United States Department of the Interior

FISH AND WILDLIFE SERVICE
South Florida Ecological Services Office
1339 20th Street
Vero Beach, Florida 32960

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Memorandum

To: Mike Piccirilli, Chief, Federal Aid, Southeast Regional Office

From: James J. Slack, Field Supervisor, South Florida Ecological Services Office

Subject: Biological Opinion for Florida Fish and Wildlife Conservation Commission Assistance to the Lake Wales Ridge Prescribed Fire Strike Team

This document transmits the Fish and Wildlife Service's (Service) biological and conference opinions based on our review of the proposal to fund the Florida Fish and Wildlife Conservation Commission's (FWC) assistance of the Lake Wales Ridge (LWR) Fire Cooperative Strike Team (Strike Team) and its effects on the following species in accordance with section 7 of the Endangered Species Act of 1973, as amended (ESA) (16 U.S.C. 1531 *et seq.*):

Florida scrub-jay (*Aphelocoma coerulescens*)	threatened
Eastern indigo snake (*Drymarchon corais couperi*)	threatened
Bluetail mole skink (*Eumeces egregius lividus*)	threatened
Sand skink (*Neoseps reynoldsi*)	threatened
Avon Park harebells (*Crotalaria avonensis)*	endangered
Britton's beargrass (*Nolina brittoniana*)	endangered
Carter's mustard (*Warea carteri*)	endangered
Florida bonamia (*Bonamia grandiflora*)	endangered
Florida perforate cladonia (*Cladonia perforata*)	endangered
Florida ziziphus (*Ziziphus celata*)	endangered
Garrett's mint (*Dicerandra christmanii*)	endangered
Highlands scrub hypericum (*Hypericum cumulicola*)	endangered
Lewton's polygala (*Polygala lewtonii*)	endangered
Papery whitlow-wort (*Paronychia chartacea)*	threatened
Pigeon wings (*Clitoria fragrans*)	threatened
Pygmy fringe tree (*Chionanthus pygmaeus*)	endangered
Sandlace (*Polygonella myriophylla*)	endangered
Scrub blazing star (*Liatris ohlingerae*)	endangered
Scrub buckwheat (*Eriogonum longifolium* var. *gnaphalifolium*)	threatened
Scrub lupine (*Lupinus aridorum*)	endangered
Scrub mint (*Dicerandra frutescens*)	endangered
Scrub plum (*Prunus geniculata*)	threatened
Short-leaved rosemary (*Conradina brevifolia*)	endangered

Snakeroot (*Eryngium cuneifolium*)	endangered
Wide-leaf warea (*Warea amplexifolia*)	endangered
Wireweed (*Polygonella basiramia*)	endangered
Highlands tiger beetle (*Cicindela highlandensis*)	candidate

These biological and conference opinions are based on information provided in the August 9, 2004, Biological Evaluation Form for funding the Strike Team, telephone conversations, e-mails, field investigations, and other sources of information. A complete administrative record of this consultation is on file in this office.

Consultation History

The Service is funding, through FWC, a continuation of existing financial support for the Strike Team. The section 7 evaluation form for supporting the Strike Team for the 2004 project, dated August 9, 2004, stated that "Prescribed burns return function to overgrown scrub and sandhill communities. The proposed action has been determined to be ultimately beneficial to these plants because of the restorative and habitat-sustaining nature of the activity" and found that all effects of the Strike Team's program to assist with prescribed burns (including mowing firebreaks) would have "no effect" on the listed species present in burn areas or were "not likely to adversely affect" them, so no biological opinion was required. A new analysis for 2005 funding of the Strike Team, carried out by the South Florida Ecological Services Office, concluded that this year's funding was "not likely to adversely affect" the Florida panther (*Felis concolor coryi*) and bald eagle (*Haliaeetus leucocephalus*), but that it would "adversely affect" other listed and candidate species.

BIOLOGICAL OPINION

DESCRIPTION OF PROPOSED ACTION

The proposed action is to provide funding to FWC, which will be used to fund the Strike Team, coordinated by The Nature Conservancy (TNC).

The goal of the Strike Team is to ensure that human communities exist compatibly within the flammable natural systems of the LWR, by implementing a cohesive, community-based fire management program to reduce wildfire risks and restore habitat for rare upland species. The Strike Team is an inter-disciplinary fire management effort with four sections: (1) Science and Risk Assessment; (2) Fire Management and Fuels Mitigation; (3) Firewise Education; and (4) Partnership Coordination.

Through the Fire Management and Fuels Mitigation section, the Strike Team proposes to assist land managers who need additional trained personnel and equipment for burning overgrown habitat. To request assistance from the Strike Team, a burn manager submits an application form, which solicits information on threatened and endangered species. Table 1, showing potential applicants, is provided below. When the Strike Team accepts an application, it will

participate in prescribed burns and conduct fireline preparation. All burn units will be primarily xeric uplands, which include Florida scrub, scrubby flatwoods, yellow sand scrub, and sandhill. These burn units are in various times-since-fire. Most units have not been burned in decades and have heavy fuel loads. Wherever possible, the Strike Team will use existing firebreaks. The Strike Team provides fireline preparation assistance, which is limited to mowing established firebreaks, using no heavy equipment and relying on hand clearing techniques.

Table 1. Potential Strike Team sites

Agency*	Site*	Acres
Archbold	Archbold Biological Station	5,200
Archbold	The Reserve	3,600
Brevard EEL	Micco	1,600
DEP-FPS	Lake June-in-Winter Scrub State Park	868
DEP-FPS	Highlands Hammock State Park	7,956
DEP-FPS	A.D. Broussard Catfish Creek Preserve State Park	8,300
DEP-FPS	Lake Kissimmee State Park	5,584
Polk County	Crooked Prairie	525
Polk County	Lakeland Highlands	605
Polk County	Hickory Lake Scrub	65
Polk County	North Walk in Water Creek	640
Polk County	Crooked Lake Sandhill	25
Polk County	SUMICA	4,035
Highlands County	Sun & Lakes Preserve	1,336
Audubon of Florida	Ridge Audubon Center	3
SWFWMD	Jack Creek	1,283
SFWMD	Lake Marion Scrub	1,866
Historic Bok Sanctuary	Pine Ridge Preserve	90
FWC	LWR WEA, Woolfenden (McJunkin) Scrub	623
FWC	LWR WEA, Mountain Lake Scrub	219
FWC	LWR WEA, Lake Apthorpe	810
FWC	LWR WEA, Carter Creek	5,959
FWC	LWR WEA, Henscratch	1,514
FWC	LWR WEA, Highland Park Estates	2,258
FWC	LWR WEA, Highlands Ridge	3,160
FWC	LWR WEA, Holmes Avenue	974
FWC	LWR WEA, Lake Blue	88
FWC	LWR WEA, Silver Lake	389
FWC	LWR WEA, Sun Ray	270
FWC	LWR WEA, Lake Placid Scrub	3,159
FWC	LWR WEA, Gould Road	212
FWC	LWR WEA, Royce Ranch	2,991
DOF	LWR State Forest, Arbuckle Tract	13,825

Table 1. (continued)

Agency*	Site*	Acres
DOF	LWR State Forest, Walk-in-the-Water Tract	6,837
DOF	LWR State Forest, Hesperides South	919
DOF	LWR State Forest, Hesperides North	363
DOF	LWR State Forest, Prairie Tract	4,873
TNC	Saddle Blanket Lakes Preserve	829
TNC	Sun Ray	9
TNC	Tiger Creek Preserve	4,823
Multiple (incl. Service)	Horse Creek/Snell Creek	5,635
Service	Carter Creek tract of LWR NWR	664
Service	Flamingo Villas tract of LWR NWR	1,292
Service	Lake McLeod tract of LWR NWR	65

*Definitions of agency and site acronyms and abbreviations:

Archbold	Archbold Biological Station
Brevard EEL	Brevard County Environmentally Endangered Lands Program
DEP-FPS	Florida Department of Environmental Protection, Florida Park Service
DOF	Florida Division of Forestry
FWC	Florida Fish and Wildlife Conservation Commission
LWR NWR	Lake Wales Ridge National Wildlife Refuge
LWR WEA	Lake Wales Ridge Wildlife and Environmental Area
NWR	National Wildlife Refuge
Service	U.S. Fish and Wildlife Service
SFWMD	South Florida Water Management District
SWFWMD	Southwest Florida Water Management District
TNC	The Nature Conservancy

The Strike Team serves as a supplemental crew to nine different agencies on the LWR. The Strike Team works in concert with conservation managers who must provide their own burn bosses, fire management plans, burn unit plans, and a partial burn crew for each burn on their property. The land managers are responsible for obtaining their own burn authorizations from the Florida Department of Agriculture and Consumer Services, Division of Forestry (DOF).

All burn units submitted to the Strike Team are reviewed by at least three members of the Strike Team steering committee (which includes personnel from the Service) and one scrub-jay expert (Reed Bowman or David Breininger). Strike Team members receive training in identification and management of listed species of the LWR at the start of each fire season. During each prescribed burn briefing, actions to avoid impacts to listed species are discussed.

Florida scrub-jay: No ring-firing will occur, to avoid entrapping jays or other animals. Known scrub-jay nests along with a 50-foot buffer will be excluded from burn units. For burns planned from February 15 to May 15 on sites with small remnant jay populations (five family groups or less), monitoring will be performed in advance of the burn to delineate territories and exact nest locations. The burn unit will be designed to ensure that active nests are not burned and less than 50 percent of a territory is burned. Also, the Strike Team coordinator will meet with the site's burn boss to ensure that the fire will be conducted so as to be beneficial to the scrub-jays on the site.

Eastern indigo snake: Train Strike Team members to identify the species and about practices to avoid harming individuals (especially running over them with equipment). Avoid using ring fires to allow the best possible opportunity for snakes to flee or hide. Strike Team members will avoid harming snakes.

Bluetail mole skink: Train Strike Team members to identify the species and about practices to avoid harming individuals, especially by restricting the use of vehicles. Restrict vehicle use as much as possible to the burn unit perimeter roads.

Sand skink: Train Strike Team members to identify the species and about practices to avoid harming individuals, especially by restricting the use of vehicles. Restrict vehicle use as much as possible to the burn unit perimeter roads.

Plant species: Train vehicle operators to recognize listed plant species, to avoid driving vehicles within populations, and to avoid any mechanical treatments other than mowing where they are present. Mowing is acceptable for all listed plant species.

Florida perforate cladonia: While regular fire management is recommended for the long-term protection of this species, individual lichens are killed by fire. In planning fires, consider removing lichens pre-fire and replacing them post-fire. Measures to promote patchy or mosaic burns are also desirable.

Scrub lupine: Fire planning for the population of this plant on Lake McLeod unit of LWR National Wildlife Refuge (NWR) is expected to emphasize the use of hand tools and foot access to minimize ground disturbance in lupine habitat. Time fires when the lupines are least active.

Highlands tiger beetle: Train Strike Team members in: (1) identification of the species, including the appearance of larval burrows; (2) habitat needs that pertain to the health of the population; and (3) specific management practices that will avoid detrimental impacts to individuals. Restrict vehicle use as much as possible to the burn unit perimeter roads.

Action Area

The action area is defined as all areas to be affected directly or indirectly by the Federal action and not merely the immediate area involved in the action. The Service has determined the action area for this project consists of the properties listed above. They are in Florida, primarily on the

LWR and nearby smaller ridges in Highlands and Polk Counties, but a few sites are in Osceola County and one is in southern Brevard County.

STATUS OF THE SPECIES AND CRITICAL HABITAT RANGEWIDE

Florida scrub-jay

The following discussion is summarized from the South Florida Multi-Species Recovery Plan (MSRP) (Service 1999), as well as from recent research publications and monitoring reports. A complete Florida scrub-jay life history discussion may be found in the MSRP. No critical habitat has been designated for the Florida scrub-jay.

Description – Scrub-jays are about 25 to 30 centimeters (cm) (10 to 12 inches) long and weigh about 85 grams (3 ounces). They are similar in size and shape to the blue jay (*Cyanocitta cristata*), but differ significantly in coloration (Woolfenden and Fitzpatrick 1996a). Unlike the blue jay, scrub-jays do not have a crest. They also lack the conspicuous white-tipped wing and tail feathers, black barring and bridle of the blue jay. The Florida scrub-jay's head, nape, wings, and tail are pale blue, and it is pale gray on its back and belly. Its throat and upper breast are lightly striped and bordered by a pale blue-gray "bib." The sexes of scrub-jays are not distinguishable by plumage, and males average only slightly larger than females (Woolfenden 1978). The sexes may be differentiated by a distinct "hiccup" call vocalized only by females (Woolfenden and Fitzpatrick 1986). Scrub-jays less than about 5 months of age are easily distinguishable from adults; their plumage is smoky gray on the head and back, and they lack the blue crown and nape (neck) of adults. Molting occurs between early June and late November, and peaks between mid-July and late September (Bancroft and Woolfenden 1982). During late summer and early fall, when the first basic molt is nearly complete, fledgling scrub-jays may be indistinguishable from adults in the field (Woolfenden and Fitzpatrick 1984). The variety of vocalizations of scrub-jays is described in detail by Woolfenden and Fitzpatrick (1996b).

Scrub-jays are in the order Passeriformes and the family Corvidae. They have been called a "superspecies complex," and described in four groups that differ in geographic distribution within the United States and Mexico: *A. californicus*, from southwestern Washington through Baja California; *A. insularis*, on Santa Cruz in the Channel Islands, California; *A. woodhousii*, from southeastern Oregon and the Rocky Mountains and Great Plains to Oaxaca, Mexico; and *A. coerulescens* in peninsular Florida (American Ornithologists' Union 1983). Other congeners include the Mexican jay or gray-breasted jay (*A. ultramarina*) and the unicolored jay (*A. unicolor*) of Central America and southwest North America (Woolfenden and Fitzpatrick 1996b).

The Florida scrub-jay has specific habitat requirements. It is native to peninsular Florida's ancient dune ecosystems or scrubs, which occur on well-drained to excessively well-drained sandy soils (Laessle 1958, 1968; Fitzpatrick et al. 1994). This relict oak-dominated scrub, or xeric oak scrub, is essential habitat to the Florida scrub-jay. This community type is adapted to nutrient-poor soils, periodic drought, high seasonal rainfall and frequent fires (Abrahamson 1984a). Xeric oak scrub on the LWR is predominantly comprised of four species of stunted,

low-growing oaks: sand live oak (*Quercus geminata*), Chapman oak (*Q. chapmanii*), myrtle oak (*Q. myrtifolia*), and scrub oak (*Q. inopina*) (Myers 1990). In optimal habitat for scrub-jays, these oaks are 1 to 3 meters (m) high, interspersed with 10 to 50 percent unvegetated, sandy openings, and a sand pine (*Pinus clausa*) canopy of less than 20 percent (Woolfenden and Fitzpatrick 1990). Trees and dense herbaceous vegetation are rare. Other vegetation noted along with the oaks include saw palmettos (*Serenoa repens*) and scrub palmetto (*Sabal etonia*), as well as woody shrubs such as Florida rosemary (*Ceratiola ericoides*) and rusty lyonia (*Lyonia ferruginea*). Although there is more species diversity in the LWR oak scrub, the Atlantic Coastal Ridge oak scrub is similar in structural composition.

Scrub-jays are rarely found in habitats with more than 50 percent canopy cover over 6 feet in height (Service 1990). Scrub-jays also prefer interspersed, exposed sand patches in the scrub matrix within which they forage and store acorns (Woolfenden and Fitzpatrick 1984). Breininger et al. (1995) noted that scrub-jays also occupy marginal habitat in large numbers in some locations.

The area covered by scrub has been reduced, fragmented, or degraded due to conversion to agricultural, commercial, and residential development. In addition, fire suppression has resulted in the succession of many areas to denser, vertically stratified scrub vegetation that no longer provides suitable habitat for scrub-jays. As a result of the direct and indirect loss of scrub habitat, scrub-jays have been extirpated in Alachua, Clay, Broward, Miami-Dade, Duval, Gilchrist, Pinellas, and St. Johns Counties, and their numbers reduced in Brevard, Hernando, Highlands, Levy, Orange, Palm Beach, and Seminole Counties (Cox 1987; Fitzpatrick et al. 1991, 1994, In Press). Fitzpatrick et al. (1994) estimated the scrub-jay population to be about 10,700 individuals. Fitzpatrick et al. (In Press) indicates that current population estimates represent only about 10 percent of pre-settlement scrub-jay population numbers.

Cox (1987) and later Fitzpatrick et al. (1994) identified several scrub areas of Florida that are occupied by over half of the existing population of scrub-jays. Fitzpatrick et al. (In Press) called these three areas "core populations" and suggested that maintenance and restoration of these areas was essential to maintaining scrub-jays in Florida. These core populations exist on Cape Canaveral/Merritt Island NWR (Brevard County), Ocala National Forest (NF) (primarily eastern Marion, southwestern Putnam, northeastern Lake, and western Volusia Counties), and the LWR (Polk, Highlands, and Glades Counties). Fitzpatrick et al. (1994) estimated that about 1,334 groups (34 percent) of scrub-jays were on Federal land, whereas 2,627 groups (66 percent) were located outside of Federal lands. Much of the LWR population resides on private property.

Scrub-jay habitat is managed on Federal lands, but because of conflicts with primary or multiple use mandates established for these lands, scrub-jay populations are not necessarily secure. Fitzpatrick et al. (1994) indicated that fire suppression at Cape Canaveral and Cape Canaveral Naval Air Station threatens the viability of this core population of scrub-jays. Furthermore, they stated that current forestry practices on Ocala NF are likely to contribute to the continued decline of scrub-jays in this core area. Scrub-jays occurring on private land also face continued threats due to habitat degradation, fragmentation, and loss.

Life History – Scrub-jays have a social structure that involves cooperative breeding, a trait that the western North American populations of scrub-jays do not exhibit (Woolfenden and Fitzpatrick 1984). Scrub-jays live in groups of two (a single mated pair) up to large, extended families of eight adults and one to four juveniles. Fledgling scrub-jays remain with the breeding pair in their natal (birth) territory as "helpers," forming a closely-knit, cooperative family group. Pre-breeding numbers are generally reduced to either a pair with no helpers or families of three or four individuals (a pair plus one or two helpers). A well-developed intra-familial dominance hierarchy exists, with breeder males most dominant, followed by helper males, breeder females, and finally, female helpers (Woolfenden and Fitzpatrick 1977). Helpers participate in sentinel duties (McGowan and Woolfenden 1989), territorial defense, predator-mobbing, and the feeding of both nestlings (Stallcup and Woolfenden 1978) and fledglings (McGowan and Woolfenden 1990). The well-developed sentinel system involves having one individual occupying an exposed perch watching for predators or territory intruders. When a predator is observed, the sentinel jay gives a warning call and all group members seek cover in dense shrub vegetation (Fitzpatrick et al. 1991).

Florida scrub-jay pairs occupy year-round, multi-purpose territories (Woolfenden and Fitzpatrick 1984; Fitzpatrick et al. 1991, 1994). Territory size averages 22 to 25 acres, with a minimum size of about 12 acres. Territories are a limiting factor for scrub-jay populations. Because of this limitation, non-breeding adult males may remain at the natal territory as helpers for up to 5 years, waiting for either a mate or territory to become available (Fitzpatrick et al. 1991). New territories are established the following ways: by replacing a lost breeder on a territory (Woolfenden and Fitzpatrick 1984); through "territorial budding," where a helper male becomes a breeder in a segment of its natal territory (Woolfenden and Fitzpatrick 1978); by inheriting a natal territory following the death of a breeder; by establishing a new territory between existing territories (Woolfenden and Fitzpatrick 1984); or through "adoption" of an unrelated helper by a neighboring family followed by resident mate replacement (B. Toland, Service, personal communication, 1996). Territories can also be obtained by creation of suitable habitat through effective habitat management efforts (Thaxton and Hingtgen 1994).

Reproduction and Demography

To become a breeder, a scrub-jay must acquire a territory as well as a mate. Evidence presented by Woolfenden and Fitzpatrick (1984) suggests that scrub-jays are permanently monogamous. The pair retains ownership and sole breeding privileges in their particular territory year after year. Courtship to form the pair is lengthy and ritualized, and involves posturing and vocalizations made by the male to the female (Woolfenden and Fitzpatrick 1996b). Copulation between the pair is generally out of sight of other jays (Woolfenden and Fitzpatrick 1984). These authors also reported never observing copulation between unpaired jays, nor courtship behavior between a female and a jay other than her mate. Age at first breeding in the Florida scrub-jay varies from 1 to 7 years, although most individuals become breeders between 2 and 4 years of age (Fitzpatrick and Woolfenden 1988). Persistent breeding populations of scrub-jays exist only where there are scrub oaks in sufficient quantity to provide an ample winter acorn

supply, cover from predators, and nest sites during the spring (Woolfenden and Fitzpatrick 1996b).

Florida scrub-jay nests are typically placed in shrubby oaks, at a height of 1 to 2 m (3 to 7 feet). Scrub oak and sand live oak are the preferred shrubs on the LWR (Woolfenden and Fitzpatrick 1984) and myrtle oak is favored on the Atlantic Coastal Ridge (Toland 1991). In suburban areas, scrub-jays nest in the same evergreen oak species as well as in introduced or exotic trees; however, they construct their nests in a significantly higher position in these oaks than when in natural scrub habitat (Bowman et al. 1996). Florida scrub-jay nests are an open cup, about 7 to 8 inches outside diameter, and 3 to 4 inches inside diameter. The outer basket is bulky and constructed of coarse twigs from oaks and other vegetation, and the inside is lined with tightly wound palmetto or cabbage palm fibers. There is no foreign material as may be present in a blue jay nest (Woolfenden and Fitzpatrick 1996b).

Nesting is synchronous, normally occurring from the beginning of March through the end of June (Woolfenden and Fitzpatrick 1990; Fitzpatrick et al. 1994). On the Atlantic Coastal Ridge, nesting may be protracted through the end of July. In suburban habitats, nesting is consistently initiated earlier (March and April) than in natural scrub habitat (Fleischer 1996).

Clutch sizes range from one to five eggs, but are typically three or four eggs. Clutch sizes are generally larger (up to six eggs) in suburban habitats, and the birds attempt to rear more broods per year (Fleischer 1996). Double brooding by as much as 20 percent has been documented on the Atlantic Coastal Ridge, compared to about 2 percent on the LWR. Scrub-jay eggs measure 1.1 inches by 0.8 inch (length by breath) (Woolfenden and Fitzpatrick 1996b), and coloration "varies from a pea green to pale glaucous green, blotched and spotted with irregularly shaped markings of cinnamon rufous and vinaceous cinnamon, these being heaviest about the larger end" (Bendire *in* Bent 1946). Eggs are incubated for 17 to 18 days and fledging occurs 16 to 21 days after hatching (Woolfenden 1974, 1978; Fitzpatrick et al. 1994). Only the breeding female incubates and broods eggs and nestlings (Woolfenden and Fitzpatrick 1984). Average production of young is two fledglings per pair per year (Woolfenden and Fitzpatrick 1990; Fitzpatrick et al. 1994) and the presence of helpers improves fledging success (Mumme 1992). Annual productivity must average at least two young fledged per pair for a population of scrub-jays to maintain long-term stability (Fitzpatrick et al. 1991). Data from Indian River County show that mean annual productivity declines significantly in suburban areas. Toland (1991) reported that productivity averaged 2.2 young fledged per pair in contiguous, optimal scrub; 1.8 young fledged per pair in fragmented, moderately developed scrub; 1.2 young per pair fledged in fragmented, suboptimal scrub; and only about 0.5 young per pair in residential lawns. Overall nest success (probability of fledging at least 1.0 young) is about 50 percent on the LWR and about 70 percent on the Atlantic Coastal Ridge in Indian River County.

Nesting failures are almost always caused by predation, most frequently by ground-based predators, including eastern coachwhip (*Masticophis flagellum*), eastern indigo snake, rat snake (*Elaphe obsoleta*), corn snake (*E. guttata*), raccoon (*Procyon lotor*), and domestic cat (*Felis catus*) (Fitzpatrick et al. 1991; Schaub et al. 1992).

Fledglings remain nutritionally dependent for about 10 weeks, during which time they are fed by both breeders and helpers (Woolfenden 1975; McGowan and Woolfenden 1990). Survival of scrub-jays from fledgling to the yearling age class averages 35 percent, while annual survival of adult males and females averages around 80 percent (Fitzpatrick et al. 1994). The maximum observed lifespan of a Florida scrub-jay is 15.5 years (Woolfenden and Fitzpatrick 1996b).

Dispersal

Scrub-jays are nonmigratory, sedentary, and permanently territorial. Juveniles remain in their natal territory for up to 5 years before dispersing to become breeders (Woolfenden and Fitzpatrick 1984). Once they pair and become breeders, generally within two territories of their natal ground, they remain on their breeding territory until death. In suitable habitat, fewer than 5 percent of scrub-jays disperse more than 5 miles (Fitzpatrick et al. 1994). All documented long-distance dispersals have been in unsuitable habitat such as woodland, pasture, or suburban plantations. Scrub-jay dispersal behavior is affected by the intervening landscape matrix. Protected scrub habitats will most effectively sustain scrub-jay subpopulations if they are located within a matrix of surrounding habitats that can be used and traversed by scrub-jays. Brushy pastures, scrubby corridors along railway and country road right-of-ways, and open, burned flatwoods provide links for colonization among scrub-jay subpopulations. Stith et al. (1996) believe that a dispersal distance of 5 miles is close to the biological maximum for scrub-jays.

Foraging

Scrub-jays forage mostly on or near the ground, often along the edges of natural or man-made openings. They visually search for food by hopping or running along the ground beneath the scrub or by jumping from shrub to shrub. Insects, particularly orthopteran and lepidopteran larvae, comprise the majority of the animal diet throughout most of the year (Woolfenden and Fitzpatrick 1984). Acorns are the most important plant food (Fitzpatrick et al. 1991). From August to November each year, scrub-jays may harvest and cache 6,000 to 8,000 acorns (DeGange et al. 1989). Acorns are typically buried 1/2 to 1 inch beneath the surface of bare sand in openings during fall, and retrieved and consumed in winter and early spring. On the Atlantic Coastal Ridge, acorns are frequently cached in pine trees, either in forks of branches, in the ends of pine boughs, under bark, or on epiphytic plants, between 1 to 30 feet in height. Other small nuts, fruits, and seeds are also eaten.

Vertebrate prey items comprise the minority of the diet, but may include a wide array of species weighing up to 0.9 ounces. Notable vertebrate prey species documented by Woolfenden and Fitzpatrick (1984) for scrub-jays on both the LWR and the Atlantic Coastal Ridge include the green treefrog (*Hyla cinerea*), squirrel treefrog (*H. squirella*), green anole (*Anolis carolinensis*), brown anole (*A. sagrei*), Florida scrub lizard (*Sceloporus woodi*), six-lined racerunner (*Cnemidophorus sexlineatus*), black racer (*Coluber constrictor*), peninsula crowned snake (*Tantilla relicta relicta*), rough green snake (*Opheodrys aestivus*), house mouse (*Mus musculus*), cotton mouse (*Peromyscus gossypinus*), oldfield mouse (*P. polionotus*), and Florida mouse

(*Podomys floridanus*). In suburban areas, scrub-jays will accept supplemental foods offered by humans, such as peanuts, corn, and sunflower seeds.

Population Dynamics – Stith et al. (1996) used a Geographic Information System (GIS) buffering procedure and 2.2-mile dispersal buffer to delineate 191 separate Florida scrub-jay subpopulations. Of these, 152 subpopulations (over 80 percent) contained fewer than 10 pairs of scrub-jays, 33 subpopulations contained between 10 to 99 pairs, and only 6 contained at least 100 pairs. The overall Florida population of scrub-jays is divided into five subregions, corresponding to the major sand deposits throughout the peninsula. Three of these subregions are considered "core populations" because they contain well over half of the State's remaining scrub-jays. These population cores occur at Merritt Island/Cape Canaveral Complex, Ocala NF, and on the southern LWR, and are respectively named the Atlantic coast subregion, the Ocala subregion, and the LWR subregion (Service 1999; Fitzpatrick et al. Unpublished Manuscript).

All existing scrub-jay populations outside of the three core population subregions consist of smaller subpopulations that are isolated to varying degrees (Fitzpatrick et al. Unpublished Manuscript). Along the Gulf coast from Levy County south to Lee County, scrub-jays historically occurred in a contiguous fourth major population: the Gulf coast subregion. Today, however, this population is divided into two subregions: the northern Gulf coast subregion and the southern Gulf coast subregion, because of the extensive amount of habitat fragmentation and loss that has occurred in Pinellas, Hillsborough, Pasco, and Hernando Counties (Fitzpatrick et al. 1994).

Status and Distribution – The Florida scrub-jay was federally listed as threatened in 1987 primarily because of habitat fragmentation, degradation, and loss (52 Federal Register [FR] 20715; Service 1987a). Scrub habitats associated with Florida's barrier islands, mainland coasts, and LWR are some of the most imperiled natural communities in the United States, with estimates of habitat loss since presettlement times ranging from 70 to more than 80 percent (Bergen 1994; Fitzpatrick et al. 1994). Historically, this vegetation occurred as large, continuous patches, some of them for over hundreds of miles (Cox 1987). Today, only relict patches of xeric oak scrub remain. Throughout the northern part of the range, population declines in scrub-jays are attributed to scrub fragmentation and degradation, due primarily to widespread fire suppression. Citrus conversion and residential development continue to be the most important factors causing the decline of scrub-jay populations in the southern extremes of their range (Fernald 1989; Fitzpatrick et al. 1991).

The decreasing trend of the Florida scrub-jay population is closely correlated with loss of scrub habitat. A statewide survey of scrub-jays conducted during 1992-1993 documented about 11,000 scrub-jays (approximately 4,000 pairs) as of 1993, extrapolating from the average scrub-jay group size of 2.8 individuals, and estimated that at least two-thirds of the population inhabits Federal lands (Fitzpatrick et al. 1994). This population estimate is no more than 15 percent of the pre-settlement population estimate and corresponds to a similar reduction in the distribution of scrub habitat. Half of all remaining scrub-jays occurred in Brevard County (1,232 families) and Highlands County (890 families) (Fitzpatrick et al. 1994). A total of 19 occupied counties

contained 30 or fewer groups of scrub-jays. The greatest population decline has occurred during the last 10 to 12 years with an estimated 25 to 50 percent reduction in scrub-jay numbers (Fitzpatrick et al. 1994).

Countywide surveys of Brevard County and Charlotte County have revealed population declines. The 1992-1993 statewide survey estimated that on Federal lands within Brevard County there were 860 pairs of scrub-jays. Surveys from outside Federal lands estimate 276 breeding pairs were present (Fitzpatrick et al. 1994). The scrub-jay population estimate on non-Federal lands dropped to 185 pairs in 1999 (Toland 1999). A countywide survey in Charlotte County showed similar numbers of scrub-jays overall, from 134 families in 1992-1993 to 135 families in 2001 (Miller and Stith 2002). The appearance of stability in the Charlotte County survey may be due to a more intensive survey effort on private property during the recent survey. Some metapopulations, such as the one known as Tippecanoe, have shown a decline of 33 families with 75 individuals in 1992-1993 to 10 families with 35 individuals in 2001. During the 1992-1993 survey, the coastal western metapopulation was estimated at 51 families with 117 individuals. These numbers dropped to 35 families with 89 individuals in 2001 (Miller and Stith 2002).

Results from population viability analysis indicate that a population of jays with fewer than 10 breeding pairs has a 50 percent probability of extinction over 100 years. This improves to a 2 to 3 percent chance of extinction for populations with at least 100 pairs. Only the three subregion core populations currently have enough breeding pairs, each with a low quasi-extinction risk and an estimated 99 percent probability of survival over 100 years (Stith 1999).

Scrub-jays will inhabit suburban areas where patches of scrub remain. In central Florida, the highest densities of scrub-jays are in areas where development is 33 percent or less (Bowman 1998). Scrub-jay increases in human-modified habitat probably result from supplemental food sources (primarily peanuts) and the initial creation of openings in the scrub and visual buffers (buildings) to neighboring jay families. However, as human development increases toward buildout, the survivorship of fledgling jays declines and failed nesting attempts increase (Toland 1991). Females from suburban territories may have fewer opportunities to pair with single males, because most males in suburban areas gain territories through breeder replacement (Thaxton and Hingtgen 1996). In addition, the potential for males remaining as helpers to inherit suitable habitat in suburban areas is reduced when compared to protected areas. Resident males may be less likely to maintain any natal territory as a breeder in suburban areas (Thaxton and Hingtgen 1996).

Scrub-jay population numbers are also affected by the frequency and severity of catastrophic mortalities. Epidemic disease is the only known catastrophe that affects Florida scrub-jay populations (Fitzpatrick et al. 1991). Archbold Biological Station experienced an epidemic between September 1979 and February 1980 that killed 70 percent of the scrub-jays on that site; 11 years later the population had still not recovered to pre-epidemic numbers. The probability of such an epidemic occurring in the future should be considered, along with habitat quality and management, to better predict the future status of scrub-jay populations in Florida. Root (1996)

used spatially-explicit models to show that an annual epidemic rate 0.001 (1 in 1,000 years) produced quasi-extinction probabilities of at least 66 percent for scrub-jays in Brevard County, Florida, under optimal habitat conditions and no dispersal, and at least 52 percent when dispersal was allowed among her modeled populations. The addition of connectivity between populations can mitigate the effects of epidemics and should be an important component of reserve designs for conservation of scrub-jays.

Eastern indigo snake

The following discussion is summarized from the MSRP (Service 1999), as well as from recent research publications and monitoring reports. A complete eastern indigo snake life history discussion may be found in the MSRP. No critical habitat has been designated for the eastern indigo snake.

Description – The eastern indigo snake is the largest non-venomous snake in North America, obtaining lengths of up to 264 cm (104 inches) (Moler 1992). According to Moler's description, its color is uniformly lustrous-black, dorsally and ventrally, except for a red or cream-colored suffusion of the chin, throat, and sometimes the cheeks. Its scales are large and smooth (the central three to five scale rows are lightly keeled in adult males) in 17 scale rows at midbody. Its anal plate is undivided. Its antepenultimate supralabial scale does not contact the temporal or postocular scales.

In the Florida Keys, adult eastern indigo snakes seem to have less red on their faces or throats compared to most mainland specimens (Lazell 1989). Several researchers have informally suggested that Lower Keys eastern indigo snakes may differ from mainland snakes in ways other than color, but morphometric or genetic data have not been provided to support claims of differentiation.

Over most of its range, the eastern indigo snake frequents a diversity of habitats.

Life History – In north Florida, eastern indigo snakes breed between November and April, with females depositing 4 to 12 eggs during May or June (Moler 1992). Young hatch in approximately 3 months. Limited information on the reproductive cycle in south-central Florida suggests that the breeding and egg-laying season may be extended. In this region, breeding extends from June to January, laying occurs from April to July, and hatching occurs during mid-summer to early fall (Layne and Steiner 1996). There is no evidence of parental care. Snakes in captivity take 3 to 4 years to reach sexual maturity (Speake et al. 1987). Female eastern indigo snakes can store sperm and delay fertilization of eggs. There is a single record of a captive snake laying five eggs (at least one of which was fertile) after being isolated for more than 4 years (Carson 1945). However, there have been several recent reports of parthenogenetic reproduction by virginal snakes. Hence, sperm storage may not have been involved in Carson's (1945) example (P. Moler, FWC, personal communication, 1998). There is no information on the eastern indigo snake lifespan in the wild, although one captive individual lived 25 years, 11 months (Shaw 1959).

The eastern indigo snake is a generalized predator and will eat any vertebrate small enough to be overpowered. Food items include fish, frogs, toads, snakes (venomous, as well as non-venomous), lizards, turtles, turtle eggs, small alligators, birds, and small mammals (Keegan 1944; Babis 1949; Kochman 1978; Steiner et al. 1983).

Population Dynamics – Eastern indigo snakes require a mosaic of habitats. A study in southern Georgia found that interspersion of tortoise-inhabited sandhills and wetlands improve habitat quality for the snake (Landers and Speake 1980). Eastern indigo snakes require sheltered retreats from winter cold and desiccating conditions, and often use burrows of the gopher tortoise (*Gopherus polyphemus*) when available (Speake et al. 1978; Layne and Steiner 1996). In habitats lacking gopher tortoises, snakes may take shelter in hollowed root channels, hollow logs, or the burrows of rodents, armadillos, or land crabs (Lawler 1977; Moler 1985b; Layne and Steiner 1996). In its Florida range, the eastern indigo snake frequents diverse habitats, including pine flatwoods, scrubby flatwoods, floodplain edges, sand ridges, dry glades, tropical hammocks, edges of freshwater marshes, muckland fields, coastal dunes, and xeric sandhill communities (Service 1999). Eastern indigos also use agricultural lands and various types of wetlands, with higher population concentrations occurring in the sandhill and pineland regions of northern and central Florida. In extreme south Florida (*e.g.,* the Everglades and Florida Keys), eastern indigos are found in tropical hardwood hammocks, pine rocklands, freshwater marshes, abandoned agricultural lands, coastal prairies, mangrove swamps, and human-altered habitats (Steiner et al. 1983). It is thought that they prefer hammocks and pine forests since most observations occur there and use of these areas is disproportionate compared to the relatively small total area of these habitats (Steiner et al. 1983).

Indigo snakes range over large areas and into various habitats throughout the year, with most activity occurring in the summer and fall (Smith 1987; Moler 1985b). In Georgia, the average range of the eastern indigo is 4.8 hectares (ha) (12.0 acres) during the winter (December to April), 42.9 ha (106.0 acres) during late spring/early summer (May to July), and 97.4 ha (241.0 acres) during late summer and fall (August to November) (Speake et al. 1978). Adult male snakes have larger home ranges than adult females and juveniles; their ranges average 224 ha (554.0 acres), reducing to 158 ha (390.0 acres) in the summer (Moler 1985a). In contrast, a gravid female may use from 1.4 to 42.9 ha (3.5 to 106.0 acres) (Smith 1987). In Florida, home ranges for females and males range from 1.9 to 150.0 ha (4.7 to 371.0 acres) and 1.6 to 326.6 ha (3.9 to 807.0 acres), respectively (B. Smith, Dynamac, personal communication, 2003). At the Archbold Biological Station, average home range size for female indigos was determined to be 19 ha (47.0 acres) and overlapping male home ranges to be 75 ha (185.0 acres) (Layne and Steiner 1996).

Status and Distribution – The eastern indigo snake was listed as threatened in 1978 (43 FR 4028) due to population declines caused by habitat loss, over-collecting for the domestic and international pet trade, and mortality caused by rattlesnake collectors who gas gopher tortoise burrows to collect snakes.

Effective law enforcement has reduced pressure on the species from the pet trade. However, because of its relatively large home range, this snake is especially vulnerable to habitat loss, degradation, and fragmentation (Lawler 1977; Moler 1985b). The primary threat to the eastern indigo snake is habitat loss due to development and fragmentation. In the wildland urban interface areas of the Reservations, residential housing is also a threat because it increases the likelihood of snakes being killed by property owners and domestic pets. Extensive tracts of undeveloped land are important for maintaining eastern indigo snakes (Moler 1985b).

Indigo snakes range from the southeastern United States to northern Argentina (Conant and Collins 1998). This species has eight recognized subspecies, two of which occur in the United States: the eastern indigo and the Texas indigo (*D. c. erebennus*). In the United States, the eastern indigo snake historically occurred throughout Florida and in the coastal plain of Georgia and has been recorded in Alabama and Mississippi (Diemer and Speake 1983; Moler 1985a). It may have occurred in southern South Carolina, but its occurrence there cannot be confirmed. Georgia and Florida currently support the remaining, endemic populations of the eastern indigo snake (Lawler 1977). The eastern indigo occurs throughout most of Florida and is absent only from the Dry Tortugas and Marquesas Keys and regions of north Florida where cold temperatures and deeper clay soils exist (Cox and Kautz 2000).

Tasks identified in the recovery plan for this species include: habitat management through controlled burning; testing experimental miniature radio transmitters for tracking of juvenile eastern indigo snakes; maintenance of a captive breeding colony at Auburn University; recapture of formerly released snakes to confirm survival in the wild; educational lectures and field trips; and efforts to obtain landowner cooperation in conservation efforts (Service 1999).

To protect and manage this species for recovery, large expanses of land must be protected. Management of these lands must be directed towards maintaining and enhancing the diversity of plant and animal assemblages within these properties. Where these goals are achieved, eastern indigo snakes will directly benefit because of improved habitat conditions. Land managers are encouraged to utilize fire as a tool to maintain biodiversity in fire dependent ecosystems.

Bluetail mole skink

The following discussion is summarized from the MSRP (Service 1999), as well as from recent research publications and monitoring reports. A complete bluetail mole skink life history discussion may be found in the MSRP. No critical habitat has been designated for the bluetail mole skink.

Description –The bluetail mole skink is a small, slender lizard that occupies xeric upland habitats in central peninsular Florida. It reaches a maximum total length of about 5 inches and the tail makes up about half the body length. The body is shiny, brownish to pink in color and marked with lighter paired dorsolateral stripes diverging posteriorly (Christman 1978a). Males develop a colorful orange pattern on the sides of the body during the breeding season. Juveniles

usually have a blue tail (Christman 1992a; P. Moler, FWC, personal communication, 1998). Regenerated tails and the tails of older individuals are typically pinkish. The legs are somewhat reduced in size and used only for surface movement and not for "swimming" through the sand (Christman 1992a).

Life History – Reproductive behavior of the bluetail mole skink is poorly known, but it is assumed to be similar to that of the peninsula mole skink (*Eumeces egregius onocrepis*), where mating occurs in the winter.

The bluetail mole skink requires open, sandy patches interspersed with Florida scrub or sandhill (high pineland) vegetation. According to the MSRP (Service 1999), there were 34 locality records for this species, all occurring on the LWR and, with the exception of one observation, above 98 feet (30 m) in elevation. Since this time, researchers have found skinks down to elevations of 82 feet (25 m) (P. Moler, FWC, personal communication, 2003).

A variety of xeric upland communities provide habitat for the bluetail mole skink, including rosemary and oak-dominated scrub, turkey oak barrens, high pine, and xeric hammocks. Areas with few plant roots, open canopies, scattered shrubs, and patches of bare, loose sand provide optimal habitats (Christman 1988, 1992a). Within these habitat types bluetail mole skinks are typically found under leaves, palmetto leaves, logs, and other ground debris. Shaded areas presumably provide suitable microhabitat conditions for thermoregulation, egg incubation, and foraging (Mount 1963). A study of skink densities underway on the LWR points to very low densities of bluetail mole skinks (S. Christman, letter correspondence, 2004). The distribution of bluetail mole skinks appears to be closely linked to the distribution of surface litter and, in turn, suitable micro-habitat sites.

Population Dynamics – Presence-absence surveys for the bluetail mole skink are difficult because it is typically found under ground debris. The Service has little information on the sizes or exact locations of bluetail mole skink and sand skink populations. Recent studies have provided useful information on the distribution of skinks, but little is known about population dynamics.

Status and Distribution –The bluetail mole skink occurs in upland vegetation on the LWR in Highlands, Polk, and Osceola Counties in central Florida. It is apparently rare throughout its range, even in the most suitable habitats (Christman 1992a). Its distribution is not uniform within the upland xeric communities. Much of the bluetail mole skink's historic habitat has been destroyed, degraded or fragmented due to residential, commercial, and agricultural development. In the absence of fire, the various scrub habitats of this ecosystem experience an increase in shrubby vegetation, closure of sandy openings, and increased canopy closure. Such overgrown vegetation is considered degraded habitat for this species.

Bluetail mole skinks are known to occur in sand pine scrub, oak scrub, scrubby flatwoods, and turkey oak barrens of Highlands County (Mushinsky and McCoy 1999). For example, these species are found in the turkey oak scrub and flatwoods habitats that occur within the Carter

Creek and Flamingo Villas tracts of LWR NWR, but there is no record or anecdotal reports of either of the skinks being observed on these tracts (F. Adrian, Merritt Island NWR, personal communication, 2003). Campbell and Christman (1982) characterized bluetail mole skinks as colonizers of patchy, early-successional habitat, which is created by disturbances such as fire and tree fall in sandhill, sand pine scrub, and xeric hammock vegetation. Myers (1990) noted that mature sand pine is susceptible to windthrow, which may be an important mechanism in maintaining the bare, sandy microhabitats required by bluetail mole skinks and other scrub endemics.

When the bluetail mole skink was listed in 1987 (Service 1987b), there were 20 locality records. Currently, 34 are known. The increase in locality records is largely the result of more intensive inventories of scrub habitats in recent years and does not imply that this species is more widespread than originally supposed. Of the known locations, only 14 are on public lands or on private lands protected under conservation easement. It is likely that continued residential and agricultural development of xeric upland habitat in central Florida has destroyed or degraded extensive tracts of habitat containing the bluetail mole skink. Estimates of habitat loss range from 60 to 90 percent, depending on the kind of upland vegetation (Christman 1988; Christman and Judd 1990; Kautz 1993; Center for Plant Conservation 1995).

Protection and recovery of the bluetail mole skink will require limiting habitat loss and restoring unoccupied but potentially suitable habitat. At the present time, the bluetail mole skink is protected on public and private conservation lands on the LWR. Expanding the system of protected xeric upland habitats on the LWR, in concert with aggressive land management on the existing conservation lands, represent the best chance to secure the future of this species. Land acquisition projects to protect areas occupied by the bluetail mole skink include the Service's LWR NWR and the State of Florida's land acquisition programs, which have purchased the LWR State Forest, the LWR Wildlife and Environmental Area (WEA), and additions to the lands managed by the Florida State Parks, including Highlands Hammock State Park, Lake June-in-Winter Scrub State Park, and the Allen David Broussard Catfish Creek Preserve State Park.

Sand skink

The following discussion is summarized from the MSRP (Service 1999), as well as from recent research publications and monitoring reports. A complete sand skink life history discussion may be found in the MSRP. No critical habitat has been designated for the sand skink.

Description – The sand skink is a lizard that reaches a maximum length of about 5 inches, and the tail makes up about half the total body length. The body is shiny and usually gray to grayish-white in color, although the body color may occasionally be light tan. Hatchlings have a wide black band located along each side of the body from the tip of the tail to the snout. This band is reduced in adults and may only occur from the eye to the snout on some individuals (Telford 1959). Sand skinks are adapted to a fossorial lifestyle: the legs are vestigial and practically nonfunctional, the eyes are greatly reduced, no external ear openings are present, the snout is wedge-shaped, and the lower jaw is countersunk.

The sand skink is fossorial and occurs primarily below the ground surface where it burrows through loose sand in search of food, shelter, and mates. Sand skinks feed on a variety of hard and soft-bodied arthropods that occur within the soil. The diet consists largely of beetle larvae and termites (*Prorhinotermes* spp.). Spiders, larval ant lions, lepidopteran larvae, roaches and adult beetles are also eaten (Myers and Telford 1965; Smith 1977). Anecdotal evidence indicates that sand skinks are diurnal and probably feed primarily during the morning and late afternoon when their preferred body temperatures are achieved (Sutton 1996). With respect to season, Telford (1959) reported skinks most active from early March through early May, whereas Sutton (1996) found skinks to be most active from mid-February to late April. These high-activity periods correspond to movements associated with breeding. Females are difficult to collect following mating, apparently due to the reduction or cessation of movements during nesting.

Life History – Usually, two eggs are laid under logs or debris approximately 55 days after mating (Telford 1959). The eggs hatch from June through July. Sand skinks reach sexual maturity at 1 to 2 years (Telford 1959; Sutton 1996) and may remain reproductively active for 2 to 3 years (Sutton 1996). No information is available on the dispersal of this species or its territory size.

The sand skink is widespread in xeric uplands with sandy substrates, but appears to be most abundant in ecotonal areas between high pine and scrub (Telford 1996). It is also found in rosemary scrub, turkey oak barrens, or open sandy areas of high pine communities (Campbell and Christman 1982). Optimal skink habitat includes areas with open canopies, scattered shrubby vegetation, and patches of bare sand with few plant roots (Christman 1978b, 1992b). However, more recent surveys have located sand skinks in areas with dense undergrowth and extensive canopy closure (H. Mushinsky, University of South Florida, personal communication, 1996), indicating that extensive loose, root free soils may not be a requisite for this species. Suitable habitat must also contain soil moisture conditions that allow for thermoregulation and egg incubation, and foraging (Telford 1959).

Population Dynamics – Little is known about the population biology of the sand skink (Mushinsky and McCoy 1995). Additionally, it is not known whether existing protected areas are adequate for recovery of the sand skink because many long-term life history and population characteristics are unknown (Service 1993a). Because of the specialized mode of locomotion used by sand skinks, researchers speculate that they do not inhabit areas with an abundance of plant roots (Christman 1992b), although old growth stands of scrub (more than 60 years old) on Archbold Biological Station have been observed to host this species in the vicinity of old fire lanes (Service 1993a). Old fire lanes and roadways are important for the persistence of a number of other scrub animals and plants, and their management is a subject of concern; for example, a study of sandlace is examining the effects of roadsides.

The Service has little information on the sizes or exact locations of sand skink populations within its range. The skink's diminutive size and secretive habits make its study difficult. Recent studies have provided useful information on the distribution of skinks, but little is known about

population dynamics. A study by Steven Christman, currently underway, is providing better information on densities.

Status and Distribution – The sand skink is threatened because of scrub habitat conversion to residential, commercial, and agricultural land uses. Another factor leading to the status of this species is habitat degradation due to fire exclusion allowing overgrowth of scrub vegetation in these habitats. The recovery of sand skinks will require restoration of habitat and possible reintroduction of individuals into successfully rehabilitated habitat.

In Highlands County, sand skinks are known to occur in sand pine scrub, oak scrub, scrubby flatwoods, and turkey oak barrens (*i.e.,* sandhill or high pinelands) (Mushinsky and McCoy 1999). For example, these species are found in turkey oak scrub and flatwoods habitats similar to those within the Carter Creek and Flamingo Villas tracts of LWR NWR, but there is no record or anecdotal reports of either of the skinks being observed on these tracts (F. Adrian, Merritt Island NWR, personal communication, 2003).

Except for a few locations where intensive research has been conducted, we have little information about the presence or abundance of sand skinks. They were not found within the Ocala NF during a survey of sites historically known to contain skinks (Telford 1992). Telford (1992) indicated that the ephemeral nature of early successional scrub habitats due to rapid changes in the vegetation may have confounded the evaluation of skinks in this area (*i.e.,* the Ocala NF), which is largely dense sand pine forest. Open habitat is available for only a few years after the sand pines are harvested, or after a fire. Additional studies have provided presence/absence data (Mushinsky and McCoy 1995; Stout and Corey 1995), which have been used to determine the existing range of the species. However, no long-term monitoring has been undertaken to evaluate the status or trends of sand skinks at these or other sites.

The existing range of the sand skink includes Highlands, Lake, Marion, Orange, Osceola, Polk, and Putnam Counties (Christman 1988). Principal populations occur on the Lake Wales and Winter Haven Ridges in Highlands, Lake, and Polk Counties (Christman 1992b; Mushinsky and McCoy 1995; P. Moler, FWC, personal communication, 1998). The sand skink is uncommon on the Mount Dora Ridge, including sites within the Ocala NF (Christman 1970, 1992b).

When the sand skink was listed as a threatened species in 1987 (Service 1987b), the Florida Natural Areas Inventory (FNAI) had recorded 31 known sites. By 1997, 114 localities were known. This increase is largely the result of more intensive sampling of scrub habitats in recent years and does not imply that this species is more widespread than originally thought. Of the known locations, 41 (35 percent) occur on public lands or private lands placed under conservation easement and offer habitat protection. It is likely that continued residential and agricultural development of xeric upland habitat in central Florida has destroyed or degraded sand skink habitat. There has been a loss, due to development, of from 60 to 90 percent of xeric upland communities historically used by sand skinks (Christman 1988; Christman and Judd 1990; Kautz 1993; Center for Plant Conservation 1995).

The most important means to make sure of the continued existence of the sand skink is to protect it from further habitat loss and degradation. Existing protected areas may not provide sufficient habitat to ensure the survival of the sand skink because many life history and population characteristics for its long-term survival are unknown (Service 1993a). Protected skink habitat (Service 1993a) consisted of private preserves such as Archbold Biological Station, Hendry Ranch, Tiger Creek Preserve, and Saddle Blanket Lakes Preserve, coupled with publicly owned lands such as Lake Arbuckle tract of LWR State Forest, Lake Louisa State Park, and Highlands Hammock State Park. Since the 1990s, the system of protected xeric upland communities on the LWR has been expanded and effective land management established. This approach represents the best opportunity to assure the sand skink's survival. Recovery of the sand skink may require rehabilitation of suitable but unoccupied habitat or restoration of potentially suitable habitat. Because sand skinks do not readily disperse, introductions into restored or created unoccupied habitat may be necessary.

In summary, little information is available to assess the status and population dynamics of the sand skink. It is endemic to central Florida and, along with the bluetail mole skink, is a habitat specialist that relies on early successional xeric scrub habitat. Estimates of habitat loss range from 60 to 90 percent, depending on the xeric community type (Christman 1988; Christman and Judd 1990; Kautz 1993; Center for Plant Conservation 1995). However, the sand skink is relatively widespread in remaining xeric uplands. Furthermore, favorable management practices can create and maintain suitable habitat conditions for sand skinks, as well as other xeric upland-dependent species. A number of actions over the last 20 years have conserved xeric uplands within the existing range of the sand skink. The State of Florida has acquired xeric upland habitat through the Conservation and Recreation Lands (CARL), Save Our Rivers, and other Preservation 2000 or Florida Forever acquisition programs. Combined, these land acquisition programs have protected at least
10,000 acres of xeric uplands (DEP 1998). The Service has acquired portions of three small tracts (totaling 1,853 acres) for the LWR NWR. Finally, private organizations such as TNC and Archbold Biological Station have purchased and manage xeric uplands on the LWR.

Avon Park harebells

The following discussion is summarized from the MSRP (Service 1999), as well as from recent research publications and monitoring reports. A complete Avon Park harebells life history discussion may be found in the MSRP. No critical habitat has been designated for Avon Park harebells.

Description – Avon Park harebells, a member of the pea family (Fabaceae), is most similar to *Crotalaria rotundifolia*, a variable species that ranges from Virginia to Panama in a wide variety of habitats. *Crotalaria* is a very large, mostly tropical genus with inflated "rattlebox" seed pods. It includes a number of robust annual weeds (DeLaney and Wunderlin 1989).

Avon Park harebells plants are perennial, appearing as clusters of fuzzy grayish leaves (DeLaney and Wunderlin 1989). The plants grow from a taproot up to 14 millimeters (mm) (0.55 inches) thick and 40 cm (16 inches) long with one to three moderately hairy, flowering stems that originate as much as 10 cm (4 inches) below the surface, and grow upright for 3 to 10 cm (1 to 4 inches) above the surface. The leaves are 8 to 19 mm (0.31 to 0.75 inches) long, broadly elliptic or round, somewhat succulent, and coated with white or yellowish-white hairs. The stems terminate in flowering racemes. After flowering, the plants enter into a phase of vegetative growth, forming clusters of stems that give a clumped or rosette appearance (DeLaney and Wunderlin 1989).

The flower, shaped like a typical pea flower, has a yellow corolla 8 to 9 mm (0.3 to 0.35 inch) long. Menges and Weekley (2003), with the assistance of Amanda Brothers, examined flower development by collecting flowers of various stages, examining them, and photographing them under a microscope. They confirmed that Avon Park harebells differs from *Crotalaria rotundifolia* by having a curved pistil rather than a bent one. As is typical of a member of the pea family, the flowers have 10 anthers with 9 of them united into a tube. "The anthers are of two morphological types…and produce pollen at different times. The pollen is produced before stigmas are receptive" (they are protandrous). Stems "usually produced fewer than four mature flowers each, although some stems produced as many as 10-12 at a time." Flowers are produced over a period of several weeks (Menges and Weekley 2003).

Maturation of fruit takes about 60 days (Menges and Weekley 2003). The seed pods are inflated and are tan to grey or maroon, and can be nearly as long as the upright stems that hold them in place. The pods were reported to contain up to 18 seeds, chestnut to maroon in color and 3.4 to 3.8 mm (0.13 to 0.15 inch) long by 2.4 to 2.6 mm (0.09 to 0.1 inch) wide (DeLaney and Wunderlin 1989). Recently, reporting on their careful work on this plant's life history in which they observed several hundred seeds, Menges and Weekley (2004) stated that the seeds in a pod will range from green ("rather soft" and immature), to purple or black, with the black seeds being the hardest and most mature. Based on fruits from 19 plants, they observed that pods ranged in length from 1.7 to 3.1 cm (0.67 to 1.2 inches), a mode of 2.7 cm (1.1 inch), and a mean and median of 2.5 cm (0.99 inch), meaning that the distribution of pod lengths is slightly skewed from a normal distribution. These measurements are very similar to earlier measurements of pod lengths of 1.4 to 2.5 cm (0.6 to 1.0 inch) (DeLaney and Wunderlin 1989).

Newly germinated seedlings can be recognized by their cotyledons, which are glabrous (not hairy), "dotted with glands, possess an evident midrib, are oval in shape, and are arranged in opposite fashion…. When emerging, the pair of cotyledons are pressed together and held vertically. True leaves that come next are hairy." (Menges and Weekley 2004).

Life History – These perennial plants are likely to be growing in February, although plant numbers in plots have been observed to increase through the spring as more plants become active (Menges and Weekley 2004). Flowering begins in mid-March and continues until June. The plants continue growth, then are dormant from late fall or early winter until about March (DeLaney and Wunderlin 1989). Their persistence through the summer apparently depends on

rainfall. At study plots, "wilting and potentially high mortality levels were associated with dry weather in May 2004" (Menges and Weekley 2004). In a given year, most plants are vegetative, not producing flowers (Slapcinsky and Gordon 2002; Archbold Biological Station 2003). Flowers appear to open about 10 a.m. Flowers seem to have only infrequent insect visitors, but they are diverse, mainly bees (Menges and Weekley 2003).

Menges and Weekley (2004) have investigated the breeding system of Avon Park harebells. To assess fecundity, they quantified fruit length and number of seeds. The found that "knowing pod length does not contribute to predictions of seed numbers per pod." They estimated fecundity by counting seeds per pod, which, in pods from 19 plants, ranged from 4 to 18 per fruit with a mean of 9.3, median 8, mode 7. "Over 80 percent of sampled pods had between 6-11 seeds, so simply counting seeds," rather than measuring pod length, provided a good estimate of how many seeds are being produced by a plant or a population.

Menges and Weekley (2003) compared fruit production from plants from which pollinators were excluded by mesh bags, with fruit production in unbagged control plants, to which pollinators had access. They bagged 10 plants and left 10 paired plants unbagged. They marked individual flowers at 1 to 3 day intervals using colored thread and relying on the flower's position on the plant. They marked 75 flowers inside bags and 66 on unbagged plants. None of the bagged flowers set fruit, while 8 fruits formed from the marked, unbagged flowers (12.1 percent fruit set). They comment that this was a small experiment, but it suggests that either Avon Park harebells plants "are not self-compatible (there is a genetic barrier to selfing) and/or that pollinators are required to move pollen among flowers within the same plant in order to effect selfing." In any case, fruit set occurs only with exposure to insects (Menges and Weekley 2003).

Menges and Weekley (2003) were unable to artificially outcross flowers by the conventional technique of removing anthers – the technique was unworkable in the field because the flowers are small, with "twisted petals, bent pistil, close juxtaposition of flower parts, and loose pollen." They also failed to pollinate flowers in the lab, so they suggested that assessment of inbreeding versus outcrossing in this species "may best be conducted using molecular genetics."

In 2003, Dr. Rebecca Dolan of Butler University and her students tested leaves using allozyme electrophoresis methods to evaluate this plant's outcrossing rates. Unfortunately, no differences in banding patterns were seen, so this method cannot be used. In 2004, Dr. Matt Gitzendanner of the Florida Museum of Natural History Genetics Laboratory experimented with a new DNA method, using leaf tissue, for obtaining molecular markers. Results are not yet reported (Menges and Weekley 2004).

Susan Wallace (Bok Tower Gardens, personal communication to Gerald "Stinger" Guala; Archbold Biological Station 2003) reported an assessment of seed germination in this species. Seed germination and survival when transplanted into pots in the greenhouse was 35 to 40 percent. To clarify this plant's germination requirements and to produce seedlings for augmentation of the small population at Carter Creek, Menges and Weekley (2004) conducted laboratory germination tests on 321 seeds from eight maternal parents. Seeds were scarified with

sandpaper or left unscarified. Germination began within 10 days of the start of the experiment and was continuing a month later. In approximately 1 month, they had 34 germinants (equal numbers scarified and unscarified), or about 11 percent. The experiment was monitored twice weekly for another several months and is planned to continue for 2 years (Menges and Weekley 2004).

The youngest seedlings, with only cotyledons, cannot be identified in the field with certainty because the cotyledons are not distinctive, although they are larger than those of most other species in the scrub habitat. Seedlings with true leaves, which are hairy, can be accurately identified as belonging to this species, but if the cotyledons fall off, the seedlings can be mistaken for resprouting ramets (new shoots from existing taproots) (Menges and Weekley 2004). They are continuing demographic studies on this species.

Population Dynamics – Ecologists at Archbold Biological Station have conducted demographic monitoring of Avon Park harebells since 1998 (Archbold Biological Station 2003; Menges and Weekley 2002, 2003, 2004). In 2004, they monitored 374 plants in 90 quadrats. According to them, "this plant prefers relatively open scrub sites," but they also found it in roadside locations that were no different from randomly-chosen roadside locations. The species "is characterized by frequent appearances and disappearances of aboveground stems. This turnover is accompanied by small shifts in position." The plants apparently become dormant over the winter, then regrow from existing roots; the new shoots in springs are apparently not seedlings. The researchers documented "massive dieback (or mortality) due to stem breakage and uprooting of plants" in a roadside population due to being run over by vehicles.

These demographic studies show that while individual plants grow rapidly and die back rapidly and there is a great deal of change in individual plots, there is little overall change in plant numbers from year to year (Menges and Weekley 2004). Menges and Weekley (2002) noted that "month-to-month changes in the condition and fate" are more variable than nearly any of the other 20 species of Florida scrub plants that they have studied. Drought is one cause, and plants are often subject to high levels of herbivory, presumably by insects, during their growing season (Archbold Biological Station 2003).

A long-term study (at least 10 years) at TNC's Saddle Blanket Lakes Preserve monitors marked plants annually. Many of them were affected by a burn in spring 2003. Beatriz Pace-Aldana showed that the plants resprouted vigorously after fire (Menges and Weekley 2003). Monitoring at Saddle Blanket Lakes Preserve has shown an overall decrease in population size with time since fire (TNC 2004). A prescribed fire in 2003 resulted in over 95 percent of the individuals resprouting. One year post-fire the population size was nearly identical to what it had been pre-fire (TNC 2004).

In 2003-2004, Archbold ecologists documented potential seedlings appearing in their demography study plots (finding 13 in April to May, of which 4 survived through June, plus an additional 3 seedlings that appeared in June). They have also studied the ramet (stem) dynamics of 439 individual plants in 95 quadrats. By 2004, they had conducted 31 censuses over seven

years (including five censuses in 2004). They observed that populations in the scrub had generally been stable or increased, while roadside populations "tended to decline in 2004" (Menges and Weekley 2004).

Status and Distribution – Avon Park harebells is one of the most narrowly-distributed LWR scrub endemic plants, restricted to northern Highlands and southern Polk Counties (DeLaney and Wunderlin 1989; TNC 1991). It has been found at only three occurrences: the Avon Park Lakes tract of the LWR WEA, TNC's Saddle Blanket Lakes Preserve, and the Carter Creek unit of the LWR WEA in Highlands County. A survey by FNAI (Schultz et al. 1999) of areas under consideration for acquisition by the State failed to find any new localities.

At the Carter Creek unit of LWR WEA in Highlands County, incomplete land acquisition limits the use of prescribed fires and makes it impossible for managers to restrict access; so unpaved streets remain accessible by motor vehicles. Plants growing on roadsides are vulnerable to being run over (Menges and Weekley 2002). At study plots within this area, overall population sizes of Avon Park harebells do not show general trends for the period from 1998 to 2004 (Menges and Weekley 2004). A map of populations is available in Menges and Weekley (2003).

TNC has monitored and mapped Avon Park harebells at its Saddle Blanket Lakes Preserve in southernmost Polk County. The species is thriving at this site, which is a model for applying prescribed fire to scrub so as to maintain the sandy openings that many endemic plants need. The species is secure here.

Little information is available on this species' status at the Avon Park Lakes tract of the LWR WEA. Much of this unit suffers the same problem of incomplete land acquisition as Carter Creek, so the same problems exist with uncontrolled vehicular access and difficulty in applying prescribed fire.

Populations of Avon Park harebells are sufficiently small and localized that Valerie Pence of the Cincinnati Zoo and Botanical Garden (in collaboration with Eric Menges and the staff of Archbold Biological Station) has proposed to employ tissue culture methods to propagate the species for reintroduction, and to produce tissue for cryogenic storage of germplasm. This approach, which uses stem tips, is considered to be less harmful to existing plants than collection of seed. Menges et al. (2004) note that "any harvest of plant parts or whole plants ideally should be monitored to detect any increases in mortality." With respect to Avon Park harebells, limited removal of leaves for genetic testing appears to have been harmless to the plants (Menges and Weekley 2004). A proposal to remove stem tips for propagation is only modestly more destructive than leaf removal, and is probably not significant in the context of this plant's high turnover of above-ground parts from herbivory and drought, as well as its quick resprouting after fire.

Hurricane Charley (August 2004) affected the range of Avon Park harebells, but caused it little or no harm. At the Saddle Blanket Lakes Preserve, sand pines fell and there was damage to larger live oaks, but the scrub oaks and the small herbs and shrubs between the oaks appeared nearly untouched.

Britton's beargrass

The following discussion is summarized from the MSRP (Service 1999), as well as from recent research publications and monitoring reports. A complete Britton's beargrass life history discussion may be found in the MSRP. No critical habitat has been designated for Britton's beargrass.

Description – The genus *Nolina* is placed in the agave family in the Flora of North America (Hess 2002), or alternatively in the butcher's broom family, Ruscaceae (Wunderlin and Hansen 2005). *Nolina* constitutes some 30 species of north and central Mexico and the United States, which has 14 species. Two are in Florida: *Nolina atopocarpa*, which is rare but scattered around the state and Britton's beargrass, which is restricted to the central peninsula (Hess 2002).

The identification key provided by Hess is probably not as useful as Wunderlin and Hansen's (2003), which points out that *N. brittoniana* has larger dry fruits (capsules), which are symmetrical, unlike the smaller, highly asymmetric fruits of *N. atopocarpa*. *N. brittoniana* has wider leaves whose surfaces appear flat, while the leaves of *N. atopocarpa* have an "accordionlike wrinkled appearance." The leaves of *N. brittoniana* are grasslike, 70 to 100 cm by 5 to 9 mm (occasionally 11 mm) (27 to 40 inches by 0.19 by 0.35 inch [occasionally 0.43 inch]) and those of *N. atopocarpa* are wiry, 45 to 85 cm by 1.5 to 4.5 mm (18 to 33 inches by 0.006 to 0.018 inch) (Hess 2002). The flowers of *N. brittoniana* are white, while those of *N. atopocarpa* are said to be greenish (Service 1996).

Britton's beargrass is a clump-forming perennial with no above-ground stem (except for the flowering stem) that grows from a short, thick, fleshy, bulblike rootstock. The grassy leaves form a rosette with the youngest leaves upright and the oldest lying nearly flat on the ground. Flowering is from early March to mid-May. The flowering stem, usually solitary, grows 1 to 1.5 m (3 to 5 feet) tall from the rosette in April. The inflorescence is a panicle with about 6 to 20 branches. When in bloom, the branches are covered with small, white flowers, making the plant very conspicuous (Wunderlin et al. 1980c; Kral 1983). The flowers are moderately fragrant when open (TNC 1995). The fruits are symmetrical, triangular in cross-section. The species is generally dioecious (*i.e.,* male and female flowers on separate plants), but a few exceptions have been documented.

Life History – Britton's beargrass produces seeds only through pollination, not apomictically. The male plants shed their pollen in the early morning (TNC 1995). The female flowers exude nectar about 24 hours after opening during the evening or before sunrise (TNC 1995). Britton's beargrass exhibits a generalist pollination syndrome, being pollinated throughout the day by a variety of visitors. At Archbold Biological Station and Lake Apthorpe Preserve, 34 pollinators

from six different families were observed visiting Britton's beargrass plants (Menges et al. 1996).

Dolan et al. (2001) examined genetic variation in 48 populations of Britton's beargrass from throughout its range, using isozymes. These researchers expected, based on the species' life history and ecology, that Britton's beargrass would not be genetically impoverished, even though it has a narrow range. They found "values for percentage of polymorphic loci, average numbers of alleles per locus and expected heterozygosity" that were lower "than those generally reported for endemic plants. Populations were fairly well differentiated. … Inbreeding rates were low and allele number and frequency did not indicate recent bottlenecks." They detected clines in allele frequency were along the species' distribution, from north to south. This pattern of genetic variation supports the need to conserve populations from throughout its range (Dolan et al. 2001; Menges et al. 1996).

Britton's beargrass occurs both as scattered individuals and in large groups of as many as 500 plants. It responds well to fire. Almost all of the plants reappear after a fire (Weekley and Menges 2003a, 2003b). Flowering of Britton's beargrass peaks 1 year after burning, then declines. At the Lake Apthorpe Preserve (now part of the LWR WEA), 75 percent of the population flowered the year after burning, dropping to 13 percent the next year (Menges et al. 1996). Although Britton's beargrass responds to fire with increased flowering, seedlings have rarely been seen (Doria Gordon, TNC, personal communication, 1997).

It is found in a wide range of xeric upland communities ranging from xeric open oak scrub to closed hammocks and sandhill at one recently-discovered site in Ocala NF.

Population Dynamics – This long-lived species resprouts after fire, so there is apparently very little turnover of individuals. Britton's beargrass can remain vigorous in fire-suppressed habitat, but the trends of populations under these conditions are unknown (Reese and Orzell 1995).

Britton's beargrass responds to fire with increased flowering the year after the fire (Menges et al. 1996). This is important in that it represents a pulse of reproduction and, potentially, recruitment of new individuals to the population. Britton's beargrass can persist in areas where fire has been suppressed for many years, but under these conditions it may only exist in a vegetative state without flowering.

Status and Distribution – The original reasons for listing this species were habitat loss by land conversion for agricultural and residential expansion. As human population growth and development continues in the LWR area, these problems are ongoing.

Britton's beargrass is typically associated with evergreen oaks such as sand live oak, myrtle oak, Chapman oak, and scrub oak. Other species occurring with Britton's beargrass include saw palmetto, and shrubs including wild olive (*Osmanthus*), staggerbush (*Lyonia*), garberia (*Garberia heterophylla*), hollies (*Ilex*), wireweed, and sandlace.

Where this species occurs in sandhill (high pineland) vegetation, the herbaceous layer is usually dominated by wiregrass, bottlebrush threeawn (*Aristida spiciformis*), Florida scrub frostweed (*Helianthemum nashii*), sandyfield beakrush (*Rhynchospora megalocarpa*), queensdelight (*Stillingia sylvatica*), and jeweled blue-eyed grass (*Sisyrinchium solstitiale*) (Wunderlin et al. 1980c).

Britton's beargrass occurs in association with several federally listed species, including Lewton's polygala, sandlace, wireweed, papery whitlow-wort, scrub blazing star, Highlands scrub hypericum, short-leaved rosemary, and Florida bonamia. It occurs with the endemic Ashe's calamint (*Calamintha ashei*), silk bay (*Persea borbonia* var. *humilis*), and sand holly (*Ilex opaca* var. *arenicola*) (Wunderlin et al. 1980c).

The distribution of Britton's beargrass, from north to south, is in Marion, Lake, Orange, Hernando, Polk, Osceola, and Highlands Counties (Hess 2002; Wunderlin and Hansen 2005). Its northern range limit is on the Ocala NF, where it was discovered recently after an herbicide treatment and prescribed fire were applied to restore a long-unburned tract of sandhill in the western portion of the Forest, south of State Road 40.

In Polk and Highlands Counties, Britton's beargrass is found mostly on the LWR, but also on smaller nearby ridges (Service 1996). It is present at most of the conservation lands and areas considered for State land acquisition on the LWR, in Polk and Highlands Counties. These areas include:

- Lake Davenport scrub
- Horse Creek scrub (South Florida Water Management District [SFWMD] and Southwest Florida Water Management District [SWFWMD])
- Lake Blue (private)
- Eagle Lake (private)
- Lake McLeod unit of LWR NWR
- Mountain Lake cutoff unit of LWR WEA (FNAI 2005)
- Tiger Creek Preserve (TNC)
- Boy Scout tract of LWR State Forest (5 individuals at one site) (Cox 2004)
- Babson/Hesperides tract of LWR State Forest and vicinity
- Lake Walk-in-the-Water tract of LWR State Forest (8 individuals at 1 site in 2002) (Cox 2004)
- Arbuckle tract of LWR State Forest (193 individuals at 12 sites in 2002) (Cox 2004)
- Hickory Lake County Park, Polk County
- Trout Lake, Polk County (private)
- Avon Park Lakes (private)
- Silver Lake (partly LWR WEA – The Preserve, owned by Highlands County, is adjacent)
- Carter Creek (LWR WEA and LWR NWR)
- Flamingo Villas tract of LWR NWR
- Henscratch/Jack Creek (LWR WEA/SWFWMD)
- Lake Apthorpe, Holmes Avenue, and Gould Road units of LWR WEA
- Sun 'n Lakes South (largely acquired for LWR WEA)

- Lake June-in-Winter Scrub State Park
- Highlands Ridge, partly in LWR WEA (Schultz et al. 1999).

Tiger Creek Preserve has numerous individuals of Britton's beargrass throughout its sandhills and xeric hammocks. The demographics of five populations were monitored from 1991 to 2000. Individuals showed extremely low mortality both in fire-maintained and long-unburned areas. Because its populations are stable, TNC no longer monitors this species, except that patches of individuals are mapped during 5-year surveys of the entire Preserve.

Carter's mustard

The following discussion is summarized from the MSRP (Service 1999), as well as from recent research publications and monitoring reports. A complete Carter's mustard life history discussion may be found in the MSRP. No critical habitat has been designated for Carter's mustard.

Description – Carter's mustard is an annual herb, 0.2 to 1.5 m (0.8 foot to 2.5 feet) tall with erect green stems. The plants usually have many slender, ascending branches forming an open, rounded crown. The leaves lack stipules and are arranged alternately on the stem. Lower leaves are lost by the time the plant flowers. Leaf size and shape varies with age and position on the plant. At the time of flowering, leaf petioles range from 0.8 to 3.9 mm (0.03 to 0.15 inch) with blades 1 to 3 cm (0.4 to 1.2 inches) long. Towards the tips of stems, the leaves are smaller and narrowly elliptical to almost linear, while closer to the bases of stems and branches, the leaves are larger and oblanceolate or spatulate. All leaves are rounded at the tip, their margins entire, and their bases attenuate to cuneate. The lower leaves may have undulated margins or lobes.

Carter's mustard plants have several to many inflorescences, which are dense, rounded racemes with 60 or more flowers. They are about the size of table tennis balls (Archbold Biological Station 2003). The inflorescences and flowers resemble the common garden spiderflower or cleome (*Cleome hassleriana*) but the garden cleome has much larger flowers (FNAI 2000a).

The flowers are open and radially symmetric, with four white petals, about 4.5 mm long, and curved toward the center of the flower at the tip. The four petals are white, about 6.0 mm (0.24 inch) long, with more than half their length in the form of a slender claw. The blade portion of the petal is nearly round with irregular margins. The six spreading stamens are irregularly subequal in length and arise from a nectar-producing floral disc. The ovary is superior, cylindric, about 2.3 mm (0.09 inch) long, and raised on a slender stalk (gynophore) about 2 mm (0.08 inch) long. The flowers are protandrous, with the anthers opening before the stigmas are receptive (Evans et al. 2000). Anthers begin to open within an hour or two after the flower has opened. The sessile stigma, which has two lobes, is receptive until 2 to 4 days after the flower opens, by which time the stamens on that flower have already dropped.

The fruit of Carter's mustard is a long, slender pod (silique) divided lengthwise by a partition (septum). The pod is flattened, cylindrical in cross-section and gently curved along its length, which is 4 to 6 cm long and 1.5 mm wide (1.6 to 2.4 inches long and 0.06 inch long). The pod is

borne on a gynophore, which is a stalk-bearing pistil 5 to 6 mm (0.19 to 0.26 inch) long, above a spreading pedicel, which is around 8.5 mm (0.34 inch) long. The pod carries numerous oblong seeds, each 1.5 mm long (Kral 1983). Fruits split apart passively to shed the seeds. Flowering occurs in September and October. Fruiting occurs in October to November and dispersal follows in November and early December.

Life History – Carter's mustard is self-compatible, although experiments by Archbold Biological Station ecologists show that fruit set from self-fertilizing (autogamous) crosses is lower than experimental hand-pollinated self-crosses and outcrosses, and seed set is lower than with hand pollinations or open-pollinated controls. The morphology of Carter's mustard flowers indicates generalist (rather than specialized) insect pollination. Flowers are visited by bees, flies and wasps. Nonetheless, since hand pollinations result in greater fruit and seed set than open pollinated controls, it appears that Carter's mustard is pollinator-limited (Archbold Biological Station 2003). Autogamy is presumably valuable to this annual species because it assures that seeds are produced, even if no other plants are nearby, or if pollinators do not visit.

Archbold Biological Station ecologists report that seedlings may remain as rosettes until the end of the dry season from fall through spring. They report that seedling mortality is generally highest in April and May, at the end of the dry season. Once the summer rains arrive, surviving plants typically bolt, "often doubling in height from month to month." There appears to be considerable variation in growth rates both in terms of time and the location of the plants, "perhaps having to do with differences in annual rainfall or in microhabitat. For example, seedlings recruiting in shadier microsites seem to elongate sooner than those in sunnier microsites" (Archbold Biological Station 2003).

In the first year after a fire, "aboveground populations experience dramatic booms" as seeds germinate. The second year after a fire brings equally dramatic crashes in population size. Small, fluctuating populations may persist in mechanically disturbed sites like firelanes or trails. The sudden (re)appearance of large aboveground populations following fire suggests the presence of a long-lived seedbank" (Archbold Biological Station 2003) and also suggests that the apparent absence of this plant from an unburned area should not be interpreted to mean that the species is absent.

Population Dynamics – Aboveground populations fluctuate wildly. Autogamy helps ensure fecundity and may be a key life history trait with respect to population recovery (Evans et al. 2000). "Annual surveys of scores of sites have been conducted at TNC's Tiger Creek Preserve, Archbold Biological Station, and Lake Placid Scrub since 1988 and at LWR State Forest since 1995. Monthly seedling survival surveys have been conducted monthly at the State Forest since 1996 and at Archbold Biological Station since 1999. Numerous lab and field germination experiments have also been conducted over the last several years" (Archbold Biological Station 2003). Monitoring at Tiger Creek Preserve ended in 2003 because populations were stable (B. Pace-Aldana, TNC, letter correspondence, 2005). Annual census data are available online (Archbold Biological Station 2005).

At the Arbuckle tract of LWR State Forest, Cox (2004) notes that Carter's mustard is only found in three burn units, and these populations "appear to fluctuate considerably depending on local climate and rainfall." Populations increased in 2002 after several years of drought were broken.

Archbold ecologists report that "genetic diversity is lower in Carter's mustard than in other species with similar ecological and life history traits. A relatively large proportion of the detected diversity (30.4%) occurs among rather than within populations. Genetic diversity is spatially organized, with a significant north-south cline in allele frequencies at one locus." (Evans et al. 2003; Archbold Biological Station 2003).

Distribution – The largest known populations are at the Archbold Biological Station and the TNC's Tiger Creek Preserve. It is present at the Lake Placid tract of LWR WEA, the Carter Creek tract of LWR NWR, LWR State Forest. In northern Polk County, its distribution is apparently less well worked-out. It is present on the Snell Creek tract of LWR NWR, probably on adjoining land belonging to the Upper Lake Marion Creek Watershed, managed by the SFWMD. It is also probably present slightly farther north on another tract of the Upper Lake Marion Creek Watershed, located near Horse Creek. Evans et al. (2000) provide a distribution map.

Off the LWR, a single herbarium specimen was collected from Spessard Holland Park in Melbourne Beach, Brevard County, but there have been no further sightings from that county, including from a recent plant survey conducted during the growing season (Schmalzer and Foster 2003). Carter's mustard was last collected in Miami-Dade County in 1942. The highly reliable Roy Woodbury reported seeing it at the DuPuis Preserve in Palm Beach County, but his sighting is not supported by a herbarium specimen (Gann et al. 2002). Carter's mustard is conspicuous only during its brief, 1-month flowering period, and its remaining habitat on the LWR outside of conservation lands has not been completely surveyed.

While habitat has been conserved since it was listed (notably at Horse Creek Scrub owned by SFWMD, the Lake Walk-in-the-Water and Arbuckle tracts of LWR State Forest, and the Carter Creek tract of LWR NWR), habitat for Carter's mustard is still presumably being lost. No new localities seem to have been found since 1996, except on conservation lands. Distributional records may be incomplete because Carter's mustard typically exists as seeds in the soil except when germination is stimulated by fire or disturbance, and the plants are inconspicuous except during their flowering period lasting about a month (Service 1996).

This plant occurs within a research project at the Carter Creek tract of the LWR NWR where Florida ziziphus was introduced and the demography of Lewton's polygala studied (Menges and Weekley 2003). Carter's mustard responded positively to a prescribed fire that was part of the project, indicating that prescribed burning elsewhere (such as at Lake Walk-in-the-Water) will prove highly beneficial.

Florida bonamia

The following discussion is summarized from the MSRP (Service 1999), as well as from recent research publications and monitoring reports. A complete Florida bonamia life history discussion may be found in the MSRP. No critical habitat has been designated for Florida bonamia.

Description – Florida bonamia is a perennial vine with long prostrate stems a meter or more (at least 3 feet) in length. It has a long, relatively slender tap root. The leathery sessile or subsessile leaves are up to 4 cm (1.6 inch) in length and ovate in shape. The flowers are solitary and sessile in the leaf axils. The funnel-shaped corolla is 7 to 10 cm (3 to 4 inches) long and 7 to 8 cm (2.7 to 3.2 inches) across. It has a deep blue or bluish-purple color with a white throat. The flowers open in the morning and are wilted by early afternoon (Romano 1999). The fruits are capsules, normally containing four seeds. The seeds are smoothish, pale brown or greenish-brown, 5 to 8 mm long, and oblong (Romano 1999). The outer face is convex and the inner two faces are flat, forming an angle (Wunderlin et al. 1980a). Florida bonamia is the only morning glory vine found in scrub areas with a large blue flower (Wunderlin et al. 1980a), but could be confused with hairy dawnflower (*Stylisma villosa*).

Life History and Population Dynamics – Florida bonamia grows for three or more years (50 FR 42068; Wunderlin et al. 1980a), flowering from spring to summer (Wunderlin 1998). It has a mixed mating system; it is highly self-compatible, it can self-pollinate, and it can produce seeds without fertilization (Romano 1999). Pollinators are essential, however, to ensure substantial seed production by self-, as well as cross-, fertilization. Florida bonamia shows some inbreeding depression in selfed fruits and seeds but it does not appear to be enough to hinder the present populations (Romano 1999). The seeds of Florida bonamia become dormant, but may do not require dormancy to germinate, particularly if the seeds are planted immediately. Hartnett and Richardson (1989) observed that populations of this species have large seed banks of dormant seeds, mostly within 1 cm (0.4 inch) of the surface, distributed rather homogeneously, with no relation to the distribution of mature plants. The seedlings germinate throughout the summer until September. This germination pattern is somewhat unusual among scrub plants, many of which germinate during the fall or winter. Germination occurs on sites with sparse vegetation that have not burned recently (Romano 1999).

Seedling survival was investigated by Romano (1999), but results from this unpublished dissertation have not yet been obtained. Hartnett and Richardson (1989) excavated several plants. They found that clumps of prostrate stems seen at the surface are connected to a large central and somewhat woody rootstock. They had no difficulty distinguishing such clump-forming, well-established older individuals from young single-stem plants that had grown from seed. According to Hartnett and Richardson (1989), fire stimulates seed production and germination as well as regrowth from clonal stems. Stem production is greatest during the first season after a fire, while seed production peaks the second year. The lag is probably due to the increased energy needed for regrowth following fire. Seed production is postponed to conserve energy. New seed production replaces the seed banks that are often destroyed by fire.

Distribution and Status – The known populations of Florida bonamia occur within, on the edge of, or near scrub habitat on the white sands associated with the ancient Pleistocene dune systems of the central ridge system (Ward 1979a). Scrub vegetation, particularly on the Ocala NF, consists of myrtle oak and sand live oak with sand pine, with openings between the trees and shrubs occupied by lichens and herbs. The LWR has additional shrub species and many endemic herbs and small shrubs. Scrub is renewed by infrequent fires or mechanical disturbances, including logging on the Ocala NF. Florida bonamia grows in a variety of growth stages of sand pine, but flowers profusely only in the open, sunny conditions of regeneration stands, and sparsely if at all in older stands.

Florida bonamia also occupies disturbed areas near roadways and clearings caused by logging operations (50 FR 42068). This species is not found on altered soils such as the clay applied to logging roads on the Ocala NF (Miller 1989). As the scrub community reaches maturity, encroachment and shading from overstory pines and oaks cause this and other smaller species to decline (Wunderlin et al. 1980a).

Florida bonamia has been collected in Hardee, Highlands, Hillsborough, Lake, Manatee, Marion, Orange, Polk, Sarasota, and Volusia Counties in peninsular Florida. Many of these records are historic: Manatee (1878, 1916), Sarasota (1878), and Volusia (1900) (Wunderlin et al. 1980a). The plant has been collected in Hardee County in 1995 and in Orange County in 1989 and 1995 (University of Florida herbarium collections catalog, accessed June 28, 2005). Florida bonamia is relatively abundant and widespread on the Ocala NF, especially along road edges, in Marion and Lake Counties. South of the Ocala NF, Florida bonamia was once collected near Mt. Dora or Tavares, but has probably been extirpated. It is present at the 120-acre Flat Lake tract of Seminole State Forest in Lake County southeast of Clermont (Schultz et al. 1999; FNAI 2005), which was purchased by TNC in 1999 (Finkelstein 1999).

In south Florida, Florida bonamia is present at most sites with scrub vegetation on the LWR, as shown by a survey of 26 sites being considered for State land acquisition (Schultz et al. 1999). Here is a summary of the south Florida distribution, based in part on Service (1996):

- Charlotte County. Seen by I.J. Stout of the University of Central Florida. No collections have been reported from this county.
- Hardee County. Reported from one site by Johnson (1981). The University of Florida Herbarium catalog includes a specimen collected by S.L. Orzell (23688, June 4, 1995), from rosemary scrub.
- Polk County. Protected at the Arbuckle tract of LWR State Forest. Reported by Schultz et al. (1999) from the following CARL acquisition areas: Horse Creek Scrub (SFWMD), Lake Blue, Lake McLeod (part of the LWR NWR), Mountain Lake Cutoff, Hesperides, the Arbuckle, Boy Scout (Cox 2004), and Lake Walk-in-the-Water tracts of LWR State Forest, Sunray/Hickory Lake South, and Trout Lake. It is not present at TNC's Tiger Creek Preserve (B. Pace-Aldana, TNC, letter correspondence, 2005), contrary to label information on herbarium specimen S.P. Christman 1935 (with D.K. Dorman), collected in 1987 (University of Florida herbarium catalog).

- Osceola County. Present immediately north of the county line, north of State Road 532, southeast of Interstate 4.
- Highlands County. Protected at the Flamingo Villas tract of LWR NWR. It is not on the plant list for Archbold Biological Station (Menges et al. 2000). Schultz et al. (1999) report it from Avon Park Lakes, Carter Creek (LWR Wildlife and Ecological Area and LWR NWR), and Lake Apthorpe and Holmes Avenue (LWR Wildlife and Ecological Area).

DeLaney (1988) found 500 plants in the Arbuckle tract of LWR State Forest. Monitoring at the Arbuckle tract found 66 in 2002 and 36 in 2003. Walk-the-Water had 14 in 2001 and 53 in 2002. Boy Scout had 150 in 2003 (Cox 2004). Cox expressed concern over these apparently declining numbers on the LWR State Forest.

Florida bonamia depends on the sunny cleared areas left by periodic fires or physical disturbance (52 FR 42068). Historically, lightning fires swept through the scrub and surrounding communities, burning large tracts of land. Today, habitat fragmentation and fire suppression have interrupted the natural burn regime. Reduced fire frequency has left many of the scrub sites overgrown and unsuitable for highly specialized scrub endemics that require open sunny patches. Florida bonamia, like other herbs of the scrub, can be found growing along roadsides that are often the only available openings. However, these areas cannot be considered a safe refuge for rare species. Roadsides are often filled with invasive exotics that compete with scrub endemics. In addition, road maintenance activities such as mowing, herbicide spraying, and soil disturbance can adversely affect native species.

Florida perforate cladonia

The following discussion is summarized from the MSRP (Service 1999), as well as from recent research publications and monitoring reports. A complete Florida perforate cladonia life history discussion may be found in the MSRP. No critical habitat has been designated for the Florida perforate cladonia.

Description – The Florida perforate cladonia is a fruticose lichen - it has a shrub-like form. The genus *Cladonia* has some 128 species in North America. Cladonias are distinguished from other fruticose lichens by their hollow erect stalks (podetia); in some species they are branched (including Florida perforate cladonia) and in others unbranched. Primary squamules may be present or absent (absent in Florida perforate cladonia) (Brodo et al. 2001). Technical identification information for the Florida perforate cladonia, including photographs, a key, and chemistry information, is provided by Brodo et al. (2001). "*Cladonia perforata* can superficially resemble *C. leporina* (which has more slender branches and different chemistry) and relatives of *C. uncialis*, none of which have round perforations along the sides of the podetia" (Brodo et al. 2001).

The Florida perforate cladonia is easy to recognize in the field by the conspicuous circular holes or perforations, typically below each forked (dichotomous) branching point of the podetia, and its wide, smooth, pale greenish yellow podetia, which are "quite shiny, with a varnished

appearance close to the tips. Podetia…1.5-5 mm [0.06 inch] in diameter, smooth and uniform, frequently perforated with oval holes ca. 1-1.5 mm [0.04-0.06 inch] long…" (Brodo et al. 2001). The branching pattern is complex and consists of roughly subequal dichotomies near the tips and, more commonly, sympodia (unequal branchings with the smaller branch deflected to one side) below (Evans 1952), resulting in a more or less compressed tuft. Individual podetia are typically 4 to 6 cm (1.6 to 2.4 inches) long (Evans 1952), although specimens of up to 8 cm (3.2 inches) across and several centimeters high have been observed (R. Yahr, Archbold Biological Station, personal communication, 1995). The oldest parts of the podetia degenerate, leaving no means of determining ages. The Florida perforate cladonia is suspected to reproduce only by vegetative fragmentation; no spore-producing organs (apothecia) have been described (Thomson 1967).

Up to eight species of reindeer lichens (fruticose, terrestrial species of *Cladonia* and *Cladina*) commonly occur in Florida scrub. They can readily be distinguished from the Florida perforate cladonia. Although *Cladonia leporina* may sometimes have small perforations in the podetia, it is a darker yellow-green color, has narrower podetia with rough surfaces, and often has conspicuous red apothecia. *Cladonia pachycladodes* is similar in color to *C. perforata* but is more of a light bluish-gray color and has finer branches, drooping at the tips. *Cladonia subsetacea, Cladina evansii*, and *Cladina subtenuis* all have much narrower, almost threadlike (filiform) podetia, usually less than 1 mm wide (Service 1999).

Life History – Several of the reindeer-lichen species of *Cladonia* and *Cladina* form a conspicuous and characteristic part of Florida's white sand scrub communities (Moore 1968). Florida perforate cladonia typically occurs in open patches of sand between shrubs in areas with sparse or no herbaceous cover. Florida rosemary is usually abundant. Such rosemary scrubs or "rosemary balds" are particularly well-drained and always have bare, white sand. At Archbold Biological Station, Florida perforate cladonia occurs in the driest microsites even within rosemary scrub (E. Menges, Archbold Biological Station, personal communication, 1995). These rosemary scrubs are on small hills surrounded by scrubby flatwoods with dense scrub oak and slash pine.

Florida perforate cladonia can occur in mats by itself or mixed with *Cladonia leporina, Cladonia prostrata, Cladonia pachycladodes, Cladina evansii, Cladonia subsetacea*, and/or *Cladina subtenuis*. These other co-occurring lichen species are not restricted to rosemary scrub and can also be found in lower, less well-drained communities like scrubby flatwoods and flatwoods, as well as other xeric upland habitats such as sandhills, from which Florida perforate cladonia is absent. Florida perforate cladonia is usually found, in addition to rosemary, with scrub oak, sand live oak, and myrtle oak. Sand pine may be abundant or scarce. Other associated plants may include saw palmetto, scrub palmetto, rusty lyonia, coastalplain staggerbush (*Lyonia fruticosa*), tough bumelia (*Sideroxylon tenax*), bigflower pawpaw (*Asimina obovata*), silk bay, gopher apple (*Licania michauxii*), the endangered Highlands scrub hypericum, the endangered wireweed, pricklypear (*Opuntia humifusa*), nodding pinweed (*Lechea cernua*), and sand spike-moss (*Selaginella arenicola*) (Buckley and Hendrickson 1988).

While Florida perforate cladonia usually occurs on bare sand, it occasionally occurs in dense, long-unburned sand pine scrub on a mat of pine needles, as observed at the southernmost portion of Archbold Biological Station, on an adjacent privately owned parcel, and under dense sand pines on the LWR State Forest (R. Yahr, Archbold Biological Station, personal communication, 1995). However, Menges and Kohfeldt (1995) found that Florida perforate cladonia decreases in dominance in sites that have gone unburned for more than 20 years. This may be due to a combination of factors that influence microhabitat, such as decreased insulation or increased litter accumulation.

Florida scrub historically burned at variable intervals, and tended to have patchy high-intensity fires (Myers 1990). The vegetation recovers relatively quickly (Abrahamson 1984a). In sand pine and rosemary scrub, however, recovery of dominant species is slower than in oak-dominated scrubs (Johnson et al. 1986) and open spaces between shrubs persist longer. Bare sand patches (or gaps), lacking fuel, may serve as refugia from fire for lichens, including Florida perforate cladonia, which cannot survive fire. These refugia provide local sources for recolonization and population recovery.

Elsewhere in Florida, the Florida perforate cladonia occupies somewhat different habitats. In the coastal scrubs of Jonathan Dickinson State Park in Martin County, this lichen is reported from open areas in oak-dominated sand pine scrub and scrubby flatwoods. The Okaloosa County sites in the Florida panhandle are on coastal beach sands in white-sand scrub. In northwest Florida, it is also found in hydric swell-and-swale habitats with stunted slash pine (*Pinus elliottii*) (Wilhelm and Burkhalter 1990; Eglin Air Force Base 2004a). Florida perforate cladonia was collected from an Okaloosa County site dominated by rosemary and "downslope into margins of gallberry swales" (specimen collected by Johnson and Blythe 1986, deposited at herbarium of Archbold Biological Station).

Population Dynamics – Florida perforate cladonia population dynamics have been inferred from observations of occupied sites. Menges and Kohfeldt (1995) found that Florida perforate lichen responded to burning by slow recolonization (within 4 years) and, later, by steady increases in dominance up to 20 years post fire, and then decreases in dominance again. It can apparently, persist in long-unburned sites (probably for more than 50 years) under a dense sand pine canopy (R. Yahr, Archbold Biological Station, personal communication, 1995). Until population trends are studied, it is probably important to provide a mosaic of times-since-fire in the landscape and to encourage patchy burns if fuels have become continuous due to long-unburned conditions.

Because Florida perforate cladonia cannot survive fire and probably recolonizes sites slowly and from local sources, such as unburned patches within sites, it is important to avoid complete burns in sites that support this species. Conducting a mosaic of burns over long time frames would, therefore, be an appropriate management approach for this species. In some cases prescribed fire may be infeasible due to the proximity of residential development or due to high fuel buildup which could lead to local extirpations. In these situations, Florida perforate cladonia might respond well to mechanical clearings adjacent to occupied patches. Evidence of this is noted by

the recolonization of some areas disturbed by off-road vehicles with a dense cover of Florida perforate cladonia (R. Yahr, Archbold Biological Station, personal communication, 1995). Patchy burns during the 1990s at Archbold Biological Station and the Lake Apthorpe property of the LWR WEA may promote the persistence of this species, creating or re-opening new bare sand patches adjacent to occupied, unburned areas.

Archbold Biological Station started a monitoring project at several sites in the winter of 1996-1997 to investigate the rate and mode of post-fire recolonization in the peninsular region of the Florida perforate cladonia's range; compare natural recolonization of Florida perforate cladonia with establishment via transplantations into unoccupied suitable habitat and with previously occupied, hand-cleared sites; and test hypotheses regarding dispersal limitations for Florida perforate cladonia's persistence and growth in several transplant sites.

Hurricanes affect coastal populations of Florida perforate cladonia. Eglin Air Force Base has worked to conserve this lichen after two storms.

Status and Distribution – The Florida perforate cladonia occurs in south Florida (Polk, Highlands, Martin, Palm Beach, and Manatee Counties) and in the Florida panhandle (Okaloosa County).

In 1991, the FNAI surveyed 111 sites throughout central and coastal Florida to determine Florida perforate cladonia's status. They found only 12 sites with this lichen, six of them at Archbold Biological Station (Service 1993b). Later, two additional sites were found at Archbold Biological Station (R. Yahr, Archbold Biological Station, personal communication, 1995).

In Polk County, Florida perforate cladonia is present on the Arbuckle tract of LWR State Forest, and has been monitored annually since 2001 (Hardin 2004). In 2003, the area with Florida perforate cladonia was mapped using GPS in five previously-mapped areas that had received prescribed fire in 2002. The area with the lichen had expanded since 2002, as lichens growing on the sandy soils had been blown by wind or washed by rains beyond the previously marked boundaries. The mapped areas covered 3.74 ha (9.3 acres) in 2003. Although other rosemary scrubs were searched, no other Florida perforate cladonia populations were found. Florida perforate cladonia exists in small numbers (perhaps a thousand thalli) on the Lake McLeod tract of LWR NWR. In addition to the protected sites for Florida perforate cladonia, the Trout Lake site in Polk County (on the Highlands County border) is privately owned (FNAI 2005).

In Martin County, one large site occurs at Jonathan Dickinson State Park. We do not have information on the effects of two hurricanes in 2004, but the storms did move a lot of sand in bare areas at the adjacent Hobe Sound NWR. Another population (size not reported) is at the Biele Tract, owned by TNC (Bradley et al. 1999), which is now the 21-acre Leopold Scrub owned by Martin County.

In Palm Beach County, two protected populations are at the Jupiter Inlet/lighthouse tract, owned and managed by the U.S. Department of the Interior, Bureau of Land Management, and one is on the Jupiter Ridge Natural Area (Steve Farnsworth, Palm Beach County DERM, personal communication, 1998). A 1997 survey revealed approximately 5,000 lichen fragments on this site.

Southwest Florida's Manatee County has one site, for which details are not available (K. DeLaney, Environmental Research Consultants, Incorporated, personal communication, 1995).

In Okaloosa County in the western Florida panhandle, Santa Rosa Island was known to have three populations of Florida perforate cladonia adjacent to the Gulf of Mexico, within Eglin Air Force Base. The largest population was on the eastern end of the Island near a Coast Guard station, and two small populations were to the west, on a restricted portion of the base. The storm surge of hurricane Opal in 1995 destroyed the two small populations and affected about half of the remaining population and its habitat. In June of 2000, the lichen was reintroduced to two sites on the restricted portion of Santa Rosa Island (Yahr 2001; Eglin Air Force Base 2004a). These introduced populations are being monitored every 5 years, or after a tropical storm. The habitat survived hurricane Ivan of 2004 more or less intact, but a significant amount of sand had shifted, burying some lichens, and much of the area had been inundated by water and contained debris (Eglin Air Force Base 2004c). Each of the 28 reintroduction plots on the restricted portion of the beach was visited after Ivan. Efforts were made to obtain partially-buried lichens by sieving, and placing the thalli on the surface. "Six of the 28 sites appeared as if there was little to no impact from the hurricane. The *Cladonia* within these plots were still on the surface of the sand and appeared healthy. Four of the 28 plots were severely damage, and little to no *Cladonia* was found. The remaining 18 plots had moderate impacts from the storms, with some individuals being buried, inundated by water, or missing" (Eglin Air Force Base 2004c). As much as 44 percent of the eastern population (near the Coast Guard station) was significantly impacted by Ivan, from burial by debris or sand, discoloration from water inundation, or fragmentation due to wind or water action.

A garden population has been established at the Historic Bok Sanctuary to support reintroductions to Okaloosa County following hurricane damage. In November of 2003, 200 thalli were sent to Bok (Eglin Air Force Base 2004b). Unfortunately, in 2004, Bok was affected by three hurricanes that forced staff to collect the thalli from the garden bed, place them in a bucket with native sand for safekeeping, and place the buckets indoors. The thalli appeared healthy after the first hurricane, but appeared to be in declining health after the later storms. Plans are to place the thalli in paper bags to dry before any future move indoors, and to provide 15 gallons of native sand from Eglin Air Force Base to provide a new sand surface for the bed (Eglin Air Force Base 2004b, 2004c).

Florida ziziphus

The following discussion is summarized from the MSRP (Service 1999), as well as from recent research publications and monitoring reports. A complete Florida ziziphus life history discussion may be found in the MSRP. No critical habitat has been designated for the Florida ziziphus.

Description – Florida ziziphus is a woody clonal shrub currently known in the wild from seven sites along a roughly 30-mile stretch of the LWR in south-central Florida (Service 1999). Historical records near Sebring (Judd and Hall 1984) extend the range southward by about 6 miles. All seven populations are found on xeric yellow sands which historically supported sandhill vegetation (USDA-SCS 1990), but three of the sites have been converted to improved pasture. Florida ziziphus is known to exist in only five remnant populations in Polk County and two in Highlands County, but none of the plants on these sites appear to reproduce sexually. These sites are threatened by continued land conversion for residential housing, agriculture, and road construction.

Florida ziziphus is a spiny shrub that averages between 1.6 to 4.8 feet tall, but can grow to over 6.6 feet. Plants occur in groups of stems, arising from what are assumed to be connected root systems. The primary branches are jointed and bent, and give rise to short, straight, spiny branchlets. The oblong-elliptic to obovate leaves are alternate and deciduous. The leaves are characterized by rounded tips, cuneate bases, and entire margins. The upper leaf surface is dark glossy green, while the underside is a dull light green. Leaves range from 2.8 to 13 cm (1.1 to 5.3 inches) long, and from 1.9 to 8.4 cm (0.75 to 3.3 inches) wide. Fragrant ziziphus flowers are small, axillary, and solitary, but are tightly bundled on short shoots. Flowers are perfect, with five greenish-yellow sepals and five white petals clasping five stamens; however, three and four merous flowers have been observed (Race and Weekley 1996). The bright yellow drupes range from 6.5 to 13 cm (2.54 to 5 inches) long and 1.9 to 6.5 cm (0.75 to 2.54 inches) wide (Judd and Hall 1984; DeLaney et al. 1989; Race and Weekley 1996).

Florida ziziphus appears to prefer high pine habitat or the transition zone between scrubby flatwoods and high pine. K. DeLaney (Environmental Research Consultants, Incorporated, personal communication, 1995) described the healthiest plants as growing on the lower slopes of turkey oak knolls with sparse cover. Based on Soil Conservation Service mapping, all of the sites where ziziphus occurs are characterized by excessively drained, nutrient poor soil types, including Tavares Fine Sand, Astatula, and Candler Sand (DeLaney et al. 1989; USDA-SCS 1990; Burkhart et al. 1997).

Habitat characterization for this species is difficult because the largest known sites are in pasture. One site is a remnant sandhill and another as an open oak-hickory, yellow sand scrub. This species seems to prefer unshaded and uncrowded microsites within these communities (C. Weekley, DOF, personal communication, 1998).

Life History – Florida ziziphus is deciduous, losing its leaves in late fall. It begins to flower in late December or early January and flowering continues through late February (varying by site and year), while the branches are still bare (Burkhart et al. 1997). Fruits begin to develop in March, with new leaves forming at the same time or soon after. The fruits ripen in May or early June. No seedlings have been found in the wild, so it is not known whether the seeds germinate in the summer or later in the year. Common pollinators (bees and flies) have been observed visiting the flowers, although it is not known if these are pollinators of Florida ziziphus. No viable seeds have been observed in the wild. Natural fruit set has been observed twice in the

wild, but few fruit were produced, and of those all aborted before maturity (K. DeLaney, Environmental Research Consultants, Incorporated, personal communication, 1995; Burkhart et al. 1997). Lack of sexual reproduction may be due to the absence of compatible genotypes at a given site and/or the age of the above ground stems (Burkhart et al. 1997).

Florida ziziphus spreads asexually by sending shoots up from its roots. These additional stems give ziziphus a clump-like appearance, where individual plants in the clump are not distinguishable. Like other members of its genus, ziziphus is capable of parthenocarpic production of fruit (fruit development without pollination), but it differs from others in its genus by not being dichogamous (having pistils and stamens that mature at different times to prevent self-fertilization) (Burkhart et al. 1997).

Sexual reproductive failure and narrow genetic variation are crucial issues in the endangerment of Florida ziziphus. Seedlings are unknown from *in situ* (wild) populations and most populations do not set fruit. About 75 percent of the fruits produced by experimental pollinations or by insect pollinations among mating types in the *ex situ* (garden) population lack viable seeds due to parthenocarpy or seed abortion. Genetic analyses suggest that reproductive failure is related to some combination of mating system limitation and narrow genetic variation.

Genetic analyses employing allozyme electrophoresis (Godt et al. 1997) and RAPDs (Weekley et al. 2002) concur that the extant breeding population of ziziphus comprises only 11 genotypes. Ongoing AFLP research confirms these genotypes and may add a few closely related genotypes (Weekley 2002). *In situ* populations are uniclonal, except for the large H01 population. Ziziphus is self-incompatible (plants with the same genotype cannot produce viable seeds) and most genotype combinations are also cross-incompatible (Weekley and Race 2001). Of the 55 crosses possible among 11 genotypes, only 8 of 38 experimentally tested are cross-compatible (Weekley et al. 2002). Sexual reproductive failure is due primarily to a single-locus gametophytic self-incompatibility system whereby genotypes must have at least one different S-allele to be cross-compatible (Richards 1986). Based on present evidence, the researchers believe that ziziphus may encompass as few as three S-alleles and as few as three S-allele mating types (Weekley et al. 2002).

Population Dynamics – Only one wild population occupies a site on public conservation lands; additionally, an introduced population has been established at the LWR NWR Carter Creek tract. A garden population comprising clones of all known genotypes and seedlings propagated from open pollinations within this population has been maintained in the Center for Plant Conservation's National Collection at Historic Bok Sanctuary since 1989. Recovery efforts for the ziziphus will include habitat protection, controlled propagation, reintroduction of this plant into unoccupied, suitable habitats, and land management of the scrubby flatwoods and high pine communities.

The two populations of ziziphus that occur in improved pasture on private lands in Polk County have similar management needs. Both sites are open and the plants are fairly vigorous, flowering annually. However, plants at one site were impacted by livestock and old age;

therefore, the landowner has fenced this site to eliminate livestock impacts. Plants at both sites are included in the regular monitoring program. Since the site has been fenced, prescribed burns are planned.

The population on the remnant sandhill (high pinelands) site on private property in Polk County is currently protected by the owners, who have posted the property as a nature preserve. However, this site is threatened by exotic pest plants. The Historic Bok Sanctuary and DOF have worked on controlling these species, but this effort will need to continue. Prescribed fire is recommended for portions of the site in order to limit the spread of exotics, encourage the growth of natural ground cover, and stimulate new growth of ziziphus. In addition, this population should be sampled and propagated for inclusion in the Historic Bok Sanctuary collection of ziziphus.

Three of the seven sites where ziziphus occurs are improved pasture. The LWR State Forest site is a degraded narrow ecotone between a high pine ridge and scrubby flatwoods. Other species in this ecotone include oaks (*Quercus* sp.), tough bumelia, scrub palmetto, dogtongue wild buckwheat (*Eriogonum tomentosum*), scrub buckwheat, and saw palmetto (DeLaney et al. 1989). The fifth site, referred to as the sandhill site, lies along the sloping edge of former sandhill. The site is surrounded by laurel cherry (*Prunus caroliniana*), oaks including live oak (*Quercus virginiana*), bluejack oak (*Q. incana*), and turkey oak (*Q. laevis*), and invading blackberry (*Rubus cuneifolius*). Within the site, ziziphus is associated with longleaf pine (*Pinus palustris),* wiregrass (*Aristida stricta* var. *beyrichiana*), scrub buckwheat, and saw palmetto (Burkhart et al. 1997).

Management for Florida ziziphus on private land depends on competing land uses and on the landowners' willingness to use land management techniques that will benefit this species. On the three pasture sites, ziziphus has been exposed to mowing. Ziziphus only produces flowers on stems at least 1 year old, so if mowing is done more frequently than every 2 to 3 years, the plant may be unable to reproduce (C. Weekley 1997). The threats of trampling and competition with invasive and exotic vegetation can be eliminated only if the private landowners support management recommendations.

Status and Distribution – Florida ziziphus was originally collected near Sebring in 1948. A second specimen was collected in 1954, perhaps from the same site as the original specimen, but the location of the latter collection is unknown. The plant remained unidentified and unnamed until 1984, when Judd and Hall (1984) determined that the original herbarium specimen represented an undescribed species, which they named *Ziziphus celata*. When it was named, the Florida ziziphus was thought to be extinct. However, it was rediscovered in 1987 at a site in Polk County (DeLaney et al. 1989).

Florida ziziphus was listed as an endangered species 2 years after its rediscovery, in July 1989 (54 FR 31190). The reasons for listing ziziphus were habitat loss, potential reproductive and genetic limitations, exotic species invasion, and the potential for over collection and vandalism (54 FR 31190). Most ziziphus habitat was converted to pasture and citrus production before the

species was rediscovered in 1987. Only the LWR State Forest population occurs on protected public land. The remaining populations are on private property. Lack of protection and reproductive failures in the wild make this species more vulnerable to extinction. Land conversion for agriculture and residential housing on the LWR has greatly reduced the amount of ziziphus habitat and has caused much of the remaining sandhill vegetation to become isolated. The further loss of any genetic material will weaken the possibilities of recovery for this species.

Florida ziziphus plants at LWR State Forest were shaded, covered in lichens, and appeared stressed (DeLaney et al. 1989; Wallace 1990), yet regenerated quickly after prescribed fire (Weekley 1996a). Plants at the more open high pine site and open pasture sites appear to grow vigorously in full sun or light canopy. This combination of a need for open canopy and quick regeneration suggests that this species is adapted to the frequent fire regime which historically maintained the high pine ecosystem.

The large Highlands County population (HO1) is in an improved pasture on private property. This population was sampled in 1989 and propagated for the National Rare and Endangered Plant Collection at the Historic Bok Sanctuary. Management needs for this population include: developing contact with the landowners, including this group in the regular monitoring program, and propagating additional samples to ensure that a backup of all genetic variability is preserved.

To offset possible losses from private lands, plants have been propagated from three different sites (nine genotypes) and are maintained in the Center for Plant Conservation National Collection at the Historic Bok Sanctuary. Plants representing two sites (eight genotypes) produced seed in 1994, while plants from one site (seven genotypes) produced seed in 1995.

The Service's recovery program for ziziphus (Service 1999) recognizes that its recovery requires the establishment of new populations in appropriate habitat on protected sites. In July 2002, an experimental introduction of ziziphus was carried out at the LWR NWR Carter Creek tract, which received 144 2-year old potted seedlings and 1,728 seeds. Based on knowledge of the maternal genotypes of the propagules, the introduction was designed to group within each of 36 16-foot radius circular plots four different configurations of transplants and potential new seedlings most likely to represent all three hypothetical mating types.

Garrett's mint

The following discussion is summarized from the MSRP (Service 1999), as well as from recent research publications and monitoring reports. A complete Garrett's mint life history discussion may be found in the MSRP. No critical habitat has been designated for Garrett's mint.

Description – Garrett's mint is a small, fragrant shrub that reaches 50 cm (20 inches) in height (Huck et al. 1989). Its taproot is branched with extensive, spreading, fibrous roots. The stem's woody base produces many woody vegetative stems. Each summer, temporary flowering shoots of limited (determinate) growth are produced, bearing abundant flowers in the fall. These stems die during the winter dry season. The leaves of Garrett's mint are sessile and have rounded

apices, cuneate bases, entire margins and glandular-pitted upper and lower surfaces (Huck et al. 1989). The leaf glands, when touched, produced the plant's characteristic menthol-like odor.

Leaves on the flowering shoots are narrowly ovate to narrowly oblong. Those that subtend the inflorescences (cymes) are 2 to 8 mm (0.08 to 0.31 inch) long and 0.5 to 1.8 mm (0.02 to 0.07 inch) wide, while those that do not subtend the cymes are approximately 5 to 11 mm (0.2 to 0.43 inch) long, and 1 to 2.5 mm (0.04 to 0.10 inch) wide. The leaves of overwintering, vegetative shoots are similarly shaped, but larger. The flower stalks (inflorescences) are typical of the mint family. Clusters of flowers appear above each pair of leaves. Technically, the inflorescence is a verticillaster (Huck et al. 1989). The flowers clustered just above paired leaves are on short stalks (cymes), with each cyme containing 1 to 3 flowers. The calyx is 6.5 to 10 mm (0.26 to 0.39 inch) long, approximately 2 mm (0.01 inch) wide at the midpoint, and bordered with an indistinct white band. The corolla is funnel shaped and abruptly bent to about 90 degrees. Its tube is 7 to 10 mm long, and its limb (from geniculum to distal edge of upper lobe) is 5 to 10 mm (0.20 to 0.39 inch) long. The corolla buds are yellow, but at maturity, the corolla is a pale cream (eventually fading to white). It has vivid purple-red markings that are often trellis-patterned on the upper lobe, but irregularly spotted on the lower lobe. The upper lobe is a recurving, cleft standard, and the lower lobe is tripartite (three parted) with a recurving middle petal. The flowers have four paired stamens that are exerted slightly beyond the lower corolla lip (Huck et al. 1989). The filaments are white, the anther sacs are brilliant yellow, and the connective is widened and may be covered with a few small, reddish and yellow glands at the basal end. The pollen is white and sticky. The pistil is white and has a slender, hirtellous style. The fruit is a schizocarp of four ovoid, brown, smooth nutlets.

Garrett's mint is very similar in appearance to scrub mint (*Dicerandra frutescens*). The two species are separated using the following characteristics:

- The leaves of scrub mint are longer than those of Garrett's mint (Huck et al. 1989);
- The anthers of scrub mint are deep purple to white in color, while the anthers of *D. christmanii* are a brilliant yellow (Huck et al. 1989);
- The corolla of scrub mint fades from a cream color to a white within 1 to 3.5 hours of opening (anthesis), while the corolla of Garrett's mint retains its cream color throughout most of the first day of anthesis (Huck et al. 1989);
- The anther connectives of scrub mint have more, and larger, glands than those of Garrett's mint (Huck et al. 1989); and
- The two species smell quite differently, scrub mint like mint and Garrett's mint like eucalyptus (Huck et al. 1989; McCormick et al. 1993).

Life History – Ecologists Eric Menges and Carl Weekley at Archbold Biological Station have monitored this species, using individually marked plants, since 1994. They have found that "seedlings typically germinate in the winter. Plants flower in the fall (peak in October) and fruits are also formed in the fall. Seeds and fruits disperse (probably very locally, judging by [scrub mint]) in the fall and winter. The basal parts of the plants are perennial and maintain leaves year-round. During the summer and fall, annual shoots with leaves are produced. Flowers and

fruits appear on these shoots. The annual shoots die back each winter" (Archbold Biological Station 2003). Plants prefer sites where canopy cover is less than 60 percent, litter cover less than 80 percent, litter depth less than 2 cm (0.8 inches), and height of surrounding shrubs less than 3 m (9 feet). The species is not present in mature oak-hickory scrub, but remains in abandoned firelane sites at the Flamingo Villas tract (Menges et al. 1999).

Population Dynamics – This species has variable population sizes because seedling recruitment varies from year to year and many seedlings may die during dry periods in spring. In many years, seedlings may survive best in partial shade. Seed dispersal appears to be limited (Archbold Biological Station 2003).

Because this plant occupies more or less open, sunny areas, the sizes of such areas are important. These "gaps" are likely to shrink between fires, as shrubs and sand pines grow. Fires enlarge the gaps and make them more connected to one another, so populations may shrink and become less connected between fires, expanding when fires open up new habitat. Fire probably kills all plants directly affected by high temperatures, but patchy fires may allow survival of individual plants. Populations probably recover after a fire via dormant seeds in a soil seed bank (Archbold Biological Station 2003).

Status and Distribution – This species has been found at only five locations, all in Highlands County. Locations are provided by Huck et al. (1989). All of the locations are between Lake Jackson and Lake Istokpoga, and north of U.S. highway 98 (Huck et al. 1989; FNAI 1996a). The historic distribution is unknown, but was probably not much larger, inasmuch as it appears to be restricted to yellow sand soil, which is limited in extent. Also, all of the woody *Dicerandra* species have very narrow ranges. The principal site for Garrett's mint, and the only one on conservation lands, is at Flamingo Villas, a tract of the LWR NWR (Archbold Biological Station 2003). This site was in poor condition when acquisition began, with wide off-road-vehicle trails, trash dumping, and informal target practice. This plant was possibly saved from extinction by its acquisition. The species is being demographically monitored at this site by researchers from Archbold Biological Station (2003), who are more concerned with the dynamics of local populations than with inventorying the overall size of the Flamingo Villas population. Work is still required to complete land acquisition, control unauthorized access, remove trash, and restore the scrub vegetation with prescribed fire or, possibly, mechanical treatments.

Highlands scrub hypericum

The following discussion is summarized from the MSRP (Service 1999), as well as from recent research publications and monitoring reports. A complete Highlands scrub hypericum life history discussion may be found in the MSRP. No critical habitat has been designated for Highlands scrub hypericum.

Description – Highlands scrub hypericum is a small, short-lived perennial herb reaching 20 to 70 cm (8 to 30 inches) in height. It is branched from the base and has a woody, fibrous root system. The stems are shorter and more numerous in winter and spring before reproductive

stalks develop. Usually there are three stems, but there can be as many as 17 stems on a healthy plant (Quintana-Ascencio and Morales Hernández 1997). During the reproductive season, all stems of mature individuals bear flowers and fruits. The leaves of Highlands scrub hypericum are opposite, simple, entire, and needle-like. Flowers are small, bisexual, and arranged in cymes. The calyx consists of five distinct sepals, while the corolla consists of five bright yellow petals that are asymmetrically shaped like the blades of a propeller. There are approximately 27 anthers. The gynoecium has three, sometimes four locules, and the ovary is superior with approximately 22 ovules aligned around the walls of the ovary (parietally). The style has three, sometimes four, white lobes. Fruits are small capsules, red when immature and dark purple at the time of dehiscence. Mature seeds are small and dark brown.

Life History – Because Highlands scrub hypericum has many-flowered stems, a single large plant can have as many as 1,600 reproductive structures (fruits, flowers, or buds) by the end of the reproductive season (Quintana-Ascencio and Morales Hernández 1997). Flowers are exposed one at a time or in small numbers (up to eight per branch) each day. The new flowers open early in the morning and the petals curl up by noon depending on the weather. This species is self-compatible, but the flowers must be visited by pollinators to set seed (Archbold Biological Station 2003). The mature purple capsules remain attached to the stem after releasing seeds. Seeds do not show any obvious primary dispersal mechanism and probably are dispersed passively by gravity.

"Native solitary bees (*Dialictus* spp. and *Augochloropsis* spp.) appear to be the primary pollinators. Other visitors include *Geron* sp., *Copestilium nigrum*, and *Bombus* sp. Pollinator visitation occurs at similar rates regardless of flower or plant density" (Archbold Biological Station 2003, citing Boyle and Menges 2001; M. Evans, personal communication *in* Quintana-Ascencio et al. 1998). Most flowering and fruiting occurs between June and September, coinciding with the rainy season and daily thunderstorms typical of the region. Stems dry at the end of the reproductive season and new ones sprout from the base in late winter and early spring. Germination occurs from November through June, but most seedlings germinate between December and February. Plants reach maturity in as little as a year.

Highlands scrub hypericum inhabits Florida scrub vegetation on upland areas with excessively-drained white sand soil (Judd 1980a). It is almost exclusively found in rosemary balds - patches of bare sand surrounding Florida rosemary within scrub vegetation. It shares these bare patches with a number of other small scrub endemic herbs, grasses, and even a few small shrubs (Christman and Judd 1990). Rosemary balds have a fire frequency from 10 to 100 years (Myers 1990) while the surrounding scrubs have higher fire return intervals. Occasionally, Highlands scrub hypericum occurs in openings in well-drained scrubby flatwoods or with turkey oak on yellow sand soil (P. Quintana-Ascencio, Archbold Biological Station, personal communication, 1995). Where found, it is locally common and can occur in large groups of several thousand individuals (Judd 1980a).

Highlands scrub hypericum is one of a suite of herbs (and a few grasses) that inhabit sunny, sandy gaps between the shrubs that dominate scrub vegetation. Many of these gap-inhabiting species are endemic to the LWR. The gap size requirements of Highlands scrub hypericum appear to be intermediate between those of two other co-occurring rosemary scrub plants: snakeroot, which is restricted to large openings (Menges and Kimmich 1996); and wireweed, which is found in large and small gaps between shrubs (Hawkes and Menges 1995).

Highlands scrub populations have a high degree of genetic differentiation among populations (Menges et al. 2001).

Population Dynamics – Most populations of Highlands scrub hypericum are relatively small. The median size for 34 populations was 539 individuals, and most populations were smaller than 1,000 plants (Menges et al. 1998). A population viability model (Quintana-Ascencio et al. 2003) concluded that "fire kills aboveground individuals, but seeds in the soil survive fire and form long-lived seed banks. Fire suppression and alteration of fire regimes constitute a threat for this species because of its dependence on fire to release local populations from competitive exclusion" (Archbold Biological Station 2003). "After fire in Florida rosemary scrub, *Hypericum cumulicola* [Highlands scrub hypericum] had higher fecundity, survival, establishment, and population growth rates than in unburned populations" (Quintana-Ascencio et al. 2003). This may be due to a number of mechanisms, including killing back of shrubs, removal of lichens, destruction of allelopathic agents that affect seed germination, and the creation of open gaps that may have higher levels of soil water (Quintana-Ascencio et al. 2003). The seed germination rate for this species is extremely low except at recently-burned sites (Quintana-Ascencio et al. 2003).

The most critical life-history stage influencing Highlands scrub hypericum's population growth rate and fitness is seed survival in the soil seed bank. The next-most-important life-history stage is seedling recruitment (Quintana-Ascencio et al. 2003). Massive recruitment of plants in favorable patches and in favorable years allows Highlands scrub hypericum populations to "increase rapidly and/or replenish the soil seed bank. Similar population explosions are documented in other short-lived perennials (Picó et al. 2002) and annual plants with a seed bank (Kalisz and McPeek 1992), which are able to cope with high or unpredictable environmental variation" (Quintana-Ascencio et al. 2003). The survival of Highlands scrub hypericum populations in fire-dependent habitats thus depends on the seed bank, while seedling recruitment is highly variable and depends on environmental cues (Picó et al. 2003).

A population viability assessment model (Quintana-Ascencio et al. 2003) strongly also affirms that fire is essential for Highlands scrub hypericum to persist over the long term. Even the largest populations may be imperiled by fire intervals greater than 50 years. Smaller populations are more vulnerable to lack of fire. These authors consider fire suppression and alteration of fire regimes to constitute threats to this species "because of its dependence on fire to release local populations from competitive exclusion" (Quintana-Ascencio et al. 2003; Quintana-Ascencio and Morales Hernández 1997; Quintana-Ascencio and Menges 2000). In planning fire regimes for scrub, it is important to take into consideration the needs of multiple plant and animal

species. Management that alternates short and long fire intervals may allow species to coexist, while invariant fire return intervals may harm some species (Quintana-Ascencio et al. 2003).

Researchers at Archbold Biological Station have developed spatially explicit disturbance-demographic models of Highlands scrub hypericum. "This spatially explicit, individual-based model improves the precision of prior matrix projections that did not include Florida rosemary or spatial structure. It allows prediction of ranges of Florida rosemary densities that will allow scrub hypericum populations to persist under various fire regimes." The model's predictions agreed with "observed differences in scrub hypericum disappearance among gaps with contrasting rosemary densities but similar times-since-fire," so this modeling approach is likely to prove useful in predicting the effects of fires and other disturbances, including mechanical treatments of overgrown scrub, such as roller-chopping (Quintana-Ascencio et al. 2004).

Status and Distribution – Highlands scrub hypericum has a narrow distribution at the southern end of the LWR in Highlands County. Early inventories of LWR endemic plants found this species at few sites – only 69 of 254 scrub sites surveyed by Christman (1988) (Archbold Biological Station 2003). This severely restricted range, combined with continuing habitat loss, led to its listing.

Highlands scrub hypericum is locally abundant, with populations larger than a thousand plants and presumably large seed banks in the soil at Archbold Biological Station, the properties of the LWR WEA (including Lake Placid, Holmes Avenue, Lake Apthorpe, and Carter Creek), Lake June-in-Winter Scrub State Park, TNC's Saddle Blanket Lakes Preserve, and the Arbuckle tract of LWR State Forest. On these lands, Highlands scrub hypericum has benefited from fire-oriented land management practices and insights provided by the intensive demographic research program at Archbold Biological Station.

Lewton's polygala

The following discussion is summarized from the MSRP (Service 1999), as well as from recent research publications and monitoring reports. A complete Lewton's polygala life history discussion may be found in the MSRP. No critical habitat has been designated for Lewton's polygala.

Description – Lewton's polygala is a relatively short-lived (5 to 10 year) perennial herb. Each plant produces one to several annual stems, which are spreading, upward-curving or erect, and are often branched. The leaves are small, sessile, rather succulent, broader toward the tip, and are borne upright, tending to overlap along the stem, like shingles. The normally opening flowers are in erect, loosely flowered racemes about 1.5 cm (0.6 inch) (Wunderlin et al. 1981b) or 3.3 cm (1.3 inches) long (Weekley 1996b). The flowers are about 0.5 cm (0.2 inch) long and bright pink (Wunderlin et al. 1981b) or purplish-red (Ward and Godfrey 1979a). Two of the five sepals are enlarged and wing-like, between which the largest of the three petals forms a keel that ends in a tuft of finger-like projections (Ward and Godfrey 1979a). A variety of insects have been observed visiting Lewton's polygala, but insect pollinators of this plant are unknown

(Weekley 1996b). Above-ground Lewton's polygala flowers are borne from February to May. This species also has short branches that hug the ground and burrow, bearing inconspicuous self-pollinating flowers - a trait that is very important to its life history.

This species is closely related to the widespread *Polygala polygama*, which forms larger clumps and has a longer root, narrower leaves and differently shaped wing sepals.

Life History – This plant has an extremely rare breeding system (amphicarpy), shared with fewer than 100 other plant species, among them several species of *Polygala* (James 1957). It has both above-ground and below-ground flowers, depends on pollinators, and is dispersed by ants. The below-ground flowers are cleistogamous (closed and self-pollinating), yet "fruit yield [is] significantly lower in flowers denied access to pollinators" (Menges and Weekley 2004; Archbold Biological Station 2003). The cleistogamous flowers have been to exist in two slightly different forms (L. Miller, Ocala NF, personal communication, 1996; Weekley 1996b).

Eighty-five to 100 percent of above-ground flowers set fruit. This high percentage of fruit suggests these plants are self-pollinators (Weekley 1996b).

Several species of ants collect Lewton's polygala seeds, but the fate of these seeds is not yet known, despite recent experiments conducted by Archbold researchers.

Weekley and Brothers (2005) observed that a species like Lewton's polygala should have a high degree of reproductive assurance, thanks to having both obligately-selfing (cleistogamous) and open-pollinated (chasmogamous) flowers, combined with a possible mechanism to guarantee delayed autonomous self pollination - something that is expected to be advantageous, because even if inbreeding depression occurs, at least viable seed is produced. To test these assumptions in Lewton's polygala, the researchers used pollinator-exclusion experiments. They followed flower development daily from breaking of the buds to flowering or fruit abscission. They also watched pollinators to "assess the likelihood of pollinator limitation." Insect visitation rates were low, suggesting that the species may be pollinator-limited. In flowers where pollinators are excluded, they found significant reductions in fruit initiation and fruit set.

Weekley and Brothers used microphotographs to evaluate the effectiveness of the selfing mechanism. They found that the mechanism that presumably ensured selfing "is largely dysfunctional, leading to the erosion of reproductive assurance." In both pollinators-excluded and open-pollinated flowers, fruit initiation and fruit set were significantly lower in flowers located near the apex of the raceme than in flowers near the base, which suggests that a shortage of resources may limit reproduction. "Reproductive assurance" is critically important to short-lived plants.

Population Dynamics – Demographic data on Lewton's polygala has been collected by Carl Weekley and others at Archbold Biological Station as part of a project to introduce Florida ziziphus to the Carter Creek tract of LWR NWR. The data show that fires stimulate seed germination and cause large short-term increases in the sizes of populations (Archbold

Biological Station 2003). An earlier study (Greenberg et al. 1995) found this species in disturbed areas on the Ocala NF, but did not obtain information on its response to disturbance.

Archbold Biological Station ecologists have followed several populations at LWR State Forest since 1996, and added a large additional study site at the Carter Creek sandhill tract of LWR NWR. The Carter Creek site, which underwent a prescribed fire (in preparation for introduction of the endangered Florida ziziphus), has yielded demographic data on Lewton's polygala, scrub plum, and scrub buckwheat (Menges et al. 2005). In the case of Lewton's polygala, they have conducted quarterly demographic monitoring.

Prescribed fire experiments at the Carter Creek tract of LWR NWR, a "degraded sandhill" that had gone unburned for some 60 years, was subjected to fires in 1996, July 2001, and May 2004. The 2001 fire produced a spectacular population boom, with populations increasing "by at least two orders of magnitude." This created problems for researchers because "high plant densities in some postburn plots made it impossible to follow individual plants, but by March 2004, mortality had reduced densities" to the extent that it was possible to collect size and fecundity data on these plants of known age (Menges and Weekley 2004). The Archbold biologists found that quarterly monitoring of seedling cohorts at this site "continues to demonstrate greater survival of plants from burned than from unburned quadrats. However, in the March 2004 census unburned quadrats outstripped burned quadrats in seedling recruits by five to one, suggesting that the beneficial effects of fire on recruitment is short-lived and that fire may temporarily deplete the soil seed bank" (Menges and Weekley 2004). A prescribed fire conducted in May 2004 was not very "successful," in the sense that it burned only 44 of 220 quadrats that had been laid out. Monitoring of this site will continue.

Monitoring by TNC at the Tiger Creek Preserve presents a similar picture-even with regular fire management, patches of Lewton's polygala often diminish or disappear within 5 years, so biologists keep on the lookout for new patches.

Status and Distribution – Lewton's polygala occurs in sandhill (high pineland) vegetation and Florida scrub of the Lake Wales and Mount Dora ridges in Highlands, Polk, Osceola, Orange, Lake, and Marion Counties of central Florida. The largest occurrence is at the Carter Creek tract of LWR NWR. It also occurs on LWR State Forest (Arbuckle and Walk-in-the-Water), Allen David Broussard Catfish Creek Preserve State Park, TNC's Tiger Creek Preserve, Pine Ridge Preserve at the Historic Bok Sanctuary, and Highlands Hammock State Park. It is present at the 120-acre Flat Lake tract of Seminole State Forest in Lake County southeast of Clermont (Schultz et al. 1999; FNAI 2005), which was purchased by TNC in 1999 (Finkelstein 1999). Finally, the species is present and locally moderately abundant at widely scattered localities on the Ocala NF in Marion County. Lewton's polygala is likely to be stable or increasing on conservation lands of the LWR, thanks to prescribed fires.

At TNC's Tiger Creek Preserve, numerous individuals of Lewton's polygala are scattered throughout the wiregrass sandhill and fire-maintained scrubby flatwoods. TNC has monitored this species since 1991 and has found that fire is crucial for the maintenance of this species. The

10-year trend for this species at Tiger Creek is stable. However, even with regular fire management, patches of Lewton's polygala often diminish or disappear within 5 years; therefore, new patches are constantly looked for to include in the monitoring program.

On the Ocala NF, Lewton's polygala may have experienced some degree of range expansion due to artificial fire regimes (Clutts 1995). The practice of winter burning may have allowed Lewton's polygala to expand its distribution from scrub vegetation into sandhill (longleaf pine). Winter burns prohibit the sexual reproduction of wiregrasses in the sandhill habitat and have resulted in an increase in the openings that would have naturally occurred in this habitat. Open areas favor establishment and persistence of Lewton's polygala. Most of the known localities for Lewton's polygala on the Forest were identified after prescribed fire or other disturbances, which presumably caused short-term population booms. Thus, when Service personnel visited known localities with Forest Service personnel in July 2004, it was not unexpected to see indications of modest population declines in the absence of further fire.

Lewton's polygala co-occurs with several other federally listed plants: clasping warea in sandhill vegetation in central Florida; Carter's mustard in sandhill farther south; Florida ziziphus in sandhill (high pineland); and pygmy fringe tree, scrub buckwheat, Britton's beargrass, and scrub plum in scrub, sandhill, and the ecotones between these habitats.

Papery whitlow-wort

The following discussion is summarized from the MSRP (Service 1999), as well as from recent research publications and monitoring reports. A complete papery whitlow-wort life history discussion may be found in the MSRP. No critical habitat has been designated for the papery whitlow-wort.

Description – Papery whitlow-wort is a small mat-forming herb with many bright yellowish-green branches radiating flatly from a taproot (Kral 1983; Small 1933). The stems are 5 to 20 cm (2 to 8 inches) long and are wiry. The leaf blades are sessile, 1.5 to 3.0 mm (0.06 to 0.12 inch) long, ovate to triangular-ovate in shape, and strongly revolute. The plant has numerous small cream-colored to greenish flowers (Small 1933; Service 1996) that produce a very thin-walled one-seeded dry fruit that remains intact, functioning as a seed (Kral 1983).

This species consists of two geographically isolated subspecies, with papery whitlow-wort (*Paronychia chartacea* ssp. *chartacea*) in the Florida peninsula (Anderson 1991; Hartman et al. 2005) and a distinct subspecies, Crystal Lake nailwort (*P. chartacea* ssp. *minima*) in the Florida panhandle. This discussion is limited to the peninsula subspecies. Papery whitlow-wort is easily identified, especially where it forms large populations in the scrub. However, another species, American nailwort (*Paronychia americana*) is present throughout its range, and has been confused with it.

Life History – Flowering and fruiting occur in late summer or fall (Anderson 1991) and the seeds mature in September or October (T. Race, Bok Tower Gardens, personal communication, 1996). This species is a short-lived perennial (Anderson 1991 and observations by staff at the Historic Bok Sanctuary). Seed germination is not affected by the allelopathic effects of Florida rosemary (Hunter and Menges 2002). Seed germination is during the winter as is typical for scrub plants, and can be very low during droughts. Biological soil crusts provide the most favorable germination conditions during drought conditions. These crusts develop in the years between fires (Hawkes 2004). Loose sand may also affect germination (Petrů and Menges 2004), as discussed in the next section.

Population Dynamics – Papery whitlow-wort is most frequently seen in open, sunny gaps in rosemary balds within scrub vegetation (Abrahamson et al. 1984; Christman 1988; Menges and Kohfeldt 1995). At Archbold Biological Station, rosemary scrubs are found only on the higher ridges and knolls surrounded by scrubby flatwoods with dense oaks. The main soil types are St. Lucie and Archbold (Abrahamson et al. 1984), which are both well-drained white sands (USDA-SCS 1989). The fire return interval in rosemary scrub can range from 10 to as long as 100 years (Johnson 1982; Myers 1990). Rosemary scrub has rosemary and scrub oaks including Chapman oak, sand live oak, Archbold oak, and occasional sand pine. The open sandy areas of rosemary scrub contain small herbs and lichens (Abrahamson et al. 1984; Hawkes and Menges 1996). These gaps in the dense vegetation are more persistent in rosemary scrubs than in scrubby flatwoods (Hawkes and Menges 1996).

Papery whitlow-wort has also has been reported from sandhill (high pineland) vegetation in the Walk-in-the-Water tract of LWR State Forest (A. Cox, DOF, personal communication, 2002) and at TNC's Crooked Lake Sandhill Preserve (B. Pace-Aldana, TNC, letter correspondence, 2002) as well as at the Tiger Creek Preserve, where it is confined to disturbed areas and pond margins (B. Pace-Aldana, TNC, letter correspondence, 2005).

Weekley and Menges (2003a, 2003b; Menges and Weekley 2004) confirmed the earlier findings of Johnson and Abrahamson (1990) and Ostertag and Menges (1994) that this plant is killed by fire and returns to the vegetation from seed. Johnson and Abrahamson (1990) had found that papery whitlow-wort appeared in rosemary balds after fires, even though it had been rare or absent prior to the burn. This strongly indicates that papery whitlow-wort maintains seed banks in the soil, waiting for suitable germination conditions. Within about 9 to 12 years after a fire, papery whitlow-wort was displaced by Florida rosemary and reindeer lichens (*Cladonia* and *Cladina*). Quintana-Ascencio and Menges (2000) showed that some gap plants such as snakeroot and Highlands scrub hypericum disappear relatively quickly after fires. To persist, these plants require large populations consisting of tens of thousands of individuals. Papery whitlow-wort persists longer after fire, which could reduce the population sizes needed for population viability. It also has many large populations over a relatively large geographic range, compared to other LWR endemic plants.

The density of papery whitlow-wort increases in relation to available open space (Hawkes and Menges 1996; Menges and Kohfeldt 1995), so the species is most abundant in disturbed, sandy areas such as road rights-of-way and recently cleared high pine (Abrahamson et al. 1984; Christman 1988; Service 1996). Papery whitlow-wort can become very abundant after a fire or on disturbed sites such as along fire lanes or trails (Service 1996; Johnson and Abrahamson 1990) and is the last of the federally listed herbaceous scrub plants that are restricted to open areas to suffer local extirpations as open areas become covered by shrubs.

Loose sand affects papery whitlow-wort. According to research by Petrů and Menges (2004) comparing natural bare areas within scrub vegetation to artificially disturbed roadsides, "the demographic responses of the species to sand movements indicate that mobile sands create constantly shifting arrays of microsites that can influence post-dispersal seed germination, survival, and growth of Florida scrub herbs. Roadside habitats have more dynamic patterns of sand movement than natural gaps and may alter selection regimes important for demographic variation of endemic Florida scrub plants." This research supports other evidence that roadsides and other artificially disturbed areas may not constitute desirable substitutes for open areas in fire-maintained vegetation. Management for papery whitlow-wort requires burning regimes that mimic the natural fire cycles of rosemary scrub.

Status and Distribution – Papery whitlow-wort occurs in Highlands, Polk, Osceola, Orange, and Lake Counties (Anderson 1991). It is present on the LWR (Kral 1983) and at least one smaller nearby ridge at the Lake McLeod tract of LWR NWR. It is not present on the Bombing Range Ridge (Avon Park Air Force Range). It is present on essentially all of the LWR scrub conservation lands. Since the last comprehensive survey (Schultz et al. 1999), it has been found in sandhills (high pineland) vegetation at the Walk-in-the-Water tract of LWR State Forest (A. Cox, DOF, personal communication, 2002). It is also present at pond edges and in disturbed areas in sandhills on the Tiger Creek Preserve, owned by TNC (B. Pace-Aldana, TNC, letter correspondence, 2005).

The northern range limit of papery whitlow-wort is in Lake County, where it occurs on the north side of Lake Louisa at Crooked River Preserve, owned by the Lake County Water Authority. It was possibly present at a nearby site, Schofield Sandhill. The only site on conservation lands in Orange County (also at the northern range limit) is the small Shadow Bay Park (formerly Lake Cane-Marsha Park) near where the Florida Turnpike crosses Interstate 4. The species was reported from localities in western Orange County, but the area has since become urbanized, and there are few if any opportunities for setting aside conservation lands in this area. The only papery whitlow-wort site in Osceola is Lake Davenport, in the northwestern corner of the County (FNAI 2005). The southernmost sites on conservation lands are Gould Road (part of the LWR WEA operated by FWC) and Archbold Biological Station, both in Highlands County south of Lake Placid (Schultz et al. 1999).

During 2003, the State and Archbold Biological Station purchased portions of the McJunkin ranch that bordered the Biological Station's preserve to the west. The recently-acquired land adds more scrub to the LWR WEA and provides a buffer for Archbold.

While FNAI data provide an overall view of the distribution of this species, intensive local inventories add important detail. The LWR State Forest is represented in the FNAI database by nine element occurrences, yet the Forest's Arbuckle tract has 188 records of this plant in its GIS database, mostly from a 1988 inventory. Of the 188 records, 23 represented more than 100 individuals (data collected by K. DeLaney, provided by A. Cox, LWR State Forest).

Archbold Biological Station has not monitored this plant because it thrives in fire lanes that usually are not threatened by invasive exotic plants (E. Menges and M. Deyrup, Archbold Biological Station, personal communication, 1995, *in* Service 1996). However, the propensity of this species to occupy fire lanes, roadsides, and other artificially disturbed areas is a conservation concern for the papery whitlow-wort, because it tends to be far more abundant in such disturbed areas than within the vegetation itself, and these disturbed areas have different physical characteristics than natural ones, including more sand movement, as noted above (Petrů and Menges 2004).

Pigeon wings

The following discussion is summarized from the MSRP (Service 1999), as well as from recent research publications and monitoring reports. A complete pigeon wings life history discussion may be found in the MSRP. No critical habitat has been designated for pigeon wings.

Description – Pigeon wings is a 0.2 to 1 m (0.5 to 3.5 feet) tall, long-lived perennial herb with erect stems. The thick horizontal root, which may grow to more than 2 m (6 feet) long, bears one to several purplish, glaucous, wiry, very straight stems. The somewhat leathery leaves consist of three leaflets. Leaflets of the upper leaves are obtuse at the tip and narrower than those of lower leaves. Pigeon wings has chasmogamous (insect-pollinated) and cleistogamous flowers (small self-pollinating flowers that remain closed). The chasmogamous flowers are usually in pairs, each corolla consisting of one standard petal that is 3.5 to 4.5 cm (1.4 to 1.8 inches) long (Fantz 1977). Isley's (1990) treatment of the pea family in the Southeast gives the standard petal length as 4.5 to 5 cm (1.8 to 2 inches) long. The flower has a small white keel. The common name of this species refers to the petals of the chasmogamous flowers, which resemble wings (Fantz 1979).

Flowers of the pigeon-wings genus *Clitoria* are easily recognizable because their pale purple flowers are inverted–upside down, compared to other members of the pea family (Fantz 1979). The inverted position of the flowers allows the anthers and stigma to touch the backs of visiting insects. The only other legume genus with inverted flowers is butterfly pea (*Centrosema*), with two species in central Florida.

The seed pod (legume) is 5 to 8 cm (2.0 to 3.1 inches) long and extends from the calyx (Fantz 1979). Pigeon wings can be confused with the other Florida species in the genus, *C. mariana*, but pigeon wings is distinguished by having purplish, glaucous stems, non-twining habit, narrow leaflets, smaller flowers, and long-stipitate fruits (Fantz 1977). Technical descriptions are also

available in Isley (1990) and Kral (1983). Dr. Paul Fantz of North Carolina State University is preparing the treatment of this genus for the Flora of North America.

Life History – Pigeon wings has two distinct kinds of flowers, insect-pollinated and self-pollinated. The former hosts insects in May to June while the latter initiates seeds in summer through late September.

Though this species may exist in a continuum of scrub to sandhill (high pineland) vegetation, it is most prevalent in intermediate vegetation called turkey oak barrens by Christman (1988). Christman and Judd (1990) reported the species from scrub, turkey oak barrens, and the edges of high pines. Others report pigeon wings from scrubby sandhills, more like hickory-dominated scrub (which could also be called the hickory phase of high pineland) (E. Menges, Archbold Biological Station, personal communication, 1997). Bea Pace-Aldana (TNC, letter correspondence, 2005) reports that a few plants are even present in small gaps in long-unburned xeric hammock. Apparent disagreements about this plant's habitat may demonstrate limits to developing and applying consistent terminology to describe a complex mosaic of vegetation, especially in a part of Florida where most of the sandhill vegetation was destroyed early in the twentieth century, making way for citrus groves. TNC at Tiger Creek Preserve and the Service at the Carter Creek tract of LWR NWR are restoring prescribed fire to turkey oak barrens, and are finding, especially at Tiger Creek, that wiregrass is increasing and the vegetation is becoming more like a classic sandhills.

There has been some disagreement about the plant's preference for white sand soils versus yellow sand soils. As mentioned above, the species has been found in turkey oak barrens and scrub hickory, both of which occur on yellow sand soils. At Tiger Creek Preserve, it is on yellow sand (B. Pace-Aldana, TNC, letter correspondence, 2005). However, Fantz (1979) regarded pigeon wings as a species of white sand soils. The species has been seen in white sand scrub at Carter Creek in Highlands County, and has been noted in the LWR State Forest on both white (Archbold) and yellow (Tavares) sands (C. Weekley, DOF, personal communication, 1998).

Population Dynamics – Pigeon wings has been monitored on the LWR State Forest (Weekley 1996c). It is an intermediate resprouter after fire. About 48 percent of the plants in study plots reappeared after fire (Weekley and Menges 2003a, 2003b; Menges and Weekley 2004). In this vegetation, plant species range from being strong resprouters, invariably reappearing after fires, to non-resprouting species that are invariably killed. Individual plants of pigeon wings appear to be relatively long-lived, based on their responses to fire.

Status and Distribution – Pigeon wings has apparently never been abundant in its central Florida range, possibly because intermediate pine/scrub habitat was not a widespread type of vegetation. This species has never been observed in large numbers. Typically, groups of 20 to 30 are found per site. The species is known from about 40 occurrences on private and protected lands. Among them are:

- The 120-acre Flat Lake tract of Seminole State Forest in Lake County, southeast of Clermont (Schultz et al. 1999; FNAI 2005), which was purchased by TNC in 1999 (Finkelstein 1999);
- TNC's Tiger Creek Preserve, where it is locally abundant in sandhill vegetation;
- Avon Park Air Force Range;
- Walk-in-the-Water and Lake Arbuckle tracts of LWR State Forest. Few plants were noted in areas of the Arbuckle tract in 2002-2004 that needed fire, raising concern over possible population decline (Cox 2004);
- Horse Creek scrub, owned by SFWMD;
- Saddle Blanket Lakes Preserve (TNC);
- Carter Creek, Lake Placid, and Lake Apthorpe tracts of LWR WEA;
- Carter Creek and Flamingo Villas units of LWR NWR; and
- Archbold Biological Station.

Pigeon wings is threatened by conversion of its habitat to agricultural, residential and commercial uses. Other threats are fragmentation of existing populations and habitat degradation by off-road vehicle use, trash dumping, and trampling.

Conservation of this plant depends largely on conservation lands that have been acquired to protect distinctive scrub and sandhill vegetation on the LWR. Acquisition of a neighboring ranch by the private Archbold Biological Station in 2003 may have benefited pigeon wings. Hurricane Charley brought at least category 2 winds to Polk County in the vicinity of Lake Wales, but the storm did minimal damage to upland native vegetation in the range of pigeon wings (broken branches, snapped sand pines, and a few snapped longleaf pines; shrubs and herbs were generally unaffected).

According to information presented at recent meetings of the LWR Ecosystem Working Group in 2003-2004, Old World climbing fern (*Lygodium microphyllum*) is not yet a severe problem in uplands, but it is appearing in wetlands, including some severe infestations. There is concern that the hurricanes of 2004 may have spread its spores. Natal grass (*Rhynchelytrum repens*) is spreading, and Carl Weekley of Archbold Biological Station (personal communication, 2004) suggests that its spread appears to be facilitated by the construction of fire lines and operation of mechanical equipment in fire management.

Pygmy fringe tree

The following discussion is summarized from the MSRP (Service 1999), as well as from recent research publications and monitoring reports. A complete pygmy fringe-tree life history discussion may be found in the MSRP. No critical habitat has been designated for the pygmy fringe-tree.

Description – Pygmy fringe tree is a shrub or small tree that is often less than 1 m (3 feet) tall, but can reach 4 m (12 feet). The twigs are opposite or sub-opposite and stiff, while the leaf scars and leaves are mostly opposite but sometimes alternate. The leaves are simple, mostly 3 to 10 cm (1 to 4 inches) long, and lacking stipules. They have short petioles and the somewhat leathery

blades are ovate to elliptic or obovate in shape, with the tips acute to rounded. The base of the blade is attenuated to the petiole. The upper surface of the blade is dark yellow-green and smooth, but the lower surface is paler and reticulate. The inflorescence is a leafy-bracted panicle that appears with the new shoots from the axils of most leaf scars from the previous season. The axis (main stem) of the inflorescence is rather short with numerous opposite branches that are spreading, slender and dropping, terminating in clusters of three to six flowers. Bracts toward the base of the inflorescence are similar to, but smaller than, the leaves. The flowers are regular, perfect and pleasingly fragrant. The four sepals are green, united at the base, and 1.5 to 2.0 mm long. The four petals are white, united at the base to a short, campanulate throat, with narrowly linear lobes, 1.0 to 1.5 cm long and somewhat spreading. The two stamens are fused (adnate) to the corolla base. The ovary is superior with a single style. The fruit is a drupe 2.0 to 2.5 cm long, oval, and green, becoming purplish-brown when ripe.

The pygmy fringe tree is deciduous (*i.e.,* leafless during the winter). Leafing occurs mid-March, budding occurs in March, and anthesis is from late March to early April. When it is in leaf, pygmy fringe tree may be confused with scrub wild olive (*Osmanthus megacarpus*).

This species was named by Small (1933). Hardin (1974) continued to recognize it as distinct from the much more widespread white fringe tree (*Chionanthus virginicus*), and Elfers (1989) reaffirmed its distinctness in an unpublished masters thesis. The species is recognized by Wunderlin and Hansen (2003, 2005).

Life History – Pygmy fringe tree inhabits excessively drained sandy soils on central Florida's LWR (and historically on the Mount Dora Ridge, Orange County). This species is found on low-nutrient St. Lucie fine sand soil which is subject to rapid drying (Wunderlin et al. 1981a), as well as other dry sand soils. Pygmy fringe tree occurs primarily in scrub as well as high pine, dry hammocks, and transitional habitats. It is abundant at a few sites, where it may form thickets along with evergreen oaks and other shrubs such as tallow wood, silk bay, and scrub hickory. In some locations, it may be the dominant plant while in others it may be codominant or subdominant (Wunderlin et al. 1981a). At Carter Creek, where it is relatively abundant, it is scattered among turkey oaks.

Although the reproductive biology of this species has not been thoroughly investigated, it is known to spread by root sprouts and occasionally by seed (Stout In Press a). The plants appear to be functionally dioecious (Gill and Pogge 1974), and the female flowers have stunted anthers that usually do not open (Goodrum and Halls 1961). The four plants in the endangered species display garden at the Historic Bok Sanctuary (2 males, 2 females) flowered and set seed in 1997 (Center for Plant Conservation 2003). After spring flowering, fruiting probably occurs in June, with seed dispersal in September (Gill and Pogge 1974; Ward and Godfrey 1979b). Seeds (drupes) may remain on the plants well into winter (Stout In Press a).

Little is known about seed dissemination of pygmy fringe tree, and seed production is variable from year to year, with mixed reports for success of germination. In nursery conditions the best results are obtained with cleaned, air-dried seed, but whole fruits have also germinated. Bok

Tower Gardens has achieved 60 to 70 percent germination rates under greenhouse conditions (T. Race, Bok Tower Gardens, personal communication, 1996).

Germination dates for pygmy fringe tree are unknown. Leafing occurs mid-March, budding occurs in March, and anthesis is from late March to early April. Recruitment is exceedingly slow in this species. At TNC's Tiger Creek Preserve (Possum Creek Trail Scrub), over 100 pygmy fringe trees have been tagged and monitored (I.J. Stout, University of Central Florida, personal communication, 1997). In more than 10 years of monitoring, hundreds of root sprouts were found, but only one seedling was located. Despite this extremely low seedling recruitment, the number of individuals at the site appears to be stable. Due to population stability and this species' reliable resprouting after fires, TNC no longer conducts detailed monitoring on this species (B. Pace-Aldana, TNC, letter correspondence, 2005).

Pygmy fringe tree is long-lived and persists in scrub that is burned on a frequency between 20 and 70 years. Monitoring at LWR State Forest shows that it is a long-lived resprouting species, resprouting after fire events (Weekley 1996d, 1999). Its above-ground stems grow from rootstocks or buried stems that survive the fires that are characteristic of the habitat (Kral 1983; Ward and Godfrey 1979b). It has been observed to resprout from rootstocks following a spring burn (Stout In Press a). Fires may have an important indirect effect on pygmy fringe tree by regulating the numbers and sizes of plants that might shade or otherwise compete with it (Kral 1983).

In the spring and summer of 1997, TNC burned sandhill vegetation containing pygmy fringe tree at Tiger Creek Preserve and the effects of fire on these individuals were monitored (I.J. Stout, University of Central Florida, personal communication, 1997). Burning to restore the sandhill vegetation's original grassy appearance continues and Bea Pace has monitored the results (Center for Plant Conservation 2003).

Pygmy fringe tree is also present at the Carter Creek tract of LWR NWR, where restoration of sandhill is being studied by Archbold Biological Station (Menges et al. 2005). Their results to date "suggest that burning is beneficial for sandhill community structure and the populations of several key species. Chainsawing as a pre-treatment has mixed results depending on the species. …The saw & burn treatment promotes more complete and intense fires" (Menges et al. 2005) and more open post-treatment subcanopies, which may have a number of benefits for restoration of sandhill vegetation and its biota. Subsequent fires may be more effective in areas impacted once with this mechanical pre-treatment to fire."

Status and Distribution – This species is protected on a substantial number of conservation lands, most of them purchased after it was listed. The Service does not have current information on threats because this shrub is considered relatively abundant and secure by managers of the conservation lands of the LWR, so limited funds for monitoring have been devoted to other species. After this plant was listed, an extensive network of state conservation lands and the LWR NWR came into existence, providing habitat and management supported by extensive ecological research and monitoring programs.

Pygmy fringe tree occurs in Seminole, Lake, northwestern Osceola, Polk, and Highlands Counties in central Florida. Wunderlin and Hansen (2005) have recently added the east side of Tampa Bay (Hillsborough, Manatee, and Sarasota Counties) to its distribution. Detailed information on localities and habitats is not yet available.

In central Florida, pygmy fringe tree is known from west of Lake Apopka in Lake County, northwestern Osceola County, and the LWR in Polk and Highlands Counties. It is no longer found in its historic habitat on the Mount Dora Ridge. One of the largest known populations is at the Carter Creek tract of LWR NWR in Highlands County, where it occurs with turkey oak and scattered longleaf pine with an understory with abundant scrub palmetto. Experimental prescribed fires and reintroductions of Florida ziziphus have been conducted here by Archbold Biological Station in a project like the one underway at TNC's Tiger Creek Preserve. Pygmy fringe tree is represented at Tiger Creek Preserve by 13 populations with few to numerous individuals, which have been mapped. Approximately 75 percent of the individuals occur in yellow sand scrub at the extreme northwestern edge of the preserve. The remaining individuals are scattered throughout xeric hammocks. Because of the stability of this plant's populations with and without fire, monitoring consists only of mapping of individuals during complete surveys, which are conducted throughout the preserve every 5 years Bea Pace-Aldana of TNC (letter correspondence, March 2005).

Pygmy fringe tree is protected in Polk County at Horse Creek Scrub (SFWMD and SWFWMD), Snell Creek (LWR NWR), Allen David Broussard Catfish Creek Preserve State Park, Saddle Blanket Lakes and Tiger Creek Preserves (TNC), Arbuckle and Walk-in-the-Water tracts of LWR State Forest; and in Highlands County at Flamingo Villas (LWR NWR) and Lake Apthorpe (LWR WEA). It is maintained as part of the National Collection of Endangered Plant Species at Bok Tower Gardens.

Pygmy fringe-tree was searched for on the LWR State Forest in 1988 (DeLaney 1988). Weekley (1996a) found only 12 plants on the Arbuckle Tract west of School Bus Road and 10 plants east of the road. In surveys conducted by Anne Cox in 2002 and 2003, many of Weekley's 22 tagged plants were relocated and others were found in burn units (numbered LA02, RC01, and SH04). In surveys conducted at flowering time in March and April 2003, 279 seedlings and saplings were observed in the RC09 burn unit. This was probably the first confirmation of seedlings occurring in the wild. At the Arbuckle tract of the State Forest, most pygmy fringe trees are at the edges of scrub adjoining a wet habitat, while in the Walk-in-the-Water tract, fringe trees are in hickory scrub, as they are at the Tiger Creek Preserve (Cox 2004).

Information is being gathered on the effects of hurricane Charley in August 2004. The LWR State Forest near Avon Park, Florida suffered only minor wind damage to the vegetation and facilities were undamaged. Scrub at Hickory Lake County Park and Saddle Blanket Lakes Preserve suffered minor wind damage, including fallen oak limbs and snapped sand pines. In general, the shrub layer was unaffected. Plants in cultivation at the Historic Bok Sanctuary survived, although nearby buildings were heavily damaged.

Sandlace

The following discussion is summarized from the MSRP (Service 1999), as well as from recent research publications and monitoring reports. A complete sandlace life history discussion may be found in the MSRP. No critical habitat has been designated for sandlace.

Description – Sandlace is a sprawling shrub with zigzag branches that tend to hug the ground, rooting at the nodes (Wunderlin et al. 1980d) and 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. Sandlace has the sheathing leaf stipules (ocreae and ocreolae) typical of the jointweed family. The leaves are needle-like and are from 0.3 to 10.0 mm (0.1 to 0.4 inches) long. The small, white or cream colored flowers have white petal-like sepals up to 3.4 mm (0.1 inch) long (Kral 1983). It flowers and fruits all year.

Sandlace, a member of the jointweed family (Polygonaceae), is one of three species of *Polygonella* that occur in Florida scrub in Highlands and Polk Counties of south central Florida (Lewis and Crawford 1995). While the species have rather similar inflorescences and flowers, the shrubby habit of sandlace is extremely distinctive.

Life History – Sandlace occupies open, sandy areas within the scrub vegetation and appears to require fire or other disturbances that create or maintain these sandy gaps. This species is killed by fire and reoccupies burned sites from seed (P. Quintana-Ascencio, Archbold Biological Station, personal communication, 2004). Surveys at TNC's Saddle Blanket Lakes Preserve in fire-suppressed scrub revealed that this species occurred less frequently on long-unburned areas with few open sand "gaps" in the vegetation.

Weekley and Menges (2003a) confirmed that sandlace does not resprout after fire, but recolonizes burned areas from seed arriving from unburned areas, and perhaps by spreading from unburned areas. Pollinators of sandlace are genus-specific bees and likely a few varieties of wasps. Little is known about seed production and germination for this species, but seedlings do not survive in the vicinity of the mature plants, which are allelopathic, meaning they produce chemicals that inhibit the growth and survival of other nearby plants (Weidenhamer et al. 1989). The major allelochemicals are gallic acid and hydroquinone (Weidenhamer and Romeo 2004). Most of the available information on the life history of this plant comes from a study of cutting and burning of scrub (Quintana-Ascencio et al. 2004). The study has emphasized the value of disturbance (fire or mechanical) in this ecosystem. Although fire kills individual plants, sandlace benefits from fires or other disturbances that create sandy gaps that can be occupied by new plants that grow from seed. Like most other LWR endemics, sandlace is threatened by fire suppression and habitat loss resulting from agricultural and residential development (Service 1999).

Population Dynamics – Because sandlace is a sprawling clonal shrub, with plants taking root where their stems touch the ground (Wunderlin et al. 1980d), individuals may spread significant distances by vegetative means. For this reason, it is difficult to identify genetically-distinct

individuals (P. Quintana-Ascencio, Archbold Biological Station, personal communication, 2004). Despite being a narrow endemic, it has the highest within-population genetic diversity of any species in the genus *Polygonella*, which includes several very widespread species (Lewis and Crawford 1995). Its abundance can easily be overestimated, because it tends to colonize disturbed areas along easily accessible road cuts and rights-of-way.

Little is known of the population biology of this species. Based on work on other scrub species, such as wireweed (Boyle et al. 2003), it is clear that the bare sand areas (gaps) occupied by sandlace fluctuate dramatically in size, expanding after a fire and contracting until the next fire. As a result, sandlace probably has metapopulation dynamics, with local populations in gaps expanding after fire and potentially going extinct, either as a result of a long interval between fires or the fires themselves.

Status and Distribution – Sandlace's range is from Orange County south through Highlands County in scrub vegetation. It occurs near Interstate 4 in Orange County and at one site in northwestern Osceola County. In Polk County, sandlace is found on the LWR from the Davenport-Poinciana area. It is also found well west of the LWR in a highly altered area just southeast of Bartow. In Highlands County, sandlace is found on the LWR as far south as the Archbold Biological Station. Because it is so easily recognized, the early status surveys of scrub (Christman 1988) provided very accurate coverage of its distribution.

Sandlace is present on the following scrub properties acquired, or under acquisition, for conservation purposes. Areas of tracts (in acres) were obtained from the FNAI database 2001 and then updated through the FNAI website in November 2004:

- The Allen David Broussard Catfish Creek Preserve State Park comprises 3,268 ha (8,077 acres) operated by Florida Department of Environmental Protection (DEP). It has a management plan, active fire management with annual requests for prescribed burning, and rare plant monitoring;
- Hickory Lake Scrub County Park is a 23 ha (57 acre) tract owned by Polk County. It has a management plan, prescribed fire management, and rare plant monitoring;
- Saddle Blanket Lakes Preserve comprises 335 ha (829 acres) and is owned by TNC;
- Sun Ray Scrub is 109 ha (270 acres) and is a component of the LWR WEA;
- LWR State Forest, operated by DOF, consists of several tracts – Arbuckle, Walk-in-the-Water, Babson/Hesperides, and Boy Scout. Collectively, they cover 10,719 ha (26,488 acres). Weekley (1996e) reported monitoring of sandlace from this site. DeLaney found 380 individuals at Arbuckle in 1988. Cox (2004) found 484 plants at 42 sites at Arbuckle in 2003 and 20 at 2 sites at Boy Scout;
- The LWR NWR, owned by the Service, consists of the Lake McLeod and Snell Creek units in Polk County and the Carter Creek and Flamingo Villas units in Highlands County. They comprise 744 ha (1,839 acres);
- The LWR WEA, administered by FWC, consists of 12 tracts, totaling over 6,543 ha (16,167 acres). The tracts include Blue Lake, Silver Lake, Carter Creek, Henscratch, Highlands, Royce, Lake Apthorpe, Lake Placid, and McJunkin;

- The Preserve, operated by Highlands County, comprises 559 ha (1,380 acres), in part, longleaf pine vegetation. Sandlace is probably present, but not confirmed;
- Highlands Hammock State Park comprises 3,743 ha (9,251 acres). It has been expanded to include scrub;
- Jack Creek, comprising 520 ha (1,285 acres), is owned by the SWFWMD. It adjoins the Henscratch Road/Jack Creek tract of the LWR WEA;
- Lake June-in-Winter Scrub State Park, located on the lake, comprises 342 ha (846 acres); and
- The private Archbold Biological Station comprises over 3,592 ha (8,877 acres). Sandlace is present, but rare.

Sandlace has benefited from the extensive State and private land acquisition programs on the LWR since it was listed and it appears to be benefiting from prescribed fire programs on these lands. A range-wide survey is being conducted in winter 2004-2005.

Scrub blazing star

The following discussion is summarized from the MSRP (Service 1999), as well as from recent research publications and monitoring reports. A complete scrub blazing star life history discussion may be found in the MSRP. No critical habitat has been designated for scrub blazing star.

Description – Scrub blazing star is a member of the aster family. Blazing stars are native to much of the eastern United States and some species are popular garden perennials and cut flowers. Scrub blazing star is attractive enough to have been tested for use as a cut flower.

Scrub blazing star is a long-lived perennial herb with a thickened, cylindric root (corm). Its stems are erect, usually unbranched, and it can grow up to 1 m (3 feet) tall. Its leaves are fleshy and narrow, 1.0 to 2.5 mm (0.04 to 0.10 inch) wide, and generally 3 to 8 cm (1 to 3 inches) long (Wunderlin et al. 1980b). Flower heads are well separated on the stem and are up to 3 cm across. They consist entirely of disc flowers, without the ray flowers that provide the petals for daisy-like flower heads. The corollas of the disc flowers are bright purplish-pink in color. The broad, separated flower heads and narrow leaves distinguish scrub blazing star from the eight other *Liatris* species in central Florida.

Life History – Peak flowering of scrub blazing star is from June through August. Seed heads mature from late July through October (Dolan et al. 1999). Flowering stems die after seed dispersal and "production of flowering stems does not seem to occur in plants younger than two years old." (Archbold Biological Station 2003).

Scrub blazing star flowers produce nectar and are purple, so they were expected to be butterfly-pollinated. Observation of flowers showed that insect visits were infrequent and were mostly between 11 a.m. and 3 p.m. The most common visitors were butterflies: skippers (Family Hesperiidae), sulfurs (Pieridae), and swallowtails (Papilionidae). At the observation site, which had a high density of scrub blazing star, butterflies were seen with pollen on their bodies and

were observed moving among plants of scrub blazing star, rather than going to flowers of other species (Evans et al. 2003). Scrub blazing star requires cross-pollination to reproduce (Dolan et al. 1999), and it may be pollinator-limited. Seedling germination is "temporally and spatially patchy" and seedlings grow slowly (Dolan et al. 1999).

Scrub blazing star is found in sunny openings, usually fire-maintained Florida rosemary bald habitats and adjoining scrubby flatwoods, but it is notable among LWR endemic plants for not being restricted to open, sunny areas. Herndon (1996, 1999) found that scrub blazing star has specific microhabitat requirements, notably a preference for shade. Unlike most other scrub endemics, scrub blazing star appears to thrive in lightly shaded areas. Twenty-five percent of scrub blazing star plants are found in open areas in direct sun, 25 percent along the edges of canopies in partial shade, and 50 percent under canopies of other rosemary bald vegetation.

Scrub blazing star occupies scrub "with both relatively short (scrubby flatwoods < 10 years) and relatively long (rosemary scrub > 20 years) fire return intervals" (Archbold Biological Station 2003). Generally, scrub blazing star is found in relatively high densities on the lower slopes of rosemary balds especially where low, thin-canopied scrub oaks (Chapman oak, sand live oak, and scrub oak) or patches of scrub palmetto and saw palmetto dominate the vegetation and where patches of open sand exist. These habitat conditions are also frequently found under individual sand pine crowns, but never in dense groves of sand pines. Over periods of years, however, shady microhabitats are not fixed within rosemary balds. Large-scale disturbance such as intense fire may decrease the amount of shade, at least temporarily until larger shrubs regrow.

Experiments indicate that scrub blazing star seed germination did not differ with distance to Florida rosemary plants (which are known to inhibit seed germination of other species), but that germination is lower in full shade or in the presence of rosemary litter (Hunter and Menges 2002). Germination also appears unaffected by the presence of ground lichens (*Cladina evansii*). A clip-and-burn experiment has been initiated. Most of the plants resprouted within a month of the treatments, and the plants are continuing to be monitored to see whether fire benefits scrub blazing star (Menges and Weekley 2004). This research is crucial for guiding the management of conservation lands and it also recognizes that the future of this species lies primarily on conservation lands and that the single most important management issue on such lands is the use of prescribed fire to mimic the historic fire regimes.

Population Dynamics – Experiments indicate that scrub blazing star seed germination did not differ with distance to Florida rosemary plants (which are known to inhibit seed germination of other species), but that germination is lower in full shade or in the presence of rosemary litter (Hunter and Menges 2002). An experiment begun in 2003 is investigating post-germination establishment and survival. Within six rosemary sites, 1,260 seeds were planted along transects between November 18 and 20, 2003. The first germinants were seen on December 10 and by December 29 (about 5 weeks after planting), 245 germinants had appeared. By July 2004, 277 had germinated. Germination peaked between 33 and 41 days post-planting. Overall, percent germination differed only slightly between recently-burned sites (less than 12 years since fire) and long-unburned (more than 30 years) (51 percent versus 46 percent, respectively).

Inhibition of scrub blazing star seedlings by rosemary appears to be weak and is present mainly near the rosemary plants at long-unburned sites and especially on the south side of a rosemary plant. A significantly lower percentage of seed germinated in full shade than in partial shade or full sun. Germination was also lower at test sites with rosemary litter (Menges and Weekley 2004). Germination also appears unaffected by the presence of ground lichens (*Cladina evansii*). Overall, germination experiments show that scrub blazing star germination is high under a variety of conditions and is inhibited little if at all by chemicals from Florida rosemary or lichens. Germination may be physically inhibited by deep litter or lichens (based on the results of experiments using sponges as substitutes for lichens) (Menges and Weekley 2004).

Studies of population dynamics began in 1996, when Herndon (1999) tagged individual plants. More plants were tagged at LWR State Forest in 1997. In 2002, almost a quarter (42 of 179) of Herndon's tagged plants were still alive for a longevity of at least 7 years. At another site, at least one third (41 of 124) survived at least 6 years (Menges and Weekley 2003). However, it is not always possible to distinguish seedlings from plants "young vegetative plants and from individuals resprouting from herbivory" (Menges and Weekley 2004). A clip-and-burn experiment has been initiated. Most of the plants resprouted within a month of the treatments, and the plants are continuing to be monitored to see whether fire benefits scrub blazing star (Menges and Weekley 2004). This research is crucial for guiding the management of conservation lands, and it also recognizes that the future of this species lies primarily on conservation lands, and that the single most important management issue on such lands is the use of prescribed fire to mimic the historic fire regimes.

Most study populations are dominated by plants that produce flowering stems. Only 3 of 10 study populations had seedlings (Menges and Weekley 2003). Demographic monitoring in 2003 suggested that population located on a roadside had "more flowering stems, more topped flowering stems, lower total flowering stem height, and fewer flowering heads than scrub populations."

"This species is unusual among LWR endemics in having low population densities and relatively high genetic variation" (Menges and Weekley 2002, citing Menges 1998). Herndon (1999) found that populations were stable due to low rates of mortality and seedling recruitment. Menges and Weekley (2002) note that monitoring of this plant is complicated by dormancy: corms may remain dormant for at least an entire year before producing new aboveground stems. This trait may help populations survive fires. Dormancy does create a problem for assuring that projects will not harm this species because the presence of dormant plants makes it difficult to ensure that plants will not be destroyed or disturbed. Evans et al. (2003) showed that this species is self-incompatible, which in small populations results in low overall seed production. Should populations become too small, self-compatibility alleles could be lost, causing a collapse of seed production.

Vertebrate (Kettenring 1999) and invertebrate herbivores (Weekley 1998; Menges and Weekley 2002) reduce reproductive output. Browsing by deer and rabbits "tops" bud-bearing or flowering stems by "removing or damaging flowering stems, inflorescences or developing achenes," while

invertebrates destroy developing flowers and fruits (Menges and Weekley 2003). In 2003, about 80 percent of aboveground individuals had flowering stems, but about a third of these plants lacked flower heads due to topping by vertebrates. The proportion of topped individuals varied significantly among 10 populations (Menges and Weekley 2003).

Unlike other endemic plants of scrub, which have metapopulation dynamics of local extinction and recolonization, there is no evidence for metapopulation dynamics in scrub blazing star. As a result, Evans et al. (2003) suggest that threats to scrub blazing star are different from threats to two other plants of the same habitat: snakeroot and Highlands scrub hypericum. Scrub blazing star's slow population declines between fires may, over the long term, be important, as are pollinator limitations. Factors influencing recruitment should be a focus of further investigation. Arranging prescribed fire regimes to accommodate a number of plant and animal species with different population (or extinction-recolonization) dynamics is inherently difficult, and they suggest that "further investigation should focus on whether [common conservation] strategies based on multiple aspects of population biology can be successful." Menges and Weekley (2002) caution that "we have only begun to accumulate information on population dynamics and responses to fire." Archbold Biological Station began collecting demographic data on this species in 2000 (Archbold Biological Station 2003).

A reciprocal transplant experiment, begun in 2001, compared seed germination from scrub and roadside populations, as well as the germination of seed reciprocally sown into the contrasting habitat. As of September 2003, overall seedling survival was highest at a roadside site and lowest in long-unburned scrub. Two-year-old plants had not yet produced flowering stems, indicating that plants take more than two growing seasons to reach sexual maturity (Menges and Weekley 2003, 2004).

The extensive (19 study populations with 892 plants in 20 study plots for 2004) and long-term (up to 7 years as of 2004) demographic studies are demonstrating the value of such longer-term work. Additional information is needed about the effects of fire management and how to best manage fire regimes on conservation lands. The longevity of this plant (Archbold Biological Station 2003) renders it relatively insensitive to reduced fire frequency.

Status and Distribution – The distribution of scrub blazing star is on the southern LWR of Polk and Highlands Counties, Florida, plus a single known site on the Winter Haven Ridge in Polk County, at Lake Blue (Schultz et al. 1999). This perennial herb is known from about 115 extant populations (Dolan et al. 1999) and it is present on most of the network of conservation lands with scrub vegetation in this area. A distribution map is available in Dolan et al. (1999).

From north to south, it occurs at:

- Camp Flaming Arrow (a privately owned site east of Lake Wales);
- Allen David Broussard Catfish Creek Preserve State Park;
- Boy Scout (Cox 2004) and Lake Arbuckle tracts of LWR State Forest;
- Saddle Blanket Lakes Preserve (TNC);

- LWR WEA (all, or nearly all, of the 12 units, including Placid Lakes, Carter Creek, Lake Apthorpe, Holmes Avenue, Hendrie Ranch, Gould Road, and McJunkin);
- Lake June-in-Winter Scrub State Park;
- Flamingo Villas tract of LWR NWR; and
- Archbold Biological Station (Schultz et al. 1999; Service 1996).

Historic and prospective loss of habitat due to commercial, residential, and agricultural uses qualified this species for endangered status. Overall, habitat is still being lost, but State, Federal, and private acquisition of conservation lands on the LWR has clearly benefited this plant, as has active land management by DOF, DEP, and FWC. Incomplete land acquisition remains a problem at some sites, such as the Carter Creek unit of LWR WEA. Habitat loss and small population sizes could result in inbreeding, which could be detrimental to this outcrossing species (Dolan et al. 1999).

Scrub buckwheat

The following discussion is summarized from the MSRP (Service 1999), as well as from recent research publications and monitoring reports. A complete scrub buckwheat life history discussion may be found in the MSRP. No critical habitat has been designated for scrub buckwheat.

Description – Scrub buckwheat belongs to the buckwheat family (*Polygonaceae*). It constitutes 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 by var. *gnaphalifolium* in Florida (Reveal 1968).

Scrub buckwheat is a long-lived perennial herb with a substantial taproot that probably provides ample food reserves for resprouting (McConnell and Menges 2002), basal rosettes, and one to three or more leafless, upright above-ground flowering stems (scapes) up to 1 m (3 feet) tall, but upwards of 10 stems have been observed in vigorous specimens, especially post-fire. It has a basal rosette of leaves that are 15 to 20 cm (5.9 to 7.9 inches) long, narrow, and white-woolly on the underside. The stem leaves are smaller than the rosette leaves. The stem terminates in a corymb, with each branch of the corymb ending in a cup-shaped involucre that holds a cluster of 15 to 20 small flowers, with each flower hanging on its stalk down below the involucre. The involucre is silvery and silky-pubescent, while the flowers are green with pink anthers (Rickett 1967; Archbold Biological Station 2005).

This species is easiest to recognize when it is in flower or fruit. In Highlands County, Archbold Biological Station (2003) reports that plants produce flowering stalks mainly during summer (May through July), but scrub buckwheat can flower at other times of year following burns. Plants on the Ocala NF have been observed with immature flower stalks between April and mid-July and bloom from May to mid-October. Seedlings have been observed in a variety of substrates within a few feet of the parent plant (Clutts 1998).

Life History – Scrub buckwheat is a perennial herb distributed widely in sandhill (high pineland) and Florida scrub in north central and central Florida from Ocala NF through the LWR. Its growing season is between April and mid-July and it flowers from May to mid-October. This species probably does not have a long-lived seed bank (Archbold Biological Station 2003).

Individual scrub buckwheat plants produce only one or a few flowers at any one time, but continues flowering for months. "Flowers have an easily accessible, generous drop of nectar. Flowers are visited by a variety of insects, including solitary digger and twig-nesting wasps (*Parancistrocerus* spp. and *Stenodynerus* spp.), flies (*Geron* spp.), small solitary bees, and occasional social wasps. Visiting wasps learn the location of each plant and use trap-line strategies. The small number of flowers per plant induces them to visit several plants and probably promotes outcrossing. Individual flowers avoid self-pollination. The anthers open and shed their pollen first, then the pistils, which have kept their stigmas tucked into a tuft of hairs at the base of the flower, straighten up and offer their receptive surfaces to incoming insects. An extremely low number of seeds and fruits developed by experimentally bagged flowers (compared to open pollinated flowers) indicates the need of pollinator services to set seed" (Archbold Biological Station 2003).

Population Dynamics – Scrub buckwheat resprouts repeatedly after fire, which is the primary agent of disturbance in its sandhill and Florida scrub habitats (McConnell and Menges 2002). Fire benefits this plant by stimulating resprouting, which is followed by "quick and heavy flowering and seed production" (McConnell and Menges 2002). New seedlings appear promptly after seed drop. McConnell and Menges (2002) observed that seedling numbers peaked during July, 2 months after an experimental fire (and a month after another experimental treatment – litter removal). Scrub buckwheat is unlike most other scrub species in that seedlings will appear in summer, not just winter. This may allow the species to take advantage of summer rains, but seedlings are likely to desiccate during hot weather.

The seedlings that appear after a fire are unlikely to originate from a seed bank. McConnell and Menges (2002) observed that the seeds are very small, and those buried deeply enough to survive heat from a Florida scrub fire (about 2 cm) would be unlikely to reach the surface. Satterthwaite et al. (2002) placed fresh seeds at the soil surface and saw high germination rates.

This species occupies both sandhill and scrub vegetation, which have very different fire regimes. Sandhill vegetation, under historic natural conditions, burned roughly every 1 to 10 years, while scrub may burn at intervals of 5 to as much as 100 years (McConnell and Menges 2002; citing Menges 1999). Over the long term, a population viability analysis by Satterthwaite et al. (2002) shows that scrub buckwheat populations require fire at intervals of 5 to 20 years to remain viable.

Prescribed burning is the "most appropriate treatment for enhancing both seed production and seedling recruitment, and linking the two in time" (McConnell and Menges 2002). Because this species tolerates a wide variety of fire intervals, prescribed fire regimes do not have to be

tailored to its specific needs. At the Carter Creek tract of the LWR NWR, biologists from Archbold Biological Station have carried out experimental fires that show promise of restoring the vegetation by suppressing evergreen oaks, reducing the sizes of turkey oaks, and improving conditions for reproduction by longleaf pines and wiregrass. This conclusion fits with monitoring and experimental work on scrub buckwheat and three other species, going back to Menges (1995), Menges and Yahr (1996, 1998), and Menges and Weekley (1999).

McConnell and Menges (2002) experimentally applied alternative treatments to promote a "demographic response" in scrub buckwheat. They applied top-clipping, litter canopy removal, shrub canopy removal, and ash addition in a replicated, factorial experiment. None of these treatments was as productive as fire. These and continuing work by Menges et al. (2005) suggest that for a long-unburned tract like the Carter Creek tract of LWR NWR, "pre-treatments to facilitate the application of fire management may be important to this and other species." In the Carter Creek experiments, a saw-and-burn treatment "created a hotter, more complete fire and more open post-treatment canopies. This had generally favorable effects on scrub buckwheat. The saw & burn treatment enhanced seedling recruitment, plant dormancy, flowering (both percentages and amount per plant) and reduced herbivory." The burn-only treatment was left with large unburned patches. These researchers are planning to analyze the effects of fire intensity on scrub buckwheat demography.

Status and Distribution – This was once a relatively widespread species. Its decline is due almost entirely to loss of sandhill habitat and to habitat degradation due to lack of prescribed fire. Its long-term prospects are favorable due to habitat acquisition after it was listed, as well as efforts by conservation land managers to restore natural fire regimes. It is now the most abundant of the "rare" species at the Tiger Creek Preserve and populations are stable, so it does not receive intensive monitoring (B. Pace-Aldana, TNC, letter correspondence, 2005). There is still some degree of threat from ongoing conversion of the remaining small fragments of sandhill (high pineland) and turkey oak scrub for agricultural, commercial, and residential purposes. Recreational motorized off-road vehicles have the potential to severely impact scrub buckwheat, but conservation lands on the LWR with scrub buckwheat generally do not have vehicle management problems. Several other endangered or threatened plants occur in turkey oak scrub with scrub buckwheat, notably pygmy fringe tree, pigeon wings, Carter's mustard, and Lewton's polygala (Christman 1988).

Scrub buckwheat occurs in the following counties:

- Putnam (Wunderlin and Hansen 2005) – no specific information is available, but the county has extensive sandhill vegetation, including some on conservation lands;
- Marion – relatively abundant in parts of the Ocala NF, with up to 71 localities reported (Service 1996);
- Pasco – sandhill area within the Green Swamp property of the SWFWMD (Service 1996). The report by a SWFWMD employee, has not been confirmed with a herbarium specimen;
- Hillsborough – reported by the 1996 recovery plan, apparently in error (not attributed to this county by Wunderlin and Hansen [2005]);

- Lake – probably still present in sandhill vegetation remnants near Clermont (Service 1996), formerly near Lake Eustis (Herbarium specimen G.V. Nash 704, May 1, 1894, Gray Herbarium, Harvard University). It is present on the 120-acre Flat Lake tract of Seminole State Forest in Lake County southeast of Clermont (Schultz et al. 1999; FNAI 2005), which was purchased by TNC in 1999 (Finkelstein 1999);
- Seminole (Wunderlin and Hansen 2005) – no further information is available on this urban county;
- Orange – southwest corner of county. Collected by S. Christman in 1987 (University of Florida herbarium catalog);
- Osceola – northwest corner of county. Collected in 1991 by Angus K. Gholsen in a "planted slash pine area with a native sandhill understory with *Prunus geniculata* (scrub plum) and *Nolina brittoniana* (Britton's beargrass) (University of Florida herbarium specimen catalog);
- Polk – on conservation lands at the Arbuckle, Lake Walk-in-the-Water, and Babson-Hesperides tracts of LWR State Forest, Allen David Broussard Catfish Creek Preserve State Park, the TNC Tiger Creek Preserve, the Carter Creek tract of LWR NWR, Pine Ridge nature preserve at the Historic Bok Sanctuary, Lake Davenport, and Horse Creek Scrub (SFWMD); and
- Highlands – on conservation lands at the Lake Apthorpe tract of the LWR WEA, Flamingo Villas tract of LWR NWR, and Archbold Biological Station, which represents its southern range limit. Also present in the Avon Park Lakes area (Schultz et al. 1999).

Scrub Lupine

The following discussion is summarized from the MSRP (Service 1999), as well as from recent research publications and monitoring reports. A complete scrub lupine life history discussion may be found in the MSRP. No critical habitat has been designated for the scrub lupine.

Description – Scrub lupine is a member of the pea family. It is unique among central Florida scrub plants because it is absent from the LWR proper, but is restricted to smaller nearby ridges. It is an herb that lives more than 1 year. The plants are usually in open areas and form large, silvery clumps. The sprawling stems with woody bases are up to 1 m long. The leaves do not have visible stipules at their bases, which distinguishes this species from the much more abundant *Lupinus diffusus*, which has obvious stipules. The leaves appear to be simple (lupines have compound leaves, but some, including scrub lupine, have just one leaflet per leaf) (Wunderlin 1998). The leaf blades are obovate-elliptic, 4 to 7 cm (1.6 to 2.8 inches) long and 2 to 4 cm (0.8 to 1.6 inches) wide. The base and end of the leaf are rounded with a sharp point at the leaf's tip. The petioles are 2.0 to 4.5 cm (0.8 to 1.8 inches) long and the stipules are very small or absent. A silvery pubescence covers the leaves and stems. The flowers are a pale flesh-colored pink and are 4 to 5 cm long. The upper petal (standard) has a black center surrounded by a maroon area. They are arranged in racemes with stalks 4 to 13 cm long. Each raceme has 5 to 14 flowers, but up to 25 on occasion (Stout In Press b). Scrub lupine seed pods are long, woody, and elliptical with a pointed end. It is distinguishable from *Lupinus villosus*, the only other pink-flowered lupine in central Florida, by not being prostrate and having hairs on the leaves and

stem. When it is not flowering, scrub lupine must be distinguished from the abundant *L. diffusus* by the absence of stipules at the bases of the leaves.

While the Service continues to recognize scrub lupine's scientific name as *Lupinus aridorum* in the List of Endangered and Threatened plants, it is worth noting that Isley's (1986, 1990) regional treatment of the pea family in the Southeast assigned the scrub lupine the name *L. westianus* var. *aridorum*. Wunderlin (1998) and Wunderlin and Hansen (2003) follow Isley's treatment.

Life History – Scrub lupine grows on well-drained sandy soils of the Lakewood or St. Lucie series (Wunderlin 1984). These soils are extremely well drained and have very little organic accumulation. The sands are white or occasionally yellow and generally support sand pine scrub (Wunderlin 1984). They are also quite acidic with a pH from 4.0 to 4.5 (I.J. Stout, University of Central Florida, personal communication, 1996).

Scrub lupine is a plant of sand pine and rosemary scrub (I.J. Stout, University of Central Florida, personal communication, 1996). Scrub lupine probably exists in sunny gaps until the growth of shrubs and sand pines causes shading. After long periods without disturbance, "gap specialist" plants of sunny sites usually become less common in scrub. After fire or other disturbances, scrub lupine seed stored in the sand germinates. Most of the sites where scrub lupine is now found have been disturbed, moderately to severely, by soil scraping, road construction, land clearing, or offroad vehicles (Stout In Press b). With these disturbances and associated vegetative responses, it is difficult to determine what the "natural" vegetative cover may have been, but Kordek (2005) has assembled historic aerial photographs for the Lake McLeod tract of LWR NWR from 1941 onward. It is very clear that the tract, in its more or less undisturbed condition of 1941, was very open, with a great deal of bare sand separating clusters of shrubs. Despite disturbances in the intervening years (including heavy all terrain vehicle traffic for a number of years) the present structure of the vegetation may not be much different from what it was. Wunderlin (1984) found the predominant overstory in vegetation with scrub lupine to be sand pine, longleaf pine, and occasionally turkey oak. The shrub layer tends to be sparse at scrub lupine sites. Wunderlin suggested this might be a result of human disturbances. Shrubs most frequently found in association with scrub lupine include Florida rosemary, although scrub lupine will not grow in the immediate vicinity of this shrub due to Florida rosemary's allelopathic effects (I.J. Stout, University of Central Florida, personal communication, 1996). Scrub lupine also occurs with sand live oak, rusty lyonia, Feay's palafox (*Palafoxia feayi*), tallowwood (*Ximenia americana*), and occasional cabbage palms (*Sabal palmetto*). The herbaceous layer is mostly wiregrass. Wunderlin's 1984 survey is important in part because many of the sites that existed at that time have been destroyed. Status surveys found scrub lupine growing in association with several other listed plants, including Florida bonamia, papery whitlow-wort, sandlace, and scrub plum (Service 1987c).

Flowering by the scrub lupine is from February or March to May. The seed pods mature by June and the seeds fall off the plant and germinate nearby or remain in a long-lived soil seedbank (T. Race, Bok Tower Gardens, personal communication, 1996; I.J. Stout, University of Central

Florida, personal communication, 1996). The plant may flower from one to three times throughout its life, though few seeds are produced the first year (I.J. Stout, University of Central Florida, personal communication, 1996).

The scrub lupine is short-lived and declines after flowering (Beckner 1982; I.J. Stout, University of Central Florida, personal communication, 1996). This reproductive cycle, combined with the susceptibility of the plant to root rot both in the wild and when cultivated, limits conservation options (Service 1996). Furthermore, the species does not transplant well, even when very young (Service 1996), but it can be propagated from seed sown *in situ*.

Status and Distribution – Scrub lupine was known from two distinct areas. In western Orange County (Orlando area) it was found on the southern Mount Dora Ridge from the Apopka-Plymouth area south, past Lake Buena Vista. A population has persisted in an open, sandy area that is used for passive recreation at Shadow Bay County Park (formerly Lakes Cane and Marsha Park). It has been monitored by Dr. I.J. Stout of the University of Central Florida for over a decade. Turkey Lake Park, a short distance north of Shadow Bay Park, has scrub vegetation, but scrub lupine has not been seen there. During construction of a new interchange connecting the Florida Turnpike to the East-West Expressway, scrub lupine plants appeared from seed at the disturbed edges of sand pine scrub vegetation. Attempts to transplant some of these individuals met with failure. As of 2003, the Florida Department of Transportation maintains marked non-mowing areas along the Turnpike at the interchange. The Service does not have recent monitoring information on the site, which is capable of supporting several dozen plants. Dr. Stout has shown that scrub lupine may be present at some heavily-vegetated scrub sites in Orange County only in the form of long-lived seed in the soil, which may germinate when the site is disturbed (I.J. Stout, University of Central Florida, personal communication, 1996). This is certainly what happened at the Turnpike construction site. No protected sites are known to exist in the county other than these two. It is reported to be present along the shoulder of the Turnpike near its junction with Interstate 4 (Christman 2001). It was found in at six sites in north-central Polk County on the Winter Haven Ridge near Auburndale and Winter Haven (Service 1999). The sites near Auburndale were threatened by land clearing for residential development. Only small tracts of scrub remained among expanses of residential development. Polk County sites totaled only about 380 ha (940 acres) (Christman 1988). The species has been conserved on the Lake McLeod unit of LWR NWR, where it is thriving on the small tract. A tract near Lake Blue, south of Auburndale, has been acquired as part of the LWR WEA. It has the potential to serve as a reintroduction site. No other conservation lands with suitable habitat exist in this area, and none are being acquired.

A great deal of practical experience in managing scrub lupine has been obtained at the Lake McLeod tract of LWR NWR, where trash has been cleared, exotic pest plants removed, and prescribed fires have been planned but not yet conducted. Dr. Stout has monitored and mapped the species with technical assistance from Ryan Kordek.

Scrub mint

The following discussion is summarized from the MSRP (Service 1999), as well as from recent research publications and monitoring reports. A complete scrub mint life history discussion may be found in the MSRP. No critical habitat has been designated for the scrub mint.

Description – The scrub mint is a dense or straggly, low-growing small shrub belonging to the mint family (Kral 1983). The plant grows from a deep, stout, spreading-branching taproot. The plants reach a height of about 45 cm (1.5 feet) when in flower. The stem's woody base produces many permanent woody vegetative stems. Each summer, these permanent stems produce temporary flowering shoots of limited (determinate) growth, bearing abundant flowers in the fall, then dying during the winter dry season. Both the flowering and vegetative shoots are stiff and ascending. The leaves vary in shape. They can be narrowly oblong-elliptic, linear-elliptic, or linear-oblanceolate (Kral 1983). The upper surface of the leaves is dark green, with the midrib slightly impressed. The lower surface is slightly paler, with the midrib slightly raised. They are 1.5 to 2.5 cm (0.49 to 0.82 inch) long, 2 to 3 mm wide, subsessile, flattish but somewhat fleshy, narrowly or broadly rounded at the apical end, have entire margins, and are not revolute.

The inflorescence of scrub mint is elongated and interrupted. At least half of the flowering shoot has flowers (Kral 1983). Clusters of flowers appear above each pair of leaves. Technically, the inflorescence is a verticillaster (Huck et al. 1989). The calyx of the flower, when the flower is open, is approximately 9 to 10 mm (0.35 to 0.39 inch) long, nearly erect, green at the tips and in the middle, but tinged with red at the base, with a broad white zone around the mouth. The corolla is 1.9 to 2.0 cm (0.75 to 0.79 inch) long, with an erect tube that is approximately 7 mm (0.28 inch) long. The external surface of the throat and limb is white or yellowish white. The upper lip is marked internally with a trellis pattern of lines and dots of deep purple, while the lower lip is maculate with larger, concentric spots from lobe bases to base of the lip. The flower has two pairs of stamens, with one pair slightly longer than the other (Kral 1983). The filaments are white, and the anthers are purple. Styles are almost white and bent forward or curved downward, usually above the anthers.

Scrub mint is similar in appearance to another *Dicerandra* species, Garrett's mint (*D. christmanii*). These two mints are separated using the following characteristics: 1) scrub mint has a minty aroma, whereas Garrett's mint smells of menthol (Huck et al. 1989); 2) the leaves of scrub mint are longer than those of Garrett's mint (Huck et al. 1989); 3) the anthers of scrub mint are deep purple to white in color, while the anthers of Garrett's mint are a brilliant yellow (Huck et al. 1989); 4) the corolla of scrub mint fades from a cream color to white within 1 to 3.5 hours of opening, while the corolla of Garrett's mint retains its cream color throughout most of the first day of flowering (Huck et al. 1989); and 5) the anther connectives of scrub mint have more, and larger, glands than those of Garrett's mint (Huck et al. 1989).

Scrub mint consists of two subspecies. The description above is focused on *Dicerandra frutescens* ssp. *frutescens*. *Dicerandra frutescens* ssp. *modesta* (blushing scrub balm) "differs from subspecies *frutescens* in flower number in a cyme, corolla coloration, upper lip shape of the

corolla, and chromosome number." The subspecific epithet "modesta" is intended to characterize the "distinctive color change stages in the corolla. Flowers are yellow-cream in the early morning, turn pink or pinkish white in the afternoon, and then blush to darker pink with age when the style is fully extended and the bifid style is open." The inflorescences of ssp. *modesta* are different from those of ssp. *frutescens*. They often have two to three flowers in opposing cymes, while ssp. *frutescens* have only one or two. Plants of ssp. *modesta* tend to have many of flowers at once, while ssp. *frutescens* tends to appear few-flowered by comparison. Flowering of ssp. *modesta* is from the end of August through the end of September (Huck 2001). The difference between subspecies in chromosome number is that ssp. *frutescens* is a hexaploid (six sets of chromosomes in each cell) ($n = 24$), while ssp. *modesta* is a tetraploid (four sets of chromosomes) ($n = 16$) (Huck and Chambers 1997, cited in Huck 2001). *D. frutescens* ssp. *modesta* was discovered after scrub mint had been listed as an endangered species.

Life History – Scrub mint is found in scrub on yellow sand soil. It is mostly restricted to excessively drained, yellow sandy soils of the Astatula and Paola soil types (Menges 1992). However, it has been found on a moderately well-drained, yellow sand of the Orsino type (Menges 1992). In these soil types, scrub mint occurs adjacent to or within disturbed areas in sand pine scrub, oak scrub and sandhill habitats (Service 1987d; Menges 1992). It occupies sites with shallow litter layers that have an incomplete, or non-existent, tree and shrub canopy (Menges 1992). Scrub mint inhabits open areas in the vegetation (Service 1996). Thus, it does not tolerate shading by other plants. Scrub mint is not often damaged by herbivores (Menges 1992). It contains essential oils which protect it from feeding animals (McCormick et al. 1993). Archbold Biological Station (2003) has collected data on individually marked plants at a number of sites since 1988.

"Although described in one publication as an obligate outcrosser, self-pollinations do produce viable, germinating seeds. … Plants are pollinated primarily by bee-flies in southern Highlands County. *Exprosopa fasciata* was the bee-fly responsible for 95 percent of flower visits, and the average flower received about 46 visits by this insect. Plants in open habitats and with more flowers received more bee-fly visits. The bee-flies tend to contact anthers in the morning and stigmas in the afternoon, increasing the chances of cross-pollination. Pollen is concealed in the anthers. When bee-flies contact spur-like appendages on the anther, this triggers pollen release. The pollen is deposited on the bee-fly and carried to another flower. Bee-flies were common in most habitats and concentrated on scrub balm, so pollinator limitation of fecundity appears unlikely" (Archbold Biological Station 2003).

Genetic variation is low in scrub mint compared with other LWR endemic plant species. There seems little differentiation in isozyme variation among populations, suggesting that they once may have been linked on long ridges of yellow sand, before most of these areas were converted to citrus. On the other hand, there is abundant morphological variation among wild populations of scrub mint (Archbold Biological Station 2003).

Population Dynamics – "Scrub balm is a short-lived perennial shrub. … Plants older than 8 years are very uncommon based on our long-term demography data. … Plants are generally killed by fire, although patchy fires allow survival of individual plants. Population recovery from complete fires is exclusively via dormant seeds in a persistent soil seed bank. Seed dispersal is very limited, and patches of postfire plants are generally in the same locations as the prefire population" (Archbold Biological Station 2003). Clipping of plants has the same effect as fire on individuals, but mowing above these low growing mints can create favorable competitive conditions" (Archbold Biological Station 2003).

Scrub mint populations fluctuate in size. "Seedling recruitment varies widely (ca. 50-fold) from year to year and survival of seedlings is often low during dry periods in late spring. Seedling microsites may require a combination of mineral soil substrates and partial shade in many years, but seedlings do survive and grow well in open postfire sites. Population size peaks about 6-8 years postfire. … After [the first decade], populations decline due to low recruitment, slow growth, and fairly high mortality (greater than 20 percent annually). … Mortality can be considerably higher during droughts. A population viability analysis suggests that optimal fire return intervals are 6 to 10 years" (Archbold Biological Station 2003). This analysis, based on research by Eric Menges and his collaborators, supersedes Menges' (1992) suggestion that although plants seem to grow most vigorously for the first 10 years after a fire, an optimum frequency of disturbance had not been demonstrated, since colonies of this plant could be found in areas burned as recently as 3 and as many as 65 years ago.

Distribution and Status – Scrub mint (*Dicerandra frutescens* ssp. *frutescens*) occurs on the southern portion of the LWR in Highlands County, from just north of Lake June-in-Winter to Archbold Biological Station (FNAI 1996b; Menges 1992). The Sun n' Lakes state land acquisition tract includes large populations of scrub mint (Schultz et al. 1999). Land acquisition is proceeding in this area, but we do not know whether scrub mint sites have yet been purchased. Scrub mint is protected at Archbold Biological Station and the Lake Placid unit of the LWR WEA, managed by FWC (Service 1996). Population sizes are not available, and in any event would be expected to fluctuate with time-since-fire. The other subspecies of scrub mint (*Dicerandra frutescens* ssp. *modesta*) occurs in the vicinity of Snell Creek and Horse Creek, in the Upper Lakes Basin Watershed lands purchased for conservation purposes by the SFWMD (Huck 2001) east of Davenport, Polk County.

Scrub mint is in cultivation at the Historic Bok Sanctuary under the auspices of the Center for Plant Conservation as part of their permanent rare plant collection. Research on its breeding system, pollinators, demographic patterns, and genetic variability is being conducted by Archbold Biological Station in conjunction with monitoring efforts (Service 1996).

Scrub plum

The following discussion is summarized from the MSRP (Service 1999), as well as from recent research publications and monitoring reports. A complete scrub plum life history discussion may be found in the MSRP. No critical habitat has been designated for scrub plum.

Description – Scrub plum is a much-branched shrub that can reach 2 m (6 feet) in height, although 0.5 m (1.5 feet) is more typical at sites with frequent fires. It grows from gnarled, half-buried trunks. Its twigs are strongly geniculate (zigzag shaped), while its lateral branches are either short, stubby spur shoots bearing leaves and flowers, or are strongly tapering and spine-like. The bark of old stems is thin, gray, usually lichen-encrusted, and forms small rectangular or square plates. The bark of new shoots is lustrous reddish-brown or purplish and smooth.

The scrub plum's leaves are crowded on the spur shoots (an arrangement typical of the Rosaceae family) and are widely spaced on the normal shoots. The fragrant white flowers of scrub plum are distinctive in being sessile, without flower stalks. They are fragrant, five-petaled, and 11 to 13 mm (0.43 to 0.51 inches) across when open. The flowers have "numerous stamens with conspicuous yellow anthers that are exerted well above the floral cup. Some flowers have a well-developed pistil equal in height to the stamens, while in other flower the pistil is vestigial and nonfunctional" (Archbold Biological Station 2003). The fruit of the scrub plum is an ovoid or ellipsoidal drupe, 12 to 25 mm (0.47 to 0.98 inch) long, and dull reddish or "vaguely peachy" (Archbold Biological Station 2003) in color. It has a thin, bitter flesh and a slightly flattened seed.

Although it is distinctive as the only plum with crooked twigs, scrub plum can be casually mistaken for other scrub and sandhill plants. Several have a similar geniculate, thorny habit of growth, including tough bumelia, hog plum (*Ximenia americana*), Florida ziziphus, and a local hawthorn, a variant of *Crataegus lepida* (Judd and Hall 1984). Hog plum has yellow fruit, straight twigs, and thorns only in the angles of leaf and stem. Florida ziziphus has entire leaf margins and yellow fruit and is exceedingly rare. Buckthorns have thorns and clustered leaves, but the leaves or twigs are very hairy (FNAI 2000b).

Flowering occurs in January to February, leafing occurs from late February to March, fruit begins to develop in late February and may continue to early May, and seed dispersal is in early May, but germination dates are unknown (Harper 1911; Ward 1979b; C. Weekley, DOF, personal communication, 1998). Archbold Biological Station's plant ecology lab reports that flowering occurs in February to March when the plants are largely leafless. Individuals drop most of their leaves in the winter dry season.

Life History – Scrub plum has a very unusual breeding system called andromonoecy, in which male and bisexual flowers are present on the same individual (Weekley and Menges 2001). Scrub plum is believed to be self-incompatible, which would make the services of pollinators essential for fruit set (Weekley 1997). The flowers attract insect visitors. Insects may disseminate the pollen of the scrub plum and birds and possibly mammals disperse the seeds.

The plants add new stems every year, especially after fire (Archbold Biological Station 2003). Fire stimulates growth and flowering; flowering and fruit production gradually declines until the next fire (Menges et al. 2005). Seedlings have not yet been observed in the wild.

Scrub plum prefers dry, sunny, nutrient-poor sites of acidic, entisols (deep, nearly featureless, sand soils). It is most typically associated with oak-dominated scrub and high pine communities. Scrub plum is native to sandhill (high pineland) vegetation and Florida scrub. Sandhill vegetation is usually thought of as having a grassy understory, although the abundance of scrub palmetto and shrubs like scrub plum and pygmy fringe tree at areas like the LWR NWR tract at Carter Creek indicate that sandhill on the Ridge may not historically have had the lawn-like appearance of many sandhill sites farther north. Sandhill is subject to low-intensity, frequent fires (every 1 to 5 years). Scrub has shrubby vegetation and is subject to high-intensity, infrequent fires. Fires maintain both habitats. In the absence of frequent fires, high pine vegetation is typically invaded by sand pines and evergreen oaks, eventually becoming upland hardwood forest (Myers 1985). Similarly, scrub may become upland hardwood forest if fire is absent (Myers 1985).

Sandhills plants that can be found in the vicinity of scrub plum include Chickasaw plum (*Prunus angustifolia*), tallowwood (*Ximenia americana*), wiregrasses (*Aristida stricta* var. *beyrichiana* and other species), broomsedges (*Andropogon* spp.), slenderleaf clammyweed (*Polanisia tenuifolia*), and largeflower wireweed (*Polygonella robusta*). The dominant tree is turkey oak, with longleaf pine. Listed species that co-occur with scrub plum in sandhills include pygmy fringe tree, pigeon wings, scrub buckwheat, Britton's beargrass, wide-leaf warea, Carter's mustard, and Florida ziziphus.

Population Dynamics – Although scrub plum's historic range was rather extensive compared to other narrowly endemic plants of Florida's central ridges, this species has declined with destruction and fragmentation of its scrub habitat.

Scrub plum plants nearly always resprout after fire (Menges and Kohfeldt 1995; Menges et al. 2005; Weekley and Menges 2001, 2003a, 2003b). Three years after a fire, more than 98 percent of burned plants had survived, though they had lesser height and crown diameter than unburned control plants (Menges et al. 2005). During 10 years of monitoring of 65 scrub plum individuals at TNC's Tiger Creek Preserve, more than 95 percent of the plants resprouted post-fire and regained their pre-burn height and width within 2 years post-fire (TNC 2004). Populations at the Arbuckle and Walk-in-the-Water tracts of LWR State Forest appear stable, but Cox (2004) did not find any seedlings or juveniles.

In 3 years of conducting experimental burning and cutting treatments at Carter Creek and collecting demographic data, 903 plants were tagged. Of these, 565 were in burn treatments, of which 454 were burned to some extent in an August 2001 burn; 99.7 percent survived or resprouted. Only 3 plants "with total consumption of the aboveground parts died" (Menges et al. 2005). As of February 2005, 4 plants had been killed by prescribed fire and 6 had died from other causes (Menges et al. 2005). Twelve plants near the study area boundaries were inadvertently damaged during site maintenance in 2004, but are expected to recover (Menges et al. 2005). Archbold Biological Station has carried out germination experiments, but has not yet reported results (Archbold Biological Station 2003).

Status and Distribution – Habitat loss due to conversion to agriculture and residential development continues to threaten this species. Removal by plant collectors has been an additional threat that land acquisitions and conservation areas are alleviating. Fire suppression has degraded the habitat required by this species. This species apparently requires periodic fire or other disturbances to maintain suitable habitat.

Scrub plum occurs in three general areas on Florida's central ridges: Lake County, west and southwest of Lake Apopka; the southwest and northwest corners of Orange and Osceola Counties, respectively; and Polk and Highlands Counties, from the City of Lake Wales south to the Highlands County/Glades County border (FNAI 1996c) on the LWR. It is absent from the Bombing Range Ridge of Avon Park Air Force Range.

Scrub plum is present on nearly all conservation lands within its range that have scrub or sandhill vegetation (FNAI 1985; Stout 1982):

- In Lake County, the 120-acre Flat Lake tract of Seminole State Forest southeast of Clermont (Schultz et al. 1999; FNAI 2005), which was purchased by TNC in 1999 (Finkelstein 1999);
- In Polk County, protected sites containing scrub plum exist at the Arbuckle and the Lake Walk-in-the-Water tracts of LWR State Forest, at the Pine Ridge Nature Preserve of Historic Bok Sanctuary, at the Allen David Broussard Catfish Creek Preserve State Park, at TNC's Tiger Creek Preserve, and probably at the Saddle Blanket Lakes Preserve; and
- In Highlands County, the scrub plum is protected on the Carter Creek tract and Apthorpe, Holmes Avenue, Lake Placid, and Gould Road areas of the LWR WEA; the Carter Creek and Flamingo Villas tracts of LWR NWR; Archbold Biological Station; and Lake June-in-Winter Scrub State Park.

Information on numbers of plants by site has not been available. The Florida Plant Conservation Program, operated by DOF, commissioned a status survey for scrub plum in late December 2003. Linda Chafin of the FNAI conducted field surveys to relocate and document known populations and seek new populations. Final results are expected to be available in 2005.

Short-leaved rosemary

The following discussion is summarized from the MSRP (Service 1999), as well as from recent research publications and monitoring reports. A complete short-leaved rosemary life history discussion may be found in the MSRP. No critical habitat has been designated for the short-leaved rosemary.

Description – This "profusely branched mint-smelling shrub [up] to about 1 meter [3 feet] tall" (Kral 1983) has short, narrow leaves and lavender flowers about 1.3 cm (0.5 inch) long that are bilaterally symmetric (with upper and lower lips). Short-leaved rosemary is similar to false rosemary (*Conradina canescens*) of the Florida panhandle, but has, as its name implies, shorter leaves: the larger leaves on well-developed flowering branches are 6.0 to 8.2 mm (0.24 to 0.31 inch) long, mostly longer than the internodes, versus 7 to 20 mm (0.28 to 0.79 inches) long,

mostly longer than the internodes for *C. canescens*. *Conradina brevifolia* also tends to have more flowers per axil than *C. canescens*: one to six per axil versus one to three in *C. canescens* (Shinners 1962; Kral 1983). Gray (1965) showed that *C. brevifolia*, like Apalachicola false rosemary (*C. glabra*) of the Florida panhandle, is morphologically not strongly differentiated from, and is less variable than, *C. canescens*. Kral and McCartney (1991) maintained *C. brevifolia* as a distinct species, while Wunderlin and Hansen (2005), without explanation, treat it as part of *C. canescens*.

Short-leaved rosemary is one of four shrubby mints in the interior central Florida scrub. The others are Ashe's calamint (*Calamintha ashei*), scrub mint, and Garrett's mint. Short-leaved rosemary can be distinguished from the scrub and Garrett's mints (*Dicerandra*) by its flowers not having sharply-bent corollas, and by its lack of the strong mint or camphor scents of the scrub mint or Garrett's mint leaves. Short-leaved rosemary and other members of *Conradina* are distinguished from *Calamintha* by differences in the branches of the flowers' stigmas and by short-leaved rosemary having appressed trichomes (hairs) on the lower sides of the leaves, while *Calamintha* has erect trichomes (Shinners 1962; Kral 1983). The other "rosemary" in central Florida scrub is Florida rosemary, a larger shrub that is not a member of the mint family, and is so distinctive it cannot be mistaken for any of the mints.

Life History – Short-leaved rosemary inhabits white sand scrub with evergreen scrub oaks and sometimes a scattered overstory of sand pine. Short-leaved rosemary is usually found interspersed in gaps between the shrubs on bare sand with other small shrubs and herbs (Service 1992). No specific information is available on the ecological requirements of short-leaved rosemary. However, existing information on the natural fire regimes of various scrub communities suggest that the white sand scrub inhabited by short-leaved rosemary requires periodic, patchy, high-intensity fires. Fire cycles of 15 to 20 years, or possibly less, reduce overstory competition and provide disturbed open sandy patches within which obligate seeding species may re-establish. Short-leaved rosemary, like other scrub mints, is probably killed by fire (Service 1996), or other disturbance, but readily germinates post-fire from seeds stored in the sand (Menges 1992). To conserve short-leaved rosemary, managers of conservation lands must restore and maintain scrub communities by mimicking the timing and intensity of natural fire regimes. Monitoring at TNC's Saddle Blanket Lakes Preserve has revealed that short-leaved rosemary readily re-establishes post-fire from seedlings (TNC 2004).

Status and Distribution – Short-leaved rosemary has a very restricted distribution in the middle of the LWR. It occurs at only about 30 sites whose total area is less than 2,400 ha (6,000 acres) in the Sebring-Avon Park area of Highlands and Polk Counties (Christman 1988; Christman and Judd 1990). Wunderlin and Hansen (2005) also report it, or *Conradina canescens*, from Hernando County, on the Brooksville Ridge. A survey of sites under consideration for acquisition by the State (Schultz et al. 1999) found no significant new sites for this plant.

Short-leaved rosemary is present on conservation lands at:

- Carter Creek unit of the LWR WEA (FWC), Highlands County;
- Silver Lake unit of the LWR WEA (FWC), Highlands County (Schultz et al. 1999);
- Saddle Blanket Lakes Preserve (TNC), Polk County;
- Sun Ray unit of the LWR WEA (FWC), Polk County (Schultz et al. 1999);
- Hickory Lake Scrub County Park, Polk County (Schultz et al. 1999), adjacent to Sun Ray; and
- Arbuckle tract of LWR State Forest (Division of Forestry), Polk County. At this site, it was surveyed by Kris DeLaney in 1988 and by Anne Cox in 2002 and 2003. Overall numbers appeared stable, with 1,496 plants at 11 sites in 2003 (plus several other unsurveyed sites with 30 to 50 plants each) and 1,525 plants in 1988. A suggestion was made that the species does not require monitoring, except after fires (Cox 2004).

It is present on non-conservation lands in the Avon Park Lakes area (two occurrences) and Silver Lake southwest of Avon Park (three occurrences) (Schultz et al. 1999).

Snakeroot

The following discussion is summarized from the MSRP (Service 1999), as well as from recent research publications and monitoring reports. A complete snakeroot life history discussion may be found in the MSRP. No critical habitat has been designated for the snakeroot.

Description – Snakeroot is a member of the carrot family (Apiaceae or Umbelliferae). It is a short-lived perennial herb with a very long taproot. The basal rosette, which may remain green during the winter or disappear briefly, is composed of wedge-shaped leaves that are thick but not succulent. The flowering stems are up to 0.5 m (1.5 feet) tall. The inflorescence is diffusely branching, with each branch ending in a tight umbel (or small head) with bristly bracts. Each plant may have hundreds of umbels. The flowers are perfect (bisexual), but the anthers open before stigmas become active (*i.e.,* flowers are protandrous), but each plant has so many flowers that functionally male and female flowers are usually present at the same time. The 10 to 15 flowers in each umbel have white petals, filaments, styles, and stigmas, but the anthers are powdery blue. Plants flower for about a month in late summer to fall (August to October) (Archbold Biological Station 2003). After fruiting, reproductive stems soon wither and die. All other *Eryngium* species in south Florida have blue flowers (Service 1996; Archbold Biological Station 2003).

Life History – The concise guide to snakeroot's life history by Archbold Biological Station (2003) summarizes intensive research on its breeding system, genetics, and population dynamics. Snakeroot requires insect pollinators to produce seed (Archbold Biological Station 2003). "Many species (at least 100) of generalist insects are frequent (0.3 visits per minute) visitors and likely pollinators. Most insects are apparently seeking nectar although some collect pollen. Pollinator visitation does not appear to limit seed production, and open pollinated seed set was very high (80 percent). Most insect movements are among flowers on the same plant or between

nearby (< 5 m apart) plants. Self and cross treatments produced similar numbers of seeds, suggesting that inbreeding depression is not acting at this life history stage" (Archbold Biological Station 2003).

Fruiting and seed dispersal is believed to occur between October and January (Wunderlin et al. 1981c; Kral 1983). Seeds are mature in November (T. Race, Bok Tower Gardens, personal communication, 1996). There seems to be no special seed-dispersal mechanism (other than gravity) (Wunderlin et al. 1981c; Kral 1983). Germination is in winter and spring. "Although some seeds can germinate shortly after maturation, most seeds remain dormant for a year or more, germinating in subsequent winter seasons. … Seedling numbers are highest during wet spring weather and in recently burned areas" (Archbold Biological Station 2003). Few plants survive as long as 10 years. "Most plants start flowering at ages 2-3 years and many continue flowering year after year. However, regression from reproductive to vegetative stages is common and our historical analyses suggest that regression is often a predictor of mortality. Nearly every aspect of the demography of [snakeroot] is affected by fire. Plants in recently burned areas live longer, survive better, grow faster, and flower earlier than those that germinate in areas that have not been burned recently" (Menges and Quintana-Ascencio 2004). Demographic data have been collected for this plant since 1988, and this species has become an important subject for research into population dynamics and population viability in relation to fire. The population viability analysis published by Menges and Quintana-Ascencio (2004) takes full advantage of that data. They note that snakeroot "populations explode within the first decade after fire. Large plants with many flowering stems are common beginning the third year postfire. Many of these plants become rather static in size and fecundity" and mortality increases, so populations tend to decline after 9 years and aboveground plants disappear "between 25 and 35 [years] postfire." The exacting habitat requirements of snakeroot mean that, despite large populations at several sites (possibly millions of individual plants in its small range, plus dormant seeds), its habitats must be managed aggressively to maintain the open, sunny gaps that snakeroot needs.

Snakeroot is restricted to Florida scrub vegetation, usually with much Florida rosemary and scrub oak. It is restricted to open, sandy areas within the vegetation, with herbs such as scrub blazing star, Highlands scrub hypericum and nodding pinweed. In the open areas between shrubs, reindeer moss (*Cladonia*) lichens cover more area than the herbs. The vegetation burns to the ground at intervals. Oaks resprout from the roots, sand pine recolonizes by seed, and rosemary and snakeroot return from seed stored in the soil (Archbold Biological Station 2003; Abrahamson et al. 1984; Abrahamson 1984a, 1984b). Shrubs and trees may affect snakeroot by shading it. Florida rosemary may affect snakeroot through allelopathy (Wunderlin et al. 1981c; Kral 1983; Richardson 1985; Archbold Biological Station 2003).

The open, sunny sand between shrubs (gaps) inhabited by snakeroot are created or enlarged by fire or other disturbance (Wunderlin et al. 1981c; Abrahamson et al. 1984). Of the endemic plant species that occur in white sand habitats in Florida scrub, it "has the greatest specialization for open microsites and recently burned areas, and seems particularly vulnerable to allelopathy [inhibition of growth caused by chemicals released by other plants] from Florida rosemary"

(Archbold Biological Station 2003). Snakeroot populations boom after a fire, peaking about 6 to 10 years post-fire, then crash. Fire intervals of greater than 20 years may lead to local extinction (Archbold Biological Station 2003). Although its growth is suppressed by rosemary, at Archbold Biological Station the plant usually occurs in the vicinity of rosemary, mostly on Psamment (sand) soils of the Archbold Series which are moderately well drained, acid (pH 4.2), and with low soil nutrient levels (trace phosphorus; potassium, 5.6 kg/ha). Other soils in the area are also infertile. A small portion of the rosemary scrub at Archbold has soils of the St. Lucie Series, which are deep fine sands. This appears to be the major series in which snakeroot is found outside of Archbold Biological Station (Wunderlin et al. 1981c; Abrahamson et al. 1984).

"Population sizes of [snakeroot] fluctuate widely, with the largest populations found shortly after fire and in disturbed areas. Local population sizes and densities are larger than most other Florida scrub endemics. Population sizes peak 6-10 years postfire. Subsequent declines can be steep, and most populations disappear (aboveground) from sites 30-34 years postfire. [Snakeroot] populations may persist longer in disturbed areas and extremely xeric, open sites. Seeds have persistent dormancy and most populations recover from fire from a persistent soil seed bank. Survival of seeds in the seed bank is probably high. Occasionally, some plants resprout in areas with very low fire intensity. Growth, survival, and fecundity are markedly higher shortly after fire and, over time, for seedling cohorts originating shortly after fire" (Archbold Biological Station 2003).

A 40-acre (6.2-ha) addition to Archbold Biological Station's property, on its west boundary had abundant snakeroot when it was purchased, apparently because snakeroot proliferated after the former owner had cleared and root-raked the area. This supports other observations that this plant requires burned or disturbed habitats.

Distribution and Status – The distribution of snakeroot is in southern Highlands County, near the town of Lake Placid. It occurs only on the southern LWR. The northernmost sites were at several sites in and around the town of Sebring, especially on the sand dune along the south side of Lake Jackson (Wunderlin et al. 1981c); this area was developed by about 1990. All other sites are in an area about 39 km (24 miles) long from the southern side of Josephine Creek to the southern tip of the LWR. Christman (1988) reported only about 20 localities, but even this number is misleading since he divided several larger sites. A survey of properties under consideration for purchase by the State did not find any new localities (Schultz et al. 1999). It is present at these sites, from south to north:

- Hendrie Ranch, a private property some 24 km (15 miles) south of Lake Placid or east of Highway 27 (roughly 8 miles south of State Road 60) (Service 1996; FNAI 2005);
- Gould Road, 212 acres, part of LWR WEA, 1 occurrence (Schulz et al. 1999);
- Archbold Biological Station (private preserve);
- Woolfenden (McJunkin) tract, 623 acres, part of LWR WEA;
- Lake Placid Scrub, 2,159 acres, part of LWR WEA (Service 1996);
- Holmes Avenue, 974 acres, part of LWR WEA, 1 occurrence (Schulz et al. 1999); and
- Lake Apthorpe, 810 acres, part of LWR WEA, 3 occurrences (Schulz et al. 1999).

The only large privately-owned tract with habitat with this species may be the Hendrie Ranch. The local distribution of snakeroot within Archbold Biological Station is quite limited. Archbold has about 90 rosemary balds, which are patches of open, dry scrub surrounded by scrubby flatwoods with dense scrub oak (Johnson 1981; Abrahamson et al. 1984). Only about 12 of the rosemary balds have snakeroot (E. Menges, Archbold Biological Station, personal communication, 1989). Snakeroot was reported to occur at Lake June-in-Winter Scrub State Park on the west side of Lake June in Winter (Service 1996), but it was not relocated after several intensive searches (Schultz et al. 1999).

Wide-leaf warea

The following discussion is summarized from the MSRP (Service 1999), as well as from recent research publications and monitoring reports. A complete wide-leaf warea life history discussion may be found in the MSRP. No critical habitat has been designated for the wide-leaf warea.

Description – Wide-leaf warea is an annual herb in the mustard family (Brassicaceae or Cruciferae). Plants may be 30 to 100 cm (1 to 3 feet) tall and the stalk may be unbranched or, more often, branching midway up the stem. Leaves are alternate, from 2 to 5 cm (0.8 to 2.0 inches) long, and 1 to 3 cm (0.4 to 1.2 inches) wide, smaller as they ascend the stalk, with a rounded apex and entire margin. On young plants, the leaves are slightly folded along the midrib, tipped upward, and the lobes at the base of leaves reach around the stem. This characteristic has led to one of the common names for the species, clasping warea. The heart-shaped clasping leaf bases and its pale green, slightly glaucous leaves readily distinguish wide-leaf warea from the three other species in its genus in Florida. The characteristic leaves provide reliable field identification even if the plants are not flowering. The pale lavender flowers of wide-leaf warea vary in individuals from almost white to almost purple. Flowers appear at the ends of the branches in spherical clusters about 5 to 6 cm across. The inflorescences are dainty, and in the field the flowering plants look almost fluffy. Individual flowers are about 1.5 cm (0.6 inch) across, with four paddle-shaped petals and six long stamens. Wide-leaf warea is also readily identifiable even as the stalk turns brown and the leaves wither, by the clusters of narrow down-curving seed pods, from 5 to 7 cm long. The pods split longitudinally, with small black seeds on either side of the center membrane (Judd 1980b; Kral 1983; Service 1999).

Slenderleaf clammyweed (*Polanisia tenuifolia*), an annual in the family Capparaceae, might be mistaken for wide-leaf warea when the plants are brown and dry at the end of the season; it is about as tall as wide-leaf warea and its seed pods are about the same size as those of *Warea*. However, the seed pods of *Polanisia* appear singly in the leaf axils rather than in groups at the ends of the stems, and are erect and straight (Service 1993c).

Life History – Wide-leaf warea seedlings may be seen from April onward (FNAI 2000c). The plants flower from mid-August to early October. The showy flowers are pollinated by various Hymenoptera (bees) and Lepidoptera (butterflies). Reproduction is exclusively sexual. The small seeds generally fall near the parent plant (Service 1987e), probably by wind action.

Senescence of the plants occurs just before the fruit matures, from late September to mid-November. The population overwinters as seeds.

Like many herbaceous plants that grow in open, sandy patches, wide-leaf warea does not tolerate shading by dense shrubs or trees. The habitat structure of the surrounding forest around the open patches is controlled under natural conditions by fire. Mechanical treatments as preparation for fire, or as a substitute, have been investigated by Menges et al. (2005).

Four species of ants (*Camponotus socius*, *Pogonomyrmex badius*, *Formica pallidafulva*, and *F. archboldi*) occur around wide-leaf warea at Lake Griffin State Park and these ants are believed to help disperse its seeds (Bard 1996).

Population Dynamics – Wide-leaf warea occurs in sandhill (high pineland) vegetation constituting well-drained, open longleaf pine woods, longleaf pine/turkey oak woods, or sand live oak/bluejack oak. Wide-leaf warea seems unable to tolerate shading or competition from other plants; it may be favored by slight disturbance, but does not generally occur in weedy sites (roadsides, cleared fields, citrus groves, or pastures) (Judd 1980b). Sandhills historically had frequent low-intensity fires that were supported by (and maintained) the grassy understory.

Because the number of plants at a given site varies greatly from year to year (T. Race, Bok Tower Gardens, personal communication, 1997), it is difficult to document trends in population numbers. Wide-leaf warea occupies a habitat which historically burned during the summer growing season. There are anecdotal reports of plants appearing at sites where they had not been seen for several years, suggesting that the species banks seeds in the soil (Service 1993c; Bok Tower Gardens 1994). Fire has been documented to stimulate germination of stored seeds of another species of *Warea*, Carter's mustard, resulting in boom-and-crash population dynamics with the fire cycle (Archbold Biological Station 2003, 2005).

Experimental propagation to field plots at the Historic Bok Sanctuary suggests that the number of flowering plants is related to the amount of rainfall during the December prior to the growing season. They also found that plants grew from seeds that had been sown into the experimental plots 2 to 4 years earlier, which indicates that seed banking in the soil is important in this species (Bok Tower Gardens 1994). Although propagation from seed in a greenhouse resulted in a high rate of germination and early survival, all of the seedlings planted outside in native yellow sand died before flowering from the action of leaf miners, lepidopteran larvae, fungus, and unknown causes (Bok Tower Gardens 1994). Direct sowing of wide-leaf warea seeds in the field was more effective. In 1990, 2,000 seeds were sown, resulting in 30 percent germination and 16 flowering plants (0.80 percent). In 1991, 5,000 seeds produced 280 seedlings (5.60 percent), and 46 flowered (0.92 percent of total seed) (Bok Tower Gardens 1994).

Status and Distribution – Judd (1980b) documented the former range of wide-leaf warea to include Lake County, western Orange County, extreme northwestern Osceola County, and northern Polk County. Since his survey, additional sites have been discovered in Lake, Polk, and Osceola Counties and several of the previously documented sites have been destroyed.

When the recovery plan for this plant was prepared (Service 1993c), 10 populations had been identified in Lake and Polk Counties, including a population at the Historic Bok Sanctuary, near Lake Wales in Polk County (Hall 1985). Wide-leaf warea is also present in a remnant sandhill vegetation within Mountain Lake Estates, near the Historic Bok Sanctuary (T. Race, Bok Tower Gardens, personal communication, 1997). Judd's (1980b) Haines City site, located west of U.S. Highway 27 and east of Lake St. Charles, about 7 km (4.3 miles) north of Haines City, appears to have been eliminated by a residential housing development (N. Bissett, The Natives, personal communication, 1997). Wide-leaf warea was found on the site of a proposed nursery along Champagne Road, northeast of Haines City and southeast of Davenport, Polk County (N. Bissett, The Natives, personal communication, 1997). This species is protected in a restored sandhill at Lake Griffin State Park in Lake County. In 1999, TNC acquired (Finkelstein 1999) the Flat Lake tract (Schultz et al. 1999) near Flat Lake, southeast of Clermont in Lake County. This tract, surrounded by orange groves, has sandhill vegetation with wide-leaf warea. It is now managed as part of Seminole State Forest (FNAI 2005).

At Lake Griffin State Park, wide-leaf warea was present on about 0.08 ha (0.2 acres) on the 8.00 ha (20.0 acre) parcel in May 1994. Park employees cleared oaks (except bluejack oak) and treated the cut surfaces with Garlon 3A (triclopyr) or Roundup (glyphosate). After removal of the oaks, centipede grass (*Eremochloa ophiuroides*) increased around the colony of wide-leaf warea. This exotic grass was treated with Poast (sethoxydim). Other exotic plants were hand-pulled or treated with herbicide, including rosary pea (*Abrus precatorius*), Chinese tallow tree (*Sapium sebiferum*), mimosa *(Albizia julibrissin*), and Sprenger's asparagus (*Asparagus sprengeri*). By 1997, about 2.0 ha (5.0 acres) had been cleared and the area covered by warea had increased to about 0.2 ha (0.5 acres). The number of individual wide-leaf warea plants increased from 57 in 1994 to 118 in 1996. Approximately 26,000 wiregrass plants were planted in the restored area to restore the original understory (Bard 1996; A. Bard, DEP, personal communication, 1997). Since then, techniques for directly seeding wiregrass have improved, and this method would probably be used in a similar situation. The Lake Griffin project was one of the first to demonstrate the feasibility of sandhill restoration, at least on a small scale.

The severe loss of habitat for this plant was carefully documented by the FNAI, which produced a land acquisition proposal, entitled the Warea Archipelago, for the Florida Conservation and Recreation Lands acquisition program, based on surveys conducted in 1991 and 1992 (R. Hilsenbeck, TNC, personal communication, 1997). The FNAI identified six tracts of land containing wide-leaf warea: Sugarloaf Mountain, Ferndale Ridge, Castle Hill, Flat Lake, Schofield Sandhill, and Lake Davenport. Five of these are in Lake County and one is in Osceola County. The FNAI conducted another survey for wide-leaf warea in 1994 and 1995 in Lake County on behalf of the Lake County Water Authority and the St. Johns Water Management District. This survey located a total of 17 sites (G. Race, Lake County Water Authority, personal communication, 1997). Unfortunately, none of these sites appear to have been acquired as of 2005 (FNAI 2005).

Wireweed

The following discussion is summarized from the MSRP (Service 1999), as well as from recent research publications and monitoring reports. A complete wireweed life history discussion may be found in the MSRP. No critical habitat has been designated for wireweed.

Description – Wireweed is one of three species of *Polygonella* occurring in scrub in southern Florida (Lewis and Crawford 1995). The other endangered species, sandlace, inhabits the LWR and vicinity, and is extremely different in appearance. Where wireweed is an herb, sandlace is a creeping shrub (Horton 1960). Hairy jointweed (*Polygonella ciliata*) is very similar to wireweed, but its geographic range does not overlap with wireweed's (Wunderlin and Hansen 2005).

Wireweed plants consist, during the winter and spring months, of a basal rosette of leaves. During the summer rainy season, a cluster of upright stems appears. The stems have small, narrow, alternate leaves. The sheaths at the plant's stem nodes (ocreae) that are characteristic of the jointweed family are ciliate (fringed). Stems and leaves range in color from green to dark red. Red coloration appears to be associated with exposure to full sunlight and with older vegetative parts (although seedlings are often red). As the stems elongate, 1 to 46 slender spike-like clusters of flowers develop at the ends of the stems. The flowering stems are as tall as 0.8 m (3 feet) (Hawkes and Menges 1995). Individual plants produce either pistillate (female) flowers or perfect (bisexual/hermaphroditic) flowers. Individual flowers are small, white to slightly pink with five sepals (covers for a flower before it opens), no petals, pink pistils, and black anthers. The gynoecium (seed-producing organ) consists of three united carpels (ovule-bearing units), each with a one-ovuled, superior ovary. The flowers are arranged in spikes, and flowering starts at the tops of the spikes and proceeds downward. The fruit is a three-sided, single-seeded dry fruit (achene), 1 to 3 mm (0.04 to 0.10 inches) in length (Horton 1963).

Life History – Wireweed seeds germinate in winter or spring. Individual plants flower for at least 1 or 2 years, but often fail to live the third year (Archbold Biological Station 2003; Hawkes and Menges 1995; 1996). Flowering is from September through November. Plants overwinter as rosettes. In May or June (Archbold Biological Station 2003; Hawkes and Menges 1995) the plants tend to lose their leaves and can for a while be nearly invisible until stems begin to grow. Wireweed is gynodioecious – plants have either only female flowers or hermaphroditic flowers. Seed is produced in abundance and is highly viable. Seeds do not become dormant and the species does not have seed banks in the soil.

Population Dynamics – Analysis of wireweed's population dynamics and population viability is based on the essential role that fire plays in maintaining this vegetation (Boyle et al. 2003) and the importance of recovery from fire for the vegetation itself and for its species (Abrahamson 1984a, 1984b).

Wireweed occupies open, sandy patches (or gaps) in the rosemary phase of Florida scrub, which itself is quite patchy, usually being surrounded by denser vegetation. The gaps are usually impermanent. Large areas of open sand may have especially dense populations that may be attractive to pollinators and may have high seed production. Because gaps are impermanent, wireweed suffers local extinctions. Because wireweed does not maintain seed banks in the soil and is killed by fire, it must colonize recently-burned areas from nearby populations (Boyle et al. 2003). Recolonization may be slow due to this species' small seeds, which have no obvious dispersal mechanisms.

Boyle (2003) prepared a metapopulation viability analysis of this plant, based on its colonization of newly-available gaps, and its subsequent local extinctions as gaps decrease in size. Boyle (2005) reports that "from 1999 to 2002, turnover among 1,210 gaps was 8%/year and dominated by local extinctions. Logistic regression shows that the incidence of *P. basiramia* within gaps increases in larger, less isolated gaps. The probability of local extinction decreases with increasing gap area. The probability that a vacant gap is colonized rises with gap area and proximity to other occupied gaps. Extinction and colonization of populations within 83 rosemary patch populations occurred more slowly (1 percent/year, 1989 - 1999) and responded less to habitat characteristics, as expected if large scale patterns integrate over smaller-scale dynamics…" In brief, wireweed is more likely to be present in large gaps that are near other gaps, and large, vacant gaps are more likely to be colonized.

Boyle's innovative metapopulation population viability assessment compliments viability assessments that have been prepared for several other LWR scrub plants. Evans et al. (2003) emphasize the importance of understanding the reproductive biology of individual rare species and the hazards of simply assuming that plants from shared habitats and shared disturbance regimes share the same risks to population viability. They conclude that "prescribed fire programs tailored to the population dynamics of these plants and reserve systems designed to accommodate extinction-recolonization dynamics should address both the positive and negative effects of fire on these plants."

Wireweed, like other small herbs of scrub openings, opportunistically occupies road edges and other artificially disturbed areas. Roadside habitats are significantly different from the bare areas within the vegetation, and may be less suitable for conservation of the scrub species. Petrů and Menges (2004) found that "the demographic responses of the species to sand movements indicate that mobile sands create constantly shifting arrays of microsites that can influence post-dispersal seed germination, survival, and growth of Florida scrub herbs. Roadside habitats have more dynamic patterns of sand movement than natural gaps and may alter selection regimes important for demographic variation of endemic Florida scrub plants."

Boyle and collaborators examined the genetic diversity and structure of wireweed populations. They found low levels of population differentiation, and "opportunistic roadside populations harbor genetic diversity similar to scrub populations" (Boyle 2005; Boyle et al. 2000). This finding somewhat allays concerns that the artificial conditions at the edges of unpaved roads, trails, and fire lanes may become genetically differentiated from populations growing under natural conditions within the vegetation.

Status and Distribution – Wireweed occurs on the LWR and the adjoining, much smaller, Bombing Range Ridge. It is present on most of the conservation lands with scrub within its range, and it is locally abundant. As of September 1999, the FNAI database had 142 element occurrence records for wireweed, of which 61 (43 percent) were on 12 different conservation lands. Another 42 element occurrence records were on sites proposed for State acquisition (Schultz et al. 1999). Data from 1983 to 2000 showed that 10 of 144 localities had more than 100 individual plants and 4 of these 10 localities had greater than 500 plants (FNAI Unpublished Data). These sites are now on sites belonging to the LWR WEA, except for a site at Hickory Lake. The FNAI data do not include abundant wireweed at Archbold Biological Station and the Arbuckle tract of LWR State Forest. A new assessment of this species' distribution and abundance will be available in 2005.

Wireweed is reported from the following conservation lands. Information is provided where available:

- The Allen David Broussard Catfish Creek Preserve State Park comprises 4,218 acres operated by DEP. It has active fire management and rare plant monitoring;
- Hickory Lake Scrub County Park, a 57-acre tract owned by Polk County. It has a management plan, prescribed fire management, and rare plant monitoring;
- Saddle Blanket Lakes Preserve comprises 829 acres owned by TNC. The tract has rare plant monitoring. TNC has conducted fires since the early 1990s, so this preserve has substantial open, sandy areas ideal for wireweed;
- Sun Ray (270 acres) is a scrub unit of the LWR WEA;
- LWR State Forest consists of three tracts. Wireweed is present on the Arbuckle and Babson/Hesperides tracts. The Forest has rare plant monitoring. The LWR State Forest is represented in the FNAI database by 13 element occurrences, but the Arbuckle tract has records for 184 records for this plant, based upon an inventory by K. DeLaney in 1988 (data provided by A. Cox). Of the 184 locations of wireweed on the Arbuckle tract, 30 of these represented more than 100 individuals. Although even today not all of this property has been searched for scrub plants, these data demonstrate that wireweed is abundant on the Arbuckle tract;
- Hickory Lake Park, operated by Polk County, south of Frostproof, comprises 57 acres. Wireweed is abundant (FNAI, letter correspondence, 2002);
- LWR NWR, Flamingo Villas tract;
- Avon Park Air Force Range comprises 106,110 acres. The tract has a management plan, land and fire management, and rare plant monitoring for wireweed, which is present on the Bombing Range Ridge;
- The LWR WEA comprises 11 tracts, totaling 16,167 acres. Wireweed is present on the following tracts: Lake Apthorpe, Gould Road, Henscratch Road/Jack Creek, Holmes Avenue Scrub, Highlands Ridge, Carter Creek, Silver Lake, Gould Road, and Lake Placid. Royce Ranch and the Woolfenden Tract (McJunkin Ranch) have not been fully inventoried but both have suitable habitat and are within the species' range;

- The Sun n' Lakes Preserve, operated by Highlands County, comprises 1,380 acres, in part longleaf pine vegetation. An overall management plan has been prepared, and the County planning department prepares annual stewardship reports (V. Pontius, Highlands County, personal communication, 2002). Wireweed is almost certainly present here, based on the tract's location adjacent to the Silver Lake tract of the LWR WEA, but we do not have confirmation;
- Highlands Hammock State Park, comprising 8,123 acres, was expanded during the 1990s to include scrub. The Park has a management plan, land and fire management, and rare plant monitoring;
- Jack Creek, comprising 1,285 acres, is owned by SWFWMD. It adjoins the Henscratch Road/Jack Creek tract of the LWR WEA;
- Lake June-in-Winter Scrub State Park, located on the lake, comprises 845 acres. It has a management plan, land and fire management, and monitoring of endangered and threatened plants; and
- Archbold Biological Station comprises 5,238 acres. The Station has a management plan, land and fire management, monitoring of endangered and threatened plants, and extensive research programs, including projects on wireweed, which is abundant here.

Habitat outside of conservation lands is still being lost by conversion to residential and agricultural development.

Highlands tiger beetle

Description – The Highlands tiger beetle is a candidate for listing. The Highlands tiger beetle is a member of the beetle family Cicindelidae (tiger beetles), which includes more than 2,000 species worldwide, with more than 100 in the United States (Pearson and Cassola 1992), and about 25 in Florida (Knisley and Hill 1992).

Tiger beetles share similar larval body forms throughout the world (Pearson and Cassola 1992). The larvae, either white, yellowish, or dusky in coloration, are grub-like and fossorial (subterranean), with a hook-like appendage on the fifth abdominal segment that anchors the larvae inside their burrows. Adult tiger beetles are medium-sized, elongate beetles, mostly with brilliant metallic green, blue, red, and yellow coloration highlighted by stripes and spots. The Highlands tiger beetle is 10.5 to 12.0 mm long (0.4 to 0.5 inches) (Knisley and Hill 1992; Deyrup 1994).

Choate (1984) described the Highlands tiger beetle as a new species in a paper that also dealt with two similar species, the Florida scrub tiger beetle (*C. scabrosa*) and *C. abdominalis*. These three species constitute the "*C. abdominalis* group." The three species are similar, very small and black (with green, blue, and purple reflections), with an orange abdomen visible from the underside. They can be distinguished by several prominent features. The elytrya (leathery forewings) of *Cicindela abdominalis* are shallowly punctured; *Cicindela scabrosa* deeply punctured, and *Cicindela highlandensis* glabrous (*i.e.,* without the punctures). The Highlands

tiger beetle also lacks conspicuous white flattened hairs on both sides of the thorax and the underside of the abdomen.

A large body of scientific literature is devoted to tiger beetles, and a tiger beetle scientific journal, Cicindela, has been published since 1969. Scientists have studied the diversity and ecological specialization of tiger beetles, and amateur collectors have long been attracted by their bright coloration and swift movements. Tiger beetle species occur in many different habitats including riparian habitats, beaches, dunes, woodlands, grasslands, and other open areas (Pearson 1988; Knisley and Hill 1992). A common habitat component appears to be open, sunny areas that are used for hunting and thermoregulation (adaptive behavior to use sunlight or shade to regulate body temperature) (Knisley et al. 1990; Knisley and Hill 1992). A photograph, drawings, and other identification information are available from FNAI (2000d).

Life History – The Highlands tiger beetle is restricted to open, sandy, well-drained, Florida scrub habitat on the LWR in central Florida (Knisley and Hill 1992, 1994, 1996; Deyrup 1994). It is found only in a fraction of suitable sites. The adults are fast running predators, easily seen, showing orange on the abdomen in flight, and are weak fliers with limited dispersal capability (Knisley and Hill 1992). Larvae of the Highlands tiger beetle live in burrows near the ground surface (TNC 1999).

Knisley and Hill (1996) considered high quality habitat to primarily be scrub or pine woodland with a high percent of open sand (greater than 50 percent) and with many natural openings which are continuous or connected to adjacent open patches, or connected by lightly disturbed trails or paths. Adult Highlands tiger beetles were never found in areas of dense scrub (except along the edges of trails), nor in areas of low shrubs. The Highlands tiger beetle was regularly found on trails with evidence of at least moderate off-road vehicle traffic and where there was evidence of past vegetation clearing or other ground disturbance (Knisley and Hill 1992, 1996). This suggests that fire suppression has caused the vegetation to become artificially dense, harming the beetle and other species. This also suggests the need for prescribed burning or alternative methods of clearing openings such as scraping with a bulldozer (Knisley and Hill 1996). Tiger beetle larvae undergo three instars (larval development stages). This period can take 1 to 4 years, with a 2-year period being the most common (Pearson 1988). The Highlands tiger beetle has a 1-year life cycle (Knisley and Hill 1996). Adults begin to emerge from mid to late May, reaching peak abundance about mid-June, then declining in numbers from mid-July onward. Only a few adults survive into late August and early September. Adults mate and begin oviposition (egg-laying) within about 2 weeks of emergence.

First instar (a stage in the life of an arthropod between two successive molts) larvae begin to appear in late June and reach peak abundance from late July to early August. Survivors develop to the second instar within 2 to 4 weeks. Second instars, which are at peak abundance from late August to October, require about 4 to 8 weeks to develop to the third instar. Third instars can be found from August through the following spring. This stage requires more food and lasts at least several months. Many third instars may nearly complete their development by December or January, but will occasionally open their burrows until they pupate. Pupation occurs in April or

early May, although some larvae of a cohort (probably less than 15 percent) will lag in their development and emerge after 2 years of development (Knisley and Hill 1996).

The major natural enemies of adult tiger beetles are robber flies (Family Asilidae) and birds. Parasitoid wasps (Family Tiphiidae, genus *Methocha*) and bombyliid flies (*Anthrax*) are the major predators of larvae (Knisley and Hill 1989; Hill and Knisley 1990). Ants may sometimes affect larvae, especially during first instar (Knisley 1987). Most tiger beetles species that have been intensely studied experienced relatively high levels of larval parasitism (10 to over 40 percent) (Knisley and Hill 1992).

Survivorship of Highlands tiger beetle larvae from first instar through the third instar ranged from about 10 to 22 percent at the three sites that Knisley and Hill (1996) studied for 2 years. The highest mortality to larvae was during their first few months, August to October. Predation by ants that took over the burrows was largely restricted to first instars. Parasitism from the parasitoid wasp *Anthrax* was a significant mortality factor for third instar larvae; most samples of larvae had parasitism rates over 15 percent, a rate similar to those found for other species of tiger beetle (Knisley and Hill 1996; Knisley 1987). Knisley and Hill (1996) also saw a small parasitic wasp, apparently *Methocha*. Robber flies were common at all of the study sites and appear to be the major predators of adult Highlands tiger beetles.

Tiger beetle larvae are predatory. They live in small burrows from which they lunge and seize passing invertebrate prey (Eissig 1926, 1942; Pearson 1988). When a prey item passes near a burrow, the larva grasps it with its strong mandibles (mouthparts), pulls it into the burrow, and feeds (Eissig 1942; Pearson 1988). All adult tiger beetles are predators that seize small prey with powerful sickle-shaped jaws (Pearson and Cassola 1992). In Florida, their prey is typically ants (Choate 1984).

Population Dynamics – This species' narrow distribution may be in part due to its lack of dispersal. Among tiger beetles there is a general trend of decreasing flight distance with decreasing body size (B. Knisely, personal communication, June 2005). Highlands tiger beetle is one of the smallest tiger beetles and an extremely weak flier (usually moving only 1 to 5 m in a flight). Species in woodland, scrub, or dune habitats seem to disperse less than water edge species, and this could further explain the apparent limited dispersal of Highlands tiger beetles (Knisley and Hill 1996). The thermal requirements of the Highlands tiger beetle may also limit its dispersal. Adults may overheat in full sun, preferring partially shaded habitats. Larval burrows tend to be near vegetation, where they are shaded for part of the day.

Status and Distribution – Highlands tiger beetle was described in 1984, so there are no records of its past distribution and abundance. It seems quite likely that it was common in scrub and sandhill vegetation of the LWR in Highlands and Polk Counties prior to the widespread destruction of upland vegetation during the past 50 years (Knisley and Hill 1992) that eradicated most of the Highlands tiger beetle's suitable habitat. Knisley and Hill (1992, 1994, 1996) found this species at 40 sites, 25 in Polk County and 15 in Highlands County. The sites are all on the LWR. The range of the Highlands tiger beetle does not extend to the south end of the LWR, but

it does extend northward to the north side of Lake Marion, east of Haines City. In recent years, a number of tiger beetle collectors have sought but not found this species in other areas in this vicinity.

The Highlands tiger beetle is present in protected areas, including the Allen David Broussard Catfish Creek Preserve State Park northeast of Lake Wales, TNC's Tiger Creek Preserve, LWR State Forest, Carter Creek and Henscratch units of the LWR WEA, the Jack Creek tract managed by the SWFWMD, and an adjoining tract of the LWR WEA. Most of the remaining sites are small, privately owned, and are subject to development activities which could negatively affect the species or its habitat.

Knisley and Hill (1996) graded sites with Highlands tiger beetles, based on numbers of tiger beetles and extent of suitable habitat. They graded the following as "B-" or better: the Allen David Broussard Catfish Creek State Preserve State Park, Flaming Arrow Boy Scout Camp (near the Babson-Hesperides tract of LWR State Forest), another site in the Hesperides area, Livingston Creek (Arbuckle tract of LWR State Forest), Tiger Creek Preserve (TNC), Tiger Creek South (Hesperides CARL project), Moon Ranch road (Carter Creek CARL project vicinity), and Flamingo Villas (LWR NWR). Preliminary results from a survey by Barry Knisley due to be completed in 2005 indicate that populations remain present on conservation lands, and are doing well.

The primary threats to the Highlands tiger beetle have been loss and inadequate management of scrub vegetation, and collection (Service 2003). Although the Highlands tiger beetle may benefit from the clearing activities that accompany pedestrian trail construction, off-road vehicle traffic will harm the species by crushing individual larvae or their burrows. An additional threat is fire suppression, which changes the nature and composition of the scrub communities.

Much of the scrub, at least in private ownership, is unsuitable for the species as a result of fire suppression (Knisley and Hill 1992). Such modified scrub is much more densely vegetated and often lacks the natural open, bare patches that the Highlands tiger beetle occupies (Knisley and Hill 1992). Knisley and Hill (1992) documented how ecological succession can change habitat and cause the decline and local extirpation of tiger beetle species. An example of this was documented for *Cicindela abdominalis* (the species to which the Highlands tiger beetle is most closely related) at a Virginia pine barrens site. Encroaching vegetation and fire suppression caused the species to be extirpated from the site during the 1930s (Knisley and Hill 1992). Little is known about the dispersal of Highlands tiger beetle, but its small size and weak flight suggest it probably has a limited dispersal (Knisley and Hill 1992). Limited dispersal could cause the species to be extirpated from isolated sites since much of the Highlands tiger beetle's habitat has been highly fragmented throughout its range.

Land managers in the area are implementing fire management for scrub vegetation that will benefit the Highlands tiger beetle. In the wake of several disastrous wildfire seasons, DOF received strong State support for fire management on State lands in the LWR and elsewhere. In addition, the research and other programs of Archbold Biological Station emphasize fire

management and development of alternatives to fire (Lohrer 1999) that will restore and enhance scrub habitats in the area. The MSRP (Service 1999) encourages the use of prescribed fire through its recovery criteria for species on the LWR that require restoration of native vegetation. Cumulatively, these efforts will enhance and restore scrub habitats on the LWR. Coupled with the increased amount of Highlands tiger beetle habitat in public and conservation ownership, the immediacy of threats to this species has been reduced in recent years.

Land acquisition on the LWR is continuing, funded by the State of Florida, the Service, and others. Most of the good examples of Highlands tiger beetle habitat are now under public or private conservation ownership. Also, the Service estimated in 2003 (Service 2003) that approximately 50 percent of the remaining available habitat for the species that was targeted for acquisition had been purchased or was being purchased.

Tiger beetles of the genus *Cicindela* may be the subject of more intense collecting and study than any other single insect genus. Knisley and Hill (1992) stated that over-collecting of the Highlands tiger beetle may be of "some importance" and suggest that over-collecting may have been partly responsible for the apparent extirpation of the species from the site where Choate had first collected it (*i.e.,* the type locality). They estimated that well over 1,000 adults had been collected at this site (Knisley and Hill 1996).

ENVIRONMENTAL BASELINE

The environmental baseline includes the effects of past and ongoing human and natural factors leading to current status of the species and their habitats.

Status of the Species/Critical Habitat within the Action Area

Florida scrub-jay – The LWR metapopulation of this species is very important to its recovery. Results from Stith's (1999) simulation model included estimates of extinction, quasi-extinction (the probability of a scrub-jay metapopulation falling below 10 pairs), and percent population decline. These were then used to rank the different State-wide metapopulations by vulnerability. The model predicted that five metapopulations (NE Lake, Martin, Merritt Island, Ocala NF, and LWR) are at low risk of quasi-extinction. Two of the five (Martin and NE Lake), however, experienced significant populations declines under a "no acquisition" option (Stith 1999). This means that, as of now, the LWR metapopulation is one of the three best in existence. While the LWR metapopulation extends into lands some distance away from the Ridge itself (for example into Avon Park Air Force Range), the Ridge is central to the metapopulation, so the lands comprising the action area are of critical importance for the maintenance of metapopulation dynamics, even though much of the actual population is on private lands outside of the action area. The lands comprising the action area also include the largest and most intact units of habitat for the scrub-jay in the metapopulation.

Eastern Indigo Snake – This species is present in a wide variety of habitats including the scrub and sandhill vegetation within the action area. Although we do not have specific information on

the eastern indigo snake's abundance within the action area, it is large enough that most properties can be expected to have habitat occupied by indigo snakes. The relatively large range of this snake and its use of a wide variety of natural and modified habitats mean that the action area comprises only a very small fraction of this species' range.

Bluetail mole skink – This species occurs in a variety of open, sandy, but appears to be rare wherever it occurs. Only 34 localities are known for this species, 14 on public land or on private land protected under conservation easement. The 14 protected sites are within the action area. It has suffered massive habitat loss and one site is being restored. It will be offered to LWR State Forest when restoration is complete. The species was listed as threatened rather than endangered because habitat loss was considered the primary threat. Purchase of conservation lands since it was listed and efforts to restore overgrown vegetation on those conservation lands appears to have improved this species' prospects. However, preliminary results of a trapping study indicate that it is far less abundant than the sand skink in the action area (Christman 2004).

Sand skink – This species occurs in open, sandy habitats, and is somewhat less rare than bluetail mole skink. Populations occur on the Lake Wales and Winter Haven Ridges in Highlands, Lake, and Polk Counties (Christman 1992b; Mushinsky and McCoy 1995; P. Moler, FWC, personal communication, 1998). The sand skink is uncommon on the Mount Dora Ridge, including sites within the Ocala NF, which has the largest area of seemingly suitable habitat for this species (Christman 1970, 1992b). As a result, the conservation lands within the action area appear to be critically important for its conservation. In 1997, FNAI had recorded 114 localities for the sand skink. Of the known locations, 41 (35 percent) were on public lands or private lands placed under conservation easement. Preliminary results of a trapping study at 9 different sites on the Lake Wales Ridge indicate that sand skinks are widespread and relatively abundant in scrub, scrubby flatwoods, and sandhill habitats (Christman 2004).

Avon Park harebells – This species has been found only in scrub and at only three occurrences. They are (in Polk County) the Avon Park Lakes tract of the LWR WEA and TNC's Saddle Blanket Lakes Preserve; and (in Highlands County) the Carter Creek unit of the LWR WEA. As a result, the action area comprises most of the existing range of this species. This plant is moderately abundant in bare sandy areas in scrub of both Saddle Blanket and Carter Creek. At Carter Creek it is relatively abundant at the edges of unpaved streets. Although this plant is moderately abundant where it occurs, those areas are so limited that a propagation and reintroduction program is underway.

Britton's beargrass – The largest remaining populations and largest tracts of occupied habitat for this species are in Polk and Highlands Counties, on conservation lands comprising the action area, in both scrub and sandhill vegetation. It is locally abundant and apparently secure, so much so that only minimal monitoring is done at the Tiger Creek Preserve, where sandhill is being restored by frequent prescribed fires. Populations of this plant are believed to be relatively stable, in large part because the individual plants are long-lived.

Carter's mustard – The largest known populations of this species are at the Archbold Biological Station in Highlands County and the TNC's Tiger Creek Preserve in Polk County. In Highlands County, it is present at the Lake Placid tract of LWR WEA, the Carter Creek tract of LWR NWR, LWR State Forest. In northern Polk County, its distribution is apparently less well worked-out. It is present on the Snell Creek tract of LWR NWR and is probably present on adjoining land belonging to the Upper Lake Marion Creek Watershed, managed by the SFWMD. It is also probably present slightly farther north on another tract of the Upper Lake Marion Creek Watershed, located near Horse Creek. Carter's mustard responded positively to a prescribed fire at the Carter Creek tract of LWR NWR. Carter's mustard typically exists as seeds in the soil except when germination is stimulated by fire or disturbance, and the plants are inconspicuous except during their flowering period lasting about a month. As a result, the distributional records may be incomplete (Service 1996). The annual habit of Carter's mustard makes assessment of its status or planning its conservation more difficult than is the case for perennial herbs or shrubs. Because this plant is restricted on the LWR to sandhill vegetation with relatively frequent fires, this plant is essentially restricted to the sandhills that have come into public ownership as the result of State, local, Federal, and private conservation land acquisitions over the past fifteen years.

Florida bonamia – This species is present at most sites with scrub vegetation on the LWR (Schultz et al. 1999), and the conservation lands comprising the action area are very important for its conservation, representing an area with sufficient habitat to maintain populations in Polk and Highlands Counties. Land managers at the LWR State Forest, who have monitored this species, expressed concern over its apparently declining numbers on the Forest's three tracts (Cox 2004). This plant does not appear to be abundant anywhere on the LWR.

Florida perforate cladonia – This species has a spotty but extremely limited distribution. In Highlands County, Archbold Biological Station has eight populations. In Polk County, Florida perforate cladonia is present on the Lake McLeod tract of LWR NWR and on Arbuckle tract of LWR State Forest, where it has been monitored annually since 2001 (Hardin 2004). In 2003, the area with Florida perforate cladonia was mapped using GPS in five previously-mapped areas that had received prescribed fire in 2002. The area with the lichen had expanded since 2002, as lichens growing on the sandy soils had been blown by wind or washed by rains beyond the previously marked boundaries. The mapped areas covered 3.74 ha (9.3 acres) in 2003. Although other rosemary scrubs were searched, no other Florida perforate cladonia populations were found. In addition to the protected sites for Florida perforate cladonia, the Trout Lake site in Polk County (on the Highlands County border) is privately owned (FNAI 2005). Overall, conservation lands in the action area (Archbold Biological Station and Arbuckle Tract of LWR WEA) protect the largest known concentrations of this species, so careful management of these lands are critical to its continued existence.

Florida ziziphus – This extremely rare shrub is restricted to Highlands and Polk Counties. It appears to be restricted to sandhill vegetation, which was largely destroyed for citrus groves and pastures. The two introduction sites constitute two of the three largest remnants of such vegetation in conservation ownership. Surprisingly, it is one of the very few sandhill species that

persists in several pastures, showing its resistance to mowing and, likely, root-raking. It is close to being functionally extinct because the nine genotypes known to exist in the wild are barely sufficient to support a rather complex breeding system that prohibits selfing and allows only selective outcrossing. Only one small wild population is protected in native vegetation on public conservation lands (at LWR State Forest) and it cannot support sexual reproduction, so introductions at Tiger Creek Preserve and the Carter Creek unit of LWR NWR are very important to preventing extinction. While some of the privately owned populations (or, more accurately, many-stemmed individuals) may remain safe for their foreseeable future, their conservation is strictly a matter of cooperation on the part of the landowners. Observation strongly suggests that this shrub will thrive when subjected to prescribed burning, but is likely to decline if left alone. Therefore, prescribed fire is a major part of the introduction projects. The two introduction sites are both within the action area.

Garrett's mint – This species is restricted to only five populations in yellow sand scrub vegetation within a very limited range east of Sebring, Highlands County. Four, on private land, can probably not be conserved because the area is becoming developed for residential purposes and because conducting prescribed fires on small tracts of privately-owned scrub is close to impossible. The species is protected, with ample habitat to support a viable population, at the Flamingo Villas unit of LWR NWR. Garrett's mint inhabits bare sand. Because the Flamingo Villas site has not burned for many years, much of the bare sand is along firebreaks and tracks maintained by off-road vehicles. It is absent from the area's sand pine and oak thickets. Extensive demographic study of this and the similar scrub mint by Eric Menges and Carl Weekley of Archbold Biological Station indicate that this plant will return from seed buried in the soil after fire. The Flamingo Villas site has been substantially cleared of trash since acquisition began.

Highlands scrub hypericum – This species has a narrow distribution at the southern end of the LWR in Highlands County and southernmost Polk County. Inventories of LWR endemic plants found this species at few sites – only 69 of 254 scrub sites surveyed by Christman (1988). Highlands scrub hypericum is locally abundant, with populations larger than a thousand plants and presumably large seed banks in the soil at Archbold Biological Station, the properties of the LWR WEA, Lake June-in-Winter Scrub State Park, TNC's Saddle Blanket Lakes Preserve, and the Arbuckle tract of LWR State Forest. No substantial privately-owned tracts of scrub remain in this area. Land acquisition projects by the State and Archbold Biological Station have brought remaining sites into conservation ownership. Conversely, the species' recovery depends on these conservation lands, all of which are in the action area. Research at Archbold Biological Station shows that this species is fire-dependent, restricted to open areas that are created, and maintained by fires and slowly disappearing as shrubs encroach.

Lewton's polygala – This species is restricted to sandhill vegetation, such as at Tiger Creek Preserve and the Carter Creek unit of LWR NWR. Recent research demonstrates that seed in the soil germinates after a fire, leading to a short-term population explosion. Population sizes decline with time after fire. Lewton's polygala occurs in sandhill vegetation and Florida scrub of the LWR. The largest occurrence is at the Carter Creek tract of LWR NWR. Within the action

area, it also occurs on LWR State Forest (Arbuckle and Walk-in-the-Water), Allen David Broussard Catfish Creek Preserve State Park, TNC's Tiger Creek Preserve, Pine Ridge Preserve at the Historic Bok Sanctuary, and Highlands Hammock State Park. Overall, the action area probably represents a majority of the populations and individuals of the species. It would be difficult to accurately compare population sizes because this species experiences population booms shortly after fires, and populations decline until after the next fire. Even with regular fire management, patches of Lewton's polygala often diminish or disappear within 5 years. TNC's Tiger Creek Preserve has numerous individuals of Lewton's polygala. Monitoring since 1991 has shown that fire is crucial for the maintenance of this species, and the 10-year trend for this species is stable. Demographic monitoring at the Carter Creek unit of LWR NWR also demonstrates boom-and-bust demography. The active prescribed fire and sandhill restoration program at Tiger Creek and the prospect of similar management at Carter Creek and other tracts is very favorable for this species.

Papery whitlow-wort – The vast majority of existing populations of this species are in Highlands and Polk Counties, mainly on conservation lands constituting the action area. This plant forms locally large populations on most of the lands in the action area. For example, the LWR State Forest's Arbuckle tract has 188 records of this plant in its GIS database, mostly from a 1988 inventory. Of the 188 records, 23 represented more than 100 individuals (data collected by K. DeLaney, provided by A. Cox, LWR State Forest). Recent monitoring (Cox 2004) indicates that populations remain large. Archbold Biological Station has not monitored this plant because it thrives in fire lanes. Overall, threats to this species have been greatly reduced by purchase of its best remaining habitats for conservation purposes since it was listed. However, the propensity of this species to occupy fire lanes, roadsides, and other artificially disturbed areas is a conservation concern, because the papery whitlow-wort tends to be far more abundant in such disturbed areas than within the vegetation itself. Prescribed fire appears appropriate to create or enlarge open, sandy areas in the scrub vegetation.

Pigeon wings – This species is present in Polk County, where it is locally abundant at the Tiger Creek Preserve and present in extensive suitable habitat at Avon Park Air Force Range, Arbuckle and Walk-in-the-Water tracts of LWR State Forest, Horse Creek Scrub, and Saddle Blanket Lakes Preserve; and in Highlands County, including several tracts of the LWR WEA, two units of LWR NWR, and Archbold Biological Station. It inhabits sandhill, scrub, and dry hammock vegetation. Conservation of this plant depends largely on conservation lands that have been acquired to protect distinctive scrub and sandhill vegetation on the LWR, plus continued appropriate management of its habitat on the Avon Park Air Force Range. Individual plants of pigeon wings resprout from large horizontal underground rootstocks and appear to be relatively long-lived, based on their responses to fire at sites like Tiger Creek Preserve, where they are thriving under a regime of frequent prescribed fires. Acquisition of conservation lands on the LWR since this species was listed has greatly reduced the threat of habitat loss, and vegetation restoration through prescribed fire on conservation lands appears to be yielding further benefits (more information will become available as a study at Avon Park Air Force Range progresses).

Pygmy fringe tree – The best-monitored population of this species within the action area is in Polk County, in sandhill vegetation at Tiger Creek Preserve, where it has been monitored since 1989. This population appears to be stable and responding well to frequent prescribed fires. Other populations are at LWR State Forest (Arbuckle and Walk-in-the-Water tracts), at the Saddle Blanket Lakes Preserve (also burned recently), and the Allen David Broussard Catfish Creek Preserve State Park. In Highlands County, the Carter Creek unit of LWR NWR may have the largest protected population. It has responded well to prescribed fire. It is also present at two units of the LWR WEA and Archbold Biological Station. These protected sites within the action area collectively represent the only prospect for conserving this species. Threats to the pygmy fringe tree have been reduced by acquisition of such conservation lands over the past 15 years, despite the loss of habitat outside of conservation lands. Available information shows that this species resprouts readily after fire, and seedlings and saplings can be found.

Sandlace – This species is found in Polk County on the Allen David Broussard Catfish Creek Preserve State Park, Hickory Lake Scrub County Park, Saddle Blanket Lakes Preserve, Sun Ray Scrub unit of the LWR WEA, and the Lake McLeod and Snell Creek units of LWR NWR. In Highlands County, it is present on the Flamingo Villas unit of LWR NWR, all or nearly all of the tracts of the LWR WEA, The Preserve (Highlands County government), Highlands Hammock and Lake June-in-Winter Scrub State Parks, Jack Creek (SFWMD), and Archbold Biological Station. All of these conservation lands are within the action area. Scrub vegetation is not expected to persist outside of the conservation lands, in part because conducting safe prescribed burns in this vegetation is difficult, and the vegetation becomes less suited to this and other scrub endemic species as time-since-fire increases. Collectively, they constitute the area available to this species for its recovery. Sandlace is locally reasonably abundant and appears to respond well to restoration of the scrub vegetation through the use of prescribed fire.

Scrub blazing star – This species is never abundant, but is present as scattered individuals in scrub throughout the action area. Overall, habitat is still being lost, but State, Federal, and private acquisition of conservation lands on the LWR has clearly benefited this plant, which is distributed on the southern LWR of Polk and Highlands Counties, plus a single known site on the Winter Haven Ridge in Polk County, at Lake Blue (Schultz et al. 1999). This perennial herb is known from about 115 extant populations (Dolan et al. 1999) and it is present on most of the conservation lands with scrub vegetation within its range. They include Allen David Broussard Catfish Creek Preserve State Park, Boy Scout (Cox 2004) and Lake Arbuckle tracts of LWR State Forest, Saddle Blanket Lakes Preserve, all or nearly all of the 12 units of the LWR WEA, Lake June-in-Winter Scrub State Park, the Flamingo Villas tract of LWR NWR, and Archbold Biological Station (Schultz et al. 1999; Service 1996). Collectively, these conservation lands constitute the area available to scrub blazing star for its recovery. Individual plants of this herb are relatively long-lived (with a life expectancy of at least 8 years, according to one report) and typically return after fire. This species is more shade-tolerant than most LWR scrub endemics, so it may be less sensitive than most to fire frequency.

Scrub buckwheat – This species can be abundant in sandhills vegetation. Fire stimulates flowering, and seeds (unusually for plants of scrub or sandhills) germinate in summer, so a fresh

crop of seedlings can emerge after a winter or spring fire. Failure to conduct prescribed fires is likely to result in population declines. Its decline is due almost entirely to loss of sandhill habitat and to habitat degradation due to lack of prescribed fire. Its long-term prospects are favorable due to habitat acquisition after it was listed, as well as efforts by conservation land managers to restore natural fire regimes. For example, it is now the most abundant of the "rare" species at the Tiger Creek Preserve and its populations are stable, so it does not receive intensive monitoring (B. Pace-Aldana, TNC, letter correspondence, 2005). Within Polk County, scrub buckwheat is present on conservation lands within the action area at Tiger Creek, the LWR State Forest, Allen David Broussard Catfish Creek Preserve State Park, Carter Creek tract of LWR NWR, Historic Bok Sanctuary, and Horse Creek Scrub. In Highlands County, it is present at the Lake Apthorpe tract of the LWR WEA, Flamingo Villas tract of LWR NWR, and Archbold Biological Station, which represents its southern range limit.

Scrub lupine – This species is very narrowly distributed and most of its former habitat has been destroyed. The only securely protected site within the action area is the 65 acre Lake McLeod unit of LWR NWR. Planning for Lake McLeod's management is underway, but already monitoring indicates that cutting and burning selected patches of shrubs is appropriate to control patches of shrubs in this very open scrub. Lake McLeod is critically important for conservation of this herb, which has not been successfully propagated.

Scrub mint – This species is present on only two conservation lands, both of which are in the action area (Archbold Biological Station and Lake Placid tract of the LWR WEA), plus a small number of non-conservation tracts that appear unlikely to persist over the long term. Seedlings will appear and thrive after a fire from seed stored in the soil. Optimal fire return intervals appear to be 6 to 10 years (Archbold Biological Station 2003).

Scrub plum – This species, like most other plants of scrub and sandhill, faces very poor prospects outside of conservation lands. It is present in both scrub and sandhill vegetation on nearly all other conservation lands within the action area. In Polk County, it is present at LWR State Forest, at Historic Bok Sanctuary, at the Allen David Broussard Catfish Creek Preserve State Park, and at Tiger Creek Preserve. In Highlands County, it is present on tracts of the LWR WEA; the Carter Creek and Flamingo Villas tracts of LWR NWR; Archbold Biological Station; and Lake June-in-Winter Scrub State Park. Nearly all plants survive fires, although a few plants burned to the ground may die (fewer than two percent after 3 years). Information on numbers of plants by site has not been available, probably because it is perceived by land managers as relatively abundant.

Short-leaved rosemary – This species has a very restricted distribution in the Sebring-Avon Park area in Polk and Highlands Counties. It was found at only about 30 sites whose total area was less than 2,400 ha (6,000 acres) (Christman 1988; Christman and Judd 1990). All the conservation lands where this scrub species is protected are within the action area. In Polk County, they are the large Arbuckle tract of LWR State Forest, Saddle Blanket Lakes Preserve (335 ha/829 acres), Hickory Lake Scrub County Park (26 ha/65 acres), and the Sun Ray unit of LWR WEA (109 ha/270 acres). In Highlands County, it is on the Silver Lake unit of LWR WEA (157 ha/389 acres). It is also present on non-conservation lands in this county. Although it has not been studied in any detail, it is believed to respond positively to periodic fire, probably returning to burned areas from seed buried in the soil. Because this species only occurs in fire-maintained scrub vegetation and because development continues in its tiny range, its conservation depends essentially entirely on appropriate management of these conservation lands, which are all within the action area.

Snakeroot – This species formerly occurred in and near Sebring. All other sites are in an area about 39 km (24 miles) long in the vicinity of Lake Placid. Christman (1988) reported about 20 localities, but even this number is misleading since he divided several sites. It is present on the Hendrie Ranch (private) (Service 1996), Gould Road (212 acres), Woolfenden (McJunkin) tract (623 acres), Lake Placid (2,159 acres), Holmes Avenue (974 acres) and Lake Apthorpe (810 acres) tracts of LWR WEA, and Archbold Biological Station (5,200 acres). Acquisition of some of the LWR WEA tracts is not complete, and the presence of private inholdings inhibits fire management by FWC; only the DOF has authority to conduct fires including private properties. There are no significant prospects for conserving this plant on private land, unless there might be a conservation easement at Hendrie Ranch. The conservation lands, which are all within the action area, are crucial to the conservation of this species. Intensive demography research at Archbold Biological Station has shown that populations of this plant explode within the first decade after fire, with large flowering plants being common beginning with the third year after a fire. Populations begin decline 9 years after a fire and plants disappear entirely between 25 and 35 years after a fire. The exacting habitat requirements of snakeroot mean that, despite large populations at a number of sites, its habitat must be managed aggressively with fire or equivalent disturbances to maintain open, sunny gaps. Archbold Biological Station has a very effective fire management, and management on the LWR WEA tracts varies depending on the presence of inholdings.

Wide-leaved warea – There is almost no possibility that this plant will be conserved on private land, with the possible exception of the private Mountain Lake Estates, outside of the action area near the Historic Bok Sanctuary. Wide-leaf warea occupies sandhill habitat which historically burned during the summer growing season. There are anecdotal reports of plants appearing at sites where they had not been seen for several years, suggesting that the species banks seeds in the soil. Fire is believed to stimulate germination of seeds. The species occurs within the action area at the Historic Bok Sanctuary. It may also occur in the vicinity of Horse Creek or other areas near Haines City in northern Polk County. This sandhill annual is stimulated to germinate and grow by fire. Population sizes probably peak the first or second year after a fire, then decline.

Wireweed – This species occurs in scrub vegetation in Polk and Highlands Counties (and apparently in sandhill vegetation at the Sun n' Lakes Preserve). Because it requires regular prescribed fire to maintain its habitat of shifting, impermanent gaps within the vegetation, it is unlikely to persist over the long term on private lands. Wireweed is reported from the Allen David Broussard Catfish Creek Preserve State Park (4,218 acres), which has active fire management; Hickory Lake Scrub County Park (57 acres) in Polk County, which has prescribed fire management, and rare plant monitoring; Saddle Blanket Lakes Preserve (663 acres), where fires have been conducted since the early 1990s, ensuring substantial open, sandy gaps ideal for wireweed; Sun Ray (270 acres), a unit of the LWR WEA; three units of LWR State Forest, especially the Arbuckle Tract, where wireweed is quite abundant; LWR NWR, Flamingo Villas tract; most of the11 tracts of the LWR WEA (16,167 acres); probably the Sun n' Lakes Preserve (1,380 acres); Highlands Hammock State Park (8,123 acres), with fire management; Jack Creek (1,285 acres); Lake June-in-Winter Scrub State Park (845 acres), with fire management; and Archbold Biological Station (5,238 acres). Wireweed is for the most part unlikely to persist off of conservation lands, and it requires appropriate prescribed fire to maintain healthy populations. Conservation lands within the action area are essential to its conservation, and they appear adequate to maintain large populations throughout its range.

Highlands tiger beetle – This species was described in 1984, so there are no records of its past distribution and abundance. It seems quite likely that it was common in scrub and sandhill vegetation of the LWR in Highlands and Polk Counties prior to the widespread destruction of upland vegetation during the past 50 years (Knisley and Hill 1992) that eradicated most of the Highlands tiger beetle's suitable habitat. Knisley and Hill (1992, 1994, 1996) found this species at 40 sites, 25 in Polk County and 15 in Highlands County, from the north side of Lake Marion, east of Haines City southward to the vicinity of Sebring.

The Highlands tiger beetle is present in protected areas, including the Allen David Broussard Catfish Creek Preserve State Park, Tiger Creek Preserve, LWR State Forest, Carter Creek and Henscratch units of the LWR WEA, and the Jack Creek tract. Many of these sites have been acquired since the first status survey was conducted in 1992. All of them are in the action area. A new status survey by Knisley (personal communication, 2005) indicates that purchase of these sites and implementation of prescribed fire has improved this beetle's status. The Service (2003) estimated that approximately 50 percent of the remaining available habitat for the species that was targeted for acquisition had been purchased or was being purchased. Like other tiger beetles, this one inhabits bare sand and cannot persist in thickets or where the ground is covered with litter. Since remaining scrub and sandhill vegetation in the tiger beetle's range is disappearing, and is unlikely to receive prescribed fire, this beetle's conservation depends mostly on the conservation lands. A separate threat to this tiger beetle is collecting, because tiger beetles may be the subject of more intense collecting and study than any other single insect genus.

Factors Affecting Species Habitat within the Action Area

The action area consists of scrub, sandhill, and limited areas of other vegetation on publicly- and privately-owned conservation lands on the LWR, almost entirely in Highlands and Polk Counties. The most important factor influencing the species covered by this biological opinion and their scrub and sandhill habitats was, until the 1990s, destruction and degradation due to agricultural and residential development. In response, the State of Florida, the Service, and other parties including local governments, TNC, and Archbold Biological Station conducted carefully-designed land acquisition programs during the 1990s, resulting in a network of conservation lands. This network appears adequate to conserve most of the species covered in this biological opinion, except for scrub lupine and wide-leaf warea. As a result, conservation concern has shifted to completing land acquisitions by making small purchases (typically single lots in unbuilt subdivisions) and to management of the conservation lands. Incomplete land acquisition in unbuilt subdivisions creates problems of potential home or other construction within flammable scrub vegetation and may greatly restrict the use of prescribed fire.

By far the largest management concern for conservation lands is fire and its management. At some sites, the proximity of housing or other land uses severely limits the use of prescribed fire even as the presence of overgrown vegetation increases the threat of destructive wildfire. Research and monitoring over the past 15 years, as explained in background information on individual species, has done a great deal to elucidate suitable fire return intervals and intensities for the LWR's listed plants. Research on Florida scrub-jays has similarly clarified suitable vegetation structure for Florida scrub-jays and their responses to fire. As a result, nearly all conservation lands in the action area have suitable fire management plans for their listed species, and fire prescriptions can confidently be made to benefit those species over a time frame of 2 to about 30 years.

The use of prescribed fire for habitat restoration and maintenance is strongly encouraged by recovery plans for all of the species covered by this plan, except that the Florida perforate cladonia requires special attention due to its extremely limited distribution and its vulnerability to fire. The scrub lupine has similar caveats because of its extremely limited distribution, although it is clearly a fire-dependent species. Construction of firebreaks is essential for carrying out prescribed fire programs, and their creation and maintenance can both create opportunities for, and destroy listed plants and the Highlands tiger beetle. A number of the plants colonize such bare, open areas, as does the beetle.

On conservation lands, exotic pest plant threats are mostly manageable (with serious concern for Old World climbing fern and somewhat less concern over several grasses, including cogon grass (*Imperata cylindrica*) and Natal grass. Unauthorized use of all-terrain vehicles or dumping is a serious concern at several sites, including the Flamingo Villas unit of LWR NWR and parts of the LWR WEA. As a result, trash removal, surveys to ensure that contaminants are not present in trash, and fencing and other measures to manage public access are quite important for management of these lands.

EFFECTS OF THE ACTION

This section includes an analysis of the direct and indirect effects of the proposed action on the species and/or critical habitat and its interrelated and interdependent activities.

Detailed planning of fires is the responsibility of land managers, not the Strike Team, and planning and fire prescriptions adopted by management agencies for their conservation lands will be followed. Because essentially all of the vegetation in the LWR area is highly fire-adapted, biological conservation problems that could be caused by excessively intense or excessively frequent fires are modest, and these risks are minimized by the careful planning that will be required before the Strike Team will participate in a burn, as well as by precautions that the Strike Team itself will employ, as described in the Description of the Proposed Action section, below. In particular, although the best time to conduct fires in Florida scrub-jay habitat is during nesting season, care will be taken to avoid burning nests.

Florida scrub-jay – Fire preparation work carried out by land managers (not the Strike Team) will include preparation of fire breaks by mechanical means. The Strike Team can assist with mowing fire breaks and fire break preparation using hand tools. Fire breaks tend to be permanent and the open sand they provide is likely to be colonized by the short-lived herbs covered by this biological opinion and to be used by numerous insects that need bare sand. For scrub-jays, this preparatory work appears to have few effects, apart from creating or maintaining bare areas that will be useful for burying acorns.

Weather conditions necessary to provide burn conditions that produce optimal scrub-jay habitat occur primarily during the early growing season before the summer rains begin. Although the early growing season coincides with the scrub-jay nesting season, burning in the winter, fall, and late summer often produces inferior results and non-optimal scrub-jay habitat. Adult and juvenile scrub-jays can avoid flames and smoke. However, the prescribed burns and associated human activity will temporarily disrupt the birds' daily behavior patterns and ability to forage for a short period.

The overgrown scrub that will be burned generally does not provide suitable nesting sites, so must burns will not contain nest sites. Although measures will be taken to avoid the loss of scrub-jay nests, it is possible that nests might be lost in prescribed fires. They typically re-nest rapidly after fire. Scrub-jay data from Archbold Biological Station suggest that the loss of individual nests as a result of fires does not have a significant negative effect on the local jay population if adequate habitat remains unburned. Habitat enhancement from ecologically-based prescribed burning outweighs the short-term detrimental impacts to scrub-jay nesting success that may occasionally occur.

Optimal scrub-jay habitat consists of evergreen oak scrub 1 to 3 m (3 to 10 feet) tall interspersed with numerous patches of bare sand (Cox 1984). Sand pine scrub, scrubby flatwoods with slash pines, Florida rosemary scrub, sandhill, and the edges of mature sand pine scrub and xeric hammocks may also provide suitable habitat. Surveys have shown that overgrown scrub does

not provide suitable habitat for scrub-jays. Family groups are often observed on the periphery of overgrown scrub in adjacent flatwoods. Successful prescribed burns on the project sites will restore marginally-usable or unusable, overgrown habitat to suitable habitat for foraging and nesting. The project is specifically intended to enhance the continued existence of this species by improving habitat conditions. Long-term negative impacts are expected to be minor.

Eastern indigo snake – The equipment used to maintain the fire breaks and conduct prescribed burns will have rubber tires. Fire crew members supported by this project will be trained to identify the species, learn about habitat needs that pertain to the health of the population, and learn about specific management practices that will avoid detrimental impacts to individuals. Personnel will use caution to avoid running over individuals when operating vehicles during preparations for prescribed burns.

Ring fires, which could trap indigo snakes inside the burn area, will not be used. If an indigo snake is observed inside the burn unit, ignition will cease and the snake will be allowed or assisted to leave the unit. If that is not successful, fire activities will be delayed to give the snake time to find refuge underground before burning is continued. If fire threatens to burn over an individual, crew members will attempt to extinguish the fire so the snake can be rescued. Any eastern indigo snakes in a burn project area may incur a brief period of disturbance to its patterns of feeding, breeding, or sheltering. Disturbance from prescribed burns will occur for only one day on each of the burn units, and the burns will be conducted in mosaic patterns, providing areas of refuge for indigo snakes. Fire treatments could conceivably kill or injure snakes, but the precautions to be taken make it very likely that snakes would successfully flee fires or escape into underground refugia. Prescribed fires are expected to improve prey species abundance in the regrowing vegetation. The eastern indigo snake inhabits fire-adapted vegetation, so the Strike Team's activities are expected, over a term of several years to a decade, to be beneficial to the eastern indigo snake.

Bluetail mole skink – The Strike Team's equipment operators will take care to avoid running over individuals during preparations. All vehicle use will be contained as much as possible to the burn unit perimeter roads. There is a risk of individuals being crushed by equipment. Fire crew members supported by this project will be trained in identification of the bluetail mole skink, in habitat needs that pertain to the health of the population, and in specific management practices that will avoid detrimental impacts to individuals. Equipment operators will take care to avoid running over individuals during burns, and vehicle use will be contained as much as possible to the burn unit perimeter roads. Bluetail mole skinks are unlikely to be seen, but if one is seen, it will be allowed to move out of harm's way on its own before equipment use is resumed. Individuals, if present, could be killed by overheating from fire or from crushing by equipment. Populations are vulnerable to habitat degradation due to overgrown vegetation caused by fire exclusion. Prescribed fire is essential to maintain and restore its habitat. After treatment, this species is likely to benefit from the availability of more open sand habitat over a term of 1 to perhaps 15 years.

Sand skink – The Strike Team's equipment operators will take care to avoid running over individuals during preparations. All vehicle use will be contained as much as possible to the burn unit perimeter roads. There is a risk of individuals being crushed by equipment. Fire crew members supported by this project will be trained in identification of the sand skink, in habitat needs that pertain to the health of the population, and in specific management practices that will avoid detrimental impacts to individuals. Equipment operators will take care to avoid running over individuals during burns, and vehicle use will be contained as much as possible to the burn unit perimeter roads. Sand skinks are very unlikely to be seen (its fossorial behavior makes the chance of seeing one remote), but if one is seen, it will be allowed to move out of harm's way on its own before equipment use is resumed. Individuals, if present, could be killed by overheating from fire or from crushing by equipment. Sand skink populations are vulnerable to habitat degradation due to overgrown vegetation caused by fire exclusion. Prescribed fire is essential to maintain and restore its habitat. After treatment, this species is likely to benefit from the availability of more open sand habitat over a term of 1 to perhaps 15 years.

Avon Park harebells – Preparation of firebreaks by the Strike Team's equipment operators using rubber-tired vehicles and other personnel may include mowing and work using hand-held equipment. Crew members are likely to be able to avoid this plant, because individuals are marked at the Carter Creek site and locations are known at Saddle Blanket Lakes Preserve. Knowledge of plant locations can be used to avoid running over plants with trucks, which may kill individuals. Plants will be subject to prescribed fire. The number of plants to be affected depends on the extent of Strike Team participation in prescribed burns at Carter Creek and Saddle Blanket Lakes. Effects on seeds in the soil are difficult to predict. All, or nearly all, of the plants are expected to survive fire. A prescribed fire in 2003 resulted in over 95 percent of the individuals resprouting. One year post-fire the population size was nearly identical to what it had been pre-fire (TNC, unpublished data). Prescribed fires are expected to immediately create suitable conditions for seed germination and survival in overgrown portions of the vegetation that would otherwise be unsuitable for this plant. In a timeframe of 1 to 2 years, fire is likely to benefit this species.

Britton's beargrass – Preparation of firebreaks by the Strike Team's equipment may include mowing using rubber-tired vehicles. Crew members may use hand-held equipment. Mowing is unlikely to seriously harm this perennial herb, which readily resprouts from its roots. The effects of being run over by trucks are unknown, but likely to be survivable. Plants will be subject to prescribed fire, which will destroy above-ground stems but spare underground rootstocks, which will resprout. Flowering of Britton's beargrass peaks one year after burning. Britton's beargrass benefits from reduction in shrub height because overgrown shrubs can shade this species, reducing sexual reproduction (Service 1999). Long-term monitoring of this species at TNC's Tiger Creek Preserve has shown that numbers of Britton's beargrass are stable to increasing with regular fire management (TNC 2004). Therefore, prescribed fire should be beneficial to this plant over the long term due to its habitat-restoring effects.

Florida bonamia – Preparation of firebreaks by the Strike Team's equipment may include mowing using rubber-tired vehicles. Crew members may use hand-held equipment. Mowing is unlikely to seriously harm this deeply-rooted perennial, which readily resprouts from its roots. Effects of being run over by rubber-tired vehicles are uncertain, but the abundance of this species along the edges of sand roads on the Ocala NF indicates that this impact is survivable. Fire will destroy above-ground stems but spare underground rootstocks, which will resprout. Plants resprout from substantial rootstocks post-fire and fire stimulates germination and growth of seeds buried deeply enough not to suffer from overheating. Over a term of five or more years, fire will benefit Florida bonamia by reducing shading and other competition from shrubs and encouraging seed germination and growth of young plants.

Carter's mustard – Preparation of firebreaks by the Strike Team's equipment may include mowing using rubber-tired vehicles. Crew members may use hand-held equipment. Mowing would almost certainly kill this annual herb, as is the case with being run over by trucks. Prescribed fires or mechanized equipment will, except in late fall, kill growing plants and probably some seed at the surface of the soil. In late fall, mature plants will have shed seed and died, while seedlings will not yet have appeared. In the first year after a fire, aboveground populations increase dramatically as seeds germinate. The second year after a fire brings an equally dramatic decline in population size. Small, fluctuating populations may persist in mechanically disturbed sites like firebreaks or trails. The effects on this plant, over a period of one to three years, will be beneficial. Carter's mustard is a species of sandhill vegetation, where fire frequencies of less than 5 years are typical.

Florida perforate cladonia – Preparation of firebreaks by the Strike Team's equipment will avoid the limited areas inhabited by this ground lichen. Land managers may consider removing lichens before a fire is conducted, and replacing them afterwards. Florida perforate cladonia is killed by fire but may persist in unburned patches or adjacent to burned areas. A study by Menges and Kohfeldt (1995) found that Florida perforate lichen recolonizes burned areas within four years and steadily increase in dominance up to 20 years post fire After about 20 years, Florida perforate cladonia decreases in dominance. It can apparently persist in long-unburned sites (probably for more than 50 years), even under a dense sand pine canopy (R. Yahr, Archbold Biological Station, personal communication, 1995). So, although fire does not benefit this lichen over a term of four years or less, it is beneficial over a term of up to 20 years because it opens up bare sand habitat that is essential for the long-term well-being of this lichen. Florida perforate cladonia has been seen to persist in overgrown sand pine scrub, but it is almost entirely a species of bare sand areas created and maintained by fire with some involvement of allelopathy.

Florida ziziphus – Preparation of firebreaks by the Strike Team's equipment may include mowing using rubber-tired vehicles. Crew members may use hand-held equipment. Mowing would destroy stems of this shrub but encourage regrowth, as has been demonstrated in pastures where plants are mowed regularly. Fires kill the above-ground stems of this shrub, which readily resprouts after fire and may require periodic fire or mowing to retain its vigor. Unburned or unmowed plants lose vigor. As a result, fire is expected to be highly beneficial to this plant over

a period of a few months up to perhaps 5 years. This species inhabits sandhill vegetation, where fire frequencies of less than 5 years are typical.

Garrett's mint – This small shrub is present only on the Flamingo Villas unit of LWR NWR, which has an existing system of firebreaks, some of which have this plant along their edges. Preparation of firebreaks by the Strike Team's equipment may include mowing using rubber-tired vehicles. Depending on the height of mowing of firebreaks, individual plants might survive high mowing. Low mowing would kill plants, to judge from clipping experiments on closely-related scrub mints. Fire will kill all plants directly affected by high temperatures, but patchy fires may allow survival of individual plants. Seed at the soil surface may also be killed by excessive heat. Populations will probably recover after a fire via dormant seeds in a soil seed bank. Because this plant reoccupies burned areas by germination of seed in the soil, and because it requires open, sunny areas or their edges, Garrett's mint is expected to benefit from burning of overgrown vegetation over a period of one to at least ten years. Historic aerial photographs of the Flamingo Villas tract show that it formerly was quite open and had ample bare sand.

Highlands scrub hypericum – Preparation of firebreaks by the Strike Team's equipment may include mowing using rubber-tired vehicles. Crew members may use hand-held equipment. Because this small herb invariably occupies open, sandy areas with little vegetation, sites with it are very unlikely to be mowed, so damage from mowing is unlikely. Vehicles could run over plants, killing them. Any plants present in burn areas are likely to be killed by fire or high heat. Because this plant is locally abundant within its narrow range, the fraction of the rangewide population of the species to be affected will be small. Prescribed fires are expected to immediately create suitable conditions for germination of seed buried in the soil in freshly opened, formerly overgrown areas where survival would have been impossible. Over a period of 1 or more years, the fire will benefit this species.

Lewton's polygala – Preparation of firebreaks by the Strike Team's equipment may include mowing using rubber-tired vehicles. Crew members may use hand-held equipment. This small herb occupies relatively open, sandy areas with little vegetation that may include edges of firebreaks and roads. Sites with Lewton's polygala are not likely to be mowed, and the plants are so low that they would almost certainly be missed by the equipment. Hand-held equipment also appears unlikely to do serious damage. Fires will kill adult plants and possibly seeds on the surface of the ground. The effects of prescribed fires in a sandhill at the Carter Creek tract of LWR NWR in 1996, July 2001, and May 2004 have been observed by Archbold researchers. The 2001 fire produced a spectacular population boom, with populations increasing "by at least two orders of magnitude," with high plant densities in some post-burn plots (Menges and Weekley 2004). Seedling cohorts at this site "continue to demonstrate greater survival of plants from burned than from unburned quadrats, although the beneficial effects of fire on seedling recruitment may be short-lived and fire may temporarily deplete the soil seed bank." (Menges and Weekley 2004). Monitoring by TNC at the Tiger Creek Preserve presents a similar picture. Even with regular fire management, patches of Lewton's polygala often diminish or disappear within 5 years. We expect that the Strike Team's activities will, over a period of several years,

benefit this species by improving its habitat and stimulating germination, growth, and seed production.

Papery whitlow-wort – Preparation of firebreaks by the Strike Team's equipment may include mowing using rubber-tired vehicles. Crew members may use hand-held equipment. Because this small herb is very persistent in even small open areas provided by firebreaks or the edges sand roads, papery whitlow-wort plants could be mowed in a few cases. Extensive damage from mowing is unlikely. Vehicles could run over plants, killing them. Individuals of this species will be killed by fire. However, overgrown scrub is unsuited to this plant. Prescribed fires are expected to immediately create suitable conditions for seeds in the soil seedbank to germinate and survive in overgrown areas where survival would previously have been impossible. Over a period of 6 months or greater, prescribed fire will benefit this species.

Pigeon wings – Preparation of firebreaks by the Strike Team's equipment may include mowing using rubber-tired vehicles. Crew members may use hand-held equipment. Mowing will harm this upright perennial herb, as will being run over by trucks. This species is likely to recovery quickly from such injury by resprouting from its massive horizontal rootstocks. Although the above-ground portions of pigeon wings plants are killed by fire, plants readily resprout from their substantial below-ground parts and quickly and profusely flower after fire (Service 1999). We expect this plant, which is moderately abundant in areas such as the Tiger Creek Preserve, to benefit from prescribed fire starting as soon as it regrows, within 2 months of the fire, to as much as 10 years later.

Pygmy fringe tree – Preparation of firebreaks by the Strike Team's equipment may include mowing using rubber-tired vehicles. Any pygmy fringe trees in mowing areas would be cut. Crew members may also use hand-held equipment to cut this species. In both cases, pygmy fringe trees are expected to readily resprout from their roots. Fire will kill the above-ground stems of this long-lived shrub or small tree. As is the case with mowing, this species will resprout and flower after fire. Pygmy fringe tree is restricted to fire-dependent scrub and sandhill vegetation, so it is presumed to be fire-dependent (Service 1999) and to tolerate a very wide range of fire intervals, possibly ranging from as little as 2 or 3 years to as long as 50 years (in scrub).

Sandlace – Preparation of firebreaks by the Strike Team's equipment may include mowing using rubber-tired vehicles. Crew members may use hand-held equipment. Mowing will injure this low shrub, as will being run over by trucks. Individuals might recover from such mechanical disturbance. Sandlace will be killed by fire. Surveys at TNC's Saddle Blanket Lakes Preserve in fire-suppressed scrub revealed that this species occurred less frequently on long-unburned areas with few open sand "gaps" in the vegetation. Young plants have been seen in abundance at recently-burned areas of the Preserve. As a result, the Strike Team's activities are expected to benefit this species, on a scale of one to 15 to 20 years.

Scrub blazing star – Preparation of firebreaks by the Strike Team's equipment may include mowing using rubber-tired vehicles and use of hand-held equipment by crew members. Mowing will injure this perennial, as will being run over by trucks, but individuals are likely to recover by resprouting from their substantial, long-lived root systems. The above-ground parts of this long-lived herb will be killed by fire. Scrub blazing star resprouts postfire (Menges and Weekley 2003). Although adult mortality is rare in unburned populations, seedling recruitment is rare as well (Menges and Weekley 2003). Over a period of several years, prescribed fire is expected to benefit this species.

Scrub buckwheat – Preparation of firebreaks by the Strike Team's equipment may include mowing using rubber-tired vehicles and use of hand-held equipment by crew members. Mowing will injure this perennial, as will being run over by trucks, but individuals are likely to recover by resprouting from their substantial, long-lived root systems. Fire kills the above-ground parts of scrub buckwheat, which has been shown to readily resprout after fire, followed by quick and heavy flowering and seed production (McConnell and Menges 2002). New seedlings appear promptly after seed drop. McConnell and Menges (2002) observed that seedling numbers peaked during July, two months after an experimental fire. Scrub buckwheat is unlike most other scrub species in that seedlings will appear in summer, not just winter. This means that a spring burn may yield seedlings within just a few months. As a result, maintenance or restoration of the sandhill vegetation by prescribed fire may benefit scrub buckwheat as soon as a few months postfire. The sandhill habitat of this plant has a natural fire return interval of no more than about 5 years.

Scrub lupine – This plant is present only at the Lake McLeod unit of LWR NWR. Because the only burning currently contemplated at this site is to reduce the height of some patches of shrubs, minimal use of equipment is anticipated. There is a risk of Strike Team members stepping on seedlings or plants, or of fire burning individual plants and almost certainly killing them. However, this lupine is believed to germinate after fire or other disturbance, even in areas where seeds may have been dormant for as much as 50 years. Fire maintains the open, sunny conditions that this herb requires.

Scrub mint – This small shrub is present primarily at Archbold Biological Station and the nearby Lake Placid tract of LWR WEA. These properties have existing systems of firebreaks, some of which have this plant along their edges. Because both tracts have active prescribed fire programs, mowing of firebreak areas with this plant is likely to be minimal. The Strike Team's mechanical equipment is rubber-tired. Depending on the height of mowing of firebreaks, individual scrub mint plants might survive high mowing. Low mowing would kill plants, to judge from clipping experiments on this species. Fire will kill all plants directly affected by high temperatures, but patchy fires may allow survival of individual plants. Seed at the soil surface may also be killed by excessive heat. Populations probably recover after a fire via dormant seeds in a soil seed bank (Archbold Biological Station 2003). Because this plant reoccupies burned areas by germination of seed buried in the soil, and because it requires open, sunny areas or their edges, it is expected to benefit from burning of overgrown vegetation over a period of one to at

least ten years. This view appears to be upheld by historic aerial photographs of Archbold Biological Station, which show that it was quite open until fire suppression was instituted.

Scrub plum – Preparation of firebreaks by the Strike Team's equipment may include mowing using rubber-tired vehicles. Any scrub plums in mowing areas would be cut. Crew members may also use hand-held equipment to cut this species. In both cases, scrub plum is expected to readily resprout from its roots. Fire will kill the above-ground stems of this long-lived shrub. As is the case with mowing, this species will resprout and flower after fire. Scrub plum is restricted to fire-dependent scrub and sandhill vegetation. Post-fire monitoring indicates very low mortality rates after a fire – less than 5 percent in a small sample, less than 2 percent in a larger sample. While presumably fire may be roughly neutral in its effects on this shrub over the short term and scrub plum has persisted on sites that went unburned for many years, over the long term (perhaps 20 or more years), we believe fire is essential to maintain suitable habitat for this species.

Short-leaved rosemary – This small shrub is present at relatively few sites, including Saddle Blanket Lakes and Carter Creek. All of the conservation lands where it occurs have existing systems of firebreaks or subdivision roads. This plant will be present at the edges of some of them, and might be subject to mowing. The Strike Team's mechanical equipment is rubber-tired. Depending on the height of mowing of firebreaks, individual short-leaved rosemary plants might survive high mowing. Low mowing would kill plants, assuming that this plant responds similarly to scrub mint. Fire probably kills all plants directly affected by high temperatures, but patchy fires may allow survival of individual plants. Seed at the soil surface may also be killed by excessive heat. Populations probably recover after a fire via dormant seeds in a soil seed bank. Based on TNC's finding from their Saddle Blanket Lakes Preserve that this plant readily re-establishes post-fire from seedlings, fire at an interval of 15 to 20 years (typical for scrub) is likely to be beneficial to populations of this plant, by creating suitable open gaps among the large shrubs, and by encouraging reproduction.

Snakeroot – Preparation of firebreaks by the Strike Team's equipment may include mowing using rubber-tired vehicles, while crew members may use hand-held equipment. Because this small herb invariably occupies open, sandy areas with little vegetation, sites with it are very unlikely to be mowed, so damage from mowing is unlikely. This small herb is killed by fire, and quickly populates sandy bare openings created by fire from its large soil seed bank. Ecologists at Archbold Biological Station have shown that this plant requires relatively frequent fires to maintain viable populations. The effects of the Strike Team's activities are expected to benefit this species over a period of about one year to the period when postfire population sizes are at their largest, 6 to 10 years postfire.

Wide-leaf warea – Preparation of firebreaks by the Strike Team's equipment may include mowing using rubber-tired vehicles, while crew members may use hand-held equipment. Because this annual herb invariably occupies open, sandy areas with little vegetation, sites with it are very unlikely to be mowed, so damage from mowing is unlikely. This annual species is expected to be killed by any fire conducted during its growing season (roughly late winter

through early fall). Seedlings are expected to appear after fire. This species is currently known in the action area only from the Historic Bok Sanctuary's Pine Ridge Preserve (sandhill vegetation surrounding the developed garden). More thorough surveys in existing and future land acquisitions may possibly reveal the presence of this species within other parts of the action area, most likely in northern Polk County. This plant is found only on open sandy patches within sandhill vegetation. It does not tolerate dense shrubs or trees, so prescribed fire is essential to maintain suitable habitat.

Wireweed – Preparation of firebreaks by the Strike Team's equipment may include mowing using rubber-tired vehicles. Crew members may use hand-held equipment. Mowing would kill or injure this herb, which seldom lives longer than 3 years. Plants might be able to regrow after being run over by trucks. Prescribed fires will kill growing plants and any seed at the surface of the soil. Because this plant forms moderately large populations in a wide range, compared to the most narrowly-distributed LWR endemic plants, the fraction of the rangewide population of wireweed to be affected will be small, and the Strike Team's approach of preferring relatively small, patchy fires will help create local sanctuaries for this species, which recolonizes burned areas by seed coming from plants in nearby unburned areas. Prescribed fires are expected to immediately create suitable conditions for seed germination from what had been overgrown, unsuitable habitat. Over 2 or more years (allowing time for seed from untreated areas to colonize newly-available habitat) prescribed fires will benefit this species.

Highlands tiger beetle – Preparation of firebreaks by the Strike Team's equipment may include mowing using rubber-tired vehicles. Crew members may use hand-held equipment. Larval individuals could be crushed by vehicles and/or be killed or injured through use of hand-held equipment. Prescribed fires are likely to kill adults and larvae, although because the larvae are restricted to bare sand, there are likely to be relatively few within areas selected for burning. Newly-created bare sand will constitute desirable habitat for this species.

CUMULATIVE EFFECTS

Cumulative effects include the effects of future state, tribal, local, or private actions that are reasonably certain to occur in the action area considered in this biological opinion. Future federal actions that are unrelated to the proposed action are not considered in this section because they require separate consultation pursuant to section 7 of the ESA.

Future management actions on conservation lands on the LWR will include prescribed fires and alternative treatments such as cutting or mowing to supplement fire. On occasion, suppression of wildfires or out-of-control prescribed fires will be necessary. Activities associated with fire management include the maintenance of firebreaks, including access roads and fire lanes, as well as the creation of temporary firebreaks. On most conservation lands, networks of access roads and firebreaks already exist. Land managers on the LWR are very likely to use cutting, logging, mowing, and possibly roller chopping to prepare LWR scrub vegetation for fire, or in lieu of fire. Successful use of prescribed fire may decrease the need for mechanical treatments in the future, after vegetation restoration is initiated.

Because prescribed fire or equivalent mechanical treatments are essential to maintain suitable scrub habitat, temporary impacts to listed species from prescribed fires is inescapable. Prescribed fires are also crucial to the management of many conservation lands due to the threat posed by wildfires in overgrown vegetation. By reducing fuel loads, prescribed fire programs can significantly reduce the threat of runaway wildfires threatening neighboring properties, in some cases, homes. Prescribed fires also serve to minimize the likelihood of damage to biological resources on conservation lands that can be caused by wildfires. When wildfires occur, damage to plants and animals from fire suppression is unavoidable.

Management of conservation lands may also include construction of fences, removal of trash or other debris, control of invasive plant species, and other activities that may damage individuals of listed species. Work of this sort has generally been carried out on conservation lands with little damage to biological resources. Research and monitoring continues on some conservation lands. Work conducted by Archbold Biological Station, TNC, and at LWR NWR has been valuable for assessing the effects of prescribed fire. Many aspects of the ecology of LWR plants are of interest in the context of basic research, although to date such research has nearly always been useful to managers. Research and monitoring projects may require small-scale vegetation management, installation of traps, tagging of plants, and other manipulations. All research/monitoring projects, as well as prescribed fires and mechanical vegetation treatments, require that personnel enter areas inhabited by these species, so a degree of trampling is inevitable. Inasmuch as scrub and sandhills vegetation are maintained by regular disturbance, primarily from fire, carefully-planned, small-scale research disturbances for research purposes and larger disturbances for vegetation management are expected to be consistent with restoring and maintaining the vegetation and its biota.

CONCLUSION

Listed Species/Critical Habitat

After reviewing the status of the Florida scrub-jay, eastern indigo snake, bluetail mole skink, sand skink, Avon Park harebells, Britton’s beargrass, Florida bonamia, Carter’s mustard, Florida perforate cladonia, Florida ziziphus, Garrett’s mint, Highlands scrub hypericum, Lewton’s polygala, papery whitlow-wort, pigeon wings, pygmy fringe tree, sandlace, scrub blazing star, scrub buckwheat, scrub lupine, scrub mint, scrub plum, short-leaved rosemary, snakeroot, wide-leaf warea, and wireweed, the environmental baseline for the action area, the effects of the proposed action, and the cumulative effects, it is the Service's biological opinion that the Service’s provision of funds to the FWC to fund the activities of the Strike Team, as proposed, is not likely to jeopardize the continued existence of any of these species. No critical habitat has been designated for these species, therefore, none will be affected.

Candidate Species

After reviewing the current status of the Highlands tiger beetle, the environmental baseline for the action area, the effects of the proposed funding, and the cumulative effects, it is the Service's conference opinion that funding FWC to assist the Strike Team, as proposed, is not likely to jeopardize the continued existence of the candidate Highlands tiger beetle.

INCIDENTAL TAKE STATEMENT

Sections 9 of the ESA and federal regulation pursuant to section 4(d) of the ESA prohibit the take of endangered and threatened species, respectively, without a special exemption. Take is defined as to harass, harm, pursue, hunt, shoot, wound, kill, trap, capture or collect, or to attempt to engage in any such conduct. Harm is further defined by the Service to include significant habitat modification or degradation that results in death or injury to listed species by significantly impairing essential behavioral patterns such as breeding, feeding, or sheltering. Harass is defined by the Service as intentional or negligent actions that create the likelihood of injury to listed species to such an extent as to significantly disrupt normal behavior patterns, which include, but are not limited to, breeding, feeding, or sheltering. Incidental take is defined as take that is incidental to, and not the purpose of, the carrying out an otherwise lawful activity. Under the terms of section 7(b)(4) and section 7(o)(2), taking that is incidental to and not intended as part of the agency action is not considered to be prohibited taking under the ESA provided that such taking is in compliance with the terms and conditions of this incidental take statement.

The measures described below are nondiscretionary and must be undertaken by the Service so that they become binding conditions of any grant or permit issued to the applicant, as appropriate, for the exemption in action 7(o)(2) to apply. The Service has a continuing duty to regulate the activity covered by this incidental take statement. If the Service (1) fails to assume and implement the terms and conditions or (2) fails to require the applicant to adhere to the terms and conditions of the incidental take statement through enforceable terms that are added to the permit or grant document, the protective coverage of section 7(o)(2) may lapse. To monitor the impact of incidental take, the Service must report the progress of the action and its impact on the species to itself as specified in the incidental take statement.

Section 7(b)(4) and 7(o)(2) of the ESA generally do not apply to listed plants species. However, limited protection of listed plants from take is provided to the extent that the ESA prohibits the removal and reduction to possession of federally listed endangered plants or the malicious damage of such plants on areas under Federal jurisdiction, or the destruction of endangered plants on non-Federal areas in violation of state law or regulations or in the course of any violation of a state criminal trespass law. The State requires permission of private landowners for collecting of State-listed plants from their property. If this project is on private land and the landowner is not the project proponent, in addition to landowner permission, a Florida Department of Agriculture and Consumer Services permit for plants may be needed. To determine if such a permit is necessary or to apply for this permit, contact: Florida Department of Agriculture and Consumer Services, Division of Plant Industry, P.O. Box 147100,

Gainesville, Florida 32614-7100, 352-372-3505. http://www.doacs.state.fl.us/onestop/plt/plantinspinst.html.

AMOUNT OR EXTENT OF TAKE ANTICIPATED

Florida scrub-jay – The Service expects that up to 150 Florida scrub-jays will be harassed by prescribed fires, both by human activity associated with conducting the burns and the fires themselves (smoke, noise, heat, etc.). Although this bird is relatively easy to census, it is possible that all nests will not be found during fire planning. In the unlikely event that nests are destroyed, finding nest remnants after the fire would be nearly impossible. Therefore, measuring take is inherently difficult. Prescribed fires with Strike Team participation will be carefully planned to minimize the possibility of take of this species, and most fires conducted in scrub will be in overgrown vegetation that will not have active scrub-jay territories or nests. In cases where scrub inhabited by scrub-jays is burned, careful planning and conservation measures will minimize the risk of losing nests. However, there remains a possibility that prescribed fire could accidentally destroy one or more nests, so the Service anticipates the possible destruction of as many as 10 occupied nests, with each nest containing up to four eggs or two chicks. The incidental take is expected to be in the form of harm, harassment, and direct mortality.

Eastern indigo snake – The Service anticipates incidental take of the eastern indigo snake will be difficult to detect for the following reasons: (1) wide-ranging distribution, not restricted to specialized habitats, (2) patchy distribution within suitable habitats, and (3) apparently suitable habitat may not be occupied. However, the Service anticipates incidental take of the indigo snake associated with conducting prescribed fires on 5 as much as 10,000 acres. Due to the lack of surveys, in conjunction with the wide-ranging activity and use of a variety of habitat types by the indigo snake, it is difficult to determine the exact number of snakes that will be taken. Layne and Steiner (1996) determined the average home range for female indigo snakes to be 19 ha (47 acres) and overlapping male home ranges to be 75 ha (185 acres) on Archbold Biological Station. Assuming those estimates are comparable to the rest of the action area, it is possible for as many as 213 female and 55 male snakes to be present on the maximum of 10,000 acres that might be burned. However, because it is unlikely that all of the 10,000 acres are occupied by the species and the indigo snake is able to escape and find refugia during prescribed fires and preparation work for fires, we anticipate that no more than 134 (50 percent) snakes will be harassed and that no more than 67 (25 percent) snakes will be injured or killed. The incidental take is expected to be in the form of harm, harassment, and direct mortality.

Bluetail mole skink – The Service anticipates incidental take of the bluetail mole skink will be difficult to detect for the following reasons: (1) its fossorial behavior, with individuals usually just beneath the surface of loose sand; (2) low density within suitable scrub and similar habitats within its limited range; and (3) apparently suitable scrub habitat may not be occupied. However, the Service anticipates incidental take of the bluetail mole skink associated with conducting prescribed fires on as much as 10,000 acres. Burns will primarily occur in scrub, scrubby flatwoods, yellow sand scrub, and sandhill. Bluetail mole skinks inhabit open sand within scrub, but also inhabit litter and shaded areas. Because skinks are patchily distributed

across the landscape and by nature prescribed fires do not burn all habitat, many skinks are likely to survive fires. Only 89.6 percent of potential Strike Team sites (Table 1) located on the LWR may provide suitable bluetail mole skink habitat. Because low quality habitat containing dense scrub vegetation is proposed for burning, it is likely that approximately 10 percent of the area to be burned is inhabited by skinks (*i.e.,* 896 acres). Therefore, we anticipate that no more than 33 percent of bluetail mole skinks will be harassed and that no more 33 percent of bluetail mole skinks will be injured or killed during the project. The incidental take is expected to be in the form of harm, harassment, and direct mortality.

Sand skink – The Service anticipates incidental take of the sand skink will be difficult to detect for the following reasons: (1) its fossorial behavior, with individuals usually just beneath the surface of loose sand; (2) low density within suitable scrub and similar habitats within its limited range; and (3) apparently suitable scrub habitat may not be occupied. However, the Service anticipates incidental take of the sand skink associated with conducting prescribed fires on as much as 10,000 acres. Burns will primarily occur in scrub, scrubby flatwoods, yellow sand scrub, and sandhill. Sand skinks inhabit open sand within scrub. Because skinks are patchily distributed across the landscape and by nature prescribed fires do not burn all habitat, many skinks are likely to survive fires. Only 89.6 percent of potential Strike Team sites (Table 1) located on the LWR may provide suitable sand skink habitat. Because low quality habitat containing dense scrub vegetation is proposed for burning, it is likely that approximately 10 percent of the area to be burned is inhabited by skinks (*i.e.,* 896 acres). Therefore, we anticipate that no more than 33 percent of sand skinks will be harassed and that no more 33 percent of sand skinks will be injured or killed during the project. The incidental take is expected to be in the form of harm, harassment, and direct mortality.

Highlands tiger beetle – The Service anticipates incidental take of the Highlands tiger beetle will be difficult to detect for the following reasons: (1) small body size of adults; (2) larva living below the surface; and (3) adults are not present year round. However, the Service anticipates incidental take of the tiger beetle associated with conducting prescribed fires on as much as 10,000 acres. Because tiger beetles are patchily distributed across the landscape, adults are not present year round, and by nature prescribed fires do not burn all habitat, many tiger beetles are likely to survive fires. Only 76.9 percent of potential Strike Team sites (Table 1) located on the LWR may provide suitable tiger beetle habitat. Because low quality habitat containing dense scrub vegetation is proposed for burning, it is likely that approximately 10 percent of the area to be burned is inhabited by tiger beetles (*i.e.,* 769 acres). Therefore, we anticipate that no more than 33 percent of tiger beetles will be harassed and that no more 33 percent of tiger beetles will be injured or killed during the project. The incidental take is expected to be in the form of harm, harassment, and direct mortality.

The Service will not refer the incidental take of any migratory bird or bald eagle for prosecution under the Migratory Bird Treaty Act of 1918, as amended (16 U.S.C. §§ 7 03-712), or the Bald Eagle Protection Act of 1940, as amended (16 U.S.C. §§ 668-668d), if such take is in compliance with the terms and conditions (including amount and/or number) specified herein.

EFFECT OF THE TAKE

In the accompanying biological/conference opinion, the Service determined that this level of anticipated take is not likely to result in jeopardy to the species or destruction or adverse modification of critical habitat.

The prohibitions against taking the species found in section 9 of the ESA do not apply until the Highlands tiger beetle is listed. However, we advise Federal Aid to consider implementing the following reasonable and prudent measures. If this conference opinion is adopted as a biological opinion following a listing or designation, these measures, with their implementing terms and conditions, will be nondiscretionary.

REASONABLE AND PRUDENT MEASURES

The Service is not aware of any reasonable and prudent measures that can be implemented to minimize take of the Florida scrub-jay, eastern indigo snake, bluetail mole skink, sand skink, or Highlands tiger beetle beyond those that are already part of the proposed action.

TERMS AND CONDITIONS

In order to be exempt from the prohibitions of section 9 of the ESA, Federal Aid must comply with the following terms and conditions, which implement the reasonable and prudent measures described above and outline the required reporting / monitoring requirements. These terms and conditions are non-discretionary:

1. Federal Aid will provide an annual report of the Strike Team's activities to specify the properties where burns were conducted in 2005, detailing burn units and subunits burned, including maps and the acreage of each burn. The report will also include, in as much detail as possible, any effects to listed species documented before, during, or after the burns. These reports will be submitted to the Endangered Species Program Supervisor at the South Florida Ecological Services Office by December 31 of each year during which any burns have taken place; and

2. Upon locating a dead, injured, or sick specimen of Florida scrub-jay, eastern indigo snake, bluetail mole skink, sand skink, or Highlands tiger beetle, initial notification must be made to the nearest Service Law Enforcement Office (Fish and Wildlife Service; 9549 Koger Boulevard, Suite 111; St. Petersburg, Florida 33702; 727-570-5398). Secondary notification should be made to the FWC, South Region; 3900 Drane Field Road; Lakeland, Florida 33811-1299; 800-282-8002. Care should be taken in handling sick or injured specimens to ensure effective treatment and care, or in the handling of dead specimens to preserve biological material in the best possible state for later analysis as to the cause of death. In conjunction with the care of sick or injured specimens or preservation of biological materials from a dead animal, the finder has the responsibility to carry out instructions provided by Law Enforcement to ensure that evidence intrinsic to the specimen is not unnecessarily disturbed.

CONSERVATION RECOMMENDATIONS

Section 7(a)(1) of the ESA directs Federal agencies to utilize their authorities to further the purposes of the ESA by carrying out conservation programs for the benefit of endangered and threatened species. Conservation recommendations are discretionary agency activities to further minimize or avoid adverse effects of a proposed action on listed species or critical habitat, to help implement recovery plans, or to develop information.

No conservation measures are prescribed.

REINITIATION NOTICE

This concludes formal consultation and conference on the action outlined in the request. As provided in 50 CFR § 402.16, reinitiation of formal consultation is required where discretionary federal agency involvement or control over the action has been retained (or is authorized by law) and if: (1) the amount or extent of incidental take is exceeded; (2) new information reveals effects of the agency action that may affect listed species or critical habitat in a manner or to an extent not considered in this opinion; (3) the action is subsequently modified in a manner that causes an effect to the listed species or critical habitat not considered in this opinion; or (4) a new species is listed or critical habitat designated that may be affected by the action. In instances where the amount or extent of incidental take is exceeded, any operations causing such take must cease pending reinitiation.

You may ask the South Florida Ecological Services Office to confirm the conference opinion as a biological opinion issued through formal consultation if the Highlands tiger beetle is listed. The request must be in writing. If the Service reviews the proposed action and finds that there have been no significant changes in the action as planned or in the information used during the conference, the Service will confirm the conference opinion as the biological opinion on the project and no further section 7 consultation will be necessary.

After listing of the Highlands tiger beetle as endangered/threatened and any subsequent adoption of this conference opinion, Federal Aid shall request reinitiation of consultation if: (1) the amount or extent of incidental take is exceeded; (2) new information reveals effects of the agency action that may affect the species or critical habitat in a manner or to an extent not considered in this conference opinion; (3) the agency action is subsequently modified in a manner that causes an effect to the species or critical habitat that was not considered in this conference opinion; or (4) a new species is listed or critical habitat designated that may be affected by the action.

The incidental take statement provided in this conference opinion does not become effective until the species is listed and the conference opinion is adopted as the biological opinion issued through formal consultation. At that time, the project will be reviewed to determine whether any take of the species has occurred. Modifications of the opinion and incidental take statement may be appropriate to reflect that take. No take of the species may occur between the listing of the

tiger beetle and the adoption of the conference opinion through formal consultation, or the completion of a subsequent formal consultation.

If you have any questions, please contact David Martin at 772-562-3909, extension 230, or Cindy Schulz at extension 305.

cc:
FWC, Tallahassee, Florida (Kate Haley)

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LWR Protected Areas Network Map