CHAPTER 5

Sensitive Plant Communities

Joan L. Walker
U.S. Forest Service
Southern Research Station, Clemson, SC

Over half of the southern landscape is forested, but nearly all of the land has been modified considerably, especially during the centuries following European settlement (See history chapters). Such extensive changes in the southern landscape have contributed to the threatened status of many plant and animal species that are now protected under the Endangered Species Act. Additionally these changes have resulted in the reduction and degradation of native plant communities. Conserving and managing communities can contribute to the conservation of natural biological diversity by protecting ecological functions and providing habitats for many individual species of concern. As targets for conservation, natural or semi-natural communities may protect rare species, especially non-vascular plants and invertebrates for which inventories are universally inadequate,

This chapter defines sensitive community and reviews assessments of southeastern sensitive communities. The chapter provides accounts of selected sensitive communities, including their distribution, composition, rare species, threats, and management. A final section summarizes factors likely to influence the success of sensitive community management.

DEFINITIONS AND CONCEPTS

"Sensitive" is a management designation for communities that are vulnerable to loss, and require special attention to insure their existence and to retain their composition (including rare species), structure, and function. The sensitivity ot natural communities results from scarcity (relatively few, small locations exist) and/or vulnerability to anthropogenic changes. Communities that are likely to lose populations are considered vulnerable. Communities that are both rare and vulnerable to human disturbances constitute the group of highly sensitive types, and are candidates for the greatest management consideration and modification. Conversely, abundant and resilient types are unlikely to be adversely impact-

ed by human activities and would not be considered for special management actions. Highly vulnerable but comparatively abundant, and scarce but not threatened communities may require special considerations, however generalizations are difficult to make.

Scarce communities include both geographically restricted (narrowly endemic) types, and those that occur over a larger area but are distributed as small, discrete patches. Natural scarcity may arise from dependence on unique and rare physical conditions, such as a specific rock type or hydrological regime, or on localized disturbances, such as fires on ridgetops. Scarcity also may be the result of losing historically abundant types. The amount of loss relative to the historical abundance has been used as an indicator of vulnerability to anthropogenic disturbances (Noss et al. 1995). Other conditions associated with the likelihood of being adversely impacted by human activities include site accessibility; suitability for other activities, such as agriculture and recreation; and proximity to other vegetation that is desirable for other uses, for example, depressions embedded in potential forest plantations.

Because of concerns about the loss of biological diversity, communities may be considered sensitive if they contain rare species. Some have numerous rare species, but because many rare species have narrow geographic ranges (narrow endemics), a general community type may have different rare species in different places.

Globally sensitive communities are of concern throughout their ranges and are therefore of national concern from a conservation perspective. But even types that are widespread may be important locally to provide habitat for target species. Managers may view locally uncommon habitats as sensitive. Though both globally and locally sensitive communities require management attention, globally sensitive habitats are the focus of this chapter.

Old growth forest, Joyce Kilmer Memorial Forest. Old growth forest remnants are rare throughout the South and they vary with forest type. Common characteristics of many old growth forests include large and old trees, a multi-layer tree canopy, a diverse ground layer, and an accumulation of standing and down dead trees *(J. Walker).*

SENSITIVE COMMUNITY DESCRIPTIONS

Several publications describe the biodiversity of the Southeast, including threatened and endangered ecosystems. Two volumes edited by Martin et al. (1993a,b) describe biodiversity and identify threatened terrestrial vegetation types (Martin and Boyce 1993). Grossman et al. (1994) identified an initial list of imperiled community types; Noss et al. (1995) lists endangered and threatened ecosystems; and White et al. (1998) identified threats to southeastern ecosystems. Results of these assessments are somewhat difficult to compare because authors had different objectives and methods.

Based on a classification system developed by The Nature Conservancy (TNC), it is clear that the South has many different communities, a high proportion of them are considered imperiled to some degree, and sensitive habitats are found in all states and in all physiographic provinces. In TNC's system plant associations are defined by dominant species in all the vegetation layers and each community is assigned a conservation rank. Community types are ranked on a global (G) scale of 1 to 5, with 1 indicating critical imperilment due to rarity, endemism, and/or threats, and 5 indicating low risk of elimination. A rank of G1 indicates a great risk of extinction of the type worldwide. Grossman et al. (1994) listed fifty-eight G1, G2 communities in the southeast (excluding Oklahoma and Texas). A 1998 report (Grossman et al. 1998) shows no less than 100 plant associations per southeastern state, and more than 400 identified in North Carolina alone. On a per state basis, no less than 10%, and as many as 30% of the identified associations are classified as imperiled (G1, *G2).*

Fewer more broadly defined sensitive communities have been recognized. Boyce and Martin (1993) evaluated the sensitivity of southeastern ecosystems defined by Kuchler Potential Natural Vegetation types, which are defined broadly on vegetation physiognomy and dominant species (Kuchler 1964). Everglades, mangroves, bottomland hardwood forests, pocosins, mountain bogs, and Carolina bays were classed as *Threatened;* and longleaf pine, spruce-fir and other high elevation forests, heath balds, maritime communities, rock outcrops, glades, grasslands, and sandpine scrub as *Vulnerable. Noss* et al. (1995) listed 48 southeastern types that have experienced over 70% losses compared to estimated presettlement areas (Table 1).

Three major trends threaten biodiversity in the Southeast (White et al. 1998). First, natural areas in general, and old growth forests in particular, have been permanently lost or changed drastically. Secondly, active fire suppression has resulted in the loss and degradation of ecosystems in all areas of the Southeast. Finally, disruptions of hydrological systems have put wetlands at risk. Considering these broad trends, White et al. (1998) identified broadly defined community types considered susceptible to continued losses of biodiversity (Table 2).

The next sections describe selected sensitive communities including distribution, composition, threats, and general management. Because it is not feasible to discuss the many specific sensitive plant communities ranked G1, G2 (Weakley et al. 1998), this chapter discusses more general community types (Table 2). Each type includes multiple associations according to The Nature Conservancy Classification system, but within a general class, communities share broad ecological characteristics such as dominant species, physiognomy, controlling processes, and landscape context. General management recommendations can be made for broad community types, but in practice site-specific variations must be considered.

Notable omissions from this chapter are sub-tropical communities in peninsular Florida, maritime communities, and bottomland forests. These are widely recognized as communities that are ecologically at risk. All are discussed by Martin et al. (1993a,b) and summarized by White et al. (1998). Messina and Conner (1998) review southern wetlands.

The following community descriptions are grouped into forests, non-forested openings in forested landscapes, and non-alluvial wetlands. Federally threatened and endangered plants occur in many communities, including but not limited to the ones discussed in this chapter. When they occur in selected communities, they will be noted. Appendix 1 contains a list of all Threatened and Endangered plants in the region, their distributions by state, and brief habitat descriptions.

FORESTS

Unusual forest communities (G1,G2 communities).— Some forest communities contain unusual combinations of plant species or populations of individual rare plants, and many of these communities are ranked G1, G2 by The Nature Conservancy. Some Gl, G2 forest types have always been rare because they are restricted to rare physical habitats, such as special soils. The coastal plain forests on marl or chalk outcrops, or forests on loess soils of the Mississippi alluvial plain

Table 1. Estimates of ecosystem loss from Noss et al. (1995; Appendix A) based on published papers, State Natural Heritage Programs, The Nature Conservancy, and expert opinions. Ecosystems are listed in declining order of percentage loss. Some estimates are based on more quantitative analysis than others, and not all states had data to report.

>95% loss; critically endangered

Old-growth deciduous forests	Southeast
S.App. Spruce-fir	TN, NC, VA
Longleaf pine	Coastal Plain
Rockland slash Pine	FL
Loblolly-shortleaf pine	West Gulf Coastal Plain
Canebrakes	Southeast
Bluegrass-Savannah-woodland	KY
Blackbelt, Jackson prairies	AL, MS
Dry prairie	FL
Wet and mesic coastal prairie	LA
Atlantic white-cedar forest	VA, NC
Native prairies	KY
Bottomland forest	WV
High quality Oak-hickory forest	Cumberland Plateau, TN

85-95% loss; endangered

Mesic limestone forest	MD	Mixed hardwood-loblolly pine	LA
Red spruce	Cntal Appalachians	Xeric sandhill	LA
Upland hardwoods	Coastal Plain, TN	Stream terrace-sandywoodland	
Old-growth oak-hickory	TN	Savannah	LA
Cedar glades	TN	Slash pine (1900-l 989)	FL
Longleaf pine	TX, LA	Gulf coast pitcher plant bogs	Coastal Plain
Longleaf pine forest (1936-87)	FL	Pocosins	VA
Calcareous prairie, Fleming glades	LA	Mountain bogs	NC
Live-oak, live-oak hackberry	LA	Appalachian bogs	Blue Ridge, TN
Prairie terrace loess oak forest	LA	Upland wetlands	Highland Rim,TN
Mature forest, all types	LA	Natural barrier island beaches	MD
Shortleaf pine-oak-hickory	LA	Ultramafic glades	VA

70-84% loss: threatened

Bottomland and riparian forest	Southeast
Xeric scrub, scrubby flatwoods, sandhills	Lake Wales Ridge, FL
Tropical hardwood hammock	Florida Keys
Saline prairie	LA
Upland longleaf pine	LA
Live oak-pine-magnolia	LA
Spruce Pine-hardwood flatwoods	LA
Xeric sandhill woodlands	LA
Flatwood ponds	LA
Slash Pine-pond cypress-hardwood	LA
Wet hardwood-loblolly pine	LA

Table 2. Sensitive communities In the South. Communities discussed by Boyce and Martin (1993), Grossman et al. (1994), Noss et al. (1995), White et al. (1998), and in this chapter are indicated with X. Blanks indicate community is not discussed. [Table Modified from White et al. 1998]

Ecosytem/community group	Boyce & Martin	Grossman et al.	Noss et al.	Whlte et al.	This Chapter
Widely distributed					
Upland forests	Resilient	X	X	X	X
Bottomland forests	Threatened		X	X	
Glades, barrens, prairies, outcrops	Vulnerable	X	X	X	X
Canebrakes	Threatened	X	X		X
Mountain					
Spruce-fir	Vulnerable	X	X	X	X
High-elevation deciduous forest	Vulnerable	X		X	
Heath balds	Vulnerable			X	
Pine forests	Vulnerable			X	X
Mountain bogs	Threatened	X	X	X	X
Grassy balds	Vulnerable	X		X	X
High-elevation cliffs	Vulnerable	X	X	X	X
Rocky stream gorges	Vulnerable	X		X	
Coastal Plain					
Longleaf pine	Vulnerable	X	X	X	X
Seepage, hillside, pitcher plant bogs	Vulnerable		X	X	X
Carolina bays, cypress domes, ponds	Threatened		X	X	X
Pocosin	Threatened		X	X	
Maritime communities	Vulnerable	X	X	X	
South Florida					
Tropical hardwoods	Vulnerable	X		X	
Slash pine	Vulnerable	X	X	X	
Florida sand pine scrub	Vulnerable		X	X	
Mangroves	Threatened			X	
Everglades	Threatened			X	

are examples. Although rare forest communities may contain rare plant species like Price's potato-bean, other rare species like small whorled pogonia, are found even in apparently common forests types. Rare forest communities are found throughout the region; state Natural Heritage Programs are the best sources for local information.

Threats and management.—Common threats to rare forest communities include invasions by non-indigenous species, such as Japanese honeysuckle, privet, and Chinese tallow tree; interruption of natural disturbance regimes; high concentrations of herbivores such as white-tail deer; outbreaks of forest pests; and direct impacts from modem forest management methods, for example clearcutting and intensive site preparation

Management options and needs vary with the type of forest and the specific threats, but controlling non-indigenous species and herbivores, and choosing benign methods to accomplish these objectives are factors to consider. Management actions that mimic natural disturbances may be particularly important because natural

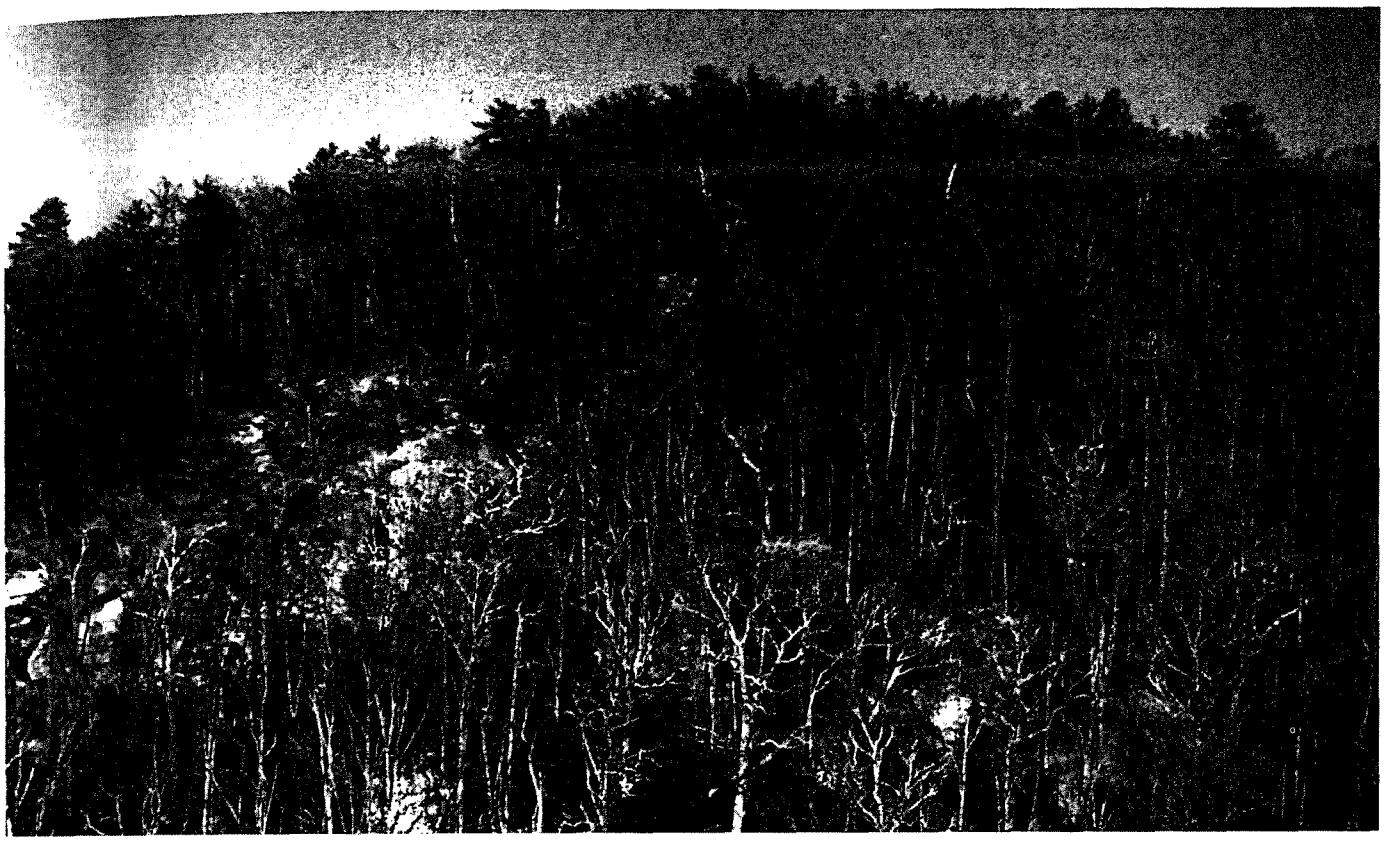


Table Mountain Pine, Rabun County, Georgia. Table Mountain pine forests occupy southern and southwestern slopes and ridges. They often occur as isolated islands in the southern Blue Ridge. In the absence of fire, this community is being changed by the invasions of oaks and shrubs. With hardwood invasion, the fuels available for prescribed fire change, making it very difficult to reintroduce fire and restore the community *(T. Waldrop).*

disturbance regimes are unlikely to be intact. Where there are rare species, management should focus on Providing conditions favorable to target plant species.

Old Growth Forest Remnants

Estimates of the amount of old growth forests vary with the criteria used to identify old growth, but by all definitions old growth remnants are scarce in the Southeast (Davis 1996). Many definitions of old growth include criteria for trees of great size or age (for a specific kind Of site and tree species), and for degree of naturalness (lack of apparent recent human disturbance) (Leverett 1996). White and White (1996) suggest that tracts that have been continuously forested (at least since European settlement) have conservation value, and they argue that such sites should be considered and protected as old growth. Even though these continuously forested stands may have younger trees established after recent natural disturbances or have experienced some harvest or grazing, such sites have undisturbed soils with associated soil biota, and may retain locally adapted genotypes of some species. The conservation value of such sites lies in unique cryptic biota and genotypes. Fragments of the presettlement forest have survived, especially on inaccessible slopes or sites, but most large old-growth remnants occur on public land.

Old growth forest composition varies with forest type, but forest characteristics generally associated with old growth forests include large, old trees; accumulations of standing and down woody debris; and multilayered canopies. The absolute sizes and ages of trees will vary with the types of trees. The Forest Service and The Nature Conservancy have developed a series of diagnostic descriptions for specific old growth forest types. For southern forest types the descriptions are available from the Southern Forest Research Station, Asheville, North Carolina.

Threats and management.-Threats to old growth remnants are similar to those described for rare forest communities: non-indigenous species invasions, high numbers of herbivores, modem management practices.

Management emphasis should be placed on preserving existing conditions, especially intact soil profiles and local genotypes. Avoid soil-disturbing man-

agement activities, and if species re-introductions are desired, choose seed sources from other nearby, relatively undisturbed sites. The future of existing sites may be extended if existing forested buffers are retained, or are developed over time. Small patches of old growth forests alone will not provide habitat for large-area dependent forest species, but in larger forested landscapes may provide important habitat features such as large trees and abundant woody debris.

Fire-dependent Pine Woodlands

At the time of European settlement pines dominated or shared dominance in some forests in all parts of the Southeast. Longleaf pine and longleaf mixed with slash, loblolly, and/or shortleaf pines dominated coastal plain forests (Christensen 1988). Sand pine occupied xeric ridges in peninsular Florida (Myers 1990). Virginia or pitch pine communities were common on dry slopes and ridges in the Ridge and Valley province, and shortleaf communities occupied similar sites in the Ouachita Mountains (Foti and Glenn 1991; Strausberg and Hough 1997). In the southern Appalachians shortleaf and Virginia pine communities occurred at low elevations, pitch pine at low to mid-elevations, and Table Mountain pine at mid-to high elevations (Vose et al. 1997; Williams 1998). Except on extremely xeric sites where edaphic factors helped maintain pine dominance, lightning and human-set fires prehistorically and historically maintained all of these.

Pine communities of the Southern Appalachians and longleaf pine communities are included in several assessments of sensitive communities (Table 2). Descriptions of montane pine (pitch and Table Mountain pine) communities and longleaf pine communities follow.

Pitch and Table Mountain Pine Communities.— In the South, pitch pine is widely distributed in the Ridge and Valley and Blue Ridge Provinces, and occurs occasionally in the Piedmont. In contrast, Table Mountain pine is restricted to the Blue Ridge. In the mountains pitch pine dominates at mid-elevation (2300 to 3200 feet above sea level), and is replaced by Table Mountain pine at higher elevations (2500 to 4600 feet above sea level). Site types for both include south and southwest slopes, ridgetops, and granite rock outcrops. Soils are generally shallow, acidic and low nutrient inceptisols.

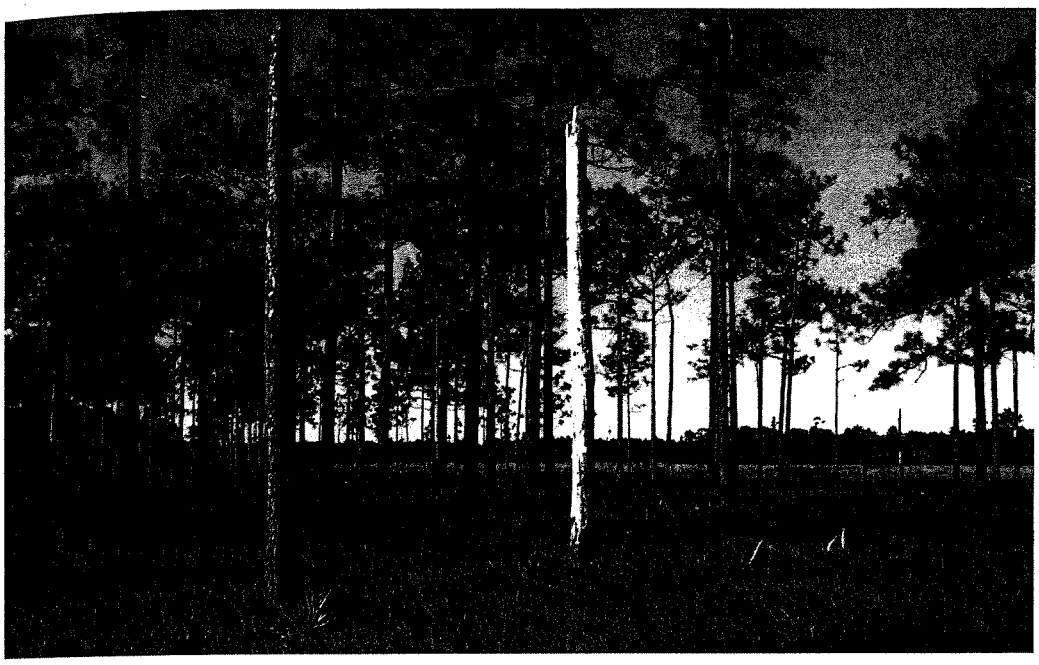
With the dominant pines, the most important canopy species are oaks, especially chestnut and scarlet oaks. A dense, sometimes continuous, small tree and shrub layer develops where fire is excluded. Common shrubs include dwarf and bear huckleberries, early lowbush blueberry, sweet-fern, mountain-laurel, and Allegheny-chinkapin. The typically sparse ground layer includes trailing-arbutus, galax, eastern teaberry, spotted wintergreen, bracken, little false bluestem, goat's rue, and mountain bellwort (Williams 1998). Some species are most abundant following fire and decline with fire exclusion including Michaux's wood-aster, horseflyweed, greater tickseed, rosette grasses, American burnweed, Canadian horseweed, rabbit tobacco, oblong-fruit pinweed, hairy and creeping bushclover, anise-scented goldenrod, and yellow Indian grass (Harrod et al., In press).

No federally listed plants are found in these communities, but there are plants of concern in some locations. Table Mountain pine has a limited distribution, and some have suggested that fire suppression has put the species at risk for long-term survival (Turrill et al. 1997).

Historically montane pine communities burned with understory-thinning fires every 5-7 years, and stand-replacing fires about every 75-100 years (Frost 1998), and fire is still important in controlling the succession of pine communities to oak-dominated communities. Fire creates the conditions required for pine reproduction: high light, exposed mineral soil. In the case of Table Mountain pine, fire opens serotinous cones to release seed onto the fire-exposed seedbed (though in some years, cones open without burning; Barden 1977). Fire also controls the invasion by fire-tender hardwoods (Williams and Johnson 1992). Where fire has been excluded, oak basal area increases; basal area and density of fire-sensitive species increase in the understory, pine reproduction declines, and the density of grasses and forbs decreases (Harmon 1982; Harmon et al. 1983; Vose et al. 1997; Williams 1998; Harrod et al. 1998). At the landscape level, fire suppression has resulted in the loss of open, low basal area stand conditions.

Threats and management.-Fire exclusion poses the dominant threat to montane communities. Overall the area occupied by pine communities has been declining since the mid-twentieth century, and without prescribed fire losses will continue (Williams 1998).

The use of fire for restoration seems a logical management choice, but exact prescriptions and schedules for re-introducing fire to long-unburned sites are not available (Vose et al. 1997). Williams (1998) suggests pulsing high- and low-intensity fires to mimic historic patterns and effects. Because hardwoods may grow to fire-resistant sizes (Harmon 1984), they may have to be removed by cutting.



Longleaf Pine Savanna Research Natural Area, Apalachicola National Forest. This area has been burned about every 3 years for decades, including fires during the growing season in recent years. The foreground shows seasonally wet woodland, which grades into a nearly treeless community with some carnivorous plants (locally known as a savanna). The savanna borders a cypress strand visible on the distant horizon. This landscape has a high diversity of grasses, sedges and herbs (R. *Costa).*

Longleaf Pine and Associated Communities..- Historically, longleaf pine dominated coastal plain sites, and shared dominance with other pines and hardwoods on the Piedmont and on dry sites in the southern Ridge and Valley and Southern Blue Ridge provinces (Ware et al. 1993). Longleaf pine woodlands occupied a range of site conditions, grading into xeric habitats such as scrub oak forests, and into wetter seepage bogs often found in transitions to cypress strands, bayhead pocosins or baygalls, and bottomlands (Stout and Marion 1993). Remnants of this widespread forest types are still found through much of the historical range; however, good examples of natural communities on productive soils are virtually non-existent.

Although longleaf pine unifies community types in the longleaf ecosystem, the vegetation varies considerably. Community composition varies with soil moisture and geography (Peet and Allard 1993; Harcombe et al. 1993), presumably associated with soil fertility and with historical biogeography. Peet and Allard (1993) recognized four major groups of communities east of the Mississippi River: xeric woodlands, subxeric woodlands, mesic woodlands, and seasonally-wet woodlands. Similar communities occur in the west Gulf Coast region.

Xeric community types are found on deep coarse sands, especially in the fall-line sandhills, along the northeast sides of major rivers that flow into the Atlantic, and on relict dune systems in the outer coastal plain. Canopy associates include turkey oak and common persimmon. Xeric communities have scattered shrubs (blueberries, dwarf huckleberry, wax myrtle) and sparse grass and herb layers. Wiregrass (pineland three-awn or Beyrich's three-awn) is the dominant grass, and bare soil is usually present. Fire is important in these communities, however, because fuel accumulates slowly the frequency was likely lower than in other types (Christensen 1988).

Sub-xeric communities occur on well-drained sandy to silty soils from the lower coastal plain through the upper coastal plain and sandhills. Few intact examples on silty soils remain, as those sites have been mostly converted to agriculture. These woodlands have widely spaced pines, an open deciduous understory, and continuous grass and herb layer. The hardwood understory species include turkey, bluejack, and sand post oaks on sandier soils, and blackjack and post oak on clayey soils. Common shrubs include blueberries, dwarf huckleberry, yaupon, and St. Andrew's-cross. Wiregrasses dominate the ground layer except in central South Carolina, which falls between the ranges of northern and southern wiregrasses, and west of Mississippi. Bluestems dominate sites outside the ranges of wiregrass. Composites and legumes are well represented (for examples, anise-scented goldenrod, gayfeathers, flax-leaf ankle-aster, silk-grasses, milk peas, hoary-peas, tick-trefoils).

Mesic longleaf woodlands occur on relatively fertile, loamy, well-drained soils. These communities are

virtually gone from the Atlantic coastal plain, but some good examples remain on the Gulf coastal plain. The ground layer is continuous with a high diversity of herbs mixed with wiregrass and bluestem. These are extremely rich in legumes. There may be as many as 100-140 species of vascular plants in 1,000 square yards, higher than any other community in North America (Peet and Allard 1993). Compared to drier community types, the diversity of trees, shrubs and herbs increase, Succession to hardwood forests in this community is rapid without fire.

Seasonally wet longleaf communities include savannahs and flatwoods. Savannahs typically have open pine canopies over graminoid-dominated and nearly shrub-free ground layers. Savannahs can be exceptionally species rich with over 40 species per 1 square yard and up to 100 species per 100 square yards. The ground layer includes a variety of grasses (bluestems, wiregrasses, toothache grass, hair-awn muhly, dropseeds), many composites (for examples honeycomb-heads, rayless-goldenrods, chaffheads, sunflowers, and goldenrods), small sedges, insectivorous species (sundews, Venus' flytrap, butterworts, pitcher-plants, bladderworts), orchids (grass-pinks, rosebud, fringed, fringeless, snake-mouth orchids), and lilies (colicroot, lilies, coastal false asphodel). Legumes are not common. Savanna communities were found throughout the coastal plains, but extensive savannahs were found in southeast North Carolina and on the Gulf coast from the central Florida panhandle west to Louisiana. Each of these regions has distinguishing endemic species. Compared to savannahs, flatwoods have denser pine canopies, sometimes have midstories with red maple, sweetgum, and water oak, have denser shrub layers,' and less diverse herb layers. Typical shrubs include runner oaks (on drier sites) and many species found in bay forests and depression ponds; herb composition overlaps with savannahs.

Many species now considered rare are associated with the longleaf ecosystem (Hardin and White 1989). These include nearly 200 plant species; twenty-six are federally listed as endangered or threatened (Table 3; Walker 1998).

Relatively frequent, low intensity fires characterized the historical fire regime. Estimates of historical fire frequency range from about every 3 years on productive sites with rapid fuel accumulation to once in a decade on xeric sites. Without fire both pine and hardwood densities increase, forest floor depth increases, and light and soil moisture availability may be reduced via increased forest transpiration in wet sites and increased in xeric sites when a duff layer accumulates and holds water. Without fire, the cover and vigor of grasses and herbs decline, and ultimately species are lost.

Threats and management..-Altered fire regimes and landscape fragmentation, which interferes with large-scale fires, are major threats to the diversity of longleaf pine communities. Conversion to other uses and to other forests types, and intensive management practices also reduce longleaf ecosystem diversity.

Managing longleaf pine forests for timber production at some level is compatible with retaining values for biological diversity. If they have been burned regularly, the ground layers of many older second-growth longleaf stands contain characteristic native species and few non-indigenous species. In contrast, high-density plantations established following intensive mechanical site preparation, are often devoid of rich herb layers, and particularly lack the grasses needed to carry fire (Walker and Van Eerden 1996; unpublished data). The loss of wiregrasses, the dominant bunch grasses producing essential fine fuels in much of the longleaf range, has been attributed to intensive mechanical site preparation (Outcalt and Lewis 1990). From the perspective of maintaining biological diversity, natural regeneration' methods limiting site preparation to prescribed fire are preferred. Uneven-aged management systems have been used in some areas, and researchers are investigating the feasibility of applying uneven-aged management for longleaf on a variety of sites.

White-bird%-in-a-nest (*Macbridea alba*) is a federally threatened species endemic to 4 counties in Florida's central panhandle. It is one of over twenty federally protected plants associated with longleaf pine communities. Many of these rare species have narrow geographic distributions. For this reason conserving longleaf pine communities throughout its range is important for conserving biological diversity *(J. Walker).*

Table 3. Federally listed species associated with longleaf pine ecosystems and direct and indirect habitat factors cited as reasons for listing. Habitat-related listing factors are coded as follows: a = drainage/fire plow lines/road work; b = silviculture activities; c = agriculture conversion; d = residential/commercial/recreational development; e = other human activities; f = fire suppression; g = herbicide/pesticide use; h = mining; i = habitat fragmentation. Trends reported by the U.S. Fish and Wildlife Service in 1990, and listing dates post-November 1 990 are shown.

Common Name	Scientific Name	Status	Codes	Trend
Hairy rattleweed	*Baptisia arachnifera*	E	b	Declining
Pigeon wings	*Clitoria fragrans*	T	c,d,f	1993
Apalachicola rosemary	*Conradina glabra*	E	b,c,f,g	1993
Beautiful pawpaw	*Deerinoothamnus pulchellus*	E	d,f	Declining
Rugel's pawpaw	*Deeringothamnus rugellii*	E	d,f	Declining
Scrub wild buckwheat	*Eriogonum longifolium var. gnaphalifolium*	T	c,d	1993
Telephus spurge	*Euphorbia telephiodes*	T	b,d,f,g	1992
Harper's beauty	*Harperocallis flava*	E	a,b,d,f,g	Improving
Pondberry	*Lindera melissaefolia*	E	a-d	Unknown
Roughleaf loosestrife	*Lysimachia asperulaefolia*	E	a-f	Unknown
White birds-in-a-nest	*Macbridea alba*	T	b,f	1992
Britton's beargrass	*Nolina brftoniana*	E	c,d	1993
Canby's dropwort	*Oxypolis canbyi*	E	a,b,c	Declining
Texas trailing phlox	*Phlox nivalis* ssp. texensis	E	a,b,d,f	1991
Godfrey's butterwort	*Pinguicula ionantha*	T	a,b,d,f	1993
Small Lewton's milkwort	*Polygala lewtonii*	E	c,d	1993
Chapman's rhododendron	*Rhododendron chapmanii*	E	b	Declining
Michaux's sumac	*Rhus michauxii*	E	b-f	Unknown
Alabama canebrake pitcher-plant	*Sarracenia rubra* ssp. alabamensis	E	a,c,g,h	Declining
Chaffseed	*Schwalbea americana*	E	b,c,d,f	1992
Florida skullcap	*Scutellaria floridana*	T	b,f	1992
Gentian pinkroot	*Spigelia gentianoides*	E	b,c,f	1990
Cooley's meadowrue	*Thalictrum cooleyi*	E	a-c,f,g	Unknown
Wide-leaf warea	*Warea amplexifolia*	E	c,d	Declining
Carter's mustard	*Warea carteri*	E	c,d	Declining
Florida ziziphus	*Ziziphus celata*	E	c,d,f	Declining

The need for frequent burning (2-5 year intervals depending on site conditions) is widely accepted, but the timing of burning is still debated. The effects of season of bum may vary among site types and current site conditions (Rebertus et al. 1993, Glitzenstein et al. 1995). In the absence of additional information, Robbins and Myers (1992) suggest managers vary the season and interval of burning randomly. Depending on current site conditions, fire alone may not restore the Plant diversity to remnant longleaf stands. Mechanical or chemical control of hardwoods may be required to facilitate the reestablishment of longleaf pines. Thinning densely stocked pine stands to restore light conditions to the understory is recommended, and locally extirpated species may have to be reintroduced.

High-elevation Conifer Forests and Associated Communities.-Red spruce-Fraser fir forests dominate 8 of the 10 high peaks areas (above 5,500 feet) in the southern Appalachians. Seven of these have well-developed spruce-fir forests (Great Smoky Mountains, Balsam Mountains, Black Mountains, Roan Mountain, Plott Balsams, Grandfather Mountain, Mt. Rogers); an eighth (Whitetop Mountain) has spruce without fir (White 1984). Excepting Grandfather Mountain, the largest remaining spruce-fir forests occur on public lands.

The composition and productivity of the canopy varies with elevation and exposure. In general, Fraser Fir achieves dominance at the highest elevations with Red Spruce increasing at lower elevations and more

protected positions. Spruce forests grade into hardwood forests, northern hardwoods, or red oak forests. Forest biomass and stature increase from higher to lower elevations and from exposed ridges to protected coves.

Although southern Appalachian spruce-fir forests share species with boreal conifer forests, the flora is distinctive. Characteristic southern trees include Fraser fii, heart-leaved paper birch, red spruce, mountain maple, and mountain ash. Shrubs include catawba rosebay, skunk currant, smooth blackberry, southern mountain cranberry, and hobblebush. Bryophyte communities are well developed in closed forests, while herb diversity increases in openings. High elevation openings provide important habitats for rare herbs, including many species that also occur in granite outcrops and seeps (See granite outcrop descriptions for a rare species list).

The forests reproduce in small-scale patches resulting from local disturbances, primarily wind. Fire is not important, probably occurring less than once in a thousand years. Given these natural processes, it is not surprising that many high elevation forests never recovered after the wholesale harvest and subsequent fires in the early twentieth century.

Threats and management.-Southern Appalachian spruce-fin- communities are threatened by two human-related causes: an infestation of an exotic insect and air pollution. Throughout its range, Fraser fir is suffering heavy mortality from an introduced Eurasian insect, the balsam woolly adelgid. The adelgid infects and kills adult trees, while seedlings and saplings appear to be more resistant. It is unknown whether resistant seedlings will survive to produce viable seed. As the canopy dies, the forest herbs are exposed to higher light and temperatures and drier soils. Thus, the indirect effects of the adelgid put the entire flora and dependent fauna (like the federally endangered spruce-fir moss spider (*Microhexura montivaga*) at risk. The stresses induced by insect attack are exacerbated by additional stresses of acid precipitation and air pollution.

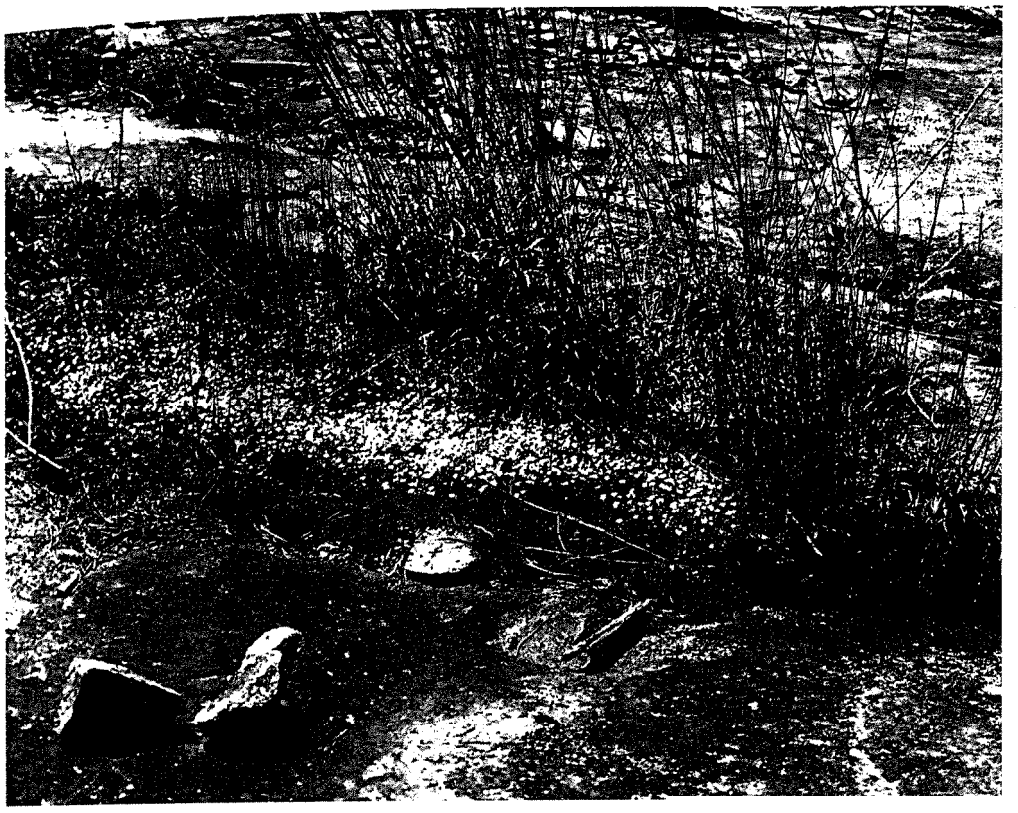
Individual stands can be sprayed to control the adelgid, but this is not practical or particularly effective, as it is difficult to spray all the feeding sites (White et al 1998). Even if genetically resistant fir populations exist, the future is uncertain for this forest type and associated rare species.

NON-FORESTED OPENINGS

Introduction and Definitions

Openings in forested landscapes were once common throughout the Southeast (DeSelm and Murdock 1993, Quarterman et al. 1993). Natural succession to the surrounding forest vegetation was inhibited by a natural disturbance regime such as fire, and perhaps grazing, or

Mt. Mitchell, NC. Fir seedlings regenerate among the skeletons of fir trees killed by the balsam wooly adelgid. This non-indigenous insect was introduced presumably on non-native silver fir planted in experimental efforts to reforest the high peaks after logging. The adelgid was discovered in the South in the mid-l 950s, but by that time had already spread through the Black Mountains. Infestations were found in the Great Smoky Mountains by the late 1950s and the Mt. Rodgers area by 1962. It is difficult to eliminate and subsequent infestations are likely. With the added stresses of acid precipitation the future of this sensitive community is uncertain *(J. Walker).*



Stone Mountain, Georgia. Ephemeral, vernal pools in granite flatrocks hold water and remain wet during winter and early spring. The pools provide microhabitats for many granite outcrop endemic plant species. The depths of water and soil accumulation determine which plants occur and how they are arranged in the pools. This small pool has several species: the reddish Diamorpha smallii (Elf Orpine), the white-flowering *Minuartia uniflora* (One-flower Stitchwort), and the old flowering stalks of little bluestem *(J. Walker).*

by physical conditions (soil nutrient status Or depth) that limit woody species establishment and productivity. Composition varies, but typically **Openings** support regionally unique species that cannot survive in the surrounding forests. Some types are rich in local endemics. Most types have become scarcer as a result of development or natural succession to other vegetation types after natural disturbance regimes were disrupted.

The terms to describe non-forested vegetation are not standardized and can confuse communication; therefore definitions are provided for terms used in this chapter. *Outcrop communities* are found where exposed rock surfaces comprise more than 25% surface cover. ***Glades*** are communities on rock or shallow soil, dominated by annual or perennial forbs, annual grasses, cryptogams, or some combination of these (Baskin et al 1994) and including less than 50% perennial grass cover. ***Barrens*** are herbaceous communities with greater than 50% perennial grass cover (DeSelm 1989, 1994). *Prairie* is applied most commonly to the tallgrass grasslands of the Midwest, but has been applied to some specific areas in the Southeast (Black, Jackson, and Grand Prairies). Only the coastal prairies of the West Gulf Coast are considered part of the midwestern grasslands. ***Canebrake*** refers to areas dominated by native giant cane. Canebrakes are not strictly herbaceous but are considered in this section because they occupy openings in forested landscapes, were once more widespread as a result of Native American land use practices, and are quickly lost to forest succession (Platt and Brantley 1997). ***Grassy bald*** applies to herbaceous vegetation complexes on the tops of high peaks in the Southern Appalachians.

The next three sections describe rock-associated communities; barrens and prairies; and canebrakes. In this order they generally represent a decreasing reliance on physical conditions (shallow soil, low moisture availability, high light) and an increasing dependence on disturbance, especially fire, for retaining their openness. Similarly, management needs grade from protecting and limiting mechanical disturbances of fragile communities, to actively reinstating disturbances, especially prescribed fire. Grassy balds are the last type of opening discussed.

Rock-associated Communities: Outcrops and Glades

Communities of rock outcrops are restricted to island-like, exposed or near-surface rock substrates, but outcrops themselves are scattered throughout the region (Quarterman et al. 1993). Community composition and structure vary geographically with rock type and

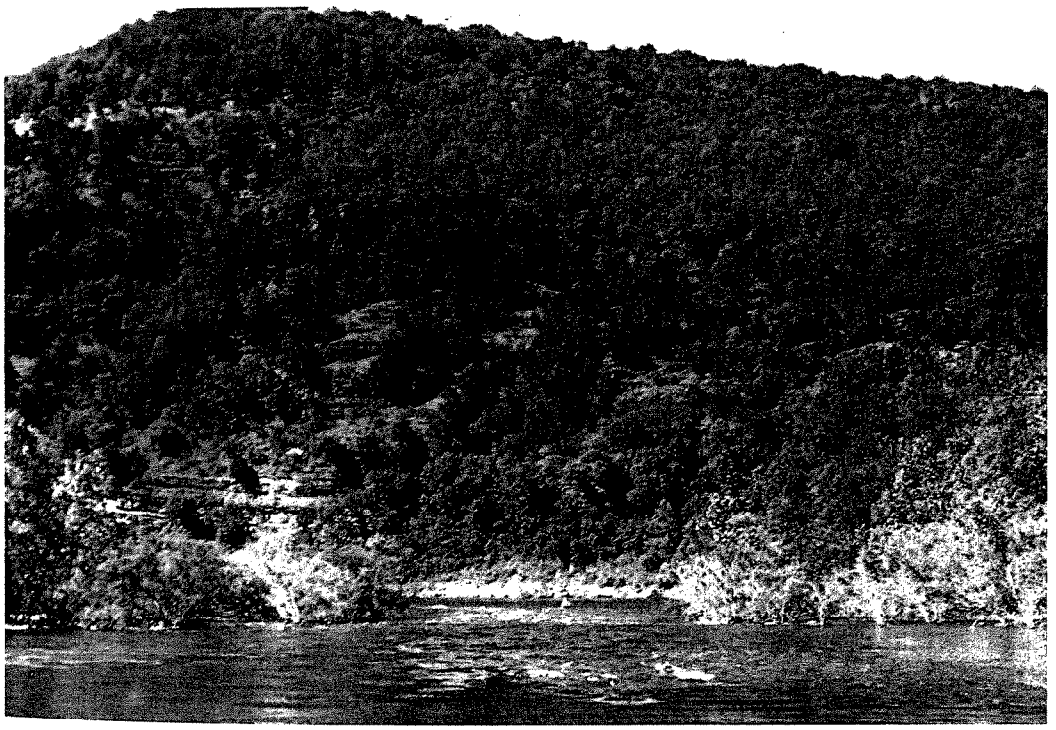
Cliff Tops on Mt. Leconte, Sevier County, TN. High elevation outcrops provide unique open habitats embedded in, or adjacent to, spruce-fir communities and grassy balds. This cliff community includes the state rare Tufted Leafless-Bulrush, the grass-like plant in the foreground, Rock Club-Moss, Cain's Reed Grass, and the federally endangered Appalachian Avens *(P. White).*

with soil type and depth. Granite (or other igneous rock) outcrop communities are found in the Piedmont of Alabama; Georgia, South Carolina, North Carolina and Virginia, and on exposed cliffs and ridges at high elevations in the Blue Ridge. Sandstone outcrops and glades occur in the Cumberland Plateau (Alabama, Georgia, Tennessee), Coastal Plain (Florida, Georgia, South Carolina), and Interior Highlands (Arkansas). The most extensive rock-associated communities occur over limestone in the Interior Low Plateau (Alabama, Tennessee, Kentucky), the Ridge and Valley province in Georgia and Tennessee, and interspersed with sandstone outcrops in the Interior Highlands (Arkansas).

Rock outcrop habitats and communities share some attributes. Except waterfall spray zones in the Blue Ridge, outcrops and glades are xeric to subxeric habitats receiving high light intensities. [Compared to Piedmont sites, growing conditions in high elevation outcrops are moderated somewhat by high rainfall, fog, and reduced evapotranspiration (Wiser 1994).] Soils are thin or non-existent, and fragile plant communities are easily dislodged. Potential vegetation is primarily herbaceous, but woody species root in crevices in the outcrop or in adjacent areas with adequate soil development. The effects of woody plant encroachment are from adjacent communities, but since individual outcrops may be small, shading from the edges can change microhabitats and their suitability for outcrop species. Finally, outcrop communities have many endemic or rare plant species, which are discussed in more detail for each outcrop type.

Woodlands dominated by Eastern red-cedar are commonly associated with rock outcrops and glades of various types (Small and Wentworth 1998). Cedar-hardwood woodlands are found on steep south to southwest facing (granite) rock outcrops in the Piedmont and southern Blue Ridge (North Carolina,

Cedar glade, Shaw Arboretum, Gray Summit, Missouri. Cedar glade communities are open patches interspersed with patches of red cedar or other woodlands. Glades typically have shallow, rocky soils, which help restrict the rate of succession to woodlands. They also provide habitat for many endemic plants, most of them small herbs *(P. White).*



Xeric limestone prairie along the Buffalo River, Arkansas. Patches of grass-dominated communities are found on hillsides and ledges in the Ozarks. To maintain the species diversity of these sensitive communities managers must control the encroachment of woody plants, cedars in this photo *(J. Walker).*

Tennessee, South Carolina, Georgia). Eastern red cedar woodlands also border limestone cedar glades and barrens in the Low Interior Plateau (Tennessee, Kentucky, Alabama) and sandstone glades in the Cumberland Plateau. On chert or cherty limestones in the Ozarks, Ashe juniper woodlands surround xeric Openings dominated by three-awn grasses, rather than bluestem. All of these communities include some species found on nearby outcrops, as well as species of local forests (Quarterman et al. 1993).

Granite outcrops.-Granite outcrop communities occur on flat to gently sloping surfaces in the Piedmont, and on exposed domes or cliffs in the southern Blue Ridge. Outcrop conditions vary from bare rock sur-

faces, to lichen covered patches, shallow pools that hold water and remain moist during winter and early spring, seepage areas sometimes with deeper pools, and marginal communities found in deeper soils where outcrops meet adjacent habitats. In depressions as soil accumulates, vegetation may develop through time from lichen and annual plant communities, through annual-perennial herb communities, to herb-shrub communities. Succession to woody vegetation is limited on steep surfaces.

The Central Georgia Piedmont is a center of endemism for flatrock granite outcrop species, with the number of endemic species decreasing along a northeast-southeast axis from the center (Murdy 1968). Flatrock endemics include little amphianthus (endangered), granite flat sedge, black-spore quillwort, Merlin's-grass, Georgia rush, spotted scorpion-weed, Small's purslane (endangered), Georgia oak, globe beak sedge, granite stonecrop, and confederate daisy.

A host of rare plants occur on mountain outcrops and cliffs, and in other high elevation openings such as grassy balds, heath balds, and seeps (See grassy balds discussion.). Wiser (1994) lists 17 species (out of a total of 288 species found in a study of 145 outdrops) that are restricted to high-elevation outcrops. These include federally endangered Appalachian avens, mountain bluet, and threatened Blue Ridge goldenrod, Heller's gayfeather, and mountain golden-heather. The high-elevation outcrop flora include local endemics, Cain's reed grass and mountain golden-heather; species related to northern Appalachian alpine species, Sitka alder, Greenland stichwort, highland rush, fir club-moss, and Northern bent grass; and southern Appalachian endemics, wretched sedge, Appalachian avens, Blueridge St. John's-wort, mountain dwarf-dandelion, Heller's gayfeather, and Piedmont groundsel. The more northerly species are considered to be relicts from Pleistocene alpine communities (Quarterman et al. 1993).

Unlike other outcrop habitats, waterfall spray zones are perpetually wet, providing conditions suitable for diverse non-vascular (mosses and liverworts) plant communities. Some species are common in more northerly locales, while other have their closest relatives in the tropics. These sheltered habitats may have served as refuges for species found in the Southeast before Pleistocene glaciations (Zartman and Pitillo 1998).

Sandstone outcrops and glades.-On the Cumberland Plateau in Alabama, Kentucky, and Tennessee, sandstone outcrops occur on canyon shoulders and on flats. They are mixed with limestone outcrops in northwestern Arkansas. Shallow soils support lichen and moss mats, while somewhat deeper soils support annual three-awn grasses'or little false bluestem and silky wild oat grass, and a variety of forbs such as lance-leaf tickseed, Michaux's wood-aster, orange-grass, Appalachian stitchwort, and small-head gayfeather. Deeper soils support a shrub-herb community. Sandstone outcrops contain some species of granite outcrops (dense-tuft hair sedge; quill fameflower, Menges' fameflower, elf orpine), as well as unique endemics such as Little River Canyon onion, woodland tickseed, and Gulf pipewort .

Plant communities of Nuttal's rayless-goldenrod with mixed grasses and forbs, (for examples, scaly gayfeather, dissected beardtongue, and sandhill St. John's-wort) are associated with sandstone boulders, flats, and ledges in the Upper Coastal Plain in Georgia, northern Louisiana, and eastern Texas. Soils are acid sandy loams or silty clay loams that can be saturated in winter, and dry and hardened in the summer. Fires starting in surrounding longleaf-wiregrass communities may have controlled succession in these habitats, but because fuel accumulates slowly, the habitats probably burned infrequently.

Limestone outcrops and glades.—The limestone outcrops and glades of central Tennessee, northern Alabama, and northern Arkansas are extensive. Early explorers described these areas, and contemporary biologists continue to study them, attempting to document their diversity and understand their ecology (Quarterman et al. 1993).

Glades vary from site to site, which is reflected in the large number of endemic and near-endemic plant species (Table 4; Baskin and Baskin 1986, 1989), and within a given site. Cryptogams and small herbs, including many winter annuals, dominate gravelly areas; perennial herbs and grasses increase in importance, and glade communities grade into grass-dominated barrens (see below) as soil depth increases. Shrubs such as false buckthorn, rusty blackhaw, winged sumac, and maidenbush, and trees, notably Eastern red cedar, can establish in crevices that afford adequate soil and water; but mostly harsh conditions keep glades open.

The limestone glades of the Ozarks are found on hillsides, benches, and ledges. They are more prairie-like than those of the Interior Low Plateau, being dominated by perennial grasses such as little false bluestem and poverty wild oat grass. Typical herbs include prickly pear cactus, Adam's-needle, Texas stonecrop, small palafox, Michaux's gladecress, large Indian-breadroot,

Table 4. Endemic and near-endemic plant species of limestone cedar glades in the Interior Low Plateau of central Tennessee, northern Alabama, and southern Kentucky (Baskin and Baskin 1986; Kartesz and Meacham 1999). ** indicates Federally Endangered; * indicates Federally Threatened; — indicates no common name.

Scientific Name	Common Name
Species** found in 3 **or fewer states	
Delphinium alabamicum Kral	Alabama Larkspur
Echinacea tennesseensis (Beadle) Small**	Tennessee Purple-Coneflower
Leavenworthia alabamica var. alabamica Rollins	Alabama Gladecress
Leavenworthia alabamica var. *brachystyla* Rollins	
Leavenworthia crassa var. *crassa* Rollins	Fleshy-Fruit Gladecress
Leavenworthia crasse. var. *elongata* Rollins	
Leavenworthia exigua var. *exigua* Rollins	Tennessee Gladecress
Leavenworthia exigua var. *laciniata* Rollins	
Leavenworthia exigua var. *lutea* Rollins	
Leavenworthia stylosa Gray	Cedar Gladecress
Leavenworthia torulosa Gray	Necklace Gladecress
Lesquerella lyrata Rollins*	Lyre-Leaf Bladderpod
Lobelia appendiculata var. *gattingeri* (Gray) McVaugh	Gattinger's Pale Lobelia
Pediomelum subacaule (Torr. & Gray) Rydb.	White-Rim Indian-Breadroot
Phacelia dubia var. *interior* Fern.	Small-Flower Scorpion-Weed
Phacelia dubia var. *georgiana* McVaugh	
Solidago shortii Torr. & Gray**	Short's Goldenrod
Talinum calcaricum Ware	Limestone Fameflower
Species **found In 4 or fewer states including the Ozarks**	
Dalea gattingeri (Heller) Barneby	Purple-Tassels
Onosmodium molle ssp. *subsetosum* (Mackenzie & Bush)Cochrane	Soft-Hair Marbleseed
Solidago gattingeri Chapman	Gattinger's Goldenrod
Species found in 5 or fewer states including Midwestern states	
Astragalus tennesseensis Gray ex Chapman	Tennessee Milk-Vetch
Dalea foliosa (Gray) Barneby**	Leafy Prairie-Clover
Hypericum dolabriforme Vent.	Straggling St. John's-Wort
Onosmodium molle ssp. *molle* Michx.	Soft-Hair Marbleseed
Viola egglestonii Brainerd	Glade Violet

large-flower tickseed, smartweed leaf-flower, rock sandwort, and limestone adder's-tongue. Associated shrubs include upland swamp-privet, fragrant sumac, and coral-berry. To distinguish these communities from Central Basin glades, Baskin et al. (1994) described them as xeric limestone prairies. Historically, xeric limestone prairies were probably maintained by fire, drought, and grazing. Without disturbances to remove woody species, shrubs invade.

Threats and management.-Threats to all outcrop and glade communities include development (construction, quarrying), agriculture (pasture), succession resulting from fiie suppression, and non-indigenous species invasions. To retain characteristic species, management must remove or prevent woody species encroachment. Managers must regulate access, perhaps identifying trails and travel corridors. Rare species should be protected and monitored.

Barrens, Prairies, and Other Perennial Grasslands

Communities discussed in this section vary from dense sod forming to bunch grass types. They generally occur as small to medium (2-20 acre) islands, separated from other openings by forested habitats. Grasses common to many barrens include little false bluestem, Indiangrass, and big bluestem. Legumes and composites are well represented. There are few endemics and few federally listed plants (e.g., endangered Schweinitz's sunflower, smooth purple-coneflower, and Tennessee purple-coneflower) associated with barrens, but most states with grassland remnants list a number of grassland species of state concern, such as Oglethorpe oak, Gattinger's pale lobelia, ridge-stem false foxglove, Heller's bird's-foot-trefoil, and Georgia American-aster (DeSelm and Murdock 1993, Deselm 1994, Webb et al. 1997, Leidolf and McDaniel 1998).

Grasslands overlap with limestone and sandstone glade distributions in the Interior **Low** Plateau (Big Barrens, Kentucky; Highland Rim and Central Basin, Tennessee), Ridge and Valley Section (Alabama, Tennessee), Cumberland Plateau (Kentucky, Tennessee, Alabama), and the Interior Highlands (mostly Ozarks, Arkansas, Oklahoma). They are found on nearly level to rolling sites in the Central Basin and Big Barrens, and occur on cliff tops, ledges and hillsides in the other areas. Little false bluestem and yellow Indian grass commonly dominate interior barrens. Additional species include side-oats grama, big bluestem, and a variety of composites and legumes.

Other grassland habitats are associated with special soil types, mostly developed over marl, chalk, or clayey substrates in the upper Gulf Coastal Plain and Mississippi Alluvial Plain (Alabama, Mississippi, Louisiana, Texas). Such soils (typically alfisols and vertisols) are not very permeable, and with shrink-swell clays provide difficult growing conditions that slow woody species invasions. These include the blackland prairies (Jackson Prairie, Black Prairie) (Alabama, Mississippi), the Grand Prairie of eastern Arkansas (over loess-capped alluvial deposits), grasslands on calcareous clayey soils in northern Louisiana, eastern Texas, and southwestern Arkansas. They occupy gently rolling topography and are dominated by little false bluestem, often with Indian grass and rarely with side-oats grama. Switchgrass and big bluestem may be found on wetter sites. Blackland prairies include many other grasses and a rich forb flora with such rare species as ear-leaf false foxglove, ridge-stem false foxglove, and whorled rosinweed (Leidolf and McDaniel 1998).

Remnants of a once-extensive coastal prairie are found in the lower West Gulf Coastal Plain of east Texas and southwestern Louisiana. This is the only southeastern grassland formally mapped as part of the midwest prairie ecosystem. As in other grasslands, species composition varies with site moisture: grama, switchgrass, little false bluestem, or Florida crown grass are found on wetter sites; little false bluestem and Indian grass are more common on upland sites.

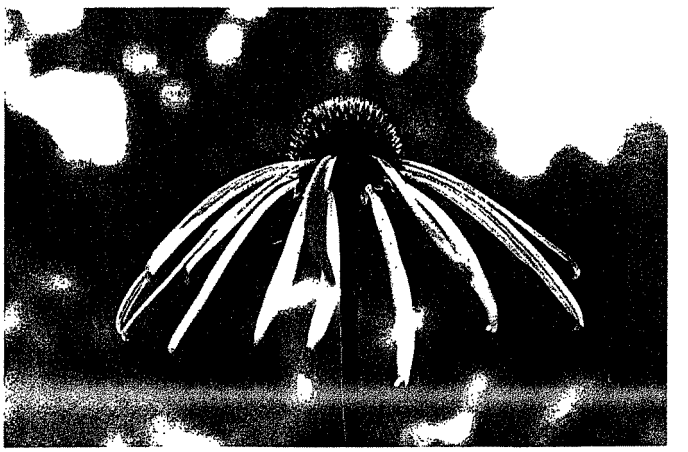
Barrens with grassland species are scattered through the Southern Blue Ridge and Piedmont (South Carolina, North Carolina, Virginia), especially on soils with high concentrations of calcium and magnesium. In the absence of occasional fires, open pine canopies may develop. These barrens provide the habitats for federally endangered smooth purple-coneflower and Schweinitz's sunflower. These may be remnant from grassland habitats historically widespread in the Piedmont (Barden 1997), and evident today as populations of grassland species in managed grassy rights-of-way.

Threats and management.—In total, grass-dominated habitats have been lost rapidly, but estimates of original extent and rate of loss are difficult to make. They continue to be threatened by conversion to agriculture, recreational use, exotic species invasions, and fire exclusion. Their conservation and restoration depend on controlling the invasion of woody species from adjacent forest habitats, and probably require prescribed burning to restore (see Chester et al. 1997) and maintain the diversity of the grassland communities.

Canebrakes

Areas dominated by giant cane were once common throughout the Southeast, especially in alluvial corridors. Based on historical accounts, canebrakes were extensive, especially on the deep rich soils of the Bluegrass Region of Kentucky, an area with almost no natural vegetation remaining (Noss et al. 1995); only scattered remnants remain. Treeless or nearly treeless (Platt and Brantley 1997) canebrakes likely developed where native Americans abandoned agricultural sites, and were maintained with periodic burning by Indians and European settlers. They declined with overgrazing by domestic livestock, frequent burning to improve grazing resources, and land clearing for agriculture.

Threats and management.-Threats to canebrakes lie in the interruption of disturbance regimes. Cane invades disturbed sites such as roadsides, old fields, and cut over forest sites, and resprouts after fires, if not burned too frequently (Hughes 1966, Platt and Brantley 1997). Existing canebrakes may benefit from a combination of overstory removal, periodic burning (once every 7-10 years), and perhaps fertilization. Recent studies have shown that cane restoration is difficult because seedlings grow slowly and competition in alluvial sites is intense (Eddleman et al. 1980, Feeback and Luken 1992, Platt and Brantley 1993). Improving extant



Smooth purple coneflower, Oconee County, SC. The endangered Smooth Purple Cone-flower is found in prairie-like grassland remnants in VA, NC, SC, and GA. Related coneflowers are found in barren and glade communities throughout the Southeast. Tennessee Purple Coneflower, restricted to the limestone cedar glades of Tennessee, is also federally endangered. All species of Purple Coneflowers (*Echinacea* spp.) are collected, often illegally, for the medicinal herb market *(J. Walker).*

Grassy balds, Roan Mountain, NC. Views are spectacular from the grassy balds of the southern Appalachians. They provide habitats for some rare plants, but they are valued as much for their cultural and historical significance. Famous displays of native rhododendrons have attracted visitors for decades. The balds are being reduced as trees and shrubs invade from adjacent communities (seen at the left In this photo). Some combination of grazing, herbicide, prescribed burning, and mechanical removal will be needed to control woody plants *(J. Walker).*

sites may prove the best option for keeping canebrakes in the southern landscape.

Grassy Balds

Grassy balds occur on mountaintops and ridges in the southern Blue Ridge Mountains (North Carolina, Tennessee), at about 4,700-6,000 feet, especially on south and west aspects (DeSelm and Murdock 1993; Lindsay and Bratton 1979; White and Sutter 1998). Grassy balds occur on shallow acid soils on gentle to steep slopes. They are generally considered to be of anthropogenic origin, and are being lost as shrubs and trees (ericaceous shrubs, fire-cherry, blackberry, oaks and hawthorns) invade from adjacent communities. Bald vegetation is a mosaic of herbaceous and shrubby communities. Although no species are considered strictly endemic to balds, balds provide habitat for a number of federally listed plants and a dozen Gl-G3 ranked species (Table 5). White and Sutter (1998) identify an additional twenty-three species of concern to the Tennessee and North Carolina state heritage programs.

Threats and management,-Woody plant encroachment and recreational use threaten bald communities. Maintenance and restoration approaches have included herbicide use, prescribed fire, mowing/hand-cutting, and grazing. A combination of these various methods will probably be most effective (Deselm and Murdock 1993).

ISOLATED WETLANDS

Among the most vulnerable wetlands are small, isolated wetlands that harbor sensitive plant communities throughout the region. They require distinct hydrological conditions to function ecologically and to retain characteristic species. Most are surrounded by lands that have been altered for agriculture or silviculture, and are affected by the practices applied to adjacent lands.

Mountain Bogs and Fens

Small wetlands occur in depressions or flats in otherwise hilly or mountainous terrain (Richardson and Gibbons; 1993; Moorhead and Rossell, 1998). Historically, mountain wetlands, locally described as bogs or seeps, probably occurred in every mountainous county in the South. They range in elevation from 1,200-1,500 ft, and overlie a variety of rock types that influence water quality. Individual sites are usually small

Table 5. Rare and endemic plants found on grassy balds (after White and Sutter 1998). Under rarity G1, G2, G3 are the top levels for globally rare plants under the Nature Conservancy ranking system. Other habitats for each species are noted. ** indicates Federally Endangered.

Scientific Name	Common Name	Distribution	Rarity	Other habitats
Carex *misera* Buckl.	Wretched Sedge	Endemic	G3	Outcrops
Delphinium exaltatum Ait.	Tall Larkspur	Northern	G3	Rich woods, rocky slope
Geum geniculatum Michx.	Bent Avens	Endemic	G1	Moist, rocky woods
*Geum radiatum Michx.***	Appalachian Avens	Endemic	G3	Outcrops
Glyceria nubigena W.A. Anderson	Manna Grass Great Smoky Mtn.	Endemic	G2	Seeps, streams
Houstonia purpurea var. *montana* (Small) Terrell**	Mountain Bluet	Endemic	G1	Rocky summits
Lilium grayi S. Wats.	Gray's Lily	Endemic	G2	Forest openings, meadows, seeps
Prenanthes roanensis Chickering	Roan Mtn. Rattlesnake Root	Endemic	G3	Seeps, woods
Rhododendron cumberlandense E.L. Braun	Cumberland Rhododendron	Endemic	G2Q	Openings
Rhododendron vaseyi Gray	Pink-Shell Azalea	Endemic	G3	Seeps, swamps
Rugelia nudicaulis Shuttlw. Ex Chapman	Rugel's-Indian-Plantain	Endemic	G3	Woods
Stachys clingmanii Small	Clinaman's Hedae-Nettle	Endemic	G3Q	Seeps, woods

Pitcher plants are the most visible of the carnivorous plants that can be found in the bogs of the coastal plain. They occur as dense extensive colonies in some sites, but are limited to isolated clumps in others. The insectivorous plants of the Southeast do not rely entirely on consuming insects, but captured insects may provide additional phosphorus and nitrogen to individuals growing in these extremely nutrient-poor habitats (*Walker).*

(1-5 acres), and often are embedded within forested vegetation or make up part of a forest and bog complex.

The soils are saturated for extended periods during the year. Technically, the wet condition of bogs is maintained primarily by rainfall input, while groundwater seepage maintains fens. Often both precipitation and ground water influence individual sites. Wetlands predominantly supplied by groundwater, especially seeping through calcareous substrates, tend to be more nutrient-rich and less acidic.

Mountain wetlands may be forested, though often with sparse canopies, or they may be open herb-dominated communities. Acidic Appalachian and Cumberland Mountain bogs (Schafele and Weakley 1990) have raised mats or hummocks of mosses, primarily sphagnum. Along with alder and willows, members of the blueberry family dominate the shrub layer. Typically scattered trees include red maple, white pine, Canada hemlock, and red spruce. Grasses, sedges and some shrubs dominate circum-neutral wetlands in high elevation flats of northwestern North Carolina, seeps and springs in the Ouachitas, and in calcareous seeps in the southern Ridge and Valley sections of Alabama and Tennessee.

Murdock (1994) listed 21 species of state concern in mountain wetlands, including federally endangered mountain sweet pitcherplant, green pitcherplant, bunched arrowhead, and threatened swamp pink.

Threats and management.—Mountain wetland occurrences have been much reduced since European settlement. Many have been destroyed directly by grazing, logging, mining, acid mine drainage, residential

Hillside bog, Kisatchie National Forest, Louisiana. Bogs on the lower coastal plain are often fiat or concave, but further inland in the geologically older marine terraces bogs may occur in seepage areas on the sides of hills (as shown in this photo). In addition to carnivorous plants, seepage bogs contain a diversity of other herbs, especially sedges, grasses and composites. Notice the young longleaf pines that have established, and the evergreen shrubs at the bottom of the slope. These communities are easily shaded out as woody species increase in the absence of fire (*R.* Costa).

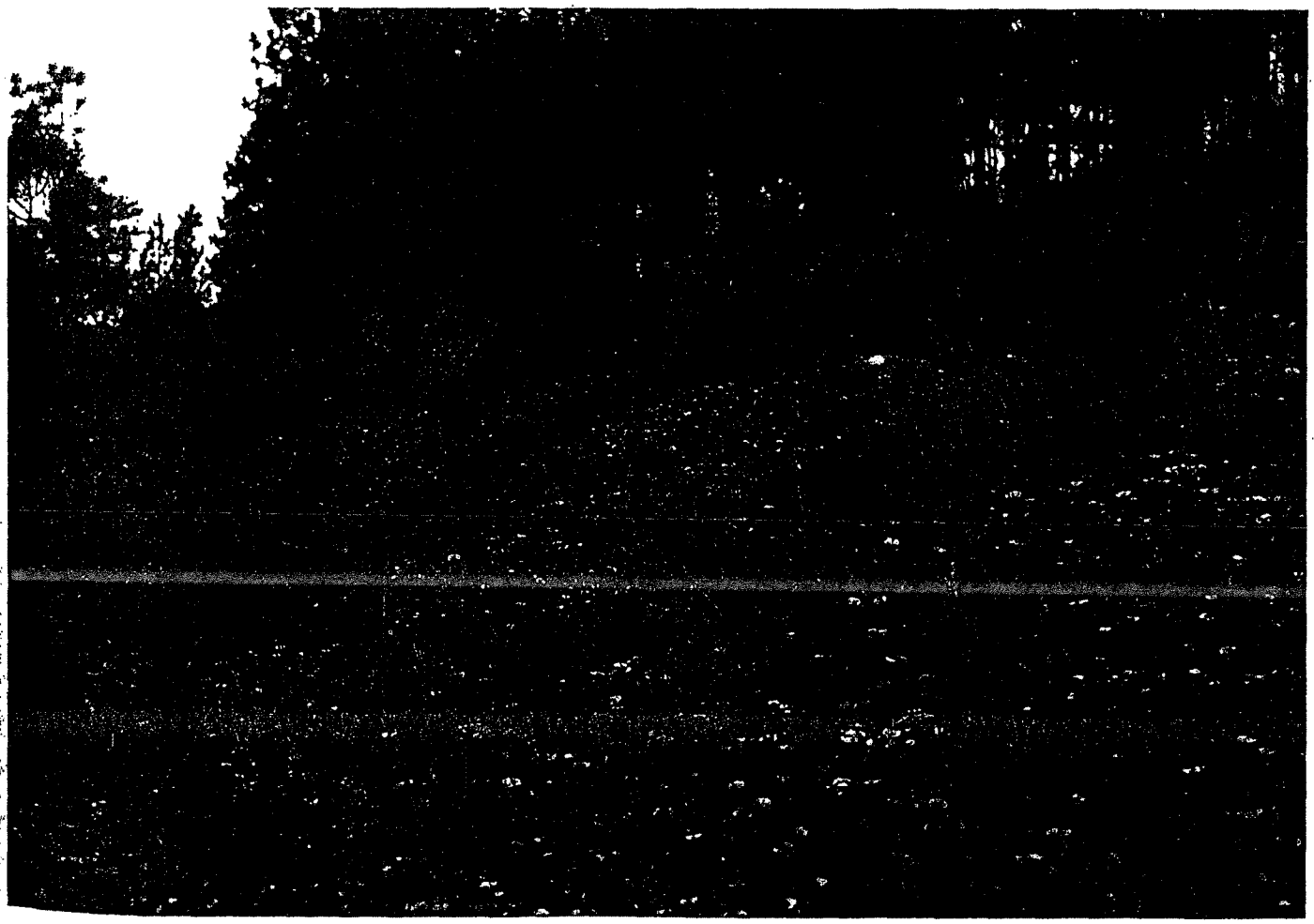


Table 6. Characteristics of three coastal plain depression habitats.

	Carolina Bays	Karst ponds	Citronelle ponds
Distribution	se NC, SC, e GA	FL panhandle w of Suwanee River and contiguous sw GA and se AL	central Gulf coastal plain-Pearl River Co.,MS to Okaloosa Co., FL
Formation process	removal of surface substrate by wind or meteoritic Impact'	dissolution of underlying limestone	dissolution and removal of kaolinitic clays from surface
Water source	rainfall, runoff, shallow seepage: some spring-fed	rainfall, runoff, shallow seepage; deep ground water	rainfall, runoff, shallow seepage
Profile	gradual side-slopes	gradual side slopes	abrupt slope, flat bottoms
References	Richardson and Gibbons 1993 Sharitz and Gresham 1998	*Sutter* and Kral 1994	Folkerts 1997

development, agriculture, inundation in artificial reservoirs, and recreational off-road vehicle use. Any activity that alters the surrounding watershed will degrade these sensitive wetlands.

Considering the **scarcity** of mountain fens, preservation and restoration may be the preferred management goals. Maintaining site hydrology is the primary objective. Secondarily, woody plant invasion must be controlled. The natural role of fire for controlling shrub and tree encroachment is debated, and its use may best be considered with respect to individual types (Schafale and Weakley 1990). For example, fire may be effective in sites that contain remnant populations of species associated with fire on the coastal plain, but may be inappropriate in other wetland types.

Coastal Plain Herb Bogs: Seepage Bogs, Hillside Bogs, Pitcher Plant Bogs

Thirty-nine carnivorous plant species, 85% of all carnivorous plant species that occur in North America, are found in the Southeast, and over half of those are endemic to the Atlantic and Gulf Coastal Plains. These species abound in wet habitats collectively referred to as carnivorous plant bogs. The bogs have acidic and low nutrient status soils and are found in poorly drained sites throughout the coastal plains including the fall-line sandhills regions. The largest examples occur in the lower coastal terraces in the East Gulf Coastal Plain (Folkerts 1982). They range from large poorly drained flats to small depressions in surrounding pine woodlands to narrow ecotones between upslope pines and downslope swamps or shrub bogs. On the Lower Coastal Plain, pitcher plant bogs grade into seasonally wet savannahs (See longleaf pine communities). Bogs grade down slope into shrubby or forested communities including shrub bogs and bayheads.

In addition to carnivorous species, the bog flora is known for its diversity of orchids (rosebud, fringed and fringeless, pogonia), lilies (yellow-eyed grass, featherling, rush-featherling, lilies) and graminoids, especially small sedges (beak sedge, nut-rushes, fimbry). Federally listed plants that occur near or with carnivorous species include Harper's Beauty (endangered) and rough-leaved loosestrife (threatened).

These communities are typically embedded in pine-dominated (longleaf pine or slash pine) woodlands or forests. Fires that started in the surrounding pine uplands and burned into the bogs were critical for eliminating or limiting woody species encroachments (Frost et al. 1986). Historically, coastal plain herbaceous bogs burned about as frequently as the surrounding uplands (approximately every 3-5 years), but in wet, very low productivity sites where fuels accumulate slowly less frequent fires may have maintained herbaceous bogs.

Coastal plain bogs have water at or near the surface for much of the year, the water coming from upslope seepage, precipitation, or both (Gibson 1983). Saturated soil conditions allow for some peat accumulations, but most of these sites have fine-textured mineral soils that can support pines, especially with fertilization. Planted pines shade out herbs, and as they grow, dry out the sites facilitating the establishment and growth of a different plant community. Saturated conditions help retard woody plant growth that can eventually shade out the herb community.

Threats and management.-Fire exclusion across the pinelands and bogs results in increased woody plant components and reduced species richness, and threatens carnivorous plant habitats. Ironically, in the past the use of prescribed fire contributed to the loss of these sensitive bog communities because fire control lines often were plowed through the bogs to prevent fire moving

into adjacent shrub communities and swamps. Maintaining these communities requires that the water sources remain intact and that sites are burned regularly to control woody species invasion. Additionally, excluding heavy equipment that can produce long-lasting ruts in these wet soils is important. If species have been lost through time, reintroductions into isolated sites may be required.

Coastal Plain Depressions and Pond

Depression wetlands are widespread throughout the Southeast, but are especially prevalent in the Coastal Plain (Ewe1 1998, Sharitz and Gresham 1998). Various overlapping types, including Carolina bays, karst Ponds, lime sinks, cypress domes, Citronelle ponds, and sandhill ponds, have been described. [Note: These habitats are physiognomically and compositionally similar to shrub dominated palustrine wetlands including shrub bogs, bayheads, bayhead or bay swamps, baygalls, streamhead pocosins, and pocosins. No habitat classification clearly distinguishes among these types (Sharitz and Gresham 1998). All are defined as non-alluvial wetlands (Sutter and Kral 1997), that is, wetlands with variable hydroperiods occurring in basins or depressions, or on slopes, with no connection to above-ground stream or river systems. Water levels are not dependent on stream or river dynamics. This section describes Carolina bays, karst ponds, and citronelle ponds (Table 6). All are generally isolated, round to oval formations, which may contain open water ponds, and are completely surrounded (historically) by forested vegetation; however, origins, distributions, and water sources differ.

Within all types vegetation varies. Factors that determine the type of vegetation at a given site include hydroperiod, fire frequency, presence of organic matter, and water source (Ewe1 1990). Furthermore, vegetation can vary considerably from year to year. Sustaining diversity through time depends in part on the presence of viable and diverse seed banks (Sutter and Kral 1994).

Depression wetlands provide essential habitat for reptiles and amphibians that tolerate or require variable hydroperiods @odd 1992, 1995; Semlitsch and Bodie 1998) and for a few rare plants including the federally endangered Canby's dropwort.

Carolina Bays.-Carolina Bays are oval-shaped and oriented with the long axis running generally northwest to southeast (Richardson and Gibbons 1993; Sharitz and Gresham 1998). Size ranges from a few acres to several thousand. Carolina Bays are associated with sandy substrates, often with underlying lenses of impervious clays that hold water in overlying layers, but surface organic layers accumulate where soil disturbances are minimal. Zoned vegetation grades from forested or shrub communities through emergent herb communities and floating and submerged aquatics in the deeper water.

Some bays are filled with predominantly evergreen shrubs and bay forest species such as fetterbush, redbay, loblolly-bay, titi, inkberry, highbush blueberry, red chokeberry, huckleberries, and wax myrtle. Others contain forest or woodland communities dominated variously by pond cypress, pond pine, tupelo, and associated species. Herb zones may ring the bays in some cases, especially where fire is used to manage the surrounding landscape.. Sutter and Kral (1994) describe pond cypress savarmahs. These unique communities have an open canopy of pond-cypress and a diverse herbaceous ground layer, which includes federally threatened Canby's dropwort.

Karst Ponds, Limesinks, Dolines.—Karst depression communities are reviewed by Sutter and Kral (1994). Unlike other isolated depression communities, these communities are influenced to some degree by deep ground water. Owing to a dependence on subsurface water, water levels change over decades rather than months, and the water quality depends partly on regional water quality.

The typically gently sloping sides of karst depressions result in a characteristically zoned vegetation: surrounding forest or shrubs give way to sandy beaches dominated by grasses and sedges, and finally to open water. They are embedded in sandy uplands dominated on yellow sands by longleaf pine, deciduous scrub oaks and hickories, and wiregrass; and on white sands by sand pine, evergreen scrub oaks, and heaths. The forested fringe typically has evergreen oaks, hollies and heaths; shrub zones are evergreen and influenced by the water levels. Open sandy beaches vary from site to site, seasonally and from year to year depending on water levels. Sedges are abundant and common herb genera include yellow-eyed grass, pipeworts, arrowheads, primrose-willows, and rose-gentians. Carnivorous sundews and bladderworts are common. Tall emergent and submerged species are found in deeper water. Rare and endemic plant species include panhandle meadow-beauty, smooth-bark St. John's-wort, Harper's yellow-eyed-grass, and Kral's yellow-eyed-grass. Karst ponds are important breeding habitat for flatwoods salamander (proposed for federal listing) and gopher frog.

Citronelle Ponds.—This habitat type is named for the Citronelle Formation, which defmes their distribution, and is synonymous with Grady ponds so named for the soil type that typifies them (Folkerts 1997). The highest concentrations (as high as 4/mi2) occur in western Escambia County, Alabama. They range in size from 6-10 feet across to occupy areas as large as 200 acres, Ponds are rain-filled by mid-winter, remain high until mid-April, and then drop through October with some drying completely. They are typically shallow and fiat-bottomed, the vegetation changing abruptly from surrounding vegetation types.

Citronelle depressions were naturally forested with pond-cypress or swamp or both. Past logging has left some ponds treeless today. Shrubs and small trees of the shallow edges include yaupon, slash pine, wax myrtle, red maple, mayhaw, Virginia willow, sweet pepperbush, and fetter bush. Spanish moss and laural-leaf greenbriar are common, but understory vegetation is never dense. Shallow water herbs include Virginia chain fern, saw-grass, pipewort, yellow-eyed grasses, Georgia tickseed, and tall pine-barren milkwort. Adjacent forests probably were mixed deciduous-broadleaf evergreen forests with longleaf pines dominating more distant uplands. There are no rare species reported from Citronelle ponds.

Threats and management.-Throughout the region, depressions are lost directly by conversion to agriculture and forestry, and are adversely affected indirectly by management in the adjacent uplands. Management in the uplands regulates both water quality and frequency of burning. Historically, depression vegetation probably burned in drought years (perhaps 1/15-20 years according to Folkerts 1997) as fire burned into them from the surrounding pyrophyllic vegetation. Fire exclusion in the uplands eliminates fire in the wetlands and results in the reduction of herbaceous community. Further, amphibians that depend on these generally fish-free environments for breeding also require nearby fire-maintained uplands to complete their life cycles. Finally, depression communities, especially in the Gulf Coastal Plain, are being lost to invasive non-indigenous plants such as privet, Japanese honeysuckle, and Chinese tallow tree.

Restoring or maintaining natural hydrology is critical for management. This may involve closing any artificial drainage ditches, as well as protecting the immediate watershed. For maintaining karst communities, protecting regional quality may be necessary to ensure sensitive community composition. Generous buffers into the uplands should be established to protect watershed quality. Fire should be used in the surrounding habitats to restore natural ecotonal patterns and habitat values. Burning may also retain habitat values for amphibians and help control non-indigenous species; To protect seedbanks, which are important in isolated wetlands, preserve natural soil dynamics and avoid large-scale disturbances that may deplete the seed bank unnaturally.

FACTORS AFFECTING SENSITIVE COMMUNITY MANAGEMENT

The goal of managing sensitive 'communities is to retain or restore the composition, structure and function of these communities. Given the losses of natural areas and disruptions in natural disturbance and hydrological regimes, most sensitive communities will depend on active management. Several factors are likely to influence the success of management. First, many sensitive communities are found on private lands and their persistence requires the commitment of private landowners to management. The value of small tracts for conserving diversity is sometimes overlooked, but populations of rare plants with possible unique genetic composition can persist for long times in small areas. Additionally, retaining small areas 'of sensitive communities may enhance larger landscape diversity.

Secondly, managers must be aware that sensitive communities often occur as inclusions in different and often highly modified landscapes, like grassland remnants in forests or forest remnants in agricultural landscapes. The integrity of sensitive communities often depends on the condition and management of surrounding lands. For example, water quality in a mountain seep may be impaired by runoff from surrounding grazed pastures. Or, the values of a coastal plain depression pond may be diminished if the surrounding uplands are not burned. Management may have to create conditions at small scales that once depended on larger scale processes (like flooding or burning), or to simulate processes (like gene flow via pollination or propagule dispersal) that once occurred at larger scales. Cooperative efforts among adjacent landowners may provide opportunities for maintaining sensitive communities on complex landscapes.

Recognizing that current landscapes are very different from conditions in which today's sensitive communities originally developed must influence the choice of management objectives. In this chapter frequent reference is made to historical conditions, but presettlement conditions are not necessarily the desired management

objectives. Also, presettlement conditions may not be achievable, for example, landscape scale burning is not feasible. However, presumed historical conditions along with current conditions and observations of recent community change do provide management guidance (White and Walker 1997). Especially on small tracts, it may be more practical to identify specific conditions to be maintained or achieved. For example, where a population of rare plants occurs, management objectives may be stated in terms of providing suitable habitat conditions for that single species. Where possible, achieving those objectives with processes that more or less resemble natural ecological process is likely to sustain other ecological values.

Third, the lack of information always presents challenges to management. In the absence of information, managers may adopt an adaptive management approach of determining actions based on available information, observing outcomes, and adjusting future actions. Monitoring to learn from management actions, and communicating knowledge gained from monitoring, will enhance the likelihood of conserving biodiversity in the South.

Finally, over the long-term managers encounter unanticipated problems. Some of these may be foreseen, but not easily controlled, such as climate change, disease epidemics, insect epidemics. The ongoing loss of Fraser fir forests presents a vivid example of an unforeseen "impact on' a forest type that has always been rare. Though remaining fir forests are protected from logging, efforts have failed to protect the forests from an exotic insect, the balsam woolly adelgid. With unpredictable threats possible for sensitive communities, a useful strategy is to manage in a way that conserves genetic diversity, thereby protecting the capacity for plant species to evolve and adapt to changing conditions over time.