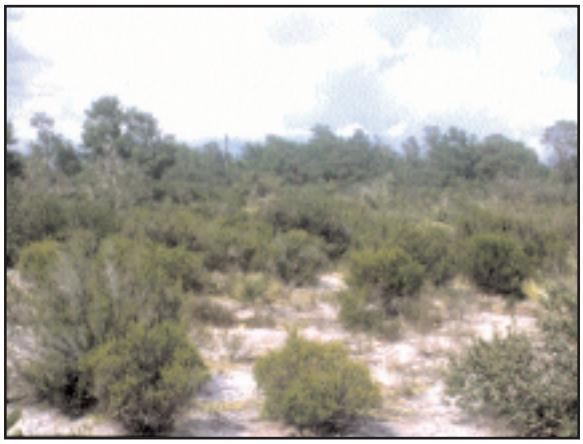
Florida Scrub

Including Scrubby Flatwoods and Scrubby High Pine

FNAI Global Rank:	**G2/G3**
FNAI State Rank:	**S2**
Federally Listed Species in S. FL:	**32**
State Listed Species in S. FL:	**100**

Florida scrub. *Original photograph courtesy of The Nature Conservancy.*



Florida scrub is a plant community easily recognized by the dominance of evergreen shrubs and frequent patches of bare, white sand. With more than two dozen threatened and endangered species dependent upon scrub, the entire community is itself endangered. Recovery of the community and its associated plants and animals will depend upon land acquisition and effective land management.

Synonymy

Florida scrub in its various phases has been called xeric scrub, sand scrub, big scrub, sand pine scrub, oak scrub, evergreen oak scrub, dune oak scrub, evergreen scrub forest, slash pine scrub, palmetto scrub, rosemary scrub, and rosemary bald. Florida scrubs may be classified as coastal or interior. Scrubs are often named by the dominant plant species, as in rosemary scrub, sand pine scrub, palmetto scrub, or oak scrub. Some authors have confused closed-canopy forests of sand pine trees with scrub. Scrubs that are very recent in origin, usually a result of man's activities, are called pioneer scrubs. Communities intermediate between scrub and pine flatwoods have been called dry or xeric flatwoods but now are referred to as scrubby flatwoods. Communities intermediate between scrub and high pine have been called southern ridge sandhills, hickory scrub, yellow sand scrub, turkey oak scrub, turkey oak barrens, and natural turkey oak barrens, but probably are best referred to as scrubby high pine. The FLUCCS code for the scrub community include: 413 (sand pine), 421 (xeric oak), and 441 (coniferous plantations).

Distribution

Coastal Florida scrub occurs sporadically on barrier islands and dunes and ridges along the Atlantic Coast in Florida and Georgia and along the Gulf Coast in Florida and Alabama (Myers 1990, Wharton 1978). On the northern Gulf Coast, coastal scrubs occur on several barrier islands

and on a narrow band along the coast from Franklin County to just across the state line in Baldwin County, Alabama. There are only a handful of coastal scrubs on the Gulf coast of the Florida peninsula. Among these are scrubs in the vicinity of Cedar Keys in Levy County, near WeekiWatchee in Hernando County, near Palma Sola in Manatee County, and near Bonita Springs, Naples and Marco Island in Lee and Collier counties. On the Atlantic coast of the Florida peninsula, scrubs occur (or formerly occurred) from St. John's County south to Miami-Dade County, where they occupy dunes and ridges immediately inland from coastal strand.

Within the South Florida Ecosystem, coastal scrubs occur in Indian River, St. Lucie, Martin, Palm Beach, and Broward counties on the Atlantic Coast, and Lee and Collier counties on the Gulf Coast. Coastal scrub formerly occurred in Miami-Dade County.

Interior Florida scrub occur sporadically on well-drained sandy ridges on the Georgia Fall Line and within the Florida peninsula from Kingsley Lake, Clay County south to Immokalee, Collier County (Myers 1990, Wharton 1978). Most interior Florida scrubs are associated with north-south tending ridges that were formed by wind and wave action during periods of higher sea level. The expansive stands of sand pine in the Ocala NF in Lake and Marion Counties are forests, not scrub, and occupy a landscape with yellow sand that may have supported high pine savanna during the earlier Holocene.

Within the South Florida Ecosystem, interior Florida scrub occurs on the Lake Wales, Winter Haven, Lake Henry, Lakeland, and Bombing Range ridges (White 1970) in Polk, Osceola, and Highlands counties; on lesser ridges within the Osceola Plain and Eastern Valley in Osceola, Okeechobee, Indian River, St. Lucie, and Martin counties; and scattered on small rises in Hardee, DeSoto, Glades, Hendry, and Collier counties (Figure 1).

Scrubby flatwoods is a scrub-like association often occurring on drier ridges in typical flatwoods or near coasts. The understory species of this vegetation type are similar to those of sand pine scrub, but the sand pine is replaced by slash pine or longleaf pine. Scrubby flatwoods occur throughout Florida, including the panhandle and northern peninsula where scrub is rare or nonexistent. Scrubby flatwoods occupy slightly higher and better-drained areas than pine flatwoods. Scrubby flatwoods are common on the Archbold Biological Station and formerly occupied much of the western flank of the Lake Wales Ridge. This community is especially well-developed on the low north-south tending ridges in Osceola and Okeechobee counties.

Scrubby high pine occurs throughout Florida where it usually is associated with peaks in high pine communities or narrow bands along steep slopes between high pine and wetlands. It sometimes occurs on well-drained sandy peaks within pine flatwoods communities. In northern Florida and the panhandle, the community generally occurs in small isolated patches. Within the South Florida Ecosystem, however, scrubby high pine once dominated much of the southern Lake Wales Ridge, especially in four regions on the eastern flank including areas around Catfish Creek, Tiger Creek, Carter Lake and (formerly) Bear Hollow (Christman 1988a). High pine and scrubby high pine (called southern ridge sandhills by Abrahamson *et al.* 1984, and others) apparently were the native plant communities of choice for citrus growers on the Lake Wales Ridge.

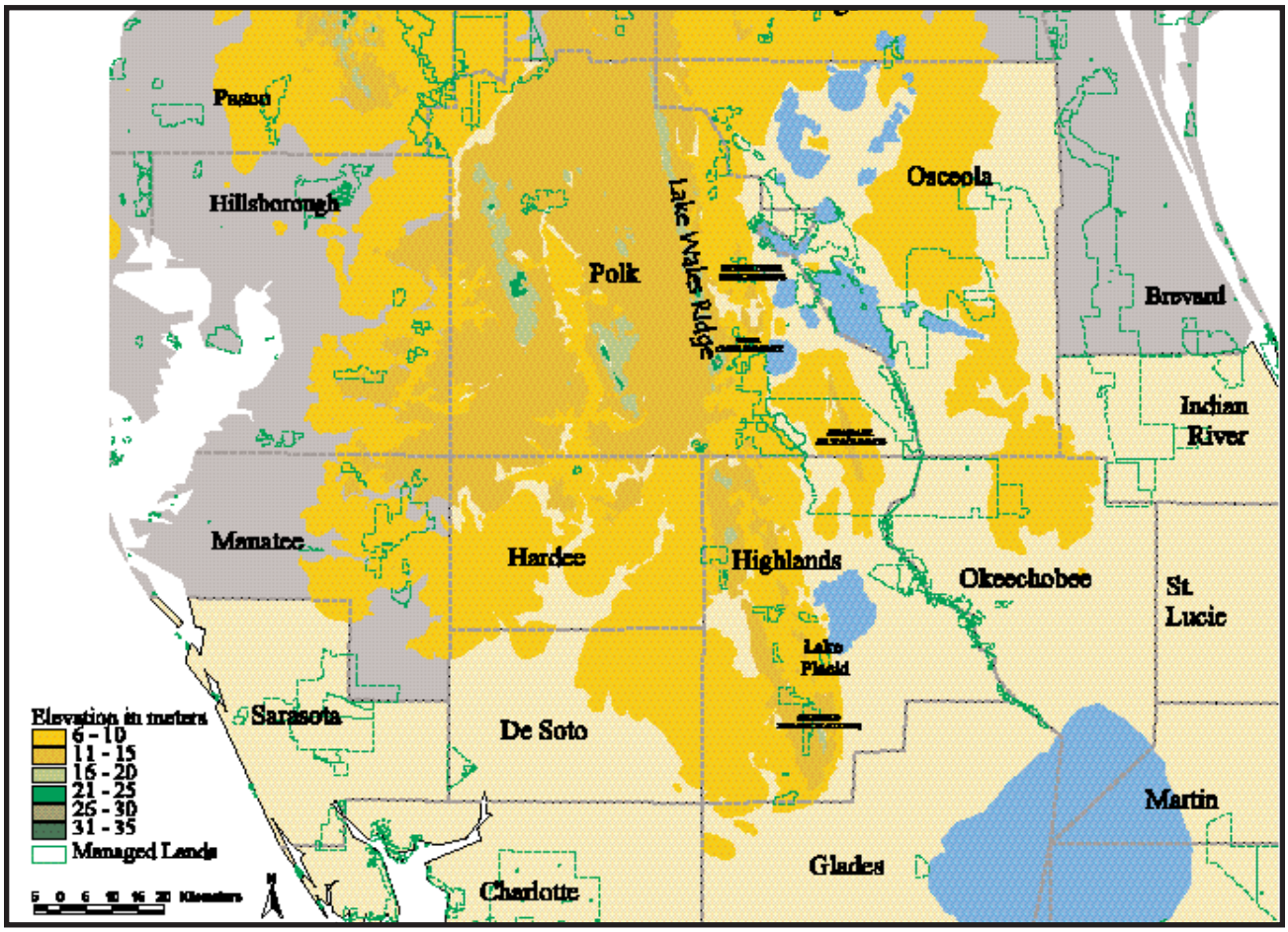


Figure 1. Conservation lands and topography in South Florida north of Lake Okeechobee.

Description

There is no single plant species that occurs in all Florida scrubs and not in other habitats as well, yet the community is easily recognized. Florida scrub can be identified by the dominance of several species of woody shrubs, especially myrtle oak or scrub oak (*Quercus myrtifolia* or *Q. inopina*), sand live oak (*Q. geminata*), Chapman's oak (*Q. chapmanii*), crookedwood (*Lyonia ferruginea*), saw palmetto (*Serenoa repens*) and Florida rosemary (*Ceratiola ericoides*); the absence of a tree canopy; the absence of a continuous vegetative ground cover; and the absence of longleaf pine (*Pinus palustris*), wiregrass (*Aristida beyrichiana*), and turkey oak (*Q. laevis*). When sand pines (*Pinus clausa*) are present in scrub they do not form a continuous canopy but occur as scattered individuals or clumps of individuals. Most scrubs occur on white sand and patches of bare sand with or without scattered clumps of ground lichens.

Scrub soils are derived from quartz, slightly to strongly acidic, very low in nutrients, and moderately to excessively well-drained. They are classified as entisols (soils with little or no horizon development) (Myers 1990). Scrub soils are practically devoid of organic matter, silt and clay. Scrub soils range from the pure white, excessively leached St. Lucie Fine Sand, to moderately leached Paola and Orsino sands that are characterized by a white surface and a yellowish subsoil.

Scrubs often occupy ecotones between longleaf pine savannas (high pine or pine flatwoods) and wetlands, and conditions within a single scrub may grade from xeric to mesic. Scrubs on the most excessively drained sites often are dominated by Florida rosemary and referred to as rosemary balds. Sand pine scrubs have scattered individuals or clumps of sand pines and oak scrubs are dominated by one or more of the shrubby oaks.

Scrubby flatwoods is floristically and functionally intermediate between pine flatwoods and scrub, and sometimes (but not necessarily) occurs as an ecotone between them (Abrahamson and Hartnett 1990). Scrubby flatwoods differs from scrub by the presence of scattered wiregrass and a preponderance of flatwoods species such as fetterbush (*Lyonia lucida*), wax myrtle (*Myrica cerifera*), and gallberry (*Ilex glabra*). Shrubby oaks, including sand live oak, Chapman's oak, and myrtle oak or scrub oak, are often dominant and slash pine, sand pine or longleaf pine may be present. Plant species typical of scrubby flatwoods that may be considered indicators of the community include tarflower (*Befaria racemosa*), scrub St. John's wort (*Hypericum reductum*), and pennyroyal (*Piloblephis rigida*). Scrubby flatwoods is more mesic than scrub, has a higher water table (Abrahamson *et al.* 1984) and the vegetation is more dense. Scrubby flatwoods is drier that flatwoods and almost never has standing water (Abrahamson *et al*. (1984). It has been suggested that scrubby flatwoods sometimes captures pine flatwoods sites that have been logged and protected from fire (see Myers 1990).

Scrubby high pine, called "southern ridge sandhills" by Abrahamson *et al.* (1984), "yellow sand scrub" by Christman (1988a), "natural turkey oak barrens" by Christman and Judd (1990), "hickory scrub" by Main and Menges (1997), "Caribbean pine-turkey oak" by Laessle (1967), "slash pine-turkey oak" by Douglas and Layne (1978), and "blackjack lands" or "blackjack ridges" by 19th century land surveyors cited in Myers (1990) is a rare, naturally

occurring plant community that is floristically and functionally intermediate between scrub and high pine. Scrubby high pine contains longleaf pine or south Florida slash pine (*Pinus elliottii* var. *densa*), turkey oak and scattered wiregrass, and has yellow sand, conditions typical of high pine. However scrubby high pine also contains typical scrub species, such as sand pine, evergreen scrub oaks, garberia (*Garberia fruticosa*), and rosemary, and it supports several species that are nearly restricted to it or reach their greatest abundances in it such as scrub hickory (*Carya floridana*), scrub beargrass (*Nolina brittoniana*), pigeonwing (*Clitoria fragrans*), Lewton's polygala (*Polygala lewtonii*), and the scrub balms (*Dicerandra* spp.) (Christman 1988a, 1988b; Christman and Judd 1990). Scrubby high pine easily is confused with man-made turkey oak barrens but references from the 18th and 19th centuries (cited in Myers 1990) attest to the natural occurrence of scrubby high pine long before the original longleaf pine savannas were logged. Scrubby high pine appears to be associated with topographically diverse landscapes where long-term fire-return intervals have been exceedingly variable (Myers and Boettcher 1987, Christman 1988b, Myers 1990).

Narrow bands of scrubby high pine often occur as ecotones on steep slopes between high pine and wetland communities. (Note that on more gentle slopes high pine usually grades almost imperceptibly into pine flatwoods.) Scrubby high pine also occurs on ridges or peaks within high pine communities perhaps because the soils there are too well-drained to support a continuous ground cover of the wiregrass needed to carry frequent fires. The community also occurs on rolling hills interspersed with ponds and marshes, especially on the Lake Wales Ridge (Christman 1988a). Scrubby high pine apparently was always uncommon in central and northern Florida, but formerly was common on the southern Lake Wales Ridge where, prior to its almost complete conversion to citrus orchards, it occupied sites with extremely well-drained sands and extremely varied topography (Christman and Judd 1990, Myers 1990).

Species Diversity

Table 1 lists the vertebrates that are characteristic of Florida scrub. All are endemic to the State of Florida. Other xeric-adapted species that are almost always encountered in scrub include the Florida mouse (*Podomys floridana*), the short-tailed snake (*Stilosoma extenuatum*), the scrub lizard (*Sceloporus woodi*), the rufous-sided towhee (*Pipilo erythrophthalmus*), the gopher tortoise (*Gopherus polyphemus*), the Florida worm lizard (*Rhineura floridana*), other subspecies of mole skinks (*Eumeces egregius* sspp.), and the crowned snakes (*Tantilla relicta* spp.). Although these animals are typically encountered in scrub, none are entirely restricted to the community; rather they are animals adapted to xeric habitats in general (Campbell and Christman 1982).

There are also many species of invertebrates that are endemic to Florida scrub. Deyrup (1989) listed 46 species of insects and spiders believed to be restricted to scrub, including 20 species restricted to scrub within the South Florida Ecosystem.

Table 2 provides a list of characteristic and occasional plant species known to occur in interior scrub, coastal scrub, scrubby flatwoods, and scrubby high pine. Many of these are listed as endangered or threatened by the FWS and are treated in "The Species" section of this recovery plan. Among the scrub endemic plants that are not federally listed are the scrub milkweed (*Asclepias curtissii*), Florida rosemary (*Ceratiola ericoides*), garberia (*Garberia heterophylla*), scrub rockrose (*Helianthemum nashii*), scrub holly (*Ilex cumulicola*), nodding pinweed (*Lechea cernua*), scrub hickory (*Carya floridana*), scrub palm (*Sabal etonia*), and sand pine (*Pinus clausa*), all of which are fairly widespread in Florida scrub. Some of these, such as sand pine, Florida rosemary, and garberia often invade disturbed high pine sites (turkey oak barrens) and probably are not in need of protection. Others, such as scrub milkweed, nodding pinweed, scrub palm and scrub rockrose may be more restricted to scrub and scrubby flatwoods and therefore in greater danger of extinction.

Wildlife Species of Concern

Federally listed animal species that depend upon or utilize Florida scrub, scrubby flatwoods, or scrubby high pine in South Florida include: the Florida panther (*Puma (=Felis) concolor coryi*), Florida scrub-jay (*Aphelocoma coerulescens*), Kirtland's warbler (*Dendroica kirtlandii*), eastern indigo snake (*Drymarchon corais couperi*), blue-tailed mole skink (*Eumeces egregius lividus*), and sand skink (*Neoseps reynoldsi*). Biological accounts and recovery tasks for these species are included in "The Species" section of this recovery plan. These species are also included in Appendix C.

The **Florida mouse** (*Podomys floridanus*) is the only species of mammal entirely restricted to Florida. Florida mice occur in open scrub, scrubby flatwoods, scrubby high pine and high pine communities where they live in burrows, especially those of the gopher tortoise. Characteristics of the habitat that favor Florida mice are similar to those that favor the Florida scrub-jay (Layne 1992). The Florida mouse is larger than other deer mice and its closest relatives apparently are in southern Mexico (Layne 1992). The Florida mouse is listed as a species of special concern by the State of Florida because of habitat loss throughout its limited range in the central peninsula.

The **sand skink** (*Neoseps reynoldsi*) is listed as a threatened species by the State and the FWS. This species is restricted to the microhabitats of loose sand and sunny exposures primarily in the rosemary scrub habitat of central Florida. In addition, it can be found inhabiting sand pine scrub, oak scrub, scrubby flatwoods, "turkey oak barrens" (Moler 1992), and was reported from definite high pine (sand hills) sites by Telford (1962) in ecotonal areas between high pine and sand pine forest in the Ocala NF. Because sand skinks spend most of their time 1 to 8 cm (0.5-3.0 in) beneath the surface of well-drained sandy soils, they cannot tolerate dense ground cover or heavily rooted vegetation. This habitat has already seen much destruction as a result of agriculture and residential development. Although the sand skink is threatened due to loss of

Florida mouse. *Original photograph by Barry Mansell.*

habitat, it is often found in the remnant habitat that exists. Since the specialized habitat of the sand skink is rapidly declining, conservation actions should be taken to preserve large tracts of scrub and high pine communities.

The **gopher tortoise** (*Gopherus polyphemus*) is a state listed species that occurs in scrub, as well as other upland communities (Appendix C). Its deep burrows provide sites for nesting, feeding, refuge from fire and predators, and protection from high temperatures and desiccation for hundreds of other species (Landers and Speake 1980, Diemer 1992, Enge *et al.* 1997). Gopher frogs (*Rana capito*), Florida mice (*Podomys floridana*), and eastern indigo snakes (*Drymarchon corais couperi*) are variously dependent on tortoise burrows. The spoil in front of a gopher tortoise burrow provides germination sites for plants and essential microhabitat for fossorial reptiles such as mole skinks (*Eumeces egregius*), and crowned snakes (*Tantilla relicta*). Over 300 species of invertebrates, 36 reptiles and amphibians, 19 mammals, and 7 birds have been found in gopher tortoise burrows (Cox et al. 1994, Jackson and Milstrey 1989, Brandt *et al*. 1993, Kent and Snell 1994, Diemer 1992). Some of the arthropods, such as the gopher cricket (*Ceuthrophilus* spp.) and scarab beetles (*Aephodius* spp., *Copris* spp., and *Onthophagus* spp.) are obligate commensals that occur nowhere except in gopher burrows (Deyrup and Franz 1994). Overall, gopher tortoise burrows provide a diversity of microhabitats that engenders a higher species richness (both plant and animal) for the high pine community. Gopher tortoises are listed as species of special concern by Florida and are declining throughout the state because of habitat loss and illegal harvesting for food.

The **Florida scrub lizard** (*Sceloporus woodi*) occurs only in central and south-central peninsular Florida and along both coasts in South Florida where it is

restricted to scrub and scrubby high pine communities. Scrub lizards occur in open, sandy habitats and are often seen running along the ground, in contrast to their many relatives in western North America which are decidedly arboreal. The Florida scrub lizard is extremely endangered where it occurs in coastal scrubs in South Florida, and is already extinct or nearly so in southwest Florida (DeMarco 1992). In Ocala NF, and where its habitat persists on the Lake Wales Ridge, the species is still common.

The **Florida gopher frog** (*Rana capito aesopus*) most typically occurs in scrub and high pine communities where it lives almost exclusively in gopher tortoise burrows. They venture out at night to feed on arthropods, spiders and other frogs, and can sometimes be seen perched at the burrow entrance on rainy or cloudy days. Following heavy rains in spring or summer, gopher frogs migrate up to a mile to spawn in isolated wetland ponds. When the tadpoles transform in 3-5 months, they must leave the water and find a tortoise burrow of their own. The gopher frog is listed as a species of special concern by Florida and is the only listed amphibian in the South Florida Ecosystem.

The **Highlands tiger beetle** (*Cicindela highlandensis*) was known only from two scrubs on the southern Lake Wales Ridge, both of which have been destroyed by development (Deyrup 1989). No doubt there are many more scrub invertebrates yet to be described, and many that will go extinct before they are described.

Plant Species of Concern

Federally listed species that depend upon or utilize the scrub community in South Florida include: four-petal pawpaw (*Asimina tetramera),* Florida bonamia (*Bonamia grandiflora*), fragrant prickly-apple (*Cereus eriophorus* var. *fragrans*), pygmy fringe-tree (*Chionanthus pygmaeus*), Florida golden aster (*Chrysopsis floridana*), Florida perforate cladonia *(Cladonia perforata*), pigeon wings (*Clitoria fragrans*), short-leaved rosemary (*Conradina brevifolia*), Avon Park harebells (*Crotalaria avonensis*), Garrett's mint (*Dicerandra christmanii*), scrub mint (*Dicerandra frutescens*), Lakela's mint (*Dicerandra immaculata*), scrub buckwheat (*Eriogonum longifolium* var. *gnaphalifolium*), snakeroot (*Eryngium cuneifolium*), Highlands scrub hypericum (*Hypericum cumulicola*), scrub blazing star (*Liatris ohlingerae*), scrub lupine (*Lupinus aridorum*), Britton's beargrass (*Nolina brittoniana*), papery whitlow-wort (*Paronychia chartacea*), Lewton's polygala (*Polygala lewtonii*), tiny polygala (*Polygala smallii*), wireweed (*Polygonella basiramia*), sandlace (*Polygonella myriophylla*), scrub plum (*Prunus geniculata*), Carter's mustard (*Warea carteri*), and Florida ziziphus *(Ziziphus celata).* Biological accounts and recovery tasks for these species are included in "The Species" section of this recovery plan. The State listed pine pinweed (*Lechea divaricata*) also occurs in the scrub community (Appendix C).

The **Florida ziziphus** is a spiny shrub that occurs on the fringe of turkey oak *(Quercus laevis)* sandhills or yellow sand oak-hickory scrub communities, and is endemic to the Lake Wales Ridge. The Florida ziziphus prefers excessively

drained, nutrient-poor soils in the high pine habitat or the transitional zone between scrubby flatwoods and high pine (DeLaney *et al.* 1989, Burkhart *et al.* 1997). The plant grows vigorously in the more open sites of high pine and pastures, where there is full sun or a light canopy. Conservation measures for this plant should include habitat preservation, captive propagation, reintroduction of this plant into unoccupied, suitable habitats, and land management of the scrubby flatwoods and high pine communities. The Florida ziziphus is currently listed as endangered by the State and the FWS.

Lewton's polygala (*Polygala lewtonii*) prefers the transitional habitat that occurs between oak scrub and high pine communities. Lewton's polygala responds favorably to highly variable fire frequencies. It resprouts quickly and there is an increase in seedling recruitment. With the continued decline of both oak scrub and high pine communities due to agricultural and residential pressures, the Lewton's polygala will also continue to decline. Conservation actions should include habitat acquisition and implementation of appropriate land management of oak scrub and high pine communities. Due to the rapid decline of its habitat, the Lewton's polygala has been listed as endangered by the State of Florida and the FWS.

The **nodding pinweed** *(Lechea cernua)* prefers habitat in the scrub and scrubby flatwoods communities. This plant responds positively to fire and soil (sand) disturbance. This Florida endemic plant has only been found throughout the south and central counties. The nodding pinweed has been and is currently under a great threat due to its rapidly declining habitat caused by agricultural, residential and commercial development. The State has listed the nodding pinweed as threatened due to its declining habitat.

Florida perforate cladonia is a federally endangered lichen endemic to the Florida high white sand scrub communities. This plant is restricted to the open, well-drained, and nutrient-poor soils that are associated with sand pine *(Pinus clausa),* and the Florida rosemary *(Ceratiola ericoides)*. Due to the increasing pressure of land conversions to citrus and residential development, scrub habitat and the Florida perforate cladonia continues to decline. Since the cladonia is presumed to be a slow growing and recolonizing plant, conservation actions should be taken to include preservation and to establish a fire regime that occurs frequently. The frequent fire cycle will reduce fuels enough to prevent large, complete fires, thus leaving bare patches of sand that can serve as refugia. Furthermore, conservation actions should protect the sites from vehicle and heavy foot traffic.

Ecology

Plant communities that are dominated by shrubs are called scrubs and differ in many ways from communities dominated by trees, which are called forests, and those dominated by grasses or grass-like plants, which are called savannas. These differences in vegetative structure are the result of the frequency of fire, which historically was determined by the local topography or "lay of the land," and by the flammability of the vegetation itself. In Florida, natural, lightning-

caused fires occur at an average rate of more than 1,000 fires/year (Komarek 1964), and before modern man created settlements, transportation corridors, and farms, these fires burned across the landscape until they ran out of fuel or reached aquatic or wetland firebreaks.

Forests develop on steep slopes, in ravines, or on peninsulas and islands where the local topography acts as a natural break to the progression of lightning-ignited fires. Fires rarely burn into Florida hammocks and when they do they generally consume only the litter on the forest floor (Platt and Schwartz 1990). Fire return intervals in Florida hammocks are generally longer than 100 years.

In southeastern North America, large expanses of flat land and rolling hills offered little impediment to the movement of lightning-caused fires and historically supported savannas dominated by various flammable grasses and including widely spaced longleaf pine (*Pinus palustris*) or, in the southern third of the Florida peninsula, South Florida slash pine (*P. elliottii* var. *densa*). The higher and drier savannas are called high pine (sometimes "sandhills") and the lower, wetter sites are referred to as pine flatwoods. Historically, savannas experienced fire-return intervals of 1 to 10 years. The plant species composition and even the physical appearance of a savanna (except for the above ground part of the grass which is temporarily burned off) are little changed by the frequent fires. Savannas, therefore, are not disclimax communities and fires in savannas are not disturbances but rather predictable, regular features of the local climate.

Scrubs became established in topographically intermediate areas with intermediate fire-return intervals usually varying from 10 to 80 years. More mesic scrubs usually experience shorter fire-return intervals because fuels accumulate faster there than in drier scrubs. Some extremely xeric rosemary scrubs are thought to burn very rarely (Myers 1990). When scrubs do burn, the fires are usually very intense, consuming the shrubs and trees, in contrast to the low-intensity surface fires typical of savannas. Fire in scrub is a major stand-replacing disturbance that removes all aboveground vegetation and restarts plant growth, usually with the same combination of species.

Once established, the natural vegetation of a community tends to perpetuate itself. For example, savannas are carpeted with highly flammable grasses and dry pine needles which tend to ignite readily and frequently, thus excluding woody plants, whereas scrubs are characterized by patches of bare sand and almost inflammable evergreen shrubs which are unlikely to burn for decades, thereby favoring woody shrubs which in turn shade the ground or release allelopathic toxins (Richardson and Williams 1988) that exclude flammable grasses.

Forests, savannas and scrubs may be further characterized as hydric, mesic or xeric. Thus forests include swamps, mesophytic forests and xeric hammocks; savannas include marshes, pine flatwoods and high pine; and scrubs include shrub bogs, gallberry flats and xeric scrubs. Most authors restrict the term "Florida scrub" to the xeric scrubs only, and we follow that convention here.

Coastal scrubs differ from interior scrubs in their geologic age, species composition, response to disturbance, and management needs (Christman 1988a, Fernald 1989, Johnson and Muller 1993). Coastal scrubs appear to be

maintained at least in part by periodic wind disturbance, especially hurricanes, whereas interior scrubs are maintained by periodic fires. Coastal scrubs are much younger than scrubs on the Lake Wales Ridge, and support few endemic species.

When scrubs are prevented from burning for a long time, some of the oaks may grow up to tree size. If these oaks become dominant and in effect capture the site, the community becomes a pioneer xeric hammock, a man-made community that usually retains a subset of scrub species but lacks most of the typical hammock species. Most pioneer hammocks can be restored to scrub with growing season fires (Abrahamson and Abrahamson 1996) which, unlike dormant season fires, will top-kill many of the oaks (S. Morrison, The Nature Conservancy, personal communication 1995a; 1995b).

When sand pines are present in scrub they do not form a continuous canopy but occur as scattered individuals or clumps of individuals. Occasionally sand pines so dominate a scrub site that it becomes a sand pine forest, with many of the typical scrub forbs, shrubs, and animals suppressed or eliminated. Sand pines are killed by fire, however, and the stand returns to scrub following a burn. If conditions after a fire are favorable for sand pine seedling survival, another sand pine forest may develop and overtop the ephemeral scrub again. Sand pines release their seeds following the heat of a killing fire, but survival of the seedlings is dependent upon adequate soil moisture for several weeks after germination (Myers *et al.* 1987). Even without a killing fire, sand pine forests will revert to scrub when the sand pines, which rarely live beyond 80 years (Cooper 1973), start dying off. Removal of the sand pines by harvesting also will return the site to scrub, as will a burn in sand pines too young to have produced seeds (less than 5 years old).

When all native vegetation has been removed from a savanna or hammock as by plowing, and the site then abandoned, a pioneer scrub may develop. This man-made community usually is dominated by the most invasive weed and scrub species, such as blackberry (*Rubus* spp.), laurel oak (*Q. hemisphaerica*), Florida rosemary, sand pine, and sand live oak. With continued fire suppression the site will become dominated by large oaks. It is not known if such a site can be returned to the original plant community.

Following the removal of longleaf pines and the exclusion of fire, high pine savanna usually is replaced by turkey oak barrens, a man-made community dominated by turkey oak with scattered remnant clumps of wiregrass, remnant longleaf pines, and areas of bare yellow sand. Often sand pine and Florida rosemary invade if a seed source is nearby. Turkey oak barrens should not be confused with scrub or with scrubby high pine.

Status and Trends

Xeric uplands in South Florida have declined in distribution and quality as a result of anthropogenic actions (Kautz 1993, Kautz *et al*. 1993, Center for Plant Conservation 1995). These declines have been attributed to loss of habitat to agricultural, commercial, and residential development, fragmentation of habitat, and altered fire regimes and hydrology. Historically, natural fire regimes were the driving force in maintaining xeric upland communities. During early settlement

of Florida, more frequent but less intense fires altered some scrubs, and more recently, suppression of fires has altered scrubs by increasing fire return intervals. Since European settlement, there has been an estimated 60 percent reduction in the aerial coverage of scrub throughout Florida (Kautz 1993, Center for Plant Conservation 1995, Enge *et al*. in press).

The scrub communities in South Florida have experienced greater losses than other areas of the state. By the early 1980s an estimated 66 percent of scrub habitat had been lost within the Lake Wales Ridge alone (Christman 1988a). Since Christman's estimate, severe freezes during 1983 and 1985 resulted in the abandonment of citrus groves in central Florida and establishment of new groves in South Florida, particularly within scrub habitat along the Lake Wales Ridge. Additionally, more scrub in the northern portions of the Lake Wales Ridge has been lost due to residential and commercial expansion south of Orlando (Fernald 1989).

Scrub communities along the Atlantic Coastal Ridge have also been destroyed, severely fragmented and degraded. Historically, these communities formed a nearly continuous band from Brevard County to Broward County (Davis 1967). Today, coastal scrubs on the Atlantic Ridge exist as fragmented islands surrounded by developed or disturbed lands. Virtually all remaining significant scrub tracts that are not currently protected are proposed for development, or are for sale (Fernald 1989).

In addition to the destruction of scrub communities caused by conversion to agricultural, residential, and commercial purposes, human uses have fragmented the remaining upland habitat. Anthropogenic features such as roads, railroads, and commercial and residential development often act as firebreaks which limit the dispersal of fire, reduce fire intensity and increase fire-return intervals. Unfortunately, the use of fire for land management purposes has been limited by the public's intolerance of fire and strict limitations on particulate air emissions (Brown 1989, Cortner *et al.* 1990).

The dependency of xeric upland plant communities on periodic fire is well-documented, but many patches have not been burned for many years, and many are now overgrown or have been invaded by more mesic, fire-intolerant vegetation (Givens *et al*. 1984). In cases where fire has been excluded for long periods, the functions and values of xeric habitats have been degraded, and many of the plant and animal species typical of these fire-maintained habitats have been reduced or extirpated. Habitat suitability, and persistence of pyrogenic species may decline as quickly as 5 to 10 years or may last as long as 100 years since the last fire depending on the community and species (Myers 1985, Breininger and Schmalzer 1990, Johnson and Abrahamson 1990, Menges and Kohfeldt 1995, Abrahamson and Abrahamson 1996, Hawkes and Menges 1996).

The effects of habitat fragmentation on species richness have been exhaustively studied (MacArthur and Wilson 1967, Diamond 1975, 1978; Simberloff and Abele 1976, 1982; Zimmerman and Bierregaard 1986). For most groups, large habitat patches in close proximity to each other provide for the greatest species diversity and minimize extinction probabilities. On the contrary, small patches that are isolated are less likely to preserve species that would otherwise be common in the mosaic of communities that existed before isolation. Since at least the Pleistocene, Florida scrub has been characterized by an insular,

discontinuous distribution, but the degree of habitat fragmentation seen today is unprecedented and certainly will cause increases in extinction rates among scrub plants and animals.

Non-native plant species are rarely a significant threat to Florida scrub. The widespread exotic, natal grass (*Rhynchelytrum repens*), sometimes colonizes along the edges of Florida scrub, but has not been reported to be a nuisance. Bahiagrass (*Paspalum notatum*) has been planted in some Lake Wales Ridge scrubs where it seems to persist and exclude recovery of native scrub species. Bahiagrass has proven difficult to eradicate. A few exotic plant species have established in coastal scrubs on the Atlantic Coastal Ridge (Table 1, Appendix E).

Management

Scrub

Because scrub is a fire-dependent community that is adapted to periodic destruction by fire only to increase in stature until the next fire, its physical structure and appearance varies with the length of time since the last fire. The density and growth rate of vegetation in scrub are related to the length of time since the last fire and the amount of available moisture, the latter varying with depth to the water table and with soil characteristics between and within scrubs. Mesic scrubs and more mesic parts of large scrubs recover faster following fire than xeric scrubs (Schmalzer and Hinkle 1992). Furthermore, natural fires probably rarely burned all of a scrub at once, but created, instead, a mosaic of scrub habitat types with differing intervals since last burned. Therefore there is no single way a natural scrub should always appear, and there is no specific fire-return interval applicable to all scrubs. A healthy, natural scrub will be devoid of living, above ground vegetation immediately after a fire, densely stocked with 2 to 4 m tall oaks before the next fire, and rarely homogeneous. Nevertheless managers should have guidelines to determine when a scrub should be burned in order to prevent it from growing into a pioneer hammock. Such a "rule of thumb," using the habitat requirements of the Florida scrub-jay was suggested by Christman (1995).

The Florida scrub-jay (*Aphelocoma coerulescens*) is a federally threatened species that is restricted to and dependent upon the Florida scrub habitat (FWS 1990). The Florida scrub-jay can be used as an indicator species for healthy, natural scrub, and its preferred habitat as the management goal for portions (but not all) of managed scrub.

Since natural scrubs usually consist of a mosaic of different scrub microhabitats maintained by different time periods since last burned, differences in soil characteristics, and differences in elevation, scrub management should seek to emulate this heterogeneity, and not impose an artificial uniformity of (for example) preferred scrub-jay habitat throughout. (Some scrub species have microhabitat requirements quite different from those of scrub-jays.) As a basic starting point for decisions regarding scrub management, we suggest that a scrub should be deemed in need of management when more than 50 percent of the scrub

area that could theoretically support scrub-jays has become unsuitable to do so because of vegetative growth since the last fire. (The 50 percent figure is admittedly arbitrary and subject to adjustment.)

According to Cox (1987), preferred scrub-jay habitat consists of scrub with oaks 1 to 3 m tall covering 50 to 75 percent of the area, open patches of bare sand covering 10 to 30 percent of the area, and no more than 20 percent canopy cover by trees. These conditions also are ideal for most scrub-adapted reptiles (Campbell and Christman 1982), including the sand skink (*Neoseps reynoldsi)* (Christman 1992), and Florida scrub lizard (*Sceloporus woodi)* (Jackson 1973), as well as most scrub endemic shrubs and forbs (Christman and Judd 1990, references in Richardson 1989).

Whenever more than one-half of a scrub can be characterized by (1) woody vegetation greater than 3 m in height, (2) areas of bare sand covering less than 10 percent of the ground, or (3) canopy cover greater than 20 percent, the scrub should be treated with prescribed fire or, if possible, a natural fire should be allowed to burn through the scrub. Managers must be flexible, of course. Some rosemary balds for example might never be characterized by woody vegetation more than 3 m tall, or bare sand areas falling below 10 percent cover, or shrubs forming a subcanopy covering more than 20 percent of the total area. Nevertheless, these scrubs might still be in need of periodic fire to maintain rare endemic scrub plants (Menges and Kimmich 1996, Quintana-Ascencio and Morales-Hernandez 1997).

If the management goal for scrubs is to maintain and restore natural communities, prescribed fires in scrub should be set in the growing season in adjacent upland communities and allowed to burn with the wind through the scrub and into natural wetland firebreaks.

Head fires die out variably as they enter the ecotone with wetlands and this maintains the natural variability of the ecotone. Head fires leave some areas intensely burned, some areas lightly burned, and some unburned, creating the habitat mosaic that insures the survival of all scrub species (Christman *et al*. 1979). Backing fires, in contrast, tend to burn the ground cover more completely and homogeneously, and to burn hotter at ground level, possibly killing animals and plant seeds near the soil surface. Furthermore, backing fires are difficult to sustain in scrub unless fuels are especially dry.

On the other hand, backing fires are easier to control. In cases where maximum control of the prescribed fire is imperative, backing fires may have to be used. Backing fires have been used successfully in scrub at The Nature Conservancy's Saddle Blanket Lakes Scrub Preserve in Polk County. A sand pine scrub there was ignited during very dry conditions in May with a wind speed of less than 4 mph, and the desired results were achieved by the backing fire (S. Morrison, TNC, personal communication 1995a).

Scrubs should be burned in the growing season because that is the period during which most lightning fires occur (Abrahamson *et al.* 1984a) and as a result the scrub plants and animals have become adapted to that regime (Abrahamson 1984b, Platt *et al*. 1988, Abrahamson 1995). In the scrubs and sand pine forests of the Ocala NF in Marion County, for example, 80 percent of the "wildfires" over a 50-year period occurred between the months of February and June (Cooper 1973).

The best time to burn Florida scrub is in March, April, or May (Robbins and Myers 1992, S. Morrison, The Nature Conservancy, personal communication 1995b, J. Thorsen, USFS, personal communication 1995, Main and Menges 1997).

Long-unburned scrub cannot be managed with winter fires such as formerly were prescribed in high pine or turkey oak barrens. Indeed, such fires, if they can be sustained at all, appear to hasten the degradation of scrub and its conversion to pioneer hammock by eliminating much of the ground layer but little of the larger woody vegetation (Abrahamson and Abrahamson 1996). Whereas growing season fire in sand pine forest or pioneer hammock will kill the sand pines and above-ground parts of the oaks, thus favoring scrub, fire in the dormant season will burn little but the ground litter (S. Morrison, The Nature Conservancy, personal communications 1995a; 1995b).

The timing of subsequent prescribed fires in scrub should be variable because no single fire-return interval could support the diversity of fire-recovery strategies and habitat preferences observed in native scrub species (Christman, *et al.* 1979, Ostertag and Menges 1994, Abrahamson and Abrahamson 1996). For example, most of the scrub oaks and other woody shrubs simply resprout from below ground within days following a fire (Abrahamson 1984b); in contrast, Florida rosemary is killed by fire and its seeds, already stored in the soil, germinate 1 to 3 years post-fire, with the new seedlings then requiring 10 to 15 years to produce seeds (Johnson 1982); the seeds of sand pine are released when the tree burns to death and germinate within days and periodically thereafter for 2 to 3 years after fire, then take 5 to 7 years to produce seeds again (Fowells 1965, Abrahamson 1984b); the fruticose lichens, *Cladonia* spp. and *Cladina* spp., take decades to re-establish following their death from fire (Buckley and Hendrickson 1988, personal observation); the scrub composite, *Balduina angustifolia* (yellow buttons), is an annual or sometimes biennial (Cronquist 1980) that is killed by fire, depending upon seeds already present in the soil for its recovery (personal observation); the scrub pinweeds, *Lechea* spp., may be absent or nearly so before fire, but appear in abundance within months after a fire (Johnson and Abrahamson 1990); and the relative abundances of scrub reptiles have been shown to vary with time since sand pine regeneration (Christman *et al.* 1979). Main and Menges (1997) provide a table with fire-return intervals that have been suggested for the various plant communities at Archbold Biological Station.

Prescribed fires are best ignited along existing roads and allowed to burn up to and through the scrub and into natural wetland firebreaks. Roads that have been routed through natural ecotones should not be used as firebreaks because this perpetuates the disturbance caused by the road, further reducing the ecological value of the ecotone. Ecotones are important habitats for many plant and animal species, some reaching their greatest abundances there, and some dependent upon them. Ecotones are transitory boundaries between ecosystem structures and functions, and sometimes serve as natural firebreaks. They should never be disturbed if natural systems management is a goal. Existing roads and firebreaks that have been constructed through natural ecotones should be abandoned and the ecotones allowed to recover.

Even worse than roads are the plowed ditches or “fire lines” that managers and fire fighters formerly dug for control of prescribed and natural fires. These ditches damage wildlife habitat and disrupt hydrology and natural soil

processes. Existing fire ditches should be restored to original grade. Written fire prescriptions should require restoration of any fire line ditches that might be plowed for emergency containment.

If artificial firebreaks, either baselines (where the fire is started) or control lines (meant to stop the spread of the fire), must be constructed, they should be temporary, created by various combinations of mowing, crushing, burning, or fire suppressant foam. Rollerchopping with heavy drums should be avoided because it can adversely affect animal habitats and soil processes, damage plant roots and rhizomes upon which scrub regeneration is dependent, and create habitat for invasive species (W. Thomson, The Nature Conservancy, personal communication 1995). Rollerchopping with empty roller drums may be acceptable where mowing is impractical.

Successful prescribed burns in sand pine scrub at Archbold Biological Station in Highlands County and in sand pine forest in the Ocala NF in Marion County were preceded by the ignition of linear backfires to establish burned strips that would serve as baselines and control lines (Abrahamson 1984a, Custer and Thorsen, no date). At Saddle Blanket Lakes Scrub Preserve, temporary firebreaks were constructed by mowing, then burning the mowed strips. At Yamato Scrub in Palm Beach County, Doren *et al.* (1987) created control lines and baselines in sand pine forest by dropping all standing sand pines and using an empty roller chopper to crush the vegetation in a 30 to 50 m wide strip encircling the burn site. In sand pine forest at Blue Springs SP in Volusia County, managers removed the standing sand pines and mowed the remaining vegetation to create temporary firebreaks (W. Thomson, The Nature Conservancy, personal communication 1995).

The required width of control lines can be determined from the predicted fire behavior as modeled by the fire prediction computer program, BEHAVE (Andrews 1986), using the National Forest Fire Laboratory fuel model for chaparral/high pocosin/mature shrub (NFFL model 4, Anderson 1982). There is no fuel model specific for Florida scrub, but the chaparral model was found to describe adequately successful prescribed burns in sand pine forest in Palm Beach County (Doren *et al.* 1987), and in sand pine forest in the Ocala NF, Marion County (Custer and Thorsen, no date). The chaparral fuel model probably could be adapted for scrub (which lacks an overstory of pine trees) as well (R. Roberts, DEP, personal communication 1995).

To reduce predicted flame height and the potential for downwind spotting (and thus the required width of the control lines), Doren *et al.* (1987) used an empty roller chopper to crush 30 to 50 m wide parallel strips perpendicular to the prescribed wind direction. This created alternating bands of chopped and unchopped fuel which was allowed to dry for 10-15 days prior to the burn. The burn was accomplished by first igniting the downwind edge of the crushed perimeter, then moving upwind to each crushed strip and igniting them in turn so that the fire burned with the wind toward the next already burning crushed strip. This pattern resulted in alternately black lining and head firing parallel strips across the entire area (Doren *et al.* 1987).

Scrub at Oscar Scherer SRA in Sarasota County was mowed with a Brown tree cutter prior to burning (Smyth 1991). On Merritt Island, managers used a Brown tree cutter, a D-6 Caterpillar with a V-blade, or a roller chopper to

prepare strips and blocks within several long-unburned oak scrubs prior to burning (Schmalzer *et al.* 1994). After drying for a week or two the crushed strips were easily ignited with a drip torch. By the time the heading fire reached the uncut scrub it had built up sufficient intensity to carry into the standing vegetation (F. Adrian, FWS, personal communication 1995). Managers at Merritt Island reported that the Brown tree cutter provided the best results, producing the best fuel bed with almost no soil disturbance.

Many scrubs adjoin turkey oak barrens or high pine upslope and grade into wetlands downslope. The best way to burn these scrubs is to ignite head fires in the turkey oak barrens and allow the fires to burn into and through the scrubs and then go out in the wetlands downslope. Certainly this is how the scrubs burned before modern man's influence, and this is the fire regime under which the plants and animals have evolved and to which they are adapted. Backing fires could also be used, but conditions must be especially dry to burn scrub with a backing fire.

Experience at The Nature Conservancy's Tiger Creek Preserve in central Florida has shown that when it is dry enough to ignite a scrub, it may be too dry to use natural wetlands as a firebreak because the duff and humus in the wetland/scrub ecotone may catch fire and smolder for weeks, causing unacceptable smoke problems on adjacent lands (S. Morrison, The Nature Conservancy, personal communication 1995b).

Certainly the humus and duff in wetlands, and especially in wetland ecotones, burned under natural conditions prior to management by modern man. Today's accumulation of surface organic matter in the ecotones around wetlands probably is greater than at most times in the past, and no doubt has lead to an increase in forested communities at the expense of scrub and savanna. Reduction of duff exposes bare mineral soil, which favors establishment of fire-dependent plant species. Some reduction of accumulated duff in wetland/scrub ecotones should be a goal of natural systems management.

On the other hand, if smoke from smoldering duff and humus is deemed unacceptable, managers may wish to pre-burn above ground vegetation in wetland firebreaks when it is possible to do so without igniting the humus, then burn the scrub toward the wetland on a later, drier, date when the scrub will burn. By pre-burning the wetland firebreak when the Keech/Byram Drought Index (Keech and Byram 1968) is less than 350, managers can reduce fuel there without igniting the humus (Melton 1989).

In general, prescribed fires in Florida scrub should be ignited early in the growing season (March to May) while the vegetation is still relatively dry. If igniting the duff within the wetland firebreak must be avoided, the scrub should be burned when the wetlands are flooded and the duff is fireproof but the scrub itself is dry enough to burn. Prescribed fires in scrub that will not depend on available wetlands for firebreaks can be set anytime between March and July.

The computer modeling program, RXWINDOW (Andrews and Bradshaw 1990) can be used to determine the best environmental conditions (fuel moisture and wind) for burning scrub based on the desired results of the burn (tree mortality, flame length, rate of spread, and intensity). The program requires input of a specific fuel model for the habitat type to be burned, but there is no fuel model for Florida scrub. The National Forest Fire Laboratory fuel model for

chaparral/high pocosin/mature shrub (NFFL model 4, Anderson 1982) was found to describe adequately prescribed burns in sand pine forest in Palm Beach County (Doren *et al.* 1987) and in Marion County (Custer and Thorsen, no date). The model has not been tested with scrub, which differs from sand pine forest in the absence of a canopy of mature sand pine trees.

Mechanical disturbance alone has been suggested as an alternative to prescribed fire in scrub when the latter is too dangerous or smoke would be an unacceptable nuisance (Fernald 1989). Scrubs that have been chopped or mowed (but not root-raked) seem to regenerate as if they had been burned, but further study is needed. Campbell and Christman (1982) and Greenberg *et al.* (1995) were unable to document significant biological differences between mechanically disturbed and burned sand pine forests in the Ocala NF, but both studies were poorly controlled. Biologists at Jonathan Dickinson SP currently are studying the advantages and disadvantages of mechanical techniques versus prescribed burning versus combinations of both in Florida scrub (R. Roberts, DEP, personal communication 1995).

The science of prescribed burning in Florida scrub is in its infancy and few publications are available. The only published summary of actual prescribed burning in Florida scrub is Schmalzer *et al*. (1994). The papers by Doren *et al*. (1987) and Custer and Thorsen (no date) are the only summaries of actual prescriptions for burns in sand pine forest. All three papers include detailed descriptions of the methods used and results obtained in actual prescribed burns. The new Archbold Biological Station fire management plan (Main and Menges 1997) is one of the best examples of a managed area burn plan.

The best sources for information about prescribed fire in Florida scrub are the people who have actually burned scrubs. Prescribed fires have been conducted in scrubs (or sand pine forests) at Archbold Biological Station in Highlands County (information source: Eric Menges), Tiger Creek, Catfish Creek, and Saddleblanket Lakes Nature Conservancy Preserves in Polk County and Lake Apthorpe Nature Conservancy Preserve in Highlands County (sources: Steve Morrison and Geoff Babb), Yamato Scrub in Palm Beach County (sources: Robert Doren and Richard Roberts), Wekiva Springs State Park in Orange County (source: Rosi Mulholland), Disney Wilderness Preserve in Osceola County (source: Walt Thomson), Jonathan Dickinson SP in Martin County (source: Richard Roberts), Blue Springs SP in Volusia County (source: Walt Thomson), Oscar Scherer SRA in Sarasota County (source: J. Smyth), Ocala NF in Marion County (sources: Jim Thorsen and George Custer), and Merritt Island NWR in Brevard County (sources: Paul Schmalzer and Fred Adrian). Those experienced with fire in scrub emphasize that plow lines are usually ineffective and attempts at control by people, equipment, and tools after the fire has escaped are often futile (Doren *et al*. 1987). The best control is prior planning.

Successful prescribed burns in South Florida scrubs will depend on thorough planning, careful preparation, using a variety of control techniques including existing wetland firebreaks, prior blacklining, mowing wide firebreaks, overstory removal, and possibly fire suppressant foam and hose layouts with sprinklers, and above all, experienced and reliable fire crews and equipment. Fire crews should first develop and improve their scrub-burning skills on small units with large adjoining wetlands.

Scrubby Flatwoods

Prescribed burning is easier in scrubby flatwoods communities than in scrub. The vegetation typically is more dense and carries a fire more readily. Scrubby flatwoods communities tend to recover more quickly from fire because higher levels of soil moisture allow the shrubs to grow faster. Fire return intervals in scrubby flatwoods typically range between 8 and 30 years. Scrubby flatwoods are often inhabited by Florida scrub-jays, therefore managers can use the scrub-jay habitat requirements to determine when a scrubby flatwoods should be burned.

Scrubby High Pine

Historically, fire return intervals in scrubby high pine probably were more variable than in other pyrogenic communities (Christman 1988a, Myers and Boettcher 1987). That is why the community is able to retain scrub-adapted species that cannot tolerate frequent fires on a long-term basis as well as high pine-adapted species that must have frequent fires. Both types of plants are able to persist even though conditions are not optimal for either. Fires at too frequent intervals can turn scrubby high pine toward high pine (S. Morrison, The Nature Conservancy, personal communication 1995a). Fires at too infrequent intervals can turn scrubby high pine toward xeric hammock. Through the centuries the community probably fluctuated between periods when it was more like high pine and periods when it was more like scrub.

Scrubby high pine is not Florida scrub-jay habitat so managers cannot use scrub-jay habitat requirements as a rule of thumb for determining when scrubby high pine should be burned. Instead, managers must be able to make on-the-ground decisions regarding when and what portions of a scrubby high pine community are in need of prescribed fire. The goals are to prevent the development of a continuous tree canopy (fire too rare); to prevent the development of a continuous ground cover (fire too frequent); to prevent the loss of woody species that resprout after fire (fire too frequent); to prevent the loss of woody and herbaceous species that reseed after fire (fire too rare). The best strategy for prescribing burns in scrubby high pine probably is to keep the burn units small, vary the timing and methodology as much as possible, and carefully evaluate the results of each burn.

Table 1. Characteristic vertebrates of South Florida scrub, scrubby flatwoods and scrubby high pine. Federal status: T=threatened; MC=FWS species of management concern. Species or subspecies in boldface are endemic to the State of Florida. Unless otherwise noted, listed birds nest in scrub. Modified from Christman 1988a and Mushinsky and McCoy 1995.

SPECIES	FEDERAL STATUS	COMMENTS
MAMMALS		
southeastern shrew, Sorex longirostris		
short-tailed shrew, Blarina brevicauda		
least shrew, Cryptotis parva		
eastern yellow bat, Lasiurus intermedius		
evening bat, Nycticeius humeralis		
nine-banded armadillo, Dasypus novemcinctus		
cottontail rabbit, Sylvilagus palustris		
Florida mouse, Podomys floridana	MC	
oldfield mouse, Peromyscus polionotus		
cotton mouse, Peromyscus gossypinus		
golden mouse, Ochrotomys nuttalli		
spotted skunk, Spilogale putorius		
BIRDS		
southeastern American kestrel, Falco sparverius paulus	MC	
mourning dove, Zenaida macroura		
common ground-dove, Columbina passerina		
eastern screech owl, Otus asio		
common nighthawk, Chordeilas minor		
Chuck-Will's-widow, Caprimulgus carolinensis		
Florida scrub-jay, Aphelocoma coerulescens	T	nearly endemic to scrub
tufted titmouse, Parus bicolor		
blue-gray gnatcatcher, Polioptila caerulea		
ruby-crowned kinglet, Regulus calendula		winter resident
northern mockingbird, Mimus polyglottos		
gray catbird, Dumetalla carolinensis		winter resident
brown thrasher, Toxostoma rufum		
northern parula, Parula americana		
pine warbler, Dendroica pinus		
yellow-rumped warbler, Dendroica coronata		winter resident
palm warbler, Dendroica palmarus		winter resident
common yellowthroat, Geothlypis trichas		winter resident

SPECIES	FEDERAL STATUS	COMMENTS
northern cardinal, Cardinalis cardinalis		
rufous-sided towhee, Piplio erythrophthalmus		
chipping sparrow, Spizella passerina		winter resident
REPTILES		
gopher tortoise, Gopherus polyphemus	MC	
Florida worm lizard, Rhineura floridana		
scrub lizard, Sceloporus woodi	MC	nearly endemic to scrub
slender glass lizard, Ophisaurus attenuatus		
six-lined racerunner, Cnemidophorus sexlineatus		
peninsula mole skink, Eumeces egregius onocrepis		
blue-tailed mole skink, Eumeces egregius lividus	T	endemic to Lake Wales Ridge
southeastern five-lined skink, Eumeces inexpectatus		
sand skink, Neoseps reynoldsi	T	nearly endemic to scrub
rough green snake, Opheodrys aestivus		
southern black racer, Coluber constrictor priapus		
eastern coachwhip, Masticophis flagellum		
corn snake, Elaphe guttata		
scarlet kingsnake, Lampropeltis triangulum elapsoides		
Florida scarlet snake, Cemophora c. coccinea		
short-tailed snake, Stilosoma extenuatum	MC	
crowned snake, Tantilla relicta		
eastern coral snake, Micrurus fulvius		
pygmy rattlesnake, Sistrurus miliarius		
AMPHIBIANS		
greenhouse frog, Eleutherodactylus planirostris		introduced
eastern spadefoot toad, Scaphiopus holbrooki		
southern toad, Bufo terrestris		
oak toad, Bufo quercicus		
pinewoods treefrog, Hyla femoralis		
narrow-mouthed toad, Gastrophryne carolinensis		
gopher frog, Rana capito	MC	

Table 2. Plants of South Florida scrub.

Plants of South Florida Scrub. * = introduced species. Species in boldface are endemic to Florida scrub or habitats intermediate between scrub and high pine or scrub and flatwoods. Federal Status: E = Endangered; T = Threatened; O = Occasional in community; C = Characteristic of community. Modified from Steinberg 1980, Abrahamson *et al.* 1984, Christman 1988a, Fernald 1989, Austin 1993, and unpublished site survey data on file at FNAI, Tallahassee, Florida.

NAME (FAMILY)	FEDERAL STATUS	INTERIOR SCRUB	COASTAL SCRUB	SCRUBBY FLATWOODS	SCRUBBY HIGH PINE
Ambrosia artemisiifolia (Asteraceae)			O		
Amorpha herbacea (Fabaceae)		O			
Andropogon arctatus (Poaceae)		O			
Andropogon brachystachyus (Poaceae)		C			
Andropogon floridanus (Poaceae)		C	C	O	
Andropogon glomeratus var. glaucopsis (Poaceae)		O			
Andropogon ternarius var. cabanisii (Poaceae)		O			
Andropogon tracyi (Poaceae)		C		O	
Andropogon virginicus var. glaucus (Poaceae)		C			O
Andropogon virginicus var. virginicus (Poaceae)		O			
Aristida condensata (Poaceae)		O			
Aristida gyrans (Poaceae)		C	C	O	
Aristida spiciformis (Poaceae)		O			O
Aristida beyrichiana (Poaceae)		O	O	C	C
Aristida tenuispica (Poaceae)		O	O		
Asclepias curtissii (Asclepiadaceae)		C	C	C	
Asclepias humistrata (Asclepiadaceae)		O			O
Asclepias pedicellata (Asclepiadaceae)		O	O		O
Asclepias tomentosa (Asclepiadaceae)		O			
Asclepias tuberosa (Asclepiadaceae)		C	O		O
Asclepias feayi (Asclepiadaceae)		C		O	O
Asimina obovata (Annonaceae)		C		O	C
Asimina pygmaea (Annonaceae)		O		O	
Asimina reticulata (Annonaceae)		O	C	O	

NAME (FAMILY)	FEDERAL STATUS	INTERIOR SCRUB	COASTAL SCRUB	SCRUBBY FLATWOODS	SCRUBBY HIGH PINE
Asimina tetramera (Annonaceae)	E		C		
Balduina angustifolia (Asteraceae)		C	C	O	C
Befaria racemosa (Ericaceae)		C	O	C	O
Bidens pilosa (Asteraceae)			O		
Bonamia grandiflora (Convolvulaceae)	T	C			C
Bulbostylus ciliatifolia (Cyperaceae)		C	O	O	O
Bulbostylus warei (Cyperaceae)		C	C	O	O
Bumelia lacuum (Sapotaceae)		C			
Bumelia lanuginosa (Sapotaceae)		O			
Bumelia reclinata var. reclinata (Sapotaceae)		O			
Bumelia tenax (Sapotaceae)		C	O	C	O
Calamintha ashei (Lamiaceae)		C			
Calamintha coccinea (Lamiaceae)		O			O
Callicarpa americana (Verbenaceae)			O		O
Callitres columellaris* (Cupressaceae)			O		
Carphephorus corymbosus (Asteraceae)		O	O	C	
Carya floridana (Juglandaceae)		C	C		C
Carya glabra (Juglandiaceae)		O			
Cassia chamaecrista (Fabaceae)		O	C		
Cassytha filiformis (Lauraceae)			C		
Casuarina spp.* (Casuarinaceae)			O		
Catharanthus roseus* (Apocynaceae)		O	O		
Ceratiola ericoides (Empetraceae)		C	C		C
Chamaesyce cumulicola (Euphorbiaceae)			C		
Chamaesyce hyssopifolia (Euphorbiaceae)		O			
Chapmannia floridana (Fabaceae)		C		O	C
Chionanthus pygmaeus (Oleaceae)	E	C			C
Chrysopsis scabrella (Asteraceae)		O	C	C	C
Cladina evansii (Cladoniaceae)		C	C	C	C
Cladina subtenuius (Cladoniaceae)		C	C	C	C
Cladonia calycantha (Cladoniaceae)		C		O	
Cladonia leporina (Cladoniaceae)		C	C	C	C

NAME (FAMILY)	FEDERAL STATUS	INTERIOR SCRUB	COASTAL SCRUB	SCRUBBY FLATWOODS	SCRUBBY HIGH PINE
Cladonia perforata (Cladoniaceae)	E	C	C		
Cladonia prostrata (Cladoniaceae)		C	C	O	C
Cladonia subsetacea (Cladoniaceae)		O			
Clitoria fragrans (Fabaceae)	T	O			C
Clitoria mariana (Fabaceae)			O		O
Cnidoscolus stimulosus (Euphorbiaceae)		C	O	O	O
Commelina erecta (Commelinaceae)		C	O	C	C
Conradina brevifolia (Lamiaceae)	E	C			
Conradina grandiflora (Lamiaceae)		C	C	C	
Conyza canadensis (Asteraceae)		O		O	O
Crataegus lepida (Rosaceae)		C			
Crotalaria avonensis (Fabaceae)	E	C			
Crotalaria rotundifolia (Fabaceae)		O	O		O
Croton argyranthemus (Euphorbiaceae)		O			O
Croton glandulosus (Euphorbiaceae)		O	O		
Crotonopsis linearis (Euphorbiaceae)		O	O		O
Cuthbertia ornata (Commelinaceae)		O	C		C
Cyperus compressus (Cyperaceae)			O		
Cyperus retrorsus (Cyperaceae)		C	O	C	C
Dalea carnea (Fabaceae)			O		
Dalea feayi (Fabaceae)		C	C		O
Dalea pinnata (Fabaceae)		O			O
Dicanthelium sabulorum (Poaceae)		O	O		
Dicerandra christmanii (Lamiaceae)	E				C
Dicerandra frutescens (Lamiaceae)	E				C
Dicerandra immaculata (Lamiaceae)	E		C		
Dicranum condensatum (Dicranaceae)		C		C	
Diodea teres (Rubiaceae)		C	O		
Elaphantopus elatus (Asteraceae)		O	O	C	
Eriogonum longifolium var. gnaphalifolium (Polygonaceae)	T	O			C
Eriogonum tomentosum (Polygonaceae)		O			O
Ernodea littoralis (Rubiaceae)			O		

NAME (FAMILY)	FEDERAL STATUS	INTERIOR SCRUB	COASTAL SCRUB	SCRUBBY FLATWOODS	SCRUBBY HIGH PINE
Eryngium aromaticum (Apiaceae)			O	C	
Eryngium cuneifolium (Apiaceae)	E	C			
Erythrina herbacea (Fabaceae)			O		
Euphorbia c.f. floridana (Euphorbiaceae)		C		C	
Euphorbia polyphyla (Euphorbiaceae)		C	O	O	
Froelichia floridana (Amaranthaceae)		O	O		O
Galactia elliottii (Fabaceae)		C	O	C	C
Galactia regularis (Fabaceae)		O	O	O	O
Galactia volubilis (Fabaceae)		O	O	O	
Galium hispida (Rubiaceae)		O		O	
Garberia heterophylla (Asteraceae)		C		C	C
Gaylussacia dumosa (Ericaceae)		C	O	C	C
Gaylussacia frondosa (Ericaceae)		O			O
Gaylussacia tomentosa (Ericaceae)		O			O
Gratiola hispida (Scrophulariaceae)		C	O	O	
Hamelia patens (Rubiaceae)			O		
Hedyotis nigricans (Rubiaceae)			O		
Hedyotis procumbens (Rubiaceae)		C	O		
Helianthemum carolinianum (Cistaceae)		O			O
Helianthemum corymbosum (Cistaceae)		C	C	O	O
Helianthemum nashii (Cistaceae)		C	C	C	O
Helianthus debilis (Asteraceae)			O		
Heterotheca subaxillaris (Asteraceae)		O	O		
Hypericum cumulicola (Hypericaceae)	E	C		O	
Hypericum gentianiodes (Hypericaceae)		O	O		
Hypericum hypericoides (Hypericaceae)		O		O	
Hypericum reductum (Hypericaceae)		C	C	C	
Hypoxis juncea (Hypoxidaceae)		O		C	
Ilex ambigua (Aquifoliaceae)		C			O
Ilex cumulicola (Aquifoliaceae)		C		O	C
Ilex glabra (Aquifoliaceae)		O	O	C	
Krigia virginica (Asteraceae)		O			

NAME (FAMILY)	FEDERAL STATUS	INTERIOR SCRUB	COASTAL SCRUB	SCRUBBY FLATWOODS	SCRUBBY HIGH PINE
Lachnocaulon anceps (Eriocaulaceae)		O		C	
Lachnocaulon minus (Eriocaulaceae)		O		C	
Lantana sp.			O		
Lechea cernua (Cistaceae)		C	C	O	
Lechea deckertii (Cistaceae)		C	C	O	O
Lechea divaricata (Cistaceae)		O	C	O	
Lechea minor (Cistaceae)		O			
Lechea sessiliflora (Cistaceae)		O			
Lechea torreyi (Cistaceae)		O			
Liatris chapmanii (Asteraceae)		O	C		O
Liatris garberi (Asteraceae)			O		
Liatris laevigata (Asteraceae)		C		O	O
Liatris ohlingerae (Asteraceae)	E	C		O	O
Liatris tenuifolia (Asteraceae)		O	O	O	C
Licania michauxii (Chrysobalanaceae)		C	C	C	C
Linaria floridana (Scrophulariaceae)		C	C		O
Lupinus aridorum (Fabaceae)	E	C			O
Lupinus diffusus (Fabaceae)		O	C		C
Lygodesma aphylla (Asteraceae)		C	O	O	
Lyonia ferruginea (Ericaceae)		C		C	C
Lyonia fruticosa (Ericaceae)		C	C	C	O
Lyonia lucida (Ericaceae)		O	C	C	
Monotropa uniflora (Ericaceae)		C	C		
Myrica cerifera (Myricaceae)		O	O	C	
Nolina brittoniana (Agavaceae)	E	C		C	C
Oncidium bahamense (Orchidaceae)			C		
Opuntia humifusa (Cactaceae)		C	C		C
Opuntia stricta (Cactaceae)			C		
Osmanthus americanus (Oleaceae)		O			C
Osmanthus megacarpus (Oleaceae)		C			C
Palafoxia feayi (Asteraceae)		C	C	C	C
Palafoxia integrifolia (Asteraceae)		O	O	O	C

NAME (FAMILY)	FEDERAL STATUS	INTERIOR SCRUB	COASTAL SCRUB	SCRUBBY FLATWOODS	SCRUBBY HIGH PINE
Panicum breve (Poaceae)		C		C	O
Paronychia americana (Caryophyllaceae)		C	C		C
Paronychia chartacea (Caryophyllaceae)	T	C		O	
Paronychia herniarioides (Caryophyllaceae)		C			O
Persea borbonia (Lauraceae)		O	O	O	
Persea humilis (Lauraceae)		C	C	C	
Phyllanthus abnormis (Euphorbiaceae)			O		
Physalis viscosa (Solanaceae)			O		
Piloblephis rigida (Lamiaceae)		O	O	C	
Pinus clausa (Pinaceae)		C	C	C	C
Pinus elliottii (Pinaceae)		C	O	C	C
Pinus palustris (Pinaceae)		O	O	C	C
Piriqueta caroliniana (Turneraceae)		O	O		
Pityopsis graminifolia (Asteraceae)		C	C	O	C
Poinsettia cyathophora (Euphorbiaceae)			O		
Polanisia tenuifolia (Capparaceae)		C	C		C
Polygala grandiflora (Polygalaceae)		O		O	
Polygala incarnata (Polygalaceae)		O			
Polygala lewtonii (Polygalaceae)	E	O			C
Polygala polygama (Polygalaceae)		O			
Polygonella basiramia (Polygonaceae)	E	C		O	
Polygonella ciliata (Polygonaceae)		C	C		O
Polygonella gracilis (Polygonaceae)		C	C	O	O
Polygonella myriophylla (Polygonaceae)	E	C			O
Polygonella polygama (Polygonaceae)		C	C	C	C
Polygonella robusta (Polygonaceae)		C	C		C
Polypremum procumbens (Loganiaceae)		C		O	O
Prunus geniculata (Rosaceae)	E	C			C
Psoralea canescens (Fabaceae)		O			
Pterocaulon virgatum (Asteraceae)		O	O	O	O
Pteroglossappis ecristata (Orchidaceae)		O	O		
Quercus chapmanii (Fagaceae)		C	C	C	C

NAME (FAMILY)	FEDERAL STATUS	INTERIOR SCRUB	COASTAL SCRUB	SCRUBBY FLATWOODS	SCRUBBY HIGH PINE
Quercus geminata (Fagaceae)		C	C	C	C
Quercus incana (Fagaceae)			O		
Quercus inopina (Fagaceae)		C		C	
Quercus laevis (Fagaceae)		O	O		C
Quercus minima (Fagaceae)		O	O	O	
Quercus myrtifolia (Fagaceae)		C	C	O	C
Quercus pumila (Fagaceae)		O	O	O	
Quercus virginiana (Fagaceae)			O		
Rhus copalina (Anacardiaceae)		O	O	O	
Rhynchelytrum repens* (Poaceae)		O	O	O	
Rhynchosia cinerea (Fabaceae)		O			O
Rhynchospora intermedia (Cyperaceae)		O	O	O	
Rhynchospora megalocarpa (Cyperaceae)		C	C	C	C
Richardia scabra (Rubiaceae)		O			
Sabal etonia (Arecaceae)		C	C	C	C
Sabal palmetto (Arecaceae)			O	O	
Schinus terebinthifolius* (Anacardiaceae)			O		
Schizachyrium niveum (Poaceae)		C		O	O
Schrankia microphylla (Fabaceae)		C	O	O	O
Scleria ciliata (Cyperaceae)			O	O	
Selaginella arenicola (Selaginellaceae)		C	C	C	C
Serenoa repens (Arecaceae)		C	C	C	C
Seriocarpus bifoliatus (Asteraceae)				O	
Seymeria pectinata (Scrophulariaceae)		C	C	O	
Sisyrinchium xerophyllum (Iridaceae)		C	C	C	O
Smilax auriculata (Smilacaceae)		C	O	C	O
Smilax laurifolia (Smilacaceae)			C		
Solidago chapmanii (Asteraceae)		C	O		O
Stillingia sylvatica (Euphorbiaceae)		C	O		C
Stipa avenaciodes (Poaceae)		C			
Stipulicida setacea (Caryophyllaceae)		C	C		O
Stylisma abdita (Convolvulaceae)		C			C

NAME (FAMILY)	FEDERAL STATUS	INTERIOR SCRUB	COASTAL SCRUB	SCRUBBY FLATWOODS	SCRUBBY HIGH PINE
Stylisma patens (Convolvulaceae)		C			
Stylisma villosa (Convolvulaceae)		O	C		O
Tephrosia chrysophylla (Fabaceae)		C			C
Tillandsia balbisiana (Bromeliaceae)		O	C		
Tillandsia fasciculata (Bromeliaceae)		O	O		O
Tillandsia flexuosa (Bromeliaceae)		O	O		
Tillandsia paucifolia (Bromeliaceae)		O	O		
Tillandsia pruinosa (Bromeliaceae)			O		
Tillandsia recurvata (Bromeliaceae)		C	C	O	O
Tillandsia setacea (Bromeliaceae)		O	O	O	O
Tillandsia usneoides (Bromeliaceae)		C	O	O	C
Tillandsia utriculata (Bromeliaceae)		O	C		O
Tradescantia roseolens (Commelinaceae)		C		O	O
Tragia smallii (Euphorbiaceae)		O			O
Tragia urens (Euphorbiaceae)		O			O
Trichostema dichotomum (Lamiaceae)		C	O	C	C
Triphora gentianoides (Orchidaceae)			O		
Usnea strigosa (Usneaceae)		C		C	C
Vaccinium arboreum (Ericaceae)		O			O
Vaccinium darrowii (Ericaceae)		C	O	C	C
Vaccinium myrsinites (Ericaceae)		C	C	C	C
Vaccinium stamineum (Ericaceae)		O	O	O	O
Vitis aestivalis (Vitaceae)			O		
Vitis munsoniana (Vitaceae)		C	O	O	O
Vitis shuttleworthii (Vitaceae)			O		
Warea carteri (Brassicaceae)	E	O	C	C	C
Woodwardia virginica (Blechnaceae)			O		
Ximenia americana (Olacaceae)		C	C		C
Xyris caroliniana (Xyridaceae)		O		C	
Yucca filamentosa (Agavaceae)		O		O	O
Zamia pumila (Cycadaceae)			O		
Ziziphus celata (Rhamnaceae)	E	C			

Literature Cited

Abrahamson, W.G. 1984a. Post-fire recovery of Florida Lake Wales Ridge vegetation. American Journal of Botany 71:9-21.

Abrahamson, W.G. 1984b. Species response to fire on the Florida Lake Wales Ridge. American Journal of Botany 71:35-43.

Abrahamson, W.G. 1995. Habitat distribution and competitive neighborhoods of two Florida palmettos. Bulletin of the Torrey Botanical Club 122:1-14.

Abrahamson, W.G., A.F. Johnson, J.N. Layne, and P.A. Peroni. 1984. Vegetation of the Archbold Biological Station, Florida: an example of the southern Lake Wales Ridge. Florida Scientist 47:209-250.

Abrahamson, W.G. and Hartnett. 1990. Pine flatwoods and dry prairies, pp. 103-149. *In* R.L. Myers and J.J. Ewel eds., Ecosystems of Florida. University of Central Florida Press, Orlando, Florida.

Abrahamson, W.G. and J.R. Abrahamson. 1996. Effects of a low-intensity winter fire on long-unburned Florida sand pine scrub. Natural Areas Journal 16:171-183.

Adrian, F.W. 1995. Letter. August 23, 1995.

Anderson, H.E. 1982. Aids to determining fuel models for estimating fire behavior. General technical report INT-122. USDA Forest Service, Intermountain Forest and Range Experiment Station; Ogden, Utah.

Andrews, P.L. 1986. BEHAVE: fire behavior prediction and fuel modeling system - burn subsystem, Part 1. General technical report INT-194. USDA Forest Service, Intermountain Forest and Range Experiment Station; Ogden, Utah.

Andrews, P.L. and L.S. Bradshaw. 1990. RXWINDOW: defining windows of acceptable burning conditions based on desired fire behavior. General technical report INT-273. USDA Forest Service Intermountain Forest and Range Experiment Station; Ogden, Utah.

Austin, D. 1993. Scrub plant guide. Gumbo Limbo Nature Center of South Palm Beach County, West Palm Beach, Florida.

Brandt, L.A., K.L. Montgomery, A.W. Saunders, and F.J. Mazzotti. 1993. Life history notes: *Gopherus polyphemus* (gopher tortoise) Burrows. Herpetological Review 24:149.

Brown, J.K. 1989. Pages 89-96 *in* MacIver, D.C., H. Auld, and R. Whitewood, eds. Proceedings of the 10th conference on fire and forest meteorology, Ottawa, Canada.

Breininger, D.R. and P.A. Schmalzer. 1990. Effects of fire and disturbance on plants and animals in a Florida oak/palmetto scrub. American Midland Naturalist 123:64-74.

Buckley, A. and T.O. Hendrickson. 1988. The distribution of *Cladonia perforata* Evans on the southern Lake Wales Ridge in Highlands County, Florida. The Bryologist 9:354-356.

Campbell, H.W. and S.P. Christman. 1982. The herpetological components of Florida sandhill and sand pine scrub associations. Pages 163-171 *in* N.J. Scott, Jr., ed. Herpetological communities: a symposium of the Society for the Study of Amphibians and Reptiles and the Herpetologists' League, August 1977. Wildlife research report 13. U.S. Fish and Wildlife Service; Washington, D.C.

Center for Plant Conservation. 1995. An action plan to conserve the native plants of Florida. Missouri Botanical Garden; St. Louis, Missouri.

Christman, S.P. 1988a. Endemism and Florida's interior sand pine scrub. Final project report GFC-84-101, submitted to Florida Game and Freshwater Fish Commission; Tallahassee, Florida.

Christman, S.P. 1988b. Tiger Creek Preserve monitoring studies, initial element occurrences: rare vascular plants and vertebrates of the uplands of Tiger Creek Nature Preserve. Unpublished report prepared for The Nature Conservancy; Winter Park, FL.

Christman, S.P. 1992. Sand skink. Pages 135-140 *in* P.E. Moler, ed. Rare and endangered Biota of Florida, volume 3, amphibians and reptiles. University Presses of Florida; Gainesville, Florida.

Christman, S.P. 1995. Management of Florida scrub at Camp Blanding, Clay County, Florida. Unpublished report prepared for Camp Blanding Training Site, Florida Army National Guard; Jacksonville, Florida.

Christman, S.P., H.I. Kochman, H.W. Campbell, C.R. Smith, and W.S. Lippincott, Jr. 1979. Successional changes in community structure: amphibians and reptiles in Florida sand pine scrub. Unpublished report prepared for the U.S. Fish and Wildlife Service; Gainesville, Florida.

Christman, S.P. and W.S. Judd. 1990. Notes on plants endemic to Florida scrub. Florida Scientist 53:52-73.

Cooper, R.W. 1973. Fire and sand pine. Pages 207-212 *in* Sand pine symposium proceedings. General technical report SE-2. Southeastern Forest Experiment Station, USDA Forest Service; Marianna, Florida.

Cortner, H.J., P.D. Gardner, J.G. Taylor. 1990. Fire hazards at the urban-wildlife interface: what the public expects. Environmental Management 14:57-62.

Cox, J.A. 1987. Status and distribution of the Florida scrub jay. Special publication no. 3. Florida Ornithological Society; Gainesville, Florida.

Cox, J., R. Kautz, M. MacLaughlin and T. Gilbert. 1994. Closing the gaps in Florida's wildlife habitat conservation system. Florida Game and Fresh Water Fish Commission; Tallahassee, Florida.

Cronquist, A. 1980. Vascular flora of the United States, Volume 1, Asteraceae. University of North Carolina Press; Chapel Hill, North Carolina.

Custer, G. and J. Thorsen. no date. Stand replacement prescribe burn. Unpublished report prepared for the USDA Forest Service, Seminole Ranger District, Ocala National Forest; Umatilla FL.

Davis, J.H. 1967. General map of natural vegetation of Florida. Circular S-178. Institute of Food and Agricultural Sciences, University of Florida; Gainesville, Florida.

DeMarco, V. 1992. Florida scrub lizard. Pages 141-145 in P.E. Moler, ed. Rare and endangered biota of Florida. vol. 3. Amphibians and reptiles. University Presses of Florida; Gainesville, Florida.

Deyrup, M. 1989. Arthropods endemic to Florida scrub. Florida Scientist 52:255-270.

Deyrup, M. and R. Franz, eds. 1994. Rare and endangered biota of Florida. vol. 4. Invertebrates. University Presses of Florida; Gainesville Florida.

Diamond, J.M. 1975. The island dilemma: lessons of modern biogeographic studies for the design of natural preserves. Biological Conservation 7:129-146.

Diamond, J.M. 1978. Critical areas for maintaining viable populations of species. Pages 27-40 *in* M.N. Holdgate and M.J. Woodman, eds. The breakdown and restoration of ecosystems. Plenum Press; New York, New York.

Diemer, J.E. 1992. Gopher tortoise. Pages 123-127 in P.E. Moler, ed. Rare and endangered biota of Florida. University Presses of Florida; Gainesville, Florida.

Doren, R.F., D.R. Richardson, and R.E. Roberts. 1987. Prescribed burning of the sand pine scrub community: Yamato Scrub, a test case. Florida Scientist 50:184-192.

Douglass, J.F. and J.N. Layne. 1978. Activity and thermoregulation of the gopher tortoise *(Gopherus polyphemus)* in southern Florida. Herpetologica 34:359-374.

Enge, E.M., B.A. Millsap, T.J. Doonan, J.A. Gore, N.J. Douglass, M.S. Robson, and G.L. Sprandel. 1997. Conservation plans for biotic regions in Florida that contain multiple rare or declining wildlife taxa. Unpublished nongame technical report, Florida Game and Fresh Water Fish Commission; Tallahassee, Florida.

Fernald, R.T. 1989. Coastal xeric scrub communities of the Treasure Coast Region, Florida: a summary of their distribution and ecology, with guidelines for their preservation and management. Technical report no. 6, Florida Game and Fresh Water Fish Commission; Tallahassee, Florida.

Fowells, H.A. 1965. Silvics of forest trees of the United States. Agriculture handbook no. 271. U.S. Department of Agriculture; Washington, D.C.

Givens, K.T., J.N. Layne, W.G. Abrahamson, and S.C. White-Schuler. 1984. Structural changes and successional relationships of five Florida Lake Wales Ridge plant communities. Bulletin of the Torrey Botanical Club 111:8-18.

Greenberg, C.H., D.G. Neary, L.D. Harris, and S.P. Linda. 1995. Vegetation recovery following high-intensity wildfire and silvicultural treatments in sand pine scrub. American Midland Naturalist 133:149-163.

Hawkes, C.V. and E.S. Menges. 1996. The relationship between open space and time since fire for species in a xeric Florida scrubland. Bulletin of the Torrey Botanical Club 123:81-92.

Jackson, J.F. 1973. Distribution and population phenetics of the Florida scrub lizard, *Sceloporus woodi*. Copeia 1973:746-761.

Jackson, D.R. and E.G. Milstrey. 1989. The fauna of gopher tortoise burrows. Pages 86-89 *in* J.E. Diemer et al., eds. Proceedings of the gopher tortoise relocation symposium. Nongame wildlife program technical report no. 5. Florida Game and Fresh Water Fish Commission; Tallahassee, Florida.

Johnson, A.F. 1982. Some demographic characteristics of the Florida rosemary, *Ceratiola ericoides* Michx. American Midland Naturalist 108:170-174.

Johnson, A.F. and W.G. Abrahamson. 1990. A note on the fire responses of species in rosemary scrubs on the southern Lake Wales Ridge. Florida Scientist 53:138-143.

Johnson, A.F. and J.W. Muller. 1993. An assessment of Florida's remaining coastal upland natural communities: final summary report. Florida Department of Community Affairs; Tallahassee, Florida.

Kautz, R.S. 1993. Trends in Florida wildlife habitat 1936-1987. Florida Scientist 56:7-24.

Kautz, R.S., D.T. Gilbert, and G.M. Mauldin. 1993. Vegetative cover in Florida based on 1985-1989 Landsat thematic mapper imagery. Florida Scientist 56:135-154.

Keech, J.J. and G.M. Byram. 1968. A drought index for forest fire control. USDA Forest Service research paper SE-38. Southeastern Forest Experiment Station; Asheville, North Carolina.

Kent, D.M. and E. Snell. 1994. Vertebrates associated with gopher tortoise burrows in Orange County, Florida. Florida Field Naturalist 22:8-10.

Komarek, E.V., Sr. 1964. The natural history of lightning. Proceedings of the Tall Timbers fire ecology conference 8. Tall Timbers research Station; Tallahassee, Florida.

Landers, J.L. and D.W. Speake. 1980. Management needs of sandhill reptiles in southern Georgia. Proceedings of the annual conference of the southeastern association of fish and wildlife agencies 34:515-529.

Layne, J.N. 1992. Florida mouse. Pages 250-264 *in* J.N. Layne, ed. Rare and endangered biota of Florida. vol. 1. Mammals. University Presses of Florida; Gainesville, Florida.

Laessle, A.M. 1967. Relation of sand pine scrub to former shorelines. Quarterly Journal of the Florida Academy of Sciences 30:269-286.

MacArthur, R.H. and E.O. Wilson. 1967. The theory of island biogeography. Princeton University Press; Princeton, New Jersey.

Main, K.N. and E.S. Menges. 1997. Archbold Biological Station fire management plan. Land Management Publication 97-1. Archbold Biological Station; Lake Placid, Florida.

Melton, M. 1989. The Keech/Byram Drought Index: a guide to fire conditions and suppression problems. Fire Management Notes 50:30-34.

Menges, E.S. and J. Kimmich. 1996. Microhabitat and time since fire: effects on demography of *Eryngium cuneifolium* (Apiaceae), a Florida scrub endemic plant. American Journal of Botany 83:185-191.

Menges, E.S. and N. Kohfeldt. 1995. Life history strategies of Florida scrub plants in relation to fire. Bulletin of the Torrey Botanical Club 122:282-297.

Morrison, S. 1995a. Telephone communication. July, 1995.

Morrison, S. 1995b. Letter. July 22, 1995.

Myers, R.L. 1985. Fire and the dynamic relationship between Florida sandhill and sand pine scrub vegetation. Bulletin of the Torrey Botanical Club 112:241-252.

Myers, R.L. 1990. Scrub and high pine. Pages 150-193 *in* R.L Myers and J.J. Ewel, eds. Ecosystems of Florida. University of Central Florida Press; Orlando, Florida.

Myers, R.L. and S.E. Boettcher. 1987. Provisional fire management plan for a portion of Tiger Creek Preserve, Florida. Unpublished report prepared for The Nature Conservancy; Winter Park, Florida.

Myers, R.L., S.E. Boettcher, and H.A. Tuck. 1987. Seedling response of sand pine (*Pinus clausa*) following fire. Association of Southeastern Biologists bulletin 34:68-69.

Ostertag, R. and E.S. Menges. 1994. Patterns of reproductive effort with time since last fire in Florida scrub plants. Journal of Vegetation Science 5:176-192.

Platt, W.J., G.W. Evans, and M.M. Davis. 1988. Effects of fire season on flowering of forbs and shrubs in longleaf pine forests. Oecologia 76:353-363.

Platt, W.J. and M.W. Schwartz. 1990. Temperate hardwood forests. Pages 194-229 *in* R.L. Myers and J.J. Ewel, eds. Ecosystems of Florida. University of Central Florida Press; Orlando, Florida.

Quintana-Ascencio, P.F. and M. Morales-Hernandez. 1997. Fire-mediated effects of shrubs, lichens and herbs on the demography of *Hypericum cumulicola* in patchy Florida scrub. Oecologia 112:263-271.

Richardson, D.R. 1989. The sand pine scrub community: an annotated bibliography. Florida Scientist 52:65-93.

Richardson, D.R. and G.B. Williamson. 1988. Allelopathic effects of shrubs of the sand pine scrub on pines and grasses of sandhills. Forest Science 34:592-605.

Roberts, R.E. 1995. Letter. July 17, 1995.

Robbins, L. and R.L. Myers. 1992. Seasonal effects of prescribed burning in Florida: a review. Tall Timbers Research, Inc. Miscellaneous publication no. 8. Tall Timbers Research Station; Tallahassee, Florida.

Schmalzer, P.A. and C.R. Hinkle. 1992. Recovery of oak-saw palmetto scrub after fire. Castanea 57:158-173.

Schmalzer, P.A., D.R. Breininger, F.W. Adrian, R. Schaub, and B.W. Duncan. 1994. Development and implementation of a scrub habitat compensation plan for Kennedy Space Center. Technical memorandum 109202, National Aeronautics and Space Agency; Kennedy Space Center, Florida.

Simberloff, D.S. and L.G. Abele. 1976. Island biogeography theory and conservation practices. Science 191:285-286.

Simberloff, D.S. and L.G. Abele. 1982. Refuge design and island biogeographic theory: effects of fragmentation. American Naturalist 120:41-50.

Smyth, J.E. 1991. Returning pyric communities to suitable habitat for Florida scrub jays at Oscar Scherer State Recreation Area (abstract). Florida scrub-jay workshop, May 23-24, Florida Department of Natural Resources; Ormond Beach, Florida.

Steinberg, B. 1980. Vegetation of the Atlantic Coastal Ridge of Broward County Florida based on 1940 imagery. Florida Scientist 43:7-12.

Stevenson, J. 1995. Telephone communication. June, 1995.

Thomson, W. 1995. Telephone communication. July, 1995.

Thorsen, J. 1995. Letter (file code 5140). July 10, 1995.

U.S. Fish and Wildlife Service (FWS). 1990. Recovery plan for the Florida scrub jay. United States Fish and Wildlife Service; Atlanta, Georgia.

Wharton, C.H. 1978. The natural environments of Georgia. Georgia Department of Natural Resources; Athens, Georgia.

White, W.A. 1970. The geomorphology of the Florida peninsula. Geological Bulletin No. 51. Florida Department of Natural Resources; Tallahassee, Florida.

Zimmerman, B.L. and R.O. Bierregaard. 1986. Relevance of the equilibrium theory of island biogeography and species-area relations to conservation, with a case from Amazonia. Journal of Biogeography 13:133-143.

Restoration of Scrub, Scrubby Flatwoods and Scrubby High Pine

Restoration Objective: Maintain and enhance the structure, function, and composition of the scrub community, and increase the spatial extent of scrub as habitat throughout South Florida to insure the long-term survival in the wild of all plant and animal species that depend upon this community for their existence.

Restoration Criteria

Scrub in South Florida may be considered restored when: (1) existing scrub habitat is preserved through land acquisition; Federal, State or local management actions; and/or private cooperative agreements; (2) when prescribed fire or other management techniques are used to restore suitable habitat from overgrown scrub; (3) when any further loss, fragmentation, and degradation of scrub habitat has been prevented; (4) when appropriate ecosystem management has been prepared, funded, and implemented for long-term perpetuation of the scrub community; and (5) when protection of scrub is adequate to ensure endemic, rare, and imperilled species that use this community have self-sustaining populations.

Community-level Restoration Actions

1. **Prevent further destruction or degradation of existing scrub communities.**

   1.1. **Secure scrub sites through land acquisition, landowner agreements, and conservation easements**. The highest priority should be placed on preventing development of remaining scrub sites. This is best accomplished by land acquisition, but other methods of preventing development such as conservation easements are sometimes useful. So much of South Florida's original scrub has already been irretrievably lost that most remaining scrub tracts should be acquired for preservation. Scrubs on the acquisition lists for Florida's CARL program for the FWS Lake Wales Ridge NWR should be acquired first. In addition, scrubs identified by Fernald (1989) and the strategic habitat conservation area scrubs identified by Cox et al. (1994) should be acquired.

   1.2. **Control public use**. Indiscriminate use of off-road vehicles and illegal sand mining have contributed to the degradation of many South Florida scrubs. These and other inappropriate public uses must be discouraged if we are to prevent further degradation of existing scrubs. Signs and fences may be required.

   1.3. **Enforce existing regulations**. Regulations against collecting threatened and endangered species must be enforced.

2. Restore existing degraded scrubs.

2.1. Permit the reintroduction of natural fires or prescribe controlled burns, and/or mechanical disturbance treatments. Scrubs that have been degraded because of fire exclusion can be restored with prescribed fires and/or mechanical disturbance treatments. Each protected scrub site should have a fire management plan prepared specifically for it. Management plans should specifically include allowing natural, lightning-ignited fires to burn through scrub preserves whenever possible. In addition, plans should specify how and when prescribed fires should be ignited if natural fires are inadequate to meet management objectives. The use of mechanical disturbance instead of or in addition to fire may be appropriate in some cases.

2.2. Encourage maintenance and recovery of natural ecotones. Ecotones are important elements of any natural landscape and should receive special attention in scrub management plans. Fire breaks and roads should be placed well away from ecotones. Ecotones that have been degraded by existing roads and fire breaks should be restored.

2.3. Eliminate or control exotic and off-site species. Some scrubs on the Lake Wales Ridge have been planted to bahiagrass (*Paspalum notatum*) for cattle forage. This turf-forming grass excludes native scrub species and persists even when burned. Mechanical soil scarification and/or chemical herbicide treatments might be necessary to reduce bahiagrass ground cover. Some coastal scrubs on the Atlantic Coast Ridge have been colonized by exotic plant species. These infestations tend to be small, localized, and probably easy to eliminate compared to exotic plant problems in other communities.

2.4. Reintroduce locally extirpated species. Because of past management practices, some scrub plant and animal species may have disappeared from existing degraded scrubs. These species can be reintroduced if natural recolonization is unlikely.

2.5. Eliminate any sources of pollution to the scrub site.

2.6. Control public use. Scrubs that have been degraded by inappropriate public use can only be restored by first eliminating that public use. Signs and fences may be necessary to discourage off-road vehicle use. In some scrubs on the Lake Wales Ridge, illegal sand mining has seriously degraded habitats.

3. Maintain scrub communities in a natural condition in perpetuity.

3.1. Continue to prescribe natural fires, controlled burns and/or mechanical disturbance treatments. Continue planning for natural lightning-ignited fires to be allowed to burn. Prescribe controlled burns and/or mechanical treatments when natural fires are inadequate to meet management objectives.

3.2. Continue to control exotic species. Exotic plant species rarely invade interior scrub, but coastal scrubs, especially on the Atlantic Coast Ridge, are sometimes susceptible to invasion by exotics. These probably can be controlled by mechanical means without the need for chemical herbicides.

3.3. Continue to control public use. Scrubs acquired for conservation of biotic resources must be protected from inappropriate public use. Sand mining, off-road vehicle use, and rare plant collecting are not compatible with scrub preservation.

3.4. Monitor for negative population trends among important scrub plant species. Each scrub preserve should have a specific monitoring plan that will alert managers

to extirpations or downward trends in populations of selected scrub species, including endemic species, listed species, and keystone species.

3.5. Monitor and correct for any point source or non-point source pollution.

4. **Recreate scrub where it has been destroyed by human activities such as mining or farming**. In Polk County efforts to recreate scrub where it had been totally destroyed on former strip mines have been promising, but less than satisfactory so far. The research, monitoring, and efforts should continue.

5. **Create scrub in regions where scrub has been destroyed by human activities**. In Osceola County, researchers have attempted to create a scrub by spreading top soil from a scrub that was being destroyed by development onto a former cow pasture. The effort has been promising but so far less than satisfactory. The research and the efforts should continue.

6. **Connect existing scrub preserves by acquiring lands for conservation between them**. Land acquisition, landowner agreements, or conservation easements should be used to prevent development of lands between existing conservation areas. Lands acquired as connectors between scrub preserves need not be scrubs. Historically, scrubs existed as "islands" in a matrix of other community types, and this pattern should be maintained as much as possible.

7. **Encourage community level research**.

7.1. Encourage research on prescribed burning in scrub. As more and more Florida scrubs are placed under management for ecological conservation the use of prescribed fire to manage scrub will become increasingly necessary. Unfortunately, there has been little prescribed burning in Florida scrub to date and there are no formal guidelines available. The National Forest Fire Laboratory does not have a fuel model for Florida scrub. Currently the U. S. Forest Service in the Ocala NF is developing a fuel model specific for sand pine forest (J. Thorsen, USFS, personal communication 1995). However, it is doubtful if such a model will describe adequately fire behavior in scrub, which lacks an overstory of sand pine trees. Managers need a fuel model for the various phases of Florida scrub.

FWS has funded DEP at Jonathan Dickinson SP to develop optimum pre-treatment methods for prescribed burning in coastal scrub and sand pine forest, and to compare stand replacement by mechanical disturbance versus prescribed burning (R. Roberts, DEP, personal communication 1995). Similar studies in Lake Wales Ridge and other interior scrubs are needed.

7.2. Encourage research on alternatives to prescribed burning. In cases where prescribed burning cannot be accomplished due to proximity of roads or other human development, mechanical disturbance may be an acceptable alternative. FWS has funded a study at Archbold Biological Station to compare the effects of mechanical treatment with prescribed fire on listed Lake Wales Ridge plants and their habitats. Similar studies in various scrub types and in other areas of South Florida are needed.

8. **Monitor habitat and ecological processes.**

8.1. Monitor land management actions. All management actions should be monitored to determine their effectiveness, and changes should be made to management activities as appropriate. Each scrub preserve should have a specific monitoring plan

to assist managers with decisions regarding prescribed burning and other land management actions.

8.2. Monitor for negative population trends among important scrub plant and animal species. Each scrub preserve should have a specific monitoring plan that will alert managers to extirpations or downward trends in populations of selected scrub species, including endemic species, listed species, and keystone species.

8.3. Monitor and correct for any point source or non-point source pollution.

9. Increase public awareness. Public understanding and approval are required for any conservation effort to be successful. Public announcements should highlight land acquisition projects such as Florida's Conservation and Recreational Lands (CARL) program and Preservation-2000. Federal initiatives such as the new Lake Wales Ridge NWR should be advertised. Environmental education programs in South Florida should be encouraged to distribute materials or develop lesson plans on scrub habitats, scrub species, and the importance of maintaining natural biodiversity. Educators and potentially interested organizations should be made aware of available resources such as brochures, slide programs, and video tapes from Archbold Biological Station, GFC, and others. Schools and the interested public should know about internet sites that feature Florida scrub.