What are the historical and projected future impacts of forest management and access on terrestrial ecosystems in the South?

Chapter 4: Effects of Forest Management On Terrestrial Ecosystems

James C. Baker and William C. Hunter
U.S. Fish and Wildlife Service

Key Findings

- Changes in land use, particularly reductions in the use of fire, have altered the structure and composition of southern forests and associated wildlife communities.
- Retaining structural elements, such as a few mature trees and snags, in young, even-aged stands provides many benefits for a variety of wildlife species.
- Early successional stands promote diversity in plant and animal communities, but many of the beneficial aspects are negated when the canopies of these stands close.
- Stands receiving silvicultural treatments that promote complex forest canopies are heavily utilized by a variety of bird species.
- A shift in intermediate stand treatments from prescribed fire to herbicides has led to widespread changes in forest structure.

Introduction

Wildlife communities are important components of southern forests (Dickson 2001). Many wildlife species have the potential to impact forest structure and species composition, and they are all affected by forest disturbance. Forest disturbance may be human-induced through prescribed burning, silvicultural treatments, or road building; or natural, by storms, insects and disease, or wildfire. These disturbance mechanisms influence forest communities by locally setting back succession. With fire, succession can be arrested at a desired point. With clearcuts, forest communities may be brought back to stand initiation and allowed to make the transition through several successional stages.

A diverse array of wildlife species exists in southern forests. Each species requires certain forest types and successional stages. Many species thrive in early successional habitat, while others require mature forests to maintain viable populations. Proper forest management has the potential to benefit a variety of wildlife species by providing a variety of forest conditions in many successional stages.

Many wildlife species or populations impact the environment in which they live. For example, white-tailed deer can affect midstory growth and tree species reproduction by overbrowsing. Beavers, which are now common in many southern forests, can impact forest communities by flooding the land. Other rodents can have major impacts by feeding on acorns in artificially reforested areas. Birds disperse the seeds of many plant species, potentially adding to plant diversity or introducing exotic species.

Relationships between animal communities and plant communities are complex. Any forest-community disturbance has the potential to positively impact some wildlife species and negatively impact others.

Wildlife communities are most affected by forest structure and species composition. Forest management, by nature, impacts these variables to produce desirable conditions for wood production. Since wildlife are dependent on the plant communities where they live, the bulk of this chapter addresses the impacts of forest management on native plant communities and subsequent effects on wildlife. Much attention is devoted to the ecology of southern forest plant communities.

Methods

This chapter reviews current scientific literature related to the impacts of forest management on terrestrial ecosystems.

Data Sources

Sources of data used in compiling this chapter are referenced throughout the text and listed in the literature cited section.

Results

Historical Perspective

To fully understand the ecology of southern terrestrial forested ecosystems today, a brief outline of the evolutionary changes of forested ecosystems in the South during the last 20,000 years is important (Bonnicksen 2000, Buckner and Turrill 1999, Delcourt and Delcourt 1998; also see chapter 2). At the height of the Wisconsian glaciation, southern forest communities were shifted further south than they are today. Oak-hickory, southern pine, and forested wetlands in particular were mostly restricted to the coastline of the Gulf of Mexico and the lower Atlantic Coast. Much of the interior, north of oak-hickory-southern pine dominated areas but south of the ice sheets, was dominated by spruce, fir, jack pine, and northern hardwood forest communities. The exact nature and condition of these forests and disturbance regimes are unknown, but the presence of large grazing herbivores and fire-adapted forest communities suggests that much of this forest land was relatively open and subject to regular disturbances (Bonnicksen 2000).

The distribution of southern forest communities began to resemble what we find today by 10,000 years before present. Spruce, fir, and northern hardwoods became restricted to the highest elevations in the Appalachians, and mixed hardwoods dominated the interior of the South. Southern pine and forested wetland communities spread northward as the glaciers retreated.

Thriving Native American communities existed over virtually all of the South, and they depended heavily on the surrounding ecosystems. Indigenous people impacted the landscape to suit their way of life. They often burned forests to drive game animals, cleared land for rudimentary agriculture, and enhanced habitat for both wildlife and people. Although cultures changed during this 10,000-year period from nomadic people to the larger and more permanent societies, human-induced disturbances were widespread throughout the region at all times during the period up until the first European contact (Bonnicksen 2000). The occurrence of these human-induced disturbances, combined with natural fires, storms, flooding, and grazing suggest the southern landscape was not composed of expansive closed canopied forests as is often suggested (Beilman and Brenner 1951, Hamel and Buckner 1998, Lee and Norden 1996).

Before European settlement, fire was a major force in shaping forest structure. Frost (1998) estimated fire frequencies at 1 to 3 years in Peninsular Florida and the lower Coastal Plain and 4 to 12 years in the Piedmont, upper Coastal Plain, Ozarks, Interior Low Plateaus, and Ouachita Mountains. The frequency of presettlement fire in the Appalachians was 7 to 25 years in most areas but 26 to 100 years in protective coves and in the Cumberland Mountains.

Only recently have scientists fully understood the importance of Native American burning in southern ecosystems. (Buckner and Turrill 1999, Delcourt and Delcourt 1997, Gross and others 1998, Williams 1998). The primary reason for this late understanding is that the Native American population when settlers arrived was vastly underestimated. Pandemics decimated Native American populations soon after Europeans arrived, and their influence on the southern landscape was reduced accordingly. Between 1500 and 1800, cultural disturbance regimes were severely altered. As a result, mosaics of forest and grassland types, including a variety of successional communities, became closed forests (Buckner and Turrill 1999). Pollen analysis of several old-growth forests in New England show that these forests developed after 1700; prior to that, these sites supported frequently disturbed communities (McLachlan and others 2000). The degree to which relict “old-growth” forest communities in the Southeast, especially what are thought to be relict hemlock stands, follow this same pattern is yet to be determined.

Despite the loss of human-induced disturbances from 1500 to 1800, explorers, naturalists, and settlers still reported expansive savannas and open woodlands in the Piedmont, Appalachians, and Interior Low Plateaus (Barden 2000, Bartram 1998, Belue 1996). In western North Carolina, Bartram in 1775 described both “high” forest (presumably closed stands) and expansive open areas, including grassy plains with scattered large trees at over 5,000 feet in elevation. Barden (2000) discusses the map made by the French cartographer Delisle in 1718 depicting the “Grande Savane” covering most of South Carolina’s (and some of North Carolina’s) Piedmont region. This map corresponds well with settlers’ descriptions in 1752 of “blackjack savannas” and the occurrence of many fire-adapted plants usually associated with prairies (Nelson 1992).

Several large tracts of native prairie existed in the Interior Low Plateaus (south-central Kentucky and adjacent Tennessee) and across the Coastal Plain in what is now Georgia, Alabama, Mississippi, and Arkansas. Two of the largest southern prairies on the Coastal Plain were the Blackbelt Prairie in the Central Gulf Region and the Grand Prairie within the Mississippi Alluvial Plain. All native prairies were perpetuated by fire.

Most of the pinelands on the Coastal Plain were burned periodically, reducing stand density and supporting a rich herbaceous layer of grasses and forbs. The influence of fire on southern forests is covered in detail in chapter 25 of this report. The habitat conditions in Eastern North America supported bison and elk herds, as well as wolves, during the first three centuries after Columbus.

By 1800, however, bison, elk, and gray wolves were extirpated in the South; beaver were nearly trapped out; and the influence of a temporary resurgent Native American influence was waning. As European-Americans spread across the South during the 1800s, they cleared forests for their settlements and agriculture on a larger scale than Native Americans had ever undertaken. Subsequent rapid population growth led to indiscriminate decimation of wildlife populations.

Under the “new management,” the frequency of burning increased. Many areas were burned annually to provide spring forage for ranging livestock. Especially in the Appalachians, the combination of increased frequency of fire and livestock grazing had many undesirable effects. Trees failed to regenerate and erosion increased on steep slopes (Ayers and Ashe 1905).

By the early 1900s, most old-growth longleaf pine had been logged. Most upland hardwoods outside the steep Appalachian Mountains had been logged and cleared for farming. Control of large predators to protect livestock severely reduced populations of several large predators, including mountain lions, black bears, and red wolves. Hunting and selling wildlife was common and had detrimental effects on white-tailed deer, bison, wild turkeys, passenger pigeons, Carolina parakeets, waterfowl, and others (chapter 1). Introduced plant diseases eradicated plant species from much of their native range, drastically reducing carrying capacity for many wildlife species (Diamond and others 2000) (chapter 3). Land was cleared for plowing over much of the South. Rice, tobacco, and cotton were major cash crops. Especially on marginal sites, farming led to massive and widespread soil erosion (Reynolds 1980).

As steam and gasoline powered machinery became available, large-scale drainage and flood control projects were completed. With flooding controlled and wetlands drained, over 30 million acres of bottomland hardwood forests were cleared for agriculture. By the 1940s, the last great bottomland forests, which were in the Mississippi Alluvial Plain and in Florida, were logged over in support of the War effort. Effects on wildlife were profound. For example, the last population of ivory-billed woodpeckers in the United States was destroyed. These changes impacted not only wildlife populations but also ecosystem resiliency. Immediately after clearing, these "new lands" were highly productive for agriculture, but many sites were depleted of nutrients after several years of cropping and erosion. Before agriculture and water control, these former forested wetlands benefited from annual soil nutrient deposition from flooding and high organic content from forest biomass. Draining and clearing compromised the natural soil recharge mechanisms. It has been demonstrated that bottomlands previously in agriculture are not as productive for forest growth as those that have remained in forests (Baker and Broadfoot 1979).

Due to difficult access, most steep mountain slopes were spared until the beginning of the 20th century. Then technology and transportation advances made steep mountainous slopes economically accessible. Logging practices changed from commercial high-grading, which was changing tree species composition, to commercial clearcutting, with little attention to sustainable practices. Between 1900 and 1930, most of the steep mountain slopes were logged, dramatically changing the nature of Appalachian forests.

During the first half of the 1900s, the amount of forested acreage was at its all time low; but the Great Depression, the boll weevil, diseases like tobacco mosaic virus, and the introduction of high-yield agriculture led to wide-scale abandonment of unprofitable farms. Through tree planting and natural seeding, abandoned agricultural fields and logged-over lands reverted to forest during the 1950s and 1960s. Southern forests recovered much of their lost acreage. As part of recovery efforts, use of fire was restricted and fire was suppressed. The use of prescribed fire, even where appropriate, became rare in the South (Croker 1987, Frost 1993). As a result, hardwood encroached into prairies and pinelands, and forests became denser all across the South. Fire suppression, extensive and unregulated clearcutting, and losses of important species like American chestnut to exotic diseases and pests, greatly altered forest conditions throughout the South.

Now, there is a growing realization that limiting fire use across the South has been detrimental to biotic diversity (Buckner and Turrill 1999; Frost 1995, 1998). However, increasing urbanization and increasing density of major roads create liability risks that may doom widespread prescribed burning for silvicultural purposes. In addition, recent industrial forest economic studies indicate that frequent burning causes some slowing of true growth rates.

Today there are more forested acres in the South than in the early 1900s. These forests, however, are greatly altered from forests encountered by European settlers. And the forests cleared by European settlers differed from those used for thousands of years by Native Americans. The common theme for the last 10,000 years is that forests were managed to meet human needs, including those of Native Americans.

Many of the forest wildlife and plant species now listed as endangered or threatened are suffering from the effects of changes in the last 500 years in conditions that existed for the previous 10,000 years. Lost forest acreage has been recovered over the last 50 years, but the new forests are not the same as those that existed for 10,000 years. Development activities and some management practices are not favorable for maintaining many species or for maintaining the integrity of southern terrestrial ecosystems.

One important lesson from the last 10,000 years of southern history, along with recent research results, is that "hands-off" management of extensive areas of southern wildland must be viewed and implemented with caution. Preservation of pristine and functioning ecosystems is an important conservation goal, but such situations are now very rare in the Southeast. Attempts to remove all human influences from some wildlands in the Southeast may appear to be an attractive conservation strategy. They certainly promote other nonconservation values, such as solitude and unique recreational opportunities. We should recognize, however, that removal of all human disturbances will have profound effects on the region's biota. Certainly, "hands-off" management in one area will not necessarily counterbalance intensive management elsewhere. To avoid regional population declines and species losses, land managers must have the flexibility to promote active management. This region's biota does not thrive in a static system, and intentional neglect does nothing but promote additional extinctions and endangerment to species at risk (for example, see Askins 2001, Barden 2000, Buckner and Turrill 1999, Cook 2000, Gross and others 1998, Holmes and Sherry 2001, Hunter and others 2001, Saenz and others 2001). This flexibility should not extend to the other extreme of promoting intensive forestry for wildlife conservation, but it does suggest that some level of active management will be necessary to maintain many still extant but imperiled species, including many found on present or proposed set-aside lands.

Wildlife and Forest Management

Landscape context issues— It is very important to view terrestrial ecosystems at a landscape level. Substantial research has been done on the effects surrounding landscapes have on the health and status of migratory birds, salamanders, and black bears. Below are summaries of our present understanding of the complex relationships for these groups of species.

Landscape context issues: migratory birds—Since the 1970s, biologists have been documenting the decline of migratory bird species from isolated woodlots and parks nestled in agricultural- or urban-dominated landscapes in the Midwestern and Northeastern United States (Harris 1984, Robbins and others 1989, Robinson 1992, Temple and Cary 1988, Terborgh 1989). These local declines have been attributed to forest fragmentation, where negative effects on populations occur due to increasing isolation of what otherwise should be suitable habitat.

Among the negative effects, the best documented are factors that reduce reproductive success, especially those associated with elevated nest predator and nest parasites like the brown-headed cowbird populations (Brittingham and Temple 1983, Dijak and Thompson 2000, Gates and Gysel 1978, Keyser and others 1998, Rich and others 1994, Robinson 1992, Wilcove 1985). However, for birds that have high dispersal capabilities, it is theoretically possible for "sink" populations—those with reproduction below which a populations can be sustained—to be large and seemingly "stable" (Pulliam 1988). The persistence of some migratory bird populations in the face of reduced reproductive success is usually explained by the immigration of individuals from more secure populations (Robinson 1992). These more secure "source" populations of forest birds, where reproduction supports a surplus of individuals, presumably are from more largely forested landscapes. In theory, the more isolated the sink population from source populations, the more likely that sink population will eventually collapse.

Other factors associated with forest fragmentation may affect birds, but are more important for other wildlife species less able to widely disperse. These other factors include: (1) increased mortality of individuals moving between patches, (2) lower recolonization rates of empty patches, and (3) reduced local population sizes resulting in increased susceptibility of species to regional extirpation or rangewide extinction (Trzcinski and others 1999). Recent studies also have documented reduction of food or other vital factors in forest fragments compared with larger, more intact habitats (Burke and Nol 1998).

Many of the negative effects to birds from forest fragmentation are associated with edges between habitat types. Edges between major habitat types can be extremely productive in terms of diversity of cover and food resources. However, predator and cowbird populations often are elevated in edges. Therefore, nesting birds that are attracted to habitat near edges may be overwhelmed by predators or cowbirds. Gates and Gysel (1978) coined the term "ecological trap" to describe situations where nesting attempts are doomed to failure (also see Donovan and Thompson 2001).

Area-sensitive species do not occur in habitat patches below a certain size. Forest-interior species are usually found in extensive areas of forest interior rather than a diversity of successional stages (Ambuel and Temple 1983, Blake and Karr 1987, Freemark and Collins 1992). However, whether any one species is area-sensitive or associated only with forest interiors varies considerably from place to place, often with respect to the surrounding land use patterns.

Most of the studies cited above were done in the Midwest and Northeast. Relatively few studies in the Southeast have duplicated the long-term studies in other regions, but there is no obvious reason not to apply findings in the Southeast [see *Southern Appalachian Assessment* (Southern Appalachian Man and the Biosphere 1996) and *Ozark-Ouachita Highlands Assessment* (U.S. Department of Agriculture Forest Service 1999)]. Results of forest fragmentation studies from landscapes dominated by agriculture and development, however, are not easily transferred to landscapes dominated largely by forest, whether actively or passively managed (Donovan and others 1997; Farnsworth and Simons 1999; Gale and others 1997; Graves 1997; Hagan and others 1996, 1997; Harris and Reed 2001; King and others 1996; Lichstein and others 2002; Marzluff and Ewing 2001; Robinson and others 1995; Simons and others 2000; Wilcove 1988).

Meta-analysis of bird studies across the Midwest suggests that as long as 70 percent forest cover is maintained in largely forested regions, daily nesting survival rates are sufficient to support source populations (Donovan and others 1997, Robinson and others 1995). Where forest cover falls below 70 percent, these and other data suggest that populations may not be sustainable, but large forest patches within a more fragmented landscape may be still able to support healthy populations. Thus, the larger the patch the more species can be supported locally (Robinson 1996).

There is little evidence of negative effects on forest birds in habitats fragmented by various silvicultural methods and associated land uses like temporary roads (Barber and others 2001, Dugay and others 2001, Hartley and Hunter 1998, Villard 1998). There are exceptions involving subtle negative edge effects for otherwise common, stable or increasing, and widespread bird species (Flashpohler and others 2001a, 2001b; Haskell 2000; Manolis and others 2000; Ortega and Capen 1999; Pornezuli and Faaborg 1999; Pornezuli and others 1993; Rosenberg and others 1999), which may reflect subtle changes in habitat condition—more so than habitat fragmentation. On balance forest bird conservation does not have to be focused on fragmentation issues in the Southeast, where overall forest cover exceeds 70 percent in entire physiographic areas (Southern Appalachian Man and the Biosphere 1996, U.S. Department of Agriculture Forest Service 1999).

Therefore, fragmentation is not considered a serious issue for migratory birds in the southern Blue Ridge and northern Cumberland Plateau and Mountains within the Appalachians and much of the Ozark and Ouachita Mountains (Hunter and others 2001). Even in these largely forested areas, local fragmentation due to urbanization may occur, as demonstrated in the southern Blue Ridge and Ozarks (Fitzgerald and others, in press; Holt 2000). Forest fragmentation from agriculture and development is most serious in the Ridge and Valley within the Appalachians, the Piedmont Plateau, the Interior Low Plateaus (outside the western Highland Rim), and the Mississippi Alluvial Plain. Much of the Coastal Plain is intermediate in its percentage of forest land cover, with forest concentrated along the lower Coastal Plain and along major river systems, often including large forest industry tracts.

Landscape context issues: salamanders—Pond-breeding salamanders require access from terrestrial habitats to vernal ponds or Carolina bays. Based on a literature review, Semlitsch (1998) recommended for several species of *Ambystoma* salamanders that buffers around breeding ponds extend to over 160 m (500 feet) and suggested that these areas provide for foraging, growth, maturation, and maintenance. However, even this strategy may not ensure population stability or dispersal among populations unless corridors or connections across the landscape are maintained. Corridors are vital if the surrounding land is hostile to salamander dispersal when timber is removed.

Chazal and Niewiarowski (1998) kept recently metamorphosed mole salamanders in field enclosures. No detrimental effects were detected for animals in recent clearcuts compared to animals in 40-year-old pine stands. These authors hypothesized that the removal of vegetation may not be as detrimental as the mechanical process by which the vegetation is removed. In contrast, Means and others (1996) show that conversion from a relatively open longleaf-wiregrass community, subject to regular burning, to a densely stocked and bedded slash pine plantation can be extremely detrimental for dispersal and access to breeding ponds by the federally threatened flatwoods salamander.

For Plethodontid (woodland) salamanders, there is much conflicting interpretation of data on population responses to clearcutting in montane habitats (Ash 1997, Ash and Pollack 1999, Herbeck and Larsen 1999, Petranka 1999, Petranka and others 1993). Steady return of populations to preharvest levels suggests that fragmentation in largely forested areas is not a serious problem. However, net change in habitat quality may be a serious issue. Important habitat components like substantial coarse downed woody material may be lacking in young stands. Failure of woodland salamanders to reoccupy suitable habitat as it develops or local declines occurring in suitable habitat would be evidence of effects associated with habitat fragmentation, which could lead to population collapse. Thus far, failure of woodland salamanders to reoccupy treated stands remains undocumented, but time lapses may be unacceptably long and the densities reached may be unacceptably low for more vulnerable species.

Fragmentation by roads can seriously restrict movement of amphibian populations. Amphibians on roads die from exposure to predators or are run over by vehicles. Indirect mortality results from lack of suitable habitat facilitating dispersal across roads. Generally, roads of any width and use likely provide some barrier to dispersal. Working in a fragmented landscape, Gibbs (1998) found that most species avoided road-forest edges, but these same species were not inhibited from crossing from forest into fields to reach breeding ponds. In another study by deMaynadier and Hunter (2000), anurans (frogs and toads) were not inhibited from crossing either narrow (5 m) or wide (12 m) roads in a forested landscape; salamanders were inhibited from crossing the wider roads. Thus, in the latter study, wide roads apparently separated salamanders into subpopulations.

Landscape context issues: black bears—Black bears in the Southeast receive a substantial amount of management attention. In addition to a federally listed subspecies in Louisiana, another potentially vulnerable population occurs in Florida. Other healthier populations are subject to hunting that requires careful management attention. Two concerns have been raised about habitat fragmentation for this species: (1) the amount of forested habitat (with a wide range of successional conditions) needed to support a healthy population, and (2) the road density that is too high to sustain a population. In the Coastal Plain, Peninsular Florida, and the Mississippi Alluvial Plain, for example, successful restoration and active management of all the major forested wetland systems would provide significant progress toward what is deemed necessary to secure black bear populations from southeastern North Carolina to Texas.

About 40,000 ha (100,000 acres) of bottomlands, in largely forested condition, are needed to support a population of between 50 and 200 bears, depending on the quality of the habitat (Rudis and Tansey 1995). By the same criteria, a population of about 1,000 black bears would require between 140,000 ha (350,000 acres) and 1,600,000 ha (4,000,000 acres). These areas could include substantial agricultural acreage. Land planted in grain crops is extensively used by black bears as long as escape cover is nearby.

Existing montane population centers such as the southern Blue Ridge in the Appalachians, the Ozarks, and the Ouachitas do not require a minimum acreage to support a healthy population, but bears may avoid heavily used roads or such roads may cause significant mortality (Clark and Pelton 1999). Narrow and infrequently used roads, however, may be heavily used by bears as movement corridors. Road edges that receive direct sunlight may provide substantial amounts of soft mast (fruit) where otherwise closed canopy forests make this important food source rare (Perry and others 2000). Management of narrow or temporary roads (closures and daylighting) may be more important than the density of such roads in largely forested landscapes.

Landscape context issues: other biota and summary—Fragmentation is a serious problem in shrub-scrub and grassland as well as forest habitat. In fact, many more species are at risk because of fragmentation of shrub-scrub and grassland habitats, rather than with mature forest habitats (Brawn and others 2001, Hunter and others 2001, Larem 1996, Lee and Norden 1996, Litvaitis 1993, Litvaitis and others 1999, Litvaitis and Villafuerte 1996, McCoy and Mushinsky 1999, Opler and Krizek 1984, Woolfendon 1996). These isolated patches of shrub-scrub and grassland habitat may be in agricultural or developed landscapes as well as in forest-dominated landscapes where stocking density has increased (Dunning and others 1995, Means and others 1996).

The challenge for land managers is to improve habitat conditions for a broad array of grassland, shrub-scrub, and mature forest species. Because of differences in land values, this challenge is theoretically more easily met in largely forested areas than in agricultural and developed areas. In heavily fragmented landscapes, attempts to improve habitat conditions for priority species may require segregation of species that depend on mature forests from species that require early successional or shrub-scrub or grassland habitat conditions.

Habitat content (composition and structure) issues—Forest management may contribute to fragmentation of a variety of landscapes, but its effects in forested-dominated landscapes are the most complex. Forest management is designed to influence the composition and structure of forests. Changes in wildlife habitat can be viewed as side effects. As with fragmentation effects, most of the research on habitat relationships in Eastern North America associated with forest management involves migratory birds.

During the latter part of the 20th century, forest cover increased in Eastern North America, while populations of many nearctic-neotropical migratory birds declined. Some researchers speculated that declines were largely attributable to accelerating loss of tropical "wintering" habitats (Robbins and others 1989b, Terborgh 1989). Losses of wintering habitat undoubtedly contributed to declines for a number of species. Recent work suggests, however, that most species of nearctic-neotropical migrants are flexible in use of tropical secondary forest [including especially shade-grown coffee and cacao (chocolate) plantations] and successional habitats (for example, see Krichner and Davis 1992, Sherry 2000).

Another bit of evidence implicating changes in the United States is the substantial variation among south-eastern physiographic areas in population trends for many forest species. Among wood-warbler species, declines have been steepest in the heavily forested interior physiographic areas, while populations in the more fragmented and heavily managed lowland physiographic areas have increased (Coastal Plain, Piedmont, Mississippi Alluvial Plain) (James and others 1996). One possible explanation that has not been explored thoroughly is that many forest bird populations may be responding to differences in forest conditions that have developed over the last 30 years (Askins 2001; Hunter and others 2001, in press; Holmes and Sherry 2001; Kilgo and others 1996).

Much of the forest cover increase in the Southeast has been through the expansion of short-rotation pine plantations and the increasing dominance of midsuccessional hardwoods that do not provide high quality habitat for forest migratory birds. (Askins and others 2001, Hunter and others 2001, Trani and others 2001). These phenomena may explain declining population trends in interior physiographic areas. They do not explain the population increases in lowland physiographic areas.

Habitat content (composition and structure) issues: migratory birds in forested wetlands in lowland physiographic areas—Most of the forest loss in bottomland areas outside the Mississippi Alluvial Plain occurred before the initiation of the Breeding Bird Survey (mid-1960s), so there may have been some response to the return of forests in the Southeast after the 1960s. Substantial losses of forested wetlands in the Mississippi Alluvial Plain during the 1960s and 1970s were attributable to increasing soybean prices. For migratory birds associated with forested wetlands, populations have been stable or increasing while there was a substantial reduction in mature forested wetlands and an increase in younger age classes during the last few decades (Hefner and others 1995, James and others 1996, see chapter 20).

In recent years, close to 100,000 acres of forested wetland in the Southeast have been drained and converted to farmland, pine or hardwood plantations, and industrial and commercial development (Sharitz and Mitsch 1993). In the Southeast, about 45 million acres were once covered by floodplain forests. About 37 million acres remained in 1952, and 33 million acres in 1975. Since then, an additional 2 million acres of forested wetlands were converted to nonwetland uses and another 1 million acres were converted to other wetland types (Hefner and others 1995). Thus, about 30 million acres of forested wetlands remained by 1985. Overall, about 30 percent of the Southeast's historical forested wetlands have been lost. In the Mississippi Alluvial Plain, losses approach 80 percent.

Most of the 70 percent of South-eastern forested wetlands that remain have been cutover at least once, and many are severely fragmented. This fragmentation has further contributed to the decline of many rare but wide-ranging species in the Southeast. Forest-interior and area-sensitive species and those that require large tracts of mature and over-mature wetland forests have been particularly hard hit.

Shrub-scrub (short) and forested (tall) pocosins and Carolina bays support large numbers of bird and amphibian species (Lee 1986, 1987; Moler and Franz 1987). Pocosins and Carolina bays occur in the South Atlantic Coastal Plain of North and South Carolina and Georgia. Originally, pocosin communities in the Southeast covered some 3.5 million acres, about 70 percent are in North Carolina (Richardson and Gibbons 1993). Considerably less than one-third of the original acreage now can be considered intact; another one-third have been irrevocably altered (Richardson and Gibbons 1993). There were probably between 10,000 and 20,000 Carolina bays prior to European colonization, the vast majority in South Carolina. Presently, few Carolina bays can be considered untouched by deleterious human activities. Both pocosins and Carolina bays have been converted to farmland or tree plantations (principally pine) or mined for peat. Areas around Carolina bays are also highly susceptible to commercial and residential development (Richardson and Gibbons 1993).

In the South Atlantic Coastal Plain of North and South Carolina, serious concerns have been raised about conversion of naturally occurring forested woodlands, especially pocosins, to bedded loblolly pine plantations or short rotation forested wetlands. In this case, the presumption was that many species of migratory birds would be significantly harmed by this conversion. However, populations of a majority of these species have been stable or increasing, especially in North Carolina where much of the concern about conversion has been concentrated.

There are many inherent reasons to be concerned about pocosin conversion to pine plantations (Moler and Franz 1987), but migratory birds may be faring relatively well [see section "Habitat content (composition and structure) issues: summary assessment of wildlife use of pine plantations" for more discussion]. Among the species that partially or totally contradict expectations are the Acadian flycatcher, red-eyed vireo, northern parula, scarlet tanager, and summer tanager in North Carolina, and the yellow-throated vireo, blue-gray gnatcatcher, yellow-throated warbler, black-and-white warbler, prothonotary warbler, worm-eating warbler, Swainson's warbler, Louisiana waterthrush, ovenbird, American redstart, and Kentucky warbler, in both North and South Carolina (see website on Breeding Bird Survey results for each species, especially refer to trend maps: http://www.mbr-pwrc.usgs.gov/bbs/

htm96/trn626/all.html). Only the populations of two species, the wood thrush and hooded warbler, typically associated with mature forest wetlands do not fit this pattern.

Migratory bird use of remaining forested wetlands should be watched closely. Monitoring should focus particularly on swallow-tailed kite, cerulean warbler, and Swainson's warbler, which serve as umbrella species in many forested wetland areas across the South.

In the Mississippi Alluvial Plain, thousands of acres have been reforested in recent years, due to efforts associated with carbon sequestration. When such treatments are contemplated, effects on wildlife should be considered. Pashley and Barrow (1993) provide guidance on managing wildlife in forested wetlands.

Habitat content (composition and structure) issues: wildlife associated with natural pine forests—Populations of many resident and temperate migratory birds associated with open pine stands are undergoing consistent long-term declines across much of their ranges (Hunter and others 1994, 2001, in press). Many other species of pine associated animals and plants associated with natural stands also are vulnerable. The reason for vulnerability is conversion of natural pine to other forest types and to other land uses.

Harvesting the products of southern pine forests remains a very important part of the southern economy, but the pine forests of today's South are very different from the forests found by European colonists and harvested for naval stores and building materials in the 19th century. Since 1952, extent of natural pine stands in the South has declined from about 70 million acres to less than 35 million acres (chapter 16). The natural pine stands being lost include those dominated by longleaf, pond, and shortleaf pines in the lowland physiographic areas and shortleaf, pitch, and Table Mountain pines in uplands [for the latter see section "Habitat content (composition and structure) issues: migratory birds in upland hardwood forests in interior physiographic areas"]. Natural stands of slash, loblolly, and sand pine are also declining, but densely stocked pine plantations are composed mostly of these three species.

The loss of most of the longleaf pine ecosystem has placed many wildlife species at risk in the Southeast (Abrahamson and Harnett 1990, Marion 1993, Stout and Ware and others 1993). At the time of European colonization, longleaf forests covered an estimated 92 million acres stretching from North Carolina to Texas, interrupted only by major floodplain forested wetlands and occasional prairies (Frost 1993, Landers and others 1995). By the 1930s most longleaf pine had been cutover at least once. About two-thirds of former longleaf pine acreage is now occupied by other pine species or has been converted to other land uses (Croker 1987, Walker 1991).

Less than 3 million acres of the original longleaf ecosystem remain. The total is considerably less if systems drastically altered by fire suppression are excluded (see chapter 16). The loss of all but a little of the longleaf pine ecosystem has led to the rarity or endangerment of at least 70 plant taxa, particularly on the Coastal Plain and Florida Peninsula but also on the southern Piedmont and other physiographic areas in the Southeast (Noss and others 1995). Among vertebrate animals, the future of the flatwoods salamander, gopher frog, indigo snake, gopher tortoise, coastal plain fox squirrel, and many other species may well depend on reinstituting growing season fire and restoring the longleaf pine ecosystems.

The loss of fire-maintained shortleaf pine communities is also placing many species at risk (Hedrick and others 1998, Wilson and others 1995). Fire-maintained pond pine stands in North Carolina pocosins also places many species at risk (Moler and Franz 1987, Richardson and Gibbons 1993). Sparse stands of sand pine are particularly important component of threatened or endangered Florida scrub communities (Myers 1990). Natural loblolly pine associated with forested wetland communities on bluffs and ridges in floodplains can provide important nest sites for species like swallow-tailed kites and bald eagles. Finally, the loss of fire as a management tool in the Appalachians has led to extirpation of many species and called into question the future of endemic Table Mountain pine communities (Buckner and Turrill 1999, Williams 1998).

Although a large number of species depend on mature southern pine forests, most attention has been focused on one species, the red-cockaded woodpecker. The red-cockaded woodpecker will recover only where large patches of mature pines are managed for the special foraging and nesting habits of this species (U.S. Fish and Wildlife Service 2000). Other species that may be found in shrub-scrub,
but optimally use sparsely stocked pine savanna and open pine stands include northern bobwhites, Bachman's sparrows and Henslow's sparrows (winter only). Southeastern American kestrels, red-cockaded woodpeckers, and brown-headed nuthatches may be found if longleaf or slash pines are old enough for cavities.

Cooperating private landowners in the North Carolina sandhills and in areas supporting quail plantations in southwestern Georgia play crucial roles in maintaining relatively healthy (and likely recoverable) red-cockaded woodpecker populations. In these cases, timber production is not necessarily the highest priority land use. Cooperative relationships are also being developed with private landowners who manage mature southern pines for timber production. Such relationships require much care and compromise from all parties. Many stands of mature southern pines (including longleaf) may have been cut and converted to other tree species or land uses earlier than originally planned by landowners who feared government regulations to restore red-cockaded woodpecker populations.

Habitat content (composition and structure) issues: migratory birds in upland hardwood forests in interior physiographic areas—Migratory bird declines in the interior South, especially in largely forested areas, may be due to the way much of the forest cover increase has come about. On public land, management has been largely passive since the massive cutting prior to Federal purchase in the 1930s. Much private land has been repeatedly high-graded, with no or little attention to future stand structure or composition. Both of these approaches to managing forests differ markedly from the intensive short-rotation, even-aged management in the lowland physiographic areas. Unfortunately, passive management and high-grading both have led to a lack of structural diversity in mature forests and a serious lack of early seral habitat for many vulnerable species.

Where a combination of even-aged and uneven-aged regeneration strategies is employed, there is increasing evidence that silviculture conducted in largely forested landscapes provides benefits not only to species requiring early successional stages, but also to a surprising number of species requiring mature forests (Annand and Thompson 1997, Bourque and Villard 2001, Pagen and others 2000, Powell and others 2000, Thompson and others 1992). Several studies have documented the importance of early successional forested habitat for providing food and cover for post-breeding and transient juvenile and adult migratory birds (Anders and others 1998; Kilgo and others 1999; Pagen and others 2000; Perry and others 2000; Suthers and others 2000; Vega Rivera and others 1998, 1999).

Some effects of disturbance frequency on general composition and structure are worth summarizing here. In the South, forests that are the least disturbed by fire and storms are in the protected coves of the Appalachians, principally Cumberland Mountains and southern Blue Ridge. Here, mixed mesophytic forests dominate and the few virgin stands that remain, such as those in the Great Smoky Mountains National Park, match up with expectations of what old-growth forests should look like. Also in the Appalachians, spruce-fir-northern hardwood and hemlock-white pine stands once established have developed over centuries with minimal disturbance. Other relatively undisturbed forests include mixed-mesic forests on the Coastal Plain, such as those on the Apalachicola Bluffs. They also include many types of forested wetlands that are removed from frequent natural floods.

When disturbances occur in today's highly altered forests, the effects differ from what would have been expected prior to European settlement. Presumably, storms of moderate intensity caused gaps in uneven-aged, multi-layered forest stands. Densely stocked stands associated with even-aged or heavily high-graded stands are typically resistant to moderate storm intensity. Extreme storms are likely to cause reinitiation of old-growth stands in a more-or-less even-aged state. They also cause younger even-aged stands to be replaced by new even-aged stands. Autogenic regeneration events are largely missing from today's even-aged or high-graded southern forests. This lack of storm-driven autogenic regeneration in midsuccessional or high-graded forest influences habitats for birds and other wildlife (Hunter and others 2001). A difference between even-aged and high-graded stands is that the former can be converted into more vertically structured stands through prescriptions. In most instances, the only option for diversifying high-graded stands is to first clearcut (i.e., start over) and have in prescription intermediate procedures intended to develop vertical stand diversity over time.

The overall lack of forest structure in many of today's forests may explain why so many bird species respond positively to timber management practices in largely forested areas. Heavy and successful use of clearcuts and forest edges by "forest-interior" or "area-sensitive" species in largely forested regions appears to be a response to the poor structure of extensive forests away from treated areas. Clearly, more research is needed on this topic. Composition also contributes to habitat quality. Forest composition is constantly changing and should be a primary consideration in largely forested regions in the interior physiographic areas. Serious issues related to composition include: (1) the active conversion of hardwoods to pine; (2) the passive conversion through fire suppression of naturally occurring southern pine stands to hardwoods; (3) the conversion, again due to fire suppression, of oak com-munities to either mesic hardwoods or white pine; (4) loss of southern Blue Ridge spruce forests; and (5) loss of naturally occurring open habitats such as glades, barrens, balds, bogs and fens.

At one end of the management-intensity spectrum are the passive management strategies now most prevalent on public land. These strategies are causing major changes in forest composition and forest biotic diversity. Passive management is causing abnormally heavy stocking, and fire suppression is causing vulnerable mountain yellow-pine communities (principally Table Mountain and pitch, but also shortleaf and longleaf) to succeed into hardwood communities (Buckner and Turrill 1999, Delcourt and Delcourt 1997). Recent southern pine beetle epidemics have all but eliminated these already vulnerable communities from many areas in the Appalachians. Similarly, oak-hickory stands are being invaded by more mesic hardwood species and white pine. These invasions of more mesic adapted species into more fire-prone conditions may lead to extremely high fuel loads during dry years. In the long run, severe and catastrophic fires will result. Catastrophic fires can further alter forest habitat conditions so that most vulnerable species do not thrive, including disturbance-dependent species in the long-run if these catastrophic events are not soon followed by subsequent prescribed burning to restore appropriate habitat conditions associated with regular fire-return intervals (Delcourt and Delcourt 1997, White and White 1996).

Like other forest types, spruce-fir-northern hardwood forests were harvested near the beginning of the 20th century. The stands that replaced them differ from those prior to harvest. Generally, spruce was replaced by fir from higher elevations and northern hardwoods from below (White 1984). Since a high percentage of the community is in public ownership, it would appear that healthy high-elevation biotic communities can be protected. Fraser fir, however, is threatened by exotic pests, possibly compounded by effects from regional air pollution (Nicholas and others 1999, Rabenold and others 1998, White and others 1993). Some effective restoration probably is possible for red spruce but would require the conversion of existing northern hardwood stands to either spruce or spruce-hardwood mixtures. Some 50,000 acres of such treatment would be needed to reach preharvested forest conditions.

As many as seven forest bird species closely associated with southern spruce-fir-northern hardwood high-peaks forests are effectively isolated from more northerly and western populations. Among these species, the northern saw-whet owl appears to be the most vulnerable to potential habitat loss (Milling and others 1998, Simpson 1992), followed by the black-capped chickadee and the red crossbill. Although widespread elsewhere, the owl and other species restricted to high-peaks forests for breeding in the Southeast need relatively high levels of conservation attention. Northern saw-whet owls respond to nest boxes, which may partially mitigate the loss of high-elevation conifers. Owls also may use other habitat, such as older northern hardwoods and hemlock (Milling and others 1998).

Habitat content (composition and structure) issues: summary assessment of wildlife use of pine plantations—Acreage of pine plantations has increased from 2 million acres in 1952 to 30 million acres today, and an additional 25 million are expected in the foreseeable future. Not surprisingly, the conservation community worries about possible effects on the future sustainability of naturally occurring forests in the South. Although a large percentage of this increase and projected increase comes from retirement of agriculture land (see chapters 16 and 6), there is also a substantial loss of natural pine communities. The loss of natural pine acreage is as much due to fire suppression and clearing for agriculture and urbanization as to conversion to plantation pine. In fact, pine plantations that are invaded by hardwoods often become indistinguishable from natural stands. On many millions of acres, fire suppression since the 1950s has allowed former pine stands to now be classified as pine-oak or even upland hardwood forest types (see chapter 16). So there is no direct correlation between loss of natural pine acreage and increase of plantation pine.

Still, much natural pine acreage and hardwood acreage (both bottomland and upland) have been converted and devoted to efficient growth of short-rotation pine in the South. Although there is general recognition that intensively managed pine plantations are not high-quality wildlife habitats when compared with natural pine and hardwood forests, statements made in several chapters of this report suggest overall that such intensification of management is a positive trend (see chapter 14). Certainly, afforestation of millions of acres of farmland provides for many benefits, from carbon sequestration to water quality improvements. Greater intensity of forest management may allow other forested acres to be set-aside for other purposes, such as wildlife and recreation. However, that intensive forest management actually allows other forest lands to be set-aside or managed for other values, such as wildlife, requires greater scrutiny.

How forests not needed for timber production will be used is unclear at best. Land use trends support that many acres of forest land will be developed, regardless of their productivity. There is no indication that funds would be available to support management of forest lands for wildlife short of commercially viable procedures. Over the last 100 years, many millions of acres of pine and hardwood forests have been left in poor condition for many species of wildlife, including both game and nongame species. Even claims that the present and projected increase in intensively managed pine plantations should bode well for early successional species is highly suspect. High stocking rates (700 to 1000 seedlings per acre), increasing use of fertilizers and herbicides for maximizing pine growth, and reduction of fire as a management tool, among other management changes, essentially have eliminated many of the benefits for early successional species of wildlife that were provided formerly in pine plantations that were less efficiently managed. There certainly is no evidence that steep population declines have been halted or reversed with the expansion of intensively managed pine plantations during the last 30 years. Declining trends continue for important species like northern bobwhite, American woodcock, and many species of high-priority nongame migratory birds associated with early successional habitats (Capel and others 1994, Hunter and others 2001, Krementz and Jackson 1999).

Another major issue in the South is the proliferation of chip mills during the last decade. An important background point is that the chip mills were established in many areas because of poor forest conditions created by repeated past "high-grading"—selective removal of the biggest and best formed trees in hardwood forests. What remains is an unhealthy forest that is poor wildlife habitat. In many of these areas, clearcutting for pulpwood is the first step toward improvement, and chip mills make clearcutting feasible. However, when these hardwood acres are replaced with densely stocked pine plantations, wildlife will not benefit for very long. The alternative often promoted as "environmentally friendly forestry" involves diameter-limit cutting for sawtimber. Diameter-limit cutting, in essence, is a form of high-grading, which was the dominant practice that led to the low-quality hardwood stands found in much of the South.

Management of pine for pulpwood and/or sawtimber need not be as bad for wildlife as is often portrayed. Effects on wildlife involve many factors, including landowner objectives, site quality, and options available for implementing management practices (Melchiors and others, in press). For example, planted loblolly pines in pocosins usually replace stands dominated by pond pine, Atlantic white-cedar, or bays. After pines are established, a manager could provide suitable habitat for many neotropical migrants by retaining a dense hardwood understory and midstory. Reduction in growth and quality of overstory pines would be relatively small.

Notably, nearly all of the forested wetlands lost in coastal North Carolina, much of which was pocosin, were converted to nonwetland uses, including pine plantations (Hefner and others 1995). Although concern for the future of remaining pocosin communities is justified, there is evidence that converting "natural" pocosin vegetation to loblolly pine can have neutral to positive effects on some of the vulnerable neotropical migrants. Neotropical migrant use of these pocosins converted to pine plantation is best when hardwoods are encouraged in the understory and midstory through precommercial and commercial thinnings and infrequent burning (Karriker 1993). Among the species appearing to be stable in these commercial forests are yellow-billed cuckoos, Acadian flycatchers, worm-eating warblers, ovenbirds, and prairie warblers. However, loblolly stands managed for sawtimber under these treatments are still less than 20 years old and have yet to show consistent use by the three highest priority species: black-throated green, Swainson's, and prothonotary warblers. These species require large patches of tall pocosins and other forested wetlands along the South Atlantic Coastal Plain. Optimum management of high-priority, nongame landbirds in pine plantations would include retention of some patches of "natural" pocosin vegetation or otherwise encouraging hardwood understory or midstory development. Conversion from hardwoods to pine or pine-hardwood mix, with appropriate management, is clearly better than no forested habitat at all. For many high-priority neotropical migrants in these habitats, however, restoration and appropriate management of forested wetland conditions would be even better.

The hypothesis that forested wetland species are making the transition to using "bedded" pine plantations is supported by studies in North and South Carolina: (1) in the Parker Tract, Weyerhaeuser Company, NC (Kerriker 1993, Wilson and Watts 1999a); (2) in the Woodbury Tract-Pee Dee River, International Paper Company, SC {Lancia and Gerwin [In press (a)]}; Mitchell and others 1999); and (3) in the ACE Basin, Westvaco Corporation, SC {Lancia and Gerwin [In press (b)]}. The latter two study areas are also the subject of a landscape-level analysis in Mitchell and others (2001). Preliminary results from these studies are promising but long-term benefits depend on maintaining substantial hardwood understories with certain structural characteristics. Heavy bird use of existing woodlands may be temporary as forest management becomes more intensive and hardwood types are replaced by pine. Regardless of the reasons, birds usually associated with hardwood forests are making substantial use of pine plantations in the Coastal Plain of the Carolinas, at least for now.

In the Ouachita Mountains, the USDA Forest Service and Weyerhauser Company, among other partners, have embarked on a watershed comparison among passively managed, moderately managed, and intensively managed sites. Preliminary results suggest that large areas under active management likely support a variety of habitat conditions at a variety of spatial scales suitable for many bird species, including many high-priority species associated with both mature forest and early successional conditions (Melchiors and others, in press). The more actively a large area is managed, the more heterogeneous the available habitat, and the less actively managed, the more homogenous the habitat. The latter support surprisingly few mature forest species in numbers higher than those found in more actively managed watersheds (Melchiors and others, in press). In contrast to the Carolina studies, where reproductive rates appear to be consistently high, studies from the Ouachita Mountains and Georgia Piedmont have revealed more complex patterns of nesting success that depend on seral stage, burning regime, and percent canopy versus understory cover (Barber and others 2001, Brunjes 1998, Howell 1998, Raftovich 1998). In addition, heavy and apparently successful use of pine habitats in the Carolinas and possibly elsewhere are generally where sawtimber is the target wood product, where sites have the propensity to support substantial hardwood growth or where maintenance of interspersed hardwood stands are maintained as "ecological legacies." Data are not available to suggest the same is true for the vast majority of pine plantations, which are managed in very short rotations on very well-drained sites with dense stocking and heavy chemical use.

In conclusion, management options exist in some locations to support healthy migratory bird populations. Study results, however, do not cover the vast majority of pine plantations and how they are managed in the Southeast. Regardless of whether some hardwood species persist in some pine plantations, priority bird species associated with older pine stands are probably harmed the most by the expansion of pine plantations. Plantation pine stands are too dense, too young, or hardwoods in their understories are too dense for the bird species usually associated with open pine stands that are frequently subjected to prescribed or natural fire. Some of these species may persist in managed pine plantations where hardwood intrusion is controlled and snags are retained (Caine and Marion 1991; Dickson and others 1983; Land and others 1989; Moorman and others 1999; Wilson and Watts 1999a, 1999b,).

For nonavian wildlife, results of studies are also mixed, but similar themes emerge for small mammals and reptiles as found for birds. Working in plantations over former pocosins in eastern North Carolina, Mitchell and others (1995) found that small mammals undergo an initial decline, but later recover to preconversion population levels as long as the plantation emulates, to some degree, the understory structure of the former pocosin. Stand thinning and growing-season burning are essential for maintaining gopher tortoise populations in slash pine plantations in southern Alabama (Aresco and Guyer 1999). Longleaf pines with cavities retained in mature park-like pine plantations in the upper Coastal Plain of South Carolina were used for evening bat roost sites and seemed preferred to potential sites in dense canopied bottomland hardwood, mixed pine-hardwood, or loblolly stands (Menzel and others 2001).

Pine plantations are generally poor wildlife habitat. However, with management adjustments (from less intensive to maintaining natural community types mixed in with plantations) many vulnerable wildlife species can successfully use these commercially driven habitat conditions. At the very least, pine plantations may provide buffers around more natural forested habitats that are clearly better than agriculture or urban areas for hardwood associated songbirds (Kilgo and others 1997, 1998)

General management considerations—Any major change in a forest affects the wildlife that live there. Some changes are caused by purposeful management actions. Others are the result of natural processes (Dickson and others 1993). Managers prescribe treatments to enhance the production of various resources or to promote a forest condition, such as habitat for a particular wildlife species or the quality of a scenic vista.

Different wildlife species and populations react differently to habitat manipulations. Some species are habitat generalists, which have the ability to survive in a wide variety of conditions. Others are habitat specialists, which require specific conditions in order to maintain viable populations. These species have evolved over time to capitalize on unique habitat niches.

An example of a bird habitat specialist is the prothonotary warbler, which needs small cavities in midstory trees or shrubs to successfully nest. Other examples of birds that are habitat specialists include cerulean warblers, Swainson's warblers, and red-cockaded woodpeckers. Habitat generalists, on the other hand, can survive and successfully reproduce in a wide variety of conditions. Examples of habitat generalists include white-tailed deer, raccoons, and coyotes.

Wildlife species also differ widely in mobility. Large vertebrates and birds generally have large home ranges. Black bears have been known to travel over 300 miles, and many birds travel between continents. Many amphibian species, on the other hand, spend their entire lives near the place they were born. Therefore, consequences of changing habitat conditions vary widely among wildlife species.

Timing and energy requirements are extremely important for migratory birds. Favorable weather conditions and adequate food are critical to sustain populations. In the context of forest management, providing as much high-quality habitat as possible is critical. Often, due to localized climatic factors, lands on which migratory species depend are less than optimal. Waterfowl, particularly ducks, are often affected by localized drought, failed seed crops, or extended freezes. When these events take place, it is critical that areas outside of preferred migratory routes provide missing elements. Even though most migratory waterfowl breed in the northern portions of this continent, pair bonding occurs on the wintering grounds. Reproductive success and survival, therefore, depend on the quality and quantity of habitat along the entire flyway, including southern forested wetlands.

Stand-Level Management

In forestry and wildlife management, the primary management unit is the stand. Stands are analogous to plant communities, but there are differences. Boundaries and sizes of natural plant communities are dictated by topography, soils, hydrology, and past history, whereas stands are delineated by human-induced disturbances. Stands are the basic land units on which specific silvicultural treatments take place. On a landscape scale, the arrangement of stands and the implementation of treatments, both spatially and temporally, have a great affect on wildlife.

In a simplified model, if management objectives are to provide a mosaic of even-aged habitats, with stands of all ages represented, land managers may arrange operations so that similar habitats are scattered across the landscape. As a result, habitat requirements of a variety of wildlife species are met locally.

Forest stands are dynamic, moving along a successionary continuum and providing different benefits at different times. In all cases, forest communities are created and maintained by disturbance and succession, whether they are natural or management induced (Oliver 1981).

Ecological Basis of Silviculture

Silviculture is the ecological art and science of managing forest stands to meet landowner objectives. It is also the applied ecology portion of forest management. Forest management considers the entire forest, which is made up of numerous stands; while silviculture deals with individual stands. Landowner objectives may include timber management, wildlife management, aesthetics, and recreational opportunities.

Silviculture is based on two basic ecological patterns. The first is succession, or the way forest communities develop over time. The second is disturbance, or an event that destroys all or part of an existing forest community. These patterns are natural phenomena in all forest types and take place on many different scales. Succession and disturbance are related because succession cannot be altered without disturbance. Plant communities develop through succession and are altered through disturbance. In a natural situation, succession and disturbance are chaotic. Disturbance events are unpredictable, both spatially and temporally.

Even though silviculture is based on natural processes, it does not precisely mimic them. Through the use of silvicultural techniques, natural processes are allowed to take place to produce desired conditions. An understanding of the underlying ecological principles is essential in comprehending silviculture and forest management.

Succession—Succession may follow two basic patterns, primary succession or secondary succession. These two basic types of succession are addressed in more detail later in this chapter. Silviculture most often mimics secondary succession, since some plant community generally occupied the site before it was subjected to disturbance. In order for succession to begin, some sort of disturbance has to take place. After the disturbance, new plants invade the site and begin to grow. Succession is accurately described as occurring along a time continuum, starting with year zero and continuing until another major disturbance. Left to their own devices, forest stands go through four distinct stages of development: stand initiation, stem exclusion, understory reinitiation, and steady state (Oliver and Larson 1990).

Succession: stand initiation—The first successionary stage is stand initiation. During this stage, water, nutrients, and sunlight are plentiful due to the lack of existing vegetation. In the South, plants quickly occupy the site and begin to compete for available resources. Herbaceous plants seed in and existing rootstocks sprout. Plant diversity is high relative to midsuccessional stages, since species with varying levels of shade tolerance all occupy the site simultaneously. Plants that reproduce from rootstocks and plants that are shade intolerant have a competitive advantage during stand initiation.

Succession: stem exclusion—As a stand matures, resource limitations occur. On upland sites, either water or nutrients may be in short supply. On bottomland sites, sunlight is usually the limiting factor. When available resources begin to limit the growth and establishment of new plants, the stand is in the stem exclusion stage. At this point on the successionary continuum, shade-intolerant understory species begin to disappear; and the plant community becomes dominated by trees. Fast-growing, shade-intolerant tree species generally overtop competing vegetation, and competition for available resources is extreme. Shade-tolerant species usually have slower growth rates and tend to lag behind. As this stage progresses, stratification occurs, usually resulting in a well-defined midstory and overstory.

Succession: understory reinitiation—Shade-intolerant tree species are usually replaced in the overstory by midtolerant species during the understory reinitiation stage. As shade-intolerant species reach full height, other species begin to out-compete them for available resources. Gap-phase dynamics begins to occur during this stage. Trees, or groups of trees, die for many reasons and are replaced either by trees that are presently in the midstory or by new reproduction. The forest canopy begins to become more heterogeneous, allowing sunlight to penetrate from above and from the sides. As trees die, resources are allocated to remaining individuals, many of which respond with increased canopy growth and diameter growth. With increased sunlight reaching the forest floor, herbaceous plants become established and flourish. Depending on forest type, species composition may shift, with shade-intolerant species giving way to more shade-tolerant ones.

Succession: steady state—The steady-state stage of succession is anything but steady, but it does tend to perpetuate itself to some extent. In many southern forest types, this stage exists only in varying degrees, with fire (historically) being the major contributing factor in arresting or setting back succession. This stage is a continuation of the understory reinitiation stage and is marked by small-scale disturbances that contribute to gap-phase dynamics. As gaps continue to form and develop over time, structure and species composition become quite complex. The presence of many gaps in various stages of development creates stand conditions where trees of many ages, sizes, and species exist simultaneously. In many systems, mature trees on the edge of gaps are more susceptible to mortality due to increased exposure, creating an expanding gap pattern of development over time.

Disturbance—Disturbances vary in severity, frequency of occurrence, and predictability. Generally, certain types of disturbance are more common in particular forest types. Low-intensity ground fires were common in southern pinelands and were characterized by high frequency and low severity. Windthrow during storms is a common disturbance in bottomland hardwood forests where trees have shallow root systems in moist soils.

An inverse relationship also usually exists between severity and frequency of disturbance. Frequent, low-intensity disturbances usually affect only part of the plant community. Low-intensity groundfires in pine stands detrimentally impact hardwood midstory and understory species but do not harm the pines in the overstory. In bottomland hardwoods, however, fires are infrequent and may potentially set entire stands back to the stand initiation stage.

Silvicultural Systems

Natural regeneration: uneven-aged silviculture—Uneven-aged management has been used successfully in several southern forest types. In this type of management, trees of several age classes are present in the stand at all times. Stands are usually regulated by volume and managed to maintain a specific diameter distribution, with many smaller trees and fewer large trees. Since most commercially desirable tree species in the South are relatively shade intolerant, the upper canopy must be reduced such that younger trees are able to grow into the overstory.

This type of management has many benefits for wildlife, especially birds. Due to high levels of canopy stratification, many bird species are able to utilize these stands (Dickson and others 1995). Different bird species rely on different portions of the canopy. Wood thrushes require dense understory growth, while cerulean warblers utilize emergents, which are individual trees that are taller than the main canopy. With respect to emergents, it has been demonstrated that canopy height is not as important as relative height. In most uneven-aged stands, larger trees act as emergents due to their size relative to their immediate neighbors.

Uneven-aged management of both pines and hardwoods requires frequent entry into the stand, increasing risks of disturbing wildlife and rutting or compacting the soil. More access roads are also generally required for this type of management, and they must constantly be open. In uneven-aged pine management in particular, increased herbicide use is often required to release pines from more shade-tolerant hardwood competition (Dickson and others 1993).

Area regulation in uneven-aged management has become an accepted method for managing both pines and hardwoods, especially when wildlife enhancement is the primary objective. Area regulation differs from volume regulation in that equal areas of land within a stand are harvested at each entry, rather than cutting the stand to a specific diameter distribution. Area regulation has been used with great success in longleaf pine and bottomland hardwoods, where large, homogeneous stands exist. In bottomland hardwoods, waterfowl habitat is enhanced, particularly in areas where foraging and pair bonding occur.

Natural regeneration: even-aged silviculture—Even-aged management is very common in the South. It lends itself well to southern ecosystems mainly because most of the commercially desirable tree species are shade intolerant. In even-aged management, only one or two age classes of trees are present in a stand.

A clearcut is the most basic technique for initiating an even-aged stand. In the following paragraphs, clearcutting with natural regeneration is addressed. Artificial regeneration will be discussed in the narrative on plantations. In clearcutting, the entire stand is removed in one harvesting operation, and a new stand of trees takes its place. Clearcut areas may be regenerated naturally from sprout reproduction, from seeds from surrounding stands, or from seeds that were in place before mature trees were removed. Hardwood stands often are regenerated with advance reproduction, which was in place before the initial harvest (Baker 1997, Hodges 1997).

From a wildlife management perspective, clearcuts have the benefit of providing maximum amounts of light reaching the ground, which improves growth of herbaceous plants (Pietz and others 1999). Many wildlife species thrive in early successional communities created by clearcutting (Wigley and others 2000). The possibility of erosion may discourage clearcutting on sites with steep slopes. In wet areas, clearcutting may raise the water table excessively because transpiration is greatly reduced by removing most plants. If the water table rises to the soil surface, establishment of a new stand may be impeded.

Seed trees were often used for regeneration in the South until about 15 years ago. This approach is losing favor to clearcutting and planting, which allows introduction of genetically improved stock. In the seed-tree method, four to eight mature trees per acre are left to provide seeds for regeneration. After the stand is regenerated, the seed trees are removed. From a wildlife management perspective, this technique provides the benefits of large amounts of light reaching the ground, while some structural elements are retained for several years after harvest (Dickson and others 1995). In some cases, seed trees are left on the site, rather than being removed.

Regeneration by the shelterwood method is common with tree species that regenerate best in partial shade. Heavy-seeded species are generally not regenerated with either seed-tree or shelterwood techniques. Shelterwood cuts are attractive to neotropical migratory bird species that are associated with either early- or late-successional stages (Dickson and others 1995). Shelterwood cuts in overcup oak stands in green-tree reservoirs have also been successful. Overcup oak acorns are disseminated widely by water, and the reduction in canopy density attracts macroinvertebrates, which are important food items for waterfowl.

In both seed-tree and shelterwood regeneration techniques, a second and sometimes third entry is made into the stand to remove remaining trees. In shelterwoods, entry is usually essential to release reproduction. Irregular shelterwoods may retain "leave trees," which are mature trees left in the stand to provide structural diversity, wildlife habitat, or seed sources. Management of two-aged stands is becoming popular on public lands and initial evidence is that with respect to forest birds, this may be an acceptable option to clearcutting (Duguay and others 2001).

Natural regeneration: intermediate treatments—Thinning is a common silvicultural technique used to concentrate growth on fewer trees. Stands are commonly thinned during the stem exclusion stage and are sometimes thinned again later in the rotation. Thinning temporarily reduces canopy coverage and allows light to reach the forest floor, promoting growth of understory plants. Thinning may also temporarily create canopy complexity, which is positive for many bird species (Dickson and others 1995, Wigley and others 2000).

Timber stand improvement (TSI) cuts are used to remove trees that are less desirable because of their species, form, or health. Although these cuts allow sunlight into the stand, in many cases they remove individual trees that are beneficial to wildlife due to their form or the presence of cavities.

Herbicide use has become extremely common in forest management. Historically, prescribed fire was used to remove unwanted vegetation. Herbicide treatments have taken the place of prescribed fire in many areas. Herbicides may be sprayed from the air or from the ground, injected into unwanted stems, or squirted onto wounds hacked through the bark. Such treatments are very effective in reducing competition and promoting crop-tree growth. Most herbicides labeled for forestry use today have extremely low vertebrate toxicity and are not immediately detrimental to wildlife. Negative impacts of herbicides usually are associated with decreases in plant diversity, but herbicides can be positive for wildlife under specific circumstances and especially where prescribed fire is no longer a viable management option (Wigley and others 2002).

Other than reducing competition, herbicides are also used to change stand structure. Individual stems in hardwood stands are commonly treated to reduce shade-tolerant species and allow space for advance reproduction (Hodges 1997). Trees treated with herbicides create snags and downed wood, which are beneficial to some wildlife species. Overstory trees are sometimes treated chemically to allow sunlight penetration, creating large upper canopy snags. Although they are beneficial to a variety of wildlife species, canopy snags usually remain standing for only a few years in the South (Dickson and others 1995).

Fertilizer application is increasingly common in southern forests. Both pine and hardwood stands are treated to increase crop-tree growth, but the practice is almost totally restricted to pine plantations. Productivity of forest sites is increased by applying nitrogen, often in combination with phosphorous (Lauer and Zutter 2001). Fertilizers are generally applied at the time of establishment and again at midrotation.

Fertilization produces several wildlife benefits. Most plant species on the site respond to increased nutrient levels, creating more browse and more fruit production. These effects, however, are usually short-lived, because stands generally reach canopy closure sooner with fertilizers than without. Responses usually last only two to three growing seasons (Dickson and others 1995).

Plantation management—Forest plantations are not all created equal. They take many forms, depending on intensity of management, species being managed, and site. Like any other plant community, a plantation is affected by hydrology, topography, and climate. Plantations range from loblolly pine plantings on old fields to hardwood fiber farms that are irrigated and fertilized. Well-managed plantations on good sites often produce vastly greater yields than natural stands. Operations in these stands are straightforward and relatively easy. Although plantations produce wood rapidly, the ecological consequences, described below, can be very large.

Plantation management: ecological consequences of plantation management—Plantations established on clearcuts retain biological legacies from the old stand in the form of seed left in place and rootstocks that have the potential to sprout. Plantations established on old pastures or agricultural fields tend to contain mainly pioneer species. Ecologically, plantations established after timber harvests tend to mimic secondary succession, while those established on old fields are more similar to primary succession. In the Mississippi Alluvial Valley, stands originating on abandoned agricultural fields contain plant communities similar to those originating from primary succession on river bars (Baker 1997). Similarly, cottonwood plantations tend to have species composition similar to natural cottonwood stands of river front origin.

Natural primary succession tends to establish stands of a single species. In a landscape mosaic, these stands provide many positive values for wildlife. These stands are usually short-lived and provide structure, cover, and food for a variety of wildlife species. On heavy clay sites that are frequently flooded, pure black willow stands provide many benefits for waterfowl. Invertebrate production is great, cover is dense, nest cavity formation is high, and temperature fluctuations are moderated. Investigators have demonstrated that ambient winter temperature is higher in black willow stands than elsewhere. As these stands break up naturally, longer-lived species take their place, providing structural components that are favorable for many migratory bird species. These stands grow rapidly during stand initiation, providing vertical structure sufficient for bird use within 2 to 5 years. Birds are a major dispersal mechanism for oaks (Hodges 1997), and as bird use increases in new stands due to increased vertical structure, oaks seed dispersal is increased.

In the South, primary succession takes place when new land is formed by river movement. In other parts of the world, it may take place after volcanic or glacial activity. Primary succession does not generally occur on sites where pine plantation establishment is the main objective. Although forest monotypes occur naturally in the South, they are restricted to hardwood species along river and stream corridors. On upland sites, where these situations exist, they must be artificially created and maintained. Even in instances where severe fires have taken place in the uplands, biological legacies still exist and no new lands have formed.

Wildlife species that thrive in early successional habitats use plantations heavily during the first few years after planting (Wigley and others 2000). Browse is abundant and species such as white-tailed deer, eastern cottontails, and black bears frequent young plantations. Small mammals also use these areas heavily; consequently, raptor use is high. Several neotropical migratory bird species use plantations early on, when insects and seeds are abundant. After canopy closure takes place, plant diversity decreases and wildlife use declines.

When plantations are first established on previously forested sites, water, nutrients, and sunlight are plentiful, supporting diverse and abundant plant communities. Even though sites are mechanically prepared and competing vegetation is usually controlled with herbicides, other plant species are still able to survive. Many wildlife species benefit from the grasses and forbs that are present on these sites during stand initiation. As the planted crop trees mature, they shade out competing vegetation, reducing plant diversity and structural complexity. As a result, soft mast, browse, and cover are reduced. Subsequently, fewer wildlife species find these sites suitable after canopy closure.

Plantation management: common plantation practices—Loblolly pine is the most common plantation-grown species in the South. Its wood has desirable properties, it grows rapidly, and it is easy to establish. That is why it is the species of choice over much of the Southeastern United States. Slash pine is also a common species for plantation management. It is similar to loblolly pine in most characteristics, and cultural practices are also similar.

Plantations may be established in a variety of ways, but they all begin with some form of site preparation. Site preparation may be as simple as removing the old stand from the site, or as intensive as chopping, windrowing, burning, ripping, bedding, and fertilizing. Site-preparation treatments are designed to give the crop trees a competitive advantage over competing vegetation. On the Coastal Plains and Piedmont, ripping and bedding are common practices, despite high costs. Seedling survival is enhanced with these practices, as is rapid early growth of planted stock. Herbicides are commonly used when sites are ripped and bedded, and are effective in reducing competition.

In managed pine plantations, positive aspects for some wildlife species are gains in vertical structure in a short time period and rapid provision of cover. Negative aspects are reductions in time until canopy closure and subsequent shading of competing vegetation (Dickson and others 1995, Wigley and others 2000). In plantings on clearcut sites, downed wood is usually abundant and in some cases snags are left. Snags left standing may present a danger to loggers, but they provide great benefits to cavity-nesting wildlife species.

Pruning is common in the West Gulf region, where production of high-quality products like poles or lumber is the goal. Many plantations are pruned to produce clear, knot-free wood on the bole in a shorter period of time than without pruning. Pruning is usually done after a thinning and has the potential to positively impact many wildlife species. It has the potential to increase canopy complexity and increase understory vegetative growth. It also increases amounts of dead wood on the forest floor, providing habitat for small mammals and increasing organic carbon levels in the soil. Use of these stands by some hawks and owls may be increased due to greater visibility and increased numbers of small mammals.

Bird use in young plantations is generally high until the canopy closes about 10 to 12 years after establishment. Use declines because there is no canopy stratification and understory vegetation decreases. Leaving mature trees in the stand creates a structural element that has the potential to greatly increase bird use, but the residuals slow the growth of crop trees where shading occurs. Structural diversity is created in the stand on two levels (Dickson and others 1995).

Wildlife Management Techniques

Active wildlife management in southern forests is very common (Dickson 2001). Substantial economic benefits are available for those willing to lease land for hunting or other recreation. Much industrial timberland in the South is leased for hunting. Game species, such as white-tailed deer, wild turkeys, bobwhite quail, and waterfowl, are primary management targets. Entire texts have been written describing practices that enhance game animal populations. This section describes common wildlife management practices in southern forests.

Maintenance of riparian vegetation along streamsides is almost universally considered essential by natural resource managers. It minimizes movement of sediment from upslope areas into streams (National Association of Conservation Districts 1994). In addition to improving stream quality, streamside buffers may benefit many rare and declining aquatic vertebrate and fish species throughout the Southeast. However, of even greater interest are benefits accrued by bird species. Streamside management zones, if widely implemented across a landscape, can support some vulnerable species. Because landbirds are not the sole concern when managing riparian habitat, the most effective conservation will balance economics with the needs of wildlife, including vulnerable neotropical migrants.

Streamside management zones (SMZ) are strips of various width along streams that are not managed like the rest of the stand. They usually contain mature deciduous trees, and timber management in these corridors either ceases or is scaled back in intensity. The primary function of SMZs is to provide a protective buffer that decreases logging impacts on streams, but SMZs also create structural diversity in stands. Wildlife use them for breeding and foraging, and as travel corridors (Machtans and others 1996). Brown-headed cowbirds are a major problem for other bird species in SMZs when the surrounding land has been recently harvested. Cowbirds utilize early successional habitat. During stand initiation after a disturbance, they often reduce nesting success of other species utilizing adjacent SMZs (Dickson and others 1993).

Melchiors (in press) and Wigley and Melchiors (1994) describe management opportunities as well as important caveats for interpreting existing data on wildlife use of retained riparian vegetation in actively managed landscapes. Existing data have been organized into three categories particularly useful for developing management recommendations: (1) streamside management zones in managed (usually short-rotation pine) forest stands, (2) riparian forest habitat in otherwise agricultural or developed landscapes, and (3) moisture/elevation gradients in largely forested landscapes (Melchoirs, in press). Current understanding of bird-habitat relationships in largely forested landscapes, especially in mountainous areas [item (3) above], indicate that forested riparian habitat is indeed important for supporting many species. Managers concerned with the plight of species depending on healthy forested riparian habitat should not place presently stable source populations at risk. Flexibility in managing riparian habitats is enhanced when large landscapes are under cooperative management. Widths of SMZs should be based on the nature of dominant land use patterns. If adjacent land is dominated mostly by mature or maturing stands, narrow SMZs may be adequate. In forests dominated by short-rotation plantation forest management, with many patches of early regeneration present during every decade, wider SMZs probably are needed. Finally, agricultural areas require the widest SMZs if vulnerable landbirds are an important goal for management. In the South Atlantic Coastal Plain, objectives for floodplain forested wetlands should suffice for SMZs.

In most, if not all, Southeastern locations, few important wildlife species would be served by narrow (10 to 25 foot) grassy streamside buffers. Such narrow and grassy riparian conditions may be adequate for minimizing erosion, consistent with the dominant land use. There is little argument among natural resource managers on the importance of maintaining forested riparian areas for wildlife in general, but several points are actively debated. These include: (1) adequate to optimal streamside widths, (2) acceptable structure and plant composition, (3) species to be targeted, and depending on the wildlife targeted, (4) the desired intensity of management consistent with balancing other priority land uses (Wigely and Melchoirs 1994). General guidelines given by Wigley and Melchiors (1994) include the correlation of SMZs with watershed size, the use of narrow SMZs on ephemeral or intermittent streams to promote diversity of bird communities in managed forests, and flexibility in SMZ width.

Costs to maintain wide SMZs can be considerable when timber production is the landowner's only or primary objective. Therefore, financial incentives, conservation easements, and partnerships through public-private programs are critical for stabilizing or enhancing riparian and aquatic habitat throughout the Southeast. Examples include the Farm Bill's Forest Stewardship program and the Partners for Wildlife program. Fortunately, many wood-producing industrial landowners and an increasing number of nonindustrial landowners are maintaining high-quality water and wildlife habitat, especially for landbirds. Nevertheless, recommendations for SMZ width and condition that go beyond State-sanctioned best management practices need to be presented to private landowners as optional treatments.

Cooperating partners should develop joint monitoring efforts in riparian habitats to better understand local responses by vulnerable species to SMZ treatments. Migration monitoring is likely to be most productive in SMZs. Results would add valuable information on timing and degree of transient passage through the South Atlantic Coastal Plain. Efforts to improve watershed management and riparian habitat condition should be monitored by collecting data along tributaries and main streams to the Flint, Chattahoochee, and Apalachicola. All these efforts should involve both public and private groups. Food plots often are claimed to increase game species abundance and health in forest lands that are being managed for hunting. Small areas cleared specifically for planting and woods roads or log landings are generally used. Specific crops planted depend on the site and the species being managed, but peas, winter wheat, ryegrass, and some commercial “wildlife mixes” are generally sown. Keeping small areas cleared has the benefit of creating ecotones, or transitional zones between habitat types, which many wildlife species use. It is debatable, however, whether perpetually cleared areas are as beneficial as those left to natural succession. Food plots may increase the carrying capacity for certain species, but substantial increases usually are not seen. The biggest benefits to hunters and wildlife managers are increases in wildlife observations and subsequent increases in opportunities to harvest game animals.

Green-tree reservoirs are sometimes placed in bottomland hardwood stands to enhance waterfowl habitat. These impoundments are flooded during the winter and early spring and have the potential to greatly benefit waterfowl. Optimally, water levels should fluctuate, increasing foraging potential for dabbling ducks. Hard-mast-producing tree species provide abundant food, and macroinvertebrates are present in great numbers. In addition to waterfowl, potential beneficiaries include reptiles and amphibians that are favored by fluctuating water levels. Warm water fisheries may also be enhanced by green-tree reservoirs. Annual growing-season flooding may decrease regeneration of desired tree species, but dormant-season flooding has little effect on timber quality or growth.

Ecological Variables

Chaotic events—Whatever management options are implemented, it is impossible to accurately predict the onset of natural catastrophic events. Wildlife populations are greatly affected by icestorms, windstorms, blight, southern pine beetles, oak decline, and a plethora of other landscape-altering phenomena. The American chestnut blight basically eradicated a major source of hard mast from the Southern Appalachians, with estimated reductions in hard-mast production of over 34 percent (Diamond and others 2000). Beech bark disease has virtually eliminated American beech from much of its native range. Acid rain has had detrimental effects on red spruce at high elevation in the Appalachians. Recently, southern pine beetle infestations in Kentucky eliminated all suitable habitat for red-cockaded woodpeckers. All of these birds had to be captured and relocated. All of these events have large, long lasting effects on forested ecosystems and the wildlife populations that depend on them.

Landscape altering events have been taking place since the beginning of time. Many have led to species extinctions. In the case of American chestnut, oaks and hickories partially fill the void. Management strategies must be resilient enough to compensate when these events take place.

Soils and topography—Soils are of paramount importance in forest and wildlife management. They dictate, to a large degree, the species assemblages that occupy sites and are directly related to productivity (Hodges 1997). Although no strong correlations exist between site productivity and diversity, sites with highly productive soils tend to be more resilient (Baker 1997).

Silvicultural operations have the potential to impact soils. Harvesting with heavy equipment may compact and rut the soil. The ability of the site to rebound depends on soil type. Wet sites with clays that shrink and swell tend to rebound more rapidly after heavy equipment traffic than more silty soils.

With respect to biodiversity and productivity, little is known about the impacts of converting natural, mixed-species forest stands to pine plantations. In grassland ecosystems, natural prairie sites with high plant diversity are more productive than those with "improved" pastures that contain only a few species. Forests on productive soils with complex structural characteristics and species assemblages have the potential to support more diverse wildlife communities.

Discussion and Conclusions

Southern forests are productive, dynamic, and diverse, supporting a vast array of wildlife communities. They support resident wildlife communities, and play a vital role in the conservation of migratory bird populations. Increased demand on southern forest resources has created complex situations for natural resource managers. Managers balance timber resource needs with habitat requirements for wildlife communities. These challenges must be faced at both the stand and the landscape level. Demand for forest products is increasing, placing greater demands on southern forests for wood production.

Ownership patterns complicate southern forest management. The majority of land in the South is held by a plethora of private owners with a wide variety of management objectives. To be effective, conservation efforts for many wildlife species must cover entire landscapes. Large-scale projects such as Partners in Flight and conservation efforts with Louisiana black bears require cooperation among forest industry, Federal and State government agencies, and nonindustrial private landowners.

At the stand level, practices for improving specific aspects of wildlife habitat in intensively managed forests can be highly beneficial. Retaining mature trees and snags in intensively managed stands provides structural complexity that many wildlife species require. Maintaining SMZs provides travel corridors for wildlife, increases structural and compositional complexity, and prevents detrimental impacts to streams.

Early successional habitat is critical for many wildlife species. Forest management practices geared toward establishing new stands provide abundant early successional habitat, but the wildlife benefits of these stands decreases after canopy closure.

Southern forests are created and maintained by natural and human-induced disturbances. These disturbances shape the structure and composition of forests and the wildlife communities that depend on them. Land use patterns are constantly changing. The changes are beneficial to some wildlife communities and detrimental to others.

Needs for Additional Research

Although copious amounts of very creditable work have been directed at the effects of plantation management on wildlife communities, particularly birds, most of it has been directed at younger stands. The benefits of providing early successional habitat are undeniable, but very little information exists comparing young plantations with different land use histories. Another area that should be given additional attention is midrotation pine plantations. Stands that have reached canopy closure but have not reached a condition to warrant thinning should be more thoroughly examined for wildlife use.

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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.