U.S. DEPARTMENT OF THE INTERIOR
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INFORMATION AND TECHNOLOGY REPORT 3

PINE PLANTATIONS AND WILDLIFE IN THE SOUTHEASTERN UNITED STATES: AN ASSESSMENT OF IMPACTS AND OPPORTUNITIES

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PINE PLANTATIONS AND WILDLIFE IN THE SOUTHEASTERN UNITED STATES: AN ASSESSMENT OF IMPACTS AND OPPORTUNITIES

By

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Pine Plantations and Wildlife in the Southeastern United States: An Assessment of Impacts and Opportunities

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Executive Summary

A growing southeastern population increasingly will expect forest management on public and private lands to address environmental and social issues that transcend individual ownership boundaries. The counsel and assistance given to individual landowners has the capability to affect long-term quality of wildlife habitat on a regional scale. U.S. Department of Agriculture (USDA) forestry assistance programs are in an excellent position to promote optimum rather than maximum production of wood products that addresses wildlife habitat and enhances nonmarket benefits associated with private forestlands.

Managers are increasingly expected to balance economically sustainable management with recreational, social, and environmental demands for forest resources. U.S. Department of Agriculture forestry assistance programs effectively address soil, water, and other environmental issues associated with nonindustrial private forest (NIPF) lands. U.S. Department of Agriculture forestry assistance programs, such as the Forest Stewardship Incentive Program, provide exceptional opportunities to improve the quality of forest resources, enhance economic profits from NIPF lands, and fulfill public expectations for productive use of public funds to address environmental issues.

Sixty-seven percent, 49 million ha (122 million acres), of southeastern timberland is held by NIPF landowners, who supply 58% of the regional yield in timber products. Dependence on southeastern timber resources in meeting international and domestic market demands for wood products is expected to increase; consequently, the future of forested landscapes across much of the Southeast will be affected by decisions made by NIPF landowners. Growing dependence on southeastern timber resources will necessitate intensive management of nonsensitive public and private forestlands and greater use of even-aged pine plantations on NIPF lands. Within the next 50 years the area of pine plantations on southeastern NIPF lands is projected to rise to 8 million ha (20 million acres).

Although financial returns from wood products remain the primary expectation stemming from timber management, provision of wildlife habitat is an issue of near equal importance to southeastern NIPF landowners. Changing demographics of landowners suggest that nontimber-related financial investment, recreation, and aesthetic goals increasingly define acceptable NIPF management scenarios. For many landowners wildlife habitat is the principal factor affecting management of forest resources. Silvicultural prescriptions applied within individual stands potentially influence habitat quality and abundance across stand

boundaries and adjacent land ownerships. The cumulative influence of forest management within multiple stands may affect the distribution of habitat on a landscape scale and provide opportunities to address regionally important wildlife and environmental priorities.

From the perspective of providing wildlife habitat, pine plantations have been criticized for an intrinsic lack of diversity in vegetation composition and plantation configuration, cumulative effects on regional declines in vegetation cover-type diversity, and deficient policies for providing long-term wildlife habitat. Silvicultural and wildlife objectives are not mutually exclusive. Enhancement of wildlife habitat associated with pine plantations may elevate recreational and aesthetic values associated with NIPF lands; however, future economic returns from timber harvest may be reduced.

Various alternatives in the physical design, location, and subsequent management of pine plantations can improve habitat quality. The spatial location of pine plantations can increase the stands' value as wildlife habitat and contribute to landscape-level habitat priorities addressing fragmentation and habitat composition. Information provided by state fish and wildlife agencies should be used to refine USDA forestry cost-share programs to address local and regional environmental issues that extend beyond discrete stands and individual ownerships.

Because they own such a large percentage of commercial timberland, the objectives and social characteristics of NIPF landowners must be considered when developing effective forest management programs. Ideally, management of NIPF resources embodies a balance of short- and long-term goals that reflect multiple objectives. Assistance programs that are narrowly focused on timber production will have limited acceptability to owners of NIPF lands that provide substantial nonmarket (e.g., aesthetic satisfaction, wildlife) values. Many NIPF landowners may, however, embrace silvicultural prescriptions that increase timber yield if the management can be shown to be compatible with other primary goals of forest ownership.

Introduction

The products derived from privately owned forestlands are determined by personal and social interests that range from economic profit to less tangible cultural and recreational values. Forest managers increasingly encounter appeals to adopt strategies that integrate economically viable production of wood products with dissimilar land uses that are driven by demands for products other than wood and fiber (Fenwood 1992; Sharitz et al. 1992; Neave 1993; Bengston 1994; Thomas 1994). Escalating requests for recreation, environmental quality, and aesthetic values, combined with rising demands for wood products, emphasize the need to address esoteric and tangible products derived from forested land (National Research Council 1990; Brooks 1993; Brunson 1993). The opportunities that forest management has in influencing the quality and distribution of wildlife habitat on private lands are substantial and of growing relevance in addressing regional environmental priorities. U.S. Department of Agriculture (USDA) forestry assistance programs are in a unique position to enhance wildlife habitat on individual land holdings, as well as over larger spatial scales.

Addressing demands for nontimber products is a growing challenge to those who define policy and management of resources associated with publicly and privately owned forestlands. There is a strong constituency among private landowners and the general public advocating improved environmental quality and recognition that forest management decisions have implications that reach beyond the boundaries of individual private ownerships. A narrow definition of forest management based only on maximum economic return from timber products will induce public criticism for a lack of attention to environmental priorities tied to forestlands (Bengston 1994). A growing southeastem population increasingly will have expectations for forest management to incorporate recreational use, environmental quality, and regionally important biodiversity issues (Boyce and Martin 1993).

The future of the southeastern' forest landscape is and probably will continue to be substantially affected by decisions made by nonindustrial private forest (NIPF) landowners. Private nonindustrial owners hold 59% of the Nation's timberland and 67% of the timberland in the southeastern United States (Fig. 1). Only 10% of the 74 million ha of southeastern forests is in public ownership, accounting for just 7% of the regional timber yield (U.S. Department of Agriculture 1988). Fifty-eight percent of the timber produced in the southeastern United States originates on NIPF lands, while 35% comes from lands held by the private forest industry (Newman and Wear 1993).

The public and private land area influenced by reforestation is substantial. In aggregate, 74 million ha of trees have been planted in the United States to replace harvested stands or to reestablish trees on land that formerly was forested (Moulton et al. 1995). Sixty-five percent of this area has been planted since 1970. Sixteen million hectares have been planted in just the last 15 years. Though the area planted is sizable, the current 1 -million-ha annual rate of

[1] For the purposes of this report, the southeastern states include eastern Texas, Oklahoma. Arkansas, Louisiana, Mississippi, Alabama, Georgia, Florida, South Carolina, North Carolina, Virginia, Kentucky, and Tennessee.

planting represents only 0.3% of the 298 million ha in forest cover across the United States. Although modest on a national scale, intensive management of forest resources in even-aged stands is of regional concern (Boyce and Martin 1993), particularly when perceived as being narrowly focused on wood production.

Reduction in the harvest of softwoods in the Pacific Northwest stemming from federal policies addressing threatened species, combined with adoption of broader management objectives on public lands, has elevated the importance of southern forests in meeting national and international market demands for timber products (Brooks 1995; Perez-Garcia 1995). Growth of southern forest timber inventories has leveled off, however, due to increased harvest and the effects of environmental and urban constraints on the management of forest resources (Cubbage et al. 1995). Consequently, the intensity in management of southern forest resources will have to be increased to meet the demand for timber products. To meet market demands, the area of southeastern NIPF lands planted to pines is expected to increase (Haynes 1990). Softwood production on public and private lands will continue to be dominated by even-aged monocultures because of their silvicultural simplicity and greater productivity (Famum et al. 1983; Oliver 1986; Knight 1987). Even with an increased emphasis on even-aged management, however, the harvest of southeastern softwoods is predicted to exceed net annual growth well into the next century.

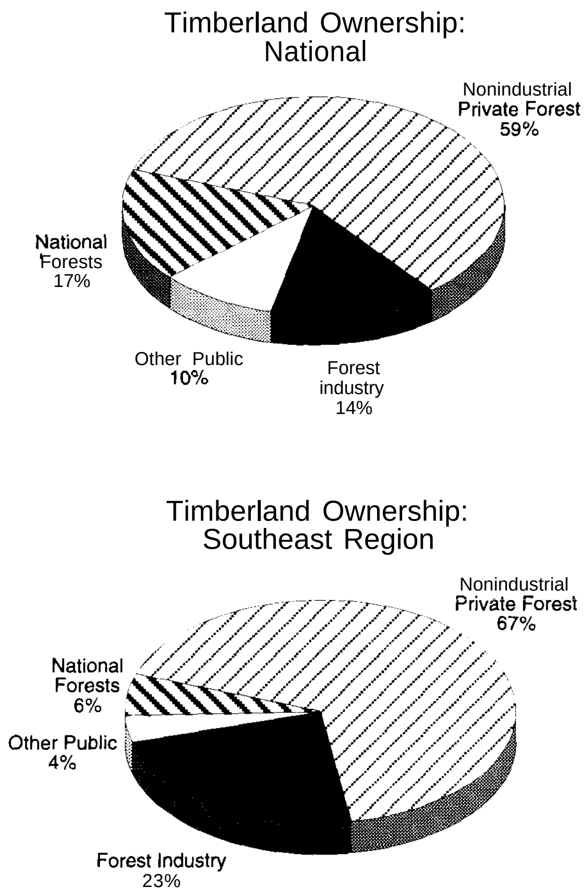

Fig. 1. National and southeastern region ownership of timberland (U.S. Department of Agriculture 1988; Birch 1994).

Growing demands for traditional as well as more sublime products, combined with the potential to modify land use over relatively large geographic areas, highlight the importance of integrating wildlife habitat with management of forest resources (Flather and Hoekstra 1989). Private forestland management can influence the distribution and abundance of wildlife on a variety of spatial scales that range from the managed stand to a group of individual land ownerships. If extensive enough, individual management practices can cumulatively affect the quality and distribution of wildlife within landscapes (e.g., township, thousands of hectares) or even regions (e.g., drainage basins, hundred thousands of hectares). The desire to provide habitat for wildlife can influence management decisions made by individual landowners (Kurzejeski et al. 1992; Melfi et al. 1995), which may in turn provide opportunities to promote landscape- and regional-scale wildlife management objectives (Wigley and Sweeney 1993; Robinson et al. 1995; Rudis and Tansey 1995).

The success of federal and state forest stewardship programs has created demand for assistance that exceeds the capacity of state foresters, extension agents, and wildlife agency personnel to develop specific, unique wildlife and forestry management plans (Brennan et al. 1993). Ideally, the provisions made for wildlife habitat associated with NIPF lands will represent a balance of short- and long-term goals that reflect landowner objectives and ecological priorities. Integration of private forestry and wildlife objectives requires coordination between silvicultural and wildlife professions, recognition of regional priorities, and effective transfer of management information to the private landowner (Young et al. 1985; Brennan et al. 1993).

Objectives

U.S. Department of Agriculture forestry assistance programs influence NIPF land management by providing economic and environmental benefits to individual landowners and society. Adoption of multiple resource objectives will heighten program support and increase landowner participation in these programs.

Our goal in this report is to furnish information to improve integration of silvicultural and wildlife management practices on southern NIPF lands. We describe the historical role of even-aged stands in southeastern forest ecosystems, address criticisms of pine plantation management on NIPF lands, summarize relations between pine plantations and habitat quality for selected wildlife species, and provide recommendations for improving habitat associated with pine plantations.

Southern Forests

Southern forests are complex vegetation associations developed along topographic and environmental gradients that have become highly fragmented due to pre-historical and recent use by humans (Sharitz et al. 1992). An expanding U.S. population, a growing southeastern economy, and an increasing world market are expected to elevate demands for southeastern softwood products well into the next century (Haynes 1990; Powell et al. 1993).

Over 60% (207 million ha) of the southeastern United States is dominated by forest cover, which represents roughly 40% of U.S. timberland (U.S. Department of Agriculture 1988). Commercial forests[2] account for 76 million ha, of which 50% are dominated by hardwoods and 34% by coniferous species. The remaining 16% is dominated by stands of mixed hardwood and softwood composition. Because they are economically important and under more intensive, short-rotation management, older pine seral stages are becoming increasingly rare throughout the Southeast. Many tracts of older pine on private lands have been harvested because landowners generally have no desire to attract threatened or endangered species (e.g., red-cockaded woodpecker *[Picoides borealis]),* whose presence may result in legal constraints on the management of forest resources (B. Wigley, Clemson State University, South Carolina, personal communication). Under current conditions, southern pine forests considered to be “old-growth’ often are as young as 60 years and rarely in excess of 100 years old (Jackson 1988).

The area of natural pine forest in the Southeast decreased by 14 million ha between 1952 and 1990 (Moulton et al. 199 I). Over the same period the area planted in pine increased from 0.8 to 10.5 million ha. These data indicate not only a net loss of 4 million ha (40,468 km^2) in southeastern pine forest but also an overall regional decrease in natural pine systems. Forest surveys completed between 1984 and 1992 indicated variation in the regional distribution of natural and planted stands of pine, owing largely to human influences (V. Rudis, U.S. Department of Agriculture, Southern Forest Experiment Station, Starkville, Mississippi, personal communication; Rudis and Tansey 1991). Natural pine forests were dominant along the southern Piedmont, selected counties on the southern coastal plain, and upland areas west of the Mississippi River. Pine plantations dominated in northern Florida and other counties throughout the coastal plain (Fig. 2).

Average per hectare timber volume in the South rose 104% between 1952 and 1992 but the regional inventory of standing softwood declined 2.5% in volume between 1987 and 1992 (Powell et al. 1993). Harvest of softwoods in the South exceeded growth by 14% in 1991, the first time since 1952 that growth did not exceed harvest. Four key factors are contributing to a decline in the softwood inventory: diminished area of southern pine forests (Moulton et al. 199 I), poor regeneration on harvested lands, elevated incidence of tree mortality, and declines in net growth of southeastern softwoods (Knight 1987; McWilliams and Moulton 1991).

A national loss of about 283,000 ha of timberland per year between 1988 and 2010 is projected (Forest Inventory and Analysis staff, U.S. Forest Service, Washington, D.C., personal communication). Although the area available for timber harvest is a nationally declining resource, timber yield must increase to meet growing demands for wood products. Future demands for wood resources can be met by more intensive management of nonsensitive forestlands held by the forest industry and increasing productivity on underutilized or unproductive NIPF lands (Burch 1994). Southeastern timber products will have to be produced by more intensive management on a smaller land base. Predictions include the continued conversion of mixed pine–hardwood and upland hardwood stands to pine monocultures and substantial increases in management intensity within even-aged plantations. The extent of natural pine forests in the Southeast is projected to decrease to about 8.5 million ha by 2030, while pine plantations on all forest ownerships may increase to about 18 million ha (Knight 1987). U.S. Department of Agriculture projections indicate that the area in southeastern NIPF pine plantations alone will exceed 7.5 million ha by 2030 (Fig. 3).

Timber is the most important southeastern agricultural crop, having twice the value of soybeans or cotton and three times the value of tobacco, wheat, or corn (U.S. Department of Agriculture 1988). Trees, particularly

[2] Commercial forests, also known as timberland, produce or are capable of producing crops of industrial wood that are not withdrawn from utilization by statute or administrative regulation. Qualifying lands are capable of producing 20 $feet^3$/acre/year of industrial wood (U.S. Department of Agriculture 1988).

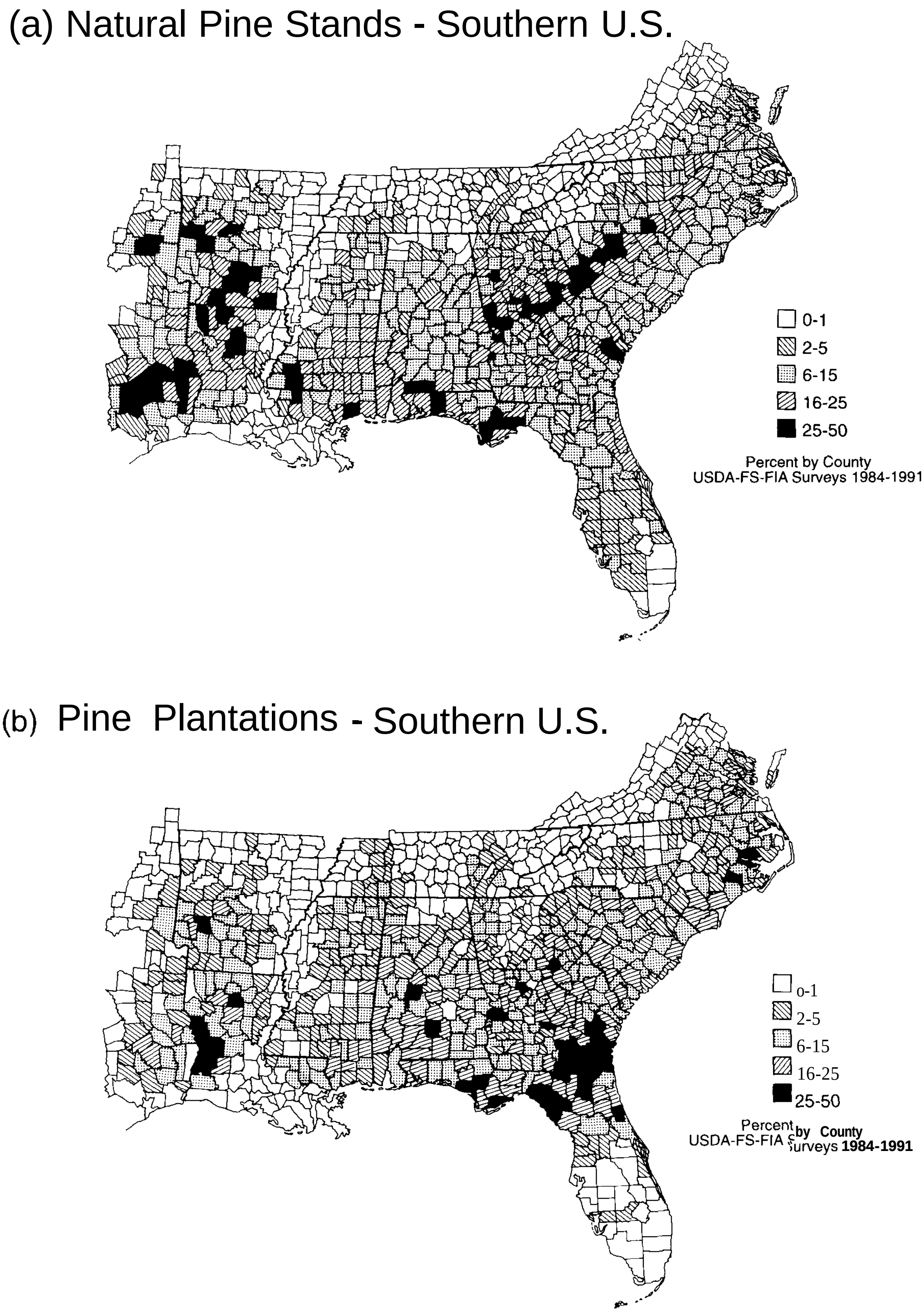

Fig. 2. Percentage of southeastern counties in natural pine stands (a) and pine plantations (b) based on 1984-9 l U.S. Forest Service inventories. (Maps provided by V. Rudis, Southeastern Forest Experiment Station, Starkville, Mississippi).

softwoods, planted on marginal cropland and pasture offer a relatively high rate of return on investment. In 1984, economic returns from southeastern softwoods and hardwoods were $6.1 billion and $1.6 billion, respectively. The amount of wood products that can be produced on southern forestlands is a function of the economics of alternative management practices and how different classes of NIPF landowners respond to economic opportunities. Although other species are present in the region and a variety of species represent numerous forest cover types (Eyre 1980), the southern pine forests are commonly associated with one or more of the following economically important species:

Loblolly pine (*Pinus taeda*) is the leading commercial timber species in the southern United States owing to its adaptability to a wide range of sites (Eyre 1980). The species is endemic to 15 southeastern states, among the fastest growing of southern pines, and forms pure stands on disturbed sites. Prior to European settlement, the loblolly-shot-deaf (*P. echinata*) pine type was confined to infrequently burned, wetter sites. In response to the suppression of wildfire, the type has expanded into drier sites historically associated with longleaf pine (P. *palustris*).

Slash pine (P. *ellottii*) is typically associated with sandy soils on wetter sites (Eyre 1980). The species aggressively invades and forms pure stands on disturbed or burned sites. Suppression of fire has contributed to the extension of this species into sites formerly dominated by longleaf pine. Because of its rapid rate of growth, it also is grown extensively on plantations.

Shortleaf pine is the most widely distributed of the southern pines. Pure stands under natural conditions are infrequent, with the species more commonly being associated with other pines and hardwoods (Eyre 1980). This forest type is diminishing in range and frequency of occurrence across the Southeast.

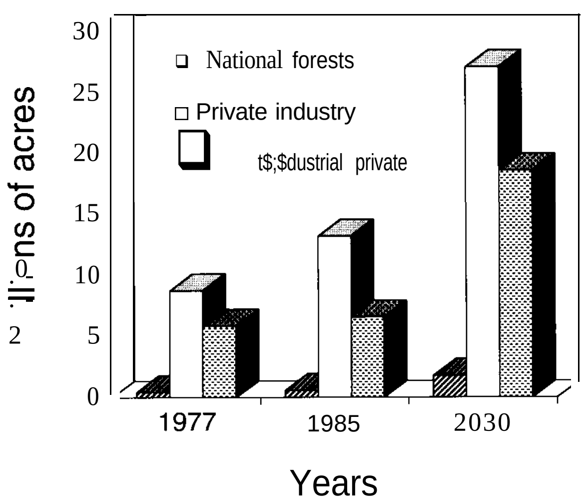

Fig. 3. Area of pine plantations on national forest, private industrial forest, and nonindustrial private forest in 1977 and 198.5, and projections for 2030. Based on data presented in U.S. Deparhnent of Agriculture (1988).

Longleaf pine, prior to European settlement, occupied an estimated 12 to 24 million ha in the southeastern region (Eyre 1980). Between 1955 and 1985 the area of longleaf pine declined from 5 million ha to 1.5 million ha (Kelly and Bechtold 1990). Longleaf pine forests typically consisted of even-aged stands resulting from relatively infrequent but heavy seed production and the requirement for successful reproduction to occur only in sites free of an overstory canopy. Clearing of land for agriculture, industrialization, urbanization, fire suppression, intensive logging, and conversion to commercial plantations of slash or loblolly pine all have contributed to the regional decline of longleaf pine forests.

An awareness of pre-settlement landscape dynamics and the impact of contemporary land use on forest ecosystems may provide a framework for managing contemporary landscapes (Hansen et al. 1993). Such knowledge will become increasingly important if silvicultural prescriptions are expected to more closely reflect "natural" conditions and address regionally important environmental issues (Fenwood 1992). Harris and Skoog (1980) characterized four principal trends affecting southeastern forest wildlife habitat: reduction of total forest acreage, diminished average size of remaining forest stands, conversion of hardwood and longleaf pine forests to alternate use, and intensification of management (e.g., plantations) on remaining pineland sites. Even-aged management has often been the focus of criticism, especially pine plantations because of the perception that they are an unnatural component of the southeastern landscape. Understanding the processes that have historically shaped the composition of the southeastern forests may increase the ability to refine the use of pine plantations in addressing important landscape-scale wildlife management questions.

Human Impacts on Forest Composition

Southeastern forest types are composed of conifers (gymnosperms), hardwoods (angiosperms), and mixtures of the two taxonomic groups (Buckner 1989). Southeastem pines typically become established in pure stands subsequent to major disturbances. Pine-hardwood mixtures are characteristically an ephemeral mid-seral stage that, if left undisturbed long enough, will become stands dominated by hardwoods. Forest characteristics often criticized as being abnormal or unsightly (e.g., even-aged stands of pine, post-fire conditions) are essential to the health and natural function of many southern forest ecosystems. The present composition of southern forests is largely the result of four contemporary types of human intervention: fire control, conversion and subsequent abandonment of forested land to agriculture, timber harvest, and silvicultural practices (Healy 1985). Prior to these modem human impacts, however, pre-Columbian native Americans had a major effect on southern forest composition (Buckner 1989; Sharitz et al. 1992).

Pre-Columbian Effects

The physical composition of North America's eastern forests at the time of European settlement was the result of natural factors (e.g., climate, geomorphology) and the effects of 12,000 to 14,000 years of habitation by Amerindians (Guffey 1977). The myth of an unbroken, primeval forest covering eastern North America at the beginning of European settlement has been perpetuated throughout much of this century (Nash 1982; Williams 1989). However, regional modification of forest composition and the open character of eastern forests, primarily through extensive use of tire by Amerindians, has been well documented (Guffey 1977; Delcourt and Delcourt 1987; Buckner 1989; DeVivo 1990). Amerindians were effective in modifying portions of North America's forested landscape through the effects of expanding populations and conversion of forest-dominated landscapes to cultivated agricultural crops. Estimates of the size of the Amerindian populations prior to European settlement range from tens of thousands to over 100 million (DeVivo 1990). Consequently, the effects of preColumbian man on eastern North American forest composition and ecology were substantial and extensive.

During the Archaic cultural period (10,000 to 2,800 Before Present [B.P.]). Amerindians occupied virtually the entire forested landscape in eastern North America (Delcourt and Delcourt 1987; Buckner 1989). Prior to 7,000 B.P., Amerindian hunting and gathering groups inhabited interior eastern woodlands, exploiting food resources affiliated with closed-canopy forests (e.g., oak and hickory mast) and early successional species associated with woodland edge and disturbed sites (Smith 1992). Intensification of horticulture and associated forest clearing occurred in the Woodland cultural period between 2,800 and 1,000 years B.P. (Delcourt and Delcourt 1987). A growing reliance on cultivation supported the further growth and dispersal of Amerindian populations (Smith 1992).

Use of fire to clear land for agricultural and cultural purposes was extensive enough to affect the evolution of forest types (Guffey 1977). Agrarian-based societies, year-round occupation of villages, and cultivation were in evidence by 3,000-l ,200 B.P. Early European explorers described extensive tracts of cleared land in temperate forest ecosystems along the Atlantic coast and throughout the Mississippi Valley (Crosby 1986). Following European settlement, woodlands adjacent to Amerindian villages were further altered by the foraging of introduced livestock (e.g., cattle and swine; Goodwin 1977). Demands for wood products for housing materials, firewood, and fencing increased as well, further altering forest composition.

From 1,200 to 500 B.P. southeastern Amerindians were highly dependent on agriculture. The continuous shift in land cultivation and successive use of fire kept the forested landscape in a mosaic of various stand ages and types. Forested areas first seen by European settlers were not necessarily virgin or primeval. One factor that may account for the lack of recognition of the open character of the eastern forest landscape may have been the high mortality of Amerindians in the sixteenth and seventeenth centuries following initial contact with European explorers (Goodwin 1977; Crosby 1986; Buckner 1989; DeVivo 1990). Human mortality stemming from introduction of European diseases is estimated to have reduced the Amerindian population in the central Mississippi Valley by at least 80%. Culturally sophisticated societies throughout the southeastern United States were decimated and, relative to population numbers prior to initial contact with Europeans in the 1500's, the region was vacant of the native population by 1700 (Crosby 1986). These epidemics preceded regional arrival of the eighteenth century settlers by decades. By the early 1800's, the former farmlands and fire-maintained uplands established by Amerindians were supporting 50- to 150-year-old, relatively even-aged forest stands that presumably were perceived as being pristine by European settlers.

Even-aged stands that regenerated following abandonment of Amerindian agricultural lands have been a component of the southeastern forest landscape affecting forest composition to a much larger degree than historically recognized (Williams 1989). Abandoned Amerindian agricultural lands probably resulted in extensive tracts of pure stands of pine (Buckner 1989). Left undisturbed, most of the stands eventually would evolve into hardwood-dominated stands. The presence of fire resulted in a landscape that was a composite of stands of mixed species composition and individual stands dominated by hardwoods or softwoods. Consequently, Amerindians were a significant ecological factor in the distribution and composition of the eastern forests, making the concept of natural vegetation difficult to define.

Contemporary Effects

The southern United States continues to experience major demographic transformations affecting forest distribution and composition. Changes range from a landscape once dominated by an agrarian society to uses increasingly influenced by modernization of agricultural production, population growth, urban expansion, and residential encroachment into rural areas (Healy 1985; Gholz and Boring 1991).

Suppression of wildfires, agricultural production, and timber harvest have been the principal agents contributing to regional changes in forest composition (Healy 1985; Jackson 1988). The contemporary forests that have regenerated naturally on cutover and abandoned agricultural lands generally are more even-aged and younger than those that existed prior to extensive use by southeastern society (Johnson 1987).

Human- and lightning-generated fires also were important elements historically influencing southern forest distribution and composition (Buckner 1989; Gholz and Boring 1991). The common southern pines are pioneer species that become established, often in even-aged stands, following wildfire. By the 1930's, wildfire control became effective throughout the Southeast, favoring the expansion of hardwood-dominated stands. Fire, whether of prescribed or wild origin, remains an influential, periodic disturbance in half of the pine plantations and one-third of the natural and oak-pine southern forests (Rudis and Skinner 1991). In recent years, apprehension about legal liability suggests suppression of burning interval and intensity and an increase in hardwood-dominated stands. Rudis and Skinner (199 1) noted, however, that fire remains an important management tool and disturbance element for the region's existing southern pine ecosystems.

The size of the South's timber base is closely related to demand for cropland (Healy 1985). As settlement swept across the Southeast, longleaf, shortleaf, slash, and loblolly pine forests were extensively cleared and converted to agricultural use. The area cultivated peaked in the early 1930's, leaving much of the remaining southeastern forests as isolated remnants embedded in a matrix of agricultural land (Sharitz et al. 1992). Economic circumstances in the 1920's, however, were to have a major influence on the relation between southeastern agricultural and forestlands.

The demand for farm products diminished at the conclusion of World War I, resulting in thousands of farm bankruptcies across the Nation (Cochrane 1993). Consequently, the economic depression that began for the rest of the Nation in 1929, commenced for the farm economy in 1920-21. The economic depression, in combination with agricultural competition from western states, resulted in abandonment of thousands of hectares of southeastern agricultural land, a trend that continued through the 1950's (U.S. Department of Agriculture 1988). Across the Southeast much of the neglected croplands and pastures seeded naturally to pine. In addition, about 0.8 million ha were planted to pine during this period. Southeastern timberland attained a maximum distribution of 87 million ha in 1962 but declined to 80 million ha by 1987 due to conversion of forested lands to urban and agricultural uses (U.S. Department of Agriculture 1989).

Subsequent to World War II, farm efficiency and output increased substantially, which, combined with escalating demands for American products, elevated pressures to bring new and more fragile lands into agricultural production (Doering 1992; Cochrane 1993). In the 1950's the amount of land in forested cover resumed a downward trend in response to urbanization and greater intensity of agricultural production. Consolidation of farms and fields with concurrent elimination of woodland cover on fields idled during previous decades reduced forest cover in the Southeast. Agriculturally related conversion of forestland extended into nonpine forest types as well. Between the mid-1950's and mid- 1970's, over 2.2 million ha of southeastern forested wetlands were lost, much of which was converted to agricultural production (Keeland et al. 1995).

Naturally regenerated stands of pine remain common on private nonindustrial lands, but they are increasingly being replaced by more intensively managed plantations of shortleaf and loblolly pine (U.S. Department of Agriculture 1989). Several federal programs (e.g., Conservation Reserve phase of the Soil Bank, Forestry Incentives Program) have promoted improved forest management on private lands in the post-1950 period. Much of this land has become an important contributor to the South's paper and wood industries.

Timber became an important southeastern industry following the Civil War (U.S. Department of Agriculture 1988). Between 1880 and 1920, the majority of remaining southeastern forests were harvested and left to regenerate naturally (Sharitz et al. 1992). Forest development in the early 1900's was accomplished largely through suppression of fire and replanting of cut-over lands. The products of these efforts were largely harvested after the Second World War to support an expanding pulp and paper industry. Between 1950 and 1978, about 10 million ha of forest were artificially regenerated in southeastern states (Oliver 1986). Tree planting on southeastern private industrial and public lands accounted for 49.2% and 5.3% of all hectares planted, respectively. In comparison, slightly over 45% (325,628 ha) of all trees planted in 1992 were on nonindustrial private lands (Moulton et al. 1993). Clearcutting has been the general trend, and even-aged, single-species prescriptions are projected to continue to dominate reforestation of southern forests.

Forest Management Objectives of the Nonindustrial Private Forest (NIPF) Landowner

Because they own such a large percentage of the Nation's timber resources, the objectives and social characteristics of NIPF landowners must be taken into consideration when developing effective forest management programs (Birch 1994). Nationwide, NIPF landowners hold 158 million ha of forestland. Forested land associated with farm ownership accounts for about 33 million ha, of which 8 million ha are located in the southeastern states (U.S. Department of Agriculture 1988). The extent of farm ownership of forested land, however, has decreased (Birch 1994) and is projected to continue to do so (Haynes 1990). Farmers currently account for 7% of the NIPF landowners and hold 8% of the private forestland in the Southeast (Fig. 4).

Current owners ofprivate forestland are younger, better educated, and more affluent than were landowners in 1978 (Birch et al. 1982; Birch 1994). The growing desire to live in rural settings influences the aesthetic and recreational values of forestland, promoting a growing trend for the nontraditional values of forestland to compete with and exceed the potential economic return of timber production (Rudis 1991; Beasley 1992). For example, between 1978 and 1994 the number of NIPF landowners in the South increased by 28% (Birch 1994). Forest cover being "part of the residence" was the leading reason given for owning forestland by NIPF landowners in this region. Although those who desire economic return from timber production still hold a greater area of forestland (29% of NIPF lands), the shift in landowner goals is indicative of changing values reflecting the desires of a more suburban, affluent population.

Owners of southeastern forestland exhibit a wide range of attitudes and abilities to manage forest resources (Haynes 1990; Birch 1994). Nonindustrial private forest landowners range from economically motivated proprietors of relatively large tracts of land, to owners adverse to economic risks who will implement silvicultural practices only if they do not conflict with other resource values, to owners who will not harvest timber under any circumstances. Because NIPF landowners often receive

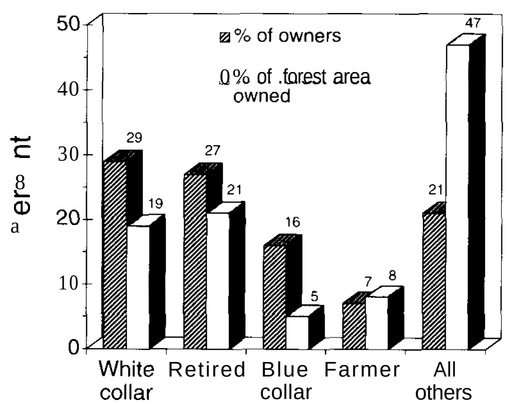

Fig. 4. Ownership of southeastern NIPF area by occupation. The "all others" category of NIPF landowners includes service workers (5%), homemakers (1%), corporations (5%), and unknown (10%). Corporate owners possess 83% of the forested land in this category.

substantial nonmarket benefits (e.g., aesthetic satisfaction, camping, wildlife) from their forested lands, they place dissimilar values on timber assets than do industrial owners (Oliver 1986; Newman and Wear 1993). Narrowly focused forestry assistance programs that operate under the premise that timber is the primary motive of NIPF landowners will have limited success in increasing production from these lands (Young et al. 1985; Bourke and Luloff 1994).

Management alternatives for southeastern NIPF landowners range from adoption of intensive management comparable to that of the private forest industry to indifference toward management of forest resources. Owners of small forested tracts with goals other than timber production may be unwilling to implement silvicultural practices that require substantial investment of time or financial resources to increase timber yields (Straka et al. 1984; Phillips and Abercrombie 1987; Cain 1988). Healy (1985) suggested a soft silviculture approach may be more compatible with the desires of the typical NIPF landowner. This approach involves management methods requiring low initial investments that fit well with nontimber objectives. For example, selective harvest of mature pine and ensuing natural regeneration may be a more financially acceptable alternative than clearcutting and planting seedlings to landowners who prefer to preserve aesthetic and wildlife values associated with a stand. Soft silviculture has lower productivity of timber resources compared with methods requiring substantial financial investment but may, in the long term, result in higher net return on dollars invested. Soft silviculture demands a more refined blending of silvicultural objectives with wildlife, environmental, or aesthetic goals than have approaches that focused on maximum stocking of trees and production of wood products. Ultimately, however, the type of silviculture employed by NIPF landowners is highly influenced by the types of products demanded by the local market. An inability of local processors to handle specific types of timber may prevent soft silvicultural harvests from being economically viable.

Forest landowners will pursue management scenarios that best meet their personal objectives and financial constraints. Only 5% of the respondents in a national survey of NIPF landowners identified income from timber as a primary expectation compared with 23% who ranked recreational and aesthetic enjoyment as their primary reason for owning forested land (Birch 1994). Yet income from wood products remains the dominant expectation of southeastern NIPF landowners (Birch 1994; Melfi et al. 1995). A recent survey of South Carolina NIPF landowners identified timber production as the principal goal of forest ownership, with provision of wildlife habitat the second priority (Melfi et al. 1995).

Private owners of forestland who identify residential, environmental, or wildlife benefits as principal reasons for ownership may embrace timber harvest if it does not conflict with, or enhance, their primary goals (Birch 1994). Therefore, forestry assistance programs will have greater success in increasing timber production from NIPF lands if it can be demonstrated that economically profitable management of timber resources can be compatible with other objectives (Young et al. 1985).

U.S. Department of Agriculture Forestry Assistance Programs to Nonindustrial Private-Forest (NIPF) Landowners

The ability of the United States to produce renewable forest resources is increasingly dependent on private lands (U.S. Department of Agriculture 1978). The area of trees planted across the United States has generally increased annually since the 1930's (Moulton et al. 1993), with a record 1.4 million ha planted in 1988 (Moulton and Richards 1993). Voluntary USDA cost-share forestry programs have played a vital role in promoting forest stewardship to NIPF landowners, increasing the economic and environmental values associated with their lands. U.S. Department of Agriculture forestry assistance programs are implemented through state forestry organizations, with supplementary support provided by the Cooperative Extension Service, Natural Resource Conservation Service, state wildlife biologists, and forestry and wildlife consultants in the private sector. Silvicultural, technical, and financial assistance has been available to NIPF landowners under the following programs.

Agricultural Conservation Program (ACP)

Nationwide, over 2.8 million ha of trees have been planted under the ACP since its initiation in 1936. Of the initial plantings, 76% of the area remains in original plantings, whereas 10% has reverted to stands dominated by tree species other than those initially planted (Kurtz et al. 1994). Only 4% of the area planted to trees under this program has been converted to pasture or cropland, while 6% has been lost to urban expansion.

Soil Bank

Nearly 0.8 million ha of trees were planted in the South during the Conservation Reserve phase (1956–61) of the Soil Bank program (Alig et al. 1980a). As of 1980, trees were still growing on 89% of this area. Analysis of a 2,024-ha sample of Soil Bank plantings indicated that only 2.5% had returned to cropland, while 5% had been converted to pasture (Kurtz et al. 1994). Thirty-five percent remained in the original planting, and 41% of the sampled area had been replanted following harvest. Four percent of the area had become dominated by hardwood trees. Conversion to nonagricultural use had impacted 13% of the sample.

Stewardship Incentive Program (SIP)

The SIP was authorized under the Forestry Title of the 1990 Food, Agriculture Conservation and Trade Act to assist NIPF landowners in enhancement of timber, wildlife, recreation, water quality, and soil conservation associated with their forested lands. SIP provides up to 75% cost-sharing for practices that enhance forest resources. Nationally, in 1993 alone, stewardship plans were implemented on over 139,036 ha, trees were planted on 15,090 ha, and improvement in wildlife habitat was completed on over 6,000 ha (Moulton 1994).

Forestry Incentives Program (FIP)

Generally limited to participants with up to 405 ha of forestland, the FIP was designed to encourage development, management, and protection of NIPF lands. Since the program began in 1974, 1.2 million ha of trees have been planted, and 0.5 million ha of woodland in 46 states have received stand improvement. Only 5% of the enrolled land has reverted to stands dominated by tree species other than those planted. Three percent has been lost to agricultural and urban use (Kurtz et al. 1994).

Conservation Reserve Program (CRP)

Since its initiation as part of the 1985 Food Security Act, about 973,000 ha of softwood and 27,000 ha of hardwood plantings have been established on CRP lands (U.S. Department of Agriculture 1993). Over 90% of the areas planted to trees were on highly erodible agricultural lands in southeastern states (Osborn et al. 1992). An additional 21,710 ha of hardwoods and 12,000 ha of softwoods were planted on cropped wetlands under the Wetland Trees conservation practice (Moulton et al. 1991).

Global Climate Change (GCC)

Intended to contribute to the reduction of greenhouse gas emissions by planting trees to sequester atmospheric carbon dioxide, the GCC originated in 1993 as part of the President's Climate Change Action Program. Initial planting of trees is being administered under FIP and SIP. In 1994, 9,308 ha of trees were planted on private lands. Projections are for plantings to eventually increase to 94,290 ha/year (Moulton 1994).

Although enhancement of timber resources historically has been the principal goal of USDA cooperative assistance programs, recreation, aesthetic values, water quality, and wildlife habitat continue to receive elevated status. U.S. Department of Agriculture forestry programs have effectively met intended legislative objectives and have a major influence on the quality of forest management administered to nonindustrial private lands. Historically, tree plantings established under these programs have remained intact providing long-term environmental benefits as well as economic returns to participating landowners and local economies (Alig et al. 1980a, 1980b; Kurtz et al. 1994).

CRP-Funded Pine Plantations and Wildlife Habitat

In contrast to USDA programs that concentrate on improving existing forest resources (e.g., FIP, SIP), the ACP, Soil Bank, and CRP have focused on economic and environmental issues associated with agricultural lands. Federal agricultural programs (e.g., ACP, Conservation Reserve portion of the Soil Bank) that advocated planting of idled cropland to grass and legume cover for 3 or more years and tree-dominated conservation practices for 10 or more years provided substantial benefits to wildlife associated with agricultural ecosystems (Berner 1988; Gerard 1995). Considerable evidence documents the CRP-related enhancement of habitat for game and nongame species (Allen 1993a; National Biological Survey 1994; Wildlife Society 1995).

Some wildlife professionals in southeastern states have been critical of extensive pine plantation planting in the CRP because of long-term effects on local and regional distribution of wildlife habitat (Allen 1993b; Capel et al. 1995). A common reproach relating to the forestry component of the CRP was that it lacked a multiple-resource emphasis, with wildlife and environmental quality receiving lesser consideration than timber production. Many wildlife personnel believe that if private landowners accept public funds (cost-sharing) for improvement and management of timber or agricultural lands, they should also bear some responsibility for meeting other environmental obligations associated with those lands.

A major issue of concern to some southeastern biologists is the transformation of remnant tracts of cropland to pine plantations within landscapes already dominated by forest cover. Although plantations provide habitat for edge- and grassland-dependent species during the initial years following establishment (Johnson 1987; Stauffer et al. 1990), there is, over the long term, a reduction in habitat quality for species dependent on crop residues and the interspersion of habitat resources associated with agricultural land. Conversely, establishment of plantations in landscapes dominated by forest may benefit wildlife species that have suffered from earlier land uses that resulted in isolation and fragmentation of forested habitats.

In contrast to effects within tree-dominated landscapes, CRP-funded pine plantations have enhanced habitat diversity in intensively farmed regions. Conversion of annually tilled land to pine plantations has increased cover type diversity and provided permanent cover in otherwise frequently disturbed landscapes. Of 72 CRP plantations sampled across the Southeast, 7 1% did not adjoin previously existing pine stands (Moulton et al. 1991). Only 5.6% of the plantations bordered existing pine stands along two boundaries, while 22.2% joined a previously established stand of pine along one side. The size of plantations sampled ranged from 0.8 to 50 ha, with a median of 10.7 ha. Plantations established under the CRP in the Southeast were planted at an average density of 750 trees/O.4 ha (Risbrudt and McDonald 1986). The average number of seedlings planted in the southcentral region was 675 trees/O.4 ha. In addition to elevating the number and diversity of vegetation types within agricultural landscapes, establishment of plantations on idled croplands may benefit aquatic habitats by contributing to lower rates of soil erosion and sediment-laden runoff entering surface waters.

Southeastern wildlife biologists (e.g., Stauffer et al. 1990; Allen 1993b; Brennan et al. 1993; Capel et al. 1995) recurrently have identified the following issues related to impacts on wildlife habitat stemming from increased use of pine plantations:

1. A lack of diversity in tree species planted and spatial composition of plantations.
2. Minimal use of management actions (e.g., thinning, prescribed burning) that would increase within-stand diversity and habitat quality.
3. Replacement of agricultural land with pine monocultures.
4. An increasing dependence on herbicides in site preparation.
5. Conversion from hardwood and mixed stand types to pure stands of pine.
6. Extensive acreage in single or similar age-class plantations.

The long-term effects of privately owned pine plantations on wildlife habitat depend on how intensively the stands are managed for timber production (McWilliams and Moulton 1991). Investigating the fate of pine plantations established under the ACP, Kurtz et al. (1980) reported that 11% of the plantations sampledcontained low stocking ofconifers, with more than 50% of basal area in hardwoods. As other tree species and age classes become established, older, less intensively managed plantations tend to exhibit greater diversity in structural characteristics, making them difficult to distinguish from naturally occurring stands (Kurtz et al. 1994; Rosson in press). Such stands were characteristically smaller and on poorer-quality sites than were plantations more intensively managed for timber production. Artificially regenerated stands established by direct seeding, hand planted on uneven terrain, or not subjected to site preparation were difficult to differentiate from stands established by natural regeneration. In contrast, overstocking (1,000 trees/O.4 ha) of plantations established under the Soil Bank and ACP was more prevalent than understocking (Alig et al. 1980a; Kurtz et al. 1980). The high rate of stocking, combined with a failure to complete precommercial thinning, led to lower vigor and growth rates in overstocked stands. Careful precommercial thinning within these stands could have increased financial returns to landowners and improved wildlife habitat.

The design and management of plantations probably has an equal or greater influence on habitat quality than does the magnitude of this silvicultural practice. The real shortcoming in terms of wildlife benefits of the CRP and other USDA cost-share programs, in which tree planting practices are used, is not simply that pine monocultures dominate selected landscapes but that these stands, once established, are not managed effectively. Most plantations could provide a greater diversity of habitat over a longer period if USDA programs required periodic management of the stands.

A commonly expressed criticism related to establishment of pine plantations under the CRP was the lack of flexibility on the part of county-level USDA staff responsible for on-ground implementation of the program in meeting landowner desires (Allen 1993b). Some CRP contractees were interested in improving wildlife habitat but often did not receive adequate advice for design of plantations because modification of contract specifications was perceived to be too complicated and time consuming. In some cases, the appropriate information was simply not available. The Appendix provides a summary of design and management actions that could be used to improve the quality of wildlife habitat associated with southeastern pine plantations.

Plantations and Wildlife Habitat

Although they have been criticized because of the conventional narrow focus on wood production (Dickson 1982; Jackson 1988), pine plantations are not without value as wildlife habitat. Numerous studies, some of which are summarized in following sections of this report, document plantation use by wildlife throughout the South. The merits of any given plantation, or any other forest stand as habitat, differ in response to the needs of individual species, the physical characteristics of the stand as they change through time, and the spatial relations to other land uses (Hansen et al. 199 1).

The worth of a pine plantation as wildlife habitat is impossible to assess until comparisons of alternative uses of the land and the needs of specific species are made. No plantation, or any other vegetation association, can provide habitat for all wildlife species. It is necessary to be specific about which species are in question and what successional stage is of concern before the disadvantages or benefits can be defined. Furthermore, patterns of habitat and wildlife species use reflect changes in stand composition. Newly established plantations that support abundant herbaceous vegetation will provide sustenance for species dependent on cover provided by such vegetation (Melchiors 199 1). Wildlife species that have exhibited regional population declines, such as the prairie warbler (*Dendroica discolor;* [Sauer and Droege 1992]), may benefit from the habitat provided by newly established plantations. As the stand matures, habitat quality for these species diminishes, until the herbaceous component is eliminated by a woody overstory. In the interim, use of pine plantations by white-tailed deer may peak when the biomass of preferred forage and security cover provided by 10- to 15-year-old pines furnishes a preferable combination of habitat traits (Skoog 1980, cited by Harris and Skoog 1980).

A pine plantation replacing a mature stand of mixed pine-hardwoods substantially lowers habitat quality for species dependent on hard mast and the physical features associated with a vegetationally and structurally diverse, older-age stand. The site's habitat potential is not eliminated but is altered to reflect conditions more suitable for a different species assemblage. Patterns of habitat composition will continue to change in response to forest succession and management activities.

Conversely, pine plantation establishment on highly erodible cropland could provide cover for wildlife where virtually none existed. The presence of trees on land removed from the annual production of crops will enhance structural diversity within an intensively farmed landscape and benefit aquatic habitats by reducing the amount of sediment carried in surface runoff. Pine plantations replacing rowcrops in a landscape dominated by forested cover will decrease habitat quality for species dependent on agricultural crops and the highly diverse landscapes associated with small, diversified farms. In contrast, the replacement of cropland with forest cover on the same site may improve habitat quality for area-sensitive avian species susceptible to higher rates of nest predation and parasitism associated with more vegetationally diverse landscapes. Consequently, the definition of a plantation's value must unite not only the within-stand characteristics but also adjacent land uses, alternative land use, and cumulative landscape-scale and regional-scale landuse patterns (Hansen et al. 1991). Ultimately, the pine plantation's affect on habitat quality is defined by spatial relations with other land uses that can be specified along political boundaries (e.g., county) or physical features (e.g., drainage basin).

Diversity in plant species composition and the configuration of vertical layers and horizontal patterns of vegetation define fundamental dissimilarities between naturally regenerating stands and plantations. While variability in tree species composition and the diversity and density of vegetation strata delimit habitat quality within individual stands, inherent physical patterns of growth and botanical features (e.g., bark, fruit) define the habitat value of individual tree species. The greater diversity of wildlife associated with deciduous forest is, in part, a function of the elevated abundance and diversity of foods and foraging strata provided by hardwood species than furnished by pines (Harris and Skoog 1980). Harris and Skoog (1980) also attributed differences in branching patterns and lower uniformity in within-stand tree height contributing to greater diversity in older, naturally seeded pine stands than found within the more uniform and younger slash and loblolly pines. The physical patterns of growth and structure exhibited by longleaf pine provide more diversity in foraging habitat than is typical of other southern yellow pines, especially when they are managed for maximum production of wood products.

Because establishment normally operates under relatively strict economic constraints, planted stands characteristically are single-age-class monocultures with, depending on the desired product, a uniform, planned end-point in time. Maximum rates of stocking and short rotations result in forfeiture of structural diversity in exchange for elevated rates of wood productivity. Plantation productivity is further enhanced through use of genetically improved stock, fertilization, extensive site preparation, and reduction of competition. These management actions prohibit variably stocked stands, layers of understory and midstory vegetation, and longer rotations that enhance or maintain habitat traits required by many forest-dependent wildlife species.

Historically, dissimilar objectives have divided wildlife and forestry professionals as to the role that forest management should have in maintenance of wildlife populations on local and regional scales (Innes 1985; Johnson 1987). In the past, forest management plans often were defined with stand-scale consideration of how silvicultural practices affected long-term viability of wildlife habitat or how modifications in management prescriptions could furnish essential habitats without significant loss to timber yield (Marquis 1986; Kingsley 1988). Contemporary management of public and private forest resources, however, is increasingly based on landscape- and regional-scale concerns and social values (Corona 1993; Burch 1994). Requests for attention to environmental values does not eliminate demands for traditional forest products but increasingly tempers the definition of socially and environmentally acceptable forest management practices (Brooks 1993).

Attempts to meet expanding markets for southeastern forest products may affect the availability and quality of habitat across multiple ownerships of land. The greatest opportunities to enhance habitat associated with pine plantations will be realized when individual NIPF goals are defined, management plans are based on an assessment of landscape- and regional-scale habitat issues, and specific methods to improve habitat quality are addressed early in the planning process.

Management of Wildlife Habitat Associated with Pine Plantations

Although management objectives vary, the desire for economic benefits derived from wood production remains the dominant expectation of NIPF proprietors who own larger tracts of forestlands. Individual plantations in NIPF ownership can serve conservation, recreation, and wildlife needs while providing economic benefits with comparatively minor adjustments in management strategies (Young et al. 1985). Plantation design and stocking rates can be modified to elevate their value to wildlife for little to no short run costs. The result, however, often will be a lower yield of fiber (Melchiors 1991). For example, early thinning of plantation pines may enhance the abundance of herbaceous ground cover, thereby improving habitat for some species of wildlife. However, the long-run cost may be fewer trees harvested. If provision of wildlife habitat is determined to be economically acceptable, ways must be found to enhance diversity in vegetation composition and physical structure of managed stands. Relatively simple modifications such as leaving grass-dominated openings within the plantation or incorporating wider spacing between rows of trees will increase within-stand diversity (Fig. 5).

Proximity to other land uses and vegetation types helps determine the value of a plantation as wildlife habitat. Identification of priority wildlife species can help to define the best physical location for plantations on a farm or multi-farm scale (Fig. 6). Similarly, regional wildlife priorities could assist in deciding where the best site for a plantation would be based on regional-scale conservation goals. For instance, a series of plantations in proximity to isolated forests rather than widely dispersed plantations established without regard to adjacent forest cover could contribute to development of a region-wide network of corridors that could benefit the

Fig. 5. Summary of some design alternatives that can enhance within-stand diversity of wildlife habitat associated with pine plantations. 1. Establish soft borders of grasses and shrubs between pine plantations and other land uses such as cropland. 2. Vary spacing between rows of trees, and maintain grass-dominated cover in rows wide enough that management, such as disking or mowing, can be applied. 3. Increase diversity in tree species planted. 4. Establish plantations adjacent to other cover types that have existing value as wildlife habitat (e.g., riparian or upland woodlands).

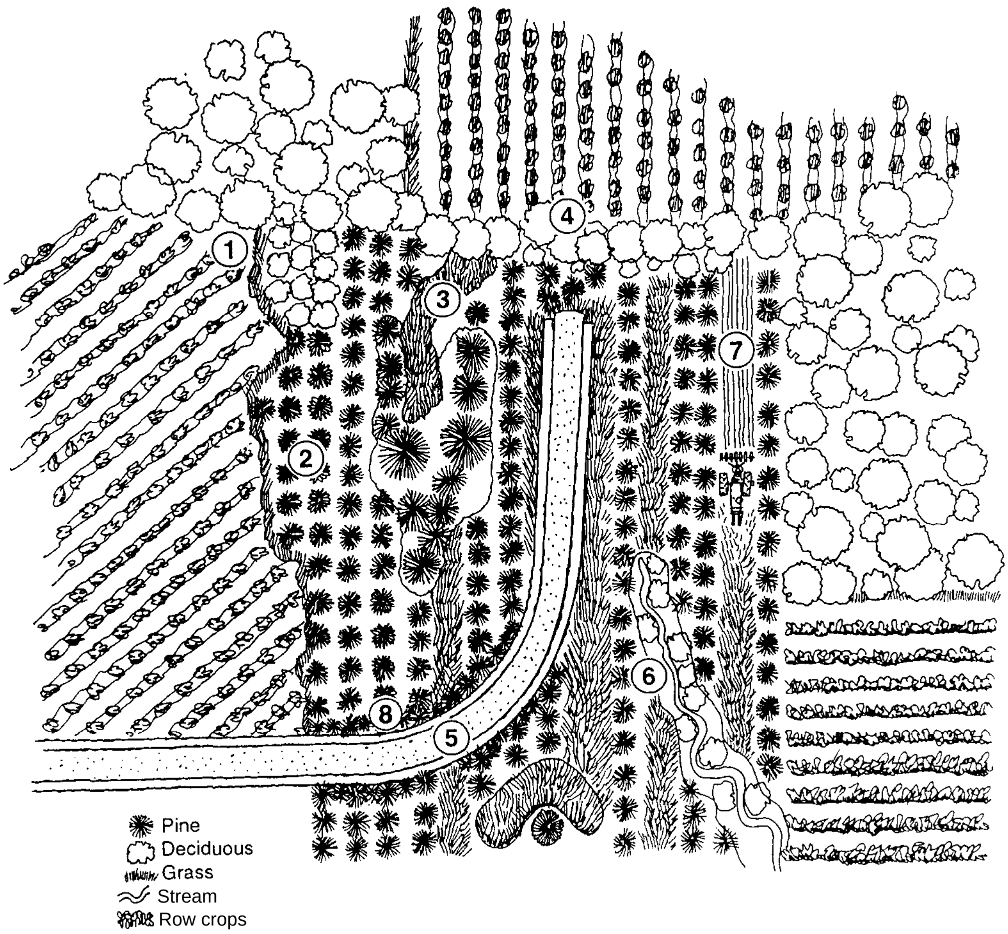

Fig. 6. Some strategies that can enhance within-stand diversity of pine **plantations** and their contributions to wildlife habitat associated with adjacent cover types. 1. Establish plantation boundaries that are irregular in shape. 2. Maintain variable stocking density and harvest patterns across the stand, and diversify species planted. 3. Create and maintain irregularly shaped, grass-dominated openings within stand boundaries. 4. Establish or preserve other vegetation types such as hardwood corridors that link other forested stands. 5. Maintain firelanes and access roads within plantation boundaries, and plant borders to grasses and legumes. 6. Maintain hardwood-dominated streamside management zones within or adjacent to plantations. 7. Vary spacing between trees within rows (>3 m) and between rows (>4 m). 8. Plant trees adjacent to roads in a pattern that provides a visual barrier to the interior of the stand.

distribution and movement of wide-ranging species (e.g., black bear [Rudis and Tansey 19951).

Within-stand Alternatives

Methods to enhance within-stand structure and diversity include longer rotations, less intensive harvesting and site preparation, retention of mature trees, greater diversity in tree species planted, spatial clustering of trees of different age classes, and preservation of snags and large woody debris. Most plantations are monocultures, but there is no fundamental reason why they cannot be composed of multiple species. It is more complicated to create and manage plantations of mixed species composition, but the benefits, particularly in relation to provision of wildlife habitat, can be substantial. Alternatives include planting faster-growing, shade-intolerant species interspersed with more tolerant species of trees. The intolerant species form an upper stratum, while slower-growing species, more tolerant of shaded conditions, add structural diversity by forming a lower stratum. Within-stand diversity in habitat can be created by planting more than one species of tree in smaller, sub-stands within plantation boundaries. The physical variety added by multiple species will enhance vertical and horizontal diversity across the plantation. Over the long term, thinning and harvesting of plantation subunits will increase within-stand diversity in vegetation composition and habitat structure.

Wider initial spacing of trees within and between rows will delay the shading effects of the tree canopy as the plantation matures, permitting a greater diversity in duration, composition, and abundance of understory vegetation. Other alternatives include only partial application of herbicides or prescribed burning within stand boundaries to maintain grasses, shrubs, and hardwood regeneration in portions of a plantation and maintaining unique sites (e.g., steep slopes, rocky or wet sites) and their endemic vegetation (Melchiors 1991).

Within-stand diversity can be enhanced by establishing permanent access roads and fire lanes at the time a plantation is created. Established roads and fire lanes will make subsequent application of prescribed bums easier and more economically acceptable as the stand matures. Road borders planted, or allowed to grow, to native grasses will increase vegetation diversity.

Plantation boundarics, particularly those established on former croplands, are typically straight and abrupt. Avoiding the creation of linear borders between highly dissimilar types of vegetation can enhance the amount of edge and habitat values associated with plantations (Wesley et al. 198 1; Corona 1993). Provision of grass- and shrub-dominated buffers between plantations and other land uses will soften the boundaries and provide a greater amount of habitat for wildlife that benefit from higher interspersion and diversity of vegetation types. Reduction in application of herbicides along plantation edges can encourage greater diversity in vegetation composition and structure providing cover and sustenance for avian species (Sotherton et al. 1993).

Depending on the wildlife species and management objective, however, increasing the area of internal openings and length and diversity of edge associated with pine plantations may be undesirable. For example, stands with low edge-to-area ratios may decrease the attractiveness of plantations to edge-associated nest parasites of neotropical migrant songbirds (Robinson et al. 1993). To be most effective in providing suitable habitat for wildlife reliant on interior forest conditions, spatial relations between pine plantations, other forest cover types, and adjacent land use should be appraised on a multi-stand or larger landscape level.

Landscape-level Considerations

The value of a plantation as wildlife habitat is affected by the management administered within the stand and relations to surrounding land uses. Most management for forest-dependent wildlife occurs at the stand level, but the long-term provision of habitat and wildlife populations is best manipulated over larger spatial scales (Harris 1984; Hunter 1990). The question of how prescriptions should be applied to manage a mosaic of stands and land uses to benefit wildlife is, however, less clearly understood than are stand-level applications (Bunnell and Kremsater 1990). The diverse goals of NIPF landowners, multiple ownerships, and divergent needs of wildlife species further complicate integration of long-term, landscape-scale and regional-scale habitat management.

Among individual ownerships (e.g., farm to multi-farm), pine plantations situated adjacent to existing riparian woodlands may provide greater habitat value than stands embedded within surrounding agricultural fields. The juxtaposition of older trees in adjacent established stands can enhance vegetation diversity and promote interstand movement of wildlife. Wooded corridors along streams and small patches of existing forest cover interspersed with plantations can provide additional cover, enhanced dispersal, and higher long-term habitat values (Franklin and Forman 1987). Vegetated leave strips and streamside management zones elevate interspersion and habitat quality for several species of wildlife associated with pine plantations (e.g., Johnson and Landers 1982; Burk et al. 1990a; Melchiors 199 1). In general, the value of these linear habitat features increases in response to greater width.

Federal forest management assistance programs and policies hold potential to enhance NIPF contributions to landscape-level or regional wildlife management and conservation objectives (Harris 1985; Dunn et al. 199 1; Rudis and Tansey 1995). Ideally, plantations should be designed to enhance natural attributes of the landscape by increasing the diversity of vegetation cover and habitats (Corona 1993). In regions of intensive agriculture or urban expansion, tree plantations can increase the effective size of riparian zones and furnish greater connectivity between isolated forest remnants (Fig. 7). Pine plantations should not displace hardwood-dominated riparian woodlands but rather be situated adjacent to existing riparian zones. These plantations would provide additional cover suitable for wildlife movement and buffer aquatic habitats from sediment- and chemical-laden runoff from adjacent croplands and urban areas.

Fragmentation of forest ecosystems is believed to be a key factor contributing to declines in reproductive success and distribution of some species of forest birds (Robinson et al. 1995). Using plantations to "buffer" isolated forests from surrounding land use and restore large "core areas" of forest cover may provide benefits to wildlife species dependent on forest-interior conditions by increasing the effective area of remnant forest stands. Planting species historically present on the site probably provides the greatest benefits to indigenous wildlife. However, even pure stands of loblolly pine, particularly if managed to increase within-stand diversity, would furnish more habitat for forest-dependent wildlife than would nonforested land uses.

Habitat Relations of Selected Species to Pine Plantations

The following text provides a synopsis of some relations between pine plantations and use by wildlife.

Eastern Wild Turkey

The future of the eastern wild turkey (*Meleagris gallopavo silvestris*) in the Southeast is closely linked with timber management practices and interspersion of forested cover with other land uses (Holbrook 1973). The effects of intensive production of forest products in even-aged pine monocultures potentially influence the distribution and quality of turkey habitat mote than any other limiting factor in the Southeast (Kennamer et al. 1980). The impacts of even-aged management of southeastern pines on eastern wild turkey populations have been of concern. However, the adaptability of the species has been underestimated, and turkey populations do exist in

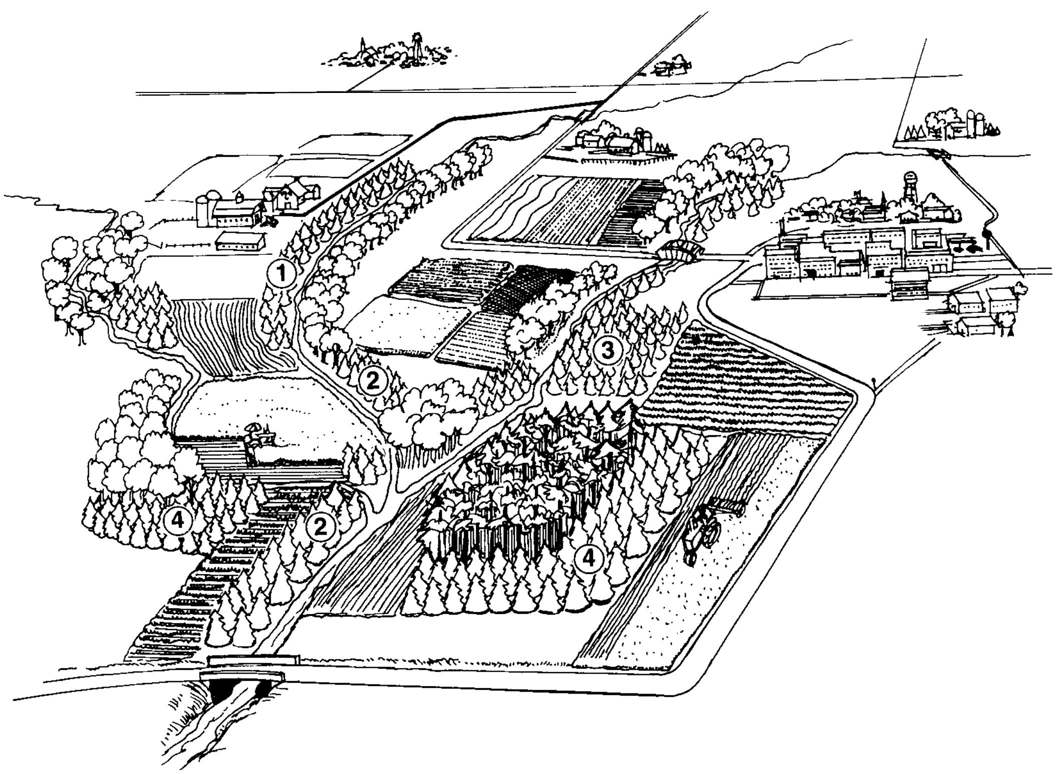

Fig. 7. Hypothetical contributions of NIPF pine plantations to landscape-level wildlife habitat issues. 1. Plantations established on croplands adjacent to surface waters could contribute to decreased amounts of surface runoff entering aquatic habitats. 2. Tree-dominated linkages between isolated tracts of riparian or upland forest could be established or enhanced with pine plantations. 3. Plantations could improve the diversity of habitat types in otherwise intensively farmed landscapes. 4. Pine plantations established adjacent to remnant tracts of deciduous woodlands or forests of special concern (e.g., longleaf pine) may buffer these tracts from the negative effects of adjacent land use.

association with intensively managed pine forests (Exum et al. 1987). Holbrook et al. (1987) stated that it was questionable whether turkeys could adapt to intensive management of Piedmont pine forests, but concluded that their research did not support the contention that conversion of mixed hardwood stands to loblolly pine plantations would eliminate turkey habitat. Most of the southeastern states have experienced an increase in wild turkey populations in recent years. Of 13 southeastern states, only Virginia reported declines in the estimated size of turkey populations between 1986 and 1989, while Alabama and Mississippi reported stable populations during this period (Kennamer and Kennamer 1990).

High quality wild turkey habitat in the southeastern United States is composed of mature stands of mixed hardwoods with relatively open understories interspersed with scattered clearings and groups of sawtimber-sized conifers. Holbrook et al. (1987) concluded that pole-sized and younger stands are of little value except as escape cover. Recent investigations, however, suggest that turkeys are more adaptable than previously recognized and that pine plantations managed under short rotations can provide important seasonal habitat (Exum et al. 1987; Lambert et al. 1990; Smith et al. 1990; Palmer et al. 1993). In Alabama, older (≥14 years) pine stands were the most highly utilized cover type throughout the year (Exum et al. 1987). Although younger stands of pine provided greater amounts of vegetative food, the stands were avoided by turkeys and thought to be too dense to permit adequate mobility.

Turkey nests are typically located in sites where the hen is concealed but not restrained from moving off the nest (Exum et al. 1987; Holbrook et al. 1987). Edges between vegetation types provide desirable nesting cover because of the increase in nearby forage diversity and cover density resulting from greater light penetration. Hen turkeys in Mississippi used loblolly pine plantations for nesting and brood rearing (Burk et al. 1990b). Of the hens monitored by Burk et al. (1990b), 81% nested in 13- to 20-year-old plantations that had been commercially thinned on an average of 4 years and had been control-burned on an average of 3 years prior to use. Plantations that had not been burned for more than 2 years were almost entirely avoided by hens. All hens monitored in another Mississippi study nested in pine plantations (Smith et al. 1990). All but one nest were located in 17- to 19-year-old plantations that had been commercially thinned and control-burned within the previous 6 years. Pine plantations were used by turkeys more than expected based on availability during all seasons except winter. Habitat for turkey broods in Alabama was characterized as high quality in older pine plantations (10 years) that had lush herbaceous vegetation and a high degree of visibility at a height of 0.5 m (Exum et al. 1987).

Pine uplands left unburned for l-3 years were generally avoided but did provide highly preferred nesting habitat for turkeys in southern Georgia (Sisson et al. 1990). Sisson et al. (1990) suggested that provision of suitable nesting cover within pine-dominated forests may be enhanced by excluding fire in scattered sites to permit development of hardwood understories. Survival rates of nesting and brooding hens in mid-rotation-aged (mean age = 16 years) pine plantations in Mississippi were similar to rates recorded for hens in more traditional habitats such as mature hardwood forests and mixed forest associated with agricultural lands (Palmer et al. 1993). Similarly, Exum et al. (1987) concluded that no habitat types used for nesting in their Alabama study were any less vulnerable to predation on turkeys than any other types.

Intensively managed pine forests can support populations of eastern turkeys as long as overall habitat diversity is maintained and plantations are linked with other vegetation types by corridors that permit dispersal and movement (Gehrken 1975). Mosaics of land use and vegetation composition provide habitat diversity and enhance spatial and temporal partitioning of habitat use. A high degree of interspersion between pine plantations, farmland, and hardwood-dominated streamside buffer strips facilitated habitat segregation in agriculturally dominated landscapes in Louisiana (Lambert et al. 1990).

Streamside management zones associated with loblolly pine plantations provided higher quality habitat for turkeys than did plantations lacking riparian buffers (Burk et al. 1990a). Streamside management zones were used for travel, roosting, feeding, and perhaps thermal regulation. Larger streamside zones (≥80 m wide) were recommended over narrower zones. Hardwood dominated leave-strips enhance a pine plantation's habitat value because they provide protective cover and increased habitat diversity (Holbrook et al. 1987).

Management Considerations

Large areas in stands <30 years old reduce turkey habitat quality (Holbrook 1973). Young, densely stocked sapling and pole-stage stands provide little escape cover. Several studies have documented the importance of relatively frequent burning to encourage vigorous growth of herbaceous vegetation and greater abundance of insects necessary forturkey broods (Holbrook 1973; Exum ct al. 1987; Burk et al. 1990b; Smith et al. 1990). Winter burning results in earlier green-up, improves the palatability and nutritional quality of understory plants, and may contribute to greater abundance of insects during the subsequent summer and fall (Holbrook 1973). Burning, as well as other types of vegetation management, should be avoided during the nesting season.

The suitability of young pine plantations for turkey habitat could be enhanced by planting trees in rows wide enough to permit access for mowing or disking of vegetation between rows (Sisson et al. 1990). Commercial thinning of pine plantations that removed every fourth row of trees created travel lanes and appeared to increase the abundance of herbaceous forage, seeds, and soft-mast-producing plants (Palmer et al. 1993).

Northern Bobwhite Quail

Because they support physical and vegetative successional characteristics similar to old fields, pine plantations provide high quality habitat for northern bobwhite quail (*Colinus virginianus*) during the initial 2 to 7 years following stand establishment (Landers and Mueller 1986; Stauffer et al. 1990; Brennan 199 1). Young age-class plantations typically furnish abundant foods and vegetative cover. However, as densely stocked plantations mature and canopies close, habitat quality declines. Preferred annual and perennial food plants were plentiful in 3-year-old Georgia plantations (Brunswig and Johnson 1973). The abundance and diversity of annual species decreased sharply after the third year, while perennial species exhibited a more gradual decline. Increasing closure of the pine canopy and greater competition from hardwoods and other woody species contributed to diminished habitat quality in older plantations. Food plants in older plantations were associated with small openings where survival of planted trees was poor.

Robinson and Barkalow (1979) reported that the conversion of coastal plain pocosins to pine plantations resulted in temporary enhancement of bobwhite quail habitat through creation of edge and an elevated abundance of preferred foods. The authors concluded, however, that as the pine canopy closed, quail populations could be expected to decline to as low as 10% of the number found following plantation establishment. Quail numbers may remain relatively stable in parts of pine plantations associated with ditches, windrows, roadsides, brush piles, densely vegetated drains, and other sites that maintain structural diversity (Brunswig and Johnson 1973; Robinson and Barkalow 1979).

Management Considerations

Early and consistent application of prescribed fire and implementation of single-tree selection provide the key opportunities to maintain and improve bobwhite quail habitat associated with southern pine plantations (L. Brennan, Tall Timbers Research, Inc., Tallahassee, Florida, personal communication). Use of prescribed fire in pine plantations is generally too little and too late to furnish substantial quail habitat improvement. Silvicultural systems that produce revenue from selective harvest of mature loblolly and longleaf pine can provide economic return and quail habitat. Fire and selective tree harvest maintain vegetative and structural diversity essential for the long-term maintenance of quail habitat.

Wide initial spacing of trees and thoughtful thinning are required to maintain vegetation composition favorable to bobwhitequail. Longer-term habitat quality could be elevated by using the lowest planting rate that is commercially viable (Brennan 1991). Landers and Mueller (1986) recommended a stocking rate at 1.8 m x 3.6 m (600 trees/0.4 ha) or 2.4 m x 3.6 m (450 trees/O.4 ha) to maintain suitable habitat for quail. They also endorsed variance in tree density throughout, rather than uniformly thinning an entire stand. Dissimilarity in tree density permits a more diverse understory, providing improved habitat over that present in a uniformly thinned stand.

Stands containing a mixture of pines, oaks, and midstory trees (e.g., flowering dogwood [*Cornus florida*]) provide better habitat than monotypic stands, regardless of species (Landers and Mueller 1986). Longleaf pine seeds are nutritionally rich and preferred by quail over other pine seeds. Rows or clusters of this species within otherwise pure stands of loblolly pine may increase the habitat quality for quail and other species of wildlife. Robinson and Barkalow (1979) suggested that the best habitat is an assorted distribution of age-classes that provides interspersion of young and older stands. Smaller plantations interspersed with other land uses may be less detrimental to local quail populations than large extensive stands (Stauffer et al. 1990).

Production of hard and soft mast, as well as other preferred foods, within pine plantations could be enhanced through provision of small openings throughout the stand (McRae et al. 1979). Landers and Mueller (1986) recommended 0.8-2.0 ha of openings per 8-12 ha of pine. To maximize the amount of edge, and possibly reduce predation rates, they recommended narrow openings in a winding configuration instead of square openings. Within larger plantations, large-scale, extensive prescribed burning should be avoided in favor of more patchy burns that maintain a mosaic of understory vegetation. Because species diversity and seed production of herbaceous vegetation is higher in disked than in burned areas (Buckner and Landers 1979), disking of plantation edges, fire lanes, or other openings is a practical, beneficial management alternative to burning in smaller plantations.

Nongame ***Birds***

Pine stands potentially supply herbaceous strata that provide suitable nesting cover for ground-nesting birds, seeds and invertebrate forage associated with trees and understory vegetation, and a woody understory for shrub-dependent species (Johnson and Landers 1982). Bird species richness and density in forest ecosystems, including pine plantations, generally are positively correlated with stand foliage volume and diversity (Noble and Hamilton 1976; Childers et al. 1986; Dickson et al. 1993). Consequently, the number and density of avian species using even-aged pine plantations can be enhanced by providing greater diversity in vegetation structure (Noble and Hamilton 1976).

Diversity and density of avian species associated with plantations are typically high in young stands, decrease in pole-sized stands, and are highest in older stands that contain diverse foliage strata. Pine plantations managed on a pulpwood rotation (≤30 years) provide habitat for early successional species but have limited suitability for birds requiring stand characteristics beyond pole timber stage (Dickson et al. 1993). Abundance and richness of avifauna were higher in thinned stands with greater variance in vegetation structure than in stands that had not been thinned.

Childers et al. (1986) concluded that establishment of loblolly pine plantations produced habitat for a variety of breeding and permanent resident songbirds. Species composition and densities changed in response to the physical characteristics and diversity of vegetation. Vegetation conditions in the initial 5 years following tree establishment provided habitat for early-succession-associated songbird species (e.g., field sparrow [*Spizella pusilla*], indigo bunting [*Passerina cynnea*]). An absence of mid- and under-story vegetation characteristic of older, intensively managed plantations, supported a lower diversity of avian species. Similar results were reported by Johnson and Landers (1982) for bird species affiliated with slash pine plantations. The number of birds recorded was lowest in 1-year-old stands, increased in 2- to 6-year-old stands, and declined until mid-rotation age (16 years). After plantations were about 28 years old, no difference in the composition of avifauna was detectable based on whether the stand had been planted or had become established through natural regeneration.

More bird species winter in southeastern pine-hardwood forests than in loblolly, shortleaf, or oak-hickory forests (Kerpez and Stauffer 1989). Although conversion of pine-hardwood stands to loblolly or shortleaf-dominated stands would not eliminate avian habitat, it would probably decrease the number of bird species provided with suitable habitat because bird species diversity decreases as the amount of hardwood present in pine stands is reduced (Noble and Hamilton 1976; Dickson et al. 1993; Thompson et al. 1993). Conversion of second-growth forest to pure loblolly pine in small scattered stands, however, does not appear to adversely affect regional diversity of avifauna (Childers et al. 1986).

Management Considerations

Pine forests of the southeastern coastal plain provide seasonally important avian habitat (Shugart et al. 1978). Few efforts to enhance habitat for nongame birds, particularly those species associated with forests, will be successful without involving private landowners (Wigley and Sweeney 1993). Provision of nongame bird habitat often occurs incidental to management for other forest and wildlife resources (Myers and Johnson 1978); therefore, decisions that benefit other species of wildlife, which may hold greater importance to private landowners, may benefit nongame birds as well.

Riparian woodlands provide vital breeding, wintering, and migratory habitat for many southeastern nongame birds (Hunter et al. 1993). Hardwood-dominated inclusions and drainageways enhance edge and increase habitat diversity, resulting in greater avian use of pine plantations (Johnson and Landers 1982). Locating pine plantations on land formerly in agricultural production and adjacent to existing riparian zones probably will furnish greater habitat values for nongame birds than would plantations isolated within annually tilled land.

The value of pine plantations as avian habitat when surrounded by agricultural lands may be improved by applying concepts used for improving habitat quality associated with shelterbelts. Schroeder (1986) found that year-round use by avian species was enhanced when two or more rows of shrubs were located between trees and crop fields. Creation of soft edges between the plantation and adjacent cropland could be accomplished with a combination of shrubs and native warm-season grasses. Avoiding straight-line boundaries may also improve habitat quality for some wildlife species by increasing the amount of edge per unit area.

Short-rotation pine stands typically lack cavities, understory nest strata, and high-energy fruits and mast necessary for many songbirds (Conner 1978; Myers and Johnson 1978). More nongame bird species occurred in loblolly pine plantations that contained snags than in stands devoid of snags (Dickson et al. 1983). Snags remaining in 1- to 3-year-old plantations increased the diversity of birds present (Johnson and Landers 1982). Nest boxes in plantations provided nest sites for some cavity-dependent avian species (Hurst 1981).

Cavities are inherently rare in southern yellow pines; however, loblolly and pond pine were more prone to develop cavities than were slash and longleaf pines in South Carolina and Florida (McComb et al. 1986). Leaving remnant hardwood trees and establishing hardwood-dominated leave-strips may increase availability of habitat for cavity-dependent birds (McComb and Noble 1980). The provision of cavities within live trees has greater long-term benefits to cavity-dependent wildlife than does retention of existing dead trees (Harris and Skoog 1980). Management actions should favor tree species most likely to develop cavities. For example, selection of "leave trees" favoring black oaks (*Quercus velutina*) and scarlet oaks (Q. *coccinea*) *over* hickories (*Carya* spp.) and white oaks (Q. *alba*) would increase the likelihood of cavity availability (Allen and Corn 1990). Red maple (*Acer rubrum*), tupelos (*Nyssa* spp.), and laurel oak (Q. *laurifolia*) are particularly susceptible to cavity formation in South Carolina and Florida (McComb et al. 1986).

Uniform spacing of trees may reduce bird species diversity (Roth 1976). Wider, more variable spacing of pines and limited control of hardwood regeneration favor well-developed understory, sub-canopy, and diversity of vegetation, resulting in higher quality habitat for nongame birds than that typical of densely stocked, even-aged stands. Frequent thinning in older, pole-sized or larger stands enhances understory diversity and habitat quality for nongame birds (Conner et al. 1983). Preservation of windrows and logging slash can support plant communities different from adjacent planted areas, enhance edge, and improve habitat quality for avian species (Myers and Johnson 1978).

If wildlife habitat is a high priority, intensive mechanical site preparation and broad-scale use of herbicides should be minimized to maintain hardwood regeneration and shrub species that furnish food and cover for wildlife associated with the early stages of plantation development (Stransky and Halls 1980; Dickson et al. 1984). Site preparation methods affected avian species numbers and diversity in young loblolly pine plantations in Mississippi (Darden et al. 1990). Herbicide applications, which required little physical alteration of habitat, left snags, perches, and logging debris favoring higher avian use than recorded in mechanically prepared sites. Impacts of site preparation methods on avian use diminished as pine trees became dominant. Because the abundance of shrubby, fruit-producing vegetation declines in pine plantations in a few years (Stransky and Roese 1984), application of management to maintain conditions favoring the presence of these species would extend the period of use by avian species. Shrub and vine growth on lands formerly in agricultural production is lower than on lands previously in forest cover (Stransky and Halls 1980). Fertilization of young plantations of loblolly pine increased total mast production and reversed the downward trend in fruit production as the stand aged (Campo and Hurst 1980).

White-tailed Deer

The white-tailed deer (*Odocoileus virginianus*) is of foremost importance to NIPF landowners of the Southeast. Deer provide one of the greatest economic returns of any game species throughout the region. The impact on white-tailed deer habitat of converting second-growth native hardwood and pine-hardwood forests to pine plantations is a concern (Felix and Sharik 1986; Speake 1970). A significant loss in diversity of food supplies can result when hardwood and hardwood-mix forests are converted to pine plantations (Felix and Sharik 1986; French et al. 1986; Johnson et al. 1986; Wentworth et al. 1987, 1990a, 1990b; Rogers et al. 1990). Yet some believe that deer do well in much of the South with only a limited supply of hard mast (T. Melchiors, Weyerhaeuser Company, Hot Springs, Arkansas, personal communication). Pine plantations do provide cover for deer, and in their early stages they provide a substantial food source as well. However, native second-growth forests are much more likely to provide a year-round food supply for deer (Felix and Sharik 1986). White-tailed deer are highly adaptable, and viable options that are compatible with timber production exist to enhance deer habitat.

Because they generally supply adequate food, cover, and water more readily, it is presumed that more diverse landscapes meet the needs of white-tail deer better than less diverse ones. Deer have smaller home ranges in more diversified habitats, seldom ranging over 3.2 km in southem forested landscapes (Wildlife Management Institute 1984). Management that increases diversity within and among stands usually improves habitat. Optimal habitat in southern forest ecosystems is provided by a mosaic of various-aged pine plantations and second-growth hardwood and pine-hardwood forests (Felix and Sharik 1986). However, even if not well interspersed among mature hardwood or hardwood-mix forests, pine plantations can still be managed to meet white-tailed deer life requisites.

Management Considerations

Many applications that promote timber production can enhance white-tailed deer habitat with little or no sacrifice of timber production (Halls 1973; Hurst et al. 1980; Hurst and Warren 1982; Warren and Hurst 1984; Maguire 1987). Silvicultural techniques that promote a flush of undergrowth generally benefit deer (Melchiors 1991). Prescribed burning, thinning, and erosion control efforts can all be compatible with white-tailed deer habitat. However, if long-term effects are not taken into consideration, these techniques may provide only seasonal benefits.

Prescribed burns prevent hardwoods from reaching the canopy and competing with pines and can have positive and negative effects on deer habitat quality. Blair and Feduccia (1977) asserted that a dense hardwood midstory in growing plantations can shade out undergrowth of herbaceous forage. Periodic fires can prevent formation of a dense hardwood midstory. Also, routine prescribed burns keep hardwoods from exceeding deer browsing reach and promote multiple sprouting from root systems, thereby increasing available browse (Blair and Feduccia 1977). In general, browse (Johnson et al. 1986) and herbage yields increase following midstory removal in mature plantations (Blair and Feduccia 1977). Eliminating hardwoods or keeping them from reaching reproductive stages, however, prevents production of valuable mast that is generally available when browse and herbaceous forage quality and quantity are limited (Melchiors 1991).

Hard mast is especially important on infertile forestlands in the South during years when herbaceous forage is negatively impacted by harsh weather (Wentworth et al. 1990b). Unless plantations are well interspersed among mature hardwood or hardwood-mix forests, some hardwoods within or adjacent to plantations should be allowed to reach reproductive maturity to provide acorns in fall and winter. The U.S. Forest Service (1980) recommends maintaining 20% of the land base in mast-producing hardwoods in pine forest types. Management to attain hard mast production should include cooler (e.g., winter) and longer rotation (3-5 year) burns. Too-frequent burns prohibit hardwoods from reaching fruit-bearing age or attaining sufficient size to resist fires and may eradicate hardwoods from the stand (Melchiors 1991). To attain reproductive-age hardwoods, selected portions of stands can be excluded from burns, at least until trees are of tire-resistant size (Warren and Hurst 1984). Hardwoods should be interspersed with pine stands so that mast is located near the cover furnished by pines.

Thinning is another silvicultural application that enhances white-tailed deer habitat. Thinning pine stands opens up the canopy and promotes understory herbaceous and midstory hardwood growth. Thinning pine plantations should be done whenever a stand is approaching or has already reached canopy closure to stimulate understory herbaceous and midstory hardwood growth and provide food and cover for deer. Thinning can be done selectively or in corridors that can provide travel lanes adjacent to pine cover frequently used by deer (Maguire 1987). One effective thinning method is to remove selected rows of trees. Resultant corridors promote structural diversity within stands and provide wildlife travel lanes. Maguire (1987) found that ungulates used such corridors more often than clearcuts or forests. These corridors provide easy access and usually contain more herbaceous forage than adjacent forests.

Erosion control can also benefit deer. Erosion control usually involves planting or maintaining naturally occurring vegetation (also called wildlife food plots) within pine plantations. When established on log landings, thinning corridors, old skid roads, roadsides, and so forth, these openings or clearings can be maintained as wildlife food plots either in natural or planted vegetation (Melchiors 1991); deer use these extensively. The common planting is either a cool-season grass or a cool-season grass and legume mix.

Species composition, nutritional quality, seasonal availability, and location of food plots should be considered so that native forage is supplemented (Melchiors 1991). Because each site has unique characteristics, local biologists and extension agents should be consulted to help determine appropriate plant species or mixes, fertilizers, planting methods, and so forth. Food plots can be strategically located to increase habitat or landscape-level diversity. They are best located in areas where there is little habitat in early successional stages (Melchiors 1991).

Plantation regeneration techniques can differentially affect habitat diversity. Clearcutting and planting have the most noticeable and immediate impact and promote rapid canopy development, while shelterwood and seedtree systems maintain some canopy layering and provide habitat heterogeneity at a stand level (Melchiors 1991). Single-stem and group selection harvest techniques allowing natural regeneration, impact habitat and wildlife the least and in mature, dense stands help to open up the canopy, promoting undergrowth and structural diversity while maintaining overstory cover. Partial harvests such as these can be used to increase within-stand diversity and habitat quality. Any of these regeneration systems can be applied strategically across forested regions to enhance diversity on habitat and landscape scales.

Hardwood-dominated riparian zones can provide a substantial supply of mast, enhance vegetation diversity, increase connectivity between habitat types, and improve cover and overall quality of white-tailed deer habitat (Melchiors 1991). To preserve the wildlife benefits provided by riparian zones, it may be best to harvest timber by individual tree- or group-selection methods rather than by shelterwood, seedtree, or clearcut methods (Melchiors 1991).

Other techniques to increase habitat diversity for deer in pine plantations include distributing timber management applications to create a mosaic of vegetation types. Young loblolly plantations should be located next to postcanopy-closure stands so that during harsh weather ample cover is provided near a dependable food source (Felix and Sharik 1986). Other techniques to increase diversity include varying tree spacings when planting, patchy burns and thinnings, and timber harvest at spatial and temporal intervals that produce uneven-aged stands. Uneven-aged stands allow for management of within-stand patchiness, canopy layering, and mixed species composition (Melchiors 1991). By planting trees at wider intervals, canopy closure is delayed, and the benefits gained from earlier vegetation stages are prolonged.

Small *Mammals*

Abundance and diversity of small mammal species are greater in young age-class plantations than in older age-class stands where the tree canopy has reduced the variety and quantity of herbaceous and shrubby understory vegetation. One-year-old loblolly pine plantations in Georgia supported dense stands of annual food plants (e.g., horseweed [*Erigeron canadensis]* and ragweed *[Ambrosia artemisiifolia*]) for seed-eating small mammals (Atkeson and Johnson 1979). By the third year following establishment of plantations, herbaceous vegetation was dominated by perennial grasses and low-growing forbs, supporting a greater abundance of herbivorous small mammals. As the pine canopy closed, herbaceous vegetation became less abundant, with a concurrent decline in the abundance of small mammals. By 15 years, unthinned loblolly plantations contained few small mammals. White-footed mice *(Peromyscus leucopus*) were most abundant in new plantations, with a consistent decline in abundance as plantations aged. Cotton rats *(Sigmodon hispidus*) were recorded in plantations of all age classes but appeared to be most abundant in 1- to 3-year-old stands. In contrast, golden mice *(Ochrotomys nuttalli)* were recorded in plantations of all age classes but were most abundant in 7-year-old stands. The greatest biomass of all animals captured was recorded in 3- to 4-year-old plantations. Biomass declined sharply subsequent to tree crown closure.

Streamside management zones provide water quality benefits and greater habitat diversity and affect habitat quality for small mammals associated with pine plantations as well (Dickson and Williamson 1988). Greater numbers of small mammals were captured in narrow (mean width = 25 m) zones than in medium (30–40 m) or wide (50 m) streamside management zones associated with loblolly pine plantations. Narrow zones lacked a tree overstory, permitting dense growth of brush and herbaceous vegetation and furnishing habitat more suitable for species such as white-footed mice and fulvis harvest mice *(Reithrodontomys fulvescens).* Medium to wide zones were characterized as having sparse understory vegetation due to shading of hardwood-dominated overstory vegetation, resulting in lower diversity and abundance of small mammals.

Management Considerations

Langley and Shure (1980) concluded that diversity in foliage height and the amount of litter on the ground surface were important variables that defined habitat quality for small mammals in pine plantations. Actions that retard growth of trees, or delay crown closure, could be used to increase in-stand diversity and furnish desirable habitat for small mammals (Atkeson and Johnson 1979). Wider spacing of trees also would maintain habitat for a greater diversity of small mammals.

Habitat features that sustain small mammal populations and vegetation diversity can be assumed to improve habitat quality for predators of small mammals in forested habitats (McGarigal and Fraser 1984; Allen 1988; Reynolds et al. 1992). For example, gray fox *(Urocyon cinereoargenteus)* habitat in forest ecosystems could be improved through provision of grass-dominated openings, a greater abundance of fruit-bearing shrubs, and other measures that increase interspersion between stand age classes (Fritzell 1988).

Gray and Fox Squirrel

Although pine seeds may be a seasonally important food (Loeb and Lennartz 1989), pine monocultures furnish inadequate habitat for tree squirrels because of the absence of hard mast and cavities associated with deciduous trees (McElfresh et al. 1980). Edges between pine stands and hardwoods may be an important habitat component for fox squirrels *(Sciurus niger).*

Management Considerations

Habitat can be improved by establishing or leaving strips of hardwood-dominated cover associated with terrain features that represent lower quality sites for pine regeneration (McElfresh et al. 1980). McElfresh et al. (1980) concluded that squirrel populations inhabiting isolated units of hardwood-dominated cover within plantations are unsustainable. Ideally, hardwood-dominated leave-strips or stringers should be connected to larger units of deciduous forest to permit emigration and dispersal. The habitat quality of streamside management zones within pine plantations for fox and gray squirrels (S. *carolinensis)* increased in response to greater width (Dickson and Williamson 1988). Locating plantations adjacent to existing mature forests will elevate their habitat quality for squirrels.

Conclusions

To meet growing demands for timber products and still maintain regional environmental priorities, forest management standards are needed that place greater significance on optimum rather than maximum production of wood products (National Research Council 1990). U.S. Department of Agriculture Cooperative Forestry assistance programs have exceptional opportunities to improve the economic returns, as well as nonmarket benefits, associated with private forestlands and to address state or regional wildlife habitat priorities. Contemporary policies of the USDA and Cooperative Forestry Assistance programs continue to improve the quality of renewable forest resources on private lands and increasingly strive to solve environmental problems that transcend the boundaries of managed stands.

Owners of nonindustrial private forestlands frequently place emphasis on nonutilitarian returns that include habitat for wildlife. Because of their relation to surrounding land use, and the desire of many private landowners to obtain maximum yields, not all forestlands have the potential to contribute to landscape-level habitat priorities. Individual forest landowners may, however, enhance wildlife habitat locally. Within specific ownerships the quality and duration of wildlife habitat associated with pine plantations can be increased through relatively simple methods that increase vegetation diversity within and in association with even-aged plantations.

The cumulative decisions made by multiple owners may affect long-term quality of habitat on a regional scale. To address how the location, composition, and management of pine plantations could contribute to regionally important habitat priorities, USDA Cooperative Forestry Assistance programs should actively solicit specific guidance from federal and state fish and wildlife agencies, as well as nature conservancy and natural heritage groups. When appropriate, silvicultural prescriptions for privately owned pine plantations should be modified to contribute to larger landscape- and regional-level objectives. Changing demographics and NIPF priorities imply that wildlife habitat improvement, as well as aesthetic and environmental concerns, would make such adjustments acceptable to a large number of these individuals.

Privately owned forestlands will continue to be a major source of wood products in the southeastern region. Southeastern landscapes have become resources to manage rather than ecological systems to preserve. Land use decisions on private and public lands increasingly are influenced by social, ethical, and environmental considerations of a diverse owner population. U.S. Department of Agriculture Forestry Assistance programs have the capability to produce needed commodities and address broader environmental values. Intensively managed pine plantations provide habitat, but their contributions could be enriched by developing within-stand diversity and increased attention to landscape-level wildlife habitat issues.

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Appendix. Recommendations for improving wildlife habitat associated with even-aged, pine plantations in the southeastern United States. Recommendations are based on information provided by wildlife biologists and represent generalized concepts for enhancement of wildlife habitat. The appropriateness of individual recommendations will vary in response to specific wildlife habitat management objectives.

General

Advocate and fund greater on-ground design and management involvement by federal and state fish and wildlife agency personnel and other resource professionals in cooperation with state forestry agencies.

Expand NIPF landowner education and outreach programs to address forest ecology, forest-related wildlife management, and to train landowners to become more proficient in habitat management, especially late-winter and early-spring prescribed bums.

Improve USDA forestry assistance programs to address regional, landscape-level conservation and environmental issues: for example, increase use of plantations to link isolated fragments of forest; supplementing width of tree-dominated riparian corridors.

Cost-share early stand treatments such as noncommercial thinning and prescribed burning.

Elevate priority and cost-share rates for establishment of multi-species stands and plantations that address wildlife, aesthetic, recreational, and landscape diversity over those designed and managed exclusively for economic gain.

Species Composition

Diversify pine species.

Advocate long-leaf pine on appropriate sites.

Advocate establishment of mixed pine-hardwood stands over monocultures.

Prohibit conversion of bottomland hardwood-dominated or mixed hardwood-pine stands to pine plantations.

Establish cost-sharing to reestablish hardwood-dominated stream corridors.

Discontinue funding plantation establishment in streamside corridors dominated by hardwoods or hardwood-pine stands.

Place greater emphasis on restoration of forested cover types dominated by native species, for example, shortleaf pine-loblolly pine-hardwoods, longleaf pine, oak-hickory.

Encourage planting of the best genetically improved pine seedling stock for faster growth.

Appendix. Continued.

Management

Encourage, or require, precommercial thinning.

Encourage commercial thinning of young age-class stands.

Increase flexibility in tree stocking rates to address wildlife objectives as well as timber production.

Advocate and initiate prescribed burning of younger stands (e.g,, 4.5 m tree height, 10 cm dbh).

Encourage longer rotations to establish sawtimber-dominated stands.

Encourage partial harvest of stands to establish multi-age plantations.

Emphasize low-intensity mechanical site preparation over use of herbicides. When herbicides are needed, favor those products that have minimal effect of plant species important to wildlife. Emphasize direct application of herbicides rather than broadcast or aerial applications.

Size and Configuration

Limit plantation size to 20 ha or smaller.

Establish irregular rather than linear plantation boundaries.

Establish or preserve hardwood corridors and firebreaks-roads planted to herbaceous cover to increase diversity within extensive plantations.

Cost-share establishment of permanent firelanes and within-stand access roads at time of stand establishment. Plant borders of tire lanes-roads to legumes or wildlife food plots.

Plant pines at wider spaces within rows (e.g., 2.4 m apart).

Encourage wider spacing between tree rows (e.g., 3.6 m) to permit disking or other management practices to maintain herbaceous cover.

Establish a ratio of 0.4 ha of permanent opening per 8 ha of trees within plantations> 20 ha.

Advocate hardwood inclusions.

Maintain remnant stands of hardwoods along field borders and drainages adjacent to and within plantations.

Establish soft borders between plantations and agricultural lands by planting, or encouraging growth of, shrubs, herbaceous cover, legumes, and native warm-season grasses.

A list of current ***Information and Technology Reports*** follows:

1. Population Biology of the Florida Manatee, edited by Thomas J. O'Shea, Bruce B. Ackerman, and H. Franklin Percival. 1995.287 pp.
2. Effects of Fire on Threatened and Endangered Plants: An Annotated Bibliography, by Amy Hess1 and Susan Spackman. 1995.55 pp.

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