Chapter 1: Terrestrial Ecosystems

What are the history, status, and projected future of terrestrial wildlife habitat types and species in the South?

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Key Findings

- There are 132 terrestrial vertebrate species that are considered to be of conservation concern in the South by State Natural Heritage agencies. Of the species that warrant conservation focus, 3 percent are classed as critically imperiled, 3 percent as imperiled, and 6 percent as vulnerable. Eighty-six percent of terrestrial vertebrate species are designated as relatively secure. The remaining 2 percent are either known or presumed to be extinct, or have questionable status.
- Species of conservation concern are dominated by amphibians and reptiles. Fifty-four amphibians, 40 reptiles, 20 birds, and 18 mammals are classed as imperiled.
- Increasing population trends are reported for wild turkey, white-tailed deer, and black bear. Populations of northern bobwhite quail, gray fox, and red squirrels have declined for several years. There have also been declines in mourning dove and American woodcock populations. Cottontail rabbit and ruffed grouse populations have demonstrated cyclical patterns. Among the migratory game birds, record harvests of ducks and geese have occurred in recent years.
- Groups of nongame birds with more than 50 percent of their species showing significant declining trends include grassland-nesting birds (70 percent), ground-nesting birds (57 percent), and shrubland-nesting birds (53 percent).
- Since presettlement, there have been significant losses of community biodiversity in the South (Noss and others 1995). Fourteen communities are critically endangered (greater than 98-percent decline), 25 are endangered (85- to 98-percent decline), and 11 are threatened (70- to 84-percent decline). Common factors contributing to the loss of these communities include urban development, fire suppression, exotic species invasion, and recreational activity.
- The term "fragmentation" references the insularization of habitat on a landscape. The change in arrangement of remaining habitats can be accompanied by a loss of habitat area. Habitat fragmentation can result in the decline of interior-dwelling birds; the decline of some large, wide-ranging species; and the loss of other specialized species. Habitat fragmentation affects the patch, connectivity, and edge characteristics of a landscape.
- Connectivity within a landscape may facilitate movement and fecundity for some species, while the size and shape of landscape patches influences the integrity of both biotic and abiotic processes. Edge characteristics also have important implications for the persistence of an array of terrestrial species with very different habitat requirements.
- The availability of hard and soft mast can influence some terrestrial vertebrate species. Mast is an essential component in the diet of many birds and mammals. Disease, insect infestation, advanced age, climatic processes, and disturbance influence mast yields.
- The ranges of many species cross both public and private land ownerships. The numbers of imperiled and endangered species inhabiting private land indicate its critical importance for conservation.
- The significance of land ownership in the South for the provision of species habitat cannot be overstated. Each major landowner has an important role to play in the conservation of species and their habitats.

Introduction

The South has an impressive diversity of terrestrial communities and species associations. These communities range from mountain spruce-fir forests to tropical hardwoods, and from coastal dunes to prairies. Centuries of settlement and land use change have brought a number of threats and pressures. The majority of the landscape has been modified considerably, resulting in the disappearance, degradation, and endangerment of native communities.

This chapter assesses the historical and present status of terrestrial species across the South. It is organized into six major sections:

1. An overview of southern historical conditions affecting terrestrial vertebrate species.
2. A review of populations, harvests, and the conservation status of species occurring in the South.

3. A review of selected sensitive communities in the region and the common threats to these communities.

4. An overview of vertebrate species that consume hard and soft mast. This section also lists several mast-producing species that occur in the South.

5. An evaluation of the significance of public and other land for maintaining species and their habitats.

6. A review of the literature on fragmentation and its influence on landscapes and the species supported by those landscapes.

Several species are included that, at one stage or another of their lives, return to land to reproduce or spend a part of their lives there. The focus is on vertebrates because information on the regional biogeography of many terrestrial invertebrate groups is lacking (Echternacht and Harris 1993). Scientific names are provided in the chapter tables; therefore, common names will be used in the text. (Note: Additional information on the status and habitat relationships of vertebrate resources across the South is provided in chapters 5 and 23, which include discussions of threatened and endangered species.)

Methods and Data Sources

Data on the conservation status of terrestrial vertebrate species were compiled from State Natural Heritage agencies using NatureServe (2000). The Natural Heritage database is an inventory of known occurrences for species of conservation concern, including federally listed species. Stein and others (2000) list multiple criteria used by Natural Heritage for assessing conservation status: occurrence (number of distinct populations or subpopulations); condition (viability of extant populations); population size; area of occupied habitat; short- and long-term population trends; known or suspected threats; susceptibility to intrinsic biological factors; and the number of protected occurrences. This methodology provides the basis for conservation status designations that indicate the degree of imperilment.

Species known to be extinct (GX), or possibly extinct (GH), are recorded independently. For example, the passenger pigeon is assigned the GX ranking because there is no question about its extinction. For a considerable number of species that have not been observed in many years, however, there remains some hope of rediscovery. That, for example, is the case for Bachman's warbler. These species were assigned the status of GH.

Information on game and furbearer abundance was obtained from the Renewable Resources Planning Act (RPA) Wildlife Report (Flather and others 1999). The RPA is a periodic assessment of natural resources on the Nation's forests and rangelands. The RPA data on game populations originated from State agencies using questionnaires developed by the USDA Forest Service and the Natural Resources Conservation Service. Data from the RPA assessments are taken from various State and Federal agencies. Population projections of harvested animals are based on surveys of experts from State wildlife agencies.

Information on rare and threatened communities was based on the comprehensive reviews conducted by Grossman and others (1994), Noss and others (1995), White and others (1998), and Walker (2001).

Information on the acreage and distribution of Federal land was obtained from the National Parks index (U.S. Department of the Interior 2000a), the Lands Report from the Fish and Wildlife Service (U.S. Department of Interior 2000b), and the Lands Area Report of the USDA Forest Service (U. S. Department of Agriculture, Forest Service 2000c). Agency reports also were compiled for national parks (U.S. Department of the Interior, Park Service 2000) and national refuges (U.S. Department of the Interior, Fish and Wildlife Service 2000), providing property descriptions and species lists.

Statewide timberland ownership data were obtained from the Forest Inventory and Analysis Research Work Unit (FIA) of the Southern Research Station (U.S. Department of Agriculture, Forest Service 2000a). For each State, the acres in both public and private ownership categories were analyzed.

A literature search was conducted for information on fragmentation, rare communities, historical conditions, and species habitat relationships. In addition, research stations and universities throughout the South were contacted to obtain additional information. The results from this effort were combined with additional information obtained from several plant and animal field guides. A list of mast-producing species was compiled using vegetation guides; terrestrial vertebrate species that include mast as a component of their diet were extracted from wildlife field guides.

Results

Historical Conditions

The presettlement landscape of the South was quite diverse: forests of different ages were interspersed with expansive savannas, dense cane thickets, barrens, and swamps. Disturbance was a major influence on the composition of southern forests, creating forest openings and resetting succession (Lorimer 2001). Forests were dynamic; natural succession progressed with shade-tolerant plants replacing pioneer species. Periodic flooding and associated sedimentation influenced the distribution and composition of local areas.

Frequent thunderstorms provided a source of natural fires, resulting in a landscape of mixed species composition. Lightning fires burned unabated (Williams 1989). Fire frequency and intensity were dominant forces (refer to chapter 25). Fire was important for the persistence of many communities including pine forests, oak-hickory forests, savannas, barrens, and prairies (Trani and others 2001).

Native Americans, through use of fire and crop cultivation (Buckner 1989, Delcourt and Delcourt 1987), further modified the composition and open character of the forest. Fires were frequently set to create openings for crops and to drive game for harvest. The effects of native inhabitation on southern forests were extensive (refer to chapter 24).

Wildlife of the presettlement South was quite impressive. Dickson (2001) describes large herds of bison and elk roaming throughout the prairies and savannas of the region. White-tailed deer and wild turkey also were numerous. Large carnivores (black bear, cougar, red wolf, and bobcat) were abundant, and a diversity of successional seres supported a variety

of prey populations. Other mammals included mink, muskrat, river otter, beaver, gray fox, red fox, spotted skunk, long-tailed weasel, bats, and numerous small mammals.

Birds present in today's forests also were likely present during presettlement (Dickson 2001). Raptors such as the Mississippi kite, bald eagle, osprey, red-shouldered hawk, and barred owl were likely occupants of historic bottomland forests. The Swainson's and Bachman's warblers inhabited cane thickets, while the yellow-breasted chat and indigo bunting populated young forests. Cavity-nesting birds such as red-headed woodpeckers, American kestrels, and great crested flycatchers were abundant in the old-growth forests of eastern Texas (Truett and Lay 1984). The ivory-billed woodpecker thrived in oak-gum forests, foraging on snags for insects.

Early records of reptiles and amphibians are limited, but these records make frequent reference to rattlesnakes and alligators (Dickson 2001). Historic forest habitats appear to have supported viable, diverse populations of herpetofauna (Gibbons and Buhlman 2001).

Extensive inundated bottomland forests supported habitat for millions of wood ducks and mallards (Heitmeyer 2001). Wood ducks commonly nested in the cavities of abundant old-growth forests. Hooded mergansers, green-winged teal, gadwall, and American widgeon also frequented flooded bottoms.

The southern landscape changed dramatically with the advent of European settlers. Settlement resulted in the extensive clearing of forest and conversion of the land to pasture or cropland (DeGraaf and Miller 1996). These lands were often managed with fire, which was also used to maintain savannas and other open areas in the East (Williams 1989). In particular, fire was used to create favorable grazing conditions for domestic animals (Healy 1985).

By 1819, all land was claimed east of the Mississippi River (Dickson 2001). Natural resources were treated as if they were inexhaustible. Forests were cut with little thought for forest regeneration, and soils were seriously depleted through erosion and excessive cropping. Wildlife species and their habitats were likewise exploited without concern for their persistence. The decline in abundance of wildlife that occurred during the last half of the 19th century remains unparalleled in the history of the South.

Deer populations nationwide plummeted to fewer than a million animals by 1900 (Dickson 2001). Bison and elk disappeared from the region. The wild turkey disappeared from several States within its range. The wood duck was drastically reduced by indiscriminate harvest. Populations of large carnivores, regarded as threats to livestock and people, were decimated, and viable populations of black bear and cougar were relegated to relatively remote areas.

The loss of bottomland forest in the Mississippi Alluvial Valley affected waterfowl and other species that were displaced into adjacent areas. Harvests of the passenger pigeon and the Carolina parakeet for market led to their demise in the early 1900s (table 1.1). Market hunting, the domestication of land, and the harvest of mature forests without regeneration led to the extirpation of some species in various Southern States (table 1.2). (Note: It is possible that some species were extirpated because their range is on the periphery of the region. Their loss may be related to random effects associated with low populations at the edges of their ranges.)

During the 1930s and 1940s, the States recognized the dire status of wildlife populations and initiated efforts to address the problem. The Duck Stamp Act (1934), the Pittman-Robertson Act (1937), and the Dingle-Johnson Act (1950) apportioned funds to States for wildlife restoration projects, habitat acquisition, and research.

These efforts came too late for some species (table 1.1). The ivory-billed woodpecker foraged in mature bottomland hardwoods along the Atlantic and Gulf coasts. Its diet consisted of wood-boring insect larvae occurring in dead and dying trees. Overhunting and intensive harvesting of virgin hardwood forests between the 1880s and 1920s led to the decline of this species (U.S. Department of the Interior 1973).

Table 1.1—Terrestrial vertebrate species classified as presumed or possibly extinct in the South

Scientific name	Common name	Former areas of occurrence
Presumed extinct		
Conuropsis carolinensis	Carolina parakeet	AL, AR, FL, GA, LA, MS, NC, OK, SC, TN, TX, VA
Ectopistes migratorius	Passenger pigeon	AL, AR, FL, GA, LA, MS, NC, OK, SC, TN, TX, VA
Monachus tropicalis	West Indian monk seal	FL
Possibly extinct		
Campephilus principalis	Ivory-billed woodpecker	AL, AR, FL, GA, LA, MS, NC, OK, SC, TN, TX
Eurycea troglodytes	Valdina farms sinkhole salamander	TX
Plethodon ainsworthi	A plethodontid salamander	MS
Vermivora bachmanii	Bachman's warbler	AL, MS, OK, SC, TN, VA

Source: NatureServe 2000.

Table 1.2—Vertebrate species extirpated from selected States within the South

Scientific name	Common name	Former areas of occurrence
Mammals		
Rodents		
Erethizon dorsatum	Common porcupine	NC, VA
Microtus ochrogaster	Prairie vole	LA
Carnivores		
Canis lupus	Gray wolf	AR, GA, KY, NC, OK, TN, TX, VA
Canus rufus	Red wolf	AL, AR, FL, GA, KY, LA, OK, TX, VA
Leopardus pardalis	Ocelot	AR, LA
Leopardus wiedii	Margay	TX
Martes pennanti	Fisher	NC, TN
Mustela nigripes	Black-footed ferret	OK
Panthera onca	Jaguar; otorongo	LA
Puma concolor	Mountain lion	AL
Ursus arctos	Grizzly or brown bear	OK, TX
Other mammals		
Bos bison	American bison	AL, AR, FL, GA, KY, LA, MS, NC, OK, SC, TN, VA
Cervus elaphus	Wapiti or elk	AL, AR, GA, KY, LA, NC, OK, SC, TN, VA
Lepus americanus	Snowshoe hare	NC
Birds		
Wading birds		
Grus americana	Whooping crane	AR, FL, KY
Waterfowl		
Cygnus buccinator	Trumpeter swan	KY, LA
Shorebirds		
Bartramia longicauda	Upland sandpiper	TN
Numenus borealis	Eskimo curlew	OK, SC
Perching birds		
Corvus corax	Common raven	AL
Other birds		
Anhinga anhinga	Anhinga	KY
Centrocercus urophasianus	Sage grouse	KS, OK
Geotrygon chrysia	Key West quail-dove	FL
Tympanuchus cupido	Greater prairie chicken	AR, KY, LA, TN
Tympanuchus phasianellus	Sharp-tailed grouse	OK, TX
Zenaida aurita	Zenaida dove	FL
Reptiles		
Snakes		
Masticophis flagellum	Coachwhip	KY

Source: NatureServe 2000.

Bachman's warbler, last observed in the 1960s, once inhabited Arkansas, Kentucky, Alabama, South Carolina, Louisiana, and Missouri. The extensive clearing of bamboo and canebrake habitat for agriculture along the Mississippi River and West Gulf Coastal Plains bottoms degraded the wintering and breeding habitat for this species (Ehrlich and others 1992). Excessive collecting for the millinery trade may also have contributed to the decline.

The Valdina Farms salamander was endemic to Texas. The amphibian occurred in isolated, intermittent pools. It is now extinct due to flooding of its only known habitat. Populations of the West Indian monk seal, which originally inhabited the Florida coast, were decimated during the 19th century. The major factor in its extermination was over-hunting, principally for blubber (to make oil) and for meat. The seal's inherent tameness increased its vulnerability to slaughter.

The last four decades of the 20th century brought legislation that furthered species conservation efforts, including the Wilderness Act (1964), the Endangered Species Act (1966,

1969, and 1973), the National Environmental Policy Act (1970), the Marine Mammal Protection Act (1971), and the National Forest Management Act (1976). Through these and several other conservation efforts, conditions for many species have improved across the South (Dickson 2001). However, the loss and modification of unique forest communities continues to affect populations of other species. The remainder of this chapter examines these influences, presenting the trends for a diversity of southern species.

Status and Trends of Terrestrial Vertebrate Species

Conservation status ranks for southern species—The databases of the State Natural Heritage agencies were used to derive a regional species list of global (G) conservation ranks. The G ranks reflect a species' rarity throughout its range. For example, a species holding the G conservation ranking of G1 in Virginia also carries the same rank elsewhere in the Nation.

These ranks are: GX (presumed extinct: intensive search has not located additional populations); GH (possibly extinct: historically known and may be rediscovered); G1 [critically imperiled globally because of extreme rarity (observations include 5 or fewer locations or fewer than 1,000 animals)] or because some factor of its biology makes it vulnerable to extinction]; G2 [imperiled globally because of rarity (observations reflect 6 to 20 locations or 1,000 to 3,000 animals)] or because of other factors making it vulnerable to extinction]; G3 [vulnerable globally because of rarity throughout its range (observations include 21 to 100 locations or 3,000 to 10,000 animals) or because it is found locally in a restricted area]; G4 (apparently secure globally, although the species may be rare in parts of its range, especially at the periphery; usually more than 100 occurrences and 10,000 individuals); and G5 (secure globally: observations are common and widespread).

Figure 1.1 shows the proportion of vertebrate taxa in each of the conservation ranking categories. One hundred thirty-two species are considered to be of conservation concern. Among terrestrial vertebrates, 28 species are classified as critically imperiled, 37 species as imperiled, and 67 species as vulnerable. Eighty-six percent of southern terrestrial vertebrate species are designated as relatively secure by Natural Heritage.

Figure 1.2 shows species ranked as presumed or possibly extinct, critically imperiled, imperiled, or vulnerable among the four major vertebrate taxa. Collectively, these species represent animals with elevated risks of extinction or of conservation concern.

The proportion of species at risk varies greatly among taxonomic groups. Forty-one percent of imperiled species are amphibians, followed by reptiles (30 percent), birds (15 percent), and mammals (14 percent). With the exception of mammals, the number of species at risk within each taxonomic group is not proportionate with their respective richness in the region. For example, amphibian species comprise only 14 percent of the terrestrial vertebrates occurring in the South, yet they comprise 41 percent of the imperiled species list. Conversely, bird species comprise 48 percent of southern terrestrial vertebrates, but only 15 percent of the imperiled species. Refer to chapter 5 for additional data on regional species richness.

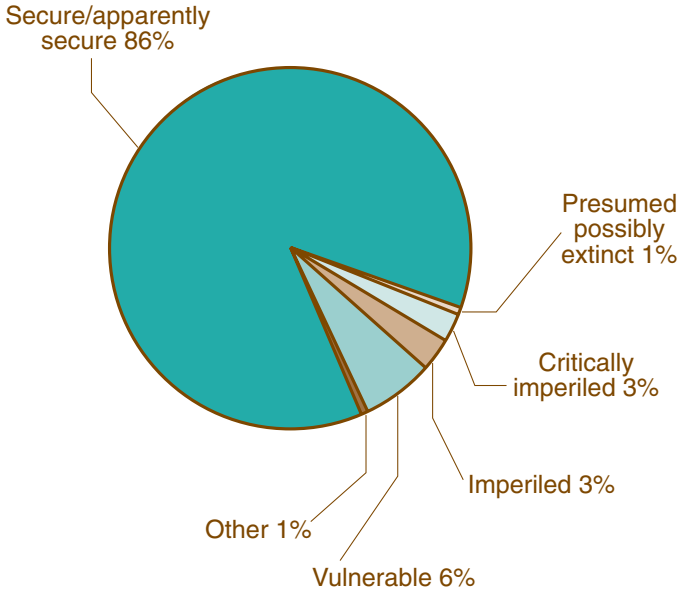

Figure 1.1—Proportion of southern terrestrial vertebrate species at risk. The Other category includes species that have not been ranked or have questionable status (NatureServe 2000).

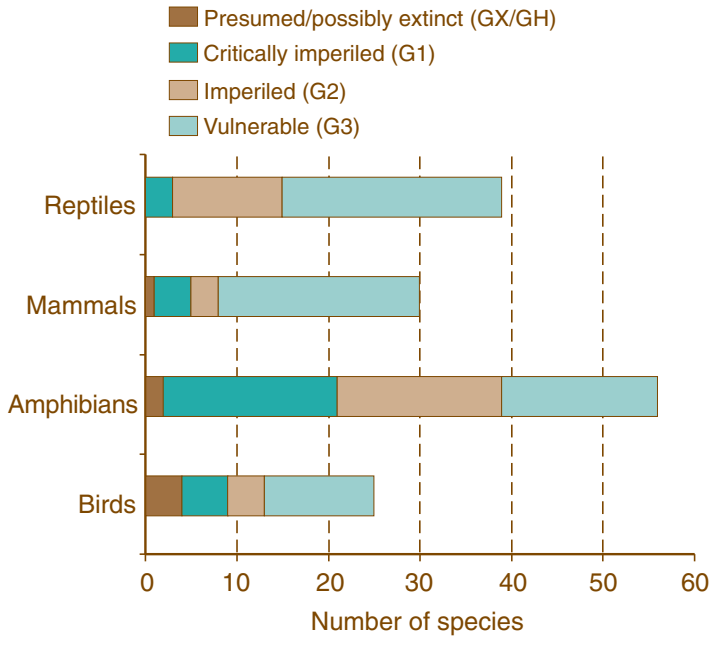

Figure 1.2—Number of terrestrial vertebrate species at risk delineated by major taxa in the South (NatureServe 2000).

Table 1.3—Amphibian species within the South with global rankings of G1, G2, and G3

Scientific name	Common name	Areas of occurrence
Frogs and toads		
G1		
Bufo houstonensis	Houston toad	TX
G2		
Rana okaloosae	Florida bog frog	FL
G3		
Rana capito	Gopher frog	AL, FL, GA, LA, MS, NC, SC, TN
Salamanders		
G1		
Desmognathus sp.1	Waterrock knob salamander	NC
Eurycea latitans	Cascade caverns salamander	TX
Eurycea nana	San Marcos salamander	TX
Eurycea neotenes	Texas salamander	TX
Eurycea rathbuni	Texas blind salamander	TX
Eurycea robusta	Blanco blind salamander	TX
Eurycea sosorum	Barton Springs salamander	TX
Eurycea sp. 1	Jollyville Plateau salamander	TX
Eurycea sp. 2	Salado Springs salamander	TX
Eurycea sp. 4	Buttercup Creek caves salamander	TX
Eurycea sp. 5	Georgetown salamander	TX
Eurycea sp. 6	Pedernales River spring salamander	TX
Eurycea sp. 7	Edwards Plateau spring salamander	TX
Eurycea sp. 8	Comal Springs salamander	TX
Eurycea tridentifera	Comal Blind salamander	TX
Plethodon petraeus	Pigeon Mountain salamander	GA
Plethodon shenandoah	Shenandoah salamander	VA
Notophthalmus meridionalis	Black-spotted newt	TX
G2		
Ambystoma cingulatum	Flatwoods salamander	AL, FL, GA, SC
Desmognathus carolinensis	Carolina mountain dusky salamander	NC, TN
Desmognathus ocoee	Ocoee salamander	AL, GA, NC, SC, TN
Desmognathus orestes	Blue Ridge dusky salamander	NC, VA
Eurycea pterophila	Blanco River Springs salamander	TX
Gyrinophilus palleucus	Tennessee cave salamander	AL, GA, TN
Haideotriton wallacei	Georgia blind salamander	FL, GA
Phaeognathus hubrichti	Red hills salamander	AL
Plethodon aureolus	Tellico salamander	NC, TN
Plethodon caddoensis	Caddo Mountain salamander	AR
Plethodon fourchensis	Fourche Mountain salamander	AR
Plethodon hubrichti	Peaks of Otter salamander	VA
Plethodon ouachitae	Rich Mountain salamander	AR,OK
Plethodon virginia	Shenandoah mountain salamander	VA
Necturus alabamensis	Black warrior waterdog	AL
Notophthalmus perstriatus	Striped newt	FL, GA
Siren sp. 1	Lesser siren (Rio Grande population)	TX
G3		
Amphiuma pholeter	One-toed amphiuma	AL, FL, GA, MS
Aneides aeneus	Green salamander	AL, GA, KY, MS, NC, SC, TN, VA
Desmognathus aeneus	Seepage salamander	AL, GA, NC, SC, TN
Desmognathus apalachicolae	Apalachicola dusky salamander	AL, FL, GA
Desmognathus brimleyorum	Ouachita dusky salamander	AR, OK
Desmognathus imitator	Imitator salamander	NC, TN

(continued)

Table 1.3—Amphibian species within the South with global rankings of G1, G2, and G3 (continued)

Scientific name	Common name	Areas of occurrence
Salamanders (cont.)		
G3 (cont.)		
Desmognathus santeetlah	Santeetlah dusky salamander	NC, TN
Desmognathus wrighti	Pigmy salamander	NC, TN, VA
Eurycea junaluska	Junaluska salamander	NC, TN
Eurycea sp. 9	Sandhills salamander	NC
Eurycea tynerensis	Oklahoma salamander	AR, OK
Plethodon punctatus	White-spotted salamander	VA
Plethodon teyahalee	Southern Appalachian salamander	GA, NC, TN
Plethodon websteri	Webster's salamander	AL, GA, LA, MS, SC
Plethodon welleri	Weller's salamander	NC, TN, VA
Necturus lewisi	Neuse River waterdog	NC

G1 = critically imperiled; G2 = imperiled; G3 = vulnerable.
Source: NatureServe 2000.

The conservation status of individual species are presented in tables 1.3, 1.4, 1.5, and 1.6. Several of these species are discussed in further detail in chapters 5 and 23, including the factors influencing imperilment and species habitat relationships. Species that are federally listed as threatened or endangered are discussed in chapter 5.

Fifty-four amphibian species are of conservation concern (table 1.3). Salamanders dominate with 51 listings; frogs and toads have 3 listings. Examples include the Houston toad, gopher frog, flatwoods salamander, Ocoee salamander, green salamander, and several species in the Plethodon, Desmognathus, and Eurycea genera.

Forty reptile species are imperiled or vulnerable (table 1.4). Reptile subgroups with global rankings of concern include turtles (19), lizards (10), snakes (9), and others (2). Oceanic and map turtles dominate this list. Other reptiles of conservation concern include the alligator snapping turtle, bog turtle, gopher tortoise, glass lizard, southern hognose snake, and crocodile.

Twenty avian species are of concern (table 1.5). Subtaxa include 2 wading birds, 3 shorebirds, 6 perching birds, and 9 others. Several of these species include the whooping crane, piping plover, Bachman's sparrow, Florida scrub jay, red-cockaded woodpecker, and lesser prairie chicken.

Eighteen mammal species are imperiled or vulnerable (table 1.6). Mammalian subtaxa with global rankings of concern include 5 bats, 8 rodents, 3 carnivores, and 2 others. Bats are represented by the Indiana bat, Rafinesque's big-eared bat, southeastern myotis, and several other species. Additional mammals include the Allegheny wood rat, red wolf, and swift fox.

Population and harvest trends for southern species—The regional population and harvest trends presented in this section, unless otherwise stated, originated from the RPA (Flather and others 1999). The RPA represented the best source of quantitative data on regional trends for multiple species at the time of this Assessment. Information was collected from cooperating State wildlife agencies. Population estimates were summed across those States that provided data. (The list of States that provided population estimates is available at the Rocky Mountain Research Station, Fort Collins, CO.) The absence of data from certain States resulted from variation in the distribution of species or the lack of data for certain years. The RPA included only States that provided estimates for 1975 to 1990 (in 5-year intervals) and 1993 in the trend analysis.

Projections were based on a weighted average percentage change from 1993 to the year 2000 and 2045 for States that provided projection estimates. The average percentage change was then applied to the 1993 population estimate in order to extrapolate a total projected population for States that provided population estimates (Flather and others 1999).

Population and harvest trends for southern species: big game species—Big game species are primarily large mammals taken for sport or subsistence. Because of State agency convention, the wild turkey also is included. The species comprising big game were the first to stimulate widespread public interest in wildlife conservation. For this reason, historical information about game species is extensive for several States.

Wild turkey populations have consistently increased since 1975 (fig. 1.3). Five States project that turkey populations will decline over the next four decades (Flather and others 1999).

For States reporting on white-tailed deer, populations have increased approximately fourfold since 1975 (fig. 1.4). There is concern among State personnel that deer may become a management problem during the next decade. Seven States expect deer numbers to decline slightly over the next 50 years (Flather and others 1999). (Additional information on deer is provided in chapters 3, 4, and 5.)

The trend in black bear numbers is positive for the four States reporting (fig. 1.5). Biologists from these States expect bear populations to decline somewhat over the next few decades (Flather and others 1999). (Note: The Florida and Louisiana subspecies of

Table 1.4—Reptile species within the South with global rankings of G1, G2, and G3

Scientific name	Common name	Areas of occurrence
Turtles		
G1		
Lepidochelys kempii	Kemp's or Atlantic ridley	AL, FL, GS, LA, MS, NC, TX, VA
Pseudemys alabamensis	Alabama redbelly turtle	AL, FL, MS
G2		
Sternotherus depressus	Flattened musk turtle	AL
Graptemys barbouri	Barbour's map turtle	AL, FL, GA
Graptemys ernsti	Escambia map turtle	AL, FL
Graptemys flavimaculata	Yellow-blotched map turtle	MS
Graptemys oculifera	Ringed map turtle	LA, MS
G3		
Macroclemys temminckii	Alligator snapping turtle	AL, AR, FL, GA, KY, LA, MO, MS, OK, TN, TX
Caretta caretta	Loggerhead	AL, FL, GA, LA, MS, NC, SC, TX, VA
Chelonia mydas	Green turtle	AL, FL, GA, LA, MS, SC, TX, VA
Eretmochelys imbricata	Hawksbill	AL, FL, GA, LA, MS, NC, SC, TX
Dermochelys coriacea	Leatherback tinglar	AL, FL, GA, LA, MS, NC, TX, VA
Kinosternon hirtipes	Mexican mud turtle	TX
Clemmys muhlenbergii	Bog turtle	GA, NC, SC, TN, VA
Gopherus polyphemus	Gopher tortoise	AL, FL, GA, LA, MS, SC
Graptemys caglei	Cagle's map turtle	TX
Graptemys gibbonsi	Pascagoula map turtle	LA, MS
Graptemys nigrinoda	Black-knobbed map turtle	AL, MS
Trachemys gaigeae	Big bend slider	TX
Lizards		
G2		
Sceloporus arenicolus	Sand dune lizard	TX
Neoseps reynoldsi	Sand skink	FL
G3		
Crotaphytus reticulatus	Reticulate collared lizard	TX
Holbrookia lacerata	Spot-tailed earless lizard	TX
Holbrookia propinqua	Keeled earless lizard	TX
Sceloporus woodi	Florida scrub lizard	FL
Coleonyx reticulatus	Reticulated gecko	TX
Cnemidophorus dixoni	Gray-checkered whiptail	TX
Ophisaurus compressus	Island glass lizard	FL, GA, SC
Ophisaurus mimicus	Mimic glass lizard	AL, FL, GA, MS, NC, SC
Snakes		
G1		
Tantilla oolitica	Rim Rock crowned snake	FL
G2		
Clonophis kirtlandii	Kirtland's snake	KY
Heterodon simus	Southern hognose snake	AL, FL, GA, MS, NC, SC
Nerodia harteri	Brazos water snake	TX
Nerodia paucimaculata	Concho water snake	TX
G3		
Pituophis ruthveni	Louisiana pine snake	LA, TX
Stilosoma exenuatum	Short-tailed snake	FL
Tantilla atriceps	Mexican blackhead snake	TX
Sistrurus catenatus	Massasauga	OK, TX
Other reptiles		
G2		
Crocodylus acutus	American crocodile	FL
G3		
Caiman crocodilus	Spectacled caiman	FL, GA

G1 = critically imperiled; G2 = imperiled; G3 = vulnerable.
Source: NatureServe 2000.

Table 1.5—Bird species within the South with global rankings of G1, G2, and G3

Scientific name	Common name	Areas of occurrence
Wading birds		
G1		
Grus Americana	Whooping crane	AL, GA, LA, OK, TX
G3		
Phoenicopterus ruber	Greater flamingo	FL
Shorebirds		
G1		
Numenus borealis	Eskimo curlew	AR, LA, NC, TX
G2		
Charadrius montanus	Mountain plover	OK, TX
G3		
Charadrius melodus	Piping plover	AL, AR, FL, GA, KY, LA, MS, NC, OK, TN, TX, VA
Perching birds		
G2		
Dendroica chrysoparia	Golden-cheeked warbler	TX
Vireo atricapillus	Black-capped vireo	MS, OK, TX
G3		
Aimophila aestivalis	Bachman's sparrow	AL, AR, FL, GA, KY, LA, MS, NC, OK, SC, TN, TX, VA
Aphelocoma coerulescens	Florida scrub jay	FL
Pipilo alberti	Albert's towhee	TX
Vermivora crissalis	Colima warbler	TX
Other birds		
G1		
Pterodroma feae	Fea's petrel	NC
Pterodroma hasitata	Black-capped petrel	FL, GA, NC, VA
G2		
Amazona viridigenalis	Red-crowned parrot	FL, TX[a]
G3		
Columba leucocephala	White-crowned pigeon	FL, TX
Pelecanus erythrorhynchos	American white pelican	AL, AR, FL, GA, KY, LA, MS, NC, OK, TN, TX
Picoides borealis	Red-cockaded woodpecker	AL, AR, FL, GA, KY, LA, MS, NC, OK, SC, TN, TX, VA
Strix occidentalis	Spotted owl	TX[a]
Thalassarche chlororhynchos	Yellow-nosed albatross	FL, NC
Tympanuchus pallidicinctus	Lesser prairie chicken	OK, TX

G1 = critically imperiled; G2 = imperiled; G3 = vulnerable.
[a] West Texas.
Source: NatureServe 2000.

black bear, of conservation concern in the region, are discussed separately in chapter 5.)

Population and harvest trends for southern species: small game species—Species classified as small game typically include resident game birds and mammals that are associated with upland (forest, range, or agricultural) habitats. There is some variation among State wildlife agencies as to which species are managed as small game. In this chapter, quail, grouse, rabbits, and squirrels are considered small game. Few State wildlife agencies monitor small game populations; therefore, the trends reviewed here should be interpreted carefully.

The populations of gray, red, and fox squirrels have been declining in the South since 1985 (fig. 1.6). Cottontail rabbit populations declined slightly between 1975 and 1980 (fig. 1.7), but recovered by 1990. One State projects that cottontail rabbit populations may decline by 2045 (Flather and others 1999).

Northern bobwhite quail populations have declined from 1975 to the present (fig. 1.8). Among the States reporting trends in bobwhite abundance, populations have declined by nearly

Table 1.6—Mammal species within the South with global rankings of G1, G2, and G3

Scientific name	Common name	Areas of occurrence
Bats		
G2		
Myotis sodalis	Indiana or social myotis	AL, AR, KY, NC, OK, SC, TN, VA
G3		
Corynorhinus rafinesquii	Rafinesque's big-eared bat	AL, AR, FL, GA, KY, LA, MS, NC, OK, SC, TN, TX, VA
Myotis austroriparius	Southeastern myotis	AL, AR, FL, GA, KY, LA, MS, NC, OK, SC, TN, TX, VA
Myotis grisescens	Gray myotis	AL, AR, FL, GA, KY, OK, SC, TN, VA
Myotis leibii	Eastern small-footed myotis	AL, AR, GA, KY, NC, OK, SC, TN, VA
Rodents		
G1		
Dipodomys elator	Texas kangaroo rat	OK, TX
G2		
Geomys texensis	Llano pocket gopher	TX
G3		
Tamias canipes	Gray-footed chipmunk	TX
Geomys arenarius	Desert pocket gopher	TX
Geomys knoxjonesi	Jones' pocket gopher	TX
Neofiber alleni	Round-tailed muskrat	FL, GA
Neotoma magister	Allegheny woodrat	AL, KY, NC, TN, VA
Podomys floridanus	Florida mouse	FL
Carnivores		
G1		
Canus rufus	Red wolf	NC, SC, TN
G3		
Vulpes velox	Swift fox	OK, TX
Panthera onca	Jaguar; otorongo	TX
Other mammals		
G2		
Trichecchus manatus	Manatee	FL, GA, LA, MS, NC, SC, TX, VA
G3		
Antilope cervicapra	Blackbuck	TX[a]

G1 = critically imperiled; G2 = imperiled; G3 = vulnerable.
[a] Exotic.
Source: NatureServe 2000.

50 percent, from 23 million birds in 1975 to 12 million birds in 1993 (Flather and others 1999). Forest (ruffed) grouse populations show a cyclical pattern, but appear to have declined since 1985 (fig. 1.9).

Bobwhite quail trends from the Breeding Bird Survey (BBS) are consistent with State agency estimates (Flather and others 1999). BBS data suggest that the abundance of this species has declined significantly ($P < 0.05$) in the South. Bobwhite numbers have declined by 2.6 percent per year from 1966 to 1996, and have declined at an even greater rate since 1985 (-5.6 percent per year).

State agency projections for most small game species suggest minor changes in future population status. Forest grouse are expected to remain stable. State biologists forecast declines for bobwhite quail, squirrels, and cottontails.

Population and harvest trends for southern species: migratory game birds—Migratory game birds include waterfowl, such as ducks and geese, and other migratory species, such as mourning doves and woodcock. The long history of migratory bird management in North America has resulted in an impressive monitoring system. Population and harvest trends originate from annual reports published by the U.S. Fish and Wildlife Service and the North American Waterfowl Plan (Flather and others 1999).

Waterfowl trends are traditionally tracked by major flyways, which are the migration routes from breeding to wintering habitat. In the South, the major routes are the Atlantic and Mississippi flyways (fig. 1.10). National duck harvests have been recorded since the early 1960s.

Over the last 25 years, 41 percent of the national harvest was taken in the Mississippi flyway and 15 percent from the Atlantic flyway. Both had large harvests during the 1970s, followed by

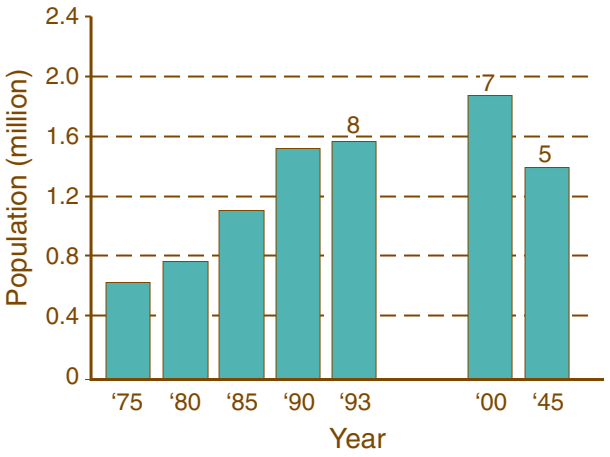

Figure 1.3—Population trends of wild turkey in Southern States that provided estimates and long-term projections [based on State wildlife agency data (Flather and others 1999)].

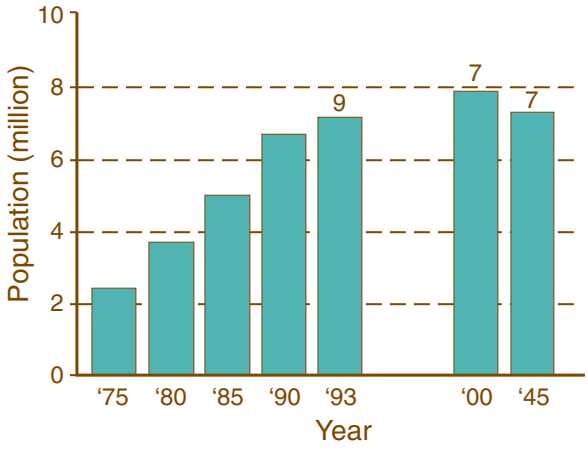

Figure 1.4—Population trends of deer in Southern States that provided estimates and long-term projections [based on State wildlife agency data (Flather and others 1999)].

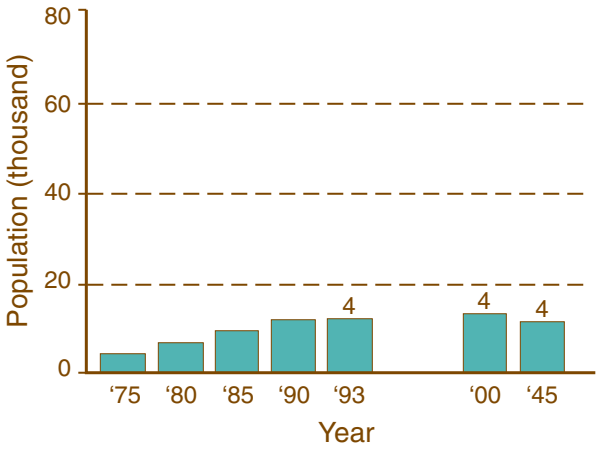

Figure 1.5—Population trends of black bear in Southern States that provided estimates and long-term projections [based on State wildlife agency data (Flather and others 1999)].

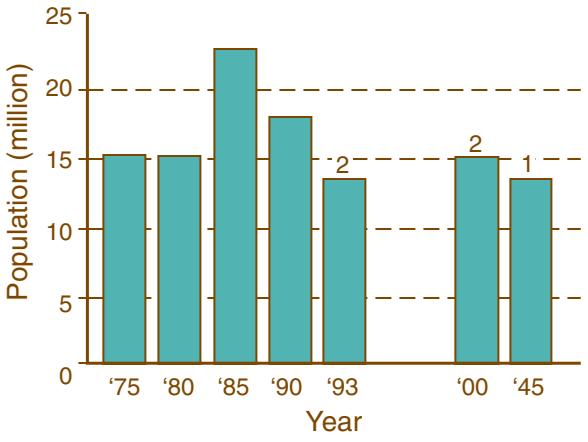

Figure 1.6—Population trends of red, gray, and fox squirrels in Southern States that provided estimates and long-term projections [based on State wildlife agency data (Flather and others 1999)].

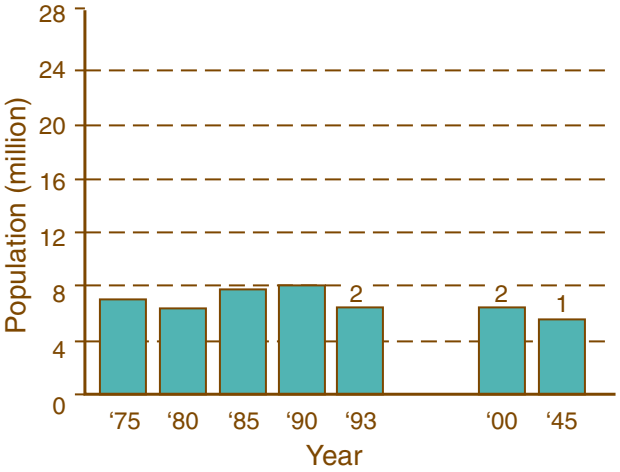

Figure 1.7—Population trends of cottontail rabbits in Southern States that provided estimates and long-term projections [based on State wildlife agency data (Flather and others 1999)].

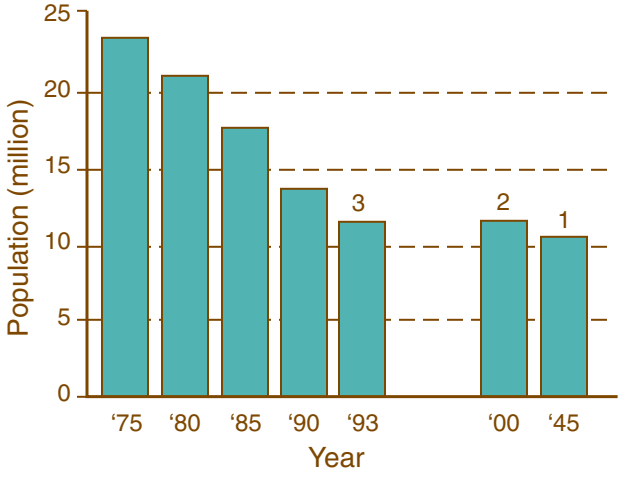

Figure 1.8—Population trends of northern bobwhite quail in Southern States that provided estimates and long-term projections [based on State wildlife agency data (Flather and others 1999)].

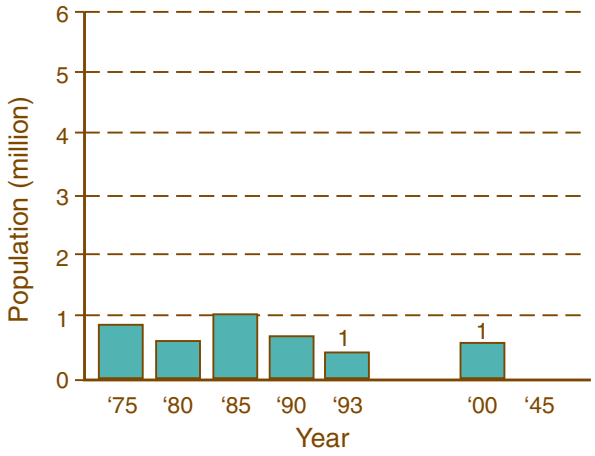

Figure 1.9—Population trends of forest grouse in Southern States that provided estimates and long-term projections [based on State wildlife agency data (Flather and others 1999)].

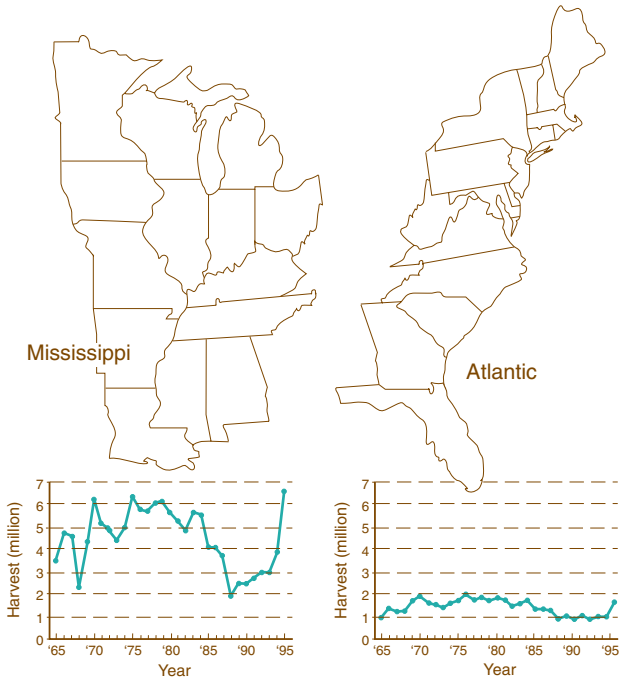

Figure 1.10—Trends in duck harvest from 1965 to 1995 by administrative flyway encompassing the South (Flather and others 1999).

substantial declines through much of the 1980s, and substantial harvest increases during the 1990s. Duck harvests in the Mississippi flyway increased by 260 percent from 1988 to 1995, with a record 6.6 million ducks harvested in 1995 (Flather and others 1999).

Trends in goose abundance were derived from surveys conducted in migration and wintering areas. Record numbers of geese were harvested for three consecutive years starting in 1993 along the Mississippi flyway (fig. 1.11). After reaching a peak harvest of about 550,000 birds in 1983, the goose harvest in the Atlantic flyway declined to nearly 180,000 birds in 1995.

Management units are traditionally used by agencies to report population trends of mourning doves and American woodcock. Both species are monitored using call-count surveys, which provide an index of population size. National trends in population indices for both species show evidence of declines, but the magnitude of the decline is greater for woodcock than for mourning doves. This pattern is confirmed by BBS data, which indicate

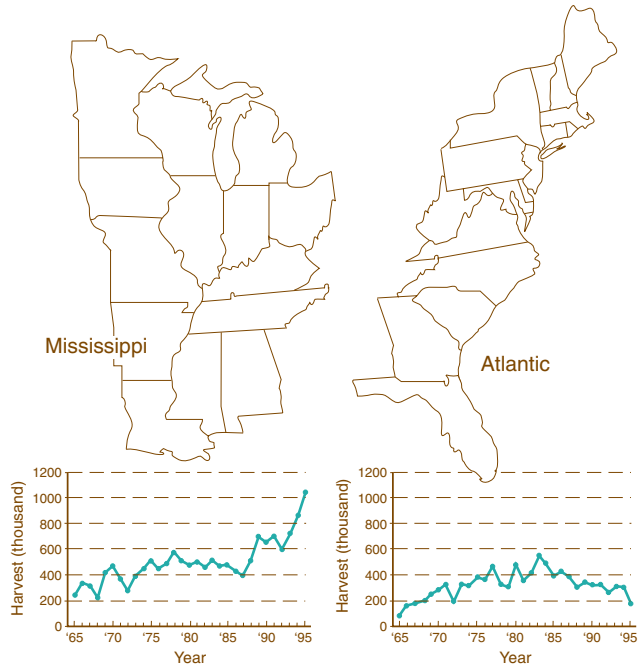

Figure 1.11—Trends in goose harvest from 1965 to 1995 by administrative flyway encompassing the South (Flather and others 1999).

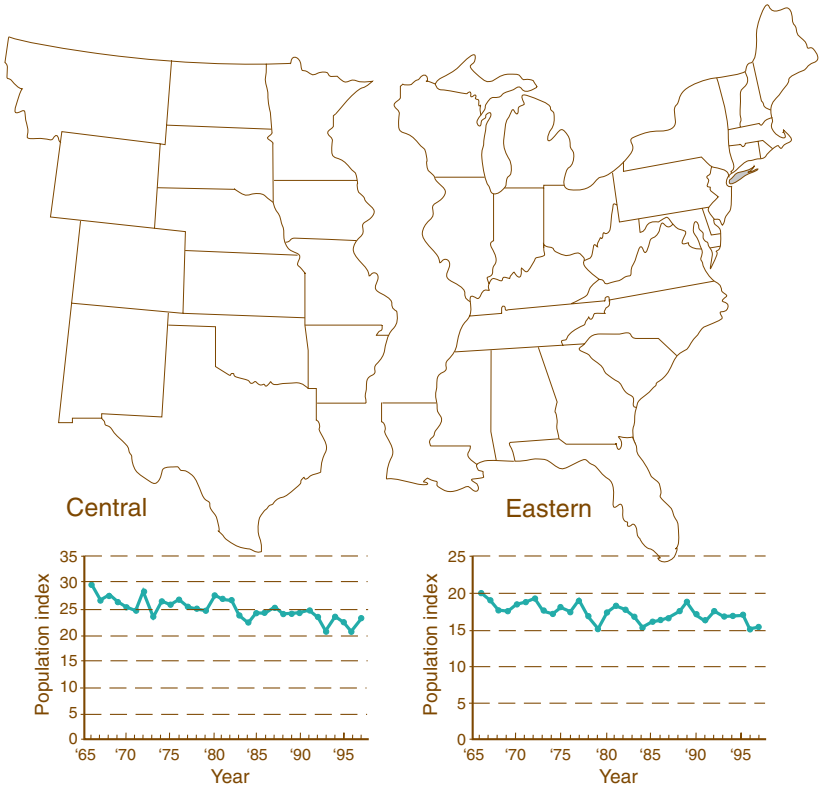

Figure 1.12—Population trends in mourning dove from 1966 to 1996 by management unit (Flather and others 1999).

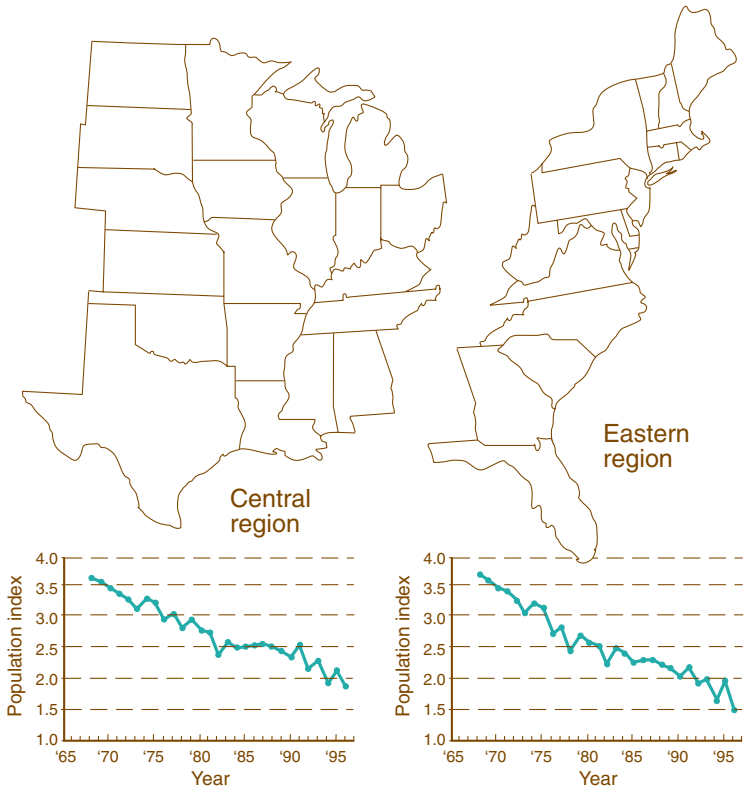

Figure 1.13—Population trends in woodcock from 1968 to 1996 by management unit (Flather and others 1999).

that doves declined annually at a rate of 0.3 percent compared to a 3.2 percent decline for woodcock over the 30-year period (Flather and others 1999).

Mourning dove calling counts indicate declining populations during the last 10 years in the eastern and central management units (fig. 1.12). Intensive agricultural practices may be influencing the breeding populations throughout much of the bird's range (Brady and others 1998). The acreage of agricultural land in the eastern management unit is positively related to dove populations because agricultural fields provide the forest edge habitat preferred by doves. Increased herbicide use and crop rotation may have contributed to observed declines (Martin and Sauer 1993). In the central management unit, the trend toward fewer and larger farms also may have influenced dove populations.

Call-count trends for woodcock show similar declines in both the eastern and central management units (fig. 1.13). Trends since 1968 indicate that the number of woodcock heard have declined by 2.5 percent per year in the eastern unit and 1.6 percent per year in the central unit (Flather and others 1999). In the last decade, this rate of decline has accelerated. Woodcock select early successional hardwood forests interspersed with fields and forest openings. As with the mourning dove, the widespread decline in woodcock may be linked with habitat alteration due to forest succession and land use intensification (Straw and others 1994).

Population and harvest trends for southern species: furbearer species—There are few comprehensive examinations of trends in furbearer populations nationwide. Often, the only available data are temporal harvest trends that reflect fur prices rather than population status. The limited information on population trends makes furbearer projections uncertain.

The RPA used a compilation of furbearer status reports completed for the International Association of Fish and Wildlife Agencies during 1993. A survey of State agency biologists provided population projections to 2003 (Southwick Associates. 1993. 1993 State and provincial survey of furbearers with emphasis on nuisance animals. Unpublished report. On file with:

Rocky Mountain Research Station, 2150 Center Avenue, Fort Collins, CO 80526).

Population projections of southern furbearers are shown in figs. 1.14, 1.15, 1.16, 1.17, 1.18, and 1.19. Of the 10 Southern States reporting beaver population projections, 5 expected population increases through 2003 (fig. 1.14). The beaver population is projected to decline in North Carolina, and remain stable (or increase) in the remainder of the South.

The majority of raccoon populations are projected to increase or remain stable throughout the South (fig. 1.15). Exceptions occur in Alabama and North Carolina, where disease-caused declines are projected (Flather and others 1999).

Of the four States reporting on muskrat populations, two expect population increases through 2003 (fig. 1.16). The remaining States (Virginia and Tennessee) project stable populations. Projections on coyote abundance are limited to Georgia and Mississippi (fig. 1.17). Both States report that coyote populations are expected to remain stable.

Bobcat projections are reported only for Florida and Oklahoma (fig. 1.18). Florida biologists report stable bobcat populations, while Oklahoma biologists report that bobcat populations are increasing. Finally, the five States that made projections for red and gray foxes (Virginia, Kentucky, Tennessee, South Carolina, and Texas) predicted stable populations (fig. 1.19).

Population and harvest trends for southern species: nongame birds— In the United States, nongame birds are not legally taken for sport, subsistence, or profit. Nongame species comprise the majority of taxa that inhabit the South. There are few data sources on populations of nongame species.

Data from the BBS were used to provide information on breeding bird trends in the South for the RPA. Details on the implementation of the BBS can be found in Droege (1990); information on statistical analyses can be found in Sauer and others (1997). The relative abundance trend for each bird species was summarized in two ways. First, the numbers of species with statistically significant increasing, decreasing, or stable trends were estimated. Second, birds were grouped according to life-history characteristics including nest

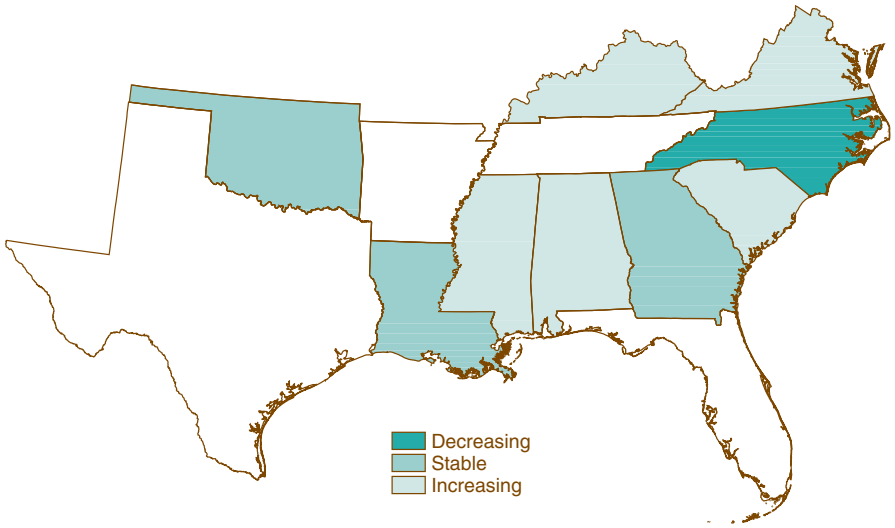

Figure 1.14—Projected trends of beaver populations in the South [based on State wildlife agency data (Flather and others 1999)]. States that provided estimates are shaded.

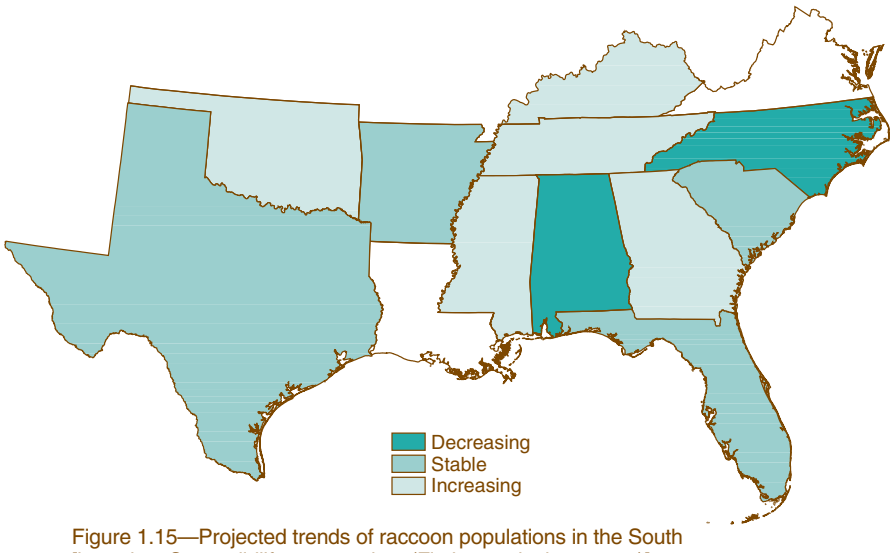

Figure 1.15—Projected trends of raccoon populations in the South [based on State wildlife agency data (Flather and others 1999)]. States that provided estimates are shaded.

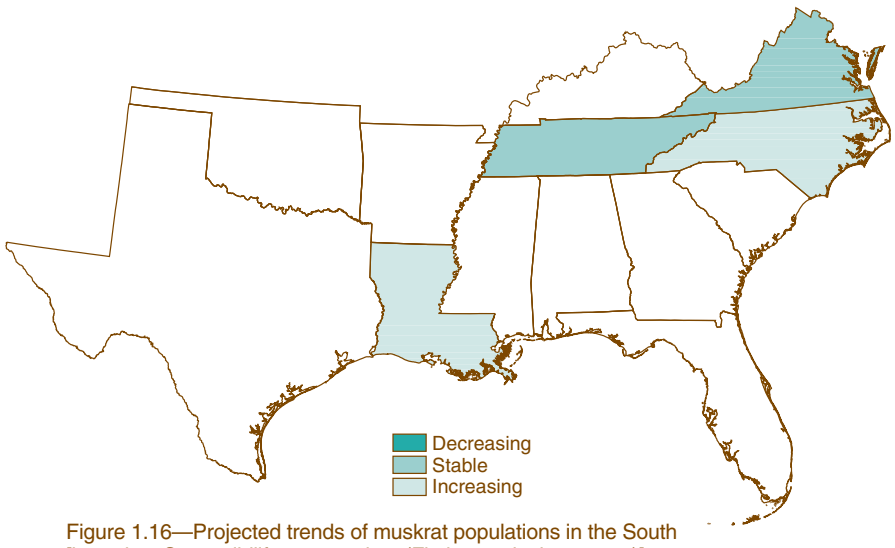

Figure 1.16—Projected trends of muskrat populations in the South [based on State wildlife agency data (Flather and others 1999)]. States that provided estimates are shaded.

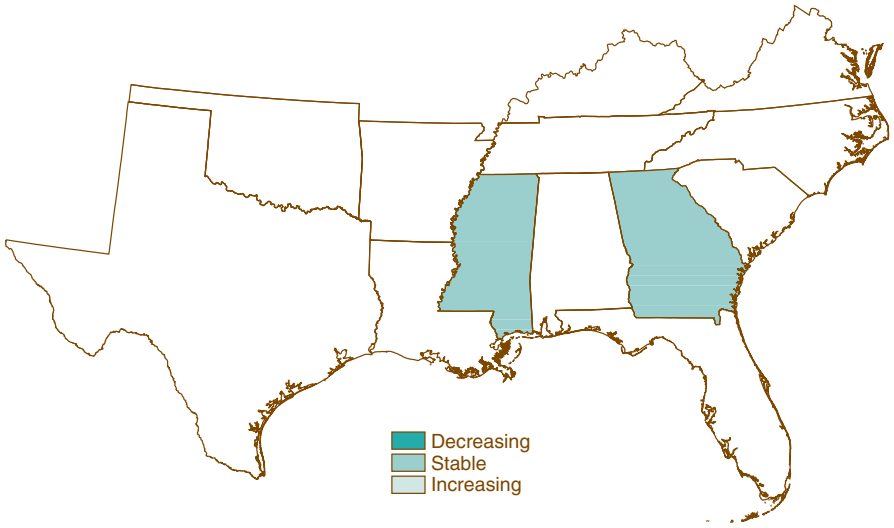

Figure 1.17—Projected trends of coyote populations in the South [based on State wildlife agency data (Flather and others 1999)]. States that provided estimates are shaded.

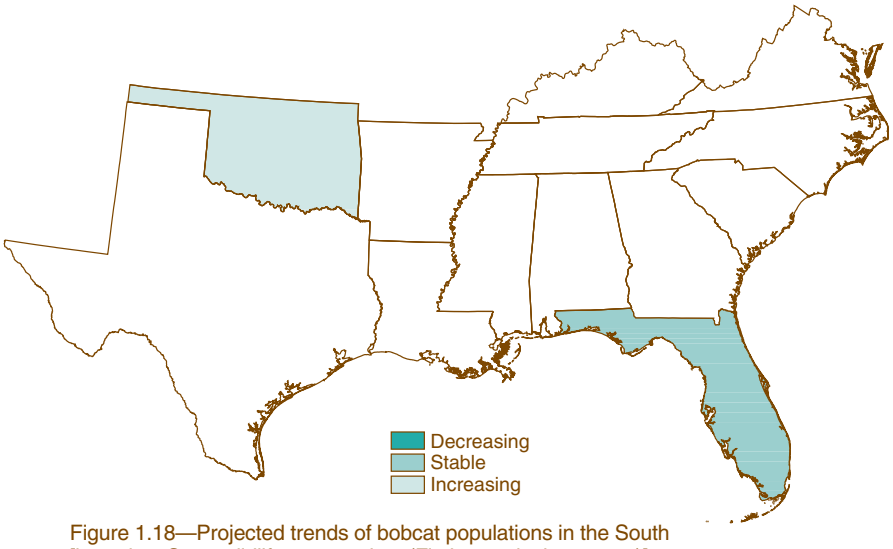

Figure 1.18—Projected trends of bobcat populations in the South [based on State wildlife agency data (Flather and others 1999)]. States that provided estimates are shaded.

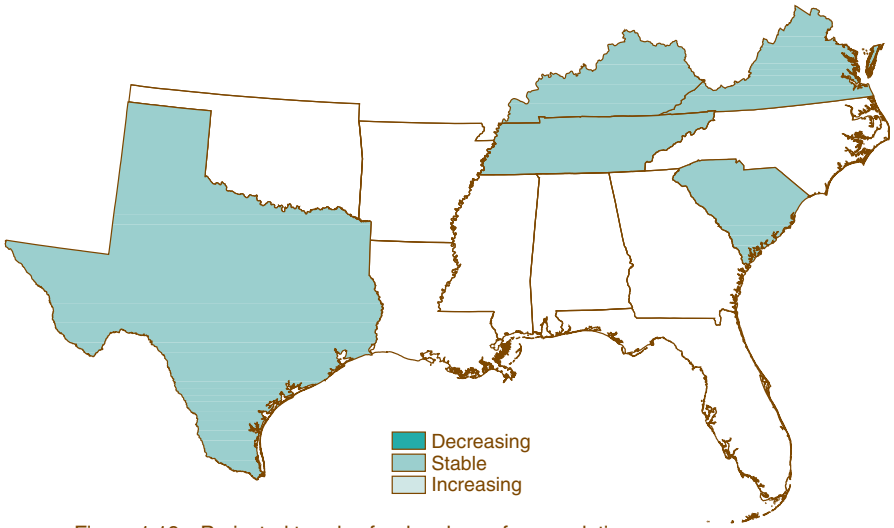

Figure 1.19—Projected trends of red and gray fox populations in the South [based on State wildlife agency data (Flather and others 1999)]. States that provided estimates are shaded.

type (cavity or open cup), nest location (ground, low, midstory, or canopy), migration status (neotropical migrant, short-distance migrant, permanent resident), and breeding habitat (woodland, shrubland, grassland, wetland, urban). The resulting trends are presented in figure 1.20.

Approximately 42.4 percent of breeding bird species appear stable, 35.2 percent have declined, and 22.4 percent have increased across the South (table 1.7). It is worth noting that Flather and others (1999) found that the percentage of declining species was greater in the South than in any other RPA region. Abundance trends among species groups vary considerably. Species with declining trends include 70 percent of grassland-nesting birds, 57 percent of ground-nesting birds, 53 percent of shrubland-nesting birds, 49 percent of open-cup nesting birds, 46 percent of urban-nesting birds, and 41 percent of neotropical migrants. Numbers of the majority of cavity-nesting species and wetland species have been stable.

Figure 1.21 suggests that bird species richness is high along the Southern Appalachians and along the Atlantic Coast from northeastern North Carolina to the Chesapeake Bay. Because some species are missed during bird count surveys including nocturnal species, raptors, and absent migrants, it is important to note that the bird richness estimates are biased low (Sauer and others 1997).

Raptors include hawks, falcons, eagles, vultures, and owls. In contrast to other bird species, raptors naturally exist at relatively low population densities and are widely dispersed in their habitats. The natural scarcity of raptors, their ability to move quickly, and the difficulties of detection inhibit the determination of population status (Fuller and others 1995).

As a group, raptors are poorly surveyed, and quantitative data are lacking to determine their population trends. Table 1.8 presents a national summary of the status and population trends of 33 species and subspecies of southern raptors. Two species, the American kestrel and burrowing owl, are declining across the United States. Mississippi kites, osprey, bald eagles, and peregrine falcons are increasing. Populations of 22 species are considered stable nationwide.

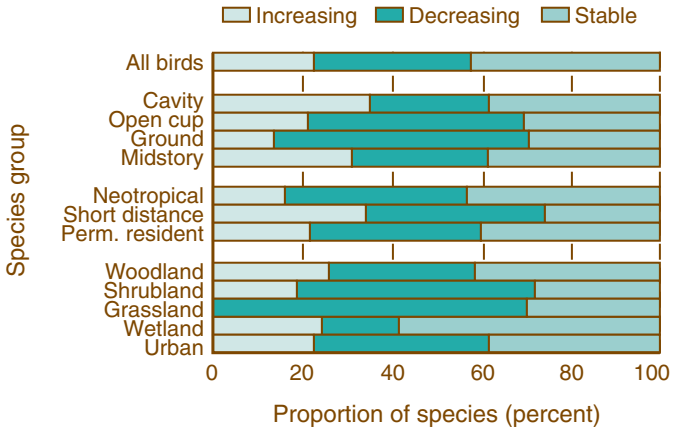

Figure 1.20—The proportion of southern bird species with increasing, decreasing, and stable trends from 1966 to 1996. Birds have been grouped by broad life-history characteristics, migration status, and breeding habitat (Flather and others 1999).

Table 1.7—Number of breeding bird species with increasing, decreasing, and stable trends from 1966 to 1996 by life history characteristics for the South

Life history characteristic	Total species	Increasing species	Decreasing species	Stable species
	N	*N (Percent)*		
All species	210	47 (22.4)	74 (35.2)	89 (42.4)
Nest type/location				
Cavity	29	10 (34.5)	8 (27.6)	11 (37.9)
Open cup	86	18 (20.9)	42 (48.8)	26 (30.2)
Ground/low	54	7 (13.0)	31 (57.4)	16 (29.6)
Midstory/canopy	65	20 (30.8)	20 (30.8)	25 (38.5)
Migration status				
Neotropical	76	12 (15.8)	31 (40.8)	33 (43.4)
Short distance	50	17 (34.0)	20 (40.0)	13 (26.0)
Permanent resident	42	9 (21.4)	16 (38.1)	17 (40.5)
Breeding habitat				
Woodland	58	15 (25.9)	19 (32.8)	24 (41.4)
Shrubland	43	8 (18.6)	13 (53.5)	12 (27.9)
Grassland	10		7 (70.0)	3 (30.0)
Wetland/open water	46	11 (23.9)	8 (17.4)	27 (58.7)
Urban	13	2 (15.4)	6 (46.2)	5 (38.5)

Source: Flather and others 1999.

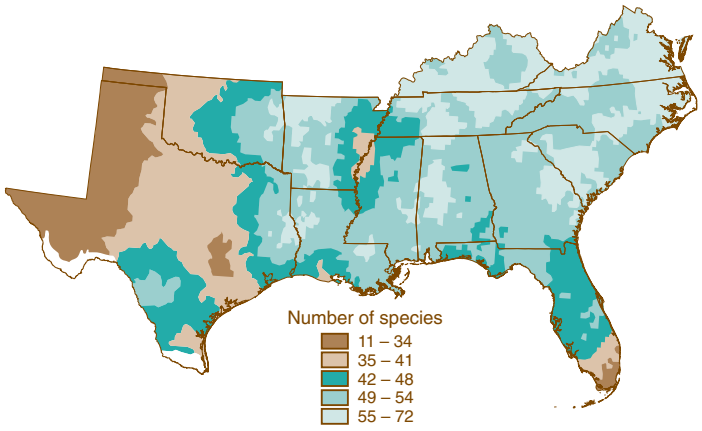

Figure 1.21—Patterns of bird richness in the South based upon counts from the Breeding Bird Survey (Flather and others 1999).

Table 1.8—The national trends of raptors that occur in the South

Scientific name	Common name	Status/Trend/Comments
Accipiter cooperii	Cooper's hawk	Stable
Accipiter gentilis	Northern goshawk	Unknown/C2[a]
Accipiter striatus	Sharp-shinned hawk	Stable/regional differences
Aquila chrysaetos	Golden eagle	Stable
Asio acadicus	Northern saw-whet owl	Stable
Asio flammeus	Short-eared owl	Stable/local concern
Asio otus	Long-eared owl	Stable/local concern
Athene cunicularia	Burrowing owl	Declining/local concern
Bubo virginianus	Great horned owl	Stable
Buteo brachyurus	Short-tailed hawk	Stable/northern range limit, about <500 birds in U.S.
Buteo lagopus	Rough-legged hawk	Stable
Buteo lineatus	Red-shouldered hawk	Stable/local concern
Buteo jamaicensis	Red-tailed hawk	Stable/local increases; Breeding Bird Survey data
Buteo platypterus	Broad-winged hawk	Stable/migration count decline in 1980s
Buteo regalis	Ferruginous hawk	Unknown/C2
Buteo swainsoni	Swainson's hawk	Unknown/C3;[b] local concern
Caracara plancus	Crested caracara	Unknown/northern range limit
Cathartes aura	Turkey vulture	Stable
Circus cyaneus	Northern harrier	Stable/nomadic, no standard survey; local concern
Coragyps atratus	Black vulture	Stable/population estimation difficult
Elanoides forficatus	American swallow-tailed kite	Stable/historical range
Falco columbarius	Merlin	Stable
Falco peregrinus anatum	American peregrine falcon	Endangered; increasing
Falco sparverius	American kestrel	Stable/Breeding Bird Survey Data
Falco sparverius paulus	American kestrel, Florida	Declining/C2
Haliaeetus leucocephalus	Bald eagle	Threatened or endangered in contiguous U.S.; increasing/status reassessment underway
Ictinia mississippiensis	Mississippi kite	Increasing/range expansion
Nyctea scandiaca	Snowy owl	Stable
Otus asio	Eastern screech-owl	Stable
Pandion haliaetus	Osprey	Increasing/good information
Rostrhamus sociabilis	Snail kite	Endangered, stable/northern range limit
Strix varia	Barred owl	Stable/western range expansion
Tyto alba	Common barn owl	Stable/local concern

[a] Proposal to list; available data are not conclusive for threatened or endangered status.
[b] Proven more widespread than previously believed or not subject to identifiable threat.
Source: Fuller and others 1995.

The status of a raptor population often reflects changes in the availability of prey species. However, changes in raptor status also can indicate subtle environmental conditions, such as chemical contamination or disease.

Nesting ospreys are concentrated along the Atlantic Coast. Most regional populations declined through the early 1970s. Following the nationwide ban on DDT in 1972, osprey productivity improved, and population numbers increased in many areas. Osprey numbers are stable, and in some areas they are increasing.

The endangered snail kite breeds in central and southern Florida wetlands, the northern extent of the range. The species declined from 1900 to 1960. Populations remain relatively stable today.

Bald eagle populations declined dramatically between 1950 and 1970. Illegal shooting, habitat alteration, and DDT adversely affected bird populations. The species was classified as endangered in 1978. Following the DDT ban, bald eagle reproduction improved, and populations began increasing. The active protection of nesting habitat and release of hand-reared eagles aided this increase. Habitat loss remains a threat in many areas (Fuller and others 1995).

Ferruginous hawk populations are stable in some areas, but declining in others. Status determination is complicated by the low density of nesting birds and fluctuation in breeding associated with cycles of prey abundance.

The peregrine falcon also suffered from contamination by DDT and other organochlorine pesticides. Peregrine

recovery has been hastened in the East by the release of hundreds of birds bred in captivity; these birds survived and produced young in the wild.

Sensitive and Rare Communities

Extent of threatened communities—Several authors have described and identified the threatened and sensitive communities in the South (Boyce and Martin 1993, Grossman and others 1994, Noss and others 1995, White and others 1998). The South supports a diversity of communities; a high proportion of them are considered imperiled to some degree (Walker 2001).

Noss and others (1995) listed numerous threatened and endangered communities that have experienced losses in the South (table 1.9). The amount of areal loss relative to the estimated presettlement area was used as an indicator of vulnerability. The 14 communities listed as critically endangered have estimated losses of over 98 percent of their area since European settlement. These include old-growth deciduous forest, spruce-fir forests, longleaf pine savannas, bottomland forest, and several types of prairies. Twenty-five endangered communities have experienced losses between 85 and 98 percent. These communities include Coastal Plain hardwoods, pocosins, mountain bogs, ultramafic glades, and Louisiana prairies.

Having experienced over 70 percent losses compared to estimated presettlement area, 11 communities are regarded as threatened. These include tropical hardwood hammocks, sandhill woodlands, and saline prairies.

In addition to the list in table 1.9, Noss and others (1995) reported 24 communities that have lost at least 50 percent of their area. These include pocosins (Coastal Plain), sand pine (Florida), baldcypress-tupelo (Mississippi, Tennessee), flatwoods-swale habitats (Florida), herbaceous marsh (Florida), calcareous forest (Louisiana), scrub-shrub swamp (Louisiana), cove hardwood forest (Tennessee), and others.

Boyce and Martin (1993) also recognized several sensitive communities that are under pressure from a variety of factors. Such factors included

Table 1.9—Ecosystem communities that have declined by 70 percent or more in the South since European settlement

Ecosystem type	Geographic area
Critically endangered: >98 percent loss	
Old-growth deciduous forests	Southeast
Southern Appalachian spruce-fir	Tennessee, North Carolina, Virginia
Longleaf pine forests and savannas	Southeastern Coastal Plain
Slash pine and rockland habitat	Southern Florida
Loblolly-shortleaf pine forests	West Gulf Coastal Plain
Canebrakes	Southeast
Bluegrass savannah-woodland and prairies	Kentucky
Black Belt and Jackson prairies	Alabama, Mississippi
Ungrazed dry prairie	Florida
Wet and mesic coastal prairies	Louisiana
Atlantic white-cedar	Virginia, North Carolina
Native prairies	Kentucky
Bottomland forest	West Virginia
High-quality oak-hickory	Cumberland Plateau, Tennessee
Endangered: 85-98 percent loss	
Red spruce	Central Appalachians
Spruce-fir forest	West Virginia
Upland hardwoods	Coastal Plain, Tennessee
Old-growth oak-hickory	Tennessee
Cedar glades	Tennessee
Longleaf pine	Texas, Louisiana
Longleaf pine forest, 1936-87	Florida
Mississippi terrace prairie, calcareous prairie, Fleming glades	Louisiana
Live oak, live oak-hickory	Louisiana
Prairie terrace-loess oak forest	Louisiana
Mature forest, all types	Louisiana
Shortleaf pine-oak-hickory	Louisiana
Mixed hardwood-loblolly pine	Louisiana
Xeric sandhill	Louisiana
Stream terrace-sandy wooded-savannah	Louisiana
Slash pine	Florida
Gulf Coast pitcher-plant bogs	Coastal Plain
Pocosins	Virginia
Mountain bogs	North Carolina
Appalachian bogs	Blue Ridge, Tennessee
Upland wetlands	Highland Rim, Tennessee
Ultramafic glades	Virginia
Threatened: 70-84 percent loss	
Bottomland and riparian forest	Southeast
Xeric scrub, scrubby flatwoods, sandhills	Lake Wales Ridge, Florida
Tropical hardwood hammock	Florida Keys
Saline prairie	Louisiana
Upland longleaf pine	Louisiana
Live oak-pine-magnolia	Louisiana
Spruce pine-hardwood flatwoods	Louisiana
Xeric sandhill woodlands	Louisiana
Flatwood ponds	Louisiana
Slash pine-pondcypress-hardwood	Louisiana
Wet hardwood-loblolly pine	Louisiana

Source: Noss and others 1995. Based on the published literature, Natural Heritage programs, and expert opinion.

Table 1.10—The Nature Conservancy's summary of distributions and threats for rare communities of the South

Geographic area	Habitat	Number of communities	Threats
Southern Appalachian Mountains	Spruce-fir	2	Nonindigenous species, recreation, air pollution, past logging, hydrological alteration, succession.
	Beech	2	
	Bog, fen	7	
	Grassy bald	1	
	Cliff, gorge	4	
	Other	1	
South Florida	Tropical hardwood	2	Development, nonindigenous species, hydrological alteration, fire suppression, burning, fragmentation, agriculture, recreation.
	Slash pine	3	
Coastal Plain	Barrier island	9	Development, grazing, fragmentation, hydrological alteration, fire suppression, nonindigenous species, agriculture, past logging, mining, burning, recreation.
	Longleaf pine	3	
	Other forests	3	
	Glade, prairie	6	
Continental Interior	Forest	7	Fire suppression, agriculture, recreation, grazing, past logging, nonindigenous species, succession, mining, hydrological alteration.
	Glade, prairie	3	
	Other	1	
Other	Outcrop	1	Recreation, grazing, agriculture, hydrological alteration, fire suppression.
	Forest	1	
	Canebrake	1	

Source: Grossman and others 1994.

urban growth, land use conversion, water diversion, exotic species, and pesticide runoff. Everglades, mangroves, bottomland hardwood forests, pocosins, mountain bogs, and Carolina bays were classified as threatened. They classified longleaf pine, spruce-fir and other high-elevation forests, heath balds, maritime communities, rock outcrops, glades, grasslands, and sand-pine scrub as vulnerable.

Grossman and others (1994) listed 57 rare communities in the South (table 1.10). Community types were ranked on a global scale based on the number of occurrences, areal extent, condition, threats, and fragility. These 57 communities had global ranks of G1 (found in 1 to 5 occurrences globally) or G2 (found in 6 to 10 occurrences globally). Twenty-one types occur in the Coastal Plain, 5 in south Florida, 17 in the Southern Appalachians, and 11 in the Continental Interior.

Communities can decline in areal extent or have their structures impoverished or compromised. Communities covering smaller areas tend to maintain smaller populations that are more vulnerable to extinction than larger populations (Soulé 1987). Communities also can lose vigor because of change in their structure, function, or composition. For example, intense livestock grazing entails replacement of native perennial grasses with exotic annuals. The factors contributing to community imperilment that are listed in table 1.10 are further discussed in the following section.

Profiles of selected rare communities—This section reviews some selected communities of concern. Each general community type can include multiple associations. Each account includes distribution, composition, threats, and potential management. Where available, steps toward restoration are presented. The accounts were developed from White and others (1998), Boyce and Martin (1993), Noss and others (1995), and Walker (2001). The discussion of communities follows White and others (1998).

Profiles of selected rare communities: old-growth forests—Although forests predominate in the South, less than 585,790 acres of old-growth forest exist (White and others 1998). The remaining old-growth forests tend to be on steeper, rockier, or mesic sites difficult to farm or harvest. Old-growth forest composition varies with forest type, but characteristics generally associated with old-growth forests include large, old trees; accumulations of woody debris; and multilayered canopies.

Many vertebrate species occur in patches of old-growth forest. These include the Jefferson salamander, the Peaks of Otter salamander, the oak toad, and the scarlet king snake (Wilson 1995). Public lands such as the Great Smoky Mountains National Park and several national forests protect some of the largest tracts in the South. With the exception of these areas, old-growth remnants are often smaller than 250 acres.

Threats to old-growth remnants include invasions by nonindigenous species, interruption of natural

disturbance regimes, outbreaks of forest pests, and timber harvest (Walker 2001).

Management options vary by forest type, but controlling nonindigenous species and herbivores, and choosing benign methods to accomplish these objectives are factors to consider. Management actions that mimic natural disturbances are particularly important because natural disturbance regimes are unlikely to be intact. Management emphasis may also include the provision of forested buffers around existing old-growth remnants.

Profiles of selected rare communities: spruce-fir forests—The spruce-fir community is confined to the highest peaks of Virginia, Tennessee, and North Carolina. Red spruce communities occur at an approximate elevation of 4,500 feet. In the northern limit of its range, Fraser fir is replaced with balsam fir. This community is characterized by relatively high moisture levels, short growing seasons, acidic soils, and extreme weather conditions. The flora is distinctive. The community reproduces in small-scale patches resulting from wind disturbance.

The presettlement extent of the Southern Appalachian spruce-fir community has been estimated as 30,000 to 35,000 acres (White and others 1998). These remote forests remained relatively undisturbed until the widespread harvests of the late 1800s (White and others 1998). In 1934, the majority of the remaining spruce-fir forest went into public protection with the establishment of the Great Smoky Mountains National Park.

Spruce-fir communities are threatened by infestations of balsam woolly adelgids. The stresses induced by insect attack are exacerbated by additional stresses of acid precipitation, which influence soil and stream chemistry. Air pollution and the deposition of heavy metals, such as lead, copper, zinc, nickel, and manganese, also contribute to the decline of this community (refer to chapter 18). They inhibit regeneration and contaminate the understory. Airborne pollution is carried with prevailing winds originating from industrial areas of southern Ohio and Indiana.

In addition, recreation activities compact soil and damage young trees. As the southern population centers expand, continued recreational pressure may further adversely affect the spruce-fir community.

Spruce-fir communities support several terrestrial species that are uncommon elsewhere. Examples include the endangered subspecies of northern flying squirrel, Weller's salamander, the endangered spruce-fir moss spider, mountain ash, and the threatened rock gnome lichen. The northern saw-whet owl, black-capped chickadee, and red crossbill also inhabit the community.

Restoration centers on enhancing the stocking of red spruce trees and increasing stand structural complexity. Appropriate silvicultural treatments include the release of spruce saplings from the understory and the removal of competing stems. In some areas, restoration may involve conversion of open areas to forests by planting seedlings.

Profiles of selected rare communities: wetlands, bog complexes, pocosins—In the last two centuries, the Nation has lost approximately 30 percent of its wetlands. Substantial losses have occurred along the southern Coastal Plain and along the lower reaches of the Mississippi River. In addition, Florida has lost 46 percent (9 million acres) of its wetlands (Stein and others 2000). Wetland loss is of special concern, because these habitats provide critical waterfowl and fish habitat.

Small wetlands occur in depressions embedded in forested areas. Soils are saturated for extended periods from rainfall and ground water seepage. Among the most vulnerable areas are small (less than 2 acres), isolated bogs that retain characteristic species. Bogs require distinct hydrological conditions to function ecologically. Intermittent fires and beaver activities may contribute to the origin and maintenance of this complex.

The exact number of remaining bogs is difficult to determine but is most certainly fewer than 150 in the entire South. Over half of the existing bogs occur on private land, and are threatened by development, grazing, off-road vehicle use, agricultural practices, and hydrological alteration.

Pocosins are freshwater wetlands dominated by a dense cover of broad-leaved evergreen shrubs or low-growing trees. They have highly organic soils that developed in areas of poor drainage. This community occurs in upland interstream areas. Peat layers are thick, and vegetation is shrubby.

The bog complex provides habitat for a diversity of herpetofauna. Wilson (1995) lists 37 species of reptiles and amphibians associated with Carolina bays, pocosins, and bogs in the South; 41 are associated with swamp habitat. These species include the bullfrog, green frog, eastern tiger salamander, four-toed salamander, mountain chorus frog, and snapping turtle. The bog turtle, threatened in the northern portion of its range, also inhabits these areas. This turtle is collected illegally, as are rare orchids and carnivorous plants. Opportunities for species to recolonize are minimal, and the community is permanently diminished.

Avian species occurring in these communities include cedar waxwing, Nashville warbler, northern water-thrush, purple finch, white-eyed vireo, and wood duck. Characteristic mammals include the long-tailed shrew, marsh rice rat, mink, muskrat, river otter, southern bog lemming, southern short-tailed shrew, and the star-nosed mole. Butterflies include the Atlantis fritillary and silver-bordered fritillary.

No vertebrates are endemic to pocosins, but the community provides habitat and refuge from adjacent landscape development. In North Carolina, 41 species of mammals inhabit pocosin and Carolina bay sites (White and others 1998).

Conservation activities include protection from heavy equipment, off-road vehicles, and foot traffic; controlling changes in site hydrology by providing buffers between adjacent sites, filling ditches and blocking drains; and restricting livestock grazing. The retention of woody debris provides valuable microhabitat for many species. Adjacent land management activities that alter the surrounding watershed degrade these sensitive communities. Restoration includes maintenance of site hydrology and woody plant control. Periodic prescribed burns adjusted to maintain vegetative conditions help to maintain the community. Species reintroduction into selected sites also may be required.

Profiles of selected rare communities: bottomland and floodplain forests—The forested wetlands of the Coastal Plain, Piedmont, and Continental Interior Provinces include bottomland hardwood forests and deepwater alluvial swamps. Bottomland hardwoods are located along waterways and in low-lying areas such as the Mississippi Delta region. Common tree species include ash, sycamore, water tupelo, cypress, willow, cottonwood, elm, oaks, river birch, silver maple, sweetgum, black walnut, and pine. Vegetative composition and structure vary with flooding duration. Trees are vulnerable to prolonged changes in hydrology and are characterized by rapid growth. Bottomland hardwoods are found almost exclusively on alluvial soils that are associated with old riverbeds, existing streams, and impoundments and their terraces. Soils are saturated year round or nearly so; the understory is sparse with vines and shrubby vegetation.

Beneficial characteristics of this community for wildlife include hard mast production, cavity tree provision, and production of abundant invertebrate biomass. In agricultural landscapes, bottomland forests serve as refuges for many species. Species associated with this community include wood stork, prothonotory warbler, marbled salamander, and the swamp rabbit. The loss of bottomland hardwood forests to agricultural conversion contributed to the decline of the Carolina parakeet and the ivory-billed woodpecker (Dickson 2001).

Many bottomland sites are productive and have been in agricultural production for long periods. Several cypress-oak reforestation projects in the Mississippi Alluvial Valley have been successful in areas where frequent flooding precludes agricultural development. Restoration of this community occurs primarily on public land.

Profiles of selected rare communities: glades, barrens, and prairies—Scattered throughout the South are naturally treeless areas referred to as prairies, glades, and barrens. Historical accounts suggest that these open communities were once widespread (Delcourt and others 1993), but estimates of original extent are uncertain. These grass-dominated communities occurred in the Piedmont, Interior Plateau, Ridge and Valley, and Coastal Plain Provinces.

Lightning fires, Native American burning, grazing by elk and bison, and soil conditions historically maintained these areas. Today, these communities occupy only a fraction of their original extent due to agricultural conversion, recreation use, exotic species invasions, fire exclusion, and the loss of large herbivores.

Forbs and grasses occurring on rocky or shallow soil dominate glades; composition varies with geology, soil type, and soil depth (Walker 2001). The limestone glades of the Ozarks, dominated by perennial grasses, have a more open nature than glades of the Interior Low Plateau. Eastern redcedar woodlands are commonly associated with glades of various types. Threats to glade communities include construction, quarrying, agriculture (pasture), fire suppression, and nonindigenous species invasion.

The barren and prairie communities contain the majority of the region's native grasslands. In the South, they include the Black, Jackson, and Grand Prairies. In these communities, grasses are dominant, and shrubs and trees are generally absent. The sites are highly productive because they retain nutrients. As a result, they support a vast array of animal and plant life. Species composition varies with site moisture. Characteristic species include little bluestem, Indian grass, and big bluestem. Composition varies depending upon specific soil and geologic types.

The size and isolation of these open areas preclude support of endemic vertebrates. Many rare species of birds, reptiles, and arthropods use these communities. Vertebrate species that have been extirpated from these communities include the greater prairie chicken, bison, and elk.

Restoration centers on the control of woody species from adjacent forest habitats and the use of prescribed burning to maintain the diversity of the grassland communities. The retention of characteristic species relies upon site-specific management.

Profiles of selected rare communities: longleaf pine and southern pinelands—Longleaf pine historically dominated Coastal Plain sites from southern Virginia to eastern Texas. It also occurred on sites in the Piedmont, southern Ridge and Valley, and southern Blue Ridge Provinces (fig. 1.22). This community once covered over 40 percent of the entire region, but it has declined by more than 98 percent (Noss and others 1995).

The community came under pressure during the mid-17th century. Demand began for naval stores and then turned

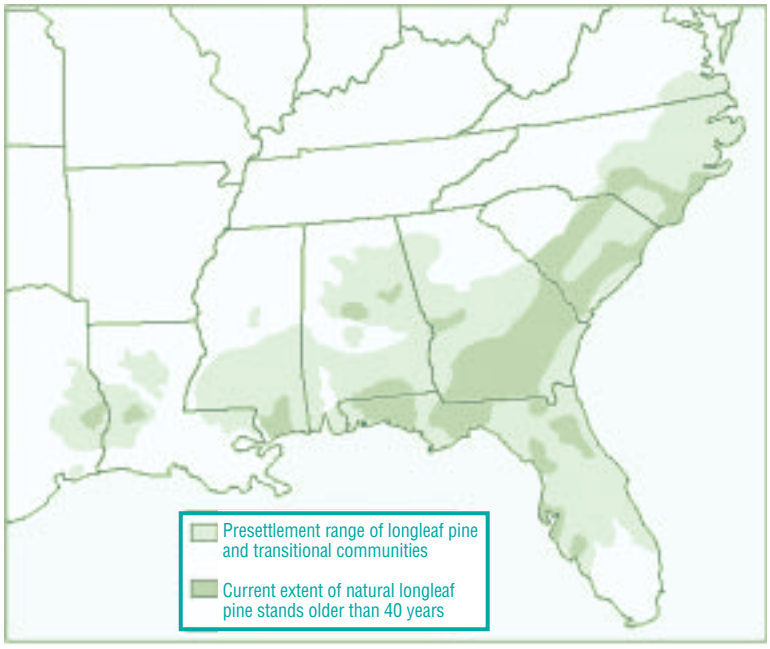

Figure 1.22—The historic and present distribution of longleaf pine in the South (White and others 1998).

to timber needs. By the 1960s, extensive areas were harvested and converted to commercial plantations of loblolly and slash pine. Fire suppression and the introduction of livestock further restricted the longleaf community to a few isolated locations comprising about 5 million acres. At present, the majority occurs on private land. Much of what remains is largely degraded due to lack of proper management.

Community composition varies with soil moisture and geography. Wiregrass and bluestem dominate the herbaceous layer. This herb layer is diverse and includes grasses, wildflowers, and carnivorous plants. In mature communities, the trees are thinly distributed and flat-topped, and have limbless lower trunks.

The community harbors several vertebrate species. The fox squirrel is a long-lived species with low reproductive rates. It depends on longleaf pine for late summer forage. The decline in longleaf communities

Table 1.11—Examples of soft and hard mast-producing species in the South

Scientific name	Common name	Scientific name	Common name
Soft mast		Berries	
Pomes		*Diospyros virginiana*	Common persimmon
Amelanchier spp.	Serviceberries	*Juniperus virginiana*	Eastern redcedar
Crataegus spp.	Hawthorn	*Lonicera japonica*	Japanese honeysuckle
Pyrus malus	Common apple	*Smilax spp.*	Greenbriers
Drupes		*Vaccinium spp.*	Blueberries
Berchemia scandens	Alabama supplejack	*Vitis aestivalis*	Muscadine grape
Callicarpa Americana	American beautyberry	*Vitis rotundifolia*	Summer grape
Celtis occidentalis	Hackberry	Hard mast	
Cornus florida	Flowering dogwood	Nuts	
Gaylussacia spp.	Huckleberries	*Aesculus octandra*	Yellow buckeye
Gaylussacia dumosa	Dwarf huckleberry	*Carpinus caroliniana*	American hornbeam
Ilex spp.	Hollies	*Carya spp.*	Hickories
Ilex cassine	Dahoon	*Carya aquatica*	Water hickory
Ilex coriacea	Large gallberry	*Carya cordiformis*	Bitternut
Ilex deciduas	Possumhaw	*Carya glabra*	Pignut
Ilex glabra	Gallberry	*Carya ovata*	Shagbark
Ilex myrtifolia	Myrtle dahoon	*Carya tomentosa*	Mockernut
Ilex opaca	American holly	*Castanea spp.*	Chinkapin
Ilex vomitoria	Yaupon	*Fagus grandifolia*	American beech
Morus rubra	Red mulberry	*Juglans cinera*	Butternut (white walnut)
Myrica cerifera	Southern bayberry		
Myrcia pensylvanica	Northern bayberry	*Juglans nigra*	Black walnut
Nyssa aquatica	Water tupelo	*Ostrya virginiana*	Eastern hophornbeam
Nyssa sylvatica	Black tupelo and Swamp tupelo	*Nyssa sylvatica*	Black gum
		Quercus spp.	Oaks
Persea borbonia	Redbay	*Quercus alba*	White oak
Prunus serotina	Black cherry	*Quercus chapmanii*	Chapman oak
Prunus spp.	Wild cherries and plums	*Quercus michauxii*	Swamp chestnut oak
		Quercus prinus	Chestnut oak
Rhus copallina	Shining sumac	*Quercus stellata*	Post oak
Rhus glabra	Smooth sumac	*Quercus virginiana*	Live oak
Rhus radicans	Common poison ivy	*Quercus falcate*	Southern red oak
Rhus typhina	Staghorn sumac	*Quercus ilicifolia*	Bear oak
Rubus spp.	Blackberries	*Quercus incana*	Bluejack oak
Sabal spp.	Palmetto	*Quercus laurifolia*	Laurel oak
Sambucus canadensis	American elder	*Quercus marilandica*	Blackjack oak
Sassafras albidum	Sassafras	*Quercus nigra*	Water oak
Serenoa repens	Saw-palmetto	*Quercus nuttalli*	Nuttall oak
Viburnum spp.	Viburnum	*Quercus phellos*	Willow oak
		Quercus pumila	Running oak
		Quercus rubra	Northern red oak

Source: Halls 1977.

has limited its range and reduced population levels. The red-cockaded woodpecker occurs in the open pinewoods, using fairly mature trees with minimal understory (Hamel 1992). Trees also must have proper heartwood conditions for nest cavities. This species has also declined, but active management has stabilized several populations. The sensitive Bachman's sparrow breeds in dense, grassy places where scattered pine trees and saplings are present.

Dodd (1995) reported that 74 amphibians and 96 reptiles occur in the range of the longleaf pine community. These include the flatwoods salamander, Red Hills salamander, striped newt, Carolina gopher frog, eastern indigo snake, gopher tortoise, eastern diamondback rattlesnake, Florida pine snake, and Florida scrub lizard.

Although the influence of longleaf reduction on the herpetofaunal community has not been assessed directly, several species may have been affected. The gopher tortoise, a keystone species in longleaf pine savanna, has declined by 80 percent over the last century (White and others 1998). Amphibians breeding in temporary ponds have been particularly affected by habitat alteration. The flatwoods salamander has disappeared from its eastern range; gopher frogs are nearly extirpated in North Carolina, Alabama, and Mississippi; and dusky salamanders appear to have declined in coastal South Carolina and peninsular Florida.

Conversion of longleaf pine forests to agriculture, slash, or loblolly pine plantations and urban development threaten the continued existence of several herpetofauna species in Georgia and Florida (Ware and others 1993). Hardwood encroachment stemming from fire suppression also has contributed to the loss of longleaf pine communities. Historically, frequent low-intensity fires reduced litter accumulation, controlled competing woody species, and improved herbaceous vigor (Walker 2001). Recent awareness of the importance of this sensitive community has encouraged restoration efforts.

Profiles of selected rare communities: Atlantic white-cedar swamps—Atlantic white-cedar once was distributed from southern Virginia to interior Georgia and from the Florida Panhandle along the Gulf of Mexico to Mississippi. Drainage, development, and harvest without regeneration have reduced Atlantic white-cedar to 10 percent of its original extent.

Much of the original community was destroyed by European settlers who cleared land for agriculture. Today, white-cedar swamps are restricted to inaccessible freshwater wetlands in small, isolated stands. Road construction and the damming of waterways continue to diminish this habitat, as does suburban encroachment, industrial runoff, and pollution.

Atlantic white-cedar swamps are unique communities adapted to variable hydrological regimes, fire, and peat soils. This community type often represents some of the only forest in regions of intense agricultural and urban development. Atlantic white-cedar areas provide habitat for many species, including black bear, deer, rabbits, and other fauna. The diversity of bird species is relatively high in Atlantic white-cedar swamps, compared to adjacent areas. The Hessel's hairstreak is a butterfly that feeds exclusively on Atlantic white-cedar.

During restoration, these stands require frequent, light fires in the dry season. Fire removes competitive vegetation and clears the seedbed for regeneration.

Hard and Soft Mast

Southern species that produce mast—Mast refers to specific kinds of fruits of woody species. Hard mast possesses a hard exterior, as in acorns, while soft mast has fleshy fruits, as in berries. Both forms of mast are important in the diets of southern wildlife. Many southern woody plants produce mast (table 1.11). Mast yields are unpredictable from one year to the next and vary according to species, location, and weather.

Pomes are fruits that have several tough, papery-walled cavities that house seed; the cavities are surrounded by thick flesh. These fruits may be large like apples or small like serviceberries. Fresh pomes have a high moisture and carbohydrate content, but are low in crude protein (Halls 1977).

A drupe is a pulpy fruit with an inner ovary wall that encloses a seed. Drupes are extensively eaten by wildlife. The fruits tend to be low in crude protein and high in carbohydrates; nutrient content varies considerably among species. Drupe producers in the South include wild cherries, plums, hackberry, and red mulberry (Halls 1977).

Berries are fruits with fleshy ovaries that envelop one or more seeds. Most species are eaten by wildlife. Fruits are usually high in carbohydrates and low in crude protein. Species that produce berries include persimmon, blueberry, and grape.

Hard mast includes nuts and one-seeded fruits (or kernels). Most have concentrations of crude fat, and some also are relatively high in crude protein (Halls 1977). Characteristic species include hornbeam, hickory, beech, walnut, black gum, and several species of oaks.

Selected species that utilize mast in their diet—Mast is an essential component in the diets of many vertebrates in the South (Combs and Frederickson 1996, Doherty and others 1996, Jensen 1982, Wolff 1996). Table1.12 lists several mast-consuming mammals, including mice, voles, woodrats, rabbits, raccoons, and foxes. Several birds also consume mast (table 1.13) including game birds (doves, quail, pheasant, grouse, turkey), waterfowl (mallards, wood ducks), woodpeckers, and songbirds (finches, thrushes, jays, and towhees). The relationship between mast and the food habits of several game species, such as deer, bear, and squirrels has been documented extensively (Fridell and Litvaitis 1991, Kirkpatrick 1989, Kurzejeski 1989, Pelton 1989, Wentworth and others 1989).

Selected species that utilize mast in their diet: white-tailed deer—Hard mast is often an important component of the fall and winter diet of white-tailed deer. Nutrition, reproduction, weight, and antler characteristics of individual animals are influenced by acorn availability (Wentworth and others 1989). In poor mast years, reproduction rates may be low, and conception may be delayed. Postnatal survival also can decline following years of minimal acorn production. Fawn weight also can be directly related to the size of the acorn crop.

Table 1.12—Selected mammals of the South that utilize hard and soft mast in their diets

Scientific name	Common name
Castor canadensis	Beaver
Clethrionomys gapperi	Southern red-backed vole
Didelphis virginiana	Virginia opossum
Glaucomys sabrinus	Northern flying squirrel
Glaucomys volans	Southern flying squirrel
Mephitis mephitis	Striped skunk
Neotoma floridana	Eastern woodrat
Neotoma mexicana	Mexican woodrat
Neotoma micropus	Southern plains woodrat
Ochrotomys nuttalli	Golden mouse
Odocoileus virginianus	White-tailed deer
Peromyscus attwateri	Texas mouse
Peromyscus boylii	Brush mouse
Peromyscus floridanus	Florida mouse
Peromyscus gossypinus	Cotton mouse
Peromyscus leucopus	White-footed mouse
Peromyscus maniculatus	Deer mouse
Procyon lotor	Raccoon
Sciurus carolinensis	Gray squirrel
Sciurus niger	Fox squirrel
Spermophilus variegatus	Rock squirrel
Sus scrofa	Wild boar
Sylvilagus palustris	Marsh rabbit
Tamiasciurus hudsonicus	Red squirrel
Tamias striatus	Eastern chipmunk
Urocyon cinereoargenteus	Gray fox
Ursus americanus	Black bear
Vulpes vulpes	Red fox

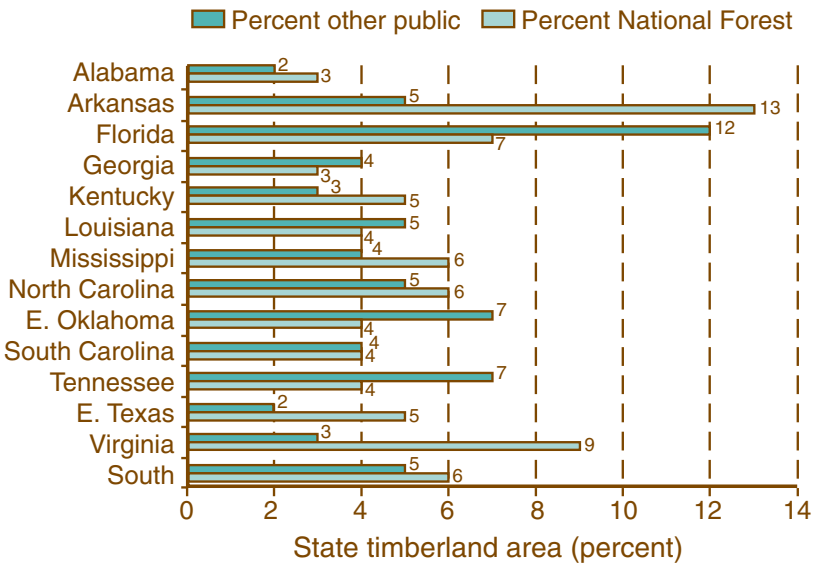

Figure 1.23—National forest and other public ownership of timberland in the South (U.S. Department of Agriculture, Forest Service 2000a).

Selected species that utilize mast in their diet: black bear—The abundance and distribution of oak mast (particularly white oak) also can influence black bear natality, mortality, and dispersal. Shifts in home range sometimes occur in response to fluctuations in hard mast availability. The birth and survival of young bears can be directly associated with oak mast crops (Pelton 1989). Poor mast years often result in increased bear movement, which can result in increased mortality due to vehicular accidents and human-bear interactions. The loss of the American chestnut likely had a significant influence on the population dynamics of black bears in the Southern Appalachians (Pelton 1989). In addition, the reliance on soft mast in the seasonal diet of black bear highlights the importance of early successional habitats in the provision of this food source (Trani and others 2001).

Selected species that utilize mast in their diet: squirrels—The availability of hard mast also can influence squirrel populations. Poor mast crops can result in population declines, while abundant mast crops may result in substantial population increases (Kurzejeski 1989). Mast comprises the majority of the fall, winter, and spring diets of red, gray, and fox squirrels. Acorns, walnuts, and hickory nuts are major food sources for these squirrels as well as for the eastern chipmunk.

Selected species that utilize mast in their diet: game birds—Hard mast provides a high-energy resource for ruffed grouse, wild turkey, bobwhite quail, and several waterfowl. These species consume acorns in proportion to their availability throughout the year; foraging for mast requires little energy expenditure (Kirkpatrick 1989). Red oak acorns have an elevated phenolic content and are less palatable than white oak species.

Factors affecting mast supply availability—In recent years, there have been concerns about the decline of mast-producing species (particularly oaks) in the South. Chapter 16 presents trend information from the FIA on oak and other overstory mast-producing trees. In addition, an examination of oak decline in the South is presented in chapter 18. The factors that may have contributed to the decline, and

Table 1.13—Selected birds of the South that utilize hard and soft mast in their diets

Scientific name	Common name
Aix sponsa	Wood duck
Anas platyrhynchos	Mallard
Anas strepera	Gadwell
Aphelocoma coerulescens	Scrub jay
Bombycilla cedrorum	Cedar waxwing
Carpodacus purpureus	Purple finch
Catharus guttatus	Hermit thrush
Certhia americana	Brown creeper
Colaptes auratus	Northern flicker
Colinus virginianus	Bobwhite quail
Columba fasciata	Band-tailed pigeon
Columba flavirostris	Red-billed pigeon
Corvus brachyrhynchos	American crow
Cyanocitta cristata	Blue jay
Cyanocitta stelleri	Stellar's jay
Ixoreus naevius	Varied thrush
Melanerpes carolinus	Red-bellied woodpecker
Melanerpes erythrocephalus	Red-headed woodpecker
Melanerpes formicivorus	Acorn woodpecker
Meleagris gallopavo	Wild turkey
Mimus polyglottos	Northern mockingbird
Parus bicolor	Tufted titmouse
Parus inornatus	Plain titmouse
Phasianus colchicus	Ring-necked pheasant
Pheucticus ludovicianus	Rose-breasted grosbeak
Philohela minor	American woodcock
Picoides pubescens	Downy woodpecker
Picoides villosus	Hairy woodpecker
Pipilo erythrophthalmus	Rufous-sided towhee
Quiscalus quiscula	Common grackle
Sitta carolinensis	White-breasted nuthatch
Sphyrapicus varius	Yellow-bellied sapsucker
Sturnus vulgaris	Starling
Toxostoma rufum	Brown thrasher
Tympanuchus cupido	Greater prairie chicken
Zenaidia macrocroura	Mourning dove

the subsequent reduction in hard mast production, are briefly mentioned here.

Many variables, including disease, insect infestation, advanced stand age, drought, and disturbance influence oak forests. Mature oaks are quite susceptible to disease and drought conditions. As these forests age, tree vigor is reduced. They become susceptible to windthrow and ice storms. Longevity varies by species and site characteristics. Lack of natural disturbance is another factor. Fire suppression has resulted in an increase in other species in former oak-dominated areas.

Chestnut blight had a dramatic influence on the American chestnut (chapter 18). Chestnut oaks, which replaced chestnuts in many places, are an important source of hard mast for wildlife populations. Gypsy moth infestations on the poor sites occupied by chestnut oaks often inhibit oak regeneration. Infested trees have a reduced capability for stump sprouting, and their acorns lack the energy reserves to remain viable. Repeated defoliation kills many oaks. When this happens, yellow-poplar often captures the site.

Contribution of Public Lands

Extent of public lands in the South—Public land comprises approximately 11 percent of timberland in the South (chapter 16). The distribution of public land between States varies considerably (fig. 1.23). For example, national forests occupy 3 percent of the timberland in Alabama and Georgia but 13 percent of the timberland in Arkansas (U.S. Department of Agriculture, Forest Service 2000a).

FIA data indicate that 4 million acres of timberland are managed by States, 1 million acres by counties and municipalities, and 16 million acres by Federal agencies (U.S. Department of Agriculture, Forest Service 2000a). State land is contained in State parks, wildlife management areas, State forests, and State natural resource areas. Counties and municipalities hold land in local parks and recreation areas, many of which contribute importantly to the conservation of habitat.

The primary Federal land management agencies in the South are the USDA Forest Service, the National Park Service, and the U.S. Fish and Wildlife Service (fig. 1.24). Federal land is concentrated in the Appalachian and Ozark Mountains, with less land in the Piedmont and Coastal Plain. The Forest Service manages approximately 60 percent of the southern Blue Ridge, the eastern edge of the Appalachian Mountain chain. In contrast, less than one-tenth of the mid-Atlantic Coastal Plain is under Federal management.

National parks and the National Park Service—The idea of preserving Federal land in national parks is rooted in the conservation movement of the late 1800s. Created in 1916, the mission of National Park Service was to conserve scenic, natural, and historic resources (Loomis 1993). Congress precluded timber harvesting, mining, and livestock grazing.

In the 1960s, the Leopold Report shifted this preservation philosophy towards ecological management (Loomis 1993). Parks were managed to restore a more natural appearance, and visitor development was directed to areas outside the parks. Park policies allowed fire as a management tool for maintaining the park environment. Recreational activities were limited

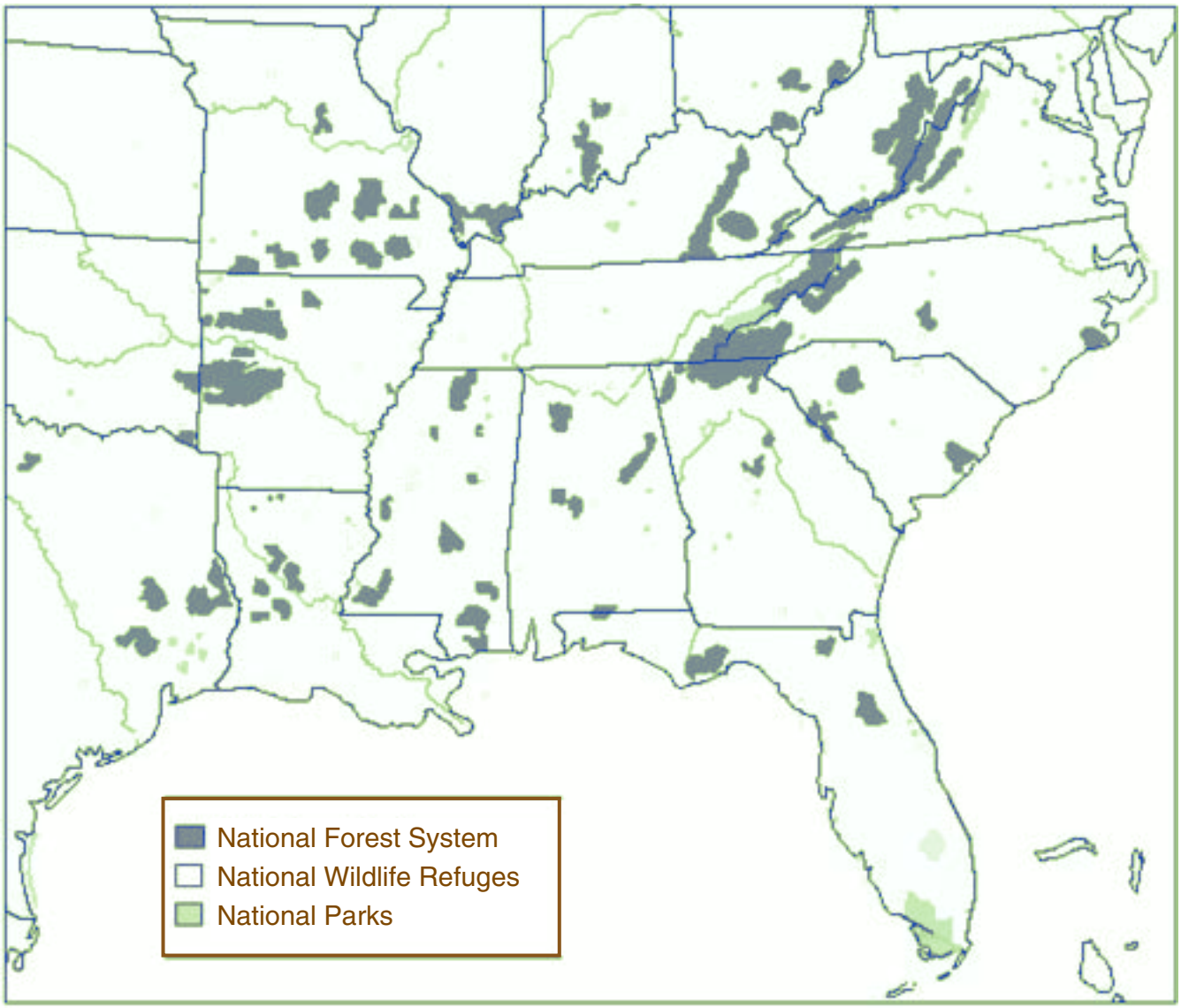

Figure 1.24—The distribution of national forests, national parks, and national willife refuges in the South (White and others 1998).

based upon soil and vegetation characteristics, concerns about water quality, and sensitivity of wildlife to human presence. Still, on National Park Service land there is ongoing conflict between preserving the natural environment and providing for visitor use.

The Agency's current mandate is to perpetuate native plant communities; manipulation of vegetation is kept to a minimum. Species management objectives include the provision of self-regulating populations. Impacts on animal populations are avoided with restrictions on the removal of individual animals.

In 2000, the National Park Service managed 97 properties in the South totaling over 5 million acres (table 1.14). These properties are in seven different designations, each of which is managed with different objectives. National parks contain outstanding natural features and generally are of a sufficient size to ensure protection from outside influences. National preserves also protect selected natural features, but allow uses such as hunting or mining if they do not impair the resources of the preserve. National seashores protect water-related areas of natural significance that occur on the Atlantic and Gulf coasts. National recreation areas emphasize recreational use. Recreational areas also may exist on national forests. National parkways protect scenic resources along travel corridors such as the Blue Ridge Parkway. National monuments and national historic sites (including national battlefields) are established to commemorate historical events (Loomis 1993).

The following area accounts describe selected National Park Service properties that provide valuable habitat for a variety of species in the South. Many areas contain impressive vertebrate diversity or provide examples of applied conservation biology. Property information is summarized from U.S. Department of the Interior, Park Service (2000).

National parks and the National Park Service: Buffalo National River, AR—The Buffalo River is one of the few remaining unpolluted, free-flowing rivers in the South. Stretching 135 miles, the Buffalo River cuts its way

Table 1.14—National Park Service national parks and monuments in the South

National Park Service property	Total acres
Alabama	
National Parks	
Horseshoe Bend National Military Park	2,040
Little River Canyon National Preserve	13,633
Tuskegee Airman National Historic Site (Private)	87
Tuskegee Institute National Historic Site	58
National Monuments	
Russell Cave National Monument	310
Total	16,128
Arkansas	
National Parks	
Arkansas Post National Memorial	749
Buffalo National River	94,328
Fort Smith National Historic Site	75
Hot Springs National Park	5,549
Little Rock Central HS National Historic Site	18
Pea Ridge National Military Park	4,300
Total	105,019
Florida	
National Parks	
Big Cypress National Preserve	720,573
Biscayne National Park	172,924
Canaveral National Seashore	57,662
De Soto National Memorial	27
Dry Tortugas National Park	64,700
Everglades National Park	1,508,607
Gulf Islands National Seashore	135,607
Timucuan Ecological and Historic Preserve	46,000
National Monuments	
Castillo de San Marcos National Monument	21
Fort Caroline National Memorial	138
Fort Matanzas National Monument	228
Total	2,706,487
Georgia	
National Parks	
Andersonville National Historic Site	495
Chattahoochee River National Recreation Area	9,206
Chickamouga and Chattanooga National Military Park	8,119
Cumberland Island National Seashore	36,415
Jimmy Carter National Historic Site	71
Kennesaw Mountain National Battlefield Park	2,884
Martin Luther King, Jr. National Historic Site	34
National Monuments	
Fort Frederica National Monument	241
Fort Pulaski National Monument	5,623
Ocmulgee National Monument	702
Total	63,790

continued

through massive limestone bluffs in the Ozark Mountains. The Buffalo National River has three designated wilderness areas within its boundaries.

Ninety-five thousand acres furnish habitat for 250 species of birds and a variety of animals. It also contains 70 mines that provide important habitat for gray, Indiana, and Ozark big-eared bats. The Buffalo National River also is along the migration route of the federally listed Eskimo curlew.

National parks and the National Park Service: Mammoth Cave National Park, KY—This park was established in 1941 to preserve one of the longest known cave systems (336 miles) in the Nation. The park also was designated as a World Heritage Site in 1981 and an International Biosphere Reserve in 1990.

The park's 52,830 acres support a variety of plants and animals including several bat species of conservation concern: southeastern bat, Rafinesque's big-eared bat, and eastern small-footed bat. There are several State-listed reptiles, including the northern coal skink, glass lizard, and the northern pine snake. Among the 872 flowering species that have been confirmed are 21 listed plants.

National parks and the National Park Service: Congaree Swamp National Monument, SC—This monument was established to protect the largest remaining tract of virgin bottomland hardwood wetlands in the South. The monument is an international biosphere reserve, a national natural landmark, a wilderness area, and a continentally important bird area.

Biodiversity is very high within the Congaree's 22,000 acres. Amphibians that thrive in the deep floodplain sloughs include the marbled salamander, the eastern newt, the southern dusky salamander, and the greater siren. Frogs include the southern leopard frog and the chorus frog. One hundred seventy-three species of birds occur in the monument, including several of conservation concern. Among these are the barred owl, pileated woodpecker, and Swainson's warbler. At different seasons of the year, prothonotory warblers, Mississippi kites, and herons use the refuge. In addition, Congaree Swamp supports important sites for the silver-haired bat, hoary bat, Brazilian

free-tailed bat, Rafinesque's big-eared bat, and southeastern bat.

Feral hogs in the park are placing this unique resource at risk. Wetland communities are subject to severe damage from hog rooting and other behavior.

National parks and the National Park Service: Great Smoky Mountains National Park, NC, TN—The Great Smoky Mountains National Park is one of the largest protected areas in the South (521,621 acres) and is World-renowned for the diversity of its plant and animal resources and the integrity of the wilderness within its boundaries. Established as a national park in 1934, it was designated as an International Biosphere Reserve in 1976 and a World Heritage Site in 1983.

The park protects some of the World's finest temperate deciduous forests. Due to the fertile soil and abundant rain, this area boasts 1,650 species of flowers and trees, 50 mammal species, and 27 salamander species. Migrating birds abound in late spring.

Existing and impending threats in the park include invasion by exotic species, air pollution, and forest diseases. Since fire suppression was initiated in the 1930s, oak regeneration has been minimal at some sites with adverse consequences for mast-utilizing species.

National parks and the National Park Service: Big Thicket National Preserve, TX—Big Thicket was the first preserve in the National Park System to protect an area of rich biological diversity. Established in 1974, it also was designated as an International Biosphere Reserve. The preserve consists of nine land units and six water corridors encompassing more than 97,191 acres. The Big Thicket is rich in biological resources and contains swamps, bayous, pine savanna, sandhills, plains, and desert.

National parks and the National Park Service: Shenandoah National Park, VA—This park extends along the Blue Ridge Mountains, encompassing over 198,000 acres. The oak-hickory forest is inhabited by deer, black bear, bobcat, and wild turkey. Species such as the chipmunk, groundhog, raccoon, skunk, opossum, and gray squirrel are frequently detected. Approximately 200 species of birds have been recorded, including flycatchers, thrushes, vireos, 35 species of warblers, and migrating

Table 1.14—National Park Service national parks and monuments in the South (continued)

National Park Service property	Total acres
Kentucky	
National Parks	
Abraham Lincoln Birthplace National Historic Site	337
Cumberland Gap National Historic Park	20,454
Mammoth Cave National Park	52,830
Total	73,621
Louisiana	
National Parks	
Cane River Creole National Historic Park	207
Jean Lafitte National Historic Park and Preserve	20,020
New Orleans Jazz National Historic Park	4
National Monuments	
Poverty Point National Monument	911
Total	21,142
Mississippi	
National Parks	
Brices Cross Roads National Battlefield Site	1
Gulf Islands National Seashore	135,458
Natchez National Historic Park	108
Natchez Trace National Scenic Trail	10,995
Natchez Trace Parkway	51,747
Tupelo National Battlefield	1
Vicksburg National Military Park	1,736
Total	200,046
North Carolina	
National Parks	
Blue Ridge Parkway[a]	88,734
Cape Hatteras National Seashore	30,319
Cape Lookout National Seashore	28,243
Carl Sandburg Home National Historic Site	264
Fort Raleigh National Historic Site	513
Guilford Courthouse National Military Park	220
Moores Creek National Battlefield	88
Wright Brothers National Memorial	428
Total	148,809
Oklahoma	
National Parks	
Chickasaw National Recreation Area	9,889
Oklahoma City National Memorial	6
Washita Battlefield National Historic Site	315
Total	10,210
South Carolina	
National Parks	
Charles Pinckney National Historic Site	28
Cowpens National Battlefield	842
Kings Mountain National Miliary Park	3,945
Ninety Six National Historic Site	989

continued

[a] Property is in two or more States.

Table 1.14—National Park Service national Parks and monuments in the South (continued)

National Park Service property	Total acres
South Carolina (cont.)	
National Monuments	
Congaree Swamp National Monument	21,867
Fort Sumter National Monument	195
Total	27,866
Tennessee	
National Parks	
Andrew Johnson National Historic Site	17
Big South Fork National River and Recreation Area	125,242
Fort Donelson National Battlefield	552
Great Smoky Mountains National Park[a]	521,621
Obed Wild and Scenic River	5,173
Shiloh National Military Park	3,997
Stones River National Battlefield	708
Total	657,310
Texas	
National Parks	
Amistad National Recreation Area	58,500
Big Bend National Park	801,163
Big Thicket National Preserve	97,191
Chamizal National Memorial	55
Fort Davis National Historic Site	474
Guadalupe Mountains National Park	86,416
Lake Meredith National Recreation Area	44,978
Lyndon B. Johnson National Historic Park	1,570
Padre Island National Seashore	130,434
Palo Alto Battlefield National Historic Site	3,357
Rio Grande Wild and Scenic River	9,600
San Antonio Missions National Historic Park	819
National Monuments	
Alibates Flint Quarries National Monument	1,371
Total	1,235,928
Virginia	
National Parks	
Appomattox Court House National Historic Park	1,775
Arlington House, The Robert E. Lee Memorial	28
Colonial National Historic Park	9,349
Fredericksburg National Military Park	7,787
George Washington Memorial Parkway	7,248
Maggie L. Walker National Historic Site	1
Petersburg National Battlefield	2,659
Manassas National Battlefield Park	5,212
Prince William Forest Park	18,661
Richmond National Battlefield Park	1,078
Shenandoah National Park	198,182
Wolf Trap Farm Park for the Performing Arts	130
National Monument	
Booker T. Washington National Monument	224
George Washington Birthplace National Monument	550
Total	252,884
Grand total	5,519,240

[a] Property is in two or more States.
Source: U.S. Department of Interior 2000a.

hawks. Permanent residents include ruffed grouse, barred owl, raven, woodpeckers, and junco. The park also supports several salamander species and two poisonous snakes, the timber rattlesnake and the copperhead snake.

The hemlock woolly adelgid, an exotic insect, currently jeopardizes the eastern hemlocks in the park. First detected 10 years ago, the adelgid is an aphid-like insect that sucks sap from branches of the hemlock. The tree loses strength and sheds its needles, and often does not survive (chapter 17).

National parks and the National Park Service: Blue Ridge Parkway, NC, VA—The Blue Ridge Parkway consists of 469 miles of road and protects the natural features of the Blue Ridge while connecting the Shenandoah National Park with the Great Smoky Mountains. The parkway encompasses 88,734 acres.

The parkway supports several species of rare plants and animals. Some of these, such as the Peaks of Otter salamander and the Blue Ridge goldenrod, do not occur in other southern areas. Ponds and wetlands near the parkway provide essential habitat for amphibians, reptiles, mammals, and birds.

Many Neotropical migrant species return to the parkway each spring. These include the scarlet tanager, veery, wood thrush, and Kentucky warbler. The autumn hawk migration also occurs along the Blue Ridge Parkway. Raptors recorded include the American kestrel, red-tailed hawk, sharp-shinned hawk, broad-winged hawk, golden eagle, and peregrine falcon.

National wildlife refuges and the Fish and Wildlife Service—A network of lands set aside for wildlife began in 1903 with the designation of Pelican Island, FL, as the first National Wildlife Refuge. The Fish and Wildlife Service has responsibility for the Refuge System. Refuge objectives include the provision and enhancement of habitat, perpetuation of migratory bird resources, preservation of natural diversity, and restoration of endangered and threatened species.

Land is acquired for game refuges, waterfowl production areas, and other reasons. Many refuges were created under the authority of the Endangered Species Act, providing anchors for biodiversity and ecosystem-level

conservation. These areas have been instrumental in the recovery of several species including the whooping crane, Key deer, and American crocodile.

The Migratory Bird Conservation Act of 1929 directed the Agency to purchase areas as refuges for migratory birds. In 1934, the Duck Stamp program established permanent funds for the acquisition of waterfowl habitats. The system has an outstanding record for the successful management of these species. The emphasis on migratory birds has now expanded to include colonial water birds, birds of prey, shorebirds, seabirds, and songbirds.

The earliest form of management consisted of law enforcement and periodic counts of wildlife. As the system expanded, there was an evolution from habitat management for a few species to ecosystem management. For example, planting vegetation for ducks evolved to planting an array of native grasses and forbs to rebuild prairie diversity. Prescribed fire was incorporated to reduce hazardous fuel loads and restore vegetation communities. Management has been altered to mimic natural disturbance for maintenance of a diversity of habitats.

One hundred seventy-two refuges spread across the South encompass approximately 4 million acres (table 1.15). The greatest concentration of wildlife refuges is in Florida and along the Mississippi and Atlantic flyways. Hundreds of species of birds, mammals, reptiles, and amphibians are supported by the diversity of habitats in the Wildlife Refuge System. Several of these properties are discussed in greater detail in the following section. Information on species and communities are summarized from U.S. Department of the Interior, Fish and Wildlife Service (2000).

National wildlife refuges and the Fish and Wildlife Service: Florida Panther National Wildlife Refuge—This refuge supports a variety of habitats, including cypress forests, swamps, pine forests, hardwood hammocks, prairies, marshes, and sloughs. Permanent and seasonal wetlands cover a majority of the refuge area (26,529 acres). The refuge is closed to the public to minimize disturbance to the Florida panther population that occurs there.

Table 1.15—U.S. Fish and Wildlife Service refuges within the South

Refuge	Total acres
Alabama	
Blowing Wind Cave	264
Bon Secur	6,678
Choctaw	4,218
Eufaula	7,953
Fern Cave	199
Grand Bay	2,496
Key Cave	1,060
Watercress Darter	9
Wheeler	34,247
FSA Interest AL[a]	743
Total	57,867
Arkansas	
Bald Knob	14,760
Big Lake	11,036
Cache River	45,232
Felsenthal	64,902
Holla Bend	6,428
Logan Cave	124
Overflow	12,235
Pond Creek	26,816
Wapanocca	5,484
White River	154,856
FSA Interest AR[a]	3,459
Total	345,332
Florida	
Archie Carr	127
Arthur R. Marshall	145,787
Caloosahatchee	40
Cedar Keys	891
Chassahowitzka	30,843
Crocodile Lake	6,688
Crystal River	80
Egmont Key	328
Florida Panther	26,529
Great White Heron	192,584
Hobe Sound	980
Island Bay	20
J.N. Ding Darling	6,315
Key West	208,308
Lake Wales Ridge	1,814
Lake Woodruff	21,559
Lower Suwannee	51,031
Matlacha Pass	393
Merritt Island	139,174
National Key Deer	8,614
Okefenokee	3,678
Passage Key	64
Pelican Island	4,824
Pine Island	602
Pinellas	394
St. Johns	6,256
St. Marks	67,122
Florida (cont.)	
St. Vincent	12,490
Ten Thousand Islands	35,034
FSA Interest FL[a]	3,124
Total	975,693
Georgia	
Banks Lake	3,559
Blackbeard Island	5,618
Bond Swamp	5,490
Eufaula	3,231
Harris Neck	2,762
Okefenokee	391,402
Piedmont	34,967
Savannah	12,011
Wassaw	10,070
Wolf Island	5,126
FSA Interest GA[a]	4,778
Total	479,014
Kentucky	
Clarks River	5,017
Ohio River Islands	410
Reelfoot	2,040
Total	7,467
Louisiana	
Atchafalaya	15,255
Bayou Cocodrie	13,169
Bayou Sauvage	22,261
Big Branch Marsh	12,642
Black Bayou Lake	1,861
Bogue Chitto	29,493
Breton	9,047
Cameron Prairie	9,621
Catahoula	6,545
D'Arbonne	17,420
Delta	48,799
Grande Cote	6,077
Handy Brake	466
Lacassine	34,379
Lake Ophelia	17,306
Mandalay	4,619
Sabine	140,717
Shell Keys	8
Tensas River	65,746
Upper Quachita	41,063
FSA Interest LA[a]	14,026
Total	510,520
Mississippi	
Bogue Chitto	6,808
Dahomey	9,167
Grand Bay	5,120
Hillside	18,678
Mathews Brake	2,419

continued

Table 1.15—U.S. Fish and Wildlife Service refuges within the South (continued)

Refuge	Total acres
Mississippi (cont.)	
Mississippi Sandhill Crane	19,713
Morgan Brake	7,372
Noxubee	46,914
Panther Swamp	35,272
St. Catherine Creek	24,931
Tallahatchie	4,839
Yazoo	12,940
FSA Interest MS[a]	29,326
Total	223,499
North Carolina	
Alligator River	156,125
Cedar Island	14,482
Currituck	4,317
Great Dismal Swamp	24,812
Mackay Island	7,150
Mattamuskeet	50,180
Pea Island	5,834
Pee Dee	8,439
Pocosin Lakes	108,692
Roanoke River	17,977
Swanquarter	16,411
FSA Interest NC[a]	6,175
Total	420,594
Oklahoma	
Deep Fork	8,387
Little River	12,029
Optima	4,333
Ozark Plateau	2,858
Salt Plains	32,057
Sequoyah	20,800
Tishomingo	16,464
Washita	8,075
Wichita Mountains	59,020
Total	164,023
Puerto Rico	
Cabo Rojo	1,857
Culebra	1,574
Desecheo	360
Laguna Cartagena	1,036
Total	4,827
South Carolina	
ACE Basin	11,772
Cape Romain	65,225
Carolina Sandhills	45,348
Pinckney Island	4,053
Santee	12,483
Savannah	14,839
Tybee	100
Waccamaw	4,978
FSA Interest SC[a]	1,430
Total	160,228
Tennessee	
Chickasaw	22,376
Cross Creeks	8,861
Hathcie	11,556
Lake Isom	1,846
Lower Hatchie	9,353
Reelfoot	8,409
Tennessee	51,359
FSA Interest TN[a]	685
Total	114,445
Texas	
Anahuac	34,296
Aransas	114,397
Attwater Prairie Chicken	9,199
Balcones Canyonlands	16,481
Big Boggy	4,526
Brazoria	43,905
Buffalo Lake	7,664
Grulla	5
Hagerman	11,320
Laguna Atascosa	57,826
Little Sandy	3,802
Lower Rio Grande Valley	77,695
McFaddin	56,181
Moody	3,517
Muleshoe	5,809
San Bernard	30,267
Santa Ana	2,088
Texas Point	8,952
Trinity Point	6,801
FSA Interest TX[a]	1,718
Total	496,449
Virginia	
Back Bay	8,315
Chincoteague	13,598
Eastern Shore	1,570
Featherstone	326
Fisherman Island	1,025
Great Dismal Swamp	83,944
James River	4,195
Mackay Island	874
Martin	146
Mason Neck	2,276
Nansemond	423
Occoquan Bay	642
Plum Tree Island	3,502
Presquile	1,329
Rappahannock River	2,975
Wallops Island	3,373
FSA Interest VA[a]	134
Total	128,647
Virgin Islands	
Buck Island	45
Green Cay	14
Sandy Point	490
Total	549
Grand total	4,089,154

[a] Farm Service Agency.
Source: U.S. Department of the Interior 2000b.

There are several listed species on the refuge. Mammals include the Florida panther and Florida black bear. Avian species include the wood stork, snail kite, bald eagle, and Florida grasshopper sparrow. The American alligator, eastern indigo snake, striped mud turtle, and loggerhead sea turtle are reptiles of conservation concern.

Habitat management objectives center on the provision of optimum conditions for the panther. Other objectives include restoration of natural diversity and implementation of environmental education programs promoting Florida panther and south Florida ecosystems.

National wildlife refuges and the Fish and Wildlife Service: St. Vincent National Wildlife Refuge, FL—This 12,490-acre island refuge is a red wolf propagation site. Additional endangered and threatened species that occur on St. Vincent Island include the bald eagle, piping plover, wood stork, eastern indigo snake, and loggerhead sea turtle.

The primary refuge objective is management and preservation of the natural barrier island and associated native plant and animal communities. Additional management objectives include the provision of habitat for migratory birds and protection of listed species.

National wildlife refuges and the Fish and Wildlife Service: Okefenokee National Wildlife Refuge, GA—Established in 1936, the Okefenokee Refuge covers 391,402 acres. The swamp contains numerous islands and lakes, along with vast areas of nonforested terrain. Prairies cover approximately 60,000 acres of the swamp. Once forested, these marsh expanses were created during periods of severe drought when fires burned vegetation and surface layers of peat.

A wide variety of bird species are supported. The prairies harbor wading birds, including herons, egrets, white ibis, sandhill cranes, wood storks, and bitterns. Scrub-shrub areas support various warblers.

Refuge objectives encompass protection of the unique environmental qualities of the Okefenokee ecosystem, and the provision of optimum habitat for a wide diversity of fish, birds, mammals, reptiles, and amphibians.

National wildlife refuges and the Fish and Wildlife Service: Tensas River National Wildlife Refuge, LA—This refuge lies in the upper basin of the Tensas River in northeastern Louisiana. It includes the site of the last documented sighting of the ivory-billed woodpecker. The refuge supports 65,746 acres of woodlands, croplands, reforested agricultural fields, and open water. The area also is home to the threatened Louisiana black bear.

Management objectives include water management for waterfowl, wading birds, and shorebirds. Cooperative farming provides habitat for migratory birds and bear. Deer are managed via public hunting.

National wildlife refuges and the Fish and Wildlife Service: Alligator River National Wildlife Refuge, NC—This 156,125-acre refuge was established to preserve a unique wetland habitat type, the pocosin, and its associated terrestrial species. Diversity of habitat types includes bogs, freshwater and brackish marshes, hardwood swamps, and Atlantic white-cedar swamps. Plant species include pitcher plants, sun dews, low-bush cranberries, bays, pond pine, red maple, and a wide variety of herbaceous and shrub species common to the South.

Refuge objectives center on the preservation of the unique wetland and the provision of habitat for the red wolf, red-cockaded woodpecker, American alligator, black bear, waterfowl, and migratory birds.

National wildlife refuges and the Fish and Wildlife Service: Mississippi Sandhill Crane National Wildlife Refuge, MS—This refuge occupies 19,713 acres of pine-savanna habitat interspersed with cypress, rivers, and marsh on the Coastal Plain of Mississippi. Water bodies such as Perigal Bayou, Old Fort Bayou, and Bluff Creek flow through various units of the refuge. Approximately 100 endangered sandhill cranes inhabit the refuge.

Refuge objectives center on the provision of habitat for the sandhill cranes and protection of the diverse savanna communities used by cranes. Crane management includes population monitoring, captive bird release, predator control, and law enforcement. Habitat restoration is accomplished via prescribed burning, vegetation manipulation, and noxious weed control.

National wildlife refuges and the Fish and Wildlife Service: White River National Wildlife Refuge, AR—Established in 1935, the White River Refuge contains the largest contiguous block of bottomland hardwood forest under a single ownership in the South.

White River supports one of the largest concentrations of wintering mallard ducks in the Mississippi flyway on its 154,856 acres. Numerous species of wading birds, shorebirds, geese, neotropical migrants, and raptors (including the bald eagle) also inhabit the area.

Refuge objectives center on the provision of optimum habitat for migratory bird and resident species, and support for a diversity of species common to the White River bottoms.

National forests and the Forest Service—The USDA Forest Service was established in 1905 to provide quality water and timber for the Nation. In the subsequent years, the Forest Service embodied the concept of multiple uses. Multiple uses refer to resource management that benefits a variety of purposes while ensuring the productivity and quality of the environment. Benefits include the provision of water, forage, wildlife, wood, and recreation.

The Weeks Act authorized purchase of lands for the National Forest System, especially deforested land, which would be reforested for watershed protection. The Clark-McNary Act (1924) further allowed the Agency to purchase private land that was potentially valuable for timberland production.

Acquisitions under the Weeks and Clark-McNary Acts further added area to the National Forest System.

The mission of the Forest Service centers on four primary objectives: (1) protection and management of natural resources on National Forest System land; (2) research on forests and forest resource utilization; (3) assistance to State and local governments, forest industry, and private landowners for land management; and (4) international assistance for the management of forest resources (Loomis 1993). The Forest Service has recently issued policies for preservation of old growth and maintenance of biological diversity.

National forests are found in 13 Southern States, Puerto Rico, and the Virgin Islands (table 1.16). Over 15 million acres in the South are managed by the Forest Service. National forest ownership ranges from 27,831 acres in Puerto Rico to 2,586,074 acres in Arkansas. In addition to Arkansas, the greatest concentrations of national forest are in Virginia (1,660,428 acres), Mississippi (1,158,967 acres), and Florida (1,152,824 acres). Hundreds of animals and plants are supported by the diversity of habitats in the National Forest System.

National forests and the Forest Service: roadless areas—Roadless areas comprise nearly 1 million acres of the southern national forests (table 1.17). Substantial acreages with this designation are in Virginia (394,000 acres) and North Carolina (172,000 acres). Roadless areas have a range of habitat types and successional seres. Habitat tends to be contiguous, providing refuge from human disturbance that can disrupt species movement and reproduction.

These areas possess ecological characteristics that are rare in developed landscapes, such as large, relatively undisturbed blocks of habitat (U.S. Department of Agriculture, Forest Service 2000b). Invasion of exotic species, erosion, sedimentation, and disruption of water flow are often less likely in roadless than in roaded areas. Species richness may be improved in roadless areas that are large enough to offer a mosaic of habitat patches in various successional stages following disturbance.

National forests and the Forest Service: wilderness areas—Wilderness areas cover 698,513 acres in the South (table 1.18). Arkansas (116,937 acres), Georgia (114,789 acres), and North Carolina (103,226 acres) have the largest amounts of wilderness in the South (U.S. Department of Agriculture, Forest Service 2000c). The Wilderness Act requires that these areas retain their primeval character without permanent developments or human habitation. Roads, timber harvesting, and motorized access are prohibited, but hunting and fishing are permitted.

One objective of managing wilderness is to preserve naturally functioning ecosystems. Relatively large blocks of undisturbed habitat are rare in

Table 1.16—National forest location and acreage in the South

Location	Gross acreage	NFS acreage	Other acreage
Alabama			
Conecuh NF	171,177	83,858	87,319
Talladega NF	740,334	389,328	351,006
Tuskegee NF	15,628	11,252	4,376
William B. Bankhead NF	348,917	180,548	168,369
Talladega PU	11,706	0	11,706
Pea River LUP	40	40	0
State total	1,287,802	665,026	662,776
Arkansas			
Ouachita NF[a]	2,004,231	1,423,459	580,772
Ozark NF	1,496,999	1,136,709	360,290
St. Francis NF	29,729	21,201	8,528
Ouachita PU	1,442	1,442	0
Ozark PU	7,115	3,263	3,852
State total	3,539,516	2,586,074	953,442
Florida			
Apalachicola NF	632,890	565,543	67,347
Chotawhatchee NF	1,152	1,152	0
Ocala NF	430,441	383,573	46,868
Oscala NF	190,932	158,255	32,677
Nekoosa PU	674	223	451
Pinhook PU	171,182	40,025	131,157
Tates Hell-New River	6,863	4,053	2,810
State total	1,434,134	1,152,824	281,310
Georgia			
Chattahoochee NF	1,515,885	749,352	766,533
Oconee NF	260,883	115,231	145,652
Chattahoochee PU	69,302	195	69,107
Ocmulgee PU	10,000	250	9,750
Yonah PU	46	46	0
Forestry Sci. Lab. EA	4	4	0
State total	1,856,120	865,078	991,042
Kentucky			
Daniel Boone NF	1,360,692	547,686	813,006
Jefferson NF[a]	54,614	961	53,653
Land between the Lakes	170,310	170,310	0
Redbird PU	686,399	145,099	541,300
State total	2,272,015	864,056	1,407,959
Louisiana			
Kisatchie NF	1,022,373	603,230	419,143
Bayou Beouf PU	2,264	980	1,284
State total	1,024,637	604,210	420,427
Mississippi			
Bienville NF	382,821	178,542	204,279
De Soto NF	796,072	506,028	290,044
Delta NF	118,150	60,015	58,135
Holly Springs NF	519,943	155,661	364,282
Lyndon B. Johnson NGL	115,438	20,309	95,129

continued

Table 1.16—National forest location and acreage in the South (continued)

Location	Gross acreage	NFS acreage	Other acreage
Mississippi (cont.)			
Homochitto NF	373,497	191,505	181,992
Holly Springs NF	119,155	66,874	52,281
De Soto PU	240	240	0
Homochitto PU	67	67	0
Forest Hydro. Lab. EA	15	15	0
Forestry Sci. Lab. EA (state college)	7	7	0
Forestry Sci. Lab. EA (Gulfport)	10	10	0
Southern Hardwoods Lab EA	3	3	0
State total	2,309,980	1,158,967	1,151,013
North Carolina			
Cherokee NF[a]	327	327	0
Croatan NF	308,234	159,886	148,348
Nantahala NF	1,349,000	527,709	821,291
Pisgah NF	1,076,511	505,420	571,091
Uwharrie NF	219,757	50,189	169,568
Nantahala PU	17,027	737	16,290
Yadkin PU	194,496	0	194,496
Forestry Sci. Lab. EA	27	27	0
State total	3,165,379	1,244,295	1,921,084
Oklahoma			
Ouachita NF[a]	723,552	350,845	372,707
Black Kettle NGL	32,537	30,710	1,827
Rita Blanca NGL	15,816	15,576	240
State total	771,905	397,131	374,774
Puerto Rico			
Caribbean NF	55,665	27,831	27,834
State total	55,665	27,831	27,834
South Carolina			
Francis Marion NF	414,699	252,288	162,411
Sumter NF	960,805	360,868	599,937
Silviculture Watershed Lab EA	15	15	0
State total	1,375,519	613,171	762,348
Tennessee			
Cherokee NF[a]	1,204,520	634,198	570,322
Cherokee PU	7,712	325	7,387
Land between the Lakes	63,852	63,852	0
State total	1,276,084	698,375	577,709
Texas			
Angelina NF	402,231	153,180	249,051
Davy Crockett NF	394,200	160,652	233,548
Sabine NF	442,705	160,656	282,049
Sam Houston NF	491,800	162,996	328,804
Black Kettle NGL	576	576	0
Caddo NGL	68,661	17,873	50,788
Lyndon B. Johnson NGL	115,438	20,309	95,129

continued

Table 1.16—National forest location and acreage in the South (continued)

Location	Gross acreage	NFS acreage	Other acreage
Texas (cont.)			
McClellan Creek NGL	1,449	1,449	0
Rita Blanca NGL	77,413	77,413	0
State total	1,994,473	755,104	1,239,369
Virginia			
George Washington NF[a]	1,635,565	960,133	675,432
Jefferson NF[a]	1,586,343	700,268	886,075
Jefferson PU	1,145	0	1,145
Kimberling Creek PU	271	27	244
State total	3,223,324	1,660,428	1,562,896
Grand total	28,882,907	15,644,482	13,287,425

PU = purchase unit; LUP = land utilization project; EA = experimental area; NGL = national grassland.
[a] Property is in two or more States.
Source: U.S. Department of Agriculture 2000a.

Table 1.17—Summary of inventoried roadless areas in the South

State	Total acreage
Alabama	13,000
Arkansas	95,000
Florida	50,000
Georgia	63,000
Kentucky	3,000
Louisiana	7,000
Mississippi	3,000
North Carolina	172,000
Oklahoma	13,000
South Carolina	8,000
Tennessee	85,000
Texas	4,000
Virginia	394,000
Total	910,000

Source: U.S. Department of Agriculture 2000c.

Table 1.18—Wilderness areas in the South

State	NFS acreage	Other acreage	Total acreage
Alabama	32,167	80	32,247
Arkansas	116,578	359	116,937
Florida	74,495	4	74,499
Georgia	114,537	252	114,789
Kentucky	16,779	658	17,437
Louisiana	8,679	0	8,679
Mississippi	6,046	0	6,046
North Carolina	102,634	592	103,226
Oklahoma	14,543	1,425	15,968
South Carolina	16,671	0	16,671
Tennessee	66,349	40	66,389
Texas	38,483	0	38,483
Virginia	87,064	78	87,142
Total	695,025	3,488	698,513

Source: U.S. Department of Agriculture 2000a.

the South. These are of particular importance to mammals that have large home ranges. Importantly, wilderness contributes to understanding wildlife in an unmanaged setting.

Implications of Habitat Fragmentation on Vertebrate Species

This section reviews the literature on habitat fragmentation and the resulting influence on the species that inhabit those landscapes. Two additional chapters of the Assessment examine fragmentation in the South. Chapter 6 presents an analysis of southern locations using remotely sensed imagery. In addition, chapter 3 examines the influence of roads and power lines on habitat fragmentation.

The definition of fragmentation—The term "fragmentation" is often used to refer to the insularization of habitat on a landscape. The change in arrangement of existing habitats is often accompanied by a loss of habitat area. A landscape may cover hundreds of square miles or a much smaller area. The definition depends on the context of its use and is shaped by the scale at which ecological processes are discussed (Trani 2002).

Fragmentation may occur when a forested landscape is subdivided into patches. Fragmentation may also occur when numerous openings for such things as fields, roads, and power lines interrupt a continuous forest canopy. It also can refer to discontinuities of vegetation in the landscape. Wetland

habitat can become fragmented when portions are drained for urban development, while prairie habitat can become fragmented by agricultural development. The resulting landscape pattern alters habitat connectivity and edge characteristics, influencing a variety of species.

Factors that contribute to landscape fragmentation—Landscape fragmentation may result from natural processes such as hurricanes, wildfires, and floods. Landscape fragmentation may also occur in association with land use conversion for urban development, agricultural use, and timber harvesting. The ecological consequences of natural or human-caused fragmentation differ depending on the pattern imposed by these factors.

Landscape modification has occurred for thousands of years. Native inhabitants modified landscapes by burning and clearing forested areas. The first European settlers divided vast forests into farmlands and settlements. This trend continues today. Much of the southern landscape is under intensive management and is becoming an increasingly complex mosaic of forest, urban, and agricultural areas.

Timber harvesting may fragment the landscape, depending on the number, size, and arrangement of harvest units (Trani 1996). Higher levels of fragmentation occur when small, numerous harvest units are dispersed over the landscape than when units are clustered. A dispersed harvest scheme increases spatial heterogeneity, patchiness, and forest edge length. However, the changes in pattern resulting from timber harvest are often temporary because the harvested area regenerates and reverts to forest. The rate of succession depends on the composition of the residual stand, browsing by herbivores, subsequent management activities, weather, and other disturbances (Wigley and Roberts 1994).

It is important to note that a forested landscape supporting a mosaic of different seral stages is not ecologically the same as a landscape containing isolated forested patches surrounded by agricultural or urban areas. Each seral stage provides habitat that varies in suitability for a particular species as it moves through the forested landscape.

Roads may contribute to forest fragmentation when their placement divides large landscapes into smaller patches and interior forest habitat is converted into edge habitat. As road density increases, the populations of some species may become isolated (chapter 3). Roads located along the periphery of a landscape have the least influence on the resulting pattern (Trani 1996). The influence of roads on habitat fragmentation varies with road width and degree of permanence. A six-lane interstate highway has a greater effect on landscape pattern than does a 20-foot forest road. Some roads, such as unimproved dirt roads, may be temporary, while others are paved and permanent.

Influence of landscape fragmentation upon terrestrial species—Harris (1988) cited fragmentation as the most serious threat to biological diversity in the Nation. Area-sensitive species requiring large tracts of habitat may decline or be extirpated locally. The movement of species between patches may be inhibited. Population persistence may be linked to the number, size, and degree of isolation of forest patches (Robbins and others 1989).

Influence of landscape fragmentation upon terrestrial species—The influence of fragmentation on the landscape can be associated with three related factors: (1) patchiness, (2) edge, and (3) connectivity.

Influence of landscape fragmentation upon terrestrial species: patchiness—Changes in patch size have been recognized as a major component of fragmentation. Species richness may decline as patch area is reduced (Ambuel and Temple 1983, Askins and others 1990, Lynch and Whigham 1984). Small remnant patches of forest surrounded by open areas constitute unfavorable habitat for many species; these remnants also have increased susceptibility to windthrow disturbance and other processes. Robinson and Wilcove (1994) suggested that fragmented landscapes become population sinks that are only sustained by immigration from nearby forest tracts that are large enough to produce a surplus of individuals.

Matthiae and Stearns (1981) found that the density of red squirrel, gray squirrel, raccoon, and red fox increased with habitat patch size. Fahrig and Merriam (1985) also reported that certain mammals were more common in large forest tracts than in smaller, isolated patches. Populations of white-footed mice and chipmunks in small forest patches declined to a point that local extirpations occurred.

Rosenberg and Raphael (1986) reported that gray foxes, ringtail cats, and northern flying squirrels were sensitive to forest fragmentation. Picton (1979) found that the presence of large mammals was correlated with the size of the mountain ranges where each species occurs. Mammal population can increase when minimum habitat size requirements are met. The insularity of populations increases with continued landscape fragmentation while larger, undeveloped areas protected these species from extinction.

Roads may or may not act as barriers to the movement of species between habitat patches. Extensive networks of roads have negative impacts on black bears, white-tailed deer, and Florida panthers (chapter 3). These negative impacts stem from loss of habitat, increased hunter accessibility, and vehicular mortality.

Long-term population declines have been observed for neotropical migrants inhabiting small forest patches. Breeding bird censuses for isolated forest patches indicate general reductions in abundance and diversity of species over the past several years (Lynch and Whitcomb 1977). Critical information for the conservation of bird species includes understanding of the relationship between reproductive success and habitat size and quality. The dependence of many breeding songbirds on large blocks of forest is well established (Robbins and others 1989, Whitcomb and others 1981).

Species sensitive to patch size tend to be highly migratory, are forest-interior specialists, build open nests, and/or nest on the ground (Whitcomb and others 1981). The worm-eating warbler, the hooded warbler, and the black-and-white warbler are generally absent in patches less than 50 acres (Hamel 1992). Other species that are sensitive to patch size include the swallow-tailed kite, broad-winged hawk, barred owl, pileated woodpecker, and black-billed cuckoo (Hamel 1992). While many species avoid

small patches, widespread permanent residents and short-distance migrants tend to predominate in small patches (Askins and others 1990).

Habitat isolation has been associated with population declines in large snakes due to increasing networks of roads (Gibbons and Buhlmann 2001). These networks divide forested habitat into smaller and smaller parcels. Likewise, amphibian mortality is intensified when a heavily traveled road separates individuals from the forest they live in and the wetland they require for breeding.

Influence of landscape fragmentation upon terrestrial species: edge—An edge is the place where two different plant communities, successional stages, or land uses come together. Fragmentation can increase the amount of edge habitat in a landscape. Inherent edges are caused by changes in soil type or topography, whereas induced edges are those created by disturbance. Induced edges can be created by land uses, including cultivation, fertilization, and harvest, and by environmental disturbances such as fires, blowdowns, and floods.

The creation of forest edge influences seedling establishment and vegetative composition. For some species, these effects persist hundreds of yards into the forest interior (Chen and others 1992). For example, the edge habitat may serve as an access point, attracting cowbirds into the interior of a forested landscape (Askins 1994).

Many species occur in edge habitat, particularly those that use one habitat for food and another for cover. Game birds, such as the American woodcock and northern bobwhite quail, occur in edge habitats. Many species in urban and agricultural landscapes are edge-adapted. Many woodland passerines favor edge habitat (Yahner and Scott 1988), which may provide enhanced forage and/or improved habitat conditions.

In contrast, excessive edge may lead to reduced populations of species dependent on large blocks of forest interior (Robbins and others 1989). Species that use continuous mature forest may be replaced by generalist species. Southern breeding birds that nest only in the interior of forests include the sharp-shinned hawk, Cooper's hawk, hairy woodpecker, winter wren, and veery (Hamel 1992). Edge can negatively affect these species, particularly in patches with large perimeter-to-area ratios (Noss 1983).

An increase in density of forest-edge and farmland species along edges may exclude certain interior and long-distance migrant species. Competition by the edge-adapted starling exerts a direct negative impact on many forest species (Harris 1988). This competition may influence bird community composition more than area-dependent changes in habitat (Ambuel and Temple 1983).

Species that occur in edge habitats are subject to high rates of mortality from predators attracted to these habitats. The raccoon, least weasel, and striped skunk often hunt for small mammals along edges. Ground nests receive predation pressure where mammals and reptiles are the dominant predators (Chasko and Gates 1982). Predation reduces the recruitment of the Kentucky warbler, scarlet tanager, wood thrush, yellow-throated vireo, and ovenbird (Temple and Cary 1988). Increases in edge density contribute to the escalation of nest predation and parasitism to levels that can bring reproductive success below replacement rates.

Nest parasitism by cowbird species may be an important factor in the decline of some breeding birds. Brood parasites lay their eggs in the nests of other species, reducing the reproductive success of their hosts. The brown-headed cowbird may have contributed to the population declines of the Acadian flycatcher, veery, American redstart, and Louisiana waterthrush (Brittingham and Temple 1983).

Influence of landscape fragmentation upon terrestrial species: connectivity—Connectivity, the degree of continuity of a landscape, is also affected by fragmentation. Connectivity may facilitate dispersal and improve habitat quality by connecting patches of habitat. It has been suggested that the population dynamics of species are affected by the spatial pattern of fragmentation (Haddad and others 2000, Hanski 1991). There is disagreement, however, on the value of corridors for the conservation of biological diversity. One view is that populations linked by corridors are vulnerable to the spread of disease and several environmental stressors (Gilpin 1987, Quinn and Hastings 1987). If corridors spread the risk of environmental stress among isolated populations, persistence time may actually be longer in fragmented landscapes (Fahrig and Paloheimo 1988).

Another view suggests that species persistence is lower in fragmented habitats than in contiguous habitats (Tilman and others 1994). These studies suggest that corridors are valuable as a conservation tool. This point of view is discussed next.

Heany and Patterson (1986) presented an extensive review of the regional patterns of mammal distribution as affected by habitat connectivity. Pelton (1986) described how the loss of connectivity restricts the distribution of black bears. When disturbance causes local extirpation, populations may be reestablished through the dispersal of individuals from source populations. Jackson (1987) reported corridors aided red-cockaded woodpeckers in colonizing existing habitat. Forest birds can often use small tracts of forest connected to large tracts by wooded corridors (Robbins 1979). Forest-interior birds and small mammals (Merriam 1990) persist in forest fragments connected by woodland corridors that ease colonization.

Species that are able to move between connected habitat patches operate demographically as a metapopulation. Corridors may permit the survival of extinction-prone populations through the immigration of individuals. Corridors also may facilitate movement of an individual within its home range. Such movement may be particularly important for species whose home range area requirements exceed the average patch size. For example, Rosenburg and others (1997) reported that migratory amphibians, such as red-spotted newts, may require corridors among seasonally used habitats. The loss of connectivity may cause local extirpation. Many amphibian and reptile species cannot move through relatively large, deforested areas to reach other suitable forest habitat. Where declines of herpetofaunal populations occur, population sizes

will not be rebuilt quickly in a fragmented landscape (Gibbons and Buhlmann 2001).

Discussion and Conclusions

Status and Trends of Terrestrial Vertebrate Species

Natural Heritage classifies 86 percent of southern vertebrate species as secure or apparently secure. The populations of these species appear to be resilient; some species such as white-tailed deer and beaver have rebounded despite incredible odds. Population trends are positive for several big game, small game, and waterfowl species. In addition, the long-term population projections for several furbearer species appear stable or increasing.

In contrast, declines in the populations of northern bobwhite quail, ruffed grouse, and woodcock warrant further management focus. The decline in breeding populations of grassland and shrubland nesting birds also is a concern in the region. The numerous species with G1, G2, or G3 conservation ranks suggest that these vertebrates are sensitive to changes in their environment. Identifying the factors that contribute to the declines of these species may be useful for predicting future conditions. Several of these factors, as well as their associated conservation measures, are examined in chapter 5.

Significant losses of community biodiversity have occurred throughout the region. Several communities have been classified as critically endangered, endangered, or threatened. An additional 24 communities have been identified as having a 50-percent loss of presettlement area. It is critical to halt further losses of these communities and to raise public awareness through education.

There appears to be a commonality of threats to sensitive species and communities of the South. Many species and communities experienced declines associated with human disturbance and settlement patterns. The growth of human populations in the South will continue to pressure species and the communities that support them. Vertebrate species and their associated habitats are influenced by urban development, fire suppression, agricultural practices, forest pest and exotic species outbreaks, and recreation activity. Other species are rare due to restrictive or specialized habitat conditions (chapter 2).

The future of a majority of these sensitive species and communities in the South depends on active restoration and management. Restoration complements species conservation by maintaining habitat composition, structure, and function. Activities that mimic natural disturbance are particularly important. Prescribed burning can enhance herbaceous diversity and control structural characteristics. Other treatments are useful for suppressing woody growth and enhancing the vigor of other species. These management techniques are described further in chapter 4.

Hard and Soft Mast

For many species, mast is an essential food source. Thus, provision of hard and soft mast is important for the management of terrestrial species inhabiting southern forests.

Many silvicultural techniques enhance mast production (chapter 4). Management of stocking density can encourage reproduction of mast-producing species and limit interspecific competition. Artificial regeneration has been successful for several species, including northern red oak, white oak, and black cherry. Genetic selection for acorn production and seedling growth also has the potential to be successful. These treatments can play an important role in southern forest areas that may experience mast decline.

The Implications of Habitat Fragmentation

Extensive literature suggests that landscape patterns affect the abundance and persistence of terrestrial species. The fragmentation of the landscape, and the consequences of that fragmentation on ecosystems and population dynamics, are concerns shared across the region.

Natural processes and human activities may influence habitat loss and isolation. Changes in patchiness, edge, and connectivity may eliminate, displace, or enhance species populations and habitats. Isolated habitat patches may reduce the number of species present simply because smaller habitats support fewer species (MacArthur and Wilson 1967). Preservation of species composition and integrity in these areas cannot be expected. Corridors may increase the movement of habitat-restricted species, thereby improving overall habitat quality (Haddad and Baum 1999, Rosenburg and others 1998).

Understanding how spatial patterns alter species habitat may provide resource managers with a basis for making land use decisions. Species respond to patterns in various ways, using certain areas for feeding and reproduction, and avoiding other areas entirely. By altering the distribution and availability of spatial resources, changes in landscape pattern influence many of the components important for the persistence of species (Merriam 1990).

The South's growing human population raises the possibility of a substantial impact on species and their habitats in the next several decades (chapter 6). In the midst of expanding populations, the provision of biological diversity has become a critical conservation issue.

The Influence of Land Ownership Patterns

The population increases projected for the South may continually increase demands on natural ecosystems, species, and their habitats during the 21st century (Boyce and Martin 1993). This prospect presents a challenge to forest resource management. Biodiversity often declines as economic development proceeds. Natural habitats for native species are replaced by industrial and urban development, while other habitats are modified or degraded. The future may also bring increased concern for conservation of endangered species and habitats and the reservation of lands for aesthetic and recreation values (Boyce and Martin 1993).

These changes highlight the important role that public lands will have in the conservation of species and their habitats. The Forest Service, Fish and Wildlife Service, and National Park Service manage millions of acres in the South. Other agencies, such as the U.S. Department of Defense and

the Tennessee Valley Authority, also manage critical habitat areas. There are numerous Federal policies that dictate the management and conservation of natural resources.

Without these public lands, many species would be in trouble. For example, over 53 percent of the species with viability concerns in the Ozark and Ouachita Highlands are known to occur only on national forests (U.S. Department of Agriculture, Forest Service 1999). The Peaks of Otter salamander is an example of an imperiled species that occurs solely on Federal land—in this case, the George Washington and Jefferson National Forests and the Blue Ridge Parkway. The Federal land in the Florida Panhandle and the central Appalachian Mountains supports concentrations of imperiled and listed species (Stein and others 2000). National wildlife refuges play a key role in the protection of listed species such as the red wolf and the Florida panther, and in the provision of key areas of habitat for waterfowl, migratory birds, and many other species. National parks are important for the preservation and management of old growth, spruce-fir, and other rare and sensitive communities of both plants and animals. National forests are key in the provision of wilderness areas, large blocks of forest interior, and a diversity of habitats.

Other public lands are also important for the conservation of species and their habitats. State agencies own significant areas designated as parks, wildlife management areas, forests, or natural resource areas. While the purposes of such areas vary, the conservation of biological diversity is often one objective for these properties. In Florida, State agencies are carrying out aggressive land acquisition programs for conserving biodiversity, using shared Federal excise tax revenues as a funding source. City and county governments also own a variety of land in parks and recreation areas that support species and their habitats.

Many imperiled and endangered species are found on public land, and this land represents a relatively small percentage of forest land in the South. It seems clear, therefore that public land is vital for maintaining imperiled and endangered species (Stein and others 2000).

The area of public land is being supplemented by acquisition efforts by private conservation organizations. The Nature Conservancy, the Trust for Public Lands, and Ducks Unlimited acquire land for conservation purposes. They either manage it or transfer it to public agencies. The Nature Conservancy has created its own system of conservation properties in the South. In contrast, the Trust for Public Lands acquires land for ultimate ownership and management by public resource agencies. Many of the trust's land transactions have been from forest industry lands that were important biologically.

The magnitude of private ownership also presents a significant challenge for southern forests. Individual landowners are changing the characteristics of future forest resources. For example, the absence of management on private land may result in declines in early successional habitat in many areas (Trani and others 2001). The small tracts typical of present land use patterns often provide little opportunity for forest management and natural disturbance sufficient to create early successional forest. A myriad of species may be influenced by this condition.

The Forest Service and other partners have initiated active reforestation programs with the private sector as part of the Lower Mississippi Valley Joint Venture. Land clearing and alteration of hydrology have resulted in environmental degradation throughout the valley. This step towards changing private land use practices may lead to restoration of the bottomland hardwood system, the provision of quality habitat, economic opportunities for landowners, and a reliable wood supply to meet society's needs.

The significant numbers of imperiled and endangered species inhabiting private land indicate the critical importance of this land for conservation (Stein and others 2000). For this reason, a variety of strategies designed to encourage conservation on private areas have been implemented by government agencies. Incentive programs have been created to encourage reforestation of private land. Recognizing the significance of private land to the imperiled species of the region is essential. Often, wildlife conservation may be more important than timber production on this land.

Industry land also offers opportunities to provide wildlife habitat. Given the incentive of green certification programs and the scale of their operations, many large corporations are taking positive actions to protect sensitive biological resources on their property (Stein and others 2000).

Industry land supports breeding bird species, game species, and other species (Wigley and others 2000). Individual companies work with government agencies to identify threatened and endangered species on their land. The Special Sites program within the Sustainable Forestry Initiative manages ecological sites to maintain wetlands, longleaf pine, and other unique communities (Weyerhaeuser and Price 2001).

Forest industry has also donated thousands of acres to State agencies and the Nature Conservancy (Owen and Helssenbuttel 1989). Donations include the Beryl Anthony Wildlife Management Area in Arkansas (7,000 acres), Great Dismal Swamp National Wildlife Refuge in Virginia (60,000 acres), and several wildlife management areas.

The significance of many types of landowners in the South in providing wildlife habitat cannot be overstated. Each major landowner has an important role to play in the conservation of species and their habitats.

Needs for Additional Research

Data are needed on the distribution, population dynamics, and habitat requirements of many southern species. Basic life history and management information is lacking for several threatened and endangered species. For some nongame birds and game species, standardized inventories lend themselves to regional assessments. For most species, however, there is a dearth of monitoring information from which to evaluate regional conditions.

Centers of amphibian and reptile diversity should be identified in sensitive communities. Long-term monitoring of amphibian and reptile populations is needed to establish population trends. Further study also is warranted to assess the impact

the expected climate changes may have on amphibians and other sensitive species.

Further research is desirable into management techniques that mimic natural disturbance for the creation of landscape patterns that are consistent with the evolutionary history of species. Applied research is needed to identify the best approaches, including burning, for restoring degraded communities and maintaining sensitive communities.

Finally, methods should be developed to quantify and forecast influences of human developments on southern biodiversity. We must identify vertebrate species that may be influenced by future habitat fragmentation, and examine how fragmentation attributes change over time.

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The southern forest resource assessment provides a comprehensive analysis of the history, status, and likely future of forests in the Southern United States. Twenty-three chapters address questions regarding social/economic systems, terrestrial ecosystems, water and aquatic ecosystems, forest health, and timber management; 2 additional chapters provide a background on history and fire. Each chapter surveys pertinent literature and data, assesses conditions, identifies research needs, and examines the implications for southern forests and the benefits that they provide.

Keywords: Conservation, forest sustainability, integrated assessment.