High Pine

FNAI Global Rank:	**G2/G3**
FNAI State Rank:	**S2**
Federally Listed Species in S. FL:	**15**
State Listed Species in S. FL:	**35**

High Pine. *Original photograph courtesy of The Nature Conservancy.*

Longleaf pine savannas, characterized by a nearly continuous ground cover of wiregrass (*Aristida beyrichiana*) and widely spaced longleaf pines (*Pinus palustris*), once covered most of the pre-settlement uplands of the southeastern United States from Virginia to Texas and south to Central Florida. These savannas included both high pine and pine flatwoods, similar plant communities at opposite ends of the moisture gradient. Today the longleaf pine savanna is almost extinct, the result of harvesting all original-growth longleaf pines and decades of fire suppression. In South Florida, the high pine community is extinct except for a few small, isolated fragmentary remnants that are not large enough to be self-sustaining or to support the full complement of native species. Most South Florida sites where high pine formerly occurred are now occupied by citrus orchards, strip mines or other human development. Remaining high pine sites are small and have been degraded by fire suppression. They now are dominated by invasive off-site species such as sand pine (*Pinus clausa*), or by species formerly restricted to the shrub layer such as turkey oak (*Quercus laevis*).

Prospects for restoring high pine to its former range in the South Florida Ecosystem appear remote.

Synonymy

The longleaf pine savannas of the southeastern United States were called “pine barrens” by the first European settlers (Williams 1837). Later, the lower, more mesic savannas came to be called “pine flatwoods” and the higher, better-drained areas, “high pine” (*e.g.* Whitney 1896). Beginning in the 1940s, Laessle (1942, 1958) and others from the University of Florida in Gainesville began referring to the plant community as “sandhills,” perhaps because they were uncomfortable using the term “high pine” for a community then largely lacking pine trees due to lumbering and fire suppression. Means and Campbell (1982) introduced the term “clayhills” for the same

community on clay-based soils, because they were uncomfortable using the term "sandhills" for a plant community on clay soils. Others have called the community longleaf pine/turkey oak, longleaf pine/wiregrass, longleaf pine ridge lands, and longleaf pine savanna. High pine sites that have been severely degraded by fire exclusion and lumbering have been called "turkey oak barrens," "turkey oak sandhills" and even "turkey oak scrub." Myers (1990), thankfully, restored the term "high pine" in his very thorough account of the community. We continue to use the term "turkey oak barrens" for former high pine sites that now lack a wiregrass ground cover and are dominated by tree-sized turkey oaks (*Quercus laevis*).

Plant communities intermediate between high pine and Florida scrub can be called "scrubby high pine," analogous to "scrubby flatwoods," which is intermediate between pine flatwoods and Florida scrub. Scrubby high pine has been known by many names, including "Caribbean pine-turkey oak" (Laessle 1967), "slash pine-turkey oak" (Douglas and Layne 1978), "southern ridge sandhills" (Abrahamson *et al.* 1984), "yellow sand scrub" (Christman 1988a), "natural turkey oak barrens" (Christman and Judd 1990), "hickory scrub" (Main and Menges 1997), and "blackjack lands" or "blackjack ridges" by 19th century land surveyors cited in Myers (1990). The FLUCCS code for the high pine community includes: 412 (longleaf pine/xeric oak).

Distribution

Longleaf pine savannas (high pine and pine flatwoods) once covered more than 29 million ha (71.6 million acres, over 70 percent of the upland area) on the southeastern coastal plain from southeastern Virginia to eastern Texas and south to central Florida (Croker 1979, Noss 1988, Means and Grow 1985). Today, only about 1 million ha (2.5 million acres, less than 3 percent of the original) remains. According to Myers (1990), the historic southern limit of the high pine community corresponded to the end of the sand ridges in peninsular Florida, reaching Martin County on the east coast, Lee County on the west coast and Highlands County in the interior.

Within the South Florida Ecosystem high pine formerly occupied much of the center of the Lake Wales Ridge in Polk and northern Highlands counties (Figure 1). Most of this area is now occupied by citrus groves and commercial development. It appears that lands with yellow sands on the southern half of the Lake Wales Ridge ("southern ridge sandhills" of Abrahamson *et al*. 1984, "hickory scrub" of Main and Menges 1997) and on the eastern flank of the Lake Wales Ridge ("natural turkey oak barrens" of Christman and Judd 1990) supported scrubby high pine rather than high pine (Christman 1988a, 1988b, 1995; Myers and Boettcher 1987, Myers 1990).

Today, small remnant vestiges of high pine still occur in Polk County at Bok Tower Gardens, Mountain Lake and around Babson Park. None is large enough to be self-sustaining or to support many of the native high pine vertebrate species (GFC 1994). The Florida Natural Areas Inventory has records for five high pine remnants in Polk County, one in Osceola County (on the Polk county line) and one in Highlands County. The Osceola and Polk County sites range from 2 to 45 ha (5 to 111 acres). The best stand of high pine

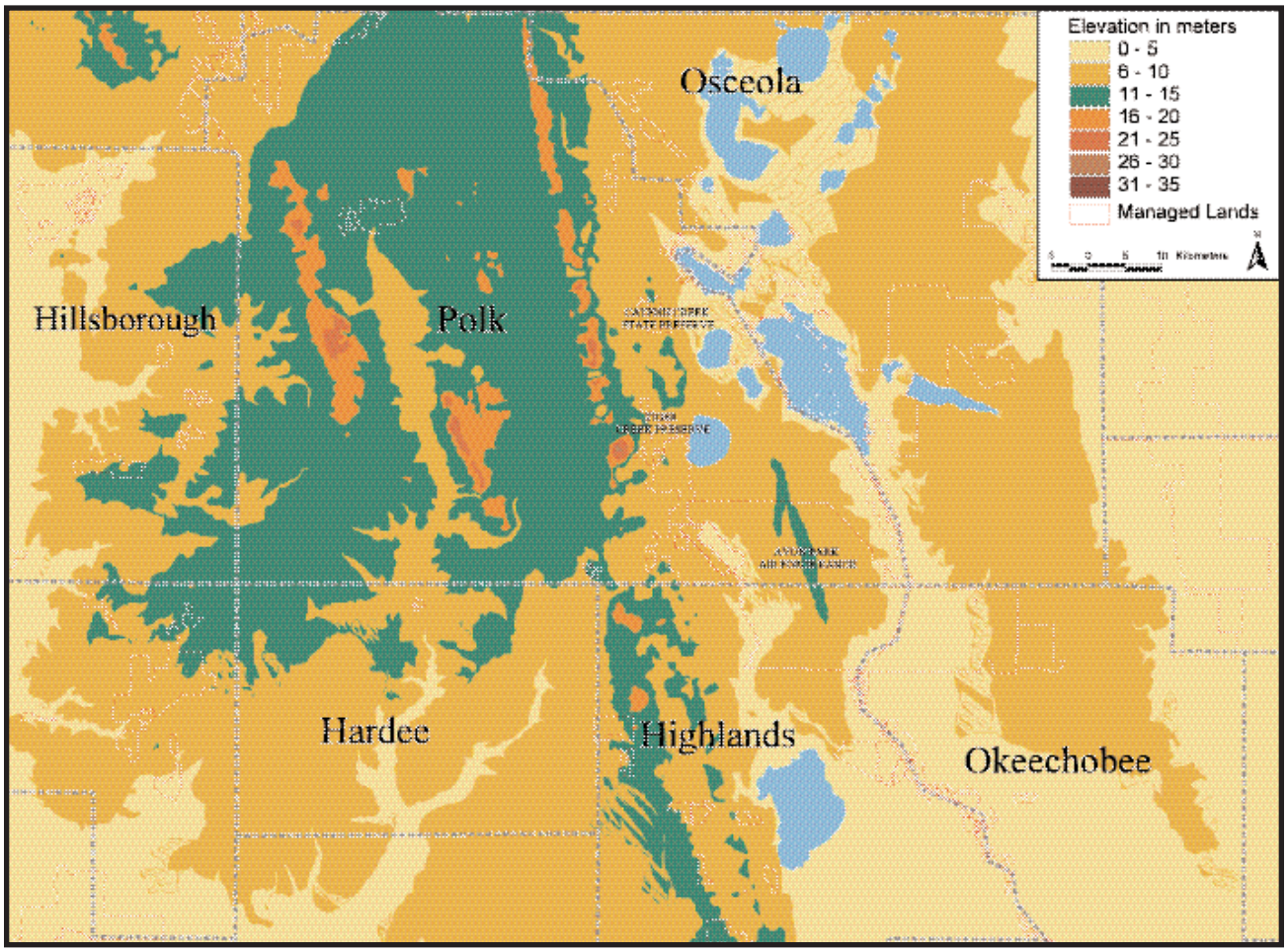


Figure 1. The distribution of high pine in South Florida north of Lake Okeechobee.

remaining in the South Florida Ecosystem covers about 440 ha (1,087 acres) on the Bombing Range Ridge within the Avon Park AFR. FNAI has no records of high pine for any of the other counties in the South Florida Ecosystem.

According to Jim Beever (GFC, personal communication 1998) there are areas of longleaf pine along the Peace River in DeSoto and Hardee counties that are high and dry enough to qualify as high pine. These occupy ridges within pine flatwoods communities. A small area of high pine occurs on a ridge along Horse Creek near Ona in Hardee County. Unfortunately, this site is part of a proposed phosphate strip mine (J. Beever, GFC, personal communication 1998).

Scrubby high pine occurs throughout Florida where it usually is associated with peaks in high pine or pine flatwoods communities or narrow bands along steep slopes between high pine and wetlands. It sometimes occurs as an ecotone between scrub and high pine. In northern Florida and the Panhandle, scrubby high pine is uncommon, generally occurring in small isolated patches. Within the South Florida Ecosystem, however, scrubby high pine once dominated much of the southern Lake Wales Ridge in the vicinity of Lake Placid, and especially in four regions on the eastern flank of the ridge near Catfish Creek, Tiger Creek, Carter Lake and (formerly) Bear Hollow (Christman 1988a). High pine and scrubby high pine apparently were the native plant communities of choice for citrus growers on the Lake Wales Ridge.

Description

The longleaf pine savannas of the southeastern United States occupy lands ranging from flat, poorly drained (even seasonally flooded) to extremely well-drained high and dry ridges. The lower, more mesic savannas are called pine flatwoods and the higher, drier stands are known as high pine. The two communities are at opposite ends of a wetness continuum, are similar in appearance, have similar fire regimes, and share many plant and animal species. Ridges within extensive areas of pine flatwoods often support more xeric species and could be considered high pine, just as low areas within high pine support flatwoods species.

The original high pine community was readily recognized by the continuous ground cover of grasses and the widely spaced longleaf pines. Today there is no virgin or old-growth high pine remaining in Florida. Examples of second growth high pine that come close to matching descriptions from early naturalists (*e.g.*, Bartram 1791, Williams 1837) can be seen at Riverside Island in the Ocala National Forest and at The Nature Conservancy's Janet Butterfield Brooks Preserve in Hernando County. There is another, smaller example near Thomasville, Georgia.

High pine communities can occur on a variety of soils, from coarse, sterile sands to fertile calcareous or phosphatic clays to rich loamy soils underlain by clays (Myers 1990). Studies by Laessle (1958, 1967) and Kalisz *et al*. (1986) have shown that there are no consistent differences in the physical or chemical properties of scrub and high pine soils. The two strikingly different plant communities are maintained by differences in fire regimes. The influence of soil type apparently is secondary or even insignificant (Myers 1990).

The original high pine community in Florida was dominated by wiregrass and

piney woods dropseed (*Sporobolus junceus*). Numerous other grasses, sedges and forbs were present as well, some making their aboveground appearances only after fire. Typical herbaceous species include wiregrass, piney woods dropseed, yellow buttons (*Balduina angustifolia*), silkgrass (*Pityopsis graminifolia*), green eyes *(Berlandiera subacaulis*), deer tongue (*Carphephorus corymbosus*), scrub dayflower (*Commelina erecta*), summer farewell (*Dalea pinnata*), blazing star (*Liatris tenuifolia*), and queen's delight (*Stillingia sylvatica*). There was no canopy or subcanopy in the original high pine savanna. Widely spaced longleaf pines, up to a meter in diameter, were the only large trees. (Some high pine communities in South Florida may have had South Florida slash pine (*Pinus elliottii* var. *densa*) instead of longleaf pine.) Turkey oak, blue jack oak (*Q. incana*), post oak (*Q. stellata*) and sand live oak (*Q. geminata*) were usually present in scattered, often multi-stemmed clumps kept low and shrubby by frequent fires. Other woody plants typical of high pine include palafoxia (*Palafoxia integrifolia*), Chapman's oak (*Q. chapmanii*), and myrtle oak (*Q. myrtifolia*). Table 1 is a list of plant species that are typically found in peninsular Florida high pine communities. It was compiled for this report from six published and unpublished species lists from high pine sites in peninsular Florida.

Most remaining high pine communities in South Florida have been degraded by logging, fire exclusion, feral hog rooting, and cattle grazing, and appear quite different today. A typical high pine site in Florida today is characterized by extensive areas of bare ground littered with dead turkey oak leaves, scattered clumps of wiregrass, widely scattered longleaf pines, and a dominant midstory of turkey oak trees. Such a community usually is referred to as turkey oak barrens, and is often invaded by scrub species such as sand pine, garberia (*Garberia heterophylla*) and rosemary (*Ceratiola ericoides*) if seed sources are nearby. Turkey oak barrens usually support a subset of the original high pine species and some scrub species as well (Campbell and Christman 1982).

Scrubby high pine is a naturally occurring plant community that is floristically and functionally intermediate between high pine and scrub. Scrubby high pine usually contains longleaf pine or south Florida slash pine, turkey oak and scattered clumps of wiregrass, and has yellow sand, all conditions typical of high pine. However scrubby high pine also contains typical scrub species, such as sand pine, the evergreen scrub oaks, garberia, and rosemary, and it supports several species that are restricted or nearly restricted to it such as scrub hickory (*Carya floridana*), scrub buckwheat (*Eriogonum longifolium* var. *gnaphthalifolium*), pigeonwing, Lewton's polygala, and the scrub balms (*Dicerandra* spp.) (Christman 1988a, 1988b, Christman and Judd 1990). Scrubby high pine easily can be 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).

Wildlife Diversity

Typical mammalian species in high pine include the Florida mouse (*Podomys floridanus*), Sherman's fox squirrel *(Sciurus niger shermani*), and pocket gopher *(Geomys pinetis)*. Typical birds are the pine warbler (*Dendroica pinus*), Bachman's sparrow (*Aimophila aestivalis*), and brown-headed nuthatch (*Sitta pusilla*). Typical reptiles are the gopher tortoise (*Gopherus polyphemus*), southeastern five-lined skink (*Eumeces inexpectatus*), eastern coachwhip (*Masticophis flagellum*), Florida pine snake (*Pituophis melanoleucus mugitus)*, and black racer (*Coluber constrictor*). Typical amphibians include the pine woods treefrog (*Hyla femoralis*), the gopher frog (*Rana capito*), and the spadefoot toad (*Scaphiopus holbrooki*). An extensive list of high pine reptiles and amphibians is provided by Campbell and Christman (1982) and Mushinsky (1985). Stout and Corey (1995) list vertebrates and invertebrates commonly captured in the high pine community. Engstrom (1993) provides lists of the characteristic birds and mammals of the longleaf pine savanna.

Wildlife Species of Concern

Federally listed animal species that depend upon or utilize the high pine community in South Florida include: the red cockaded woodpecker (*Picoides borealis*), sand skink (*Neoseps reynoldsi*), bluetail mole skink (*Eumeces egregius lividus)*, and eastern indigo snake (*Drymarchon corais couperi*). Biological accounts and recovery plans for these species are included in "The Species" section of this recovery plan. Several State listed species occur in the high pine community. These include: the Sherman's fox squirrel, Florida mouse, Florida pine snake, gopher tortoise, short-tailed snake (*Stilosoma extenuatum*), and gopher frog (Appendix C). The high pine community is important for these and other wildlife species of concern, as it provides cover, food, roosting, or nesting in well drained, white to yellow sands.

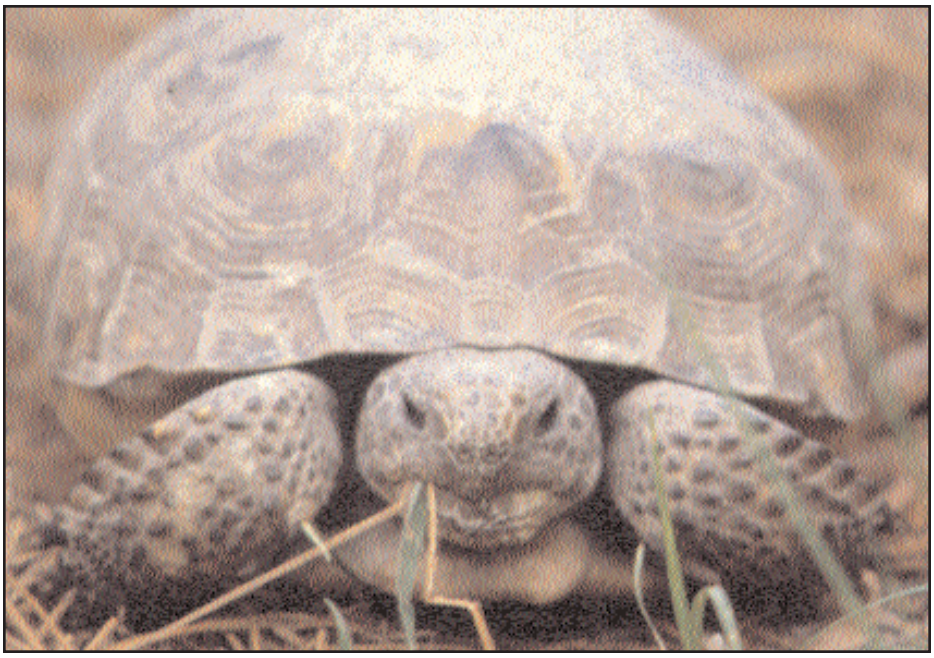
The primary habitat for the **Sherman's fox squirrel** is the fire maintained, mature longleaf pine-turkey oak, high pine and flatwoods communities (Humphrey 1992). Although the total population size of the fox squirrel is unknown, its numbers have been proportionally declining with habitat loss resulting from fire suppression and development. Longleaf pine seeds and turkey oak acorns are considered to be the fox squirrel's primary diet. Nesting usually occurs in large oaks and often contains Spanish moss *(Tillandsia usneoides)*, which provides insulation (Humphrey 1992). The specialized habitat of the remaining fox squirrels is greatly threatened due to increasing pressures of agricultural, commercial, and residential development. Habitat preservation and reclamation, including prescribed fire management, of large areas (at least 25 km^2, or 9.7 sq mi) of heterogeneous, natural high pine habitat are the most needed conservation actions for the Sherman's fox squirrel (Humphrey 1992). The State has listed the fox squirrel as a species of special concern.

The **red-cockaded woodpecker** prefers open, frequently burned, mature longleaf pine, sparse midstory communities (Rodgers *et al.* 1996). These mature high pine areas provide a food source and roosting and nesting habitat necessary to sustain red-cockaded woodpeckers. Red-cockaded woodpeckers

feed primarily on arthropods by scaling back the bark of trees in their preferred pine-dominated habitats (Rodgers *et al.* 1996). Population surveys have determined that although suitable habitat in privately owned forests could be inhabited by red-cockaded woodpeckers, these mature forests are rapidly declining as a result of fire suppression, development, and timber production. The majority of the existing red-cockaded woodpecker populations are fragmented and occur on Federal lands. The fragmented high pine forests are incompatible with sustaining large or stable populations of red-cockaded woodpeckers. Currently, the FWS has the red-cockaded woodpecker listed as endangered under the ESA. The State has the red-cockaded woodpecker listed as threatened. Despite the protected legal status of red-cockaded woodpecker, the population has continued to decline throughout South Florida, principally as result of habitat deterioration (Rodgers *et al.* 1996). Habitat preservation and reclamation, including prescribed fire management of old-growth pines, should be one of the conservation actions for the red-cockaded woodpecker. Measures should also be taken to prevent further fragmentation of suitable habitat by creating corridors of old-growth pines between population centers.

The **southeastern American kestrel** *(Falco sparverius paulus)* uses high pine communities for nesting and foraging habitat. Although no systematic statewide surveys have been completed to estimate the current population size, it can be expected that the southeastern American kestrel population decline will continue in conjunction with the loss of foraging and nesting habitat due to timber harvest of the high pine forests. Data from the FWS' Breeding Bird Survey also suggests a declining kestrel population in Florida between 1966 and 1979 (Rodgers *et al.* 1996). Kestrels are found nesting predominately in longleaf pine snags, but also can be found in sand pines, turkey oaks, live oaks *(Quercus virginiana)*, and in post oaks (Rodgers *et al.* 1996). These nesting habitats preferred by southeastern American kestrels have declined and are continuing to decline rapidly throughout Florida. Loss of nesting snags due to agricultural conversion and developmental pressures appears to be the dominant factor affecting kestrels'decline. Habitat preservation of both nesting and foraging habitat is crucial to the conservation of the southeastern American kestrel. Currently, the State has the southeastern American kestrel listed as threatened.

The **gopher tortoise** is considered a keystone species in the high pine community because 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.* 1987, Jackson and Milstrey 1989, Brandt *et al*. 1993, Kent and Snell 1994,



Gopher Tortoise. *Original photograph by Dawn Jennings.*

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.

The **eastern indigo snake** can be found in a variety of habitats in South Florida ranging from swamps to xeric uplands, including high pines. It can often be found in high pines in association with gopher tortoise burrows as oviposition sites in high pines. Eastern indigo snakes require large tracts of land for survival which leads to its declining numbers. Habitat loss, overcollecting for the pet trade, and mortality resulting from gassing tortoise burrows for rattlesnake collection are responsible for the placement of the eastern indigo snake on the State and Federal threatened list. Large and unaltered expanses of land must be preserved in order to protected the eastern indigo snake.

According to radio telemetry studies, the **Florida pine snake** occupies well drained, xeric sites, including longleaf pine-turkey oak associations. This snake is extremely fossorial and is often found associated with the tunneling system of the pocket gopher and, to a lesser extent, the gopher tortoise (Moler 1992). There have been serious declines in the numbers of Florida pine snake in the last 20 years due to habitat alteration, excessive collecting, and road mortality. Fire management and preservation of high pine habitats are the most needed conservation actions for the Florida pine snake. The Florida pine snake is currently listed by the State as a species of special concern.

The endemic **short-tailed snake** is chiefly restricted to longleaf pine-turkey oak plant associations, but can also be found in upland hammock and sand pine scrub (Moler 1992). Although little is known about this cryptic species, we know it is

Short-tailed snake. *Original photograph by Joseph Wasilewski.*

a burrower and is seldom seen above ground outside of the spring and fall seasons. The short-tailed snake's specialized habitat of well-drained soils is under tremendous pressures by agriculture, building construction, and timbering/clearcutting of longleaf pines and sand pine scrub. Obvious conservation measures must include preservation and enhancement of these rapidly declining habitat communities. The short-tailed snake is currently listed as threatened by the State.

The **sand skink** 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 to 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 with extinction due to its losing battle with humans for its habitat, it is often abundant 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 high pine and scrub communities.

Plant Species of Concern

Federally listed plant species that depend upon or utilize the high pine community in South Florida include: Britton's beargrass (*Nolina brittoniana*), tiny polygala (*Polygala smallii*), Carter's mustard (*Warea carteri*), scrub

buckwheat (*Eriogonum longifolium* var. *gnaphalifolium*), Florida bonamia (*Bonamia grandiflora*), papery whitlow-wort (*Paronychia chartacea*), wide-leaf warea (*Warea amplexifolia*), pigeon wings (*Clitoria fragrans*), Lewton's polygala (*Polygala lewtonii*), Florida ziziphus (*Ziziphus celata*), and scrub plum (*Prunus geniculata*). 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*) can also be found utilizing the high pine community.

The **wide-leaf warea** is a plant endemic to the high pine (or sandhill) habitat. Clasping warea is limited to dry, open longleaf pine woods, longleaf pine/turkey oak woods, or live oak/bluejack oak woods that occur on well-drained, sterile, white to yellowish sands on the Lake Wales Ridge. It does not generally occur in weedy areas and requires fire management to facilitate its growth. Conservation actions for the wide-leaf warea should include fire management and preservation of high pine habitat. This species is currently listed as endangered by the State and the FWS.

The **scrub plum** prefers dry, sunny, nutrient-poor sites found in its native habitat of high pine and scrub oak communities. The scrub plum has been listed as endangered by the State and the FWS due to its rapidly declining habitat. The habitat type lends itself to numerous threats due to fire suppression and developmental pressures. Fire, or equivalent artificial disturbance, appears to be necessary for perpetuation of the species. The scrub plum readily resprouts after a fire or mechanical disturbances and colonizes the sunny openings created by the disturbances.

Ecology

Forests, scrubs and savannas are general terms for plant communities that are dominated by trees, shrubs, or grasses, respectively. The 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, fires burned across the landscape until they ran out of fuel or reached aquatic or wetland firebreaks.

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, especially wiregrass, and including widely spaced longleaf pines, or in the southern third of the Florida peninsula, South Florida slash pine. 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 parts of the grasses, forbs and shrubs which are 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.

Longleaf pines are uniquely adapted to existence in a fire-maintained landscape. The bark is thick and relatively fireproof. The limbs are high on the

trunk, above the flames. The needles are long and when they fall they tend to drape on encroaching shrubs causing them to be engulfed in fire. Longleaf seedlings remain in the "grass" stage for up to 20 years during which time they develop a strong root system while the vulnerable apical meristem is protected from fire in a thick sheath of needles. At some point the longleaf seedling bolts rapidly and within a few weeks the tender growing tip is raised 2 to 4 m (6 to 13 ft) above the ground and is once again safe from ground fires. Typically longleaf pines are vulnerable to death by fire only during the brief bolting phase.

Fires in the high pine community typically consume only the grasses and above-ground portions of woody shrubs. High pine fires tend to be relatively cool and slow burning compared to the catastrophic conflagrations typical of scrub. They usually occur during the season of most frequent lightning, in Florida from May through September, which corresponds with the growing season for the plants.

If fires are excluded from high pine, the woody shrubs grow larger and eventually dominate the site, shading out the grasses and forbs. Turkey oak barrens are former high pine sites in which the turkey oaks (and sometimes blue jack oaks) attain tree size. At its extreme, such a degraded community becomes a pioneer xeric hammock, with large sand live oaks and laurel oaks (*Quercus hemispherica*) replacing the turkey oaks. Such a community has almost no herbaceous vegetation ground cover, and almost none of the original high pine species.

Not to be confused with man-made turkey oak barrens is scrubby high pine, which is a natural community characterized by a combination of high pine and scrub species. Myers (1990) cites several 18th and 19th century descriptions of areas within the larger high pine landscape that were dominated by turkey, blue jack or post oaks. Scrubby high pine appears to be maintained by a highly irregular fire regime in which periods of frequent fire favor high pine species and other periods of less frequent fire allow proliferation of scrub species at the expense of wiregrass and longleaf pine. The constantly shifting pattern of fire return intervals allows both kinds of plants to coexist over the long term.

High pine is a stable, climax community characterized by a preponderance of "K-selected" species. That is, most high pine plant and animal species are long-lived with low reproductive rates. Long-term survival for populations of typical high pine plant and animal species depends more on each individual living a long time rather than producing a large number of offspring every year. Adult mortality is low. Some examples include wiregrass, which is almost unknown to reproduce in nature either sexually or asexually (Hebb 1957, 1971; Clewell 1986, 1989; Myers 1990); longleaf pines which live for centuries and whose recruitment is highly episodic (Platt *et al.* 1988 and numerous references therein), gopher tortoises which don't reach sexual maturity until 10 to 20 years of age (Diemer 1992), and red-cockaded woodpeckers, which nest only in living pine trees more than 60 years of age and require a year or more to construct the nesting cavity (Rudolph and Conner 1991).

High pine animals tend to have large home ranges. Individual eastern indigo snakes range over 50 to 100 ha (124 to 247 acres) (Moler 1992); Florida pine snakes are known to range over 12 to 96 ha (30 to 237 acres); in Florida,

a single family unit of red-cockaded woodpeckers requires 140 to 200 ha (346 to 494 acres) or more (DeLotelle *et al.* 1987, Wood 1996). For this reason the Florida GFC will not condone public acquisition of high pine communities deemed too small to support viable populations of native vertebrates: "To ensure the long-term viability of all sandhill vertebrate species, tracts less than 2,025 ha (5,000 acres) should not be acquired, unless they are contiguous with extensive publicly-owned lands" (GFC 1994).

Status and Trends

Florida has experienced more than an 88 percent loss of high pine since European settlement (Kautz *et al*. 1993). Most of the South Florida Ecosystem is outside the original range of high pine. Where high pine did occur (primarily on the central portion of the Lake Wales Ridge) nearly all has been eliminated and replaced with citrus groves or residential development. In South Florida the Florida scrub community is endangered, but the high pine community essentially is extinct. There are no stands of high pine within the South Florida Ecosystem large enough to meet the Florida GFC's criteria for public acquisition (GFC 1994).

All of the vertebrate species that are characteristic of high pine in Florida are declining in numbers and most are protected as threatened or endangered. Some of these species may be able to persist in degraded high pine sites or in other xeric habitats. The gopher tortoise is capable of persisting in other xeric habitats if illegal hunting is curtailed. The indigo snake is actually more common in wetland communities, but often uses gopher tortoise burrows for winter refuge. The Florida mouse, endemic to Florida, occurs in scrub habitats as well as high pine. The pocket gopher is able to thrive in heavily disturbed former high pine, including improved pastures and road shoulders. In South Florida, the red-cockaded woodpecker has been all but extirpated in high pine and the last populations, now nearing extinction as well, are confined to pine flatwoods. The Sherman's fox squirrel still occurs in high pine communities where domestic dogs and cats have not yet become dominant.

Management

Under natural conditions, the high pine community burned on average every 1 to 8 years (Robbins and Myers 1992, Christensen 1981). Such frequent burning prevented the establishment of hardwood trees, and maintained the open, park-like aspect of the savanna community. Unlike fires in scrub, fires in high pine are low-intensity, easy to ignite and easy to control. Land managers in Florida have been "firing" the pine savannas since Florida's original inhabitants, 12,000 years ago (Robbins and Myers 1992). Data from charcoal and fossil pollen found in lake sediments indicate that fires have occurred in South-central Florida for at least the last 50,000 years (Watts and Hansen 1988).

The intact high pine community is easily managed with growing season prescribed fires. Most herbaceous plant species native to the high pine community flower (and presumably produce seed) more profusely after growing season fires than they do after dormant season fires (Robbins and

Myers 1992, Streng *et al*. 1993). Growing season fires result in higher rates of top-kill and complete kill of the oaks and other hardwood species (Streng *et al*. 1993). Fires in the dormant season tend to result in increased biomass of hardwood trees. The Florida DEP, the Florida chapter of The Nature Conservancy, and the FWS and the USFS are experienced at prescribing fires in Florida high pine communities.

It has been demonstrated, especially on Florida state parks, that reintroduction of frequent growing season fires into degraded high pine (*i.e*., turkey oak barrens) will return the site to high pine in less than a decade. In most cases, the reintroduction of growing season fires is all the management necessary to restore high pine on turkey oak-dominated sites. In some cases it may be necessary to kill turkey oaks that have become too large to be killed by normal fires. This can be done by girdling and/or herbicide treatment.

Robbins and Myers (1992) suggest determining seasonal burn schedules and fire return intervals in managed high pine by random. They even provide a table of randomly generated numbers between 1 and 10 for managers to use in scheduling prescribed burns. Their purpose is to avoid an artificially uniform schedule of burning, but attentive, on-the-ground managers can probably devise a better way to determine when a site should be burned.

Myers (1990) admonished land managers to not overlook four important aspects of prescribed burning in high pine: (1) Maintain variability in season, frequency and regularity of burning both within and between sites; (2) recognize the natural variability in high pine sites, from the typical open wiregrass savanna to scrubby high pine associations that are transitional to Florida scrub; (3) maintain ecotones; and (4) recognize that other, adjacent communities, such as cutthroat grass glades, seepage meadows, and seepage slopes, were dependent on fires that originated in high pine and pine flatwoods. Some of these communities have changed to bayheads and gallberry or titi thickets because, like scrub, the connectivity between them and the pinelands has been severed and they no longer are exposed to fire.

Healthy, intact high pine communities, with their continuous ground cover of grasses and frequent fires, generally are not susceptible to invasion by exotic species. However, some degraded high pine sites have been invaded by the exotic cogongrass (*Imperata cylindrica*), which is difficult to eradicate and may exclude some native high pine species (Simons 1990). Cogongrass may hinder efforts to restore high pine. Various combinations of burning, herbicide application and mechanical removal have been used to control cogongrass, but more research is needed.

Table 1. Vascular plants of high pine in peninsular Florida.

The species are arranged in decreasing order of frequency of occurrence and importance on six published and unpublished plant species lists compiled from high pine communities in the Welaka area, Putnam County (Laessle 1942), Gold Head Branch State Park, Clay County (White and Judd 1985), the Ordway Preserve, Putnam County (Franz and Hall 1990), 2 sites in Polk and Osceola counties (Bridges and Reese 1996), the Avon Park Air Force Range, Highlands County (FNAI 1996), and a site in Osceola County (FNAI 1998). Species received a score of 1 for each list on which they occurred with the following two adjustments: Laessle (1942) ranked the plants from the Welaka area high pine site as dominant, common, frequent or rare and these were given scores of 1.5, 1, 0.5 and 0.25, respectively. Bridges and Reese (1996) ranked 35 species on their list as characteristic or restricted to high pine, and these were given scores of 1.5. Scores were summed and the species listed in decreasing order. The number of lists on which each species occurred is in parentheses.

* = introduced.

Aristida beyrichiana (6)	*Quercus geminata (5)*
Pinus palustris (6)	*Smilax auriculata (5)*
Balduina angustifolia (6)	*Stillingia sylvatica (5)*
Pityopsis graminifolia (6)	*Tephrosia chrysophylla (5)*
Bulbostylus ciliatifolia (6)	*Palafoxia integrifolia (5)*
Quercus laevis (6)	*Aster tortifolius (5)*
Sporobolus junceus (6)	*Chapmannia floridana (4)*
Carphephorus corymbosus (5)	*Cnidosculous stimulosus (5)*
Commelina erecta (5)	*Lygodesma aphylla (5)*
Dalea pinnata (5)	*Polygonella gracilis (5)*
Liatris tenuifolia (5)	*Sorghastrum secundum (5)*
Licania michauxii (5)	*Pterocaulon virgatum (5)*
Opuntia humifusa (5)	*Bulbostylus warei (4)*
Lechea deckertii (4)	*Yucca flaccida (4)*
Phoebanthus grandiflorus (4)	*Andropogon brachystachyus (3)*
Quercus chapmanii (4)	*Andropogon floridanus (3)*
Stylisma patens (4)	*Andropogon gyrans (3)*
Quercus myrtifolia (4)	*Andropogon virginicus var. glaucus (3)*
Andropogon ternerius (4)	*Aristida purpurascens var. purpurascens (3)*
Asclepias tuberosa (3)	*Berlandiera subacaulis (3)*
Chrysopsis scabrella (4)	*Cuthbertia graminea (3)*
Crotalaria rotundifolia (4)	*Cyperus filiculmis (3)*
Cyperus retrorsus (4)	*Dychoriste oblongifolia (3)*
Eryngium aromaticum (4)	*Eriogonum tomentosa (3)*
Galactia elliottii (4)	*Galactia regularis (3)*

Helianthemum corymbosum (4)	*Indigofera caroliniana (3)*
Paspalum setaceum (4)	*Myrica cerifera (3)*
Polanisia tenuifolia (4)	*Pinus clausa (3)*
Pteridium aquilinum (4)	*Polypremum procumbens (3)*
Schizachyrium scoparum (4)	*Selaginella arenicola (3)*
Schrankia microphylla (4)	*Serenoa repens (3)*
Seymeria pectinata (4)	*Tillandsia usneoides (3)*
Stipulicida setacea (3)	*Aeschynomene viscidula* (3)*
Tragia urens (4)	*Asclepias verticillata (3)*
Trichostema dichotomum (4)	*Asimina obovata (3)*
Elephantopus elatus (4)	*Aster concolor (3)*
Hedyotis procumbens (4)	*Cassia chamaecrista (3)*
Triplasis americana (4)	*Centrosema virginianum (3)*
Vaccinium myrsinites (4)	*Chamaesyce cordifolia (3)*
Croton argyranthemus (3)	*Aster undulatus (2)*
Cuthbertia ornata (2)	*Befaria racemosa (2)*
Dicanthelium acicular (3)	*Buchnera americana (2)*
Paronychia hernarioides (2)	*Ceratiola ericoides (2)*
Quercus incana (2)	*Chrysopsis gossypina (2)*
Rhynchospora megalocarpa (2)	*Crotonopsis linearis (2)*
Stylosanthes biflora (3)	*Dicanthelium ensifolium var. unciphyllum (2)*
Ximenia americana (2)	*Dicanthelium portoricense (2)*
Astragalus obcordatus (3)	*Digitaria villosa (2)*
Cassia nictitans (3)	*Eragrostis virginica (2)*
Diospyros virginiana (3)	*Eragrostris refracta (2)*
Gaylussacia dumosa (3)	*Eriogonum longifolium var. gnaphalifolium (2)*
Penstemon multiflorus (3)	*Eupatorium compositifolium (2)*
Rhus copallina (3)	*Fimbristylus puberula (2)*
Tephrosia florida (3)	*Froelichia floridana (2)*
Tillandsia recurvata (3)	*Gratiola hispida (2)*
Agalinis filifolia (2)	*Hedyotis uniflora (2)*
Amsonia ciliata (2)	*Hieracium gronovii (2)*

Andropogon virginicus var. virginicus (2)	*Hieracium megacephalon (2)*
Aristida condensata (2)	*Hypericum tetrapetalum (2)*
Aristida gyrans (2)	*Krameria lanceolata (2)*
Aristida spiciformis (2)	*Lachnocaulon beyrichianum (2)*
Asimina incarna (2)	*Lechea sessiliflora (2)*
Asimina reticulata (2)	*Liatris pauciflora (2)*
Ludwigia maritima (2)	*Andropogon virginicus (2)*
Lyonia fruticosa (2)	***Bonamia grandiflora (2)***
Lyonia lucida (2)	*Ceanothus microphyllus (2)*
Orbexilum lupinellum (2)	*Cenchrus gracillimus (2)*
Paronychia americana (2)	*Clitoria mariana (2)*
Paronychia chartacea (2)	*Cyperus globulosus (2)*
Paronychia patula (2)	*Desmodium strictum (2)*
Pinus elliottii var. densa (2)	*Dicanthelium malacon (2)*
Piriqueta caroliniana (2)	*Dicanthelium ovale (2)*
Polygonella robusta (2)	*Galactia volubilis (2)*
Polymnia uvedalia (2)	*Gymnopogon ambiguus (2)*
Psoralea canescens (2)	*Hypoxis juncea (2)*
Quercus minima (2)	*Lechea torreyi (2)*
Rhynchosia difformis (2)	*Lespedeza hirta (2)*
Rhynchospora grayi (2)	*Liatris chapmanii (2)*
Rhynchospora intermedia (2)	*Liatris gracilis (2)*
Schizachyrium sanguineum (2)	*Lonicera sempervirens (1)*
Scleria pauciflora (2)	*Opuntia pusilla (1)*
Tephrosia virginiana (2)	*Piptochaetium avenacioides*
Verbesina heterophylla (2)	*Polygala grandiflora (2)*
Vernonia angustifolia (2)	*Polygonella polygama (1)*
Viola septemloba (2)	*Schoenocaulon dubium (2)*
Vitus rotundifolia (2)	*Sisyrhinchium nashii (2)*
Xyris caroliniana (2)	*Solidago chapmanii (2)*
Stylodon carneus (2)	*Scutellaria multiglandulosa (1)*
Tephrosia hispidula (2)	*Andropogon virginicus var. decipiens (1)*

Vaccinium stamineum (2)	*Anthaenantia villosa (1)*
Warea carteri (1)	*Aristida mohrii (1)*
Aristolochia serpentaria (2)	*Aristida purpurascens var. virgata (1)*
Arnoglossum floridanum (2)	*Aristida rhizomophora (1)*
Asclepias amplexicaulus (2)	*Aristida simpliciflora (1)*
Asclepias humistrata (2)	*Asimina pygmaea (1)*
Aster walteri (2)	*Aster adnatus (1)*
Bulbostylus stenophylla (2)	*Aster dumosus (1)*
Bumelia reclinata (2)	*Aureolaria pectinata (1)*
Callicarpa americana (2)	*Axonopus affinis (1)*
Conyza canadensis (2)	*Axonopus furcatus (1)*
Desmodium viridiflorum (2)	*Bumelia tenax (1)*
Diodea teres (2)	*Cacalia floridana (1)*
Garberia heterophylla (2)	*Carphephorus odoratissimus (1)*
Gelsemium sempervirens (2)	*Carphephorus paniculatus (1)*
Ilex glabra (2)	*Carya floridana (1)*
Krigia virginica (2)	*Cassytha filiformis (1)*
Lyonia ferruginea (2)	*Castanea pumila (1)*
Magnolia grandiflora (2)	*Chionanthus pygmaeus (1)*
Phoradendrom serotinum (2)	*Chrysopsis mariana (1)*
Quercus stellata (2)	*Clematis reticulata (1)*
Ruellia carolinensis (2)	*Crataegus lepida (1)*
Cuscuta pentagona (1)	*Hupericum reductum (1)*
Cyperus nashii (1)	*Hypericum hypericoides (1)*
Cyperus retrofractus (1)	*Hypericum reductum (1)*
Dalea feayi (1)	*Hypoxis curtissii (1)*
Desmodium ciliare (1)	*Ilex ambigua (1)*
Desmodium floridana (1)	*Ilex opacum (1)*
Desmodium marilandicum (1)	*Juncus dichotomus (1)*
Desmodium tenuifolium (1)	*Juncus scirpoides (1)*
Dicanthelium ensifolium var. breve (1)	*Juniperus silicicola (1)*
Dicanthelium strigosum var. glabrescens (1)	*Lechea cernua (1)*

Digitaria cognata (1)	*Lechea minor (1)*
Digitaria gracillima (1)	*Lechea mucronata (1)*
Elephantopus nudatus (1)	*Linaria floridana (1)*
Eragrostris elliottii (1)	*Lolium perenne* (1)*
Eragrostris spectabilis (1)	*Lupinus diffusus (1)*
Erigeron strigosus (1)	*Nolina brittoniana (1)*
Eryngium yuccifolium (1)	*Osmanthus megacarpus (1)*
Euphorbia cordifolia (1)	*Palafoxia feayi (1)*
Euthamia tenuifolia (1)	*Panicum acuminata (1)*
Galactia mollis (1)	*Panicum anceps (1)*
Gymnopogon chapmanianus (1)	*Panicum clandestinum (1)*
Helenium flexuosum (1)	*Panicum virgatum (1)*
Helianthemum nashii (1)	*Parthenocissus quinquefolia (1)*
Helianthus radula (1)	*Paspalum notatum* (1)*
Paspalum plicatulum (1)	*Stylisma abdita (1)*
Persea humilis (1)	*Tephrosia spicata (1)*
Phlox nivalis (1)	*Tillandfsia fasciculata var. densispica (1)*
Pluchea rosea (1)	*Tillandsia utriculata (1)*
Polygala lewtonii (1)	*Toxicodendron pubescens (1)*
Polygala setacea (1)	*Tradescantia roseolens (1)*
Prunus geniculata (1)	*Trichostema setaceum (1)*
Pyrrhopappus carolinianus (1)	*Utricularia subulata (1)*
Quercus falcata (1)	*Vaccinium darrowii (1)*
Quercus hemispherica (1)	***Warea amplexifolia (1)***
Quercus inopina (1)	*Xyris brevifolia (1)*
Rhynchelytrum repens (1)	*Xyris jupicai (1)*
Rhynchosia reniformis (1)	*Agerantina jucunda (1)*
Rhynchosia tomentosa (1)	*Bulbostylis barbata* (1)*
Rhynchospora fernaldii (1)	*Centrosema floridana (1)*
Rubus cuneifolius (1)	*Desmodium canescens (1)*
Sabal etonia (1)	*Eupatorium album (1)*
Salvia azurea (1)	*Eupatorium mohrii (1)*

Schizachyrium niveum (1)	*Euphorbia exserta (1)*
Scutellaria arenicola (1)	*Gaillardia aestivalis (1)*
Silphium compositum (1)	*Gaylussacia nana (1)*
Sisyrhinchium xerophyllum (1)	*Gaylussacia tomentosa (1)*
Solidago fistulosa (1)	*Helianthemum carolinianum (1)*
Solidago odora (1)	*Heterotheca subaxilaris (1)*
Oxalis stricta (1)	*Prunus serotina (1)*
Phaseolus sinuatus (1)	*Pteroglossapsis ecristata (1)*
Physalis arenicola (1)	*Salvia lyrata (1)*
Sceleria ciliata (1)	*Setaria geniculata (1)*
Schizachyrium hirtiflorum (1)	*Smilax glauca (1)*
Scleria triglomerata (1)	*Spermolepis divaricata (1)*
Smilax bona-nox (1)	*Toxicodendron radicans (1)*
Acalypha gracilens (1)	*Vaccinium arboreum (1)*
Andropogon tracyi (1)	*Zornia bracteata (1)*
Aristida tenuispica (1)	
Asclepias tomentosa (1)	
Eupatorium capillifolium (1)	
Eustachys petraea (1)	
Gnaphalium obtusifolium (1)	
Haplopappus divaricatus (1)	
Lechea divaricata (1)	
Leptoloma cognatum (1)	
Matelea pubiflora (1)	
Monarda punctata (1)	
Oenothera laciniata (1)	
Onosmodium virginianum (1)	
Panicum hemitomon (1)	
Phytolacca americana (1)	
Prunus angustifloia (1)	

Literature Cited

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 Science 47:209-250.

Bartram, W. 1791. The travels of William Bartram (M. van Doren, ed. 1955). Dover Publications; New York, New York.

Beever, J. 1998. Telephone communication. March 24, 1998.

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.

Bridges, E.L. and G.A. Reese. 1996. Upper lakes basin watershed natural resource inventory. A project of the natural resource inventory of Save Our Rivers lands. Draft final report prepared for the Southwest Florida Water Management District; Homestead, Florida.

Campbell, H.W. and S.P. Christman. 1982. The herpetological components of Florida sandhill and sand pine scrub associations. Pages 163-171 *in* N. Scott, ed., Herpetological communities. Wildlife research report no. 13. U.S. Fish and Wildlife Service; Atlanta, Georgia.

Christensen, N.L. 1981. Fire regimes in southeastern ecosystems. *In* "Fire Regimes and Ecosystem Properties" (H.A. Mooney, T.M. Bonnickson, N.L. Christensen, J.E. Lotan, and W.A. Reiners, eds.). U.S. Dep. Agric. For. Serv. gen. tech. rep. no. WO-26, pp. 112-136.

Christman, S.P. 1988a. Endemism and Florida's interior sand pine scrub. Final Project report GFC-84-101, prepared for Florida Game and Fresh Water 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, 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. and W.S. Judd. 1990. Notes on plants endemic to Florida Scrub. Florida Scientist 53:52-73.

Clewell, A.F. 1986. Natural setting and vegetation of the Florida Panhandle. Report prepared for U.S. Army Corps of Engineers; COESAM/PDEI-86/001. Mobile, Alabama.

Clewell, A.F. 1989. Natural history of wiregrass (*Aristida stricta* Michx. Gramineae). Natural Areas Journal 9:223-233.

Cox, J., D. Inkley and R. Kautz. 1987. Ecology and habitat protection needs of gopher tortoise (*Gopherus polyphemus*) populations found on lands slated for large-scale development in Florida. Nongame wildlife program technical report no. 4. Florida Game and Fresh Water Fish Commission; Tallahassee, Florida.

Croker, T.C. 1979. The longleaf pine story. Journal of Forest History January, 1979:32-43.

DeLotelle, R.S., R.J. Epting and J.R. Newman. 1987. Habitat use and territory characteristics of red-cockaded woodpeckers in central Florida. Wilson Bulletin 99:202-217.

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

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.

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.

Engstrom, R.T. 1993. Characteristic mammals and birds of longleaf pine forests. Pages 127-138 *in* S.M. Hermann, ed. The longleaf pine ecosystem: ecology, restoration and management. Proceedings of the 18th Tall Timbers fire ecology conference. Tall Timbers Research Station; Tallahassee, Florida.

Florida Game and Fresh Water Fish Commission (GFC). 1994. Agency strategic plan for the Florida Game and Fresh Water Fish Commission 1995-1998. Tallahassee, Florida.

Florida Natural Areas Inventory (FNAI). 1996. Element occurrence record, eocode: CTB0000000*153*FL. Florida Natural Areas Inventory; Tallahassee, Florida.

Florida Natural Areas Inventory (FNAI). 1998. Element occurrence record, eocode: CTB0000000*067*FL. Florida Natural Areas Inventory, Tallahassee, Florida.

Franz, R. and D.W. Hall. 1990. Vegetative communities and annotated plant lists for the Katharine Ordway-Swisher Memorial Sanctuary, Putnam County, Florida (1985-1989). Ordway Preserve research Series report no. 3, Florida Museum of Natural History; Gainesville, Florida.

Hebb, E.A. 1957. Regeneration in the sandhills. Journal of Forestry 55:210-212.

Hebb, E.A. 1971. Site preparation decreases game food plants in Florida sandhills. Journal of Wildlife Management 35:155-162.

Humphrey, S.R. 1992. Rare and endangered biota of Florida. volume 1. Mammals. University Presses of Florida; Gainesville, Florida.

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.

Kalisz, P.J., A.W. Dorian and E.L. Stone. 1986. Prehistoric land-use and the distribution of longleaf pine on the Ocala National Forest, Florida: an interdisciplinary synthesis. The Florida Anthropologist 39:183-193.

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.

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.

Laessle, A.M. 1942. The plant communities of the Welaka area. University of Florida Publications, Biological Science Series IV; Gainesville, Florida.

Laessle, A.M. 1958. The origin and successional relationships of sandhill vegetation and sand pine scrub. Ecological Monographs 28:361-387.

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

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.

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.

Means, D.B. and H.W. Campbell. 1982. Effects of prescribed burning on amphibians and reptiles. Pages 89-97 *in* G.W. Wood, ed. Prescribed fire and wildlife in southern forests. Belle W. Baruch Forest Science Institute, Clemson University; Georgetown, South Carolina.

Means, D.B and G. Grow. 1985. The endangered longleaf pine community. ENFO 85:1-12.

Moler, P.E. 1992. Rare and endangered biota of Florida. Volume III. Amphibians and reptiles. University Presses of Florida; Gainesville, Florida.

Mushinsky, H. 1985. Fire and the Florida sandhill herpetofaunal community with special attention to responses of *Cnemidophorus sexlineatus*. Herpetologica 41:333-342.

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.

Noss, R.F. 1988. The longleaf pine landscape of the southeast: almost gone and almost forgotten. Endangered Species Update 5:1-8.

Platt, W.J., G.W. Evans, and S.L. Rathbun. 1988. The population dynamics of a long-lived conifer. American Naturalist 131:491-525.

Robbins, L.E. 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.

Rodgers, J.A., Jr., H.W. Kale II, and H.T. Smith. 1996. Red-cockaded woodpecker. Pages 81-102 *in* Rare and endangered biota of Florida. volume 5. Birds. University Presses of Florida; Gainesville, Florida.

Rudolph, D.C. and R.N. Conner. 1991. Cavity tree selection by red-cockaded woodpeckers in relation to tree age. Wilson Bulletin 103:458-467.

Simons, R.W. 1990. Terrestrial and freshwater habitats. Pages 99-157 *in* S.H. Wolfe, ed. An ecological characterization of the Florida springs coast: Pithlachascotee to Waccasassa Rivers. Biological report 90(21). U.S. Fish and Wildlife Service; Jacksonville, Florida.

Stout, I.J. and D.T. Corey. 1995. Effects of patch-corridor configurations on nongame birds, mammals, and herptiles in longleaf pine-turkey oak sandhill communities. Nongame wildlife program project RFP-86-003 and –003A, Florida Game and Fresh Water Fish Commission; Tallahassee, Florida.

Streng, D.R., J.S. Glitzenstein and W.J. Platt. 1993. Evaluating effects of season of burn in longleaf pine forests: a critical literature review and some results from an ongoing long-term study. Pages 227-264 *in* S.M. Hermann, ed. The longleaf pine ecosystem: ecology, restoration and management. Proceedings of the 18th Tall Timbers Fire Ecology Conference. Tall Timbers Research Station; Tallahassee, Florida.

Telford, S.R., Jr. 1962. New locality records for the sand skink (*Neoseps reynoldsi*) in central Florida, with comments on their habitat. Quarterly Journal Florida Academy of Sciences 25(1):76-77.

Watts, W.A. and B.C.S. Hansen. 1988. Environments of Florida in the late Wisconsin and Holocene. Pages 307-323 *in* B.A. Purdy, ed. Wet site archaeology. The Telford Press; Caldwell, New Jersey.

White, D.L. and W.S. Judd. 1985. A flora of Gold Head Branch Ravine and adjacent uplands, Clay County, Florida. Castanea 50:250-261.

Whitney, M. 1896. The soils of Florida. U.S. Department of Agriculture Bulletin 13:14-27.

Williams, J.L. 1837. The territory of Florida. A.T. Goodrich; New York, New York.

Wood, D.A. 1996. Promoting red-cockaded woodpecker welfare in Florida. Nongame wildlife management bulletin no. 1. Florida Game and Fresh Water Fish Commission; Tallahassee, Florida.

Restoration of High Pine

Restoration Objective: Maintain and enhance the structure, function, and composition of the high pine community to ensure the long-term survival in the wild of all plant and animal species that depend upon this community for their existence.

Restoration Criteria:

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

Community-level Restoration Actions

1. **Prevent further destruction or degradation of existing high pine communities**.

    1.1. **Secure high pine sites through land acquisition, landowner agreements, and conservation easements.** The highest priority should be placed on preventing development of remaining high pine 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 high pine has already been irretrievably lost, that if any high pine tracts can be located they should be acquired for preservation.

    1.2. **Control public use.** Inappropriate public uses such as off-road vehicle racing and trash dumping should be prevented with signs and fences if necessary.

    1.3. **Enforce existing regulations.** Regulations against taking protected species must be enforced.

2. **Restore existing degraded high pine communities.**

    2.1. **Permit the reintroduction of natural fires or prescribe controlled burns.** High pine communities that have been degraded because of fire exclusion can be restored with prescribed fires. Each protected site should have a fire management plan prepared specifically for it. Management plans should specifically include allowing natural, lightning-ignited fires to burn through high pine 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.

2.2. **Encourage maintenance and recovery of natural ecotones.** Ecotones are important elements of any natural landscape and should receive special attention in natural area 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 high pine communities are infested with cogongrass. This invasive exotic should be controlled with herbicides and mechanical treatments.

2.4. **Reintroduce locally extirpated species.** Red-cockaded woodpeckers and wide-leaf warea should be reintroduced into appropriate high pine sites from which they have been extirpated. High pine sites are considered appropriate if all the critical requirements (*e.g.*, old growth longleafs for red-cockaded woodpeckers) of the species are met.

2.5. **Eliminate any sources of pollution**.

2.6. **Control public use.** High pine communities that have been degraded by inappropriate public use can only be restored by eliminating that public use. Signs and fences may be necessary to discourage off-road vehicle use, trash dumping, and illegal plant and animal harvesting.

3. **Maintain high pine communities in a natural condition in perpetuity.**

3.1. **Continue to prescribe natural fires or controlled burns.** Continue planning for natural lightning-ignited fires to be allowed to burn. Prescribe controlled burns when natural fires are inadequate to meet management objectives.

3.2. **Continue to control exotic species.**

3.3. **Continue to control public use.**

3.4. **Monitor for negative population trends among important high pine animal and plant species.** Areas of high pine within ecological preserves should have specific monitoring plans that will alert managers to extirpations or downward trends in populations of selected species, including endemic species, listed species, and keystone species.

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

4. **Restore high pine where it has been destroyed by human activities such as mining or farming**. Most of the citrus groves on the Lake Wales Ridge were established on high pine sites. Today many of these groves are being abandoned. We may have the opportunity to restore high pine on some of these sites, although we do not yet know how to do this.

5. **Create high pine in regions where it has been destroyed by human activities**. It may be possible to create high pine on former strip mines, although this has not yet been attempted.

6. **Connect existing high pine 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.

7. **Encourage research on ground cover restoration.** In northern Florida The Nature Conservancy and the Florida DEP are restoring high pine on turkey oak barrens sites where the ground cover is still at least partly intact. On sites where the ground cover has been completely destroyed, high pine restoration is still not feasible. We need to learn how to restore wiregrass on former citrus groves and strip mines where it has been eliminated.

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. Managers should have a site-specific plan for monitoring vegetation response to prescribed fires and other land management actions.

   8.2. **Monitor for negative population trends among important high pine plant and animal species**. Each high pine preserve should have a monitoring plan that will alert managers to extirpations or downward trends in relative population levels of selected plant and animal 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 (CARL) program and Preservation-2000.