plant's management needs well enough to be sure it is safe on protected sites.

Reasons: Because the number of flowering individuals at a site varies drastically, it is important to search for this species in the year after a fire. Because fires in scrub occur at long intervals, it will take years to map out the distribution of *Warea carteri* in preserves and elsewhere. The 1990 edition of this plan tentatively called for protection of at least 5 sites for reclassification, and wanted monitoring and evaluation of minimum viable population size.

Ziziphus celata – Florida ziziphus or lotebush (E)

Life history: Shrub, spreading clonally from its root system, almost certainly resprouting after fire

Objective: Prevent extinction

Criteria: Reverse decline of the plants at the Lake Arbuckle tract of Lake Wales Ridge State Forest (probably through prescribed fire). Protect other sites, if possible, through conservation agreements with pasture owner(s). Build up and maintain a germplasm collection. Search for more populations.

Reasons: Recovery depends on the existence of enough genetically distinct individuals to constitute a minimum viable population. If so, the same recovery goals apply to it as to *Chionanthus pygmaeus*.

The secondary objective of this plan is to enhance the prospects for recovery of other listed plants and animals of the central Florida scrub and other dry habitats, and to obviate the need to list several plants of dry habitats (and moist habitats adjoining dry habitats) that are of concern, including: *Calamintha ashei*, *Hypericum edisonianum*, *Lechea cernua*, *Panicum abscissum* (cutthroat grass), and *Schizachyrium niveum* (scrub bluestem grass). Other scrub endemics will also benefit, for example *Quercus inopina* (Archbold oak), *Ilex opaca* var. *arenicola* (scrub holly), and distinctive local populations of *Cyrilla* and *Crataegus* (as noted by R. McCartney, Woodlanders, Inc., Aiken S.C. and S. Christman). Because upland native vegetation is rapidly being destroyed or fragmented, the land acquisition process cannot be allowed to slow from its current pace. Delay will cause the loss of irreplaceable habitat. Habitat Conservation Plans prepared for Florida scrub jays and other threatened animals will not provide an alternative to land acquisition for these plants.

B. NARRATIVE OUTLINE

1. **Protect habitats of the plants.** The primary conservation measure for these species is to protect native populations in their habitats of scrub and high pineland in Highlands, Polk, and (for some species) other counties.

- 1.1 **Maintain an inventory of sites and species.** To assess progress toward creating a network of protected sites, to detect unmet conservation needs, and to allow land managers for different agencies to assess their activities in an ecosystem context, it is important to have overall database(s) that, as a minimum, tell which species occur at which sites. The potential for habitat conservation plans (task 1.41) makes it useful to assemble the available information on unprotected sites with listed species.

A great deal of information is available from surveys conducted since 1980, and this information is accessible through the Florida Natural Areas Inventory and perhaps other sources. The problem is to find inexpensive ways to update and improve the existing data. Recent surveys have shown that existing inventories are far from complete.

Work at Archbold Biological Station on the distribution of the Florida scrub jay may provide a geographic information system (GIS) framework on which to add plant distributions and habitat mapping appropriate to plants (for example, high pineland). Well-designed maps are valuable tools, uniquely able to show how each species has its own distribution. This educational function is useful both to managers and to the wider public.

Data management for individual protected sites is covered in task 2.6.

- 1.2 **Conduct surveys for selected species, either on lands where they might be protected or on protected sites.** No inventory work can be conducted without landowner permission.

- 1.2.1 ***Lupinus aridorum* surveys.** Surveys along the Florida Turnpike right-of-way west of Orlando are essential. Plants might be found along Interstate 4 south of Orlando, particularly near state road 535. The surveys must map or mark the plants in a way usable to the Florida Department of Transportation. Difficulties with listed scrub plants on limited-access rights of way have made clear the need to have survey information well in advance of any construction plans.

- 1.2.2 ***Cladonia perforata* awareness.** Biologists working in scrub need to know how to identify and to be on the lookout for this lichen, which is easy to spot and relatively easy to identify (little if any magnification is required). It has been carefully searched for, especially on the Lake Wales Ridge in Highlands and Polk counties, along the southeastern coast, and on the coast of the western Florida panhandle. It definitely has a limited, spotty distribution. But it has recently been found at sites that had been at least cursorily surveyed. It will be essential to carefully inventory (or re-inventory) any land acquisition sites, and to follow up any new discoveries with searches of the immediate neighborhood. Good illustrations (including line drawings and photographs) will help managers and other biologists identify this species.

- 1.2.3 ***Warea carteri* surveys.** Germination and flowering of this annual species is stimulated by fire, so post-fire surveys should be conducted, especially in Brevard County where there is only one recent herbarium specimen of this plant. Surveys are also needed for monitoring purposes in preserves. Because of the need to conduct surveys after fires, it will take years to build up an accurate view of this plant's distribution, abundance, and conservation status.
- 1.2.4 ***Polygonella basiramia* identification.** Some uncertainty remains over the identification of this plant (versus *Polygonella ciliata* and *P. gracilis*), and therefore its geographic range is somewhat unclear. Herbarium specimens from as many protected sites as possible (especially Avon Park Air Force Range) should be evaluated by a systematist to assure that they have been identified correctly. If they aren't already available, voucher specimens must be collected from protected sites, especially in Polk County where the distributions of the two species might overlap. The systematics of these species was reviewed by Nesom and Bates (1984), and there is no apparent need for further systematics investigations.
- 1.2.5 **Surveys in "outlying" counties.** Scrub sites on the southern Lake Wales Ridge have been more or less adequately inventoried. As opportunities arise in connection with proposed state land purchases or other activities, botanical inventories should be conducted in scrub and high pineland in Osceola, Orange, Lake, Pasco, Hernando, Citrus, Sumter, Marion, Volusia, Hardee, and Manatee counties. There is always the possibility of finding *Cladonia perforata*, *Bonamia grandiflora*, *Eriogonum longifolium* var. *gnaphalifolium*, *Nolina brittoniana*, *Polygala lewtonii*, or new *Dicerandra* populations.
- 1.3 **Continue land acquisition following plans adopted by governments and private conservation organizations.** Land purchase needs to be pursued before other land conservation options, such as conservation easements on private land, because real estate and agricultural development is proceeding too rapidly for other methods of land protection to contribute more than marginally to the recovery of these species.
- 1.3.1 **The Lake Wales Ridge** and nearby ridges remain the centerpiece for land acquisition strategy, as described above in "Existing conservation measures," p. 44.
- Lupinus aridorum*, followed by the species of *Dicerandra* (with their own recovery plan) are the highest priorities for habitat acquisition in the Lake Wales Ridge area due to their restricted distributions. The State has acquired the first *Ziziphus celata* to be discovered with intact native vegetation. No site *Cladonia perforata* site on the Lake Wales Ridge is currently available for purchase. At the time of writing, acquisition prospects appear good for the narrowly distributed *Dicerandra christmanii* (the only site is being purchased by the Fish and Wildlife Service), reasonably good for

Crotalaria avonensis and *Conradina brevifolia* (Carter Creek is a problem), and very good for the more widely distributed species.

Both the State and the Service have focused their acquisition plans on the best available large, unfragmented remnants of scrub (the State is also interested in good examples of other natural vegetation). The focus on large sites is consistent with Fernald's (1989) assessment that preserves should be at least 500 acres for ease of management and to maintain the vertebrate fauna. In particular, researchers at Archbold Biological Station have shown that scrub jays need relatively large preserves. To allow dispersal of birds between preserves, the preserves must be reasonably close together or have smaller "stepping stone" patches of scrub. Stepping stones for jays may be valuable plant refuges. Eric Menges (Archbold Biological Station, pers. comm. 1995) emphasized the need for fire management in scrub preserves aimed at the needs of the scrub endemic plants.

Steven Christman (pers. comm. 1988) suggested 30 acres as a feasible preserve size for plants and lizards. Fernald (1989), writing about the scrubs of the Atlantic Coastal Ridge, suggested establishing as many small preserves as possible, with a minimum practical size for management purposes "of about 10-15 acres for botanical preserves and 50 acres for scrub community preserves." (p. 60, Fernald). Donald Richardson (Ecological Consultants, Inc., pers. comm. 1995) sets 10 acres as a minimum size for scrub management. The viability of a small preserve depends on the nature of its neighbors: citrus groves may be much more compatible than residential areas, which create problems of fire protection and depredations by pets, feral dogs and cats, trash dumping, and off road vehicles. The smallest tract on which acquisition is underway for the National Wildlife Refuge is a 50-acre site for *Lupinus aridorum*. No larger sites exists for the lupine. The State's Lake Wales Ridge project (including the formerly separate "Warea archipelago" project) has several small sites.

- 1.3.2 Outside the Lake Wales Ridge region are significant portions of the ranges of several of these plants. The recovery objectives seek the conservation of each species in as much of its former range as feasible. If an opportunity becomes available to purchase land for *Lupinus aridorum* in Orange County, or if desirable habitat for *Prunus geniculata* or *Polygonella myriophylla* becomes available in that county, it would contribute to recovery. Should any of the species be found in Pasco, Hernando, Citrus, or Volusia counties, acquisition might be considered. Unfortunately, intensive biological surveys like the ones that were conducted on the Lake Wales Ridge and a few other areas are not available elsewhere, so it isn't possible to develop a detailed acquisition plan for these species. However, sites that are known to have a particular species may, upon closer inspection, also have others. A costly acquisition by Palm Beach County, the Jupiter Ridge Natural Area, was well justified as one of the last opportunities to conserve coastal scrub (with Florida scrub jays and the endangered *Asimina tetramera*). Since acquisition, two more endangered plants have been found at

the site: *Polygala smallii* (previously known from the Miami area) and *Cladonia perforata*. This shows the benefits of conserving ecosystems, not just species.

Land acquisition may be feasible to conserve *Paronychia chartacea* subsp. *minima*. Better information on its habitat will be developed as status surveys are completed for other karst pond endemic plants that have been under consideration for Federal listing. Searches aimed at *Paronychia* itself need to be conducted.

1.4 Pursue non-acquisition land conservation measures that offer opportunities to conserve plants at sites that are not suitable or not available for acquisition.

1.4.1 Ensure that habitat conservation plans for Florida scrub jay and threatened lizards (see task 621.) help conserve other members of the scrub biota. When a development project would cause take of listed animals, the developer must develop a Habitat Conservation Plan (HCP) for those animals and for any listed plants on the project site in order to obtain a take permit for the animals. Because scrub jays and the lizards often occur with listed plants, HCP's present opportunities to conserve the plants (for example, an HCP conserved a valuable *Eryngium cuneifolium* site).

1.4.2 Use conservation easements and other non fee-title ownership options.

Conservation easements are recognized under both Federal and Florida state law, and may in some cases protect habitat while allowing it to remain in private ownership. Non-binding conservation agreements with landowners may also prove useful as a supplement to land acquisition. While conservation easements will probably be a minor part of recovery for these species, compared to acquisition, they may prove valuable in areas off the Lake Wales Ridge where ranching or citrus remains the predominant land use.

1.4.3 Protect land through regional and local county planning. Fernald (1989) provides detailed guidance for the southern Atlantic Coastal Ridge. Although development pressures on the coastal ridge differ from those in the center of the peninsula, many of his recommendations are applicable to the Lake Wales Ridge.

The first edition of this recovery plan expressed hope that scrub and other native vegetation might be protected through the State's requirement for counties to develop comprehensive plans, and by the State's procedures for planning Developments of Regional Impact (DRI's). These programs seem to have had little effect, with a few exceptions such as Hillsborough County's scrub protection program, enacted as part of its Land Alteration and Landscaping Ordinance (Ordinance 87-2). Any legal protection for scrub and/or high pineland should distinguish between sites with few or no endangered species and those sites with numerous endangered species and/or the most seriously endangered species (such as *Ziziphus celata* and *Lupinus aridorum*). There is also a need to balance the need to mitigate for wetland loss against the need to conserve valuable uplands.

County planning/permitting has the potential to encourage compatible land uses adjacent to biological preserves. For example, dense residential development adjacent to scrub in biological preserves is undesirable because of the possibility of intense scrub fires (especially wildfires) affecting houses or people. Some scrub preserves, such as Jonathan Dickinson State Park, are coping with residential neighbors, but it would be preferable to prevent such conflicts. Domestic animals such as cats are not compatible with scrub jays.

Fernald suggested that golf courses can be designed to protect scrub (p.100, fig. 44). Golf course designers can obtain expert advice on working with scrub vegetation, and suitable propagated plant material is readily available.

Some permitting procedures such as use permits for sand mines may also foster conservation of native vegetation. Provisions in county plans setting minimum acreages for agricultural zoning and provisions for "sunsetting" abandoned or illegally platted subdivisions may be vital for habitat protection, because some important areas have remained undeveloped because they were platted and sold off in small parcels.

1.4.4 Protect and manage small publicly-owned or institutional sites. Some valuable small tracts of scrub are in public or institutional ownership; for example, tracts at South Florida Community College in Avon Park and Avon Park Airport (Christman 1988c). Although they are seldom owned by the utilities, electric power line rights-of-way may offer some opportunities for protecting scrub plants and animals. It should be possible to assist some owners and managers by providing vegetation-renewal services (e.g. cutting the vegetation to the ground to simulate the effects of fire). Management of small "stepping stone" habitats for Florida scrub jays could benefit plants.

2. **Manage protected habitat.** The State has estimated the management costs for proposed land acquisitions (Florida Dept. Environmental Protection, Division of State Lands 1994). These cost estimates include visitor and recreational facilities (for parks) and include management costs for a great deal of native vegetation other than scrub and high pineland. Nevertheless, these figures provide a reasonable guide to the start-up and operating costs for the network of preserves needed to meet the objectives of this plan.

<u>Management Costs</u>	<u>Start-up</u>	<u>First year</u>
Saddle Blanket Lakes (Div. of Recreation and Parks)	65,041	65,041
Catfish Creek (Div. of Recreation and Parks)	43,497	43,497
Horse Creek Scrub (The Nature Conservancy)	92,212	47,002
Lake June in Winter (Div. of Recreation and Parks)	206,614	206,614
Lake Walk-in-the-Water and Hesperides (Div. of Forestry)	94,940	48,724
<u>Lake Wales Ridge Ecosystems, 17 sites (The Nature Conservancy)</u>	<u>774,045</u>	<u>426,335</u>
Total costs	1,276,349	837,213

- 2.1 **Develop model fire management plans** for Lake Wales Ridge scrub, coastal scrub, and high pineland.

Site-specific fire management plans (task 2.4.2) may benefit some species at the expense of others unless they incorporate a high degree of variability in the period-between-fires. Model plan(s) incorporating variable fire return intervals for scrub and high pinelands should be produced to guide site-specific plans (A. Herndon, Florida International Univ., in litt. 1995; Menges and Kohfeldt 1995). Additionally, the technical aspects of fire planning (fuel models, weather) need not be done separately for each site.

- 2.2 **Initial inventory for each protected site.** Managers need to start out with at least minimal information, such as a checklist of biota, aerial photograph(s), photocopy of the soil survey sheet, and at least a simple vegetation map (perhaps drawn on an aerial photograph or the soil survey). Deficiencies should be noted and remedied.

- 2.3 **Conduct initial conservation measures at each protected site.** As sites are protected, management begins with boundary control (usually fences, gates, and signs) and trash cleanup. Dumping and recreational driving have caused problems at many sites, so it is essential for managers to effectively take control of sites to prevent any further degradation. Sites range from nearly pristine (Placid Lakes was a good example) to badly affected by dumping (Flamingo Villas). Control of off-road vehicles and other uses is particularly important at *Lupinus aridorum* sites, which are being badly impacted. Trash dumping is a particularly severe problem at Flamingo Villas.

- 2.4 **Establish management objectives for each site; determine what management services are needed at each site.** Site-by-site written objectives are essential because 1) The sites are diverse in terms of vegetation, species, expected public use, and adjacent land use. 2) The conservation needs of particular species will dictate that their management be emphasized at particular sites, and 3) without written objectives, essential management tasks will probably be neglected in the competition for managers' attention and funds.

"Management services" are what that must be done to implement management objectives, from tending fences and gates to providing prescribed fires and suppressing wildfires. While practical considerations of providing management services will influence goals, managers must not become preoccupied with management services until they know what they want to accomplish. We expect that in practice, services will be planned immediately after objectives.

- 2.4.1 **Set management objectives.** Ensure that objectives for each site mesh to meet the overall recovery objectives of the species.

Management objectives will generally be stated in terms of the desired condition of the vegetation and fire regime, with supplementary objectives as needed for restoration of damaged areas, maintaining good relations with neighboring land owners, and accommodating any public use. Because the plants that occur in scrub

share habitat with Florida scrub jays, objectives will reflect the jay's well-understood habitat requirements. In many scrub areas, it may be appropriate to treat Florida rosemary as a key management species, because many other plants are associated with it. In high pineland and other vegetation, management objectives may be stated in terms of reversing the effects of many years of fire suppression. Special care must be taken in setting objectives for vegetation intermediate between scrub and high pineland (which is inhabited by several of the species, such as scrub plum). There is uncertainty as to whether some of these sites are truly intermediate or merely degraded, so management objectives will be tentative and monitoring of threatened and endangered species will be designed to show the effects of management measures (such as restoration of fire, planting of wiregrass and pine trees).

- 2.4.2 Develop fire and other vegetation management plans.** Different land management agencies in Florida have their own procedures, but they all cooperate in responding to wildfires, and often in conducting prescribed fires. Interagency fire cooperation already exists. Preserve managers need site-specific plans for fire that will take into account the needs of each plant and animal species of conservation concern. Such plans should explain how competing conservation requirements are reconciled. Prescribed fires in Florida scrub jay habitat during the nesting season require incidental take permits under the requirements of the Endangered Species Act.

Managers must be able to respond to wildfires without causing unnecessary collateral damage to biological resources. With careful planning, prescribed burning may be feasible even near houses or busy roads (Palm Beach County is conducting small burns in urbanized areas). Mechanical scraping, either of entire stands or of limited areas within stands, may serve as an acceptable substitute for burning in some cases (experiments planned for Jonathan Dickinson Park will be relevant). Restoring naturalistic fire regimes in degraded high pineland depends on being able to restore the wiregrass and longleaf pines that provide the fine fuels that in turn make possible low-intensity, rapidly-spreading fires. Restoration of high pinelands that had lost their wiregrass was considered impossible until recently, but work underway at preserves in Florida is changing that perception. Planting of wiregrass seedlings is too costly to be feasible for large sites. Direct seeding may be an alternative.

- 2.4.3 Control exotic pest plants.** Threats are discussed on page 42. For most scrub preserves, the threats are not yet as overwhelming as they are in the Everglades or Miami pine rocklands, but preserve managers must control exotic pest infestations before they get out of hand. The Forest Service's campaign to eradicate cogon grass and Palm Beach County's work with Brazilian pepper are examples. It is quite possible that new exotic pest plant threats will emerge (the recent spread of tropical soda apple is a reminder).

Both site-by-site efforts to control pest plants and involvement in broader biological control initiatives are needed. Control efforts may have to extend beyond

removal of existing infestations: seed may be spread with road building materials, and fill dirt or crushed limerock may provide nutrient-enriched substrates on which pest plants can thrive. Additionally, limerock from south Florida is likely to be contaminated with *Neyraudia* seeds. For preserve managers, control of dumping (especially yard waste, which may contain air potato, Boston fern, and other noxious weeds) is an important means of preventing exotic plant infestations.

The problem of spreading exotic pest plants through dumping is one reason why preserve managers must consider restricting motor vehicle access.

2.4.4 Develop a special management plan for *Lupinus aridorum* and other plants on highway rights-of-way. The Florida Turnpike right-of-way is crucial to the survival of this lupine in the wild. Site-specific plans for ensuring the plant's future should be developed and implemented by the Florida Department of Transportation in cooperation with others.

2.4.5 Site specific *Cladonia perforata* management in preserves. This lichen occupies otherwise bare sand in full sun. This implies that it moves into sites where shrubs and sand pines increase their cover slowly after fires, and that fires are infrequent. On the Gulf and southeast Atlantic coasts, hurricanes probably help maintain the openness of the sites. On the Lake Wales Ridge, *Cladonia* sites are rosemary balds that presumably have extremely low fertility and extremely slow growth rates for the shrubs that inhabit them. It is not known how *Cladonia perforata* reoccupies sites after disturbance or how it reacts to trampling (a factor on the Gulf coast and possibly at Archbold).

Paula T. DePriest (National Museum of Natural History, Smithsonian Institution) worked on the recovery of *Cladonia perforata* from Hurricane Opal of 1995. At the time of writing she had suggested a course of action and has visited *Cladonia perforata* sites both on the Gulf and at Archbold Biological Station. DePriest's suggestions show that lichen management plans can and should incorporate monitoring aimed at understanding the establishment of this lichen (including reintroduction plots at Eglin) and analysis of genetic variation. An additional resource for lichen conservation is the International Association for Lichenology, International Committee for Conservation of Lichens (ICCL). The ICCL was accepted as a Specialist Group for lichens in the Species Survival Commission (IUCN/SSC) in 1994.

It appears that post-hurricane restoration plans are needed for *Cladonia perforata* both in the Panhandle and in southeast Florida.

Obtaining a consensus of fire and lichen experts on fire management for this lichen is likely to require five to ten years of demographic monitoring, including recovery after fire.

- 2.4.6 **Genetic monitoring for *Liatris ohlingerae*.** This obligate outbreeder forms low-density populations, so on smaller sites it will be necessary to ensure that there is sufficient within-population genetic diversity for reproduction.
- 2.5 **Provide management services for each site.** Conduct actions planned in task 2.4. Keep records of the actions taken and their effects.
- 2.6 **Monitor each site.** For each site, develop a list of necessary monitoring tasks and identify an agent to conduct the tasks and ensure continuity and quality of monitoring. Monitoring at the community level (see task 5 for individual species) should be able to detect vegetation change during the fire cycle: amount of open space between shrubs and height of shrubs (in scrub); grassiness and demography of oaks and pines (high pineland). The goal will be to see whether the site and its biota are maintaining their integrity or if degraded sites are being effectively restored. Photography of permanent plots, or photography from specific locations are likely to be useful. Monitoring and data storage methods have to be inexpensive and efficient because management budgets are always tight. Costly monitoring protocols are likely to be abbreviated or abandoned prematurely. Standardization of monitoring methods and databases would help managers by making it easier for new personnel to learn the methods, and by making it possible to compare data from different sites.
3. **Conserve germplasm** of species that are likely to lose much of their gene pools or can't be adequately protected in the wild. *Lupinus aridorum* and *Ziziphus celata* are the most logical candidates for germplasm conservation, followed by the other most narrowly distributed species: *Crotalaria avonensis*, *Conradina brevifolia*, *Liatris ohlingerae* (and *Dicerandra* species, with their own recovery plan). The other species are likely to be safe in the wild.
- 3.1 **Conduct genetic studies to ensure that propagated plants represent the genetic diversity of their species.** There is little likelihood of attempts to replicate individual populations as part of recovery. If propagated material represents the species, then an introduction using that propagated material will also represent the species. Therefore, genetic studies need to be done at the time plants are taken into propagation, and should be unnecessary when material is taken from propagation to a reintroduction site. Genetics management planning should be confined to assuring the integrity of the propagated material. The Center for Plant Conservation (CPC) has guidelines for propagation and reintroduction, and the guidelines are reviewed periodically. The draft Fish and Wildlife Service propagation policy requires a genetics management plan for every reintroduction, and refers explicitly to CPC guidelines. For these species, there is no need for genetics management to become complex.
- Genetic testing is not expensive relative to the cost of maintaining live plants. For example, in the case of *Torreya taxifolia*, genetic testing has assured that material collected for botanical gardens (some 150 accessions) fully represent the species.

- 3.2 **Place seed in long-term storage.** *Lupinus aridorum* seeds appear to remain dormant for 50+ years in nature, so this is an ideal candidate for seed storage. The Center for Plant Conservation has a cooperative agreement with the U.S. Department of Agriculture, National Germplasm System, to store seed of endangered species. Dormancy testing of seeds is needed to determine whether storage for this or other species is feasible. Germination experiments by Susan Wallace (while she was at Bok Tower Gardens, unpublished) show that seeds of some of these species have little dormancy, indicating that they will not remain viable in long-term storage.
 - 3.3 **Propagate plants.** The Center for Plant Conservation prefers to collect seed rather than cuttings from wild plants, which has the advantage of only minimally disturbing wild plants. Cuttings from wild plants are advantageous in that they allow propagation of genotypes that occur in the wild. William Gensel (North Carolina State Univ., in litt. 1984) emphasized that propagating wild genotypes ensures against inadvertent selection favoring genotypes adapted to cultivation but not to the wild.
 - 3.4 **Establish and maintain collections of living plants.** Bok Tower Gardens has a collection of some of these species, part of the Center for Plant Conservation's National Collection of Endangered Plants. Although this collection is designed for germplasm conservation, it also provides useful information on the reproductive/population biology of these species, including longevity of individual plants, phenology, and seed germination requirements. The establishment of such collections is prerequisite to the next task (4).
4. **Establish and manage new populations** for the most seriously endangered species that cannot be recovered by protecting existing populations. Introductions can be designed to yield guidance for management of protected sites, and introductions may function as experiments in plant population biology, in cases where it is possible to frame hypotheses about how particular species become established, or about their physical requirements. Scientists, however, have had to be modest about their abilities to elucidate why plants are distributed as they are in the wild, and attempted introductions may fail for reasons that can't readily be elucidated, such as inability of seedling plants to survive the physical environment (including light, heat, cold, water relations, and nutrients), predation, disease, allelopathy, and lack of mycorrhizal associates.

Transplanting wild plants, especially salvage from sites undergoing development, is not a satisfactory conservation measure (Fahselt 1988), nor is it an appropriate mitigation measure for development projects. Transplanting of entire mature plants is unlikely to work (as has been demonstrated with *Prunus geniculata*).

Translocations of plants should be within their historic ranges, preferably into historic sites where long-term protection, management, and funding are provided. Source material for introductions should be from the nearest possible source site with a large enough population to provide starter material. In urgent (no-other-alternative) situations, exceptions may be made on a case-by-case basis (possibly *Lupinus aridorum* in Orange County, if habitat restoration on public land doesn't work). This plan does not contemplate moving the most tightly-distributed plants

(such as *Eryngium cuneifolium*) outside their native ranges, nor does it endorse the notion of creating scrub on sites previously occupied by other vegetation (a prime objection is that such a new site would probably lack many of the endemic scrub arthropods).

New populations will be planned in accordance with current Fish and Wildlife Service policy with respect to propagation and introductions.

- 4.1 **Prioritize species for establishment of new populations.** The most narrowly distributed species covered in this plan are *Ziziphus celata*, *Lupinus aridorum*, *Crotalaria avonensis*, and *Eryngium cuneifolium*. The narrowly-distributed *Dicerandra* taxa have their own recovery plan. Preliminary work on *Ziziphus* introduction was underway at the time of writing. For the lupine, propagation or planting seeds in the wild should be attempted. Introduction may be necessary for full recovery of the two other species (but this plan did not adopt full recovery as an objective).
- 4.2 **Evaluate selected ecological and reproductive requirements of the species selected for introduction.** The restriction of some scrub plants to sites with yellow or white sand, or their association with species such as rosemary or scrub hickory, will help guide the selection of suitable sites for new populations. Research results on the relationships of microhabitat features such as gaps between shrubs will be helpful in finding or creating suitable sites. Soil surveys for the counties are available. Comparison of floristic lists of sites may be helpful. Although selecting sites carefully may minimize the risk of failure, the definitive way to determine whether a particular site is suitable for a species is to introduce that species and observe the results. It may prove worthwhile to conduct detailed genetic testing of *Ziziphus celata* to map clones, if the species continues to appear to be (or is proven) self-incompatible. Results from task 3.1 will indicate whether further genetic studies are necessary or useful.
- 4.3 **Introduce founder plants into sites for new populations.** Decisions must be made for each species on whether to transplant young nursery-grown plants or to sow seed, how many plants or how much seed is needed, where to place them, and how (or whether) to mark the sites. Records must be kept of the origins of the founder plants.
- 4.4 **Monitor new populations and arrange suitable management accordingly.** The new populations should be examined regularly for numbers and condition of the plants and for threats to the site. Attention to newly-established populations should not be allowed to detract from similar monitoring and protective management of natural populations, which are more important (Task 2). The most straightforward way to encourage spread of newly-established plants is through an established fire management plan. In special cases, or to foster the initial spread of a population, other methods can be employed including clearing of nearby shrubs to create new open areas of bare sand, ready for colonization.

5. **Assess species-by-species progress; ensure that recovery objective for each species is appropriate; plan for post-recovery monitoring.** Task 2 is the principal measure of progress toward recovery, but it must be supplemented by monitoring oriented to individual species.
 - 5.1 **Conduct population viability analysis for selected short-lived herbs with limited distributions.**
 - *Warea carteri*, an annual, germinates and flowers mainly after fire. In addition to a search for more populations (Task 113), detailed demographic information should be collected on this species. At the time of writing, Eric Menges at Archbold Biological Station was collecting such data.
 - *Eryngium cuneifolium* has a small geographic range and is absent from many seemingly suitable sites. This is becoming a very well-studied species, thanks to research by Eric Menges and his collaborators at Archbold Biological Station.
 - *Lupinus aridorum*, a short lived “perennial” species, flowers strongly only once or twice in its life. It would be helpful if demographic information were available on the similar but more abundant *Lupinus westianus* of the Florida panhandle coast, which colonizes bare sand dunes and road rights-of-way. It should make an excellent surrogate for *L. aridorum* (Kral 1983, Wunderlin 1984b). The demographic data collected by Stout and Charba (1994) need to be assessed to see whether there is a reasonable possibility of maintaining viable population(s) of this species on sites that can be protected.
 - 5.2 **Refine recovery objectives as new information is generated in Task 51.**
 - 5.3 **Plan post-recovery monitoring.** The Endangered Species Act requires that the Fish and Wildlife Service “shall implement a system in cooperation with the States to monitor effectively for not less than 5 years the status of all species which have recovered . . . ” (sec. 5(g)(1)). Monitoring plan(s) must be ready when delisting is proposed.
6. **Enforce available protective legislation.** Employ local, State, and Federal regulations to protect sand pine scrub vegetation containing these plant species.
 - 6.1 **Initiate Section 7 consultation when applicable.** Section 7 of the Endangered Species Act applies to Federal activities which might affect listed species. Several of these nineteen species are known to occur on lands with Federal surface ownership (*Bonamia grandiflora*, *Eriogonum longifolium* var. *gnaphalifolium*, and *Polygala lewtonii* on Ocala National Forest and the Navy bombing range within the Forest, and *Polygonella basiramia* on Avon Park Air Force Range). Few consultations are anticipated. The extent of Federal minerals ownership beneath scrub and high pineland sites has not been evaluated, but seems minimal except for Federal property.
 - 6.2 **Enforce take and trade prohibitions.** The nineteen species are protected by trade provisions of the Endangered Species Act (including its prohibition against removing and reducing to possession any endangered plant from areas under Federal jurisdiction;

maliciously damaging or destroying any such species on any such area; or removing, cutting, digging up any such species), by the Preservation of Native Flora of Florida Act, and by State regulations regulating removal of plants from state lands. Violation of these State prohibitions (including Florida criminal trespass law) is also a violation of the Endangered Species Act.

A few of the species have horticultural value as ornamentals, and several are sold in the native-plant trade within Florida for scrub restoration or scrub-style native landscaping. *Prunus geniculata* and *Nolina brittoniana* are offered by native plant nurseries in Florida (Association of Florida Native Nurseries 1993, 1995). *Chionanthus pygmaeus* was offered in interstate commerce by at least one nursery. *Liatris ohlingerae* is easily grown from seed, and could attain limited horticultural popularity. *Conradina brevifolia* is readily propagated, but its widespread, nonthreatened relative, *Conradina canescens* from the Florida panhandle, offers excellent horticultural material. If *Conradina brevifolia* were threatened by collection of wild plants for horticultural purposes, the Service could have proposed to more regulate trade more stringently by listing *Conradina canescens* as a threatened species by similarity of appearance.

Federal and State regulation of endangered plants does not address legitimate concern that horticultural use of these species can threaten the genetic integrity of natural populations. This concern has led to suggestions that endangered species should not be commercially available, or that records should be kept of sources and out-planting locations for horticultural projects, just as for conservation projects, so that introductions and resulting population dynamics can be reconstructed (Doria Gordon, The Nature Conservancy, in litt. 1995). The same questions are being raised with respect to the use of native plants for wetlands restoration and other mitigation projects (where long-distance transport of plant material is common). At the present time, use of these listed plants for horticultural purposes does not pose serious conservation problems inasmuch as plantings are likely to be small and may not be very permanent. If problems arise, they will have to be addressed through voluntary cooperation with propagators/vendors. Within the Center for Plant Conservation network and Board, there is increasing support for ornamental use of endangered plants (B. Meilleur, Executive Director, Center for Plant Conservation, as summarized in notes from meeting of Georgia Plant Conservation Alliance meeting, Athens, Feb. 1996). Planting of these species for mitigation or other vegetation restoration purposes may be subject to approval by permitting agencies, and can be reviewed on a case by case basis.

The Endangered Species Act's prohibition against take of endangered or threatened animals may indirectly benefit these plants, because the threatened Florida scrub jay, sand skink, and blue-tailed mole skink occupy the same scrub habitat. Habitat conservation plans developed for these species may benefit the plants (as explained above, task 1.41).

7. **Provide public information about scrub and its unique biota.** When the first edition of this recovery plan was published, the general public scarcely knew or appreciated the scrub biota, except perhaps for the Florida scrub jay. Educational efforts, especially those conducted by Archbold Biological Station, have been successful. Without this successful effort, the Lake Wales

Ridge National Wildlife Refuge would not have been created. The State's system of biological preserves depends for its funding and future success on a broad base of public understanding and support. Similarly, in the private sector, The Nature Conservancy, Bok Tower Gardens, and Archbold Biological Station, and other institutions, depend on public support. In this sense, public information and education is absolutely essential to these species' recovery. Organizations such as the Florida Park Service, the Florida Native Plant Society and garden clubs play crucial roles in increasing public appreciation of scrub, high pineland vegetation, and their plant species.

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PART III. IMPLEMENTATION SCHEDULE

The Implementation Schedule is a guide to the program for meeting the recovery objectives set forth in Part II of this plan. This schedule briefly describes each task, gives its number, its priority, its duration, and its estimated cost. All the costs for all parties in recovery are identified in the implementation schedule, so the schedule shows the total estimated cost of recovery for the nineteen species, exclusive of the cost of land acquisition.

Priorities in Column 4 of the following Implementation Schedule are assigned as follows:

- 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 impact short of extinction.
- Priority 3 -** All other actions necessary to provide for full recovery of the species.

NOTE: Each task in the Implementation Schedule is assigned a priority number. While the number reflects the importance of the activity, it **does not** relate to the order in which tasks will be accomplished.

Abbreviations in the Implementation Schedule are listed at the bottom of the schedule.

IMPLEMENTATION SCHEDULE

Priority	Task	Task Description	Task Duration	Responsible Agency	Cost Estimates (000's)			Comments
					FY 1	FY 2	FY 3	
1	1.2.1	<i>Lupinus aridorum</i> surveys	1 year	FWS-E'S, FDACS-DF, FNAI?, pvt	\$2,000			
1	1.3	Continue land acquisition.	6 years	FDEP-SL, FWS-RW, counties, WMD, TNC, Archbold Biol. Sta.	NA	NA	NA	Each agency has its own land acquisition plan (e.g., U.S. Fish and Wildlife Svc. 1993b, Fla. Dept. Envir. Protection, Div. State Lands 1995).
1	2.1	Develop model fire management plans.	1 year	Arbuckle Group, FDACS-DF, FWS-RW, FDEP-RP, USAF (Eglin, Avon Pk), TNC, Palm Beach Co., outside experts	9,000			
1	2.2	Inventory each protected site.	1 year	FDF, FWS-RW, FDEP, WMD, counties, TNC, pvt, USAF; Arbuckle Group		2,000		
1	2.4.1	Establish management objectives at each site.	1 years	same as 2.1		5,000		
1	2.4.2	Develop fire management and other management service plans.	1 year	same as 2.1.		9,000		
1	2.4.4	Management plan for <i>Lupinus aridorum</i> and other highway plants	1 year	FDOT with FWS-E'S, TNC, pvt	4,000			
1	2.4.5	Site specific <i>Cladonia perforata</i> management	10 years	FDEP-RP, Palm Beach Co., Archbold Biol. Sta., TNC, USAF (Eglin). Lichen specialists	2,000	1,000	7,000	

Priority	Task	Task Description	Task Duration	Responsible Agency	Cost Estimates (000's)			Comments
					FY 1	FY 2	FY 3	
1	2.5	Provide management services at each site.	continuous	FWS-E'S, FWS-RW, USFS, Arbuckle Group, USAF (Eglin, Avon Pk), FDEP, FDF, TNC, counties (Orange, Polk, Palm Beach, Highlands), Archbold Biol. Sta.	1,000,000	1,000,000	1,000,000	These figures reflect State of Florida estimates of total management costs for state preserves on the Lake Wales Ridge. These costs include most of the items in this plan. Many costs are not directly related to conserving the plants, but it is difficult to separate out the "plant" costs in an overall budget.
1	2.6	Monitor each site.	continuous	same as 2.5 TNC is a prime source of methodological expertise, along with Archbold Biol. Sta.	20,000	20,000	20,000	Monitoring of these species, while an essential part of management, has to be planned separately. The draft of this plan suggested a budget of \$10,000 per year. Doria Gordon (The Nature Conservancy) thought this was probably too low for all the species and sites.
1	3.1	Genetic studies on propagated plants to ensure they represent genetic diversity of their species	1 year	Universities, Bok	15,000			Essential for <i>Lupinus aridorum</i> and <i>Ziziphus celata</i>
1	3.2	Long term storage of seed	continuous	Bok, USDA	5,000	5,000	5,000	Cost of seed storage needs to be determined; once in storage, annual cost would seem to be low.
1	3.3	Propagate plants.	3 years	Bok	8,000	8,000	8,000	
1	3.4	Maintain collection of living plants.	continuous	Bok	17,000	17,000	18,000	Costs much higher if salaries, facility upkeep included.
1	4.1	Prioritize species for establishment of new populations.	1 year	FWS-E'S, Bok, TNC, land managers	1,000			

Priority	Task	Task Description	Task Duration	Responsible Agency	Cost Estimates (000's)			Comments
					FY 1	FY 2	FY 3	
1	4.2	Evaluate ecological/ reproductive requirements of species under consideration for new populations.	2 years	Archbold, TNC, Bok, FDACS-DF, FWS-E'S		10,000	5,000	May require more time and funds if genetic testing of wild populations is needed.
1	4.3	Introduce founder plants into sites for new populations.	2 years?	propagating agency, land manager		7,000	2,000	
1	4.4	Monitor new populations.	continuous	land managers		1,000	1,000	
1	7.	Provide public information.	continuous	FWS-E'S, FWS-RW, FDACS-DF, Bok, Counties, Archbold	1,000	1,000	7,000	Public information budget for state preserves/National Wildlife Refuge could be substantial, especially if visitor center(s) are developed. Living exhibits in a naturalistic setting would be desirable. Bok is a possible site for educational work.
2	1.1	Maintain an inventory of sites & species.	continuous	FNAI, land managers			1,000	
2	1.2.2	<i>Cladonia perforata</i> awareness	4 years	land managers (possibly including Palm Beach Co., USAF (Eglin), BLM, FDEP-RP, Archbold), univ.	400	400	400	
2	1.2.3	<i>Warea carteri</i> surveys	2 years	FWS-E'S, FNAI		2,000	2,000	
2	1.2.5	Surveys in "outlying" counties	1 year?	FWS-E'S, FNAI			5,000	Opportunities for surveys may arise on short notice.
2	1.4.1	Ensure that habitat conservation plans for animals help conserve plants.	10 years	FWS-E'S	NA	NA	NA	A routine part of the FWS workload for Habitat Conservation Plans
2	1.4.3	Arrange land protection through regional/local planning.	5 years	RPC, counties	NA	NA	NA	Will attention to scrub increase costs of planning?

Priority	Task	Task Description	Task Duration	Responsible Agency	Cost Estimates (000's)			Comments
					FY 1	FY 2	FY 3	
2	1.4.4	Arrange protection & management of small sites	2 years	Arbuckle group, land managers, utilities, owners of sites			?	Assistance to landowners would cost time and/or money.
2	2.3	Conduct initial conservation measures at protected sites	1 year (at each site)	land managers	1,000	1,000	1,000	
2	2.4.3	Control exotic pest plants	ongoing	land managers, Arbuckle Group, USFS [for cogon grass], EPPC	5,000	5,000	5,000	Expenditures will be concentrated on a few sites
	2.4.6	Genetic monitoring for <i>Liatris ohlingerae</i>	5 years?	land managers, univ.				
2	5.1	Conduct population viability analysis for short-lived herbs	1 year	Univ., Archbold	8,000?			
2	5.2	Refine recovery objectives	5 years	all parties				
2	5.3	Plan post-recovery monitoring	2 years	FWS-E'S, land managers				
3	1.2.4	<i>Polygonella basiramia</i> identification	4 months	Univ.		500		Cost of mailing herbarium specimens, staff time
3	1.4.2	Use conservation easements, etc. to conserve habitat	10 years	FWS-E'S, TNC, others				Requires staff time
3	6	Enforce protective legislation	continuous	FWS-LE, DPI, FDEP-RP, FDF				Requires staff time

ABBREVIATIONS for the implementation schedule

Arbuckle Group	Arbuckle working group of land managers in Polk and Highlands counties
Bok	Bok Tower Gardens (through membership in the Center for Plant Conservation)
EPPC	Florida Exotic Pest Plant Council. This is a valuable forum for exchanging information on pest plant control and for emphasizing the need for control.
FDACS-DPI	Division of Plant Industry, Florida Department of Agriculture and Consumer Services
FDACS-DF	Florida Division of Forestry, Florida Department of Agriculture and Consumer Services
FDEP-SL	Florida Department of Environmental Protection, Division of State Lands
FDEP-RP	Florida Department of Environmental Protection, Division of Recreation and Parks
FDOT	Florida Department of Transportation
FNAI	Florida Natural Areas Inventory
FWS-E'S	U.S. Fish and Wildlife Service, Southeast Region, Ecological Services (endangered species listing, recovery, and consultation)
FWS-RW	U.S. Fish and Wildlife Service, Southeast Region, Refuges and Wildlife (including realty)
FWS-LE	U.S. Fish and Wildlife Service, Southeast Region, Law Enforcement
Lichen specialists	Lichen biologists in the United States; International Association for Lichenology, International Committee for Conservation of Lichens (ICCL). The ICCL was accepted as a Specialist Group for lichens in the Species Survival Commission (IUCN/SSC) in 1994.
Land managers	Managers of public and private lands with these listed plants (including provision of fire management services by FDOT outside of its own lands). Includes Bok, FDACS-DF, FDEP-RP, FDOT, USFWS-RW, governments of Polk, Highlands, Palm Beach counties, the Lake County Water Authority, the USAF, USFS, WMD private organizations including Archbold Biological Station, a Boy Scout camp, and others.
Palm Beach Co.	Palm Beach County Department of Environmental Resources Management (county scrub preserves)
pvt	Private individuals or organizations
RPC	Regional Planning Councils (Florida)
TNC	The Nature Conservancy, Florida Chapter, including its Lake Wales field office.
univ.	Universities and other research institutions, such as the Smithsonian Institution (for lichens) or perhaps Archbold Biological Station
USAF	United States Air Force: Eglin Air Force Base and Avon Park Air Force Range
USDA	United States Department of Agriculture, germplasm conservation programs
USFS	Forest Service, U.S. Department of Agriculture
Utilities	Electric utilities, possibly gas transmission pipeline companies.
SWFWMD	Southwest Florida Water Management District; the South Florida Water Management District [SWFWMD] may also be involved. The boundary between the two Districts follows the east side of the Lake Wales Ridge.

PART IV. APPENDICES

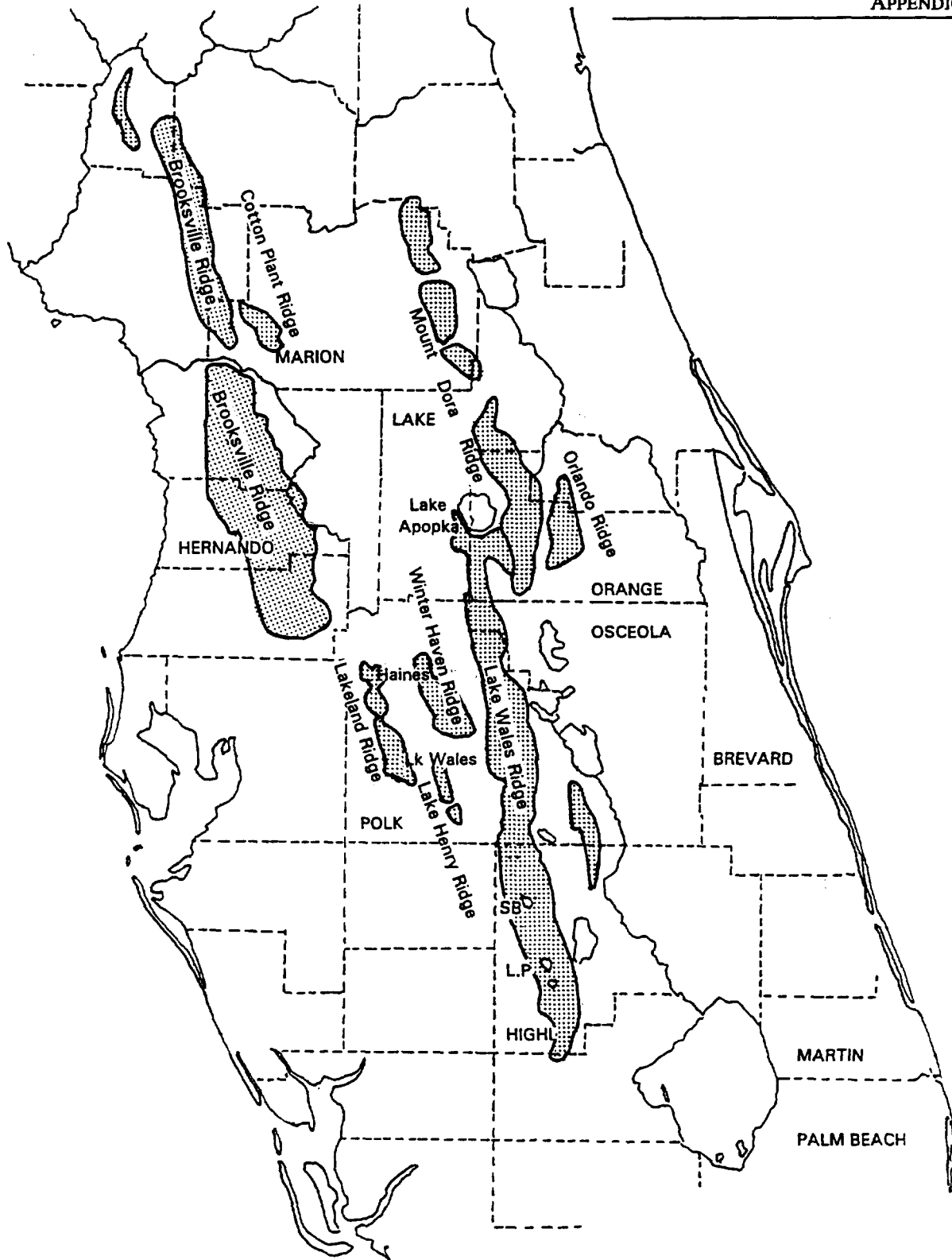
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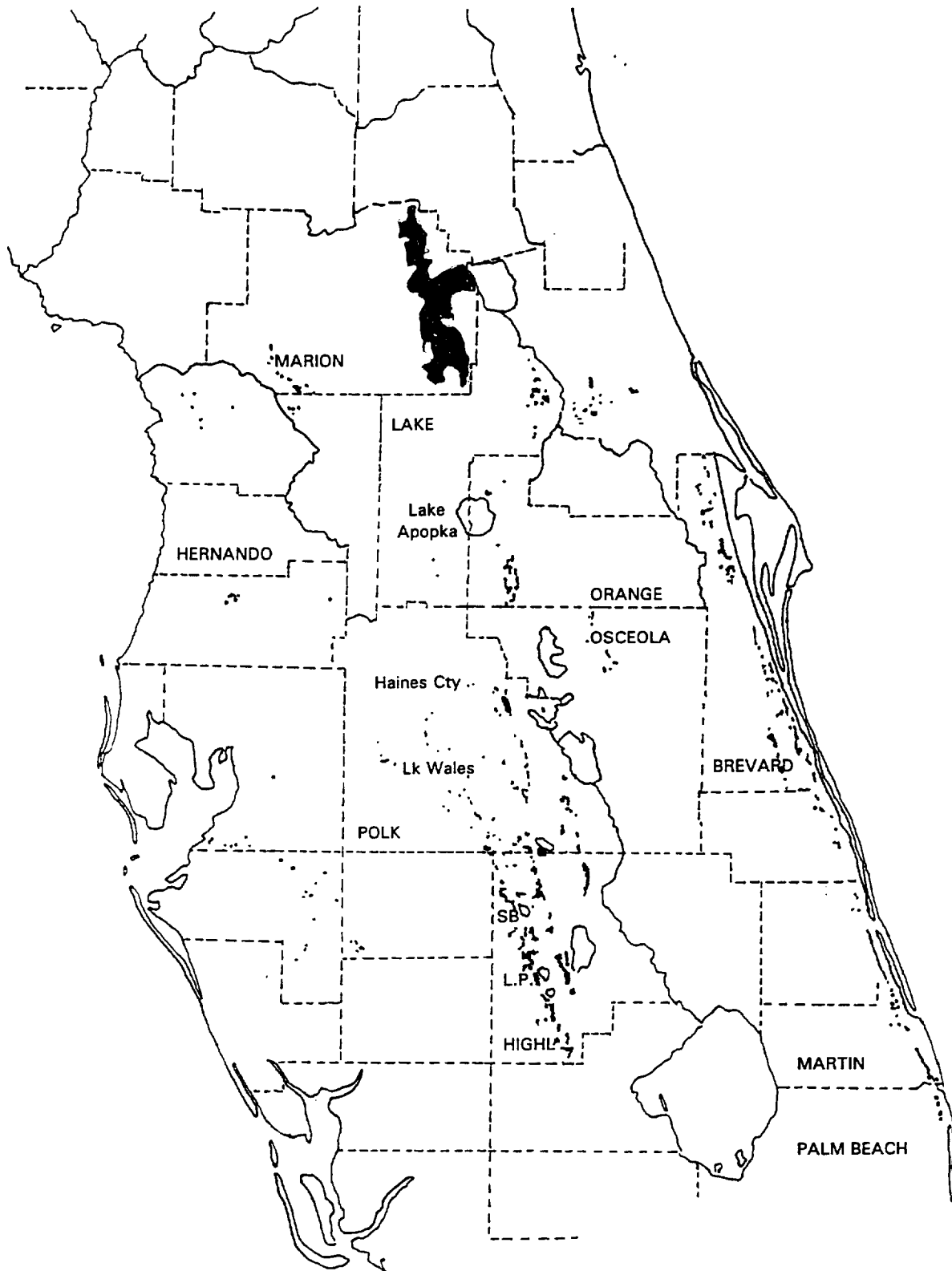
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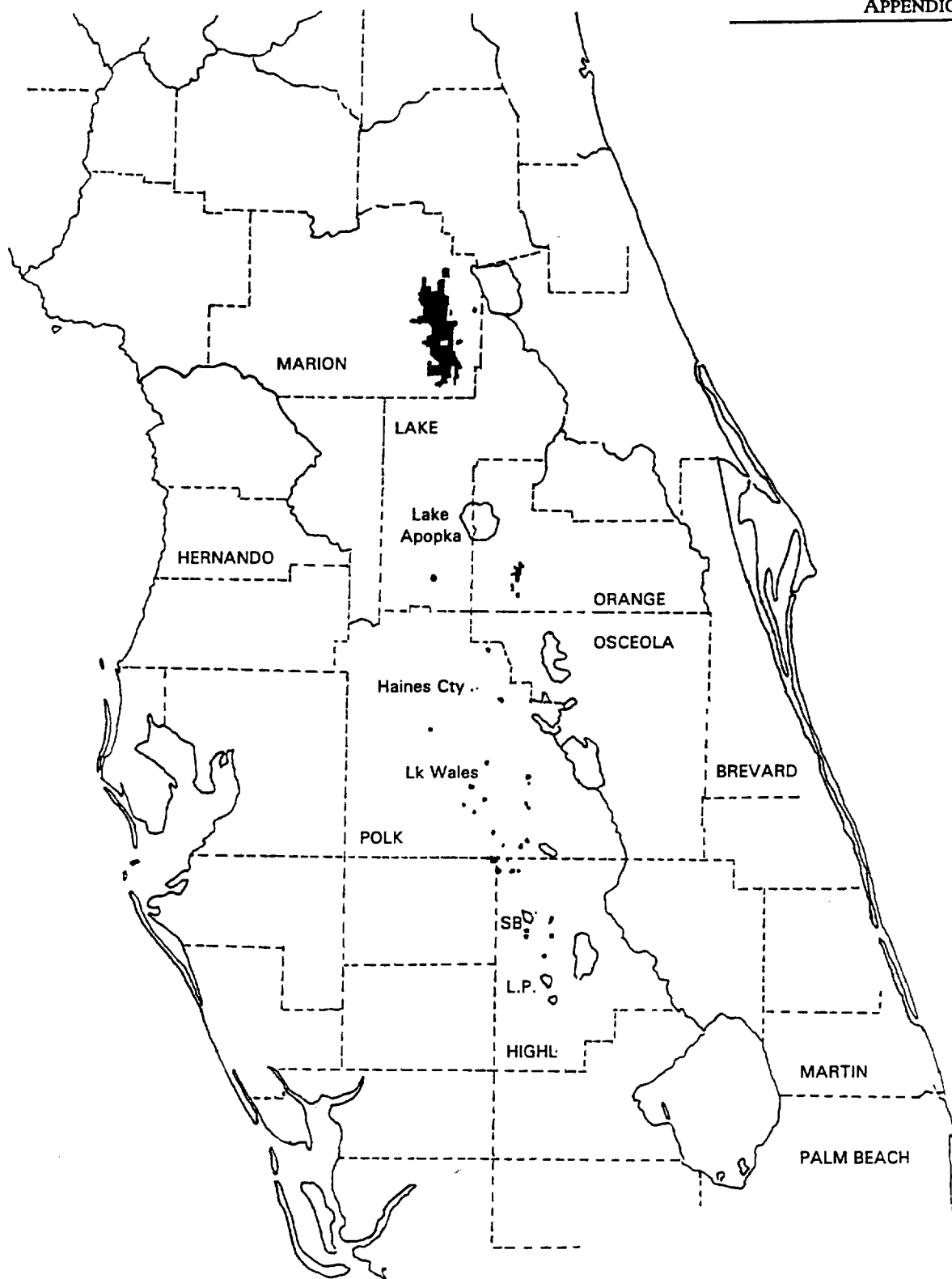
C. PRELIMINARY MAILING LIST 128



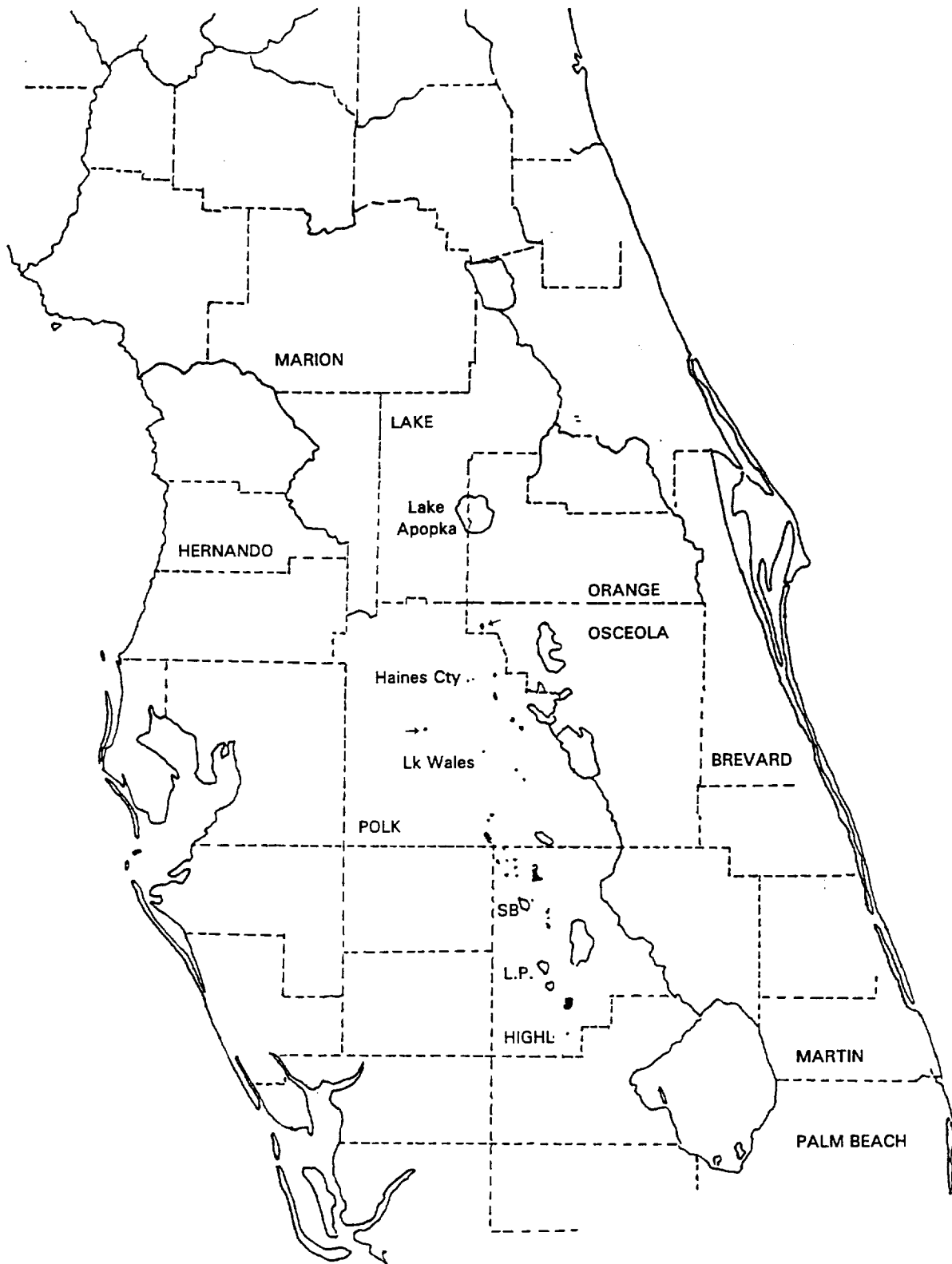
Map 1. Major Ridges of Central Florida, redrawn from White (1970).



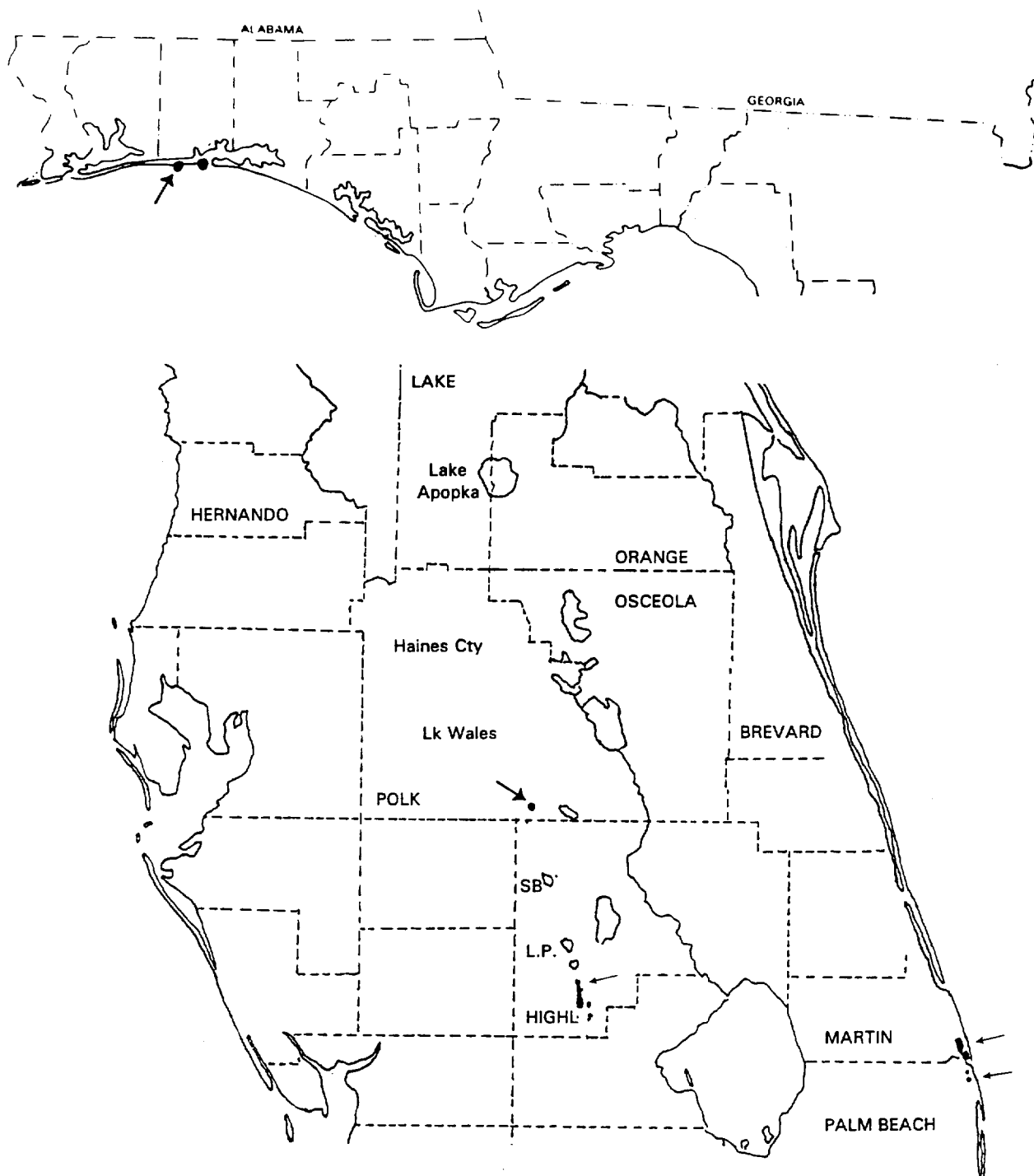
Map 2. All central Florida scrubs included in Christman's (1988) database, plus selected scrubs with Florida scrub jays from Fitzpatrick et al. (1994).



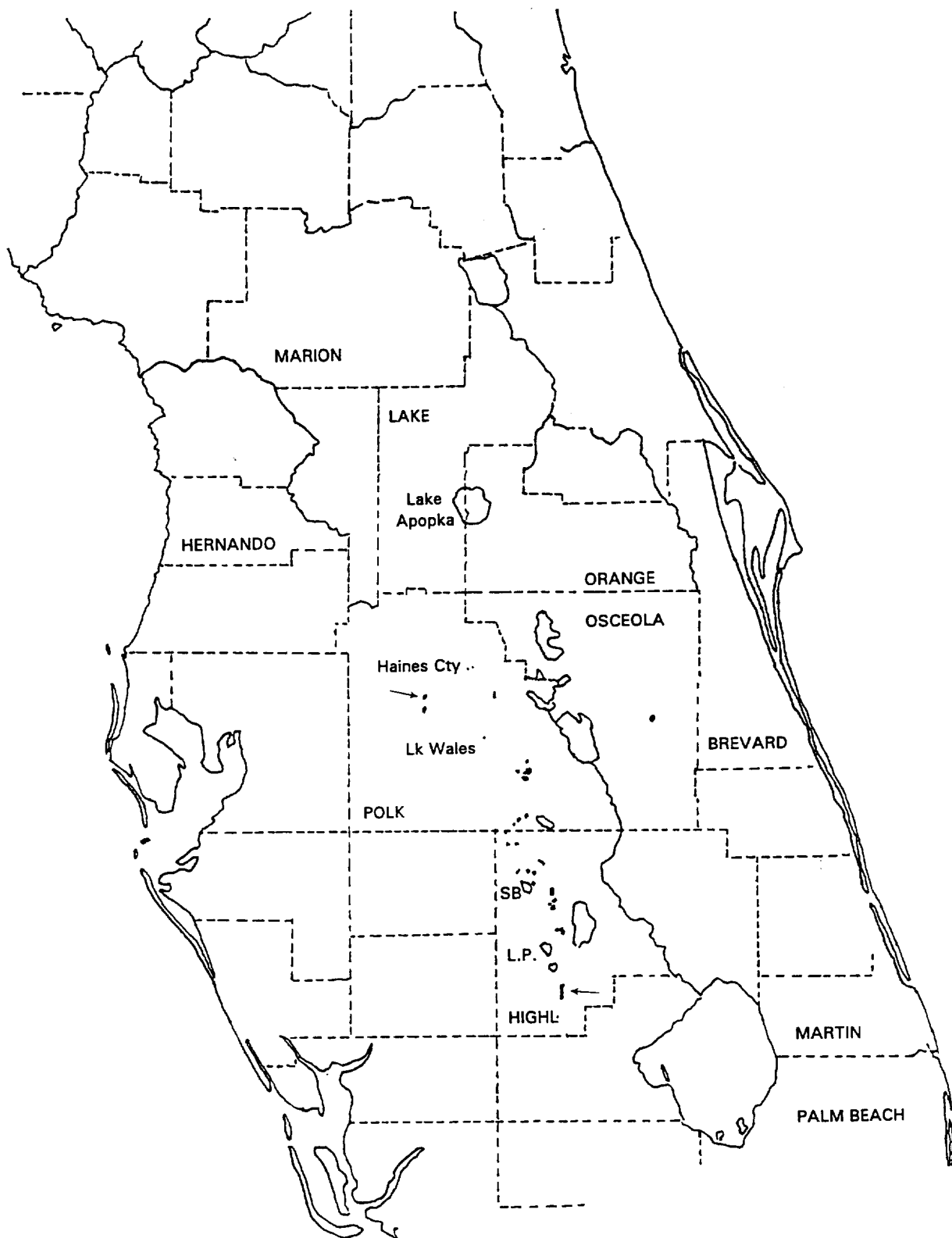
Map 3. Distribution of *Bonamia grandiflora*. Map shows the approximate shape of the plant's distribution in Ocala National Forest (Marion County).



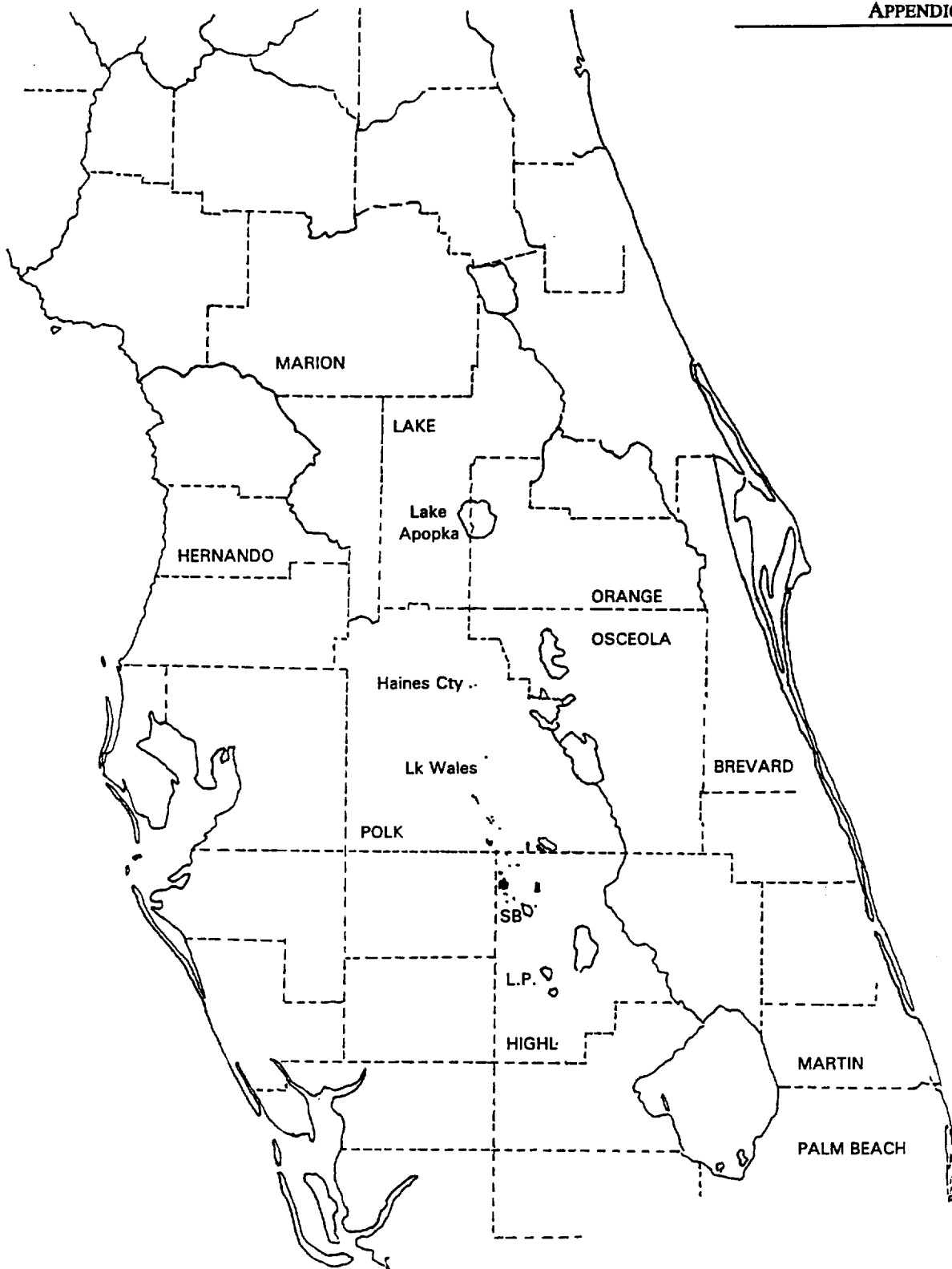
Map 4. Distribution of *Chionanthus pygmaeus*, pygmy fringe tree. The distribution of *Chionanthus virginicus* overlaps, so plants have to be in flower or fruit for accurate identification.



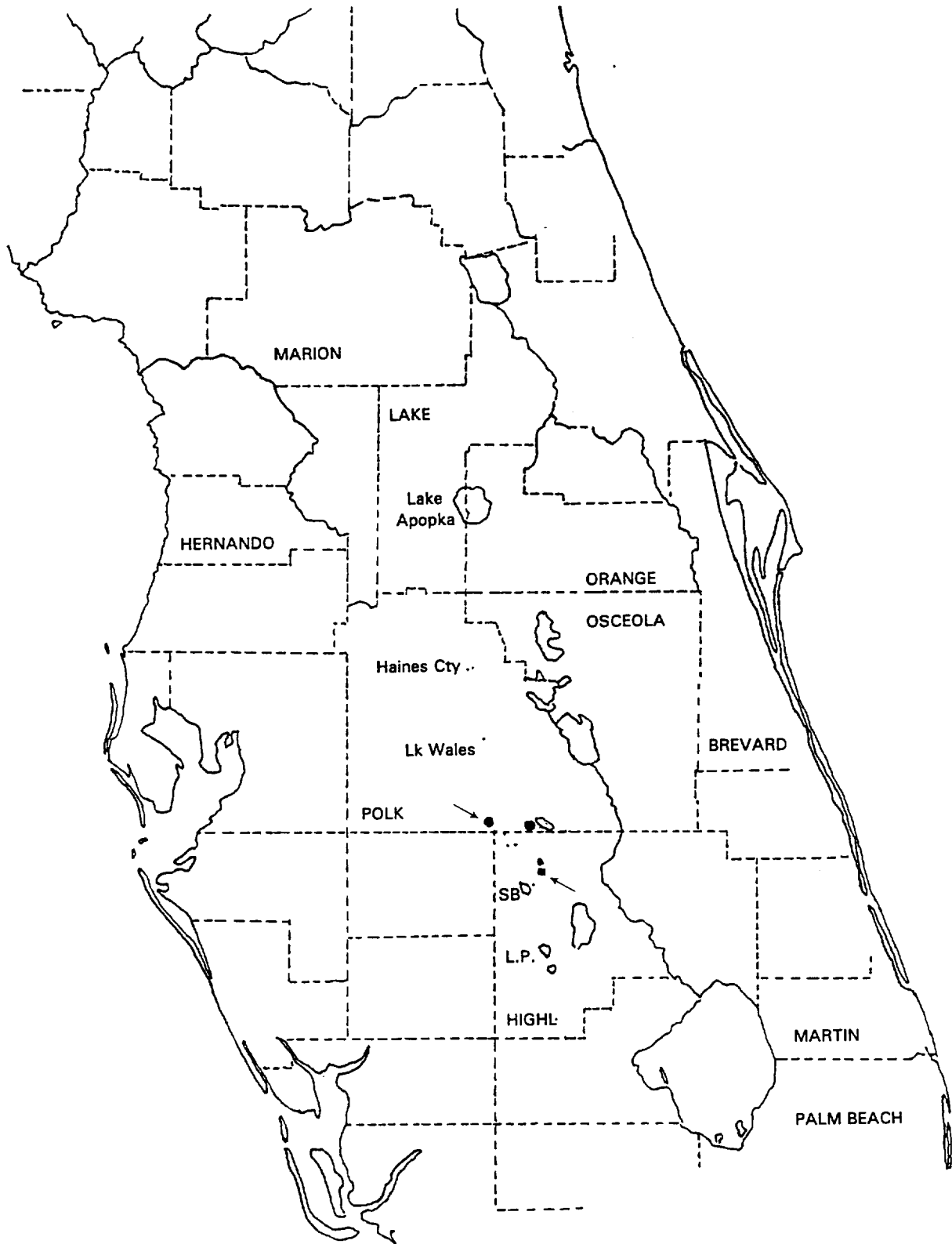
Map 5. Distribution of *Cladonia perforata*, the Florida perforate cladonia [lichen]. Southern Polk County near Avon Park, Highlands County near Lake Placid (Archbold Biological Station and vicinity), Martin County (Jonathan Dickinson State Park), Palm Beach County (Jupiter lighthouse and a nearby natural area), Okaloosa County (Eglin Air Force Base).



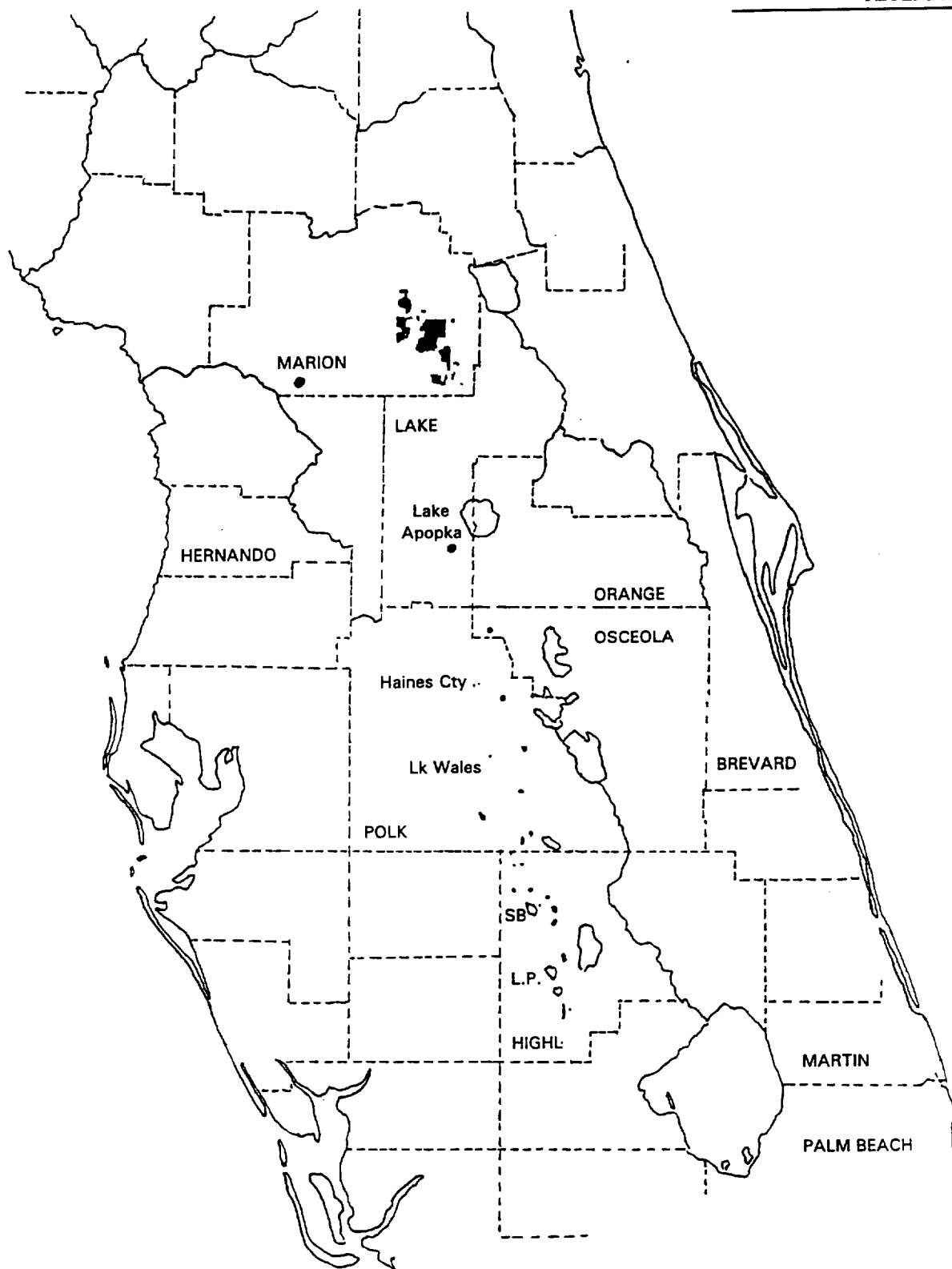
Map 6. Distribution of *Clitoria fragrans*, pigeon wings, in scrub vegetation.



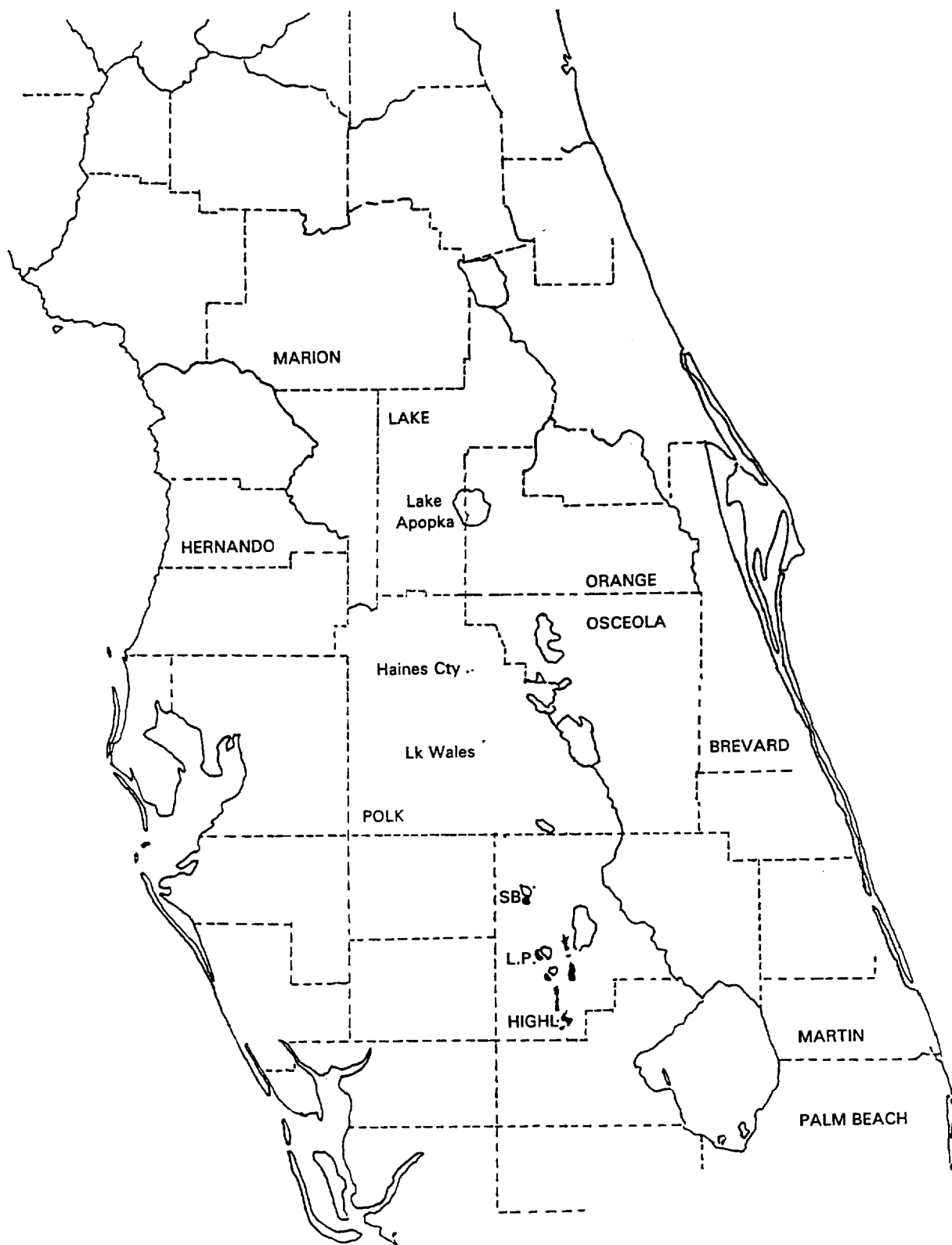
Map 7. Distribution of *Conradina brevifolia*, short-leaved rosemary. This is the only species of *Conradina* in Highlands and Polk counties.



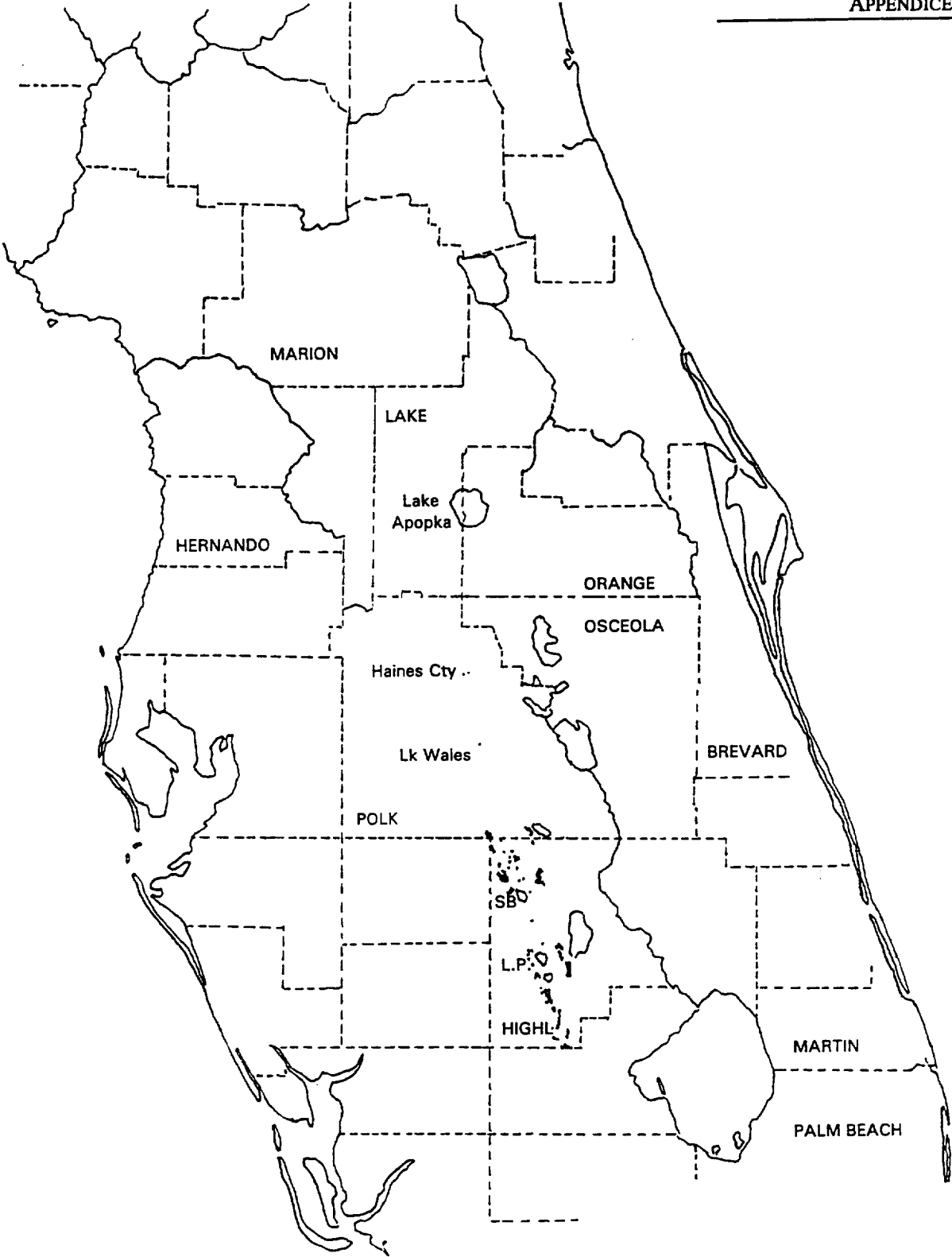
Map 8. Distribution of *Crotalaria avonensis*, Avon Park harebells.



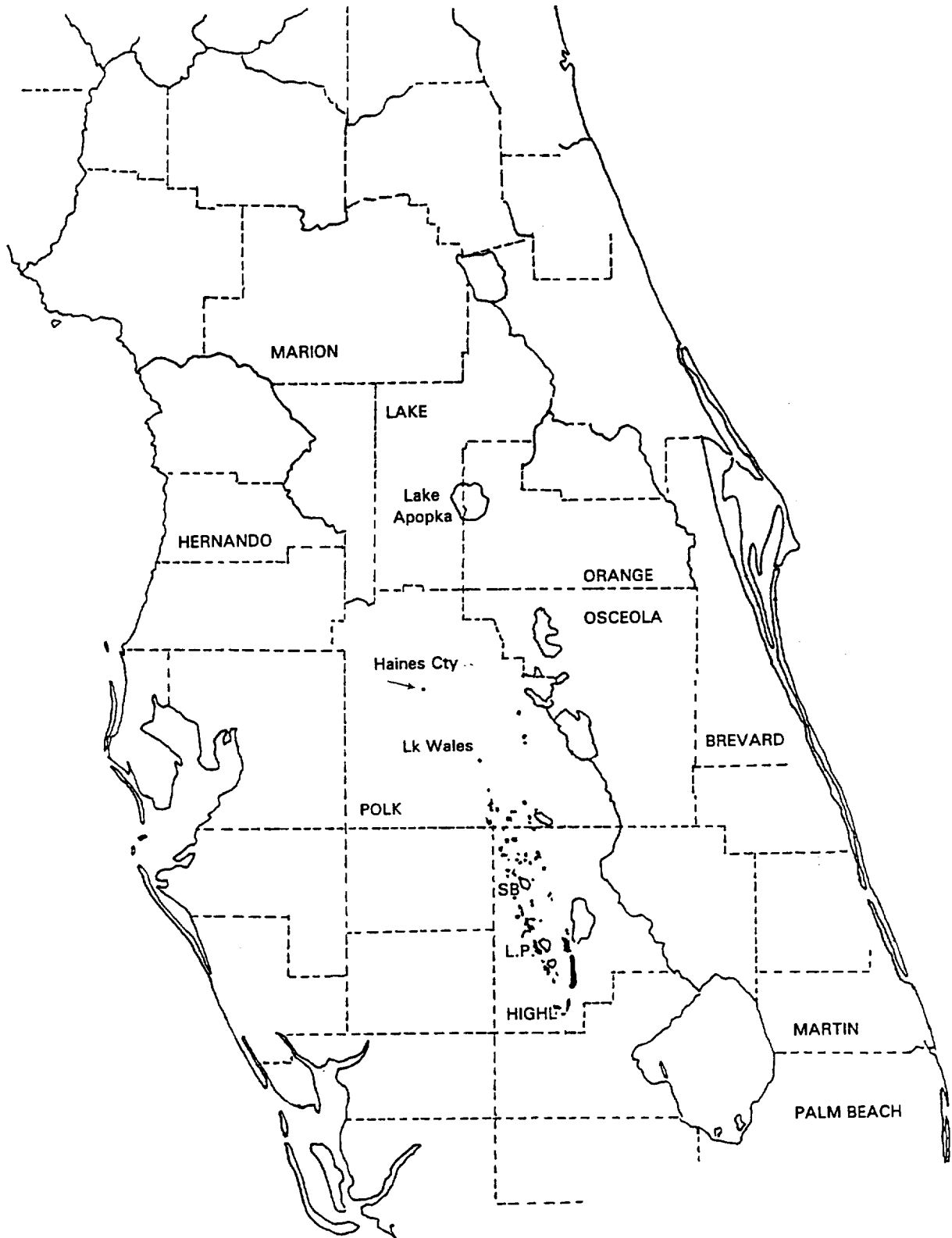
Map 9. Distribution of *Eriogonum longifolium* var. *gnaphalifolium*, scrub buckwheat, in scrub vegetation on the Lake Wales Ridge. Information from high pineland sites and sites outside of Polk and Highlands counties are less complete, except for Ocala National Forest (Marion County), where it has been carefully mapped by the Forest Service.



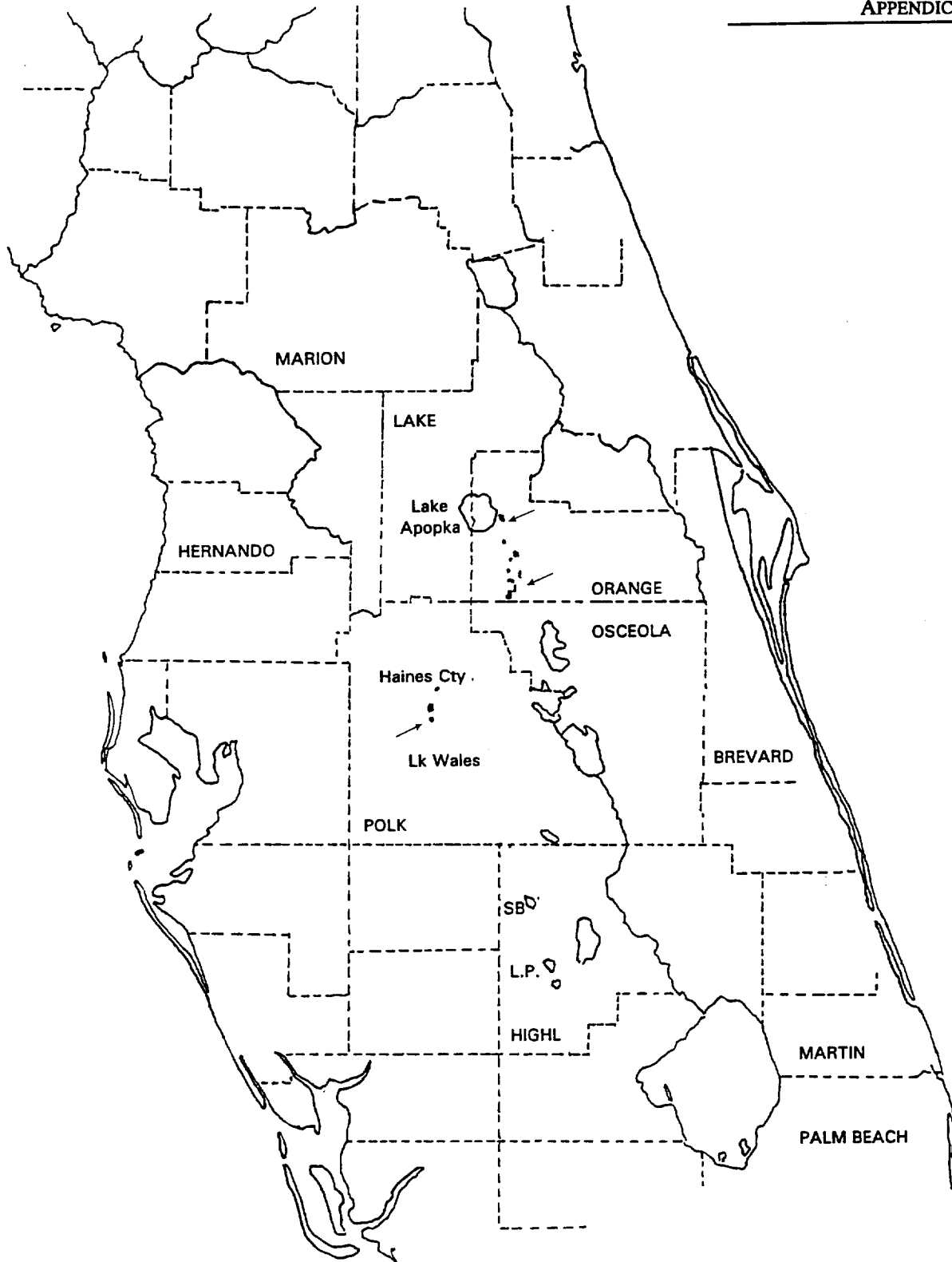
Map 10. Distribution of *Eryngium cuneifolium*, a snakeroot. Restricted to area from Sebring (SB) to south of Lake Placid (LP).



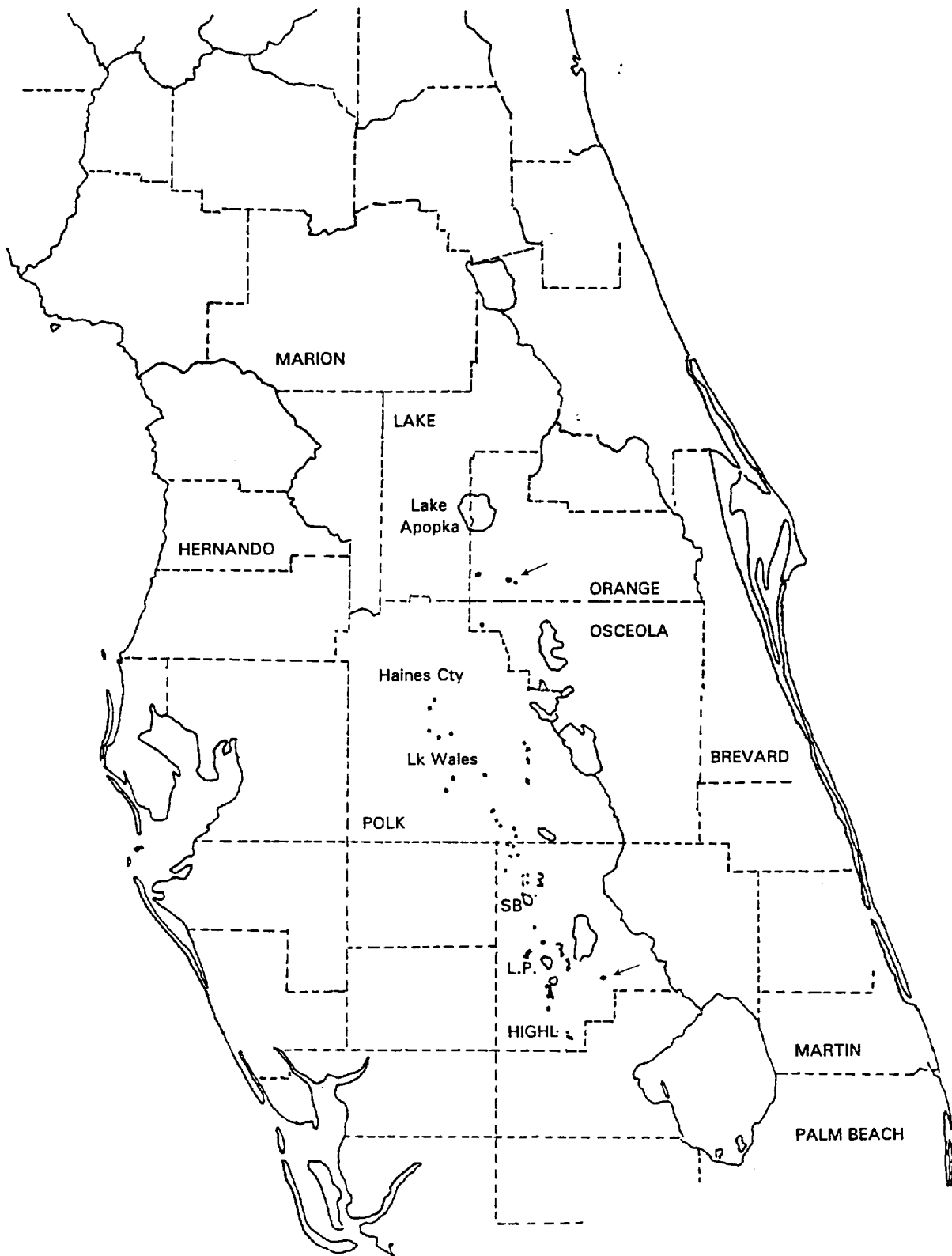
Map 11. Distribution of *Hypericum cumulicola*, scrub St. Johns-wort.



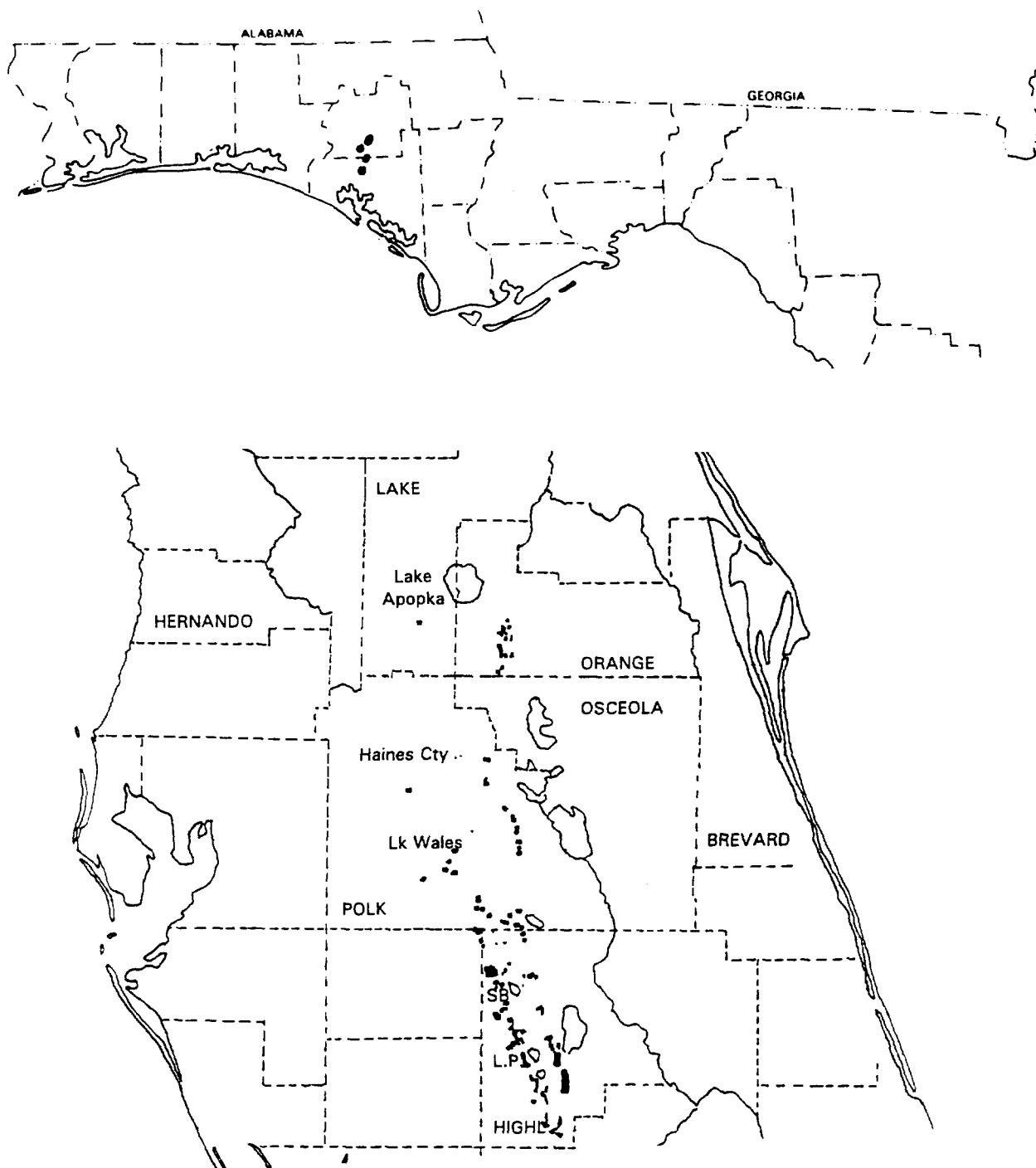
Map 12. Distribution of *Liatris ohlingerae*, scrub blazing-star.



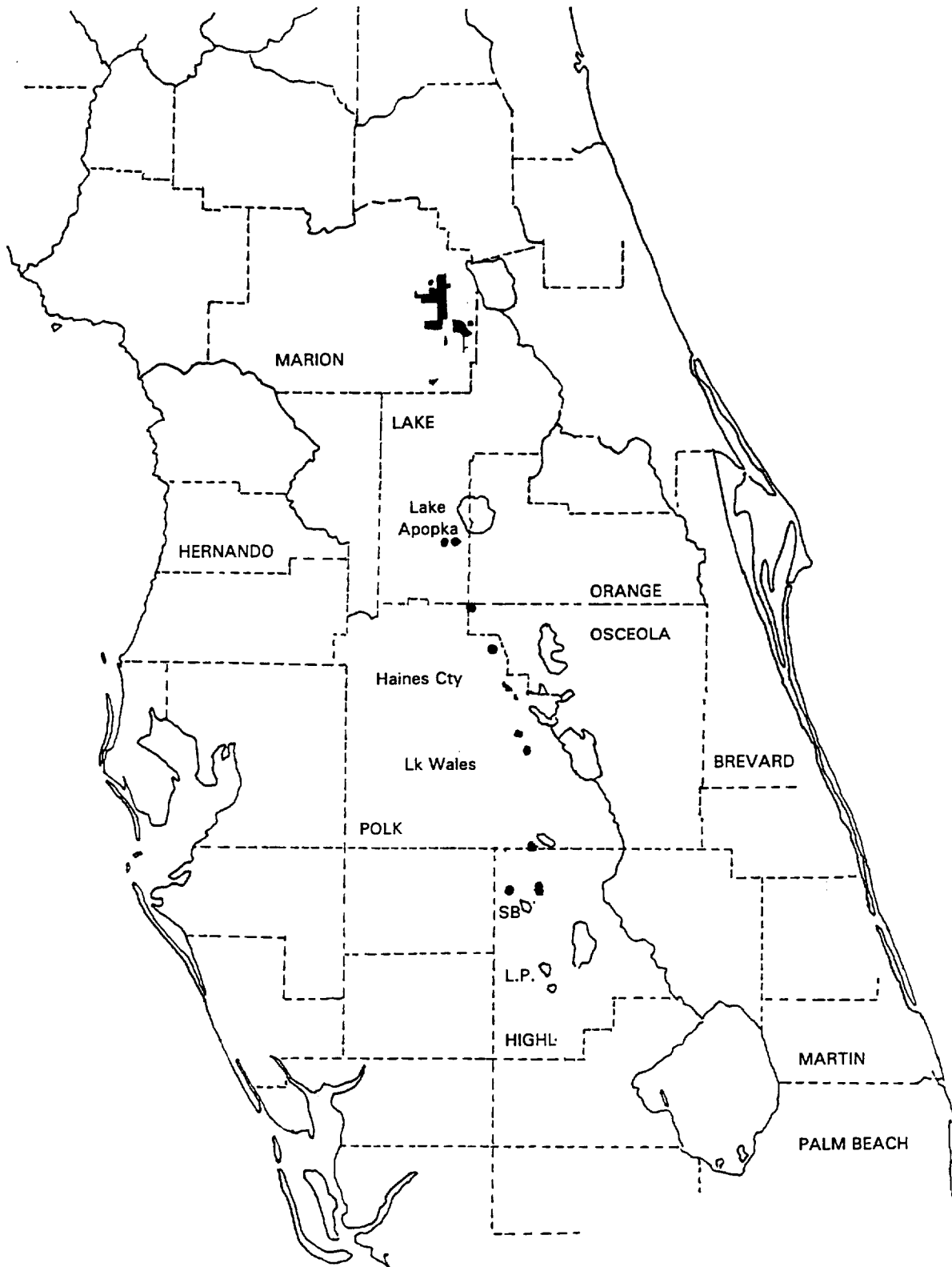
Map 13. Distribution of *Lupinus aridorum*, scrub lupine. Distribution in Orange County is roughly from Ocoee to the vicinity of Interstate 4 near Lake Buena Vista. The Polk County distribution is between Bartow and Winter Haven.



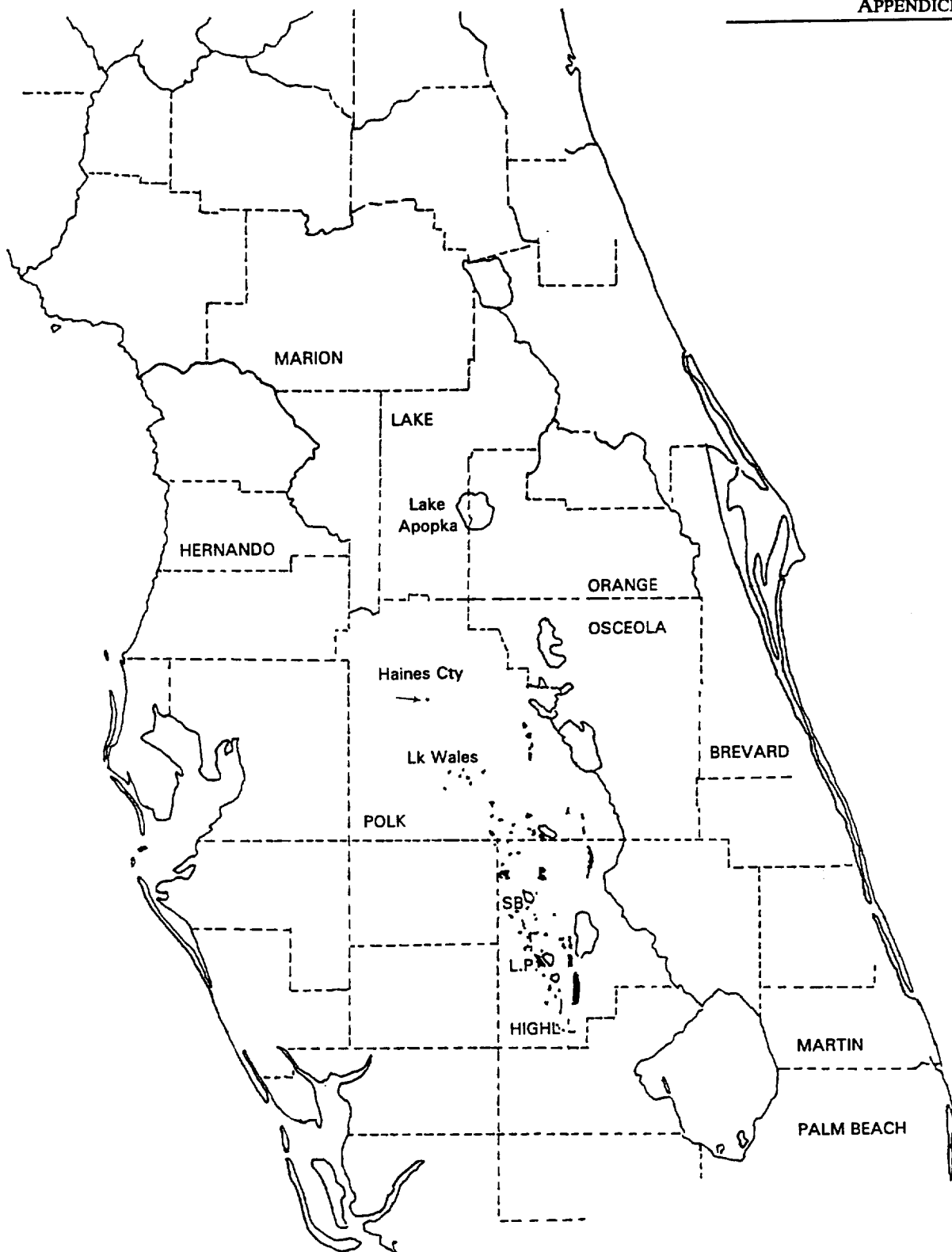
Map 14. Distribution of *Nolina brittoniana*, scrub beargrass. The plant was historically collected in central Lake County (Eustis) and in central Hernando County, and may have been collected in southern Marion County.



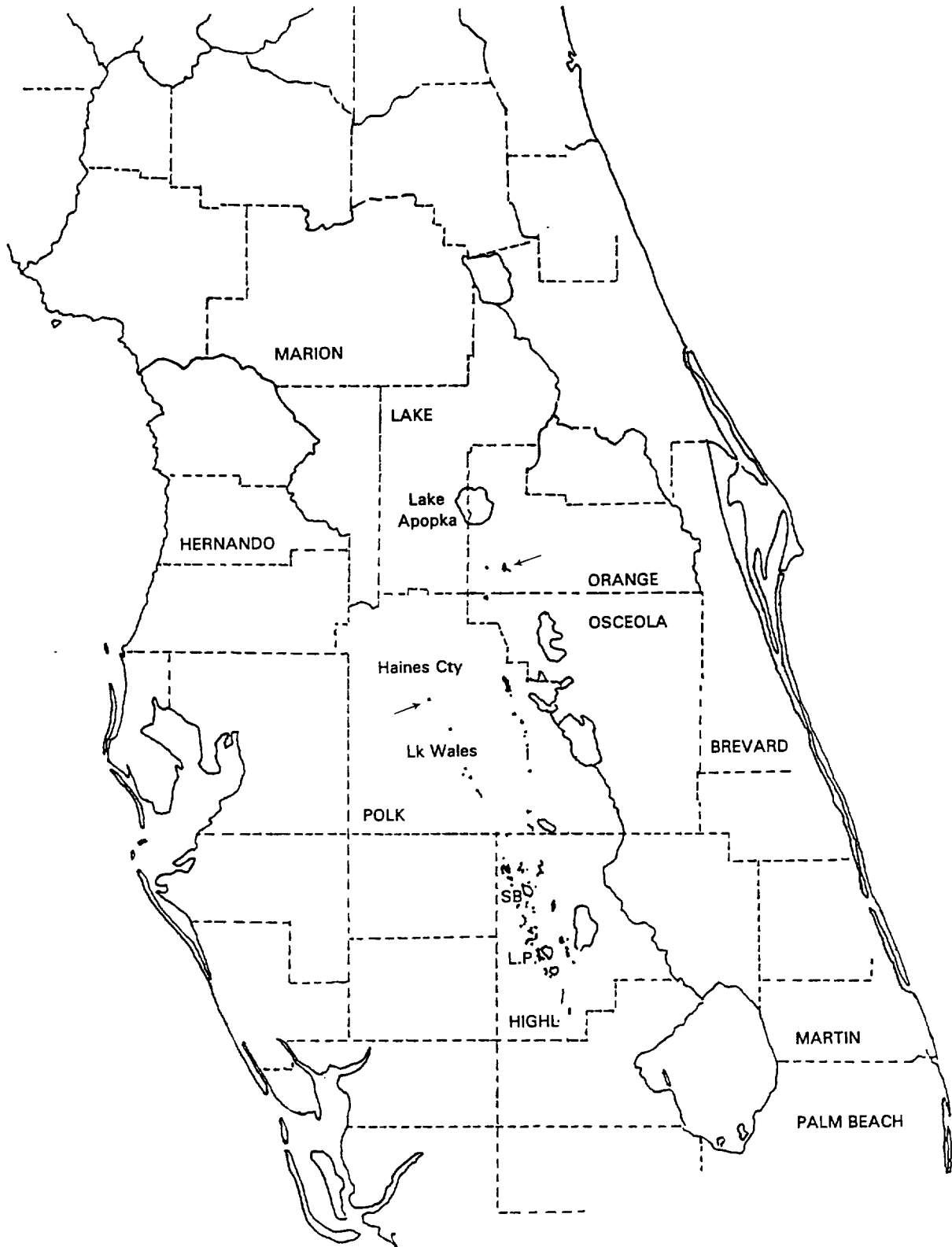
Map 15. Distribution of *Paronychia chartacea* ssp. *chartacea* in the peninsula (Lake and Orange to Highlands counties) and *P. chartacea* ssp. *minima* in the Panhandle (Bay and Washington counties).



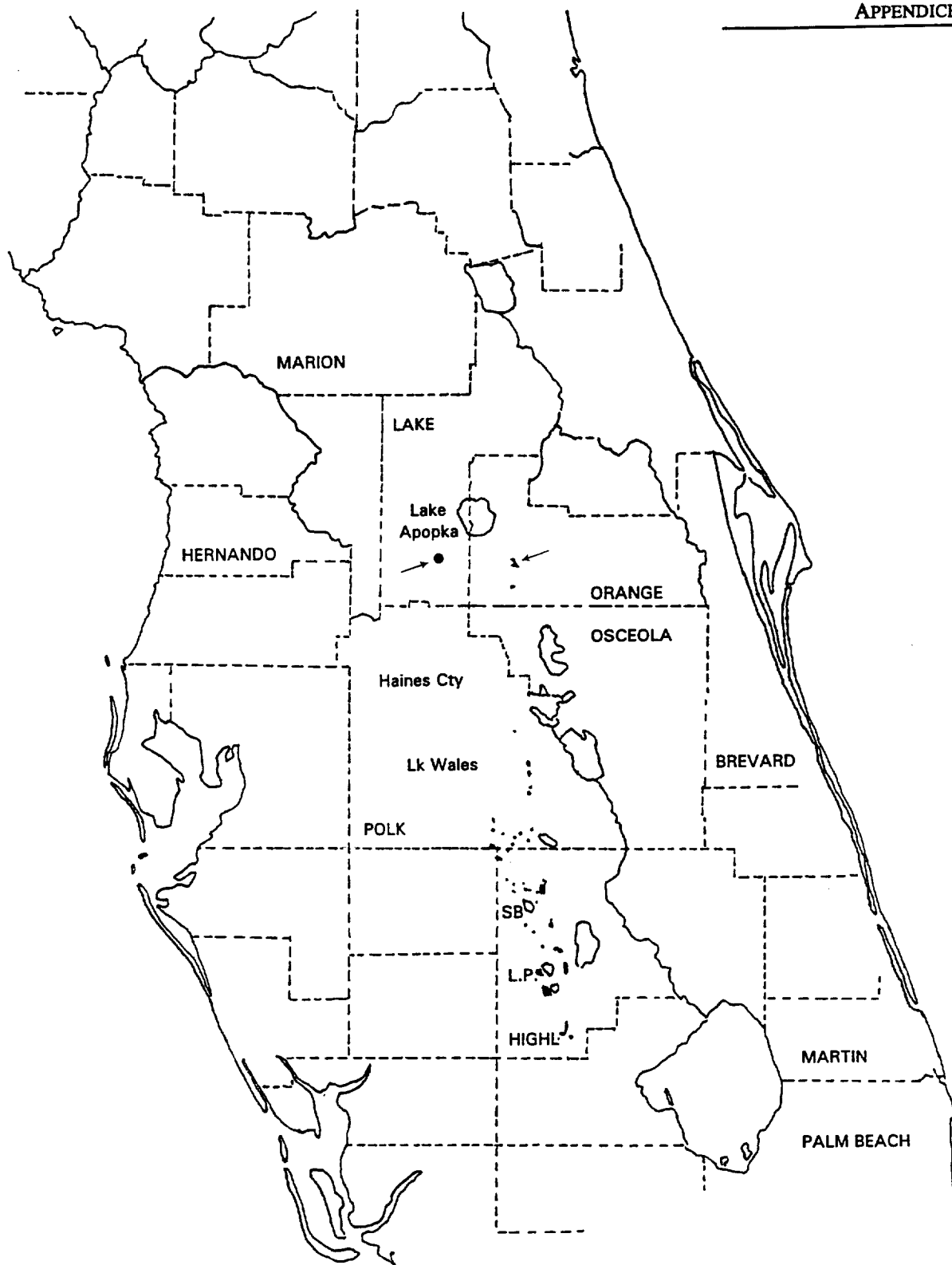
Map 16. Distribution of *Polygala lewtonii*. Distribution in Ocala National Forest, Marion County provided by USDA Forest Service. Southern limit of distribution is at the Carter Creek area near Sebring, Highlands County.



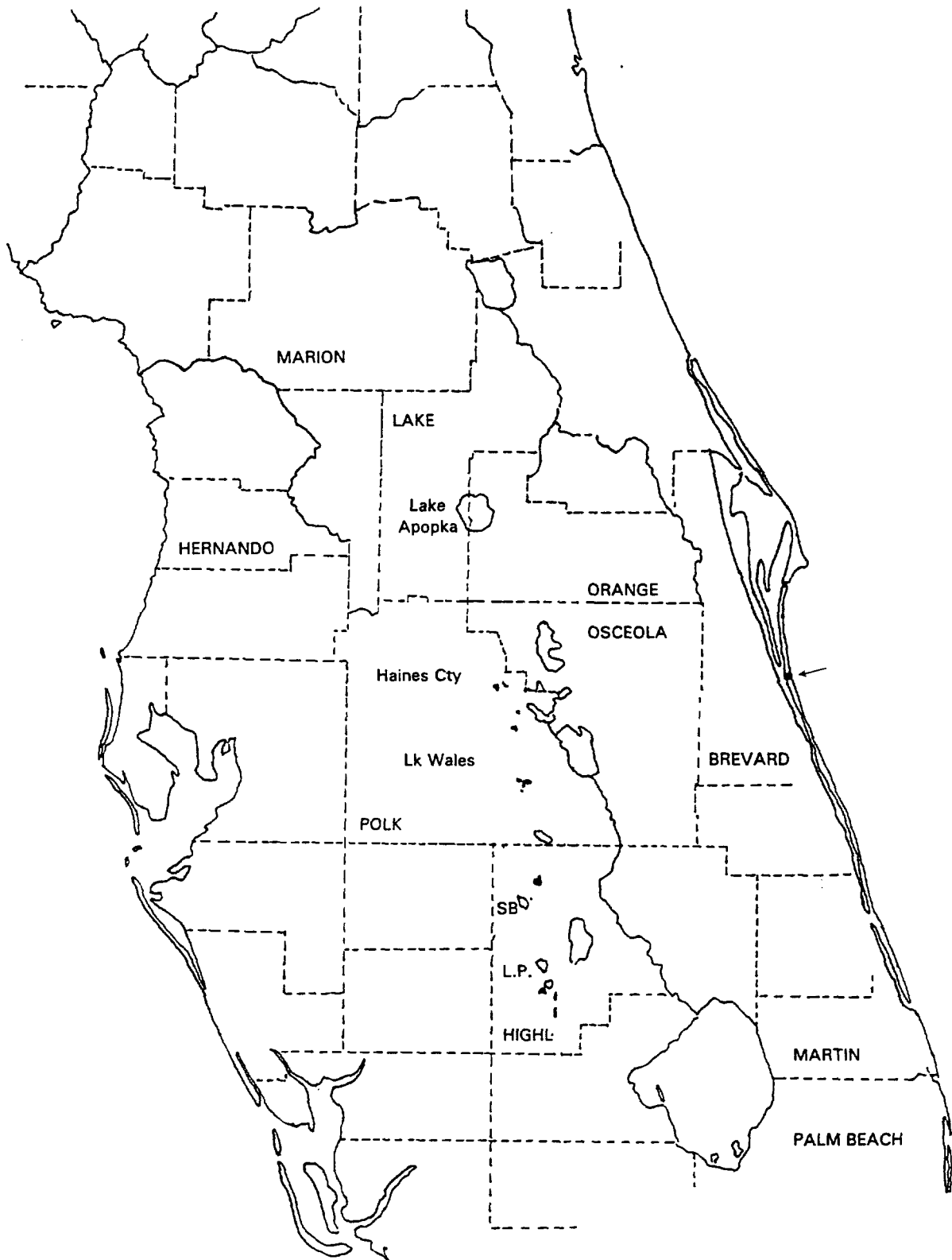
Map 17. Distribution of *Polygonella basiramia*, a wireweed.



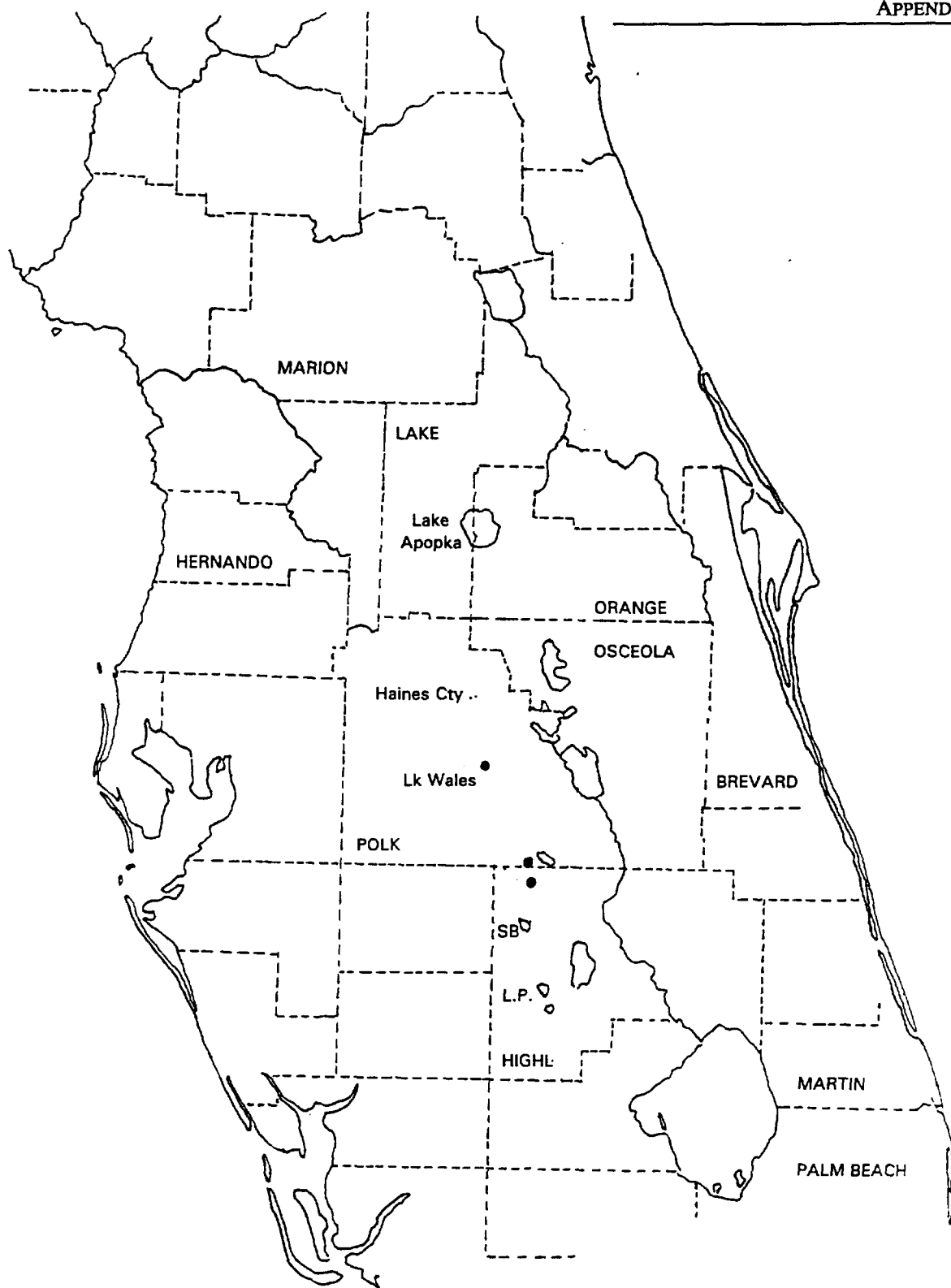
Map 18. Distribution of *Polygonella myriophylla*, sandlace.



Map 19. Distribution of *Prunus geniculata*, scrub plum. Distribution includes the hills west of Lake Apopka.

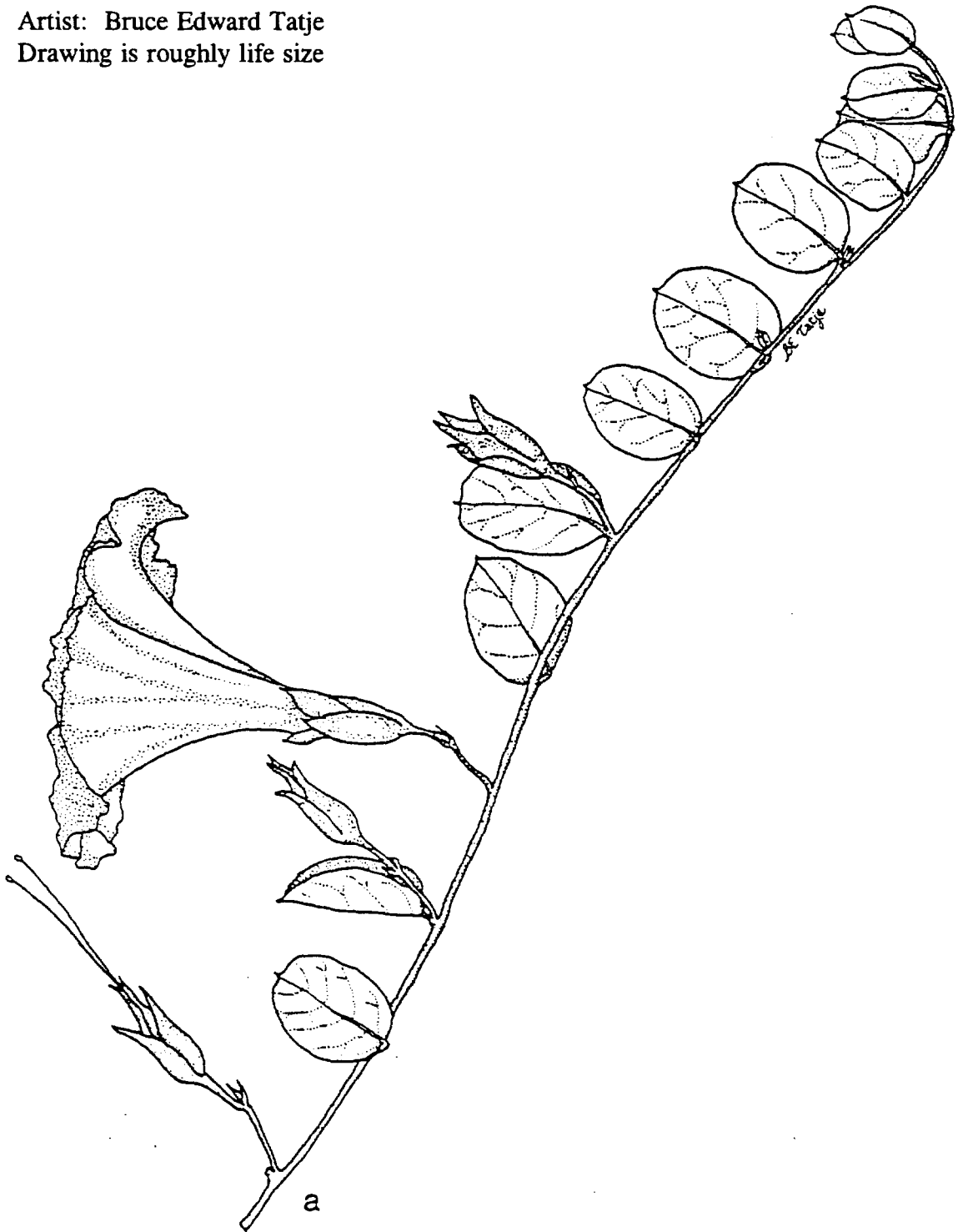


Map 20. Distribution of *Warea carteri*, including one locality on the barrier island, Brevard County. Formerly occurred in pine rocklands of Miami/Coral Gables, but last collected there about 90 years ago.



Map 21. Known distribution of *Ziziphus celata*: near Lake Wales, southeast of Avon Park, and the Arbuckle tract of Lake Wales Ridge State Forest (where it is protected). Collected near Sebring (SB on map) in 1948 but not found there since then.

Artist: Bruce Edward Tatje
Drawing is roughly life size



Drawing 1: *Bonamia grandiflora*



a. flowering branch X 3/4

b. flower X 4 1/2

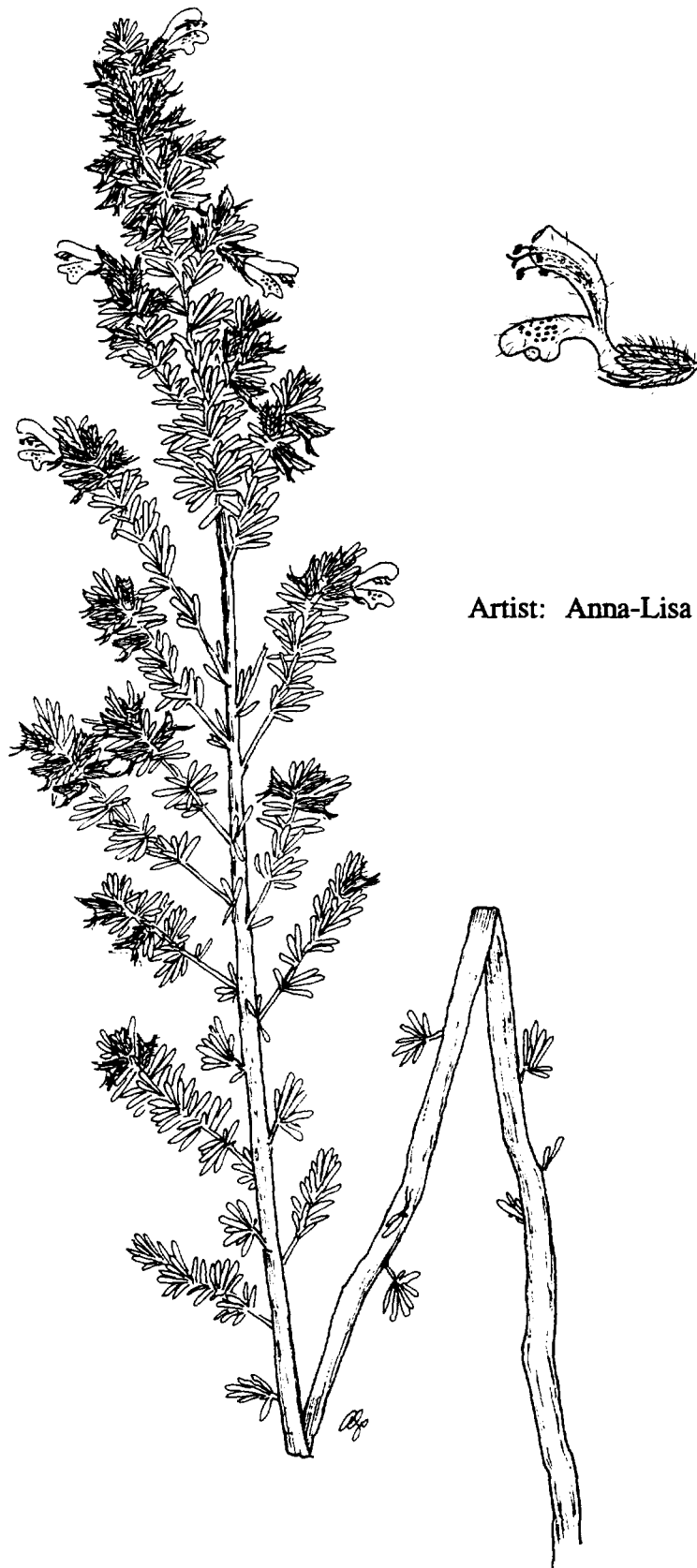
c. fruit X 3/4

Artist: Lisa C. Magahee

Drawing 2: *Chionanthus pygmaeus*

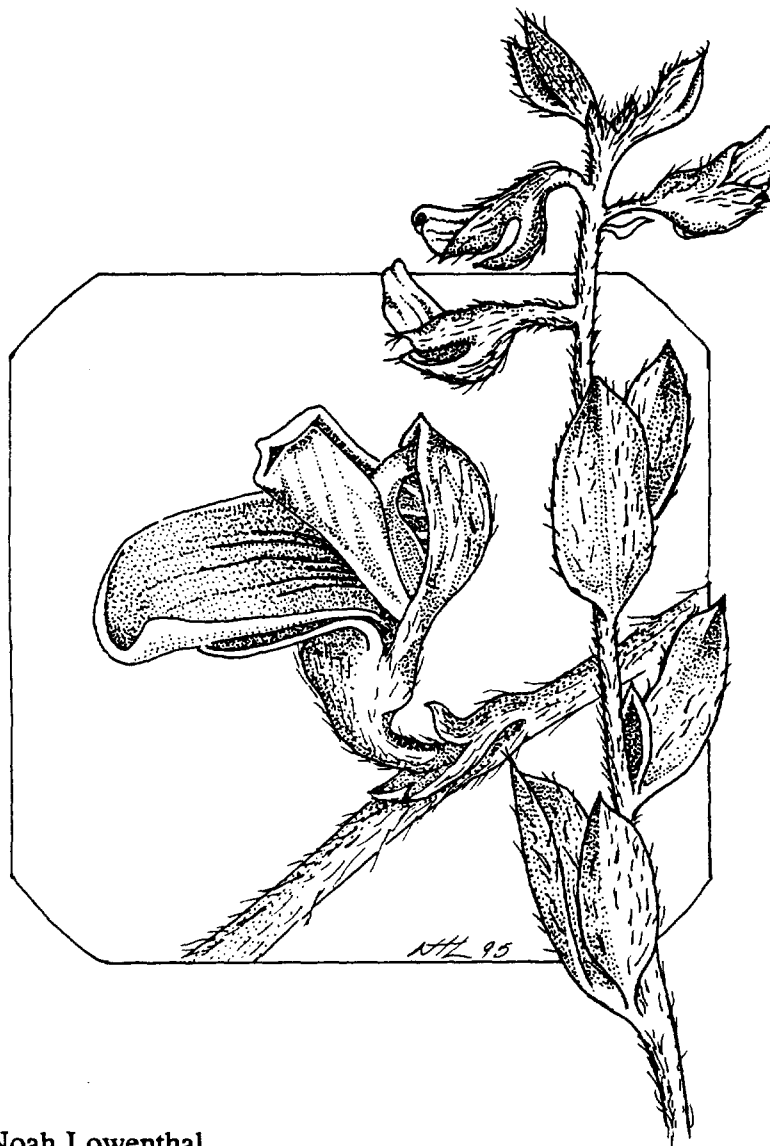
Artist: Lisa C. Magahee

Drawing 3: *Clitoria fragrans*



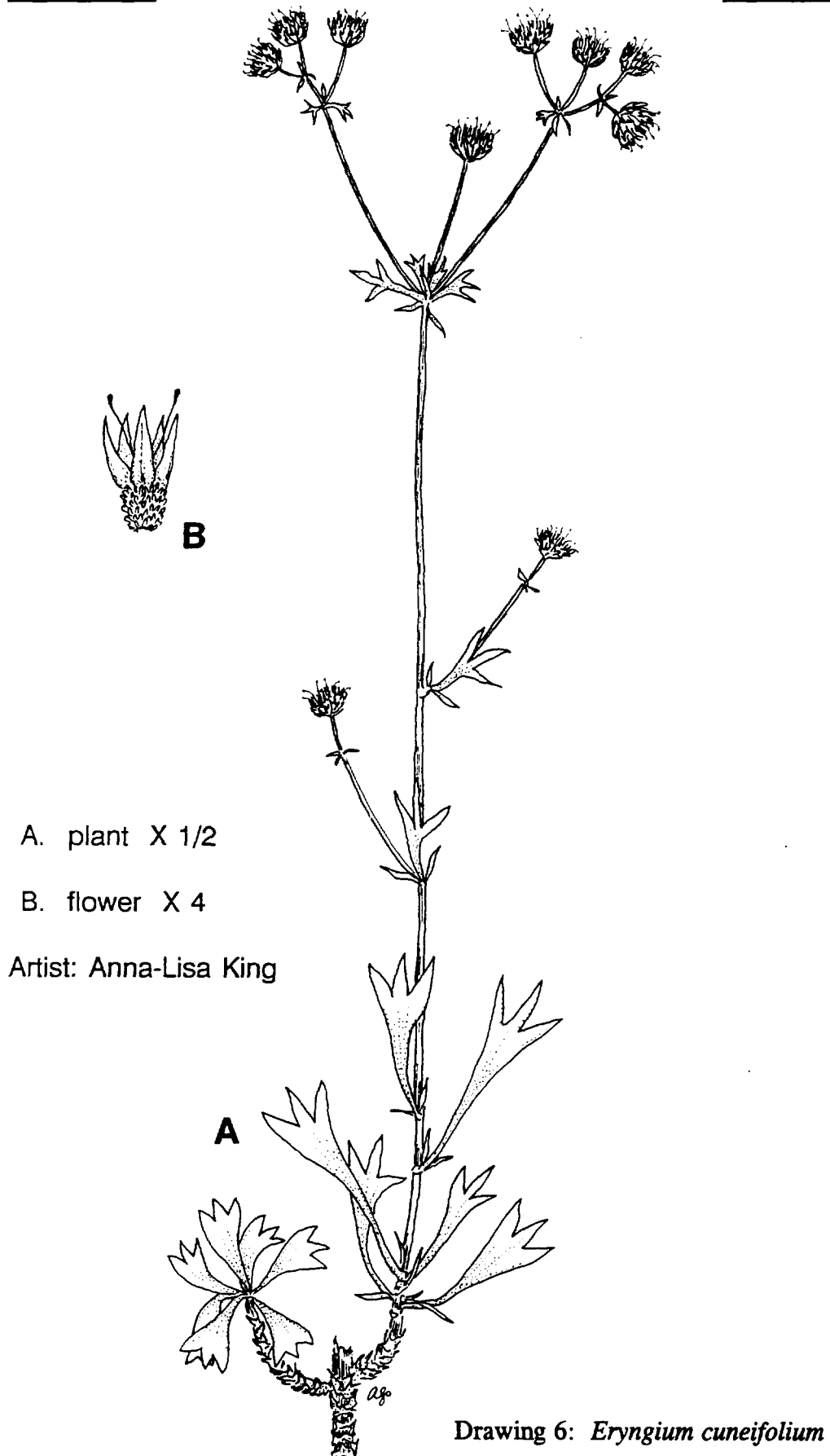
Artist: Anna-Lisa King

Drawing 4: *Conradina brevifolia*



Artist: Noah Lowenthal

Drawing 5: *Crotalaria avonensis*

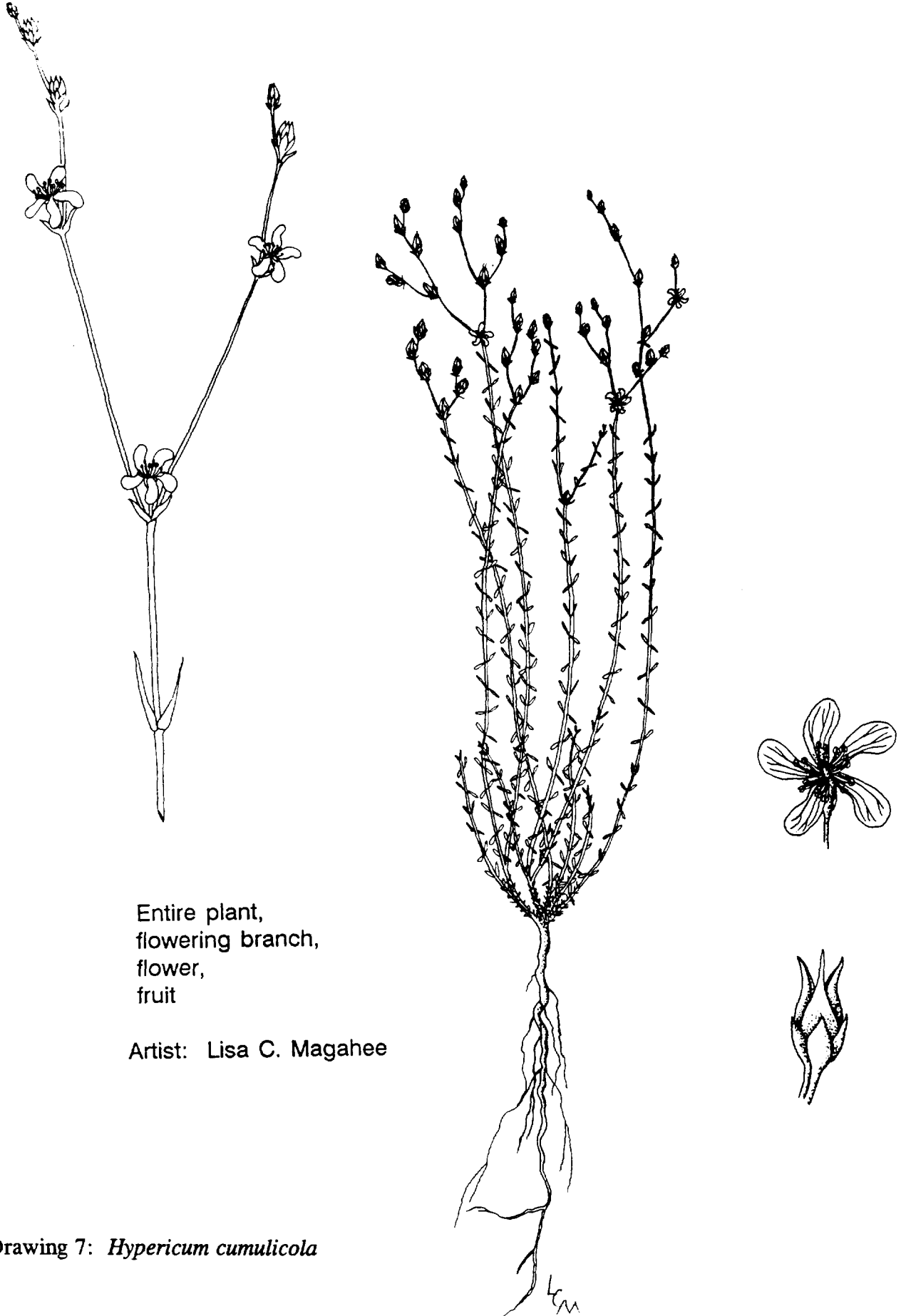


A. plant X 1/2

B. flower X 4

Artist: Anna-Lisa King

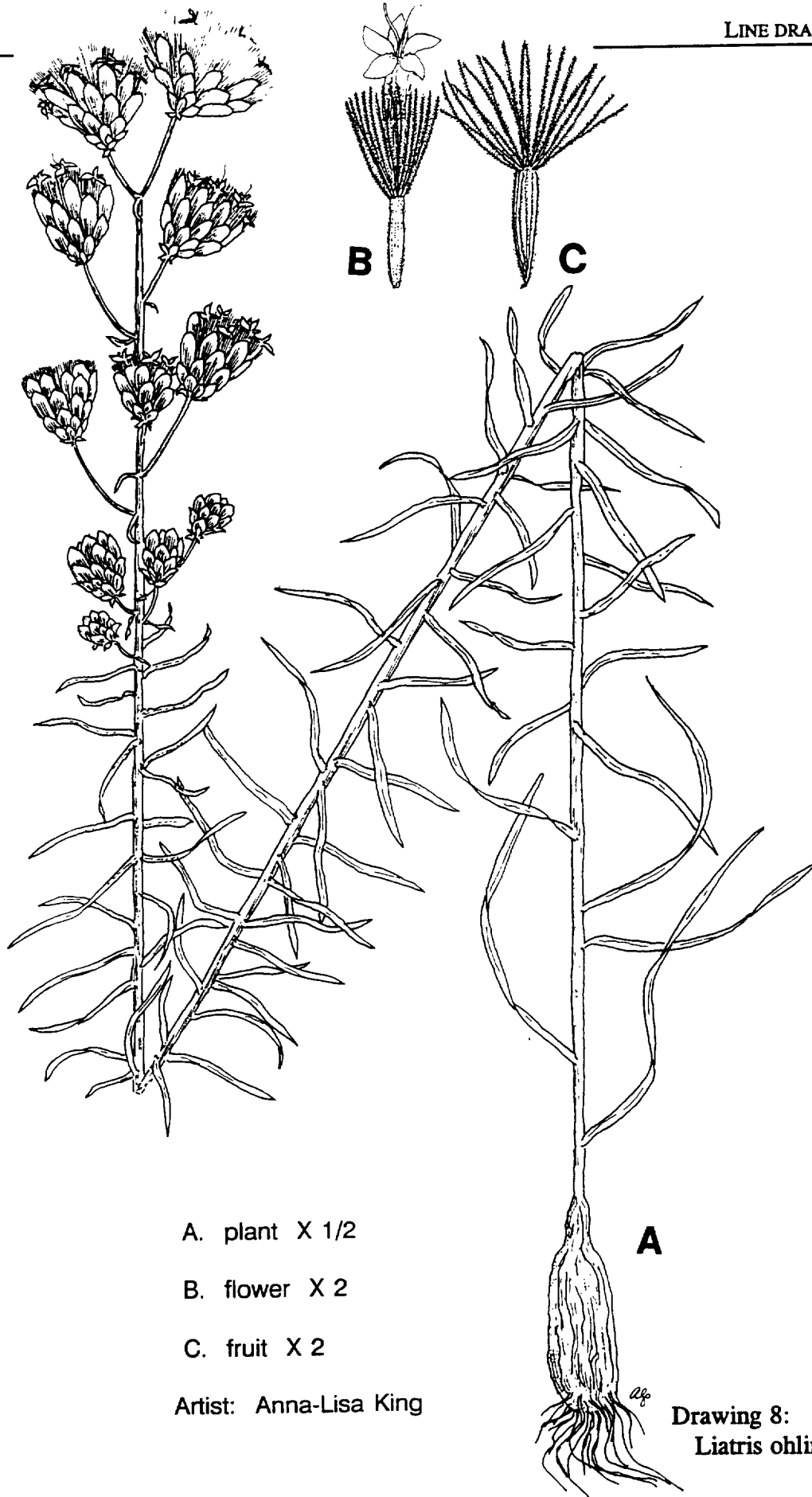
Drawing 6: *Eryngium cuneifolium*



Entire plant,
flowering branch,
flower,
fruit

Artist: Lisa C. Magahee

Drawing 7: *Hypericum cumulicola*



A. plant X 1/2

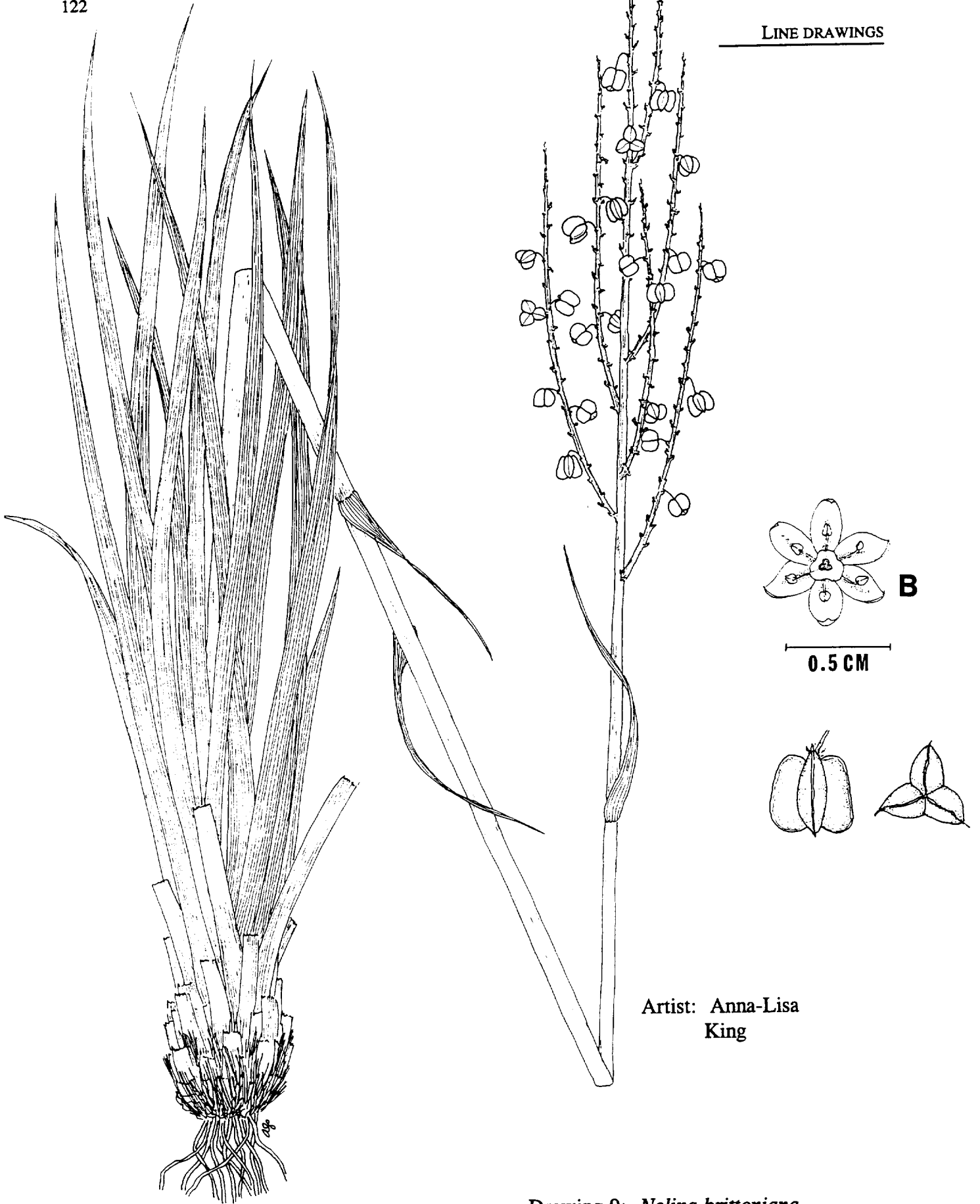
B. flower X 2

C. fruit X 2

Artist: Anna-Lisa King

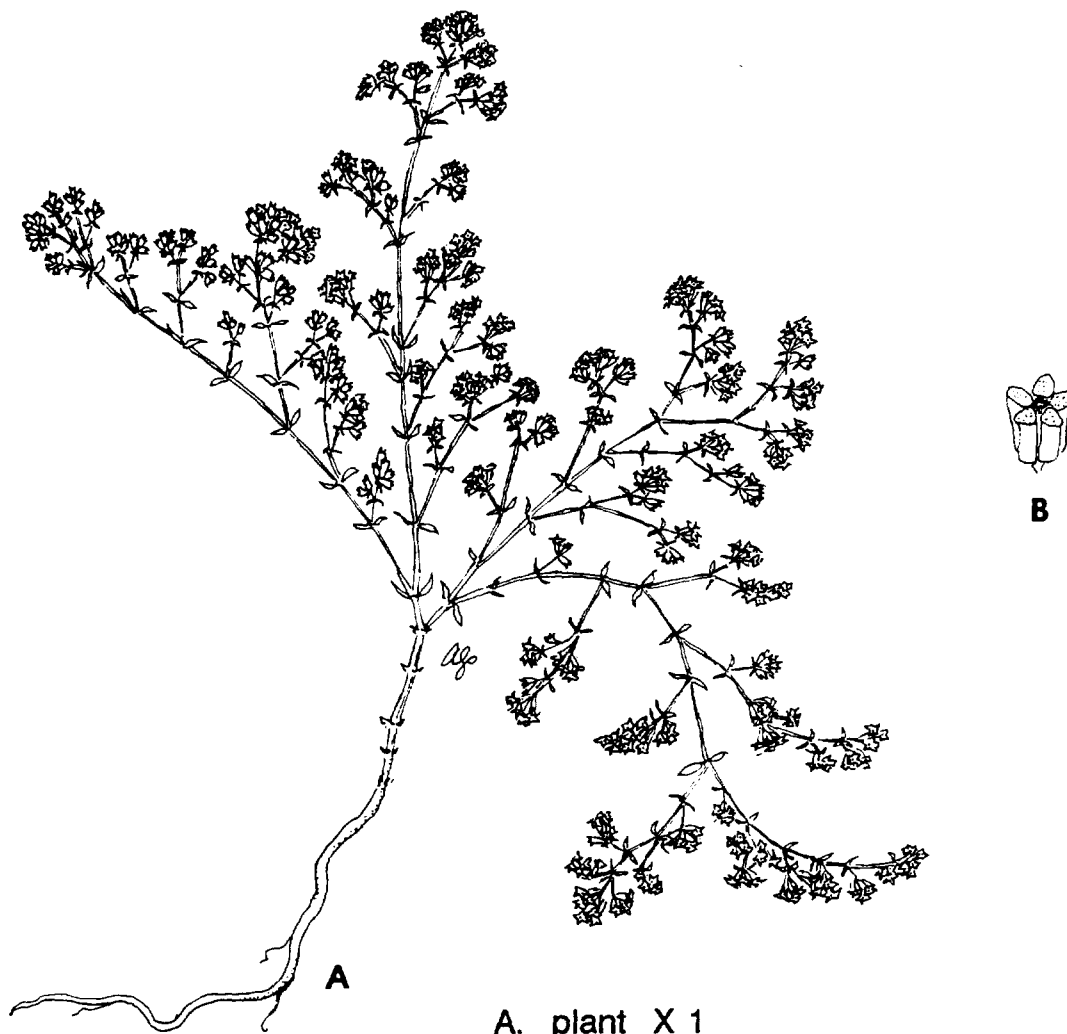
A

Drawing 8:
Liatris ohlingerae



Artist: Anna-Lisa King

Drawing 9: *Nolina brittoniana*

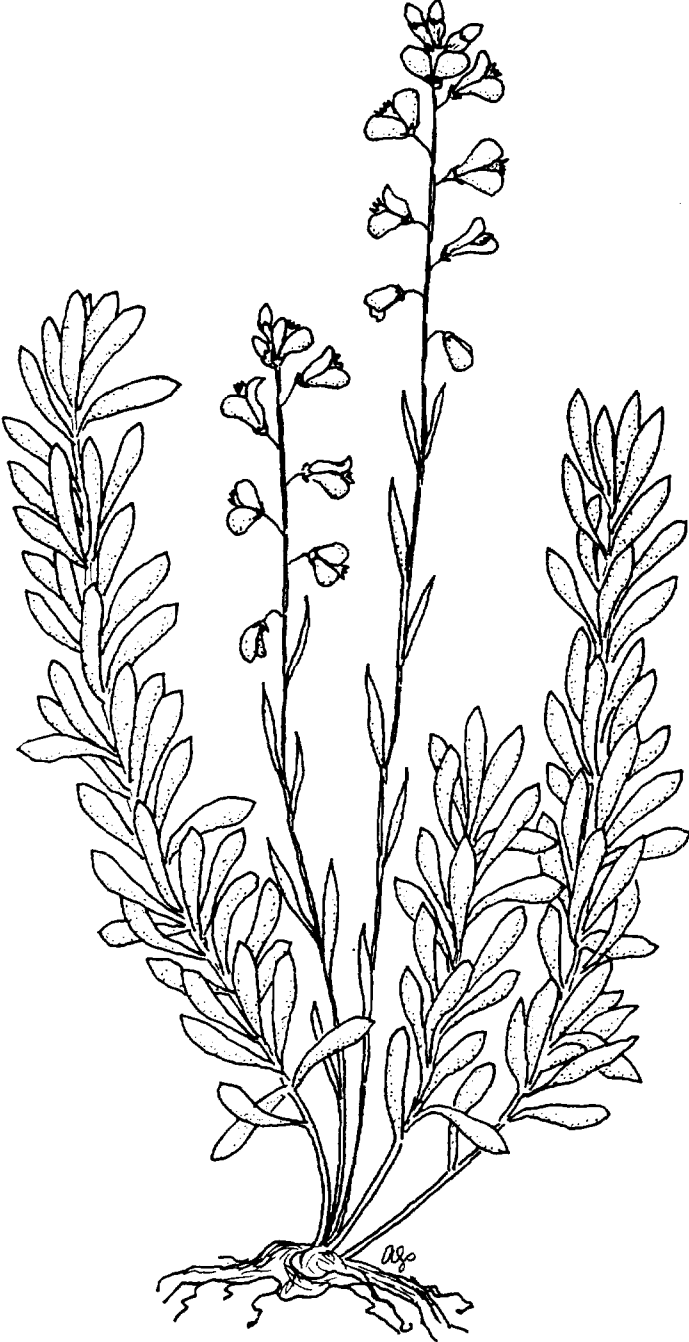


A. plant X 1

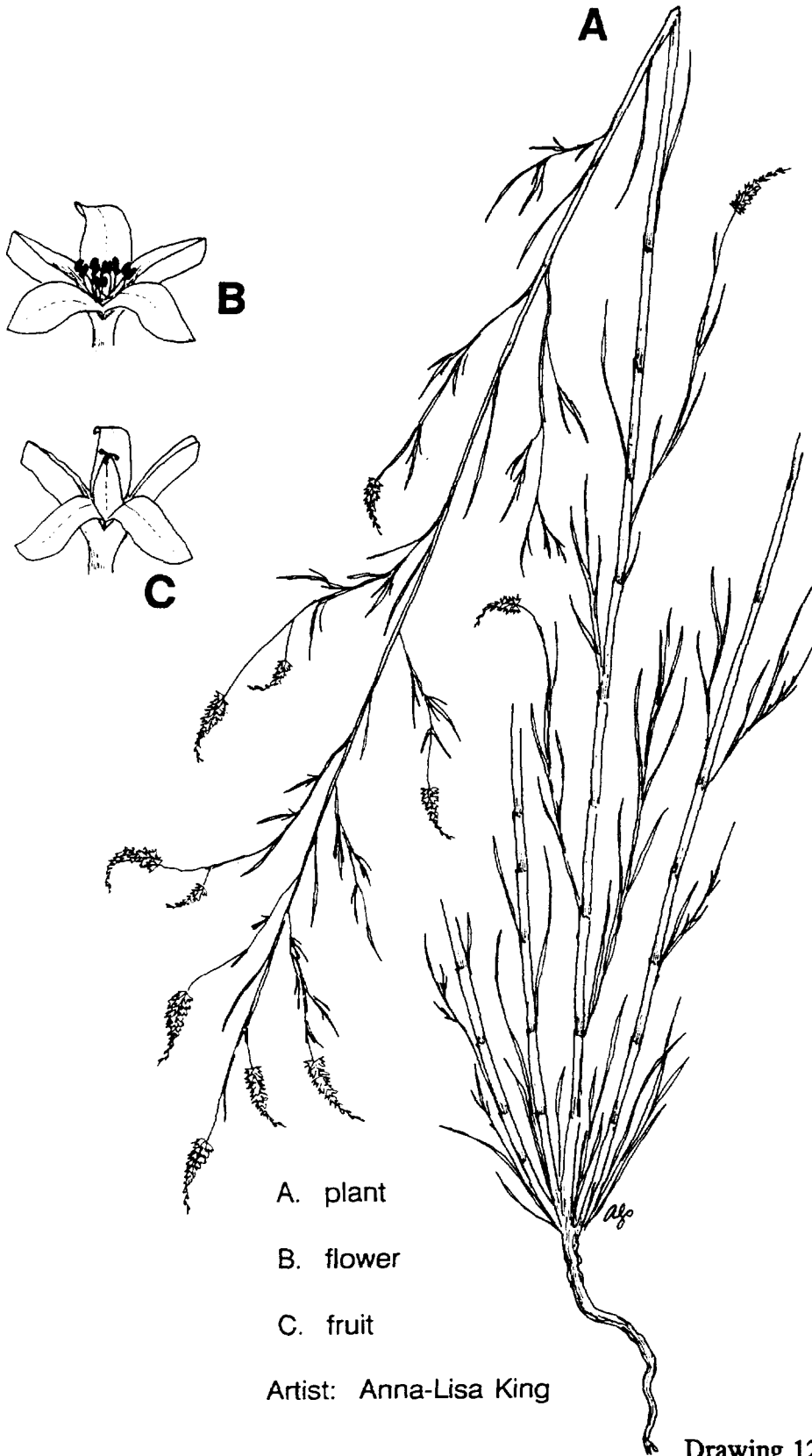
B. flower X 4

Artist: Anna-Lisa King

Artist: Anna-Lisa King



Drawing 11: *Polygala lewtonii*



A. plant

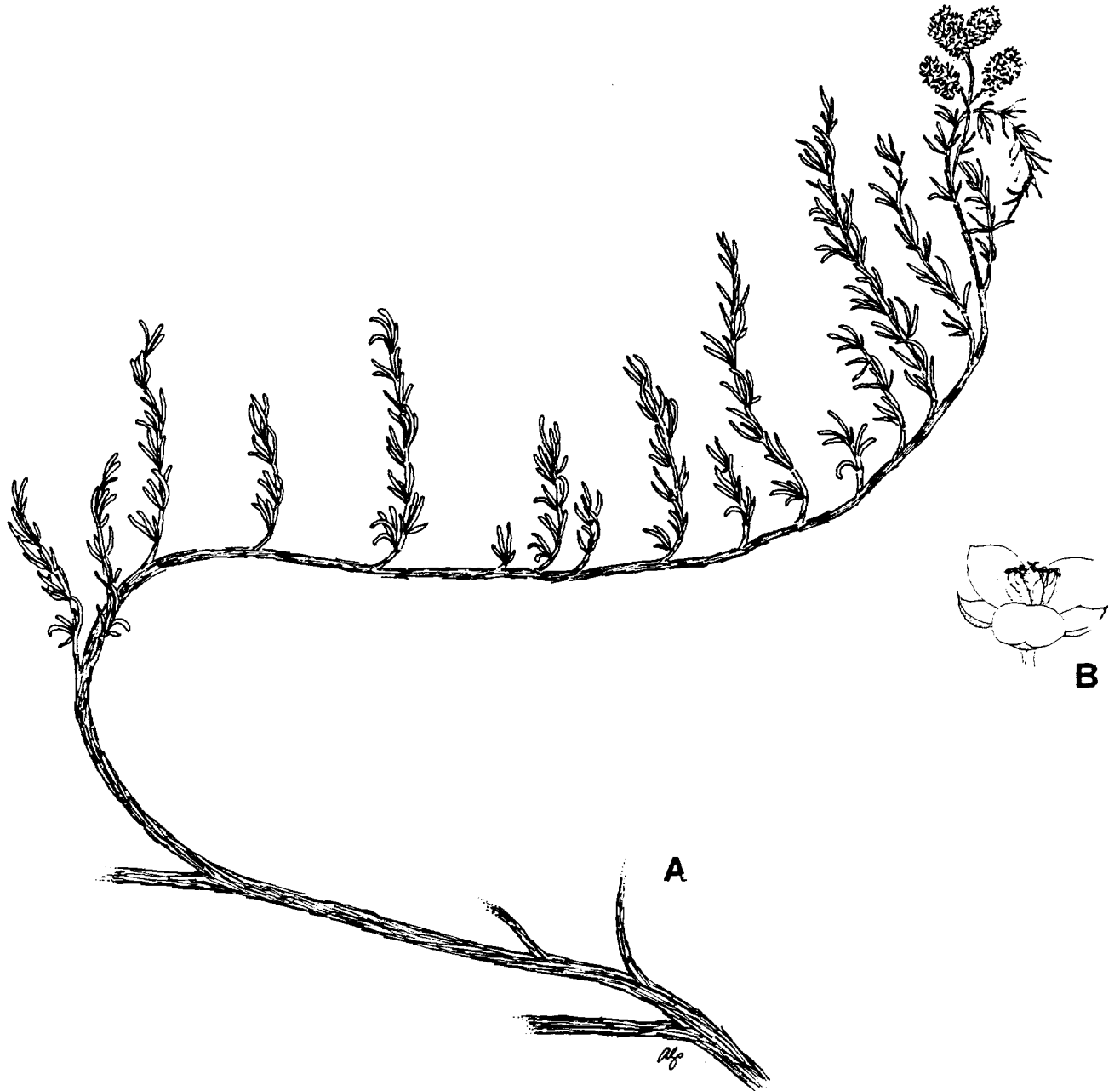
B. flower

C. fruit

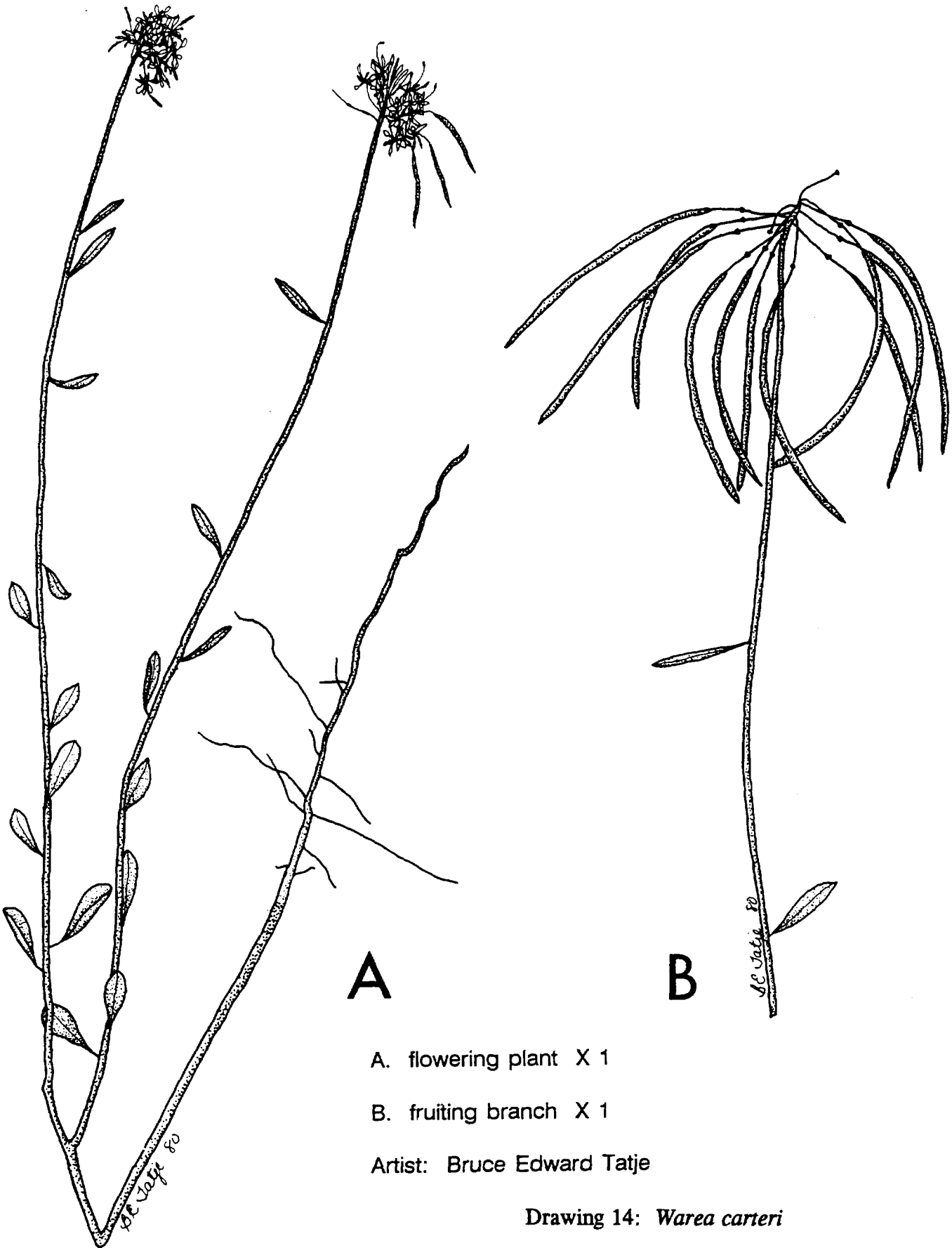
Artist: Anna-Lisa King

Drawing 12:
Polygonella basiramia

Artist:
Anna-Lisa King



Drawing 13: *Polygonella myriophylla*

Drawing 14: *Warea carteri*

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