What conditions will be needed to maintain animal species associations in the South?

Chapter 5: Maintaining Species in the South

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Key Findings

- Geographic patterns of diversity in the South indicate that species richness is highest in Texas, Florida, North Carolina, and Georgia. Texas leads in the richness of mammals, birds, and reptiles; North Carolina leads in amphibian diversity. Texas dominates vertebrate richness by virtue of its large size and the variety of its ecosystems.
- Loss of habitat is the primary cause of endangerment of terrestrial vertebrates. Forests, grasslands, shrublands, and wetlands have been converted to urban, industrial, and agricultural uses. Other factors include environmental contaminants, commercial exploitation, coastal development, fire suppression, river and stream modification, and wetland degradation.
- Species that are federally listed as threatened or endangered consist of 22 birds, 33 mammals, 7 amphibians, and 17 reptiles. Florida leads with the number of threatened (16) and endangered (26) vertebrates; Texas is second in endangered species (23); while Mississippi is second in the number of threatened species (11).
- Birds of high concern include the red-cockaded woodpecker, bald eagle, piping plover, whooping crane, wood stork, black-capped vireo, Florida scrub jay, and the roseate and least terns.
- Habitat destruction and the paucity of large tracts of undisturbed land threaten far-ranging mammals such as the Florida panther, red wolf, and the Louisiana black bear. Other mammals of concern include the Carolina and Virginia northern flying squirrels, the river otter, and several rodents.
- Twenty species of bats inhabit the South. Four are listed as endangered: the gray bat, Indiana bat, and Ozark and Virginia big-eared bats. Human disturbance to hibernation and maternity colonies is a major factor in their decline.
- The South is the center of amphibian biodiversity in the Nation. However, there are growing concerns about amphibian declines. Potential causes include habitat destruction, exotic species, water pollution, ozone depletion leading to excessive ultraviolet radiation, acid deposition, synthetic chemicals, and prolonged drought conditions.
- Seven species of amphibians are listed as threatened or endangered by the U.S. Fish and Wildlife Service: the Houston toad, Flatwoods salamander, San Marcos salamander, Barton Springs salamander, Red Hills salamander, Shenandoah Mountain salamander, and Texas blind salamander. These species are imperiled due to physiological constraints that limit them to moist habitats, relatively small ranges, and highly specific sites.
- Reptile species of concern include the Louisiana pine snake, eastern indigo snake, crocodile, glass lizard, bluetail mole skink, gopher tortoise, and bog turtle. General problems faced by reptiles include habitat destruction, pet trade, negative public attitudes, degradation of aquatic habitats, and fire suppression or the lack of sufficient prescribed burning.
- Many reptiles and amphibians are long-lived and late maturing, and have restricted geographic ranges. Managing for these species will require different strategies than those in place for birds and mammals. The paucity of monitoring data further inhibits their management.

Introduction

The biodiversity of the South is impressive. Factors contributing to that diversity include regional gradients in climate, geologic and edaphic site conditions, topographic variation, natural disturbance processes, and the activities of Native Americans and European settlers (Boyce and Martin 1993, Delcourt and others 1993, Healy 1985). These factors have contributed to the diversity of several species groups: salamanders, snakes, and turtles (White and others 1998). The evolution of plants and animals, combined with the isolation that characterizes some habitats, produced remarkable levels of endemism—species that are restricted to special habitats.

The terrestrial vertebrate fauna of the South, including the entire States of Texas and Oklahoma, consists of 1,208 species. This total includes 170 amphibians, 197 reptiles, 595 birds, and 246 mammals (NatureServe 2000). Species richness is highest in Texas, Florida, North Carolina, and Georgia (fig. 5.1). North Carolina leads in amphibian diversity, while Texas leads in the richness of mammals, birds, and reptiles.

The variation in species richness among States is influenced by

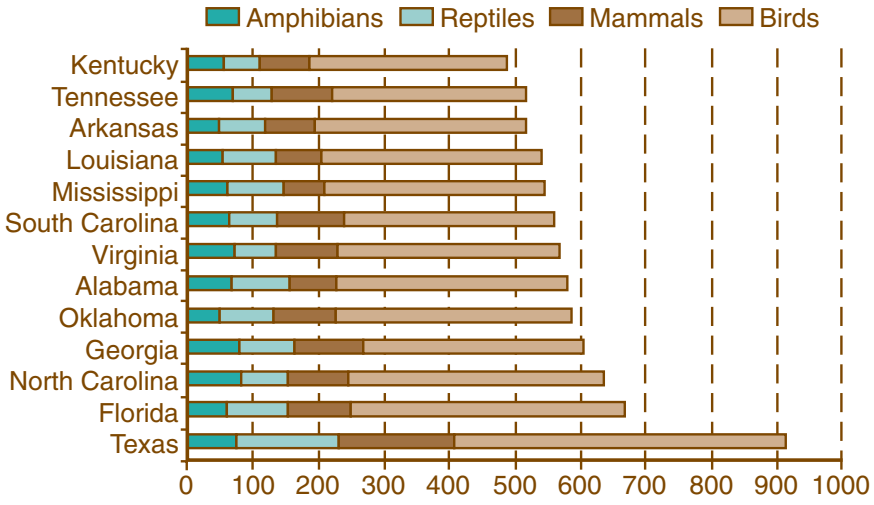

Figure 5.1—Geographic patterns of diversity by State within the South (NatureServe 2000).

differences in size, geographic location, and environmental complexity (Stein and others 2000). Texas leads the region with 911 vertebrate species; diversity there is influenced by the State's large size and its diversity of habitats (NatureServe 2000). Florida, North Carolina, and Georgia each support over 600 vertebrate species. The smallest number of species (487) occurs in Kentucky. Texas and Florida support species typical of Latin America and the Caribbean that reach their northern limits there (Stein and others 2000). For example, the northern limit for the American crocodile is in the Florida Keys and south Florida.

This diverse array of vertebrate species is found in a variety of habitats. A habitat is comprised of the physical and biological resources that allow a species to survive and reproduce. The habitat requirements for some species may be quite narrow, while those for another may be rather broad.

A species may require a certain habitat structure such as vegetation height, percent canopy cover, floristics, seral stage, patch size, or diversity and interspersion of plant communities. Some species are constrained by abiotic factors such as the precise cave temperatures required by many bat species. These features of habitat influence the distribution and abundance of species (Dickson 2001).

The habitat conditions for southern species have been modified by several factors (Buckner 1989). Habitat loss and degradation are serious threats to the region's fauna (Noss and others 1995, Williams 1989). The rapid growth of the human population has resulted in land use conversion, urban sprawl, and habitat fragmentation (White and others 1998). Landscape modification has been accompanied by habitat isolation, water and air pollution, and altered disturbance regimes (Lorimer 2001, Trani and others 2001). In addition, southern wildlife has been influenced by the introduction of exotic species and the overexploitation of native species. Of particular concern is collection of species for the pet trade and overharvest of commercial species (Flather and others 1998). These factors have influenced species and their habitats in different ways.

This chapter provides an overview of the habitat associations of birds, mammals, reptiles, and amphibians in the South. The focus is on vertebrates because information on the regional biogeography of many terrestrial invertebrate groups is lacking (Echternacht and Harris 1993). Additional information on plant and animal associations is provided in chapters 1, 2, and 23.

Taxa groups are described, and general habitat associations for each are summarized. The status, distribution, and habitat requirements are provided for selected species of concern. Finally, conservation and management actions are suggested for enhancing habitat associations and mitigating known threats.

The following sections discuss the conditions needed to maintain and enhance conditions for species that occupy the terrestrial habitats of the South. Scientific names are provided in the chapter tables and the master species list in the Assessment appendix; therefore, only common names are provided in the text.

Methods and Data Sources

Data on the status of threatened or endangered vertebrate species of the South were compiled from the U.S. Department of the Interior (2000). That agency provided information on the distribution of listed species by State. Its recovery plans and other agency publications were used to compile information on life history, ecology, and management of individual species.

Regional species richness in each vertebrate taxon was compiled from State Natural Heritage offices (NatureServe 2000). This database is an inventory of all known occurrences for species of conservation concern. Information was derived from the database to determine geographic patterns of diversity by State in the South. The system was also used to verify the status and distribution of species included in the fauna accounts.

Information on bird habitat associations was obtained from Partners in Flight (2000) conservation plans. These plans highlight the factors that imperil bird species in physiographic areas and recommend management actions. The conservation plans were used to identify species of conservation concern (Pashley and others 2000).

Habitat associations for herpetofauna (reptiles and amphibians) were summarized from the comprehensive review conducted by Wilson (1995). Additional literature reviews and reference materials supplied information on reptile and amphibian ecology.

State agency bear biologists were surveyed for information about the current status, habitat needs, and management concerns about black bears. Nine States responded with information: Alabama, Arkansas, Florida, Kentucky, Mississippi, North Carolina, Oklahoma, Texas, and Virginia.

Information on mammal habitat relationships was compiled from extensive literature searches, field

guides, and texts on southern wildlife. Research stations and universities throughout the South were contacted to obtain additional information on selected species.

Results

Birds

The moderate climate and diverse forests across the South support abundant and diverse communities of breeding, wintering, and migrating birds. This vertebrate group comprises 17 major orders and 55 families (Echternacht and Harris 1993). The order Passeriformes dominates the region's avifauna in the number of different families (19) and species (127). These include the flycatchers, crows, swallows, jays, titmice, wrens, vireos, grackles, orioles, finches, sparrows, and warblers among others.

The South supports 595 avian species (NatureServe 2000). The number of bird species ranges from 505 in Texas to 296 in Tennessee. Florida has 419; North Carolina, 390; Oklahoma, 359; and Alabama, 355. These totals include perching birds, shorebirds, wading birds, waterfowl, raptors, and other birds (fig. 5.2).

Perching birds, which include the passerines mentioned above, comprise the majority of bird species. Examples of shorebirds include plovers and curlews, while wading birds include sandhill cranes and flamingos. Mottled ducks, Canada geese, wood ducks, hooded merganser, and mallards represent waterfowl. Eagles, hawks, kites, vultures, and owls are some of the species classified as raptors. The Natural Heritage designation of "other birds" includes gamebirds, such as bobwhite quail, ruffed grouse, American woodcock, wild turkey, and several dove species. This group also includes woodpeckers; open ocean birds such as cormorants, petrels, and pelicans; rails; and many other species.

The coastal wetlands support the greatest number of species. In fact, the South supports the largest number of wading species in the United States (White and others 1998). Thirty-one species occur solely at high elevations in the Appalachian Mountains.

The South also provides habitat for summer breeding populations, birds that overwinter in the region, and birds that migrate to South America. Coastal habitats, maritime forests, and longleaf pine savanna are all important to migrating species.

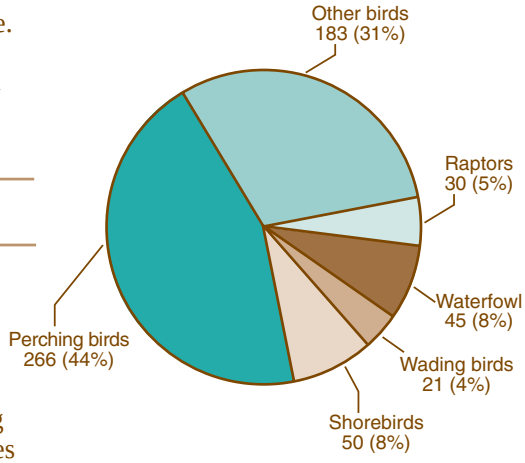

Figure 5.2—Species richness by major subgroups of avian taxa occurring within the South (NatureServe 2000).

Twenty-one species of birds are listed as threatened or endangered (table 5.1). Several of these species inhabit the Coastal Plain. In addition, several birds are classified as imperiled or vulnerable by the Natural Heritage agencies (chapter 1). These species are in jeopardy due to habitat loss, habitat fragmentation, or coastal development (Hall 1995). The dependence on breeding and staging areas has made shorebird populations vulnerable to disturbance. Colonial waterbirds have declined as a result of habitat degradation.

In contrast, the status of other species has improved during the past decade. The status of the brown pelican as well as several species of raptors (ospreys, bald eagles, and peregrine falcons) has improved due to habitat protection and restrictions on the use of DDT (Fuller and others 1995).

There is a substantial body of information on bird-habitat relationships, and extensive long-term monitoring programs have been in place for several decades. The distribution and composition of bird communities is influenced by local habitat and landscape conditions. Local habitat features include forest type, understory, number of foliage layers, canopy structure, and successional stage. Landscape conditions influencing bird populations include patch size, interspersion of vegetative communities, forest fragmentation, edge length, interpatch distance, interior forest, adjacent land use, and spatial heterogeneity.

The following section discusses bird-habitat associations in the South. Species of concern are identified, and recommendations for their management are provided.

Partners in Flight physiographic areas—Partners in Flight (PIF) is an organization formed to promote bird conservation. It is comprised of Federal and State agencies, conservation groups, and forest industry. PIF uses physiographic areas as conservation planning units for evaluating population trends, habitat conditions, land use practices, and emerging conservation issues (fig. 5.3). Boundaries defined by geomorphology, topography, and vegetative communities are based

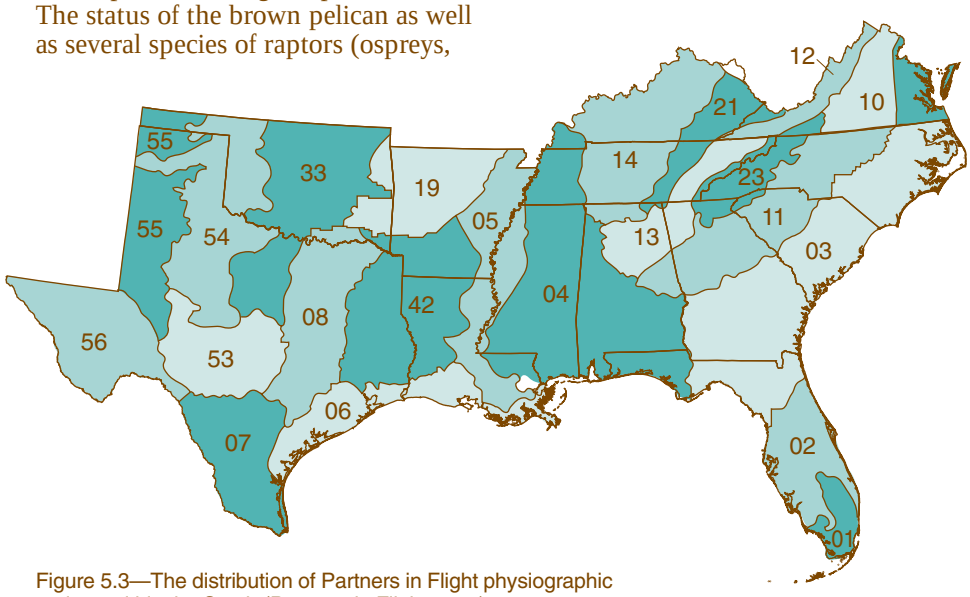

Figure 5.3—The distribution of Partners in Flight physiographic regions within the South (Partners in Flight 2000).

Table 5.1—Bird species in the South that are listed as threatened or endangered

Scientific name	Common name	Areas of occurrence
Wading birds		
Grus americana	Whooping crane (E)	FL, OK, TX
Grus canadensis pulla	Mississippi sandhill crane (E)	MS
Raptors		
Falco femoralis septentrionalis	Northern aplomado falcon (E)	TX
Haliaeetus leucocephalus	Bald eagle (T)	AL, AR, FL, GA, KY, LA, MS, NC, OK, SC, TN, TX, VA
Polyborus plancus audubonii	Audubon's crested caracara (T)	FL
Rostrhamus sociabilis plumbeus	Everglade snail kite (E)	FL
Shorebirds		
Charadrius melodus	Piping plover (T)	AL, AR, FL, GA, KY, LA, MS, NC, OK, SC, TN, TX, VA
Mycteria americana	Wood stork (E)	AL, FL, GA, SC
Numenus borealis	Eskimo curlew (E)	OK, TX
Perching birds		
Ammodramus maritimus mirabilis	Cape sable seaside sparrow (E)	FL
Ammodramus savannarum floridanus	Florida grasshopper sparrow (E)	FL
Aphelocoma coerulescens	Florida scrub-jay (E)	FL
Dendroica chrysoparia	Golden-cheeked warbler (E)	TX
Empidonax traillii extimus	Southern willow flycatcher (E)	TX
Vireo atricapillus	Black-capped vireo (E)	LA, MS, OK, TX
Other birds		
Pelecanus occidentalis	Brown pelican (E)	LA, MS, TX
Picoides borealis	Red-cockaded woodpecker (E)	AL, AR, FL, GA, KY, LA, MS, NC, OK, SC, TN, TX, VA
Sterna antillarum	Least tern (E)	AR, LA, MS, OK, TN, TX
Sterna dougallii dougallii	Roseate tern (T, E[a])	FL, GA, KY, NC, SC, VA
Strix occidentalis	Spotted owl (T)	TX
Tympanuchus cupido attwateri	Attwater's greater prairie chicken (E)	TX

T = Threatened; E = endangered.
[a] Threatened in the United States where not listed as endangered.
Source: U.S. Department of the Interior (2000).

upon physiographic strata established by the North American Breeding Bird Survey (Peterjohn and others 1995). Physiographic areas are distinguished by having distinct species assemblages, land uses, and conservation issues.

Bird conservation plans prepared for each physiographic area identify species and habitats of conservation concern. Seventeen physiographic areas lie predominately in the South (table 5.2). All of the plans are available online at www.blm.gov/wildlife/pifplans.htm.

The conservation plans prioritize birds of concern and their habitat using several criteria for ranking a species' vulnerability: relative abundance, size of breeding and nonbreeding ranges, threats during breeding and nonbreeding seasons, population trends, and relative density. Numerical scores are given for each criterion, with higher scores reflecting higher vulnerability. Species of concern are represented by scores of 22 and above; these species are the focus of the physiographic area conservation plans.

Table 5.3 presents a summary of the birds of concern for the southern physiographic areas. Species of concern that occur in several physiographic areas include the swallow-tailed kite, red-cockaded woodpecker, Acadian flycatcher, Bell's vireo, brown-headed nuthatch, wood thrush, prairie

warbler, cerulean warbler, prothonotary warbler, worm-eating warbler, Swainson's warbler, Louisiana waterthrush, Kentucky warbler, Bachman's sparrow, and Henslow's sparrow. These species and the physiographic areas they inhabit are described below. Management recommendations from the plans follow Pashley and others (2000) unless otherwise cited.

PIF physiographic areas: mid-Atlantic Coastal Plain—This physiographic area extends from the Atlantic Ocean south of Long Island to the Virginia-North Carolina border. The landscape is dominated by forested wetlands, salt marshes, and barrier islands. Upland forests grade from pine-dominated areas on the outer Coastal Plain to hardwood forests on the inland areas. This landscape has been altered by human settlement for approximately four centuries. Human population growth is expected to continue, placing further demands on the region's natural resources.

The mid-Atlantic Coastal Plain supports 185 bird species; 20 (11 percent) are of concern. Among those species, the prairie warbler occupies pine savanna habitat, while the Bachman's sparrow occurs in grassy understories. Salt marshes support important breeding and wintering populations of the black duck, black rail, salt marsh sharp-tailed sparrow, and seaside sparrow. The Acadian flycatcher, cerulean warbler, and prothonotary warbler inhabit forested wetlands. Mixed upland forest supports the wood thrush in well-developed midstories and the worm-eating warbler and Kentucky warbler in dense understories. Henslow's sparrows may also occur along the edges of salt marsh habitat, in areas of regenerating pines, and on former grasslands.

Conservation issues center on managing human population growth while maintaining functioning ecosystems. The extensive forested habitat is heavily fragmented; maintaining blocks large enough to support a diversity of breeding birds is a priority. Protection of critical sites for wintering species must be integrated with conservation plans for breeding habitats. Specific recommendations include restoration of pine savanna conditions through prescribed burning; protection of barrier dunes to minimize losses in species productivity; protection of sites with greater than 125 acres of high marsh; identification of forest areas that support significant populations of prothonotary and cerulean warblers; and the restoration of open lands greater than 125 acres with Henslow's sparrow potential.

PIF physiographic areas: mid-Atlantic Piedmont—The mid-Atlantic Piedmont is separated from the southern Piedmont at the North Carolina-Virginia line. It extends north through Virginia, Maryland, and Pennsylvania before terminating in northern New Jersey. The rolling topography formerly supported extensive hardwood forests including oak-hickory, Appalachian oak, and loblolly-shortleaf pine. Approximately 45 percent of the physiographic area is presently forested, 45 percent is in agricultural production, and the remainder is in urban areas.

The mid-Atlantic Piedmont supports 137 bird species; 11 (8 percent) are of concern. Deciduous and mixed forest habitats support the wood thrush, cerulean warbler, Louisiana waterthrush (in riparian forest buffers), and Kentucky warbler (in dense understory). The shrub-scrub areas and barrens support the bobwhite quail (in decline). The American woodcock (also in decline) requires an interspersion of forest clearings and second-growth hardwoods. Agricultural pastureland supports a large population of grasshopper sparrows and other grassland species.

Table 5.2—Species richness by physiographic area for birds of the South (Partners in Flight 2000)

Physiographic area	State(s)	Total species	Species of concern	
			No.	*%*[a]
01 – Subtropical Florida	FL	103	14	13.2
02 – Peninsular Florida	FL	128	21	15.2
03 – South Atlantic Coastal Plain	FL, GA, SC, NC	161	26	15.5
04 – East Gulf Coastal Plain	FL, AL, MS, LA, TN	161	20	12.2
05 – Mississippi Alluvial Valley	MS, LA, AR	143	17	11.9
06 – Coastal Prairies	LA, TX	168	20	11.5
08 – Oaks and Prairies	TX, OK	147	13	8.7
10 – Mid-Atlantic Piedmont	VA	137	11	8.0
11 – Southern Piedmont	AL, GA, SC, NC	125	14	11.2
12 – Mid-Atlantic Ridge and Valley	VA	166	14	8.4
13 – Southern Ridge and Valley	AL, GA, TN	131	21	16.0
14 – Interior Low Plateaus	AL, TN, KY	159	15	9.4
19 – Ozark-Ouachita Plateau	AR, OK	151	17	11.2
21 – Northern Cumberland Plateau	AL, TN, KY, VA	144	18	12.5
23 – Southern Blue Ridge	GA, SC, NC, VA	156	20	12.8
42 – West Gulf Coastal Plain	LA, AR, TX, OK	130	18	13.8
44 – Mid-Atlantic Coastal Plain	VA	185	20	10.6

[a] Species of concern represented by scores of 22 and above.

Table 5.3—Bird species of concern in the South (Partners in Flight 2000)

Scientific name	Common name	Physiographic areas[a]
Egretta rufescens	Reddish egret	02, 04, 08
Eudocimus albus	White ibis	01, 02
Anas rubripes	American black duck	44
Anas fulvigula	Mottled duck	01, 02, 06
Elanoides forficatus	Swallow-tailed kite	01, 02, 04, 05, 06, 08, 42
Rostrhamus sociabilis	Snail kite	01, 02
Buteo brachyurus	Short-tailed hawk	01, 02, 03
Tympanuchus cupido	Greater prairie chicken	06, 08
Colinus virginianus	Northern bobwhite	03, 04, 08, 11
Laterallus jamaicensis	Black rail	02, 03, 08, 44
Rallus longirostris	Clapper rail	02, 03, 06
Grus Canadensis	Sandhill crane	02
Charadrius alexandrinus	Snowy plover	02
Charadrius wilsonia	Wilson's plover	02, 03, 06
Charadrius melodus	Piping plover	03, 44
Haematopus palliatus	American oystercatcher	02, 03, 04, 08
Sterna forsteri	Forster's tern	06
Columba leucocephala	White-crowned pigeon	01
Coccyzus americanus	Yellow-billed cuckoo	04, 05, 08, 13, 14, 42
Coccyzus minor	Mangrove cuckoo	02
Caprimulgus carolinensis	Chuck-will's-widow	04, 13, 42
Caprimulgus vociferus	Whip poor will	10, 11, 12, 14
Chaetura pelagica	Chimney swift	14
Amazilia yucatanensis	Buff-bellied hummingbird	06
Picoides borealis	Red-cockaded woodpecker	01, 02, 03, 04, 11, 13, 19, 21, 23, 42, 44
Campephilus principalis	Ivory-billed woodpecker	03
Contopus virens	Eastern wood-pewee	12, 44
Empidonax virescens	Acadian flycatcher	10, 13, 19, 21, 23, 44
Tyrannus dominicensis	Gray kingbird	01, 02
Tyrannus forficatus	Scissor-tailed flycatcher	06, 08, 42
Lanius ludovicianus	Loggerhead shrike	02
Vireo griseus	White-eyed vireo	05, 42
Vireo bellii	Bell's vireo	04, 05, 06, 08, 14, 19, 42
Vireo flavifrons	Yellow-throated vireo	12, 13, 21, 23, 44
Vireo altiloquus	Black-whiskered vireo	01, 02
Aphelocoma coerulescens	Florida scrub-jay	01, 02, 03
Tachycineta cyaneoviridis	Bahama swallow	01
Petrochelidon fulva	Cave swallow	01, 06, 08
Sitta pusilla	Brown-headed nuthatch	02, 03, 04, 05, 10, 11, 13, 19, 23, 42, 44
Thryomanes bewickii	Bewick's wren	11, 12
Hylocichla mustelina	Wood thrush	03, 05, 10, 12, 13, 19, 21, 23, 44
Toxostoma longirostre	Long-billed thrasher	06
Vermivora bachmanii	Bachman's warbler	03, 04, 05
Vermivora pinus	Blue-winged warbler	05, 13, 14, 44
Vermivora chrysoptera	Golden-winged warbler	12, 13, 21, 23
Parula americana	Northern parula	03, 05, 12
Dendroica pensylvanica	Chestnut-sided warbler	23
Dendroica caerulescens	Black-throated blue warbler	04, 05, 12, 13, 21, 23
Dendroica fusca	Blackburnian warbler	23
Dendroica dominica	Yellow-throated warbler	03, 13, 23
Dendroica discolor	Prairie warbler	01, 03, 04, 10, 11, 12, 13, 14, 19, 21, 23, 42, 44

continued

Table 5.3—Bird species of concern in the South (Partners in Flight 2000) (continued)

Scientific name	Common name	Physiographic areas[a]
Dendroica cerulea	Cerulean warbler	03, 04, 05, 10, 11, 12, 13, 14, 19, 21, 23, 42, 44
Mniotilta varia	Black-and-white warbler	23
Protonotaria citrea	Prothonotary warbler	03, 04, 05, 06, 11, 13, 19, 21, 42, 44
Helmitheros vermivorus	Worm-eating warbler	03, 04, 05, 08, 10, 11, 12, 13, 14, 19, 21, 23, 42, 44
Limnothlypis swainsonii	Swainson's warbler	03, 04, 05,06, 08, 11, 12, 13, 14, 19, 21, 23, 42, 44
Seiurus motacilla	Louisiana waterthrush	12, 13, 14, 19, 21, 23, 42
Oporornis formosus	Kentucky warbler	04, 05, 06, 10, 11, 13, 14, 19, 21, 23, 42, 44
Wilsonia citrina	Hooded warbler	03, 21, 23, 42
Wilsonia canadensis	Canada warbler	23
Piranga rubra	Summer tanager	21
Aimophila aestivalis	Bachman's sparrow	02, 03, 04, 06, 10, 11, 13, 14, 19, 21, 23, 42, 44
Spizella pusilla	Field sparrow	10, 11, 13, 14, 19, 21
Ammodramus henslowii	Henslow's sparrow	03, 06, 10, 11, 12, 14, 19, 21, 44
Ammodramus caudacutus	Saltmarsh sharp-tailed sparrow	03, 44
Ammodramus maritimus	Seaside sparrow	01, 02, 03, 04, 06, 44
Passerina ciris	Painted bunting	03, 05, 06, 08, 19
Spiza americana	Dickcissel	06, 14, 19
Icterus spurius	Orchard oriole	04, 05, 13, 42
Icterus graduacauda	Audubon's oriole	06

[a] Physiographic areas: 01 – Subtropical Florida, 02 – Peninsular Florida, 03 – South Atlantic Coastal Plain, 04 – East Gulf Coastal Plain, 05 – Mississippi Alluvial Valley, 06 – Coastal prairies, 08 – Oaks and prairies, 10 – Mid-Atlantic Piedmont, 11 – Southern Piedmont, 12 – Mid-Atlantic Ridge and Valley, 13 – Southern ridge and valley, 14 – Interior Low Plateaus, 19 – Ozark-Ouachita Plateau, 21 – Northern Cumberland Plateau, 23 – Southern Blue Ridge, 42 – west Gulf Coastal Plain, and 44 – Mid-Atlantic Coastal Plain.

Conservation issues center on the management of human population growth and protection of conservation areas. Enhancement of grassland habitat also is a priority. Specific recommendations include management of areas that support significant populations of cerulean and Kentucky warblers, restoration of natural barrens that support shrub-nesting species, and monitoring priority species in disturbed areas.

PIF physiographic areas: mid-Atlantic Ridge and Valley—This physiographic area extends from western Maryland through the mountains of Virginia. Consisting of mountain ridges and intervening valleys, the predominant forest type is oak-hickory. Relict patches of spruce-fir occur on high mountain ridges. Agricultural production and urban development dominate in the lower valleys. Human populations are relatively sparse and confined to the valleys, while coal extraction occurs on public and private forests. Disease and insect pests are important disturbance factors; the pesticides used for gypsy moth control impact other foliage insects that are important bird food (Hunter and others 2001).

The mid-Atlantic Ridge and Valley supports 166 bird species; 14 (8 percent) are of concern. Early successional shrub habitat (including barrens and disturbed sites) supports the whippoorwill, golden-winged warbler, and prairie warbler. The wood thrush and worm-eating warbler occupy mature deciduous forest, while the Louisiana waterthrush is found in late successional stands near streams. The black-throated blue warbler and the blackburnian warbler use northern hardwood and spruce-fir forests.

Conservation issues center on long-term planning on public land to meet the habitat needs of species requiring specific seral stages. On public land, it is important to balance the needs of early successional species with those requiring mature forest (Trani and others 2001). Specific actions needed for this physiographic area include management of high-elevation spruce-fir habitat, intensive surveys for Appalachian Bewick's wren, identification of breeding sites for golden-winged warbler, and the maintenance of composition and structural diversity.

PIF physiographic areas: northern Cumberland Plateau—The Cumberland Plateau is a predominantly forested, gently rolling tableland bordered by the eastern rim of the Interior Low Plateaus and the Cumberland Mountains (fig. 5.3). The area includes eastern Kentucky and Tennessee, southwestern West Virginia, and a small area in western Virginia. Forests dominated by oaks and hickories are common. Various pine species are dominant on drier sites.

The northern Cumberland Plateau supports 144 bird species; 18 (12 percent) are of concern. Among species

of concern, the Acadian flycatcher, wood thrush, worm-eating warbler, and Swainson's warbler inhabit mixed mesophytic forests. Coniferous forests support the red-cockaded woodpecker (low-elevation yellow pine) and Bachman's sparrow. Bewick's wren and golden-winged warbler use early successional habitat, while Henslow's sparrow occurs in grassland areas. Both habitats exist only due to disturbance.

Conservation issues center on the maintenance of species composition and vegetation structure. Widespread timber harvesting and fire suppression have reduced both old-growth and young forest habitats. The current structure of the mid-seral forest may not be optimal for many midstory and understory breeding birds. As a result of diminishing habitat quality, several high-priority birds have undergone significant population declines. The northern Cumberland Plateau is one of the most heavily forested physiographic areas in the South. Specific recommendations include management of 12 to 15 percent of forests for long-rotation sawtimber or old growth, increased use of fire in low-elevation yellow pine habitat, and maintenance of shrub-scrub conditions.

PIF physiographic areas: southern Ridge and Valley—This physiographic area includes the southern end of the Ridge and Valley and the tablelands of the southern Cumberland Plateau. It is in eastern Tennessee, northwest Georgia, and northeast Alabama. The upland forest is predominantly in oak-hickory and pine (shortleaf or loblolly) types.

The southern Ridge and Valley supports 131 bird species; 21 (16 percent) are of concern. Early successional scrub-shrub habitat is occupied by the Bewick's wren, blue-winged warbler, and orchard oriole. The hardwood forest component supports the Acadian flycatcher, yellow-throated warbler, prothonotary warbler, worm-eating warbler, and Swainson's warbler among others. Red-cockaded woodpeckers and brown-headed nuthatches are found in southern pines.

Conservation issues focus on the conversion of hardwood forest to monocultures of loblolly pine. A large percentage of natural vegetation has been cleared for agriculture and urban development. Birds dependent on mature forest may be at risk because the amount of public land may not be sufficient to support viable populations of sensitive species (Hunter and others 2001). Enhancement of habitat for these species will require the use of long-rotation harvests. Specific recommendations include expansion of longleaf habitat using prescribed fire and the enhancement of scrub habitat.

PIF physiographic areas: southern Blue Ridge—The Southern Blue Ridge runs along the border between Tennessee and North Carolina, extending into South Carolina, Georgia, and Virginia. The area is comprised of rugged mountains, broad ridges, steep slopes, and deep ravines. Spruce-fir forests at the highest elevation transition into northern hardwoods, hemlock-white pine, and Appalachian oaks at lower elevations. Cove forests occur on mesic sites, while fire-associated yellow pines occur on dry ridges. Disturbances from fire, grazing, and storms are primary factors in determining forest composition and structure.

The southern Blue Ridge supports 156 bird species; 20 (13 percent) are of concern. Among species of concern, the northern saw-whet owl, black-capped chickadee, red-breasted nuthatch, golden-crowned kinglet, red crossbill, and yellow-bellied sapsucker are distinct subspecies whose ranges are centered within the southern Blue Ridge. With the exception of the sapsucker, each species occupies high forested peaks. The yellow-bellied sapsucker, as well as the golden-winged warbler, inhabits disturbed forest areas. Among species of concern requiring mature forest in the southern Blue Ridge are Acadian flycatchers, yellow-throated vireos, wood thrushes, blackburnian warblers, Swainson's warblers, Kentucky warblers, and Canada warblers.

Conservation issues include population declines of both migrant and resident birds. The rapid construction of new homes and associated developments along roads contribute to habitat loss and fragmentation. Another concern is the decline of high-elevation spruce-fir forests resulting from exotic pests and reduced air quality. Atmospheric pollution is reducing tree growth, insectivore food availability, and supplies of important minerals necessary for successful bird reproduction (Hunter and others 2001). Many species in this habitat are in isolated endemic populations that may be genetically distinct from populations elsewhere. Populations of priority birds, such as the Appalachian subspecies of Bewick's wren, have declined in recent years. Maintenance of early successional habitat is a conservation need. Other recommendations include management of riparian zones and the provision of old-growth forest.

PIF physiographic areas: southern Piedmont—This physiographic area extends through central North Carolina, South Carolina, and Georgia into eastern Alabama. Plains, hills, tablelands, and numerous rivers characterize the Piedmont. The area lies between the Appalachian Mountains and the Coastal Plain. The dominant vegetation includes oak-hickory and mixed hardwood forests. Shortleaf, loblolly, and scattered longleaf pines are prevalent on disturbed sites.

The southern Piedmont supports 125 bird species; 14 (11 percent) are of concern. Among species of concern, the prairie warbler, Bachman's sparrow, and Henslow's sparrow are supported by grassland and shrub habitat. Southern pine forests support the red-cockaded woodpecker and brown-headed nuthatch, while prothonotary and Swainson's warblers use the bottomland hardwoods. Upland hardwood habitat supports the whippoorwill, wood thrush, and cerulean warbler.

Conservation challenges focus on human population growth, urban sprawl, and the intensification of agriculture and timber harvesting. Several bird populations have declined in patches of protected mature forests embedded in suburban settings. In addition, changing land use has resulted in a loss of early successional habitat. Public lands provide core areas in the Piedmont on which to manage habitat. The maintenance of bird communities requires coordination among public agencies, forest industry, and private landowners.

PIF physiographic areas: south Atlantic Coastal Plain—The south Atlantic Coastal Plain covers northeastern Florida, southern Georgia, the eastern Carolinas, and the Great Dismal Swamp in Virginia. Coastal areas contain barrier islands, maritime forests, marshland, and estuaries. Inland areas support bottomland hardwood forests, pocosins, and

Carolina bays. Fire-maintained forests of longleaf, shortleaf, and loblolly pine once dominated upland areas.

The south Atlantic Coastal Plain supports 161 bird species; 26 (15 percent) are of concern. Among species of concern, the American kestrel, red-cockaded woodpecker, and brown-headed nuthatch require pine forest, and Henslow's sparrow requires pocosin grasslands. The swallow-tailed kite, northern parula, Swainson's warbler, and hooded warbler occupy bottomland and upland hardwood forests. The prairie warbler and painted bunting are found in the scrub-shrub habitat.

Conservation concerns include fire management, land conversion, and short-rotation pine plantations. Restoration of fire-maintained pine savanna benefits pine-grassland species, particularly the red-cockaded woodpecker. Pine plantations are used by other species, but the maintenance of age class diversity is important. Other recommendations include maintenance of large tracts of bottomland forest in river systems to benefit black-throated green warblers and breeding swallow-tailed kites, and retention of coastal maritime forest and scrub-shrub habitats for the bunting and in-transit migrants.

PIF physiographic areas: peninsular Florida—This physiographic area extends from the northern edge of Lake Okeechobee in central Florida to the Suwanee River in northern Florida. Habitat includes sandhill, scrub, and xeric hammock communities. Longleaf pine, turkey oak, and wiregrass characterize the fire-dependent sandhill communities. Dominant scrub vegetation includes sand pine and scrub oak. Xeric hammocks support live oak, laurel oak, and saw palmetto. Upland hardwoods, wetlands, and mangroves are also locally common to abundant in the physiographic area.

Peninsular Florida supports 128 bird species; 21 (15 percent) are of concern. Among species of concern, crested caracara (threatened), burrowing owl, Florida scrub jays (endangered), and grasshopper sparrows inhabit the scrub and grassland habitat. Wetland and mangrove habitats support the swallow-tailed kite, snail kite (endangered), and short-tailed hawk. The painted bunting occurs in maritime scrub, while the American kestrel, red-cockaded woodpecker, and Bachman's sparrow use pine forests.

Conservation actions are directed at fostering cooperative relations with private landowners, and encouraging proper habitat management through education, tax breaks, and conservation easements. Conservation goals also include the public acquisition of acreage in sandhills, oak scrub, upland forest, and floodplain swamp communities.

PIF physiographic areas: subtropical Florida—This physiographic area extends south from Lake Okeechobee in central Florida to the Florida Keys. The tropical ecosystem contains the Everglades and the Big Cypress Reserve. Fire is an important feature in the pine, marsh, and prairie communities. Hurricane disturbances create early successional habitat. Distinct dry and wet seasons influence the nesting cycles of many birds.

Subtropical Florida supports 103 bird species; 14 (13 percent) are of concern. Pine rocklands, flatwoods, and sand scrub habitats are used by the Florida scrub jay, sedge wren, and palm warbler. Grassland and dry prairie communities support the sandhill crane and grasshopper sparrow. The short-tailed hawk, white-crowned pigeon, and gray kingbird inhabit subtropical deciduous forests. The reddish egret, white ibis, wood stork, seaside sparrow, and several species of rails use the brackish saltwater and freshwater marsh habitats of the Everglades. Mangrove swamps support the mangrove cuckoo, the black-whiskered vireo, and the Cuban subspecies of the yellow warbler.

Conservation concerns are directed towards the rapidly growing human population in the region. Habitats have been lost by converting land to urban and agricultural uses, such as sugarcane and citrus production. Other problems include pollution and alteration of the hydroperiod and natural water cycles. Recommendations include aggressive acquisition programs and the maintenance of pine-dominated stands and prairies through prescribed burning. Programs for bird conservation were created by the Surface Water Improvement and Management Act, Florida's Everglades Forever Act, and the South Florida Ecosystem Restoration Task Force.

PIF physiographic areas: Interior Low Plateaus—The Interior Low Plateaus extend from Alabama northward across central Tennessee and Kentucky into southern Illinois, Indiana, and Ohio, encompassing the central basin and Tennessee Valley. Oak-hickory and beech-maple forests were historically the most abundant cover types. There were also tallgrass prairies and oak savannas in the northern section. Barrens and glades are rare in the central regions, and forested wetlands occur along major waterways.

The Interior Low Plateaus support 159 bird species; 15 (9 percent) are of concern. Priority species inhabiting hardwood forest include the whippoorwill, cerulean warbler, and Louisiana waterthrush. The grassland, savanna, and old-field habitats support the Bewick's wren, blue-winged warbler, and dickcissel.

Conservation issues center on habitat loss from land conversion, habitat deterioration, and fragmentation. Pastureland has replaced grassland and savanna, while glades and barrens have become urban areas. Fire suppression has allowed woody vegetation to encroach into open areas. Floodplain forests have been converted to reservoirs or row crops. Previous forest management and chipping of all woody vegetation have influenced canopy characteristics, understory development, and age structure of upland forests.

Specific recommendations include the reestablishment of greater prairie chicken and swallow-tailed kite populations, maintenance of existing forested acreage, and the restoration of forested wetlands, warm season grasses, and oak savannas.

PIF physiographic areas: Ozarks and Ouachitas—The Ozark Mountains extend from southern Missouri into northern Arkansas and consist of dissected plateaus covered by oak forest with glade and savanna inclusions. The ridge and valley system of the Ouachitas covers central Arkansas, reaching into eastern Oklahoma. Vegetation includes shortleaf pine and deciduous forests. The vegetation changes to prairie in the northern reaches.

The Ozarks and Ouachitas support 151 bird species; 17 (11 percent) are of concern. Deciduous and mixed forest habitat supports the whippoorwill, worm-eating warbler, and Kentucky warbler. The red-cockaded woodpecker and Bachman's sparrow occur in pine savanna; populations of both species have declined dramatically due to fire exclusion and forestry practices. The Bewick's wren and the field sparrow use early successional habitat; both species are undergoing significant declines.

Conservation actions include the improvement of shortleaf pine, glade, and savanna communities through the use of thinning, overstory removal, and dormant season burns. Other activities include the prevention of forest fragmentation stemming from urbanization and the management of habitat required by early successional species.

PIF physiographic areas: East Gulf Coastal Plain—The East Gulf Coastal Plain extends from Louisiana and western Florida northwards through Mississippi and Alabama into Tennessee and Kentucky. Numerous streams and rivers break the rolling topography. Uplands are dominated by shortleaf pine and mixed hardwoods. Loblolly pine and bottomland hardwood forests occur in the lowland areas.

The East Gulf Coastal Plain supports 161 bird species; 20 (12 percent) are of concern. Swallow-tailed kites, prothonotary warblers, and Kentucky warblers occur in the forested wetlands and other habitat. The northern bobwhite, Mississippi sandhill crane (endangered), red-cockaded woodpecker, and sedge wren occupy the pine and savanna habitats. Chuck-will's-widow occurs in upland hardwoods, while the LeConte's sparrow and orchard oriole are present in the scrub habitat. Numerous spring migrants use the maritime forests. Emergent wetlands support the reddish egret, yellow and black rails, and Nelson's sharp-tailed sparrow. Snowy, piping, and Wilson's plovers inhabit the beach dunes community.

Conservation issues include the conversion of longleaf pine and upland hardwoods to other species, hydrological alteration, land use changes including coastal development, and the changes in species composition and structure resulting from fire suppression. Specific recommendations include maintenance of large tracts of longleaf pine and upland hardwoods for red-cockaded woodpeckers, swallow-tailed kite, cerulean warbler, Swainson's warblers, and associated species. Other actions include the control of exotic plants and the restoration of maritime forest, emergent wetlands, and beach dunes that are important to priority breeding and wintering birds.

PIF physiographic areas: Mississippi Alluvial Valley—Encompassing the floodplain of the Mississippi River, the valley includes eastern Louisiana, eastern Arkansas, northwestern Mississippi, and portions of Tennessee, Kentucky, and Missouri. The South's biggest concentration of bottomland hardwoods is in the Mississippi River Valley, where agricultural conversion has resulted in forest fragmentation. The Mississippi River and its flood regimes, which influence vegetation communities and bird habitat conditions, shape this physiographic area.

The Mississippi Alluvial Valley supports 143 bird species; 17 (12 percent) are of concern. Among species of concern, the swallow-tailed kite, northern parula, and painted bunting are supported by bottomland hardwood forests. Marsh, wetland, and open land support several species of shorebirds and waterfowl and provide important wintering areas for mallards, wood ducks, and other birds.

Conservation recommendations target the restoration of bottomland hardwood forest to support healthy populations of a suite of birds. Since settlement, over 80 percent of the forest has been cleared for agriculture and other uses. The hydrology has been dramatically altered, inhibiting ecosystem functions. The resulting forest fragmentation has reduced the ability of the area to support many bird populations. The Lower Mississippi Valley Joint Venture leads restoration efforts (Pashley and others 2000).

PIF physiographic areas: West Gulf Coastal Plain—The West Gulf Coastal Plain is located in northwestern Louisiana, southwestern Arkansas, eastern Texas, and southern Oklahoma. The physiographic area is characterized by loblolly pine, shortleaf pine, and longleaf pine forests on the uplands, hardwood forests in the bottomlands, and grasslands in the southernmost areas.

The West Gulf Coastal Plain supports 130 bird species; 18 (14 percent) are of concern. Among such species, the American kestrel, chuck-will's-widow, scissor-tailed flycatcher, brown-headed nuthatch, Bewick's wren, prairie warbler, and Bachman's sparrow are supported by pine forests and associated grasslands. The swallow-tailed kite, white-eyed vireo, worm-eating warbler, Swainson's warbler, and hooded warbler occupy hardwood forests and other supported habitats. The bottomland forests and riparian habitats are important for stopover migrants.

Conservation issues include fire suppression and regeneration practices that have replaced native species with loblolly or slash pine. Although many bird species occur in young pine plantations, others such as the red-cockaded woodpecker require native pine savanna conditions or mature longleaf pine stands. Specific recommendations include the maintenance of mature longleaf pine stands with fire, prevention of additional forest conversion to agricultural uses, and deterrence of bottomland hardwood loss due to inundation by reservoirs. The importance of these hardwoods for area-sensitive species and spring migrants extends beyond the West Gulf Coastal Plain.

PIF physiographic areas: oaks and prairies—This physiographic area extends from the Red River of Oklahoma southward into Texas. Tallgrass prairie, post-oak savanna, bottomland hardwood forests, riparian forests, and upland hardwood forests associated with dense scrub layers characterize the area. Wetlands and freshwater marshes are associated with streams, rivers, and reservoirs.

The oaks and prairies support 147 bird species; 13 (9 percent) are of concern. Among such species, the greater prairie chicken, northern bobwhite, scissor-tailed flycatcher, Bell's vireo, and painted bunting are supported by grassland and scrub habitats.

Conservation issues focus on the loss of prairie habitat. Areas of tallgrass prairie have been converted to crop production; less than 10 percent of

original prairie exists. The continued loss of tallgrass habitat inhibits restoration efforts by reducing genetic diversity; preservation of remaining habitat is critical. Encroachment by heavy woody growth and exotic species also causes loss of grassland habitat. Prescribed fire and grazing management through incentive programs are beneficial.

PIF physiographic areas: coastal prairies—This physiographic area is found along the Gulf Coast shoreline in Louisiana and Texas. The area supports a complex of marshes, upland grassland, and forested habitat. Marsh communities include salt, brackish, and freshwater marsh. The majority of grassland habitats have been converted to pasture and rice farms. Forested areas occur along major rivers, beach-front ridges, salt domes, and manmade levees. These woodlands are comprised of hackberry and live oak, while the bottomland hardwood forests contain the cypress-tupelo, hackberry-ash-elm, and oak-willow forest types.

The coastal prairies support 168 bird species; 20 (11 percent) are of concern. Priority grassland birds include the greater prairie chicken, short-eared owl, sedge wren, and Sprague's pipit. The bottomland hardwood forest supports the swallow-tailed kite, American woodcock, prothonotary warbler, and Swainson's warbler. Bell's vireo and painted bunting occupy scrub-shrub habitat. In addition, many passerine species use the coastal habitat during spring migration.

Conservation concerns focus on the alteration of natural communities in the coastal prairies. Oil and gas development, dredging, and impoundments have degraded marsh habitat. Grazing animals have degraded grassland and woodland areas. Specific recommendations include cooperative management with private landowners, incentive programs, and identification of potential habitat for priority birds. Other actions include marsh restoration, retention of forested wetlands, exotic species control (especially Chinese tallow), and monitoring the influence of rice crop conversion on waterbird species.

Additional information on the habitat associations of bird species in the South can be found in Hunter and others (2001) and Hamel (1992). The physiographic associations for nonbird taxa are not as well developed as those presented above for birds. Therefore, the habitat needs of mammals, reptiles, and amphibians will be discussed by broad taxonomic grouping.

Amphibians

Two orders of amphibians are present in the Southern United States: Caudata (salamanders) and Anurans (frogs and toads). The South supports the highest density of amphibian species in North America (Echternacht and Harris 1993). The total includes 107 salamanders and 63 species of frogs and toads (fig. 5.4). In individual States, the number of amphibian species ranges from 80 in North Carolina to 49 in Arkansas (NatureServe 2000). Numbers in other States are 77 in Georgia, 75 in Texas, 73 in Virginia, and 70 in Tennessee.

The Southern Appalachians have an unusually large number of salamander species, because many plethodontid species evolved there. These lungless animals are believed to have evolved in fast-flowing, oxygenated streams. The numbers of salamanders inhabiting North Carolina (50), Virginia (48), Tennessee (48), and Georgia (44) reflect the importance of the Appalachian Mountains. The number of salamanders occurring in the Coastal Plain is lower because habitat and temperature are less suitable and because densities of terrestrial and aquatic predators are higher (Echternacht and Harris 1993).

Numbers of frogs and toads are highest in the southernmost Coastal States. Numbers of species are 43 in Texas, 33 in Georgia, 32 in Florida, 31 in Louisiana, 31 in South Carolina, and 30 in Alabama (NatureServe 2000). The majority of southern species are in five families: true frogs; tree, chorus, and cricket frogs; true toads; narrowmouth toads; and spadefoot toads. Eleven species are endemic to the South (Echternacht and Harris 1993).

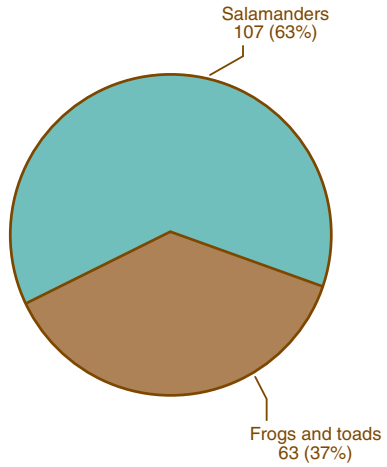

Figure 5.4—Species richness by major subgroups of amphibian taxa occurring within the South (NatureServe 2000).

Table 5.4—Amphibian species in the South that are listed as threatened or endangered

Scientific name	Common name	Areas of occurrence
Frogs and toads		
Bufo houstonensis	Houston toad (E)	TX
Salamanders		
Ambystoma cingulatum	Flatwoods salamander (T)	AL, FL, GA, SC
Eurycea nana	San Marcos salamander (T)	TX
Eurycea sosorum	Barton Springs salamander (E)	TX
Phaeognathus hubrichti	Red Hills salamander (T)	AL
Plethodon shenandoah	Shenandoah Mountain salamander (E)	VA
Tyhplomolge rathbuni	Texas blind salamander (E)	TX

Source: U.S. Department of the Interior (2000).

Seven species of amphibians are listed as threatened or endangered by the U.S. Fish and Wildlife Service (table 5.4). In addition, several amphibians are classified as imperiled or vulnerable by the Natural Heritage agencies (chapter 1).

Amphibians have complex life cycles and inhabit a variety of environments. Habitats include ephemeral pools, caves, forests, wetlands, savannas, and several aquatic habitats. The longleaf pine-wiregrass community, cypress-gum swamps, isolated wetlands, and mixed hardwood-pine habitats support a diversity of species. The federally listed flatwoods salamander is found in the longleaf pine-wiregrass ecosystem. Coastal Plain forests provide habitat for ambystomatid species. In even greater abundance in the South are the many species of tree frogs, toads, and other frogs. Pine barrens tree frogs occur in Coastal Plain forests from Alabama northwards (Gibbons and Buhlmann 2001).

Amphibians are very different physiologically from reptiles, but the two groups are classified together as herpetofauna. Amphibians are more restricted by environmental moisture than other terrestrial vertebrates. They depend on areas where there is sufficient moisture for reproduction and survival. Since the glandular thin skin of amphibians is permeable to water, evaporative water loss is a serious problem. In addition, drought affects egg laying and larvae survival. The demands of water balance and thermoregulation may restrict movement, which occurs in a narrow range of environmental conditions.

Many amphibian species have geographic ranges that are restricted to particular physiographic regions. Some salamander species are considered glacial relicts that were isolated on mountaintops that retained northern climates (Gibbons and Buhlmann 2001). Similarly, frog species such as the pine barrens tree frog, Houston toad, and Florida bog frog occur in small, isolated populations throughout their ranges. The distances between such disjunct populations make recolonization difficult.

Salamanders—The majority of southern salamanders are in six families: mole salamanders, amphiumas, hellbenders, lungless salamanders, waterdogs or mud-puppies, and sirens. Salamanders are inconspicuous species that are important components of the forest ecosystem. They are small, secretive, and primarily nocturnal. They range from 5 cm to over 1 m in length. Limited data suggest that generation times are relatively long. For example, the generation times for several species of salamanders range between 4.4 and 9.5 years.

The rate of reproduction in amphibians is highly variable, but many species exhibit low frequencies of reproduction. Often salamanders breed only in alternate years, when they lay a single clutch of eggs.

Moisture is a limiting factor for all salamander species. Some species are totally aquatic, but even the terrestrial species can only survive in moist microhabitats. *Ambystoma* and *Hemidactylus* salamanders require moist, friable soils for burrowing. Several terrestrial species migrate to aquatic habitats for egg deposition, while others require damp micro-habitats. In addition, some aquatic species use terrestrial habitat for dispersal and other seasonal activity.

Salamanders inhabit areas with a variety of physiographic features, but rivers, streams, and stream margins figure prominently in their occurrence (table 5.5). Coastal bayous, ponds, and slow-moving rivers support sirens and amphiumas, while the hellbender occurs in cooler, fast-flowing upland rivers.

Table 5.5—The relationships of amphibians to physiographic features and other habitat elements[a]

Forest cover types	Salamanders		Frogs and toads	
	No.	*%*	*No.*	*%*
Physiographic feature				
Sandhills	3	3	8	20
Flatwoods	12	13	12	30
Narrow stream margins	29	32	3	8
Broad stream margins	22	24	20	50
Swamps	16	17	17	43
Cypress strands	10	11	5	13
Cypress ponds	14	15	12	30
Cypress drains	13	14	9	23
Willow heads	11	12	9	23
Bays and pocosins	15	16	14	35
Rivers and streams	34	37	9	23
Permanent ponds	8	9	20	50
Vernal ponds	16	17	27	68
Lakes	9	15	13	33
Specific requirement				
Closed canopy	76	83	11	28
Open canopy	12	13	32	80
Shrub thickets	0	0	8	20
Moist soil	69	75	25	63
Sandy or friable soils	5	5	18	45
Leaf litter	75	82	22	55
Snags	0	0	2	5
Fallen logs	70	76	5	13
Rock outcrops	8	9	1	3
Crevices and/or caves	11	12	0	0
Seepages	23	25	12	30
Potholes	12	13	22	55
Aquatic rocks and/or logs	30	33	0	0
Aquatic vegetation	10	11	26	65

[a] Data are summarized from species accounts presented in Wilson (1995).

Leaf litter, fallen logs, moist soils, and other surface debris serve as refuges from drying conditions. The ringed and streamside salamanders use moist soil, while the flatwoods and Jefferson salamanders use leaf litter. Fallen logs provide an important habitat component for the marbled and mole salamanders. Several species, including the spotted and Mabee's salamanders, also prefer closed-canopy conditions adjacent to water sources.

Table 5.6 shows the associations between 23 vegetative cover types (following Hamel 1992) and salamanders in the South. Mesic, mixed pine, and hardwood forests support 72 percent of species, including ringed, marbled, and mole salamanders. Sixty-four percent of the salamanders occupy mesic, upland hardwoods. These species include streamside, smallmouth, seepage, and dusky salamanders. White pine-hemlock and bottomland forests are used by slightly less than half of the southern salamanders. Jefferson, spotted, and green salamanders occupy white pine-hemlock forests, while several amphiuma species are found in bottomland hardwood forests. Xeric oak-hickory forests also support a variety of salamanders.

Salamander diversity appears to be less on the Coastal Plain than in the Appalachian Mountains. The former has much sandy, well-drained soil, high summer temperatures, and higher densities of predators (Echternacht and Harris 1993).

Connectivity between preferred forest habitats reduces population isolation and promotes dispersal (Wilson 1995), a management concern for many amphibian species. Many salamanders are adapted to travel only short distances in response to habitat alteration, while others with restricted geographic ranges become imperiled if habitat modification is rapid enough to preclude dispersal to similar habitats (Gibbons and Buhlmann 2001).

Table 5.7 illustrates relationships between salamander occurrence and forest successional stage. The seral stages follow those used by Hamel (1992): grass-forb, seedling-sapling, poletimber, and sawtimber. Note that not all cover types contain each seral stage. The Everglades type, for example, only exists in the grass-forb stages.

Table 5.6—The relationship between forest cover type and amphibian occurrence in the South[a]

Forest cover types	Salamanders		Frogs and toads	
	No.	*%*	*No.*	*%*
Everglades	4	4	9	23
Tropical hardwoods	0	0	14	10
Longleaf-slash pine	6	7	14	35
Pine-flatwoods	9	10	19	48
Virginia-pitch pine (xeric upland pines)	19	21	10	25
Longleaf pine	7	8	22	55
Loblolly-shortleaf pine	28	30	15	38
White pine-hemlock	43	47	10	25
Pond pine	5	5	14	35
Longleaf-scrub oak	2	2	8	20
Mixed, pine-hardwood (mesic)	66	72	33	83
Mixed, pine-hardwood (xeric)	0	0	22	55
Spruce fir	10	11	0	0
Upland hardwoods (mesic)-white oak-red oak	59	64	19	48
Cypress tupelo	26	28	22	55
Bottomland hardwoods-(sweetgum-willow oak)	43	47	31	78
Sweetgum–yellow-poplar	30	33	20	50
Bay-pocosin	20	22	22	55
Live oak (maritime)	6	7	12	30
Maple-beech	24	26	9	23
Cove hardwoods	29	32	7	18
Spartina	0	0	4	10
Elm-ash	1	1	4	10
Oak-hickory (xeric hardwoods)	38	41	15	38
Cave dwelling	6	7	0	0
Aquatic dependent	19	21	0	0

[a] Data summarized from species accounts presented in Wilson (1995).

Most salamander species find optimum habitat conditions in sawtimber stands.

Frogs and toads—The South is inhabited by numerous species of frogs and toads, each with its own particular requirements. The region supports such diversity due to its warm, humid climate, diversity of vegetative communities, and abundance of aquatic environments, particularly wetlands.

Wilson (1995) places these species into: (1) terrestrial species that migrate to standing water for egg deposition, (2) semiaquatic species requiring terrestrial habitat for dispersal, and (3) aquatic species that may use terrestrial habitat during rainy conditions. Each species requires standing water for egg deposition and larval development.

Several species exhibit two distinct stages: an aquatic larval stage (tadpole) and an adult stage. The eggs develop into tadpoles, which then undergo a complex metamorphosis into adults. The two stages have different habitat requirements that influence distributions and habitat associations.

Tadpoles consume algae and bacteria, while adult frogs and toads rely upon invertebrates. Some species, such as the pig frog, remain semiaquatic as adults, while others become terrestrial. Frogs and toads are important prey for wading birds, raptors, foxes, raccoons, and snakes.

Moisture also is a limiting factor for most frog and toad species; even terrestrial species require moist microhabitat (table 5.5). In addition

to broad stream margins, frequently used habitats include both permanent and seasonal swamps and ponds. Many species, including the American toad and southern cricket frog, require moist soils for burrowing.

Leaf litter, potholes, and aquatic vegetation often provide moisture (table 5.5). The oak toad and pine barrens tree frog use leaf litter, while the southern chorus frog and the bird-voiced tree frog use aquatic vegetation. Potholes provide an important habitat component for Brimley's chorus and southern leopard frogs (Wilson 1995). Species that prefer open-canopy conditions include the Houston toad and the northern cricket frog.

Although wetlands are important breeding habitats, many frog and toad species spend part or all of their nonbreeding season in trees and shrubs. Forest structure creates diverse habitats with many niches. Forests also contribute organic matter and moderate the temperature and evaporation rate of adjacent aquatic habitats.

Southern frogs and toads inhabit a wide variety of forest cover types (table 5.6). Mesic, mixed pine and hardwood forests support 83 percent of species, including the American toad, Cope's gray tree frog, and northern cricket frog. Seventy-eight percent of the species inhabit bottomland hardwood forests, including Woodhouse's toads, pine woods tree frogs, squirrel tree frogs, and gray tree frogs. Longleaf pine, cypress-tupelo, and bay-pocosin habitats are used by over half of the frog species in the region. Oak and southern toads and southern cricket frogs occupy longleaf pine forests, while several tree frogs are characteristic of cypress-tupelo associations. It appears that a majority of species finds optimum and suitable habitat conditions in the grass, sapling, and poletimber stages (table 5.7).

Table 5.7—The relationship between forest successional stage and amphibian occurrence in the South[a]

Taxa subgroup/ habitat conditions	Grass/ forb	Seedling/ sapling	Pole-timber	Saw-timber
	Number of species			
Salamanders[b]				
Optimal[c]	0	0	0	76
Suitable[d]	10	15	25	5
Marginal[d]	6	50	54	0
Frogs and toads[e]				
Optimal	15	0	0	7
Suitable	16	34	31	14
Marginal	8	4	5	13

[a] Summarized from Wilson (1995).
[b] Based on habitat relationships information from 92 species.
[c] Habitats in which the species occurs with highest frequency.
[d] Habitats in which the species occurs with successively lower frequency.
[e] Based on habitat relationships information from 40 species.

Habitat management for amphibians—The complex life cycle of frogs and toads requires management of both terrestrial and aquatic habitats. Tiger salamanders and other ambystomas breed in the water but remain terrestrial during nonbreeding season. Thus, providing only one habitat component would fail to maintain viable populations of these species. Some terrestrial species require ponds or other standing water during the breeding season. Consequently, the removal of barriers such as roads between terrestrial habitat and aquatic habitat is important.

The semiaquatic species require aquatic areas that have rocks, woody debris, or other similar shelter in the water. Emergent and floating vegetation is important for breeding of some species. The adjacent terrestrial habitat also is important because many species, such as the *Eurycea* and *Desmognathus* genera, spend significant portions of their lives foraging and occupying terrestrial areas. Buffers adjacent to streams provide access to upland forested habitats. Aquatic habitats should be protected against thermal changes, water pollution, and excessive siltation (Wilson 1995). Habitat alteration due to dredging, channelization, and impoundment can be detrimental to many species.

Forest management alters the vegetative composition, seral stage, and structure of amphibian habitat. For example, prescribed burning temporarily removes leaf litter, herbaceous cover, and woody understory vegetation. Vegetative structure, snags, loose bark, and surface debris are important factors in managing amphibian habitat. Disking, windrowing, and furrowing during some forestry operations (Gibbons and Buhlmann 2001) may negatively impact species dependent upon the understory. Conversion from one forest type to another may be beneficial to some species and detrimental to others. The change in successional stage from sawtimber to grass-forb that results from timber harvest may enhance habitat suitability for one species, yet create marginal habitat for another.

Amphibian declines—Reported declines of amphibian populations have drawn considerable attention over the past two decades. Many are associated with high elevation, pristine areas that are remote from surrounding landscape modification. Amphibians are particularly sensitive to their environment. Their permeable skin and the lack of protective eggshells make them vulnerable to toxicants present in soil and water.

Southern species showing evidence of declines include the flatwoods salamander, Red Hills salamander, Texas blind salamander, wood frog, southern dusky salamander, and green salamander. Numerous others are categorized as imperiled and vulnerable (chapter 1). Endemic species are of particular concern in the Edwards Plateau, Ozark Highlands, Atlantic Coastal Plain, and Appalachian Mountains.

Amphibian declines have been attributed to several factors. These include habitat loss, wetland alteration, climate changes leading to droughts, diseases, exotic species, and agricultural chemicals. Other factors include acid precipitation and ultraviolet radiation. These are briefly reviewed later.

Wetlands and vernal pools are important for several amphibians. There have been significant losses of wetlands in the last two centuries (chapter 1). Declines in wetland quality through eutrophication, pollution, and fish stocking also impact amphibian populations. The hellbender is affected by stream degradation, while the gopher frog is influenced by the conversion of pine and hardwood forests to tree plantations, agriculture, and urban uses. In addition, habitat fragmentation by roads contributes to the mortality of breeding adults and dispersing juveniles (Wilson 1995).

Ozone depletion in the upper atmosphere increases the amount of ultraviolet radiation on the Earth's surface, particularly at high elevations. Ambient radiation damages cellular DNA (Reaser and Johnson 1997); amphibians with low levels of photolyase enzyme have embryos that are susceptible to ultraviolet radiation, which causes mortality and abnormal development, including skeletal, eye, and skin deformities.

Their porous skin makes amphibians susceptible to herbicides, pesticides, heavy metals, and petroleum products in aquatic systems. Pollutants such as gasoline, oil, and antifreeze sometimes occur in runoff into amphibian habitat. Relatively high nitrate levels cause physical and behavioral abnormalities in a number of species; synthetic chemicals interfere with hormonal processes, inhibiting amphibian development (Reaser 1996). The application of fertilizers and pesticides, particularly by aerial spraying, often impacts amphibians far from the point of application in nontarget areas.

The introduction of exotic species, such as fish, crayfish, and bullfrogs, into lakes and wetlands also influences amphibian populations. Fish introduced into wetlands for mosquito control prey upon amphibian eggs and larvae. Chytrid fungi, trematode parasites, and viruses carried by exotic fish may also contribute to population declines.

Several of the factors discussed above have been implicated as causes of amphibian abnormalities. These include parasite infestation, toxin contamination, radiation, radioactive salts, ground-level ozone, excessive heating of eggs, and reformulated gasoline (Reaser and Johnson 1997). Of these, only the parasite, toxin, radiation, and predation hypotheses have supportive evidence. The frequency of malformations is highest in frogs that have recently metamorphosed from tadpoles.

Concern about the status of amphibian populations is clearly warranted. Physiological constraints, limited mobility, and changes in site characteristics hinder recolonization of sites of local extinction. The temporal and spatial population dynamics of many amphibians are not well understood; it is unknown whether observed declines exceed natural population fluctuation.

There are other concerns facing individual amphibian species. Many of these are discussed in the section on reptiles, as these concerns are shared by herpetofauna as a group. In addition, some of these concerns are mentioned in Species accounts presented next.

Species accounts—The following are accounts for selected amphibian species that are of concern in the South. Several are federally listed as threatened or endangered. Others are classified as imperiled or vulnerable by Natural Heritage agencies. The species accounts and management recommendations follow Wilson (1995) unless otherwise noted.

Species accounts: flatwoods salamander—The population of this threatened species has declined during the past 10 to 15 years (Wilson 1995). The cause of the decline is uncertain, and the salamander is uncommon throughout its range from South Carolina, southern Georgia, and Florida westward to Mississippi.

The salamander inhabits pine flatwoods dominated by longleaf and slash pines and wiregrass, which is important for egg disposition. It is often found in association with cypress ponds, swamps, and pitcher plant bogs that are used for reproduction.

Management activities focus on avoidance of intensive site preparation before harvest, avoidance of prescribed burning during peak surface activity and breeding periods (November through April), and protection of breeding ponds. Fish stocking should be avoided (Bury and others 1980).

Species accounts: Florida bog frog—This species is classified as imperiled by Natural Heritage and is a species of special concern in Florida (NatureServe 2000). The frog is currently known to exist in 23 localities in the Panhandle (Moler 1992b). Many are found on the Eglin Air Force Base.

This frog species inhabits nonstagnant acidic seeps and the shallow backwaters of larger streams. It is frequently found in association with sphagnum moss and early seral stages of Atlantic white-cedar. Shrubby streamside habitats that do not have developing hardwood forests are preferred. The frog's diet consists of insects and other small arthropods.

Stream contamination and impoundment, and forest succession threaten the survival of this species (Moler 1992b). Conservation actions center on the protection of suitable habitat. Management of streamside vegetation to maintain the shrub-bog community is advised.

Species accounts: gopher frog—This uncommon species is classified as vulnerable by Natural Heritage (NatureServe 2000). Alabama, Florida, Georgia, Mississippi, North Carolina, and South Carolina list the frog as of special concern. The gopher frog historically was distributed along the Gulf and Atlantic Coastal Plain, with isolated populations in the Valley and Ridge Province of Alabama. It was last documented from Louisiana in the 1960s. The frog has declined throughout its range with the loss of longleaf pine habitat (Martof and others 1980).

The gopher frog is associated with sandy pine flatwoods, turkey oak-pine sandhills, and xeric hammocks. It breeds in shallow, temporary ponds with open canopies and emergent herbaceous vegetation. Ditches and borrow pits are occasionally used. Adults seek refuge in the burrows of gopher tortoises, mice, and crayfish. Stump holes, root mounds, dense grass clumps, and thick mats of leaf litter may also be used.

The frog is an opportunistic feeder with a diet of arthropods, small frogs, and toads. Predators include water snakes, turtles, bluegills, and mosquitofish.

Management centers on protection of the sandhills and scrub-oak ecosystems

and halting the losses of this habitat to circular irrigation farming and industrial development. Prescribed burning and other management practices that retain the open scrub nature of this habitat benefit this species (Wilson 1995), while practices that drain or alter breeding ponds are detrimental.

Species accounts: green salamander—This species is classified as vulnerable by Natural Heritage and is a species of special concern in Alabama, Georgia, Mississippi, and North Carolina (NatureServe 2000). Impoundment of several rivers in the Carolinas has extirpated several known populations.

The unique habitat of this species is limited and localized. The green salamander lives in damp crevices in shaded rock outcrops and under the bark of cove hardwood trees. It also is found in upland areas of Virginia pine and white pine-hemlock with mountain laurel understories. The salamander's diet consists of small insects, spiders, and earthworms.

Conservation efforts focus on protection of rock outcrops and the establishment of buffer zones in areas of timber harvest.

Species accounts: Houston toad—This endangered species is restricted to southeastern Texas, where its population is very small and fragmented. Human alteration of natural watersheds has eliminated many of its natural breeding pools, resulting in hybridization with the Gulf Coast toad and the Woodhouse's toad (Wilson 1995).

This toad inhabits areas with sandy, friable soils and is found most often in loblolly pine or mixed deciduous habitats interspersed with grassy areas under a range of conditions. Breeding habitats include roadside ditches, temporary ponds, and other seasonally flooded low spots. The toad's diet consists primarily of insects.

The recovery plan requires protection of critical habitat for this species. Habitat is maintained in a pristine state, and several breeding projects have been attempted. Development projects have been regulated in areas designated as critical habitat (Brown 1975).

Species accounts: one-toed amphiuma—This species is classified as vulnerable by Natural Heritage and listed as rare in Georgia (NatureServe 2000). It occurs in restricted geographic areas in northern Florida, Mobile Bay in Alabama, and the Ochlocknee River drainage in Georgia.

This semiaquatic salamander requires mucky habitats in association with permanent streams (Means 1992). Management actions center on protection of muck areas, which are threatened by sand and silt sedimentation during construction activities. Other actions include the regulation of amphiuma collection.

Species accounts: Red Hills salamander—This species is listed as threatened at both the Federal and State level. It is confined to a narrow belt within the Tallahatta and Hatchetigbee geological formations in the Red Hills of Alabama (Wilson 1995).

This nocturnal salamander lives in burrows on high, steep, uncut slopes with high soil moisture content and full tree canopy (Dodd 1991). The burrows are often near the base of a tree or under siltstone outcroppings. The salamander feeds on spiders and insects (U.S. Fish and Wildlife Service 1983, 1990b).

The majority of land in its range is privately owned. Habitat has been reduced by timber harvest, conversion of forest to agriculture, and ridgetop clearing. Overcollecting may have caused a decline in some areas. Feral hogs are a threat in localized areas (NatureServe 2001).

Conservation actions include cooperation with private and corporate landholders to restrict clearcutting and heavy site disturbance. Under public ownership, two areas have been set aside to support limited populations (NatureServe 2001). These include Alabama Forestry Commission and U.S. Army Corps of Engineers lands. In 1991, International Paper Company initiated work on a Habitat Conservation Plan (HCP) for this species. Other companies subsequently developed HCPs (Bailey 1995). Research needs include determination of the microhabitat effects of timber management practices and the collection of data on reproductive viability and recruitment within existing populations.

Species accounts: Shenandoah salamander—This species is endangered due to restricted range, habitat modification, and competitive interactions with the redback salamander. Inhabiting the high-elevation mountains of Virginia, the species requires talus slopes with deep soil pockets in mixed coniferous and deciduous forests. Its diet consists of small arthropods and earthworms.

Conservation efforts include restriction of construction activities that could disturb the limited talus habitats of this salamander (Martof and others 1980). Any construction of trails, roads, or overlooks in the Shenandoah National Park should be carefully monitored so as not to impact this salamander's limited habitat.

Species accounts: Tennessee cave salamander—This species is classified as imperiled by Natural Heritage and is listed as endangered in the States of Alabama and Tennessee (NatureServe 2000). The salamander is found in permanent streams and pools in limestone caves of central and southwest Tennessee, northern Alabama, and extreme northwest Georgia. It is believed to occur in approximately 1 percent of the caves in its range.

The Tennessee cave salamander feeds on arthropods, other small aquatic insects, and earthworms. Management centers on restricting human access and protecting limestone cave habitat. The species is very sensitive to pollutants and disturbances within its habitat (Wilson 1995).

Reptiles

The reptiles of the South belong to three orders: Crocodilia (alligators and crocodiles), Squamata (lizards, amphisbaenians, and snakes), and Testudinata (turtles). The South supports a diversity of reptiles (fig. 5.5), including 89 snakes (11 endemic), 75 lizards (6 endemic), 29 turtles (13 endemic), and 4 other reptiles (including 2 crocodilians). The number of reptile species ranges from 155 in Texas to 54 in Kentucky (NatureServe 2000). Species richness is impressive in Florida (94), Alabama (87), Georgia (87), and Mississippi (86).

The South's Coastal Plain possesses North America's highest diversity of reptiles (Gibbons and others 1997, White and others 1998). Twenty-nine percent of southern reptiles are classified as endemic (Dodd 1995a).

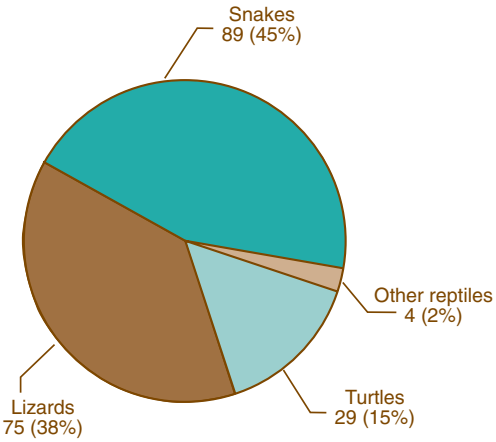

Figure 5.5—Species richness by major subgroups of reptilian taxa occurring within the South (NatureServe 2000).

Reptiles occupy forest, freshwater, marine, and urban habitats. Most use the same habitat for breeding and nonbreeding activities, but aquatic and marine species require adjacent terrestrial habitats in order to successfully reproduce.

The forested mountain regions also support an abundance of reptiles, including worm snakes, copperheads, ringneck snakes, bog turtles, and coal skinks. The longleaf pine-wiregrass community is vital habitat for the gopher tortoise and important habitat for mole skinks, glass lizards, scarlet snakes, pine snakes, and coachwhip snakes. Cypress-gum swamps are home to rainbow snakes, mud snakes, western green watersnakes, and striped crawfish snakes (Gibbons and Buhlmann 2001). Some reptiles play important roles in southern communities in nutrient cycling. Their burrows provide refuges for other species during extreme climatic conditions.

The numbers of turtles in Mississippi (31), Texas (30), Alabama (30), Georgia (27), Louisiana (26), and Florida (26) reflect the abundance of coastal and freshwater habitats. Numbers of lizard species in Texas (51) and Florida (38) far surpass the richness in other Southern States (NatureServe 2000). Both States are relatively large and have a wide variety of habitats in them. The number of lizards residing in the remaining States ranges from 17 species in Oklahoma to 8 species in Kentucky.

The number of snakes tends to be highest in the southernmost Coastal States. There are 73 in Texas, 46 in Florida, 42 in Alabama, 42 in Mississippi, 41 in Georgia, and 41 in South Carolina. Species richness in the mountain States is slightly lower. Virginia supports 30 snake species. Snakes reach their highest diversities in southern forests and their peripheral habitats, such as rivers, streams, and isolated wetlands.

Seventeen species of reptiles are listed as threatened or endangered by the U.S. Fish and Wildlife Service (table 5.8). In addition, numerous reptiles are classified as imperiled or vulnerable by the Natural Heritage agencies (chapter 1). Many of these species occur on the Coastal Plain; several are narrowly restricted endemics.

Although the variation in life-history traits is quite marked, many species of reptiles have long lives, variable reproductive rates, and high mortality among eggs and neonates. Such combinations of life-history characteristics are particularly common among turtles, crocodilians, and snakes.

Table 5.8—Reptile species within the South that are listed as threatened or endangered

Scientific name	Common name	Areas of occurrence
Turtles		
Caretta caretta	Loggerhead (T)	AL, FL, GA, LA, MS, NC, SC, TX, VA
Chelonia mydas	Green turtle (E)	AL, FL, GA, LA, MS, NC, SC, TX, VA
Clemmys muhlenbergii	Bog turtle (T)	GA, NC, SC, VA
Dermochelys coriacea	Leatherback; tinglar (E)	AL, FL, GA, LA, MS, NC, SC, TX, VA
Eretmochelys imbricata	Hawksbill (E)	AL, FL, GA, LA, MS, NC, SC, TX, VA
Gopherus polyphemus	Gopher tortoise (T)	AL, LA, MS
Graptemys flavimaculata	Yellow-blotched map turtle (T)	MS
Lepidochelys kempii	Kemp's or Atlantic ridley (E)	AL, FL, GA, LA, MS, NC, SC TX, VA
Pseudemys alabamensis	Alabama red-belly turtle (E)	AL
Sternothesis depressus	Flattened musk turtle (T)	AL
Lizards		
Eumeces egregius lividus	Bluetail mole skink (T)	FL
Snakes		
Drymarchon corais couperi	Eastern indigo snake (T)	AL, FL, GA, MS, SC
Nerodia clarkii taeniata	Atlantic salt marsh snake (T)	AL
Nerodia paucimaculata	Concho water snake (T)	TX
Other reptiles		
Alligator mississippiensis	American alligator (T)	AL, AR, FL, GA, LA, MS, NC, OK, SC, TX
Crocodylus acutus	American crocodile (E)	FL

T = Threatened; E = endangered.
Source: U.S. Department of the Interior (2000).

Due to their ectothermic physiology and seasonal inactivity, reptiles have relatively slow growth rates, advanced ages at maturity, and advanced generation times. Lizards have the youngest ages at maturity (1.5 years), while turtles and crocodilians have the oldest age at maturity (20 to 50 years). Age at maturity is estimated at over 30 years for some marine turtles.

Rates of reproduction are variable. Clutch frequency in sea turtles varies from one to four clutches every 3 to 4 years, whereas annual multiple clutches are common for some freshwater turtles. Reproduction occurs in alternate years (or less often) for terrestrial tortoises. Most lizards produce at least one clutch each year, and multiple clutches per year are common. In contrast, biennial reproduction is typical in snakes.

Turtles—Six turtle families are found in the South. These include the sea turtles, snapping turtles, water and box turtles, mud and musk turtles, tortoises, and softshell turtles. The greatest diversity occurs in the Coastal Plain, which supports a variety of freshwater and coastal marsh species and several species of sea turtles.

The gopher tortoise is a keystone species in the communities where it occurs. Its burrows provide refuges for a variety of species, including indigo snakes and diamondback rattlesnakes. The tortoise is threatened throughout its range as a result of habitat destruction associated with land development (Echternacht and Harris 1993).

Turtles are scavengers, herbivores, and carnivores and often contribute significant biomass to various ecosystems. They provide dispersal mechanisms for plants, contribute to environmental diversity, and foster symbiotic associations with a diverse array of organisms.

Many species have experienced significant declines in abundance and distribution during the last century. Among such species are the bog turtle, spotted turtle, common box turtle,

Table 5.9—The relationships of reptiles to physiographic features and other habitat elements[a]

Habitat element	Turtles		Lizards		Snakes		Alligators/ crocodiles	
	No.	*%*	*No.*	*%*	*No.*	*%*	*No.*	*%*
Physiographic feature								
Sandhills	1	2	8	40	14	25		
Flatwoods	1	2	4	20	12	21		
Narrow stream margins	2	5	1	5	7	12		
Broad stream margins	11	27	1	5	18	32	1	50
Swamps	14	34	0	0	13	23	1	50
Cypress strands	2	5	0	0	8	14		
Cypress ponds	3	7	0	0	6	11		
Cypress drains	1	2	0	0	4	7		
Willow heads	1	2	0	0	3	5		
Bays and pocosins	3	7	1	5	9	16		
Rivers and streams	21	51	0	0	10	18	1	50
Permanent ponds	12	29	0	0	9	16	1	50
Vernal ponds	3	7	0	0	2	4		
Lakes	15	37	0	0	8	14	2	100
Marshes	13	32	0	0	16	28	1	50
Specific requirement								
Closed canopy	0	0	0	0	5	9		
Open canopy	29	71	14	70	43	75	2	100
Forest openings	3	7	10	50	8	14		
Shrub thickets	1	2	2	10	4	7		
Moist soil	5	12	3	15	11	19		
Sandy or friable soils	36	88	12	60	18	32		
Leaf litter	3	7	11	55	34	60		
Snags	0	0	4	70	3	5		
Fallen logs	0	0	11	55	35	61		
Rock outcrops	0	0	4	70	4	7		
Crevices and/or caves	0	0	1	5	5	9		
Seepages	4	10	0	0	1	2		
Potholes	1	2	0	0	3	5		
Aquatic rocks and/or logs	23	56	0	0	12	21	1	50
Aquatic vegetation	17	42	0	0	13	23	2	100

[a] Data summarized from species accounts presented in Wilson (1995).

gopher tortoise, common slider, and alligator snapping turtle. Some species, such as map turtles, have limited ranges, placing them at risk from habitat alteration or illegal collection for the pet trade. Disease also appears to contribute to population declines in some turtles. The diamondback terrapin was exploited heavily for food during the 19th century. Although the species recovered, the terrapin is again imperiled due to regional harvesting, habitat destruction, vehicular mortality, and drowning in crab traps (Lovich 1995).

Although the habitat requirements of marine turtles are beyond the scope of this terrestrial assessment, concerns over the future of these species warrants mention. Five species of marine turtles frequent the beaches, bays, estuaries, and lagoons of the South: loggerhead, green, Kemp's ridley, leatherback, and hawksbill turtles. These species have had dramatic declines attributable to commercial turtle fishing, exploitation of the juvenile populations, beach development, polluted water, incidental take, and diseases such as fibropapillomas. Monitoring is difficult due to their longevity. They continue to be threatened and their conservation involves international efforts.

Forest conditions influence both aquatic and terrestrial turtles. Map turtles, cooter turtles, and musk turtles inhabit streams and rivers that are influenced by adjacent riparian forests. Forest cover reduces sedimentation rates, affects water temperature, and influences availability of basking sites (Gibbons and Buhlmann 2001). In addition, many species such as mud turtles use terrestrial habitat for nesting and winter dormancy, spending the summer in wetland areas. Riparian forests are also quite important for map turtles.

Turtles inhabit areas with a variety of physiographic features (table 5.9). Not surprisingly, rivers, streams, swamps, lakes, and marshes figure prominently in their occurrence. Ninety percent of the species depend on aquatic environments. Common and alligator snapping turtles are found in swamps, deep rivers, and canals while marshes support bog and painted turtles. River and stream habitats support several species of map turtles.

Turtles are also associated with sandy soils, logs, and rocks that serve as shelter and as basking surfaces. The ornate box turtle and gopher tortoise require sandy or friable soils in which to burrow or deposit eggs (Wilson 1995). A majority of species (71 percent) prefers open-canopy conditions that aid in thermoregulation. Such species include the painted turtle, spotted turtle, Alabama map turtle, and striped mud turtle.

Tables 5.10 and 5.11 list the vegetative cover types and successional stages that are associated with turtles in the South. Bottomland hardwood forests support 81 percent of species, including the wood turtle, the common map turtle, and the Pascagoula map turtle. Sixty-three percent of the turtles occupy cypress-tupelo forests. These species include the Barbour's, the Escambia, and the yellow-blotched map turtle. Mesic, mixed pine-hardwoods stands are used by slightly over half of the southern species, including the painted and spotted turtles. Approximately one-third of the species find optimum or suitable habitat in grass-forb cover; most of these species presumably are associated with aquatic conditions.

Lizards and snakes—Four families of lizards inhabit the South. These species include anole, fence, collared, and horned lizards; whiptails; skinks; and glass lizards. All lizards are terrestrial; most species have small home ranges.

Sandhills and flatwoods are important habitats for lizards (table 5.9). The Florida scrub lizard, the island glass lizard, and the coal skink inhabit these areas. Leaf litter, fallen logs, and snags provide shelter as well as places to hunt for prey. The fence lizard and five-lined skink are associated with snags, while the slender glass lizard and the broad-head skink use fallen logs. Friable soils are an important habitat component for 60 percent of the species. Mimic and eastern glass lizards deposit eggs and burrow in these soils. The majority of species (70 percent) require an open forest canopy, a forest opening, or a rocky outcrop as basking sites for thermoregulation. Such species include the slender and island glass lizards, the collared lizard, and the Great Plains skink.

Twenty-one forest cover types are associated with lizards in the South (table 5.10). Although lizards in the region use a variety of forest cover, over half of the species inhabit longleaf pine-scrub oak, xeric mixed pine-hardwood, and live oak stands. Longleaf pine and scrub oak forests support the fence lizard, island glass lizard, and mimic glass lizard. The sand skink, ground skink, and six-lined racerunner occur in mixed pine and hardwoods. Live oak forests are used by 55 percent of the southern lizards, including the mole skink and broadhead skink. Mesic, mixed pine-hardwood stands also support a variety of lizards. Approximately half of the species find optimum conditions among grasses and forbs (table 5.11).

Three families of snakes occur in the South: nonvenomous snakes, coral snakes, and pit vipers. Species that inhabit the water are especially prevalent. Three of the largest snakes in North America occur in the region: the indigo snake, eastern diamondback rattlesnake, and timber rattlesnake.

In the absence of a large assemblage of mammalian predators, snakes assume special importance as top predators in some communities, and their low metabolic rates allow them to occur at impressive densities in undisturbed habitat (Echternacht and Harris 1993).

Since the larger species of snakes have fairly large home ranges—125 to 250 acres—fragmentation of existing habitat poses a significant threat (Wilson 1995). Several snakes, such as the brown snake and the common garter snake, have significant populations in suburban areas.

The majority of snake and lizard species have become imperiled due to insular populations, restricted ranges, habitat degradation, or the loss of suitable habitat. Malicious killing, biocides, exotic species, and illegal trade have also contributed to their decline.

Many snakes require shelter in the form of friable soil, fallen logs, leaf litter, rocks, or similar surface debris (table 5.9). As with lizards, snakes require open-canopy forest conditions to aid thermoregulation. Habitat management that leaves surface debris and tree stumps can benefit their habitat. Leaf litter and fallen logs provide refuges for snakes as well as their prey, which include invertebrates, small mammals, and amphibians. Racer and ringneck snakes are found in leaf

Table 5.10—The relationship between forest cover type and reptile occurrence in the South[a]

Forest cover types	Turtles		Lizards		Snakes		Alligators/ crocodiles	
	No.	*%*	*No.*	*%*	*No.*	*%*	*No.*	*%*
Everglades	8	20	2	10	13	23	1	50
Tropical hardwoods	5	13	4	20	13	23	1	50
Mangroves	5	13	2	10	3	5	2	100
Longleaf-slash	2	5	4	20	11	19		
Pine-flatwoods	3	7	8	40	23	40		
Virginia-pitch pine (xeric upland pines)	1	2	5	25	14	25		
Longleaf pine	4	10	15	19	21	37		
Loblolly-shortleaf pine	5	12	7	35	20	35		
White pine-hemlock	4	10	2	10	16	28		
Pond pine	2	5	2	10	4	7		
Longleaf-scrub oak	2	5	10	50	13	23		
Mixed, pine-hardwood (mesic)	22	54	8	40	37	65		
Mixed, pine-Hardwood (xeric)	3	7	11	55	15	26		
Spruce fir	0	0	0	0	1	2		
Upland hardwoods (mesic) - white oak-red oak	9	22	3	15	25	44		
Cypress tupelo	26	63	3	15	12	21	1	50
Bottomland hardwoods- (sweetgum-willow oak)	33	81	5	25	29	51	1	50
Sweetgum-yellow-poplar	16	39	1	5	9	16		
Bay-pocosin	9	22	3	15	10	18		
Live Oak (maritime)	1	2	11	55	22	39		
Maple-beech	4	10	1	5	16	28		
Cove hardwoods	0	0	0	0	3	5		
Spartina	7	17	0	0	3	5	2	100
Elm-ash	0	0	0	0	5	9		
Oak-hickory (xeric hardwoods)	4	10	3	15	24	42		
Aquatic dependent	37	90	0	0	15	26		

[a] Data summarized from species accounts presented in Wilson (1995).

litter, while fallen logs are important habitat components for indigo and corn snakes. Seventy-five percent of snake species are associated with open canopy forest; these include scarlet and Kirtland's snakes.

Forests provide essential habitat components for terrestrial species as well as those that live in aquatic habitats. Table 5.10 presents the 26 vegetative cover types that are associated with snakes in the South. Snakes use a diversity of forest cover; there are, however, a group of specific types that are used most often. Mesic, mixed pine and hardwood forests support 65 percent of species, including the western worm snake, corn snake, and rat snake. Fifty-one percent of the snakes occupy bottomland hardwoods. These species include the mud, rainbow, and scarlet king snake. Mesic upland hardwoods and xeric oak-hickory hardwoods are used by over 40 percent of the southern species. The prairie king snake, milk snake, and the common water snake occupy mesic hardwood types, while eastern and southern hognose snakes are characteristic of xeric hardwoods. The pine flatwoods forests also support a variety of snakes.

Table 5.11 illustrates the relationships between snake occurrence and forest successional stage. Approximately half of the species find suitable habitat in seedling-sapling and poletimber conditions. Slightly more species find optimum and suitable conditions in grass-forb stages than in sawtimber stands.

Crocodilians—Two native species of crocodilians, the America alligator (family Alligatoridae) and the American crocodile (family Crocodylidae), occur in the South. A large breeding population of the introduced spectacled caiman, native to the American tropics from southern Mexico to Argentina, occurs in Dade County, FL (Echternacht

Table 5.11—The relationship between forest successional stage and reptile occurrence in the South[a]

Taxa subgroup/ habitat condition	Successional stage			
	Grass	Sapling	Pole-timber	Saw-timber
Turtles[b]				
Optimal[c]	13	0	0	0
Suitable[d]	3	8	8	4
Marginal[d]	0	7	5	8
Lizards[e]				
Optimal	10	1	0	1
Suitable	3	13	14	11
Marginal	3	6	2	1
Snakes[f]				
Optimal	7	1	0	6
Suitable	33	46	43	29
Marginal	11	8	6	8
Alligators and crocodiles[g]				
Optimal	2	0	0	0
Suitable	0	0	0	0
Marginal	0	2	1	0

[a] Summarized from Wilson (1995).
[b] Based on habitat relationships information from 41 species.
[c] Habitats in which the species occurs with highest frequency.
[d] Habitats in which the species occurs with successively lower frequency.
[e] Based on habitat relationships information from 20 species.
[f] Based on habitat relationships information from 57 species.
[g] Based on habitat relationships information from 2 species.

and Harris 1993). This exotic species is discussed further in chapter 3.

The alligator is a wide-ranging animal that occurs from coastal North Carolina south to Florida and westward to eastern Texas. It has recovered from previous declines and now has pest status in Louisiana and Florida. The alligator creates marsh pools that provide habitat for many other species. Its larger and more secretive relative, the American crocodile, is restricted in its North American range to extreme south Florida.

During the last century, wetland drainage for agriculture and development activities permanently reduced alligator populations in freshwater marshes. Recent environmental contamination has been associated with declines in alligator populations (Woodward 1995). Widespread pollution of wetlands by toxic petrochemicals and metals may continue to threaten population viability. Although the status of the Florida alligator population appears secure, continued habitat loss and toxic contamination may compromise its conservation.

The crocodile remains endangered, while the alligator is federally listed as threatened due to "similarity of appearance." This designation reflects the special instance when a species so closely resembles a listed species that it is difficult in the wild to differentiate between the two. The effect of this difficulty is an additional threat to the listed species.

The alligator is doing well in suitable habitat, while the crocodile is struggling to survive in its limited range in southern Florida (Wilson 1995). Management plans for both species protect aquatic and terrestrial habitat, particularly for nesting and basking. Management includes captive programs to manage the species for meat and hide production, as well as effective protection from poaching.

Not surprisingly, both species occur in areas limited in the number of physiographic features and vegetative cover types (tables 5.9, 5.10, and 5.11). Lakes, marshes, rivers, streams, permanent ponds, and swamps figure prominently in their occurrence. Aquatic vegetation is important to both species; rocks and logs in the water serve as useful basking areas. Alligators and crocodiles require open canopy forest conditions to aid thermoregulation. This need may explain their use of stands of grasses and forbs.

Six vegetative cover types are associated with these species in the South. Mangrove and spartina habitat supports both species. Tropical hardwoods, cypress tupelo, and bottomland hardwood forests are also occasionally used. Additional details on each species are presented in the Species accounts at the end of the reptile section.

Habitat management for reptiles—The general problems faced by reptiles in southern forests center on the environmental impacts resulting from human activities. Difficulties in assessing problems and monitoring populations hinder management of these vertebrates.

The life history and ecology of reptiles differ markedly from those of other taxa. Many reptile species take longer to mature and have long lifespans. For example, the forest-inhabiting box turtle and snapping turtle take over 10 years to reach sexual maturity (Gibbons and Buhlmann 2001). Managing for sustainable populations of long-lived, late-maturing species requires different strategies than for short-lived, rapid turnover species (Congdon and others 1994, Ernst and others 1994).

The primary threats to reptiles in the South stem from habitat destruction and alteration, including changes in water quality. The drainage of wetlands and temporary ponds has reduced the population of striped newts (Dodd 1995a) and extirpated the flatwoods salamander from a portion of its range (White and others 1998). Destruction of wetlands has reduced spotted turtle populations, and other aquatic habitats do not meet the turtle's specialized needs.

Impoundments have affected several species of map turtles native to large

southern rivers. The damming of streams to form reservoirs has contributed strongly to the eliminating several species (Mitchell 1994). In addition, the removal of dead trees and the dredging of river bottoms, which harbor mollusks that the turtles eat, have negatively affected these species.

The gopher tortoise and other reptiles have become threatened in part because of the loss of longleaf pine habitat (Dodd 1995b, Guyer and Bailey 1993). Many species of snakes and box turtles are also declining in numbers due to loss of suitable habitat. Accidental death by vehicles and intentional killing are other factors contributing to snake decline. Several of these reptiles, such as short-tailed snakes and flattened musk turtles, have relatively small geographic ranges. Others, such as the pinewoods snake, coal skink, and Webster's salamander, have disjunct populations that make them quite vulnerable to habitat loss. Effects of habitat alteration can be far-reaching.

Management of sea turtles has emphasized the acquisition and protection of nesting habitat. Other concerns include ocean pollution, fishing and shrimping nets, beach development, and enforcement of international regulations. The identification of migration routes and other life history information also will benefit future management strategies.

Degradation of aquatic habitat is the primary management concern for freshwater turtles. Conservation actions are directed at monitoring the extent of thermal pollution, dredging, channelization, and incidental takes by commercial fishing. Protection of nesting beaches and adjacent nest areas, and the prevention of deliberate killing are also important management priorities.

In addition to intentional killing, which affects snakes as well as turtles, several reptiles suffer direct losses due to exploitation. Unregulated harvest affects a number of the listed turtle and tortoise populations, as well as the majority of sea turtles. Collection for the pet trade is another serious management problem. Some species, particularly the genera *Clemmys* and *Graptemys*, require strict regulation due to rising demands in domestic and foreign pet markets. Commercial collectors also threaten the spotted turtle and box turtle.

The invasion of introduced exotics can also be detrimental to native reptiles. Fire ants, in particular, have been implicated in the reduction of terrestrial egg-laying reptiles (Mount 1986).

Management can enhance reptile habitat in many ways. One way is through the retention of microhabitat features that provide refuges. For example, the disruption of underground root systems in managed pine plantations may displace species such as the eastern diamondback rattlesnake. The importance of leaving terrestrial buffer zones around forest wetlands is well documented (Burke and Gibbons 1995, Semlitsch and Bodie 1998). The retention of habitat elements such as leaf litter, snags, coarse woody debris, and fallen logs benefits the habitat of many reptiles (refer to the individual subtaxa sections mentioned earlier and Species accounts that follow).

Delayed sexual maturity and individual longevity contribute to the vulnerability of reptiles and inhibit the recovery of several threatened species. Several reptiles have existed virtually unchanged for centuries. Unfortunately, some of the same traits that allowed them to survive the ages predispose them to endangerment. Conservation actions should be directed towards areas of high species diversity, species with limited distributions, and locations such as shallow wetlands and coastal zones where reptiles are at risk. Insufficient knowledge of the distribution and ecology of native reptiles is a major shortcoming in any regional effort to detect change and avoid loss in these taxa.

Species accounts—The following are the species accounts for selected reptiles that are of concern in the South. Several are federally listed as threatened or endangered. Others are classified as imperiled or vulnerable by Natural Heritage agencies. Management recommendations follow Wilson (1995) unless otherwise cited.

Species accounts: Alabama redbelly turtle—This endangered species is restricted to Mobile Bay in southern Alabama. It has declined due to habitat modification and because it was trapped and netted for food (Dobie and Bagley 1988). Habitat disturbance has altered the turtles' nesting and feeding habitat.

Primary habitat areas are the upper, freshwater portions of Mobile Bay, where there are abundant supplies of submerged plants and algae, which are preferred foods.

Conservation actions emphasize protection of the primary nesting site on Gravine Island, restriction of herbicide use, and limitation of dredging activity on the lower Tensaw River.

Species accounts: alligator snapping turtle—This species is classified as vulnerable by Natural Heritage and is listed in the States of Alabama, Georgia, and Texas (NatureServe 2000). The turtle has declined due to habitat loss and commercial exploitation for food and the pet trade.

The species is typically found in deep rivers and canals, but may also occur in lakes, swamps, and small streams. Although it nests on land, the turtle is primarily aquatic and feeds on fish, mollusks, and crayfish.

Conservation measures include regulation of collection and the protection of suitable habitat with adequate prey populations (Wilson 1995).

Species accounts: American alligator—This species is federally listed as threatened due to similarity of appearance to the American crocodile. The alligator ranges from coastal North Carolina to extreme southern Florida, west to east Texas, and north to central Arkansas. Current threats include the conversion of habitat for recreational use and urban development.

Alligators prefer large, shallow lakes, fresh or brackish marshes, and savannas that border aquatic habitat. Alligators are strictly carnivorous and will eat any animal they can subdue and swallow.

Conservation actions for the American alligator focus on habitat protection and control of human disturbance.

Species accounts: American crocodile—The crocodile is federally listed as endangered. The species occurs in south Florida and the Florida Keys. It inhabits the Caribbean, Central America, and South America. Habitat loss is the primary reason for this species' imperilment in the South (Moler 1992a).

The crocodile is found in brackish or salt water in coastal canals,

mangrove thickets, or tidal creeks. The crocodile is carnivorous. Conservation actions center on protection of the remaining habitat in southern Florida (Wilson 1995).

Species accounts: Atlantic salt marsh snake—This threatened species is restricted to a small coastal strip in Florida. It is imperiled by wetland habitat alteration stemming from drainage and impoundment.

This snake preys on fish and is typically found in salt marshes, tidal creeks, and mangrove swamps. Conservation action for this species is concerned with protection of the remaining unaltered habitat (Conant and Collins 1991).

Species accounts: bog turtle—This threatened species occurs in southwestern Virginia, eastern Tennessee, northern Georgia, and the Carolinas. The bog turtle is in jeopardy due to collection for the pet trade and habitat loss. The drainage of grassy and marshy wetlands has resulted in the destruction of the required habitat for this species.

The bog turtle feeds on a variety of animals including tadpoles, frogs, various invertebrates, and baby rodents. The species does not tolerate closed-canopy forests. Management actions focus on the maintenance of early seral (grassy) habitat and halting the illegal pet trade (Ernst and others 1994). Drainage of wetlands is detrimental to this species (Wilson 1995).

Species accounts: Florida scrub lizard—This species is classified as vulnerable by Natural Heritage (NatureServe 2000). Disjunct populations occur along the east coast of Florida, in central Florida, and in isolated areas on the west coast of Florida. The species is threatened by conversion of habitat to other uses.

The lizard prefers open sandy edges in xeric sand pine scrub and longleaf pine habitat (Conant and Collins 1991). It feeds on ants, beetles, spiders, and other small arthropods.

Conservation strategies focus on the management of sand pine scrub and longleaf pine-turkey oak habitats to retain the open character that the lizard requires. The Ocala National Forest manages large areas of this habitat (Wilson 1995). Habitat maintenance often requires prescribed burning.

Species accounts: gopher tortoise—This threatened species occurs in Florida, Georgia, South Carolina, Mississippi, Alabama, and Louisiana. Habitat loss and the pet trade are the primary factors contributing to the decline of the tortoise (U.S. Fish and Wildlife Service 1990c).

Well-drained sandy soils supporting pine and scrub oaks in the sandhills are preferred habitat. The tortoise feeds on grasses, forbs, and other vegetation (Ernst and others 1994).

Habitat management for the gopher tortoise includes selective harvest and prescribed burning to maintain the open, grassy nature of sand ridges. Ground disturbance such as heavy site preparation and root raking can be detrimental to young tortoises (Wilson 1995).

Species accounts: indigo snake—The population of this threatened species has declined rapidly in recent years. Primary threats appear to be habitat loss and exploitation for the pet trade (Speake and others 1982). The indigo snake is currently found in southeastern Georgia and Florida.

The species coexists with gopher tortoises throughout much of its range and frequently uses tortoise burrows. Preferred habitat is pine-scrub oak woodlands and palmetto-covered hills with well-drained sandy soils. Indigo snakes may also be found in mesic habitats bordering swamps, streams, or canals. The snake feeds on frogs, toads, birds, small mammals, and other reptiles.

Conservation actions necessary to protect indigo snake populations include the retention of existing habitat, maintenance of pine-scrub oak woodlands in a subclimax condition, and protection of gopher tortoise burrows (Moler 1992c).

Species accounts: Louisiana pine snake—This species is endemic to eastern Texas and western Louisiana, primarily in areas currently or once dominated by longleaf pine. The species is associated with fire-maintained pine forests on well-drained sandy soils with well-developed herbaceous vegetation (Rudolph and Burgdorf 1997). Pocket gophers are the primary prey of Louisiana pine snakes, and pocket gopher burrows are used for escape from predators, avoidance of high temperatures, and hibernation. The species has apparently declined in recent decades, and existing populations are thought to be small and isolated (Reichling 1995, Rudolph and Burgdorf 1997).

Loss of habitat due to conversion to intensive silviculture and changes in the fire regime are the primary causes of population decline. Fire suppression and inadequate prescribed fire have resulted in widespread successional changes in pine forests throughout the range of Louisiana pine snakes, leading to loss of herbaceous vegetation and pocket gophers. Habitat loss and degradation has been more extensive on private than on public land. Roads and associated vehicle traffic are very likely impacting populations in much of the remaining habitat.

Conservation action centers on the management of fire-maintained pine habitat on a scale sufficient to support viable populations of this species. Prescribed burning sufficient to maintain abundant herbaceous vegetation and support of pocket gopher populations are required.

Species accounts: mimic glass lizard—This species is classified as vulnerable by Natural Heritage (NatureServe 2000). The lizard occurs on the Atlantic Coastal Plain from North Carolina to Florida and westward as far as the Pearl River in Mississippi. The species is imperiled due to excessive development and habitat modification in its range.

The lizard inhabits open-canopied pine forests with thick forest litter. It feeds on a variety of invertebrate prey as well as small lizards and snakes (Palmer and Braswell 1995).

Conservation actions to benefit this species include maintaining an open canopy through burning and thinning (Wilson 1995).

Species accounts: bluetail mole skink—This threatened subspecies occurs in Florida. Residential development and agricultural conversion have altered its habitat. The mole skink prefers open, sandy edges in sand pine scrub and sandhill habitats. The species consumes a variety of invertebrate prey, including ants, beetles, and spiders.

Conservation actions for this species focus on protection of essential habitat areas from conversion to other uses (Conant and Collins 1991).

Species accounts: rim rock crowned snake—This species is classified as critically imperiled by Natural Heritage and occurs solely in Florida (NatureServe 2000). Development and the resultant habitat loss threaten the snake.

This snake is found in flatwoods, tropical hardwood hammocks, and pastures and on fossil coral reefs (Porras and Wilson 1979). This snake consumes insects and other small arthropods.

Because of the intense development occurring in the habitat of this species, conservation action centers on the protection of suitable habitat (Wilson 1995).

Species accounts: ringed map turtle—This threatened turtle inhabits the Pearl River drainage of southern Mississippi and southeastern Louisiana. Primary threats are illegal collection for the pet trade and habitat degradation (U.S. Fish and Wildlife Service 1988).

This turtle leaves the river to bask and to lay eggs. Preferred habitat includes river stretches with moderate current, sandbars, and debris for basking sites. The diet is comprised of insects and mollusks. Because this turtle is restricted to the Pearl River, modifications of natural conditions there could prove detrimental.

Species accounts: sand skink—This species is classified as imperiled by Natural Heritage (NatureServe 2000). It is restricted to well-drained sandy soils in the interior central Florida highlands. Much of this habitat has been converted to citrus groves and residential areas.

The sand skink lives in loose, dry sandy areas with sparse grass cover. It subsists on a diet of ants, spiders, termites, beetle larvae, and other invertebrates.

Protection of the remaining habitat and acquisition of additional areas are the primary conservation actions required to preserve this species (Christman 1992). In addition, the use of prescribed fire is important for maintaining the open nature of sand skink habitat.

Species accounts: short-tailed snake—This species is classified as vulnerable by Natural Heritage and is endemic to Florida (NatureServe 2000). Habitat destruction is the primary threat, particularly in central Florida, where land is in demand for agricultural, residential, and other uses (Wilson 1995).

The primary habitats of this snake are longleaf pine-turkey oak and sand pine scrub communities with loose sandy soils. It feeds on small snakes and lizards.

Management actions center on the protection of remaining occupied habitat from development and the retention of prey populations (Campbell and Moler 1992).

Species accounts: southern hognose snake—This species is classified as imperiled by Natural Heritage (NatureServe 2000). The snake occurs primarily on the Coastal Plain from North Carolina westward into southern Mississippi. There is one disjunct population in central Alabama. Development of preferred habitat is the primary cause for imperilment, but fire ants may also be impacting populations (Wilson 1995).

This snake is found in sandhills, pine-scrub oak woodlands, pine and wiregrass flatwoods, and other open xeric communities with loose, sandy soils (Martof and others 1980). It feeds primarily on toads, frogs, and lizards.

Conservation actions for this species include the protection and restoration of remaining habitat, restriction of additional development, and fire ant control.

Mammals

Terrestrial, marine, and freshwater habitats in the South are home to 246 mammalian species (NatureServe 2000). The number of mammals ranges from 176 species in Texas to 62 species in Mississippi. There are 102 species in Georgia, 101 in South Carolina, 96 in Oklahoma, and 95 in Florida. The total includes rodents, carnivores, bats, whales, dolphins, and other mammals (fig. 5.6).

This vertebrate group comprises 11 major orders and 26 families (Echternacht and Harris 1993). All but five families have one or more sensitive species (Laerm and others 2000). These families include Didelphidae (opossum), Dasypodidae (armadillo), Castoridae (beaver), Myocastoridae (nutria), and Suidae (wild boar). The order Rodentia dominates the region's mammalian fauna in the number of different species. This order includes chipmunks, squirrels, pocket gophers, mice, rats, voles, muskrats, nutria, and beavers. Examples of carnivores include the Florida panther, red fox, bobcat, river otter, and mink. The category of "other mammals" in figure 5.6 includes the Florida manatee, white-tailed deer, eastern cottontail rabbit, opossum, armadillo, shrews, moles, and several other species.

Five mammal species are known or presumed to be extinct or extirpated from the region. These are the jaguar, ocelot, gray wolf, elk, and bison (Echternacht and Harris 1993). Beavers were once extirpated in the South but were reestablished over the past two decades.

Endemic species represent a relatively small percentage of the mammals in the region. Eight rodent species are endemic to the Coastal Plain: the southeastern pocket gopher, colonial pocket gopher, Sherman's pocket gopher, Cumberland Island pocket gopher, oldfield mouse, Florida mouse, Perdido Key beach mouse, and round-tailed muskrat (White and others 1998). The region also has eight species of introduced mammals, including the coyote, wild boar, and nutria.

Thirty-three species of mammals are listed as threatened or endangered (table 5.12). These include the Key deer, red wolf, Louisiana black bear, Indiana bat, gray myotis, Virginia northern flying squirrel, and southeastern beach mouse. Ten of the listed rodent species inhabit the Coastal Plain of Florida or Alabama.

In addition, 12 species are classified as imperiled or vulnerable under the Natural Heritage system (chapter 1).

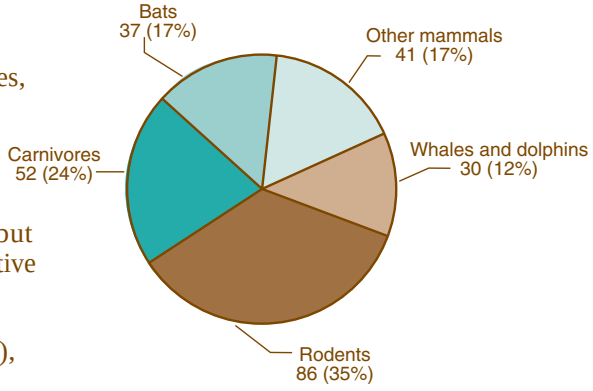

Figure 5.6—Species richness by major subgroups of mammalian taxa occurring within the South (NatureServe 2000).

Table 5.12—Mammal species within the South that are listed as threatened or endangered

Scientific name	Common name	Areas of occurrence
Bats		
Corynorhirus townsendii ingens	Ozark big-eared bat (E)	AR, OK
Corynorhinus townsendii virginianus	Virginia big-eared bat (E)	NC, VA
Myotis grisescens	Gray bat (E)	AL, AR, FL, GA, KY, OK, TN, VA
Myotis sodalis	Indiana bat (E)	AL, AR, GA, KY, MS, NC, OK, SC, TN, VA
Rodents		
Glaucomys sabrinus coloratus	Carolina northern flying squirrel (E)	NC, TN
Glaucomys sabrinus fuscus	Virginia northern flying squirrel (E)	KY, NC, VA
Microtus pennsylvanicus dukecampbelli	Florida salt marsh vole (E)	FL
Neotoma floridana smalli	Key Largo woodrat (E)	FL
Oryzomys palustris natator	Rice rat (E)	FL
Peromyscus gossypinus allapaticola	Key Largo cotton mouse (E)	FL
Peromyscus polionotus allophrys	Chocawhatcher beach mouse (E)	FL
Peromyscus polionotus ammobates	Alabama beach mouse (E)	AL
Peromyscus polionotus niveiventris	Southeastern beach mouse (T)	FL
Peromyscus polionotus peninsularis	St. Andrew beach mouse (E)	FL
Peromyscus polionotus phasma	Anastasia Island beach mouse (E)	FL
Peromyscus polionotus trissyllepsis	Perdido key beach mouse (E)	AL, FL
Sciurus niger cinereus	Delmarva Peninsula fox squirrel (E)	VA
Carnivores		
Canus rufus	Red wolf (E)	NC, TN, FL
Herpailurus yogouaroundi cacomitli	Gulf Coast jaguarundi (E)	TX
Leopardus pardalis	Ocelet (E)	TX
Panthera onca	Jaguar; Otorongo (E)	TX
Puma concolor	Puma (T)	FL
Puma concolor coryi	Florida panther (E)	FL
Puma concolor cougar	Eastern puma (E)	KY, NC, SC, TN, VA
Ursus americanus luteolus	Louisiana black bear (T)	LA, MS, TX
Whales and dolphins		
Balaenoptera physalus	Fin whale (E)	AL, FL, GA, LA, MS, NC, SC, TX, VA
Eubalaena glacialis	Black right whale (E)	FL, GA, NC, SC, VA
Megaptera novaeangliae	Humpback whale (E)	AL, FL, GA, LA, MS, NC, SC, TX, VA
Physeter catodon	Sperm whale (E)	NC
Other mammals		
Monachus tropicalis	Caribbean monk seal (E)	FL
Odocoileus virginianus clavium	Key deer (E)	FL
Trichecchus manatus	Manatee (E)	AL, FL, GA, LA, MS, NC, SC, TX
Sylviagus palustris hefneri	Lower Keys marsh rabbit (E)	FL

T = threatened; E = endangered.
Source: U.S. Department of the Interior (2000).

These include the Rafinesque's big-eared bat, gray-footed chipmunk, round-tailed muskrat, Allegheny woodrat, and swift fox. These species are in jeopardy due to habitat loss, land use change, human disturbance, and coastal development.

The white-tailed deer is the most widespread browsing species represented in the region today. Elk have recently been reintroduced into selected locations. The absence of large carnivores (wolves, jaguar) reflects history since European settlement (chapter 1). The black bear is the largest carnivore now in the South. Four wild canids occur in the region. The coyote has expanded its range, while the red wolf is critically imperiled due to habitat loss and hybridization with other canids. Red and gray foxes remain relatively common. The Florida panther is in jeopardy, while the bobcat remains widespread throughout the region.

The absence of large predators has encouraged the proliferation of raccoons, opossums, and skunks. These species demonstrate broad ecological tolerance, inhabiting virtually every type of habitat available. They consume a variety of foods: frogs, turtles, snakes, mice, berries, and other vegetation. These mammals are rapidly becoming urban wildlife in many communities of the South.

Rodents are a diverse group that persists in abundance in many areas. They tend to have high birth rates that permit the maintenance of stable populations despite predation pressure and control measures. The rodent species that are most at risk in the South have narrow distributions. In beach habitats, feral cats represent a significant threat. Pesticide residues affect shrews and other insectivores. The fox squirrel that inhabits longleaf pine savannas is threatened by fire suppression and land use conversion (White and others 1998).

The absence of mountain barriers and other opportunities for isolation and speciation contribute to the lack of species richness among squirrels and burrowing mammals (Echternacht and Harris 1993). The eight species of sciurid rodents in the region include the 13-lined ground squirrel, gray squirrel, fox squirrel, and two flying squirrels. The region's 10 burrowing rodents include the hairy-tailed mole, eastern mole, and star-nosed mole; woodchuck; eastern chipmunk; and 5 species of pocket gophers. Soil type is the primary factor determining the ranges of pocket gophers.

The following sections discuss the habitat needs for two of the highest profile groups of mammals: bats and carnivores. Additional species are also profiled in the Species account section that concludes the segment on mammals.

Bats—The 20 species of bats in the South are key components of forested ecosystems. Four bats are listed as endangered: the gray bat, Indiana bat, and Ozark and Virginia big-eared bats (table 5.13). The southeastern bat, the eastern small-footed bat, Rafinesque's big-eared bat, and Wagner's mastiff bat are of special concern.

Forest bats depend on forests for shelter, roosting sites, and foraging areas. Bats are in two major classes: cave bats and tree bats. Cave bats inhabit caves during all or part of the year, while noncave species seldom enter caves. Some of their ranges are limited to relatively small geographic areas. Insectivorous bats have tiny

Table 5.13—Bat species occurring within the South

Scientific name	Common name	Status
Artibeus jamaicensis	Jamaican fruit-eating bat	Limited numbers
Corynorhinus townsendii	Townsend's big-eared bat	Endangered[a]
Corynorhinus rafinesquii	Rafinesque's big-eared bat	Special concern
Eptesicus fuscus	Big brown bat	Common
Eumops glaucinus	Wagner's mastiff bat	Rare
Lasionycteris noctivagans	Silver-haired bat	Relatively uncommon
Lasiurus borealis	Eastern red bat	Common
Lasiurus cinereus	Hoary bat	Relatively common
Lasiurus intermedius	Northern yellow bat	Relatively common
Lasiurus seminolus	Seminole bat	Common
Molossus molossus	Pallas mastiff bat	Limited numbers
Myotis austroriparius	Southeastern bat	Special concern
Myotis grisescens	Gray bat	Endangered
Myotis leibii	Eastern small-footed bat	Special concern
Myotis lucifugus	Little brown bat	Scarce or locally common
Myotis septentrionalis	Northern long-eared bat	Common
Myotis sodalis	Indiana bat	Endangered
Nycticeius humeralis	Evening bat	Common
Pipistrelle subflavus	Eastern pipistrelle	Common
Tadarida brasiliensis	Brazilian free-tailed bat	Locally common/abundant[b]

[a] Two subspecies: Ozark big-eared bat and the Virginia big-eared bat.
[b] Two subspecies: LeConte's free-tailed bat and the Mexican free-tailed bat.
Source: Adapted from Harvey and Saugey (2001).

eyes and are capable of sight, but most species locate prey by echolocation.

Bats hibernate in a variety of locations including leaf litter, woody debris, caves, hollow trees, and rock crevices. Many species hibernate under exfoliating bark and in tree cavities, mines, and buildings. Roosting sites range from solitary sites to caves containing thousands of individuals. Sites selected for roosting and hibernation meet precise environmental conditions, such as stable temperatures and high relative humidity. Disturbance often results in the abandonment of the site.

Bats have evolved to fill a variety of food niches. These mammals begin foraging at dusk. The diet consists of insects and other arthropods and varies by species.

Widespread pesticide use caused significant declines in bat populations during the past several decades (Harvey and others 1999). This threat has diminished somewhat with pesticide use regulations. The current threat to bats stems from habitat destruction and cave disturbance. Few caves meet the narrow temperature and humidity requirements for hibernation. The large numbers of bats occupying specific caves make these species vulnerable to disturbance of an individual cave.

Various locations are used as maternity roost sites. Snags are used by Indiana, northern, and evening bats, while hollow trees are important for Rafinesque's and southeastern bats. A particular threat is human disturbance to hibernation and maternity colonies. Hibernating bats wake when disturbed and expend critical winter stores of fat. Summer maternity colonies have low tolerance of disturbance; disturbed parents will often abandon their offspring. Bats produce an average of one offspring per year, but some species give birth to three or four babies at a time. The low rate of reproduction results in populations that can be quickly destroyed with little opportunity for recovery. Other adverse impacts include habitat destruction; direct killing; vandalism; and predation by raptors, raccoons, skunks, and snakes (Tuttle 1995).

A number of forest management actions can enhance bat habitat. Seed-tree and shelterwood harvests open up forest canopies, creating foraging opportunities by reducing branch obstructions (Krusic and others 1996). Retention of cavity trees and snags, creation of large snags, and designation of streamside zones also are beneficial (Harvey and Saugey 2001, Kulhavy and Conner 1986). The creation of ponds can also enhance habitat by providing water, breeding sites, and a source of insect prey (Wilhide and others 1998).

Even-aged poletimber stands often are unsuitable for bole and cavity users and do not provide the cavities and bark characteristics preferred by bats (Pierson 1998). Clearcutting eliminates roosting opportunities until replacement trees of suitable size become available (Harvey and Saugey 2001). However, the resulting availability of herbaceous growth results in increased insect populations (Barclay and Brigham 1998). Stand rotations long enough to allow for cavity development are important for species that require cavities.

Prescribed burning can enhance invertebrate biomass by reducing midstory trees and shrubs, allowing the regeneration of herbaceous plants. The resulting canopy gaps provide additional foraging opportunities. However, fire may jeopardize bats hibernating on the ground during winter when they are torpid and slow to arouse (Harvey and Saugey 2001). The impact of dormant-season burning on species that roost in ground litter is unclear. Snags used by bats may be felled by fire if their bases burn through, resulting in the loss of cavities or roosting sites under exfoliating bark.

Finally, recreational caving should be minimized to prevent disturbance to maternity and hibernating colonies. Properly designed gates on cave entrances afford the best protection. Other protective measures include limiting the use of pesticides and preventing destruction of habitat.

Carnivores—Carnivores are a viable component of the southern landscape, whose management has changed significantly over the last several decades. The perception that carnivores must be eliminated is no longer widely held. These mammals contribute to ecosystem stability by controlling rodent populations.

There are few reliable density estimates for furbearers because they are secretive and difficult to census. Most are territorial. Population density is relatively low, reflecting their position at the top of the food chain. Two carnivores (the bobcat and river otter) are protected under the Convention for the International Trade of Endangered Species of Fauna and Flora (CITES) and are monitored closely by States that allow harvest of these species (Leopold and Chamberlain 2001).

The diet of carnivores is primarily composed of other animals. Bobcats, river otters, weasels, and mink characteristically have diets in which animal material exceeds 95 percent. The amounts of fruits, berries, and seeds vary with seasonal availability. For example, gray and red fox foods change from animal foods in the fall and winter to invertebrates and fruits during spring and summer.

Each species is associated with specific habitats that provide required food, water, and cover. Often, areas that are diverse in vegetative composition, structure, and seral stage are inhabited by a diversity of these mammals. A substantial number of carnivores depend on forested ecosystems to provide one or more habitat requirements. Mosaics of cover types and the ecotones between successional stages enhance prey and other food diversity. The structural components important to many mammals include mature trees, standing dead trees, woody debris, and patchy understories. Structural diversity and decaying trees provide suitable cover and foraging habitat.

Habitat quality determines the stability of these populations, while habitat loss is the primary threat to these species. Habitat modification influences species distribution and abundance. Forest clearing, grassland conversion, irrigation, and wetland drainage have improved habitat for some species and damaged habitat for others. The expanded range of the coyote throughout the South resulted from urbanization and the removal of large predators such as red wolves and Florida panthers.

Species with restrictive habitat requirements are vulnerable to losses of habitat. The swift fox depends on native shortgrass prairie communities; its range has become restricted due to the conversion of prairies into cultivated fields. Mammals associated with wetland habitats are not very resilient

to habitat modification. For example, river channelization reduces habitat suitability for river otters (Allen 1988).

Large mammals such as the red wolf, Florida panther, and black bear have extensive home ranges. The maintenance of a mosaic of vegetation types and multiple seral stages supports prey populations and the food-producing plants that comprise the diet of these species. In contrast, the majority of carnivores depend on much smaller geographic areas. These species rely on a diversity of cover types in relatively close proximity to provide seasonal cover and food. Red foxes, gray foxes, and weasels are associated with early to mid-successional vegetation and the ecotones between these communities. Management that maintains fencerows, shelterbelts, and riparian vegetation will benefit these species and enhance their distribution.

The elimination of woody debris influences small mammal populations and makes them easier prey for associated predators. Timber harvest and prescribed burning change vegetation composition and enhances understory growth. However, timber removal may harm other mammals that require mature forest. In some cases, the protection of critical habitat may be the preferred management strategy.

Conservation of wetland carnivores centers on prevention of wetland degradation. Vegetative structure, surrounding land use, water quality, and cover diversity influence habitat quality for these mammals. For example, the manipulation of water levels and the planting of desired vegetation can enhance habitat. The maintenance of water availability and prey species also improves habitat potential. Debris and structural diversity along shorelines enhance prey availability for river otters. The removal of aquatic shoreline vegetation reduces availability of prey for mink.

Important habitat features for carnivores as well as other mammals occurring in the South are summarized in table 5.14. Detailed information for selected species is presented in the following section.

Species accounts: beaver—This species was extirpated from most of its southern range by the 1950s due to extensive trapping that began in the 18th century. Restocking programs

Table 5.14—Important habitat components and associated management guidelines for selected mammals in the South (continued)

Species	Key components of habitat	Management guidelines
Raccoon	Wetlands, riparian habitats, suitable den sites and winter food.	Preserve wetlands and riparian areas; maintain snags or diseased trees for den sites; encourage mast species; maintain fencerows.
Red fox	High degree of habitat edge; interspersion of mosaic of woodland, shrubland, cropland, and grassland habitat.	Maintain woodlots in agricultural areas to enhance vegetation diversity; maintain fencerows for travel corridors; encourage softmast production.
Red squirrel	Dense or clumped stands of mature forest; multi-storied stands; suitable nest sites; sufficient shade for cone storage.	Maintain large deciduous trees with cavities; preserve densely branched trees; provide clumped stands near mature conifers with interlocking crowns.
Ringtail cat	Rocky, brushy areas, talus slopes or wooded habitats in close proximity to water.	Maintain riparian vegetation in association with draws and ridgelines as travel corridors.
River otter	Water quality; permanent surface water, vegetative cover adjacent to wetlands; structural cover to provide foraging and den sites.	Maintain vegetative cover adjacent to wetlands; increase pool to riffle ratios; ensure water permanence; encourage beaver establishment.
Spotted/striped skunks	Ecotones between forest/shrubland and agricultural lands; riparian areas in arid regions.	Maintain woodlots in agricultural areas to enhance vegetation diversity; maintain fencerows for travel corridors; encourage softmast production.
Swift fox	Mid to shortgrass prairie habitats suitable to support an adequate prey base.	Establish vegetative communities to support prey base; maintain interspersion of grassland communities with agricultural lands.

Source: Adapted from Allen (1988).

in Louisiana, Mississippi, Alabama, Florida, Georgia, Oklahoma, Virginia, Arkansas, and North and South Carolina have led to viable populations across most of the South (Jones and Leopold 2001).

Beavers use freshwater habitats such as ponds, small lakes, and streams. Slow-moving streams and creeks with proximity to trees and shrubs that provide a food source are important. Beaver damming can flood forests, causing substantial economic impact from prolonged flooding. However, beavers create a complex successional mosaic of aquatic and terrestrial habitats that enrich landscape diversity. The creation of wetlands positively influences ground water, water quality, structural diversity, and erosion resistance. Beaver impoundments create favorable conditions for fish, birds, and amphibians. Beaver ponds on intermittent streams provide aquatic habitat conducive to the river otter.

River channelization significantly affects habitat quality by reducing amounts of riparian vegetation, macroinvertebrates, and fish biomass. The modification of river flow rates also reduces the number of islands occurring in the channel, impacting potential den habitat.

Species accounts: black bear—Black bears historically ranged over most of the South. Habitat loss, fragmentation, and unrestricted harvest have significantly changed their distribution and abundance.

Their current distribution is restricted to relatively undisturbed forests in the Appalachian Mountains and the Interior Highlands of Arkansas and in scattered coastal areas from Virginia to Louisiana (Vaughn and Pelton 1995). Populations appear to be secure and increasing in parts of Virginia, Tennessee, North Carolina, northern Georgia, and northern South Carolina, where they support regulated hunting seasons. In Tennessee, the species is known only from the mountains in the eastern part of the State (Chapman and Laerm, in press). In Kentucky, the black bear is designated as a species of special concern. Texas biologists indicate there is no resident breeding population there.

Two subspecies are of special concern. The Louisiana black bear is designated as threatened on the Federal species list and as endangered by the States of Mississippi, Louisiana, and Texas. The Florida subspecies is listed as threatened by the Florida Game and Fresh Water Fish Commission. Until recently, this subspecies was considered for protection under the Federal Endangered Species Act. Both subspecies populations are restricted to islands of public land and inaccessible areas of bottomland forest.

Black bears inhabit diverse forest habitats and are often found in oak-hickory and mixed mesophytic forests. Forested areas of 150 to 300 square miles with limited human intrusion are needed to sustain viable populations. In coastal areas, the species occupies pocosins, hardwood bottomlands, Carolina bays, mixed hardwood hammocks, cypress swamps, pine flatwoods, and sand pine scrub. Black bears need dense understory cover, such as laurel thickets and greenbriar, to provide refuge cover in the Coastal Plain.

Adequate denning cover is a necessary component of black bear habitat in the South. Such cover includes cavities in large trees, logs, stumps, rock outcroppings, and impenetrable thickets. Females and cubs are very susceptible to disturbance. Black bears need secure corridors to make seasonal movements for food, for dispersal of younger animals, and for movement by males during the breeding season (Pelton 2001).

The diet of black bears is primarily hard and soft mast, including berries, nuts, acorns, wild cherries, and grapes, as well as invertebrates. In some areas, bears feed on agricultural crops such as corn, wheat, or soybeans. Black bears will occasionally eat opossums, armadillos, feral pigs, raccoons, and young white-tailed deer.

The seasonal variations in availability of soft and hard mast influence shifts in home range to locate these foods. State biologists indicate that during periods of drought and food scarcity, bears further disperse and become victims of vehicular accidents, nuisance control, and illegal hunting.

Bear populations in the Southern Appalachians have been monitored since the 1960s. Although bear populations have increased during this period, the illegal trade in bear gall bladders has raised concerns about the effect of poaching. Because bears have low reproductive rates, their populations recover slowly from losses.

Habitat degradation continues to threaten black bears in the South. Forest fragmentation and the conversion of forests to agriculture, urban development, and pine monocultures restricts available habitat (Pelton 2001). The fragmented nature of black bear populations in the Coastal Plain may contribute to a loss of genetic diversity. As the human population in the South continues to expand into bear habitat, increased incidents of road kills are being reported in North Carolina, Tennessee, and Florida. As people settle into established bear ranges, increased human-bear interactions are inevitable. Poaching and increased access capabilities can result in overexploitation.

Components of black bear management include hunting access, habitat, protection, nuisance control, education, and research (Pelton 2001). Access can be restricted through road gating, designation of no-hunting zones, and provision of escape cover. Habitat management includes oak enhancement, protection of old growth (for den trees), and management of forest openings for soft mast production. The establishment of black bear sanctuaries and viable corridors on public land has protected bears in the region (Vaughn and Pelton 1995). Texas has proposed the establishment of bear "recovery zones" through a partnership among Federal and State agencies, forest industry, and other owners of large parcels of timberland. Stringent law enforcement also is required to reduce illegal hunting. Finally, State biologists suggest that education of the general public is critical to increase awareness and acceptance of regulations such as those that discourage feeding of bears.

Species accounts: bobcat—Bobcats are found throughout the South with the exception of north-central Kentucky, coastal Louisiana, and eastern Virginia (Leopold and Chamberlain 2001). Population density varies according to habitat type and prey density.

Bobcats use several habitats, preferring areas with dense understory vegetation that supports prey populations. A mixture of mature and early successional forest habitats is best. Other habitats include agricultural

fields and pastures. Home ranges of bobcats throughout the Southeastern United States range from less than 740 acres to 17,830 acres. Home ranges may reflect road avoidance. Important prey species include rabbits and various rodents, opossum, game birds, and snakes (Chapman and Laerm, in press).

There are no major threats to bobcats in the South due to their wide distribution and ecological tolerance. Potential risks include overharvest by trapping, forest fragmentation, and road construction.

Species accounts: Carolina northern flying squirrel and Virginia northern flying squirrel—These two endangered subspecies inhabit high-elevation sites in the Southern Appalachians. The Carolina squirrel occurs in isolated locations in North Carolina and Tennessee, while the Virginia subspecies is in Virginia and West Virginia. The disjunct distribution of these subspecies in the Southern Appalachians suggests they are relicts that have become isolated in small patches of suitable habitat by changing climatic and vegetation conditions since the last Ice Age (U.S. Fish and Wildlife Service 1990a).

Flying squirrels are associated with high-elevation boreal habitats, especially spruce-fir and northern hardwood forests (Fridell and Litvaitis 1991). They occur in conifer-hardwood ecotones consisting of red spruce and fir associated with mature beech, yellow birch, maple, and several other species. Widely spaced, mature trees and snags provide cavities for nesting. Understory components do not appear to be important components of northern flying squirrel habitat (U.S. Fish and Wildlife Service 1990a).

Their diet consists of lichens, fungi, seeds, fruit, staminate cones, and insects. Periodic dependence on certain species of fungi may be a factor in restricting the species to high-elevation, mesic habitats (U.S. Fish and Wildlife Service 1990a).

The limited range of this species makes it vulnerable to natural and human-related impacts. Isolated populations suffer from insufficient gene pools. Other concerns include habitat destruction, insect pests such as the balsam woolly adelgid and the gypsy moth, recreational use, acid rain (which contaminates their mycorrhizal food source), and heavy metals (lead, copper, nickel, zinc, and manganese) in forest litter and soil (U.S. Fish and Wildlife Service 1990a).

Conservation strategies include determination of species distributions, protection of occupied sites from human-related disturbance, and implementation of habitat management guidelines on national forests and parks.

Species accounts: coyote—The distribution of coyotes has extended into the South during the past few decades in response to the elimination of gray and red wolves from their former ranges. Prior to 1970, red wolves were common throughout the South, but trapping and poisoning eliminated free-ranging populations. Gray wolves also once inhabited Kentucky, Tennessee, Virginia, and North Carolina. Removal of these two species contributed to coyote expansion. Leopold and Chamberlain (2001) indicate that coyote populations have expanded throughout the South, with the exception of southern peninsular Florida. The current population density of coyotes is unknown.

Coyotes occupy a broad range of habitats and occur in grassland, forest, agricultural fields, and urban areas. In the South, this species has been observed in open fields, brushlands, thickets, young forest, and forest-edge habitats. Habitat use by coyotes in the South is diverse and reflects their opportunistic feeding habits.

Their diet includes rabbits, small mammals, ground-nesting birds and their eggs, amphibians, lizards, fish, snails, crustaceans, insects, carrion, fruits, and plant roots (Chapman and Laerm, in press).

There are no known threats to coyote survival in the region. Animal damage control programs in the Western United States have been unsuccessful.

Species accounts: Florida panther—The Florida panther, one of 30 subspecies presently recognized, is the only subspecies of mountain lion remaining in the South. The species originally ranged from eastern Texas eastward through Arkansas, Louisiana, Mississippi, Alabama, Florida, Georgia, and portions of Tennessee and South Carolina. Due to large-scale habitat destruction and indiscriminant shooting, panthers were extirpated throughout most of their range by the early 1900s. Although periodic sightings are reported in remote areas of selected States, it is unlikely that viable populations exist outside of Florida. Currently, the population is estimated at between 20 and 50 animals.

Panthers prefer large remote tracts that are typically heavily vegetated and have minimal human disturbance. These animals use highly diverse habitats including hardwood hammocks, saw-palmetto woodlands, sawgrass prairies, cypress strands, and oak-pine woodlands. Home ranges average 200 square miles for males and 75 square miles for females.

Panthers subsist on a variety of mammalian prey, particularly white-tailed deer and feral hogs. In the northern portion of its range, feral hogs constitute the bulk of the diet, whereas white-tailed deer are more important in the southern portion. Panthers also readily take raccoons, armadillos, rabbits, and other small animals (Clark 2001).

Loss of habitat is the greatest threat to viable panther populations, but illegal shooting and highway collisions also are major problems. Off-road vehicle traffic has increased, making accessible large areas that formerly had been isolated wilderness. Intolerant of human disturbance, panthers are sensitive to habitat fragmentation stemming from road construction, agricultural development, and urban expansion. Other threats include parasites, diseases such as feline distemper and upper respiratory infections, and inbreeding depression. Panther populations are losing genetic diversity by 3 to 7 percent per generation; at this rate, extinction is probable in the next few decades (Clark 2001). Reduced prey base also is a concern. Panthers consume up to one deer or hog weekly. Due to habitat alteration, these prey animals may not be sufficiently abundant in Florida to meet this need.

Since panther habitat includes public and private land, management efforts must be coordinated. The key to panther conservation is habitat protection and acquisition of large, interconnected blocks of woodland. The recovery plan recommends: (1) enhancing existing populations

through genetic management including captive breeding programs and genetic restoration; (2) protecting and managing existing habitat, including prescribed burning and exotic plant control; (3) establishing public support by educating private landowners; and (4) reintroducing panthers into areas of suitable habitat (U.S. Fish and Wildlife Service 1995). Potential release sites include the lower Coastal Plain of Alabama, Mississippi, Arkansas, and Louisiana and the lower Apalachicola River in Florida.

Species accounts: gray fox and red fox—Foxes occur throughout Virginia, North Carolina, South Carolina, Georgia, Alabama, Mississippi, Louisiana, and eastern Texas. The gray fox does not occur in coastal Louisiana or the Florida Keys, while the red fox does not inhabit the southern Florida peninsula. The population density of red and gray foxes in the South is not known.

Foxes occur in a variety of habitats. The red fox prefers open habitats including old fields, shrublands, pastures, and mixed hardwood forests; the gray fox is more of a woodland-edge species. Both prefer areas supporting an interspersion of different vegetative communities. Hollow logs, trees, brush piles, and rock outcrops are often used as dens. Patterns of habitat use change seasonally with food availability.

Foxes are opportunistic feeders. During the fall and winter, small animals comprise the bulk of their diet. Common prey includes rabbits, voles, mice, wood rats, and various birds (Fritzell 1987). Fruits, berries, arthropods, and amphibians are added to the diet during the summer and fall.

The planting of blackberry, honeysuckle, and other soft mast enhances fox habitat. Prescribed burning maintains old fields and forests in desirable condition. Cultivation of trees that produce hard mast also is important.

Trapping, hunting, road kills, and rabies are the major causes of fox mortality. The decline in red fox populations in some areas of the South has been attributed to interspecific interaction with coyotes.

Species accounts: gray bat—The U.S. Fish and Wildlife Service lists this species as endangered. The species distribution in the South includes the cave regions of Alabama, Arkansas, Kentucky, and Tennessee, but a few occur in Florida, Georgia, northeastern Oklahoma, Mississippi, Virginia, and North Carolina. Bat populations have become fragmented during the past few decades (Harvey and Saugey 2001). Ninety-five percent of gray bats hibernate in 10 caves.

Gray bats are year-round cave residents but usually occupy different caves in summer and winter. During the winter, they hibernate primarily in deep vertical caves with large rooms acting as cold-air traps (42 to 52 °F). Maternity roosts are established in warm, humid caves that provide domed ceilings capable of trapping body heat from bat clusters. Less than 5 percent of available caves in the South have the right properties of temperature, humidity, and structure to make them suitable for gray bat occupation (Harvey and Saugey 2001).

Like many bats, this species hunts for insects above forested rivers and streams. Moths, beetles, flies, mosquitoes, mayflies, and other insects are important in the diet.

The primary reasons for population declines include disturbance, vandalism, cave destruction, and pollution. Disturbance during hibernation depletes energy reserves and increases mortality. Conservation actions focus on the protection of occupied caves and appropriate management of the surrounding forest and aquatic foraging sites. Cave gates and fences must be properly designed to allow bat movement. This species is recovering due to the protection of four critical caves (Harvey and Saugey 2001).

Species accounts: Indiana bat—The Indiana bat is listed as endangered by the U.S. Fish and Wildlife Service. This species is known to occur throughout much of the Midwestern and Eastern United States; however, it has been virtually eliminated from much of its former range. The bat occurs in the northern portions of the South, including Tennessee, Virginia, and Kentucky. Isolated sightings have been made in the Carolinas, Alabama, and Mississippi. The current population of the species nationwide is estimated at 400,000 individuals; approximately 85 percent of the population is limited to 7 caves (Harvey and Saugey 2001).

During the summer, maternity roosts are established between exfoliating bark and the bole of snags, in hollow trees, or in live trees. Male bats often use pitch pine and shortleaf pines. These bats need winter caves or mines retaining stable temperatures of 39 to 46 °F and standing water that maintains relative humidity. The bats forage above streams, water bodies, and open areas. Riparian, upland, and floodplain forests are also used.

During hibernation, the Indiana bat is extremely vulnerable to any type of disturbance. Factors contributing to its decline include cave disturbance, improperly designed cave gates, and intentional killing. Habitat loss stemming from deforestation and stream channelization is another concern. Natural elements that imperil the species include flooding of occupied caves, exposure to freezing temperatures, and cave ceiling collapse. Forest management centers on the provision of summer roost sites and foraging habitat.

Species accounts: mink—Mink occur throughout the South, with the exception of central Florida and western Texas. They are common in the marshes along the Atlantic and Gulf Coasts and are widespread in Virginia, North Carolina, and South Carolina (Chapman and Laerm, in press). Population densities vary with the type and permanence of aquatic habitat and are influenced by climate, trapping, and intraspecific interaction.

Mink require wetland habitats, such as marshes, swamps, riverbanks, and streams. Habitat use varies by geographic area and season. There are no published data on mink home ranges or habitat use patterns in the South. Muskrats, mice, and lagomorphs are the preferred prey; mink diets also include birds, amphibians, crawfish, and fish.

Habitat degradation as a result of wetland alteration is a concern in the South. Mink are vulnerable to environmental contaminants, particularly mercury and pesticide residues, concentrated in prey foods. The prevention of high levels of environmental contaminants is needed to ensure habitat quality for this species.

Species accounts: Ozark big-eared bat and Virginia big-eared bat—These two subspecies are endangered and are federally protected throughout their respective ranges. Only a few caves in eastern Oklahoma, Arkansas, and Missouri are known habitats for the Ozark subspecies. The Virginia bat inhabits eastern Kentucky, Virginia, North Carolina, and West Virginia, but fewer than five caves are known to contain nursery colonies of this subspecies (Harvey and Saugey 2001).

The bats inhabit caves in limestone and schist formations throughout the year. Adjacent land use does not appear to influence cave selection. Roosting sites are often near mature bottomland and upland hardwood forests adjacent to water. Important habitat features include hollow trees, loose bark, and rock shelters. The bats prefer relatively cold, well-ventilated locations and are often found near cave entrances when hibernating. Big-eared bats forage in forested areas among the canopies of large trees, consuming beetles, flies, mosquitoes, gnats, moths, and many other insects.

The species is vulnerable to pesticides and human disturbance of their caves. They are easily disturbed and quick to take flight. Conservation actions center on the protection of roosting sites and the retention of hollow trees.

Species accounts: red wolf—The red wolf is an endangered species. The original distribution of the wolf included southern Illinois, Indiana, and Pennsylvania south to Florida and west to southern Texas. Indiscriminate trapping, hunting, and poisoning, loss of habitat, and expansion of urban and agricultural areas contributed to the demise of this species. The last remnant populations in the wild were verified in southern Louisiana and Texas in the 1970s.

In the late 1980s, efforts were made to translocate wolves to five locations: Alligator River National Wildlife Refuge, North Carolina; Bull's Island, South Carolina; St. Vincent Island, Florida; Horn Island, Mississippi; and the Great Smoky Mountains National Park. Recent threats center on genetic dilution due to hybridization with wild dogs and coyotes.

Historically, the wolf was found in old-growth forests, pine forests, bottomland hardwood forests, coastal prairies, and marshes. Current information on wolf ecology is limited to studies in the coastal marshes of Texas and Louisiana during the 1960s and 1970s and to observations at restoration sites (Crawford and others 2001). Heavy vegetative cover along bayous and fallow fields is ideal habitat. Home ranges vary from 17 to 38 square miles, depending upon habitat and prey density. Red wolves require large tracts of land relatively free of human development, paved roads, and livestock.

Red wolves are opportunistic predators, preying upon feral pigs, white-tailed deer, nutria, eastern cottontails, swamp rabbits, marsh rice rats, and fox squirrels. They will also eat birds, rodents, frogs, and turtles. A diversity of prey is necessary for sustaining population levels.

The recovery plan objectives center on the achievement of population levels large enough to ensure genetic integrity (U.S. Fish and Wildlife Service 1989). Potential reintroduction sites are examined for biological factors (prey abundance, habitat types) and socioeconomic factors (agricultural practices, land ownership patterns, proximity of towns). Areas of at least 170,000 acres are required by this species. The absence of coyotes is preferable to avoid hybridization. Site considerations include the potential for wolf-livestock interaction and human disturbance. Public attitudes about wolves are significant factors in their recovery.

Species accounts: river otter—The river otter is listed as a threatened species in Tennessee and as a species of concern in Oklahoma and Virginia. Otters occur regionally in many habitats associated with waterways, and their numbers are increasing in some parts of the region. The species is increasing in abundance throughout Virginia, where it is most common in the Coastal Plain and Piedmont. It also is relatively common in western Tennessee. Reliable census procedures for the river otter have not been developed, and few researchers have attempted to estimate population levels.

River otters use a variety of aquatic habitats including coastal estuaries, marshes, and streams. Riparian and shoreline vegetation bordering waterways is an important component of river otter habitat. Beaver impoundments, submerged trees, and logjams provide shelter and foraging areas for otters. Otters feed primarily on fish; other foods include aquatic insects, birds, small mammals, snakes, and amphibians.

Threats to otter populations include the clearing of bottomland forests, wetland modification, and pollution of aquatic environments. Otters are frequently caught in traps intended for beaver; the low reproductive potential of the otter, and the restricted nature of its habitat make the species susceptible to overharvest. As a result of trapping pressure, the otter was given protection under the Convention on International Trade in Wild Species of Endangered Flora and Fauna.

Strict population monitoring is needed. Continued management includes the restoration of otter populations in Kentucky, Oklahoma, Tennessee, and North Carolina. Reintroduction in the Great Smoky Mountains National Park began in the 1980s, where otter populations were once extirpated.

Species accounts: white-tailed deer—Deer are widespread and relatively abundant throughout the Southern United States. Populations on some islands have declined. Deer populations have fluctuated dramatically since European settlement of the South. Populations in the past declined to critical levels because of intensive hunting, widespread agricultural clearing, and other habitat alteration. Populations have rebounded during the last several decades due to farm abandonment, lower hunting pressure, and the extirpation of large predators. In some locations, populations are increasing to levels that make the species a pest.

The endangered Key deer is restricted to the lower Florida Keys. Four other subspecies of concern occur on Sapelo and Blackbeard Islands in Georgia and on Hilton Head Island, Bull's Island, and Hunting Island in South Carolina.

White-tailed deer use a wide range of habitat types and benefit from a mosaic of wetlands, forests, farmland, and early successional habitats. Preferred foods are acorns, blueberries, sumac, grapes, hawthorns, common persimmons, dwarf palmettos, and blackberries.

There are no threats to the survival of the white-tailed deer in the region.

However, coastal development has contributed to the decline of the island subspecies. Key deer are threatened by habitat loss, poaching, vehicular accidents, and attacks by feral dogs (White and others 1998).

Discussion and Conclusions

Based on listings from the U.S. Department of Interior (2000), every Southern State contains species that are under Federal protection (figs. 5.7 and 5.8). The endangered category refers to species that are in danger of extinction in the foreseeable future throughout significant portions of their range. The threatened designation is assigned to species likely to become endangered in the future. Status determinations are based on modification or restriction of habitat, commercial overutilization, disease or predation pressure, the inadequacy of existing regulations, and other factors affecting continued existence.

There are a number of different explanations for the number of listed species in a State. A State may support many unique habitats with high species richness. Texas is the largest State in the South in both area and species richness. The wide range of environmental conditions and diverse habitats that occur in Texas also support the second highest level of protected species. Larger areas on average support a greater diversity of habitats and a wider variety of species, listed or otherwise.

A species that has been extirpated from adjacent States may persist in areas that support the last remnants of suitable habitat. For example, the red wolf formerly ranged from Texas to the Atlantic Coast. It presently occurs in North Carolina, Tennessee, and Florida, where it has been reintroduced. The Florida panther, another far-ranging mammal, once occurred throughout the region. This species presently is found solely in isolated areas in Florida.

A high number of listed species may also reflect an inherently fragile fauna, such as that in the high-elevation habitats of the Southern Appalachians. It also may reflect a high level of endemic species, such as those associated with scrub habitats of central Florida. Finally, the number of listed species in a State may reflect

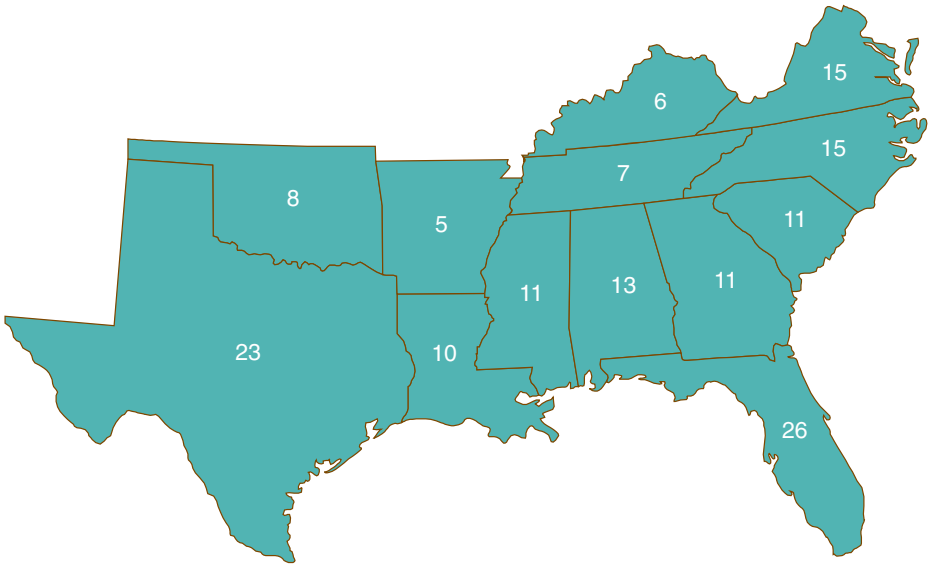

Figure 5.7—The distribution of terrestrial vertebrates listed as endangered throughout the South (U. S. Department of the Interior 2000).

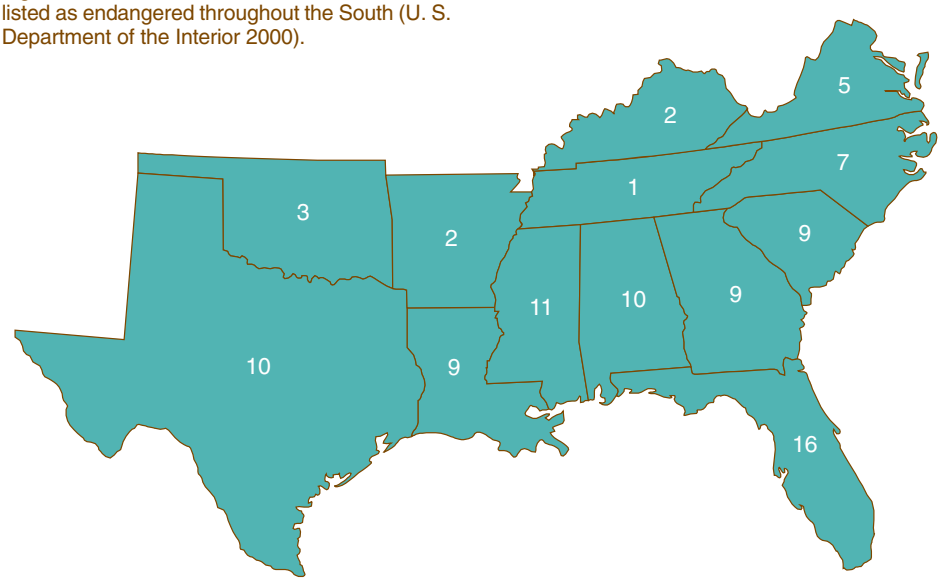

Figure 5.8—The distribution of terrestrial vertebrates listed as threatened throughout the South (U. S. Department of the Interior 2000).

deteriorating environmental conditions and modification of natural ecosystems, such as longleaf pine forests. Each of these factors contributes to the number of federally protected species in a State. Each reason has bearing on how habitat is managed and protected.

Various natural and human-caused factors contribute to a species imperilment. Some species occur in a very localized geographic area or in a few isolated areas of suitable habitat. These narrowly restricted species tend to be vulnerable to local disturbances that would have little effect on species with wide ranges. The summits and the bogs of the Southern Appalachian Mountains support some highly vulnerable species, such as the northern flying squirrel and the water shrew.

Scattered populations in fragmented habitat can be at risk. They become demographically isolated because they have little or no interaction with other populations. These isolated populations are prone to inbreeding depression and genetic drift, which inhibit viability. Localized populations are also vulnerable to catastrophic events such as floods, droughts, and fires.

Many species have declined because of habitat alteration stemming from human activities. These species are

unable to adapt due to changes in habitat features such as vegetative composition and structure and water quality.

Several factors repeatedly surface as threats to terrestrial vertebrates. The most prevalent factor is human development for urban, industrial, and agricultural land uses. Environmental contamination is a second prominent threat, especially in the Southern Appalachians and along the gulf coast. Coastal development contributes to endangerment on both the gulf and Atlantic Coasts. Exploitation occurs primarily on shorelines and in coastal wetlands. Other factors contributing to species endangerment include fire suppression, introduction of exotic species, and the loss of aquatic and wetland habitats.

Habitat loss affects all species, including migrating birds, wide-ranging mammals, and species like the gopher tortoise, which cannot disperse over long distances. Imperiling factors influence species unequally. Turtles are especially vulnerable to human exploitation for food and pets. Bats and snakes are heavily impacted by human disturbance. Beavers and river otters are imperiled by channel modification and impoundments. Environmental contaminants impact the spruce-fir forests used by the northern flying squirrel and the high-elevation mountain streams occupied by a diversity of salamanders. The use of agricultural pesticides affects gamebirds, bats, and amphibians. Wetland alteration affects the Mississippi sandhill crane, mink, and several species of frogs and toads. Lastly, coastal development negatively influences the habitat of the southeastern beach mice, wood storks, marine turtles, and Key deer.

Often, it is difficult to identify a specific factor responsible for the changes observed in a species population. For example, many migratory birds that breed in the South are also dependent on wintering habitats outside of the country. Neotropical migrants are influenced by the loss of wintering habitat in the tropics, while wintering mallard populations are affected by breeding habitat in the prairie pothole region. Therefore, it is vital to understand the temporal and spatial context in which a species occurs. Local changes in the population of species may be a result of dramatic changes in habitat occurring elsewhere.

Maintaining viable populations of southern vertebrate species requires the protection of critical habitat as well as the proactive management of other habitat. Public lands have a key role in species conservation (chapter 1). In some instances, protecting sensitive habitats from further alteration is the best management action. In other instances, active enhancement may be the most appropriate action. For example, treatments may be needed to increase understory growth, create multiple seral stages, restore unique habitats, and control exotic species. Professional foresters, resource managers, and conservationists play an important role in this regard.

There have been notable success stories in managing southern vertebrates. Restrictions on pesticides have improved the status of bald eagles. Red-cockaded woodpeckers have benefited from the management of mature pine forests, provision of artificial cavities, and translocation efforts. River otters and beavers have been restored to areas they formerly inhabited. Alligator populations have rebounded because of management of harvest levels and the protection of wetlands. Many of these species have proven far more resilient and adaptable than once thought.

However, additional efforts are necessary to restore and enhance ecosystem integrity and resiliency on the southern landscape. Management plans should consider the assemblage of reptiles, amphibians, birds, and mammals. Herpetofauna have traditionally received less management attention than other vertebrates. Wetland buffers, travel corridors, and forest composition are important for their viability. Many species are long-lived and late maturing, and have restricted geographic ranges; their management requires different strategies than those used for birds and mammals. Management remains somewhat hindered, however, by the limited knowledge about the status of terrestrial vertebrates and their habitat relationships.

Land ownership patterns associated with the occurrence of southern species have management implications. Approximately 90 percent of the land in the South is privately owned. The protection and management of species habitats can no longer be relegated solely to public land. To be successful, comprehensive conservation strategies require the cooperation of private landowners. Cooperative forestry programs and county extension services are two sources of expertise that contribute to the management of private lands.

In the past few decades, residential and industrial areas have grown rapidly to serve an expanding southern population. Although the extent of southern forests has remained relatively stable in recent years, human and wildlife interactions have increased, and they will continue to do so. Public perceptions about particular species can hinder or foster conservation efforts, highlighting the role of environmental education.

One role for wildlife professionals in the South is to identity the species that face imperilment, determine the actions necessary to eliminate those threats, and then take the necessary actions. Another role is to provide and manage habitat for several game species. The many species inhabiting the southern landscape have a wide variety of habitat requirements; an understanding of these requirements can lead to management plans that promote viable populations and habitat enhancement.

Needs for Additional Research

Further research is needed on the status, distribution, population trends, and habitat requirements of many southern species. Although there are standardized inventories for bird and game species across the region, there is a lack of comparable monitoring protocols for many other species. The importance of regional monitoring and long-term research cannot be overstated.

Additional data are necessary to examine the attributes that make some species associations resistant or resilient to disturbance. We need to understand why some associations are more fragile than others. We also need to know how to mitigate negative disturbance factors.

Habitat relationships of listed and imperiled species need further study.

Examination of the connections between landscape patterns, land uses, and the presence or absence of concern species also would prove beneficial. The establishment of regional databases and standardized sampling protocols for monitoring trends of terrestrial species across all public lands also is needed.

A profound need exists for the coordination of regional inventories on public lands to monitor the status and trends of reptile and amphibian populations. Assemblages associated with specific habitats need to be identified.

Further research is necessary on the distribution, ecology, and life history of herpetofaunal species and communities. In particular, additional data are needed on species such as the flatwoods salamander, gopher frog, southern hognose snake, and pine snake. This basic information is essential to developing land management programs for these species.

Additional research is needed to determine the impact of natural and human-caused factors on the development and environment of amphibians. Additional information needs include the identification of critical habitats and migration routes. The concern over amphibian declines highlights the lack of basic information about these species.

The ecology of furbearers, such as mink and weasel, is poorly understood, as are the potential impacts on other carnivores resulting from coyote expansion throughout the South. Basic ecological data are needed on free-ranging red wolves to address the challenges of restoration. The degradation of river otter habitat suggests the need for continued monitoring to ensure population viability. Careful monitoring of black bear populations also is essential to ensure their continued existence over the long term.

Finally, there is a paucity of information about specific habitat needs for several bat species and the influence of different silvicultural treatments on their populations.

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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.