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Bird Communities Associated With Succession and Management of Loblolly-Shortleaf Pine Forests

Joseph M. Meyers and A. Sydney Johnson[1/]

Abstract.--Published data from 17 winter and 32 summer bird censuses were used to determine changes in bird species composition, richness, and density in relation to plant succession and forest management in loblolly-shortleaf pine forests. Recommendations for habitat management are offered.

INTRODUCTION

Birds are a major faunal component of our forests. They are becoming a more valued recreational resource as man modifies and eliminates forests (Payne and DeGraaf 1973). Birds are useful as indicators of hazardous environmental conditions; the cases of DDT and PCB's provide good examples of how bird populations can forewarn us of potential hazards of pollutants. Bird populations, because of their great mobility, are important seed dispersers and vectors of diseases (Shugart et al. 1975). However, there are few data relating to the ecological roles of birds in forest ecosystems. Research on this subject has been emphasized for less than two decades and has established only a basic understanding of forest avifauna.

Likewise, forest management for birds other than a few game species has received serious consideration only recently. In the past wildlife management was synonymous with game management. "Nongame" management--management of wildlife other than game and commercially important species--is largely a product of increased environmental awareness in the 1970's. But, the term "nongame" is a vague one that does not describe animals; it only tells us what they are not. Wildlife management should not be approached on game and nongame terms but on a holistic basis with consideration for entire plant and animal communities. The purpose of this paper is to describe the possible bird communities that are associated with successional stages of loblolly-shortleaf pine (Pinus taeda-P. echinata) forests and how they can be managed in ways compatible with sound management of other forest resources.

THE LOBLOLLY-SHORTLEAF PINE PLANT COMMUNITY

The loblolly-shortleaf pine forest type, a major component of the southeastern forest (fig. 1), is widely distributed throughout the Southeast in both the Piedmont and Coastal Plain provinces, except in Florida and Tennessee. The loblolly-shortleaf type includes forests composed of 50 percent or more loblolly pine, shortleaf pine, and other southern pines, except longleaf (P. palustris) and slash (P. elliottii). Loblolly and shortleaf pines occur separately or in combination and are commonly associated with oak (Quercus spp.), hickory (Carya spp.), and sweetgum (Liquidambar styraciflua) (U. S. Forest Service 1969).

Loblolly-shortleaf forest is a subclimax or developmental stage in a successional sere leading to oak-hickory climax. Oak-hickory and other hardwoods formed the original cover of much of the region (Oosting 1942, Wahlenberg 1949). But, in the Coastal Plain large areas were forested with subclimax pines. Fire, and agriculture practiced by the Indians were important factors in arresting succession. Even in the Piedmont, extensive pine forests occurred on dry upland sites on gray soils derived from granite, gneiss, sandstone, or slate; hardwoods dominated sites on red clay loams (Pinchot and Ashe 1897, Harper 1943, Nelson 1957, Brender 1974).

Land Use History

Beginning late in the 18th Century, a wave of settlement moved southwestward from Virginia and North Carolina, and in little over a half century the entire region was settled by subsistence farmers and planters. Most of the loblolly-shortleaf type is in the old Cotton

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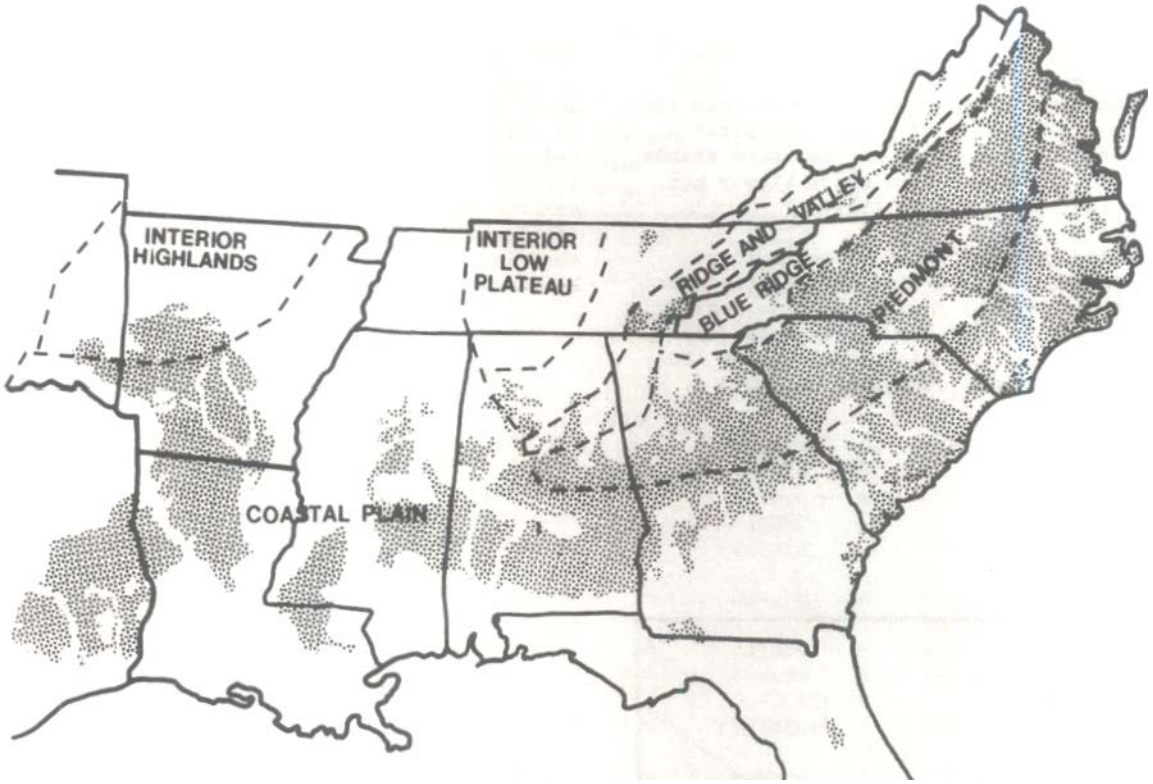


Figure 1.--Loblolly-shortleaf pine forest of the southeastern United States. (U. S. Forest Service 1969).

Belt where intensive agriculture and the nature of the climate, soils and topography combined to produce severe soil erosion and loss of fertility. There were several periods of land abandonment, the most recent and most important coinciding with the economic depression and invasion by the cotton boll weevil (Anthonomus grandis) in the 1920's. Abandoned fields were invaded by loblolly pine and, on drier sites, shortleaf pine. Virtually all of the natural stands of loblolly-shortleaf remaining today developed on abandoned agricultural fields. Most stands established before 1945 have been heavily cut. Some have regenerated naturally; others have been planted and are under management for pulpwood.

Secondary Succession

Old Field Stage

On Piedmont uplands the first seral stage is a succession of herbs and grasses through the fifth year. Crabgrass (Digitaria sanguinalis) and horseweed (Erigeron canadense) dominate the first growing season following cultivation in the Piedmont, and young plant growth, less than 0.3 m, is present during the first bird breeding season. Taller growth up to 2 m develops by the end of the first year. In the second year the dominant species are aster (Aster pilosus) and ragweed (Ambrosia artemisiifolia). Broomsedge (Andropogon spp.) attains dominance in the third year and persists until shaded out by pines, which begin to appear in the third year. Various shrubs (e.g. Rubus, Rhus, Prunus) and small deciduous trees also occur with the pines until canopy closure (Oosting 1942, Johnston and Odum 1956).

Elsewhere in the loblolly-shortleaf type, succession is less uniform and less predictable. This is especially true of the early stages where species composition of invading annuals and perennial grasses may vary with structure and fertility of soils, drainage, and previous land use. Soil fertility may also affect species composition and growth rates of trees.

Pine Forest Stage

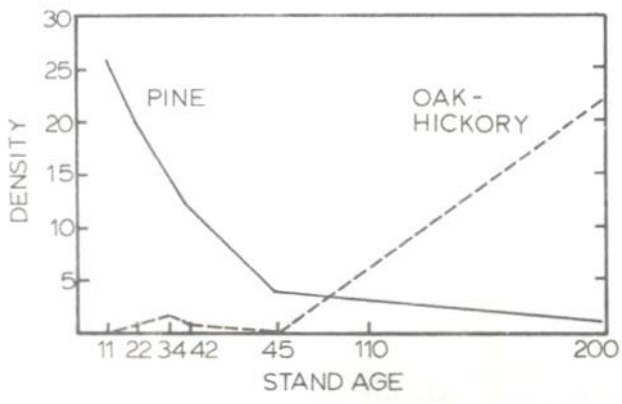
By the 11th year pine dominates well seeded areas. Trees are 2.4-4.6 m tall with a broomsedge and shrub groundstory (Oosting 1942). Tree density is dependent on ample seed stocking, but differences in density diminish as stands age; dense pine thickets thin naturally on fertile sites and open-growth stands form closed canopies (Brender 1973).

Canopy closure usually occurs between 10 and 20 years. Only small patches of ground-story plants exist in dense stands of this age class; there is essentially only one stratum of vegetation. More open, natural pine stands have hardwoods of tree size which slowly but steadily increase (Oosting 1942).

A shade tolerant hardwood understory appears in the later seral stages of the pine forest (fig. 2). The decline in pine density is accompanied by a steady increase in density of hardwoods. Natural pine stands 60 to 100 years old have a well developed hardwood understory and ground cover.

Figure 2.--Piedmont forest succession from loblolly-shortleaf pine to oak-hickory hardwoods. (redrawn from Oosting 1942).

Mixed Pine-Hardwood Stage



During the transition from pine to hardwood forest, habitat conditions are quite diverse. For this discussion we define mixed pine-hardwoods as stands with greater than 10 percent and less than 50 percent loblolly, shortleaf, and other southern pines, except slash and longleaf. Mixed stands usually occur in age classes between 80 and 120 years (fig. 2); however, younger stands can have a substantial amount of hardwoods depending on site conditions. Brender (1973) states that on poor sites, red heart disease (caused by Fomes pini) becomes established earlier, and pine stands begin to break up at age 60. Also, when pines are cut, many stands revert to hardwoods (Wahlenberg 1949); in the absence of fire, root stock of hardwoods in the understory is released when pines are removed.

Mixed pine-hardwoods develop three vertical strata of vegetation--groundstory (0-3 m), understory (3 to 10 m), and overstory (over 10 m). Hortizontal clumping (patchiness) is more prevalent in mixed stands. Lightning, red heart disease, and the southern pine beetle (Dendroctonus frontalis) cause small openings and thereby create uneven age classes. Snags (dead standing trees) become more abundant as the pine forest is replaced by mature oak-hickory forest.

AVIAN COMMUNITIES

We divided the avian community into the two major populations--winter populations and summer breeding populations. More data have been accumulated on breeding bird populations. Data collected in spring and summer are more reliable than those collected during winter or migratory seasons because of breeding season territoriality in most bird species. Large flocks of winter foragers or migrants complicate studies at other times of the year. Statistical differences in non-breeding bird studies are difficult to detect because of high variances or low sampling effort.

For this review we analyzed winter bird populations from 17 census locations throughout the Southeast (table 1). These censuses include from 1 to 10 years of data and range through the succession of loblolly-shortleaf pine to mature oak-hickory forests. We also analyzed summer breeding bird communities from 31 census locations with 1 to 16 years of data (table 2).

Temporal Patterns

In the eastern United States a large proportion of the bird species are migratory. Some species migrate to the Southeast, while other species cross the Gulf of Mexico and spend the winter months in the Neotropics. There also are resident or sedentary species, such as the Carolina Chickadee (Parus carolinensis) 1(and Tufted Titmouse (P. bicolor). With migration, bird communities change seasonally. During the spring and summer, breeding territories are established and individual breeding birds are relatively sedentary. However, in the winter months interspecific flocks are common in most habitats. For example Kinglets (Regulus spp.), a northern coniferous forest breeder, are abundant winter residents in the southeastern forest and usually are found in pine forests with large groups of chickadees and titmice.

2/ All common names are those standardized and listed with scientific names by the American Ornithologists' Union check-list committee (American Ornithologists' Union 1957, 1973, 1976).

Table 2.--Locations and habitat data for breeding bird censuses of loblolly-shortleaf pine forest stands and other pine-hardwood stands.

Census No.	Location	Plot size	Stand type [1]	Percent pine overstory	Stand age [2]	Years of data	Source [3]
1	Livingston Par., La.	12 ha	pine	88%	6 yr.	1	NH 1976 [4]
2	Warner Robbins, Ga.	10	pine	70	∿7	1	AFN 6(6)
3	Raleigh, N.C.	13	pine	∿50	∿7	1	AFN 21(6)
3a	Raleigh, N.C.	13	pine	∿50	∿9	1	AFN 23(6)
4	Durham, N.C.	7	mixed	35	1-10	1	AFN 20(6)
5	Oakland, Md.	11	pine	100	10-20	1	AFN 3(6)
6	Durham, N.C.	8	pine	95	10-20	1	AFN 20(6)
7	Livingston Par., La.	12	pine	100	20	1	NH 1976 [4]
8	Romney, W.Va. [5]	4	pine	90	20	1	AFN 21(6)
9	Durham, N.C. [5]	10	pine	100	20-30	1	AFN 20(6)
10	Snowhill, Md.	9	pine	97	25-30	1	AFN 2(6)
11	Pine Bluff, Ark.	62	mixed	30	<30	1	AFN 9(6)
12	Athens, Ga.	10	pine	100	∿35	1	AFN 1(6)
13	Athens, GA.	8	pine	95	33	1	AFN 17(6)
14	Warner Robbins, Ga.	8	mixed	<20	∿35	1	AFN 7(6)
15	Durham, N.C.	10	pine	95	30-40	1	AFN 20(6)
16	El Dorado, Ark.	4	pine	57	35	2	AFN 14-15(6)
17	Southport, N.C.	12	mixed	40	35-40	2	AB 27(6),31(1)
18	Savannah, Ga.	7	pine	95	40-45	3	AFN 19-21(6)
19	Chapel Hill, N.C.	35	pine	92	30-60	1	AFN 20(6)
20	Livingston Par., La.	12	pine	100	45-46	2	NH 1976 [4]; AB 28(6)
21	Durham, N.C.	10	pine	85	70-80	1	AFN 20(6)
22	El Dorado, Ark. [6]	8	mixed	30	mature	1	AFN 11(6)
23	Savannah, Ga. [6]	10	mixed	32	mature	10	AFN 17,19-24(6); AB 25-27(6)
24	Romney, W.Va.	6	mixed	30	mature?	1	AFN 21(6)
25	Fairfield, Ala. [7]	10	mixed	24	mature	2	AFN 3-4(6)
26	El Dorado, Ark. [7]	9	mixed	20	mature	5	AFN 11(6)
27	N. Wilksboro, N.C. [8]	16	mixed	?	mature	16	AFN 8-9,11,14-24(6); AB 25-26,29(6)
28	Chapel Hill, N.C.	9	beech-maple	9	mature	2	AB 27-28(6)
29	Livingston Par., La.	12	S. mixed hdwd.	6	mature	1	NH 1976 [4]
30	Durham, N.C.	11	oak-hickory	<5	mature	1	AFN 20(6)
31	Berkley Spr., W.Va.	6	oak-hickory	0	mature	1	AFN 11(6)
32	Athens, Ga.	9	oak-hickory	∿5	mature	1	AFN 1(6)

1/ Pine = loblolly-shortleaf pine; mixed = pine and hardwoods.

2/ Mature pine stands are >45 years old; mature, mixed, oak-hickory, and beech-maple stands are >75 years old.

3/ AFN = Audubon Field Notes, AB = American Birds; volume and number are listed with each citation; see Breeding Bird Census.

4/ Noble and Hamilton 1976.

Edge effect accounted for 4 of 14 species and 220 individuals/km2.

6/ Slash and longleaf pine are 28% of the overstory, while loblolly is 4%.7/

7/ Some recent logging was done on the plot.

8/ White pine-shortleaf pine and oak community in the mountains.

Temperature and Latitudinal Gradients

During the winter, the number of bird species (richness) is closely related to the number of frost-free days (Bock and Lepthien 1974, Tramer 1974a). The mild and fairly stable winter climate of the Southeast is apparently important to many bird species that do not tolerate harsh northern winters. Climate does not seem to affect species numbers in areas with more than 245 frost-free days. Because of this relationship, more bird species should be present in pine forests in Louisiana than in Virginia or North Carolina. Also, more species should be present in milder coastal areas than interior habitats. Tramer (1974b) states that temperate zone winter ranges appear to be regulated by the effects of climate on food supply.

In general breeding bird species richness is inversely related to latitude; however, breeding species richness is less in the southeastern than in the northeastern United States. Various explanations for this were presented by Tramer (1974b).

Winter Bird Community

Successional Trends

Quay (1947) completed a detailed study of winter bird populations in an upland plant sere near Raleigh, North Carolina. His study was conducted during one winter, and density estimates within seral stages may reflect favorable or unfavorable climate that year. However, his study does delineate changes in winter bird populations associated with plant communities in that specific region.

Data on winter bird populations from the 17 census locations (table 1) were analyzed for changes in species richness and density with changes in the plant community (figs. 3, 4). In most censuses (source AFN, AB--see table 1) it was not possible to calculate the Shannon Index for species diversity (MacArthur and MacArthur 1961) because data tabulation was in rounded whole numbers (means) and included symbols (+) for uncommon species.

Species richness in winter populations increased in the early seral stage from 7-15 species in old fields to 27-30 species in young open-canopy pine stands with patches of older trees or open wet areas. However, very few data were available for this seral stage, and the apparent trend could be due in part to temperature gradients. Quay's (1947) study showed a slight decrease in species richness from bare ground to herb and broomsedge-pine habitats (fig. 3).

Census data for stands after canopy closure indicate a decrease in species richness, which is not reversed until age 35 (fig. 3). Dickson and Segelquist (1978) found stands of dense pine saplings (age 15) practically devoid of birds; younger and older stands had substantially more species and higher densities. Bird densities (fig. 4) also follow the same trend in the few censuses available for these seral stages. In Louisiana winter bird densities decreased 50 percent (fig. 4, table 1) from a 7-year-old pine stand to a closed canopy stand (age 20); however, a 45-year-old pine stand showed an additional decrease in density from the 20-year-old stand (Noble and Hamilton 1976). These data contradict studies by Quay (1947) and Dickson and Segelquist (1978). Apparently reduced winter bird species and density in the 45-year-old stand was the result of annual burning, which eliminates the lower vegetative stratum (Noble and Hamilton 1976).

From mature pine to mixed pine-hardwood seral stages there is considerably higher density and species richness with the increase in percent hardwoods (figs. 3, 4). Decreases in density and species richness in mature stages of forest succession are apparent in colder, more northerly environments, e.g. North Carolina and Virginia (figs. 3, 4). This difference possibly results from greater availability of food in the southern latitudes (Tramer 1974b).

Species Composition

Fringillids (sparrows, towhees, goldfinches, etc.) are the major group of winter birds in young seral stages. Savannah Sparrow (Passerculus sandwichensis), Field Sparrow (Spizella pusilla), Dark-eyed Junco (Junco hyemalis), and Song Sparrow (Melospiza melodia) are common fringillids in old fields during the winter (Quay 1947, Odum and Hight 1957). Other common species in early stage old fields (0-5 years old) are Eastern Meadowlark (Sturnella magna), Bobwhite (Colinus virginianus), Killdeer (Charadrius vociferus), and Mourning Dove (Zenaida macroura). As shrubs, vines, and small pines become available for cover and foraging, White-throated Sparrow (Zonotrichia albicollis), Cardinal (Cardinalis cardinalis), Rufous-sided Towhee (Pipilo erythrophthalmus), and wrens become abundant.

The pine or mixed pine-hardwood forest is used by a variety of bird groups and foraging guilds. Woodpeckers are common through the winter in forest stands of all ages but are most abundant in mature stands. Golden-crowned and Ruby-crowned Kinglets (Regulus satrapa and R. calendula) are common to abundant in pine and mixed pine-hardwoods. These species breed in northern coniferous forests and winter in southern pine forests. They are commonly found in flocks with permanent residents, such as Carolina Chickadees, Tufted Titmice, and Downy

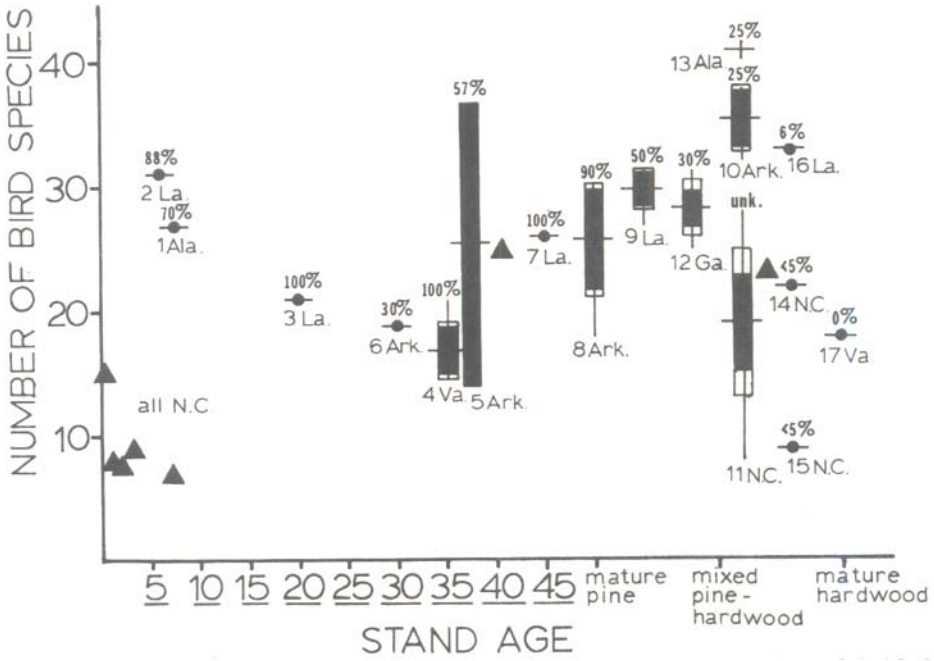


Figure 3.--The relationship of winter bird species richness with succession of loblolly-shortleaf pine forests. Vertical line represents the range, horizontal line the mean, hollow rectangle one standard deviation on either side of mean, and solid rectangle 95% confidence interval on either side of mean. Percent pine is given above each symbol and census location and number below each figure. Solid triangles refer to quay 1947.

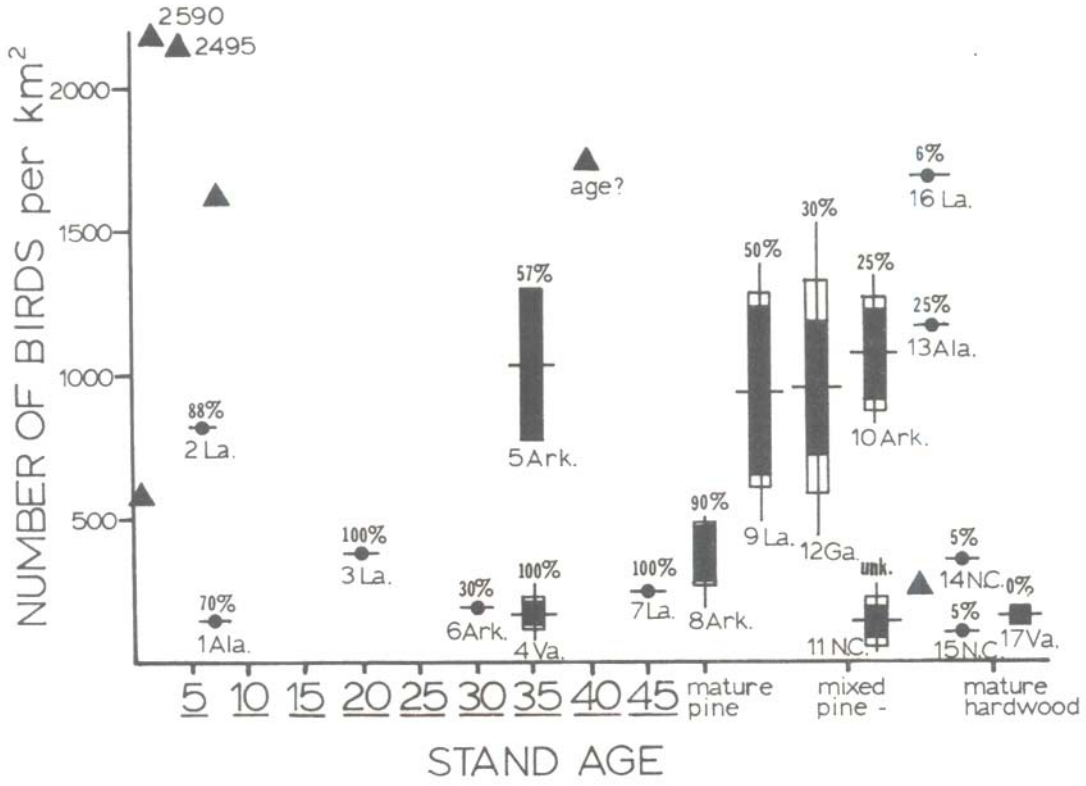


Figure 4.--The relationship of winter bird density with succession of loblolly-shortleaf pine forests. See figure 3 for interpretation of symbols.

Woodpeckers (Picoides pubescens). In most cases pine forests in the Piedmont loblolly-shortleaf type have higher populations in winter than deciduous forests because of the addition of kinglets to the permanent resident populations (Johnston and Odum 1956). Pine warblers (Dendroica pinus), permanent residents, are common in pine stands of all age classes. Another parulid, the Yellowrumped Warbler (D. coronata), is abundant in some years in young seral stages, and is also commonly found in flocks of permanent residents in older forest stands.

Summer Breeding Bird Community

Successional Trends

Breeding bird habitat in the Southeast is grouped into four broad stages; (1) grasslands, (2) shrubland, (3) pine forest, and (4) hardwood forest (Johnston and Odum 1956). Most of our discussion will be concerned with the first three stages and the transition i.e. mixed pine-hardwoods) from pine to oak-hickory.

Grasslands are predominant in the southern Piedmont and the Coastal Plain during the first 3 years of natural succession. Bird populations and species richness are low during this stage (figs. 5, 6). Only two or three species breed in this habitat in the Southeast. However, in the shrub and young pine stage a rapid increase in breeding density and species takes place. Shrubs add patches and an additional vegetative stratum for nesting. This increase is short-lived as pine canopy closure at 10-20 years eliminates the ground cover and understory vegetation. Densities decrease from 600 territorial males per km^2 to 200-300 per km^2. Breeding bird species also decrease about 50 percent. These reduced populations are common in pine stands from age 15 to 30 years.

Pine tree density decreases rapidly from age 11 to age 34 (fig. 2). This natural thinning allows greater light penetration to the ground and development of understory vegetation. At stand age 35 densities and species of breeding birds again rapidly increase to values similar to those of the shrubland stage. Bird species richness is higher from stand age 40 to 80 than in any younger age class (fig. 5). Again richness and density in the annually burned stand (census 20) was considerably lower (60-70 percent less) than for unburned or irregularly burned plots (figs. 5, 6).

Mixed loblolly-shortleaf pine-hardwood forests are important breeding habitat for many species. Density and species richness in these stands are similar to mature hardwood forests. The average density of breeding pairs(territorial males) in mixed pine-hardwood is 550 per km^2. Approximately 20 breeding species (mapped territories, not visitors) are found in mesic pine-hardwood forest. Bottomland pine-hardwood forests (census 22; figs. 5, 6) are higher in total density and species richness than drier sites. Within the loblolly-shortleaf pine type the mixed pine-hardwoods and mature pine stands have the highest density and species diversity.

Relationships in Breeding Bird Populations

Density and species richness are highly correlated in breeding bird communities. Note that the graphs of species richness (fig. 5) and breeding bird densities (fig. 6) are very similar. Increase in population density is caused primarily by the addition of new species (Trainer 1968). Territoriality would limit increase in density of bird species already present. Species diversity in breeding bird populations also is highly correlated with number of species.

Foliage height diversity, an indirect measurement of the amount of leaf surface area present in the horizontal strata of the forest, is positively correlated with bird species diversity (MacArthur and MacArthur 1961). Roth (1976) shows that spatial heterogeneity or patchiness is also significantly correlated with bird species diversity. Both of these vegetative measurements are useful to bird managers as indicators of bird diversity. But diversity should not be the sole objective in bird habitat management. Densities and species composition and distribution should also be considered.

Species Composition

Figure 7 presents breeding bird species composition and densities with succession in loblolly-shortleaf pine stands. This list is not complete, but it contains the major breeding birds of concern to managers. Rare and endangered species will be discussed in a later section. Birds with large territories, such as raptors, are not well represented in breeding bird censuses because census techniques for breeding raptors are not compatible with passerine census techniques.

Three common breeding species of the grassland stage in the Southeast are Bobwhite, Eastern Meadowlark, and Grasshopper Sparrow (Ammodramus savannarum). Fall and winter Bobwhite populations are highest in 2-year-old fields in pine plantations (Brunswig and Johnson 1972). In unmanaged natural succession Bobwhite breeding populations presumably would be higher in 3- to 5-year-old fields than in managed pine stands of the same age, as management speeds up succession and shortens the duration of optimum breeding habitat. The

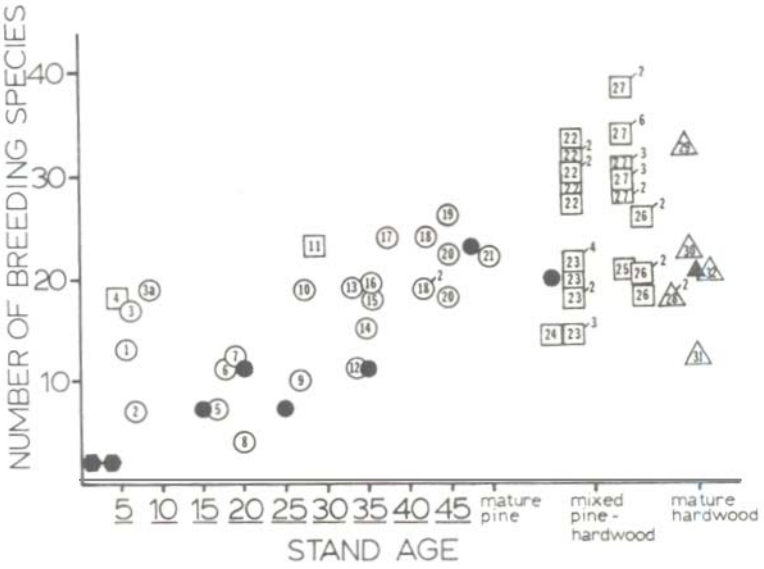


Figure 5.--The relationship of breeding bird species richness with succession of loblolly-shortleaf pine forests. Hexagon = grassland, circles = 50 to 100% pines, squares = 10 to 49% pine, triangles = < 10% pines. Numbers on symbols refer to censuses in table 2. Numbers outside the symbols refer to duplicate points. Solid symbols refer to Johnston and Odum 1956.

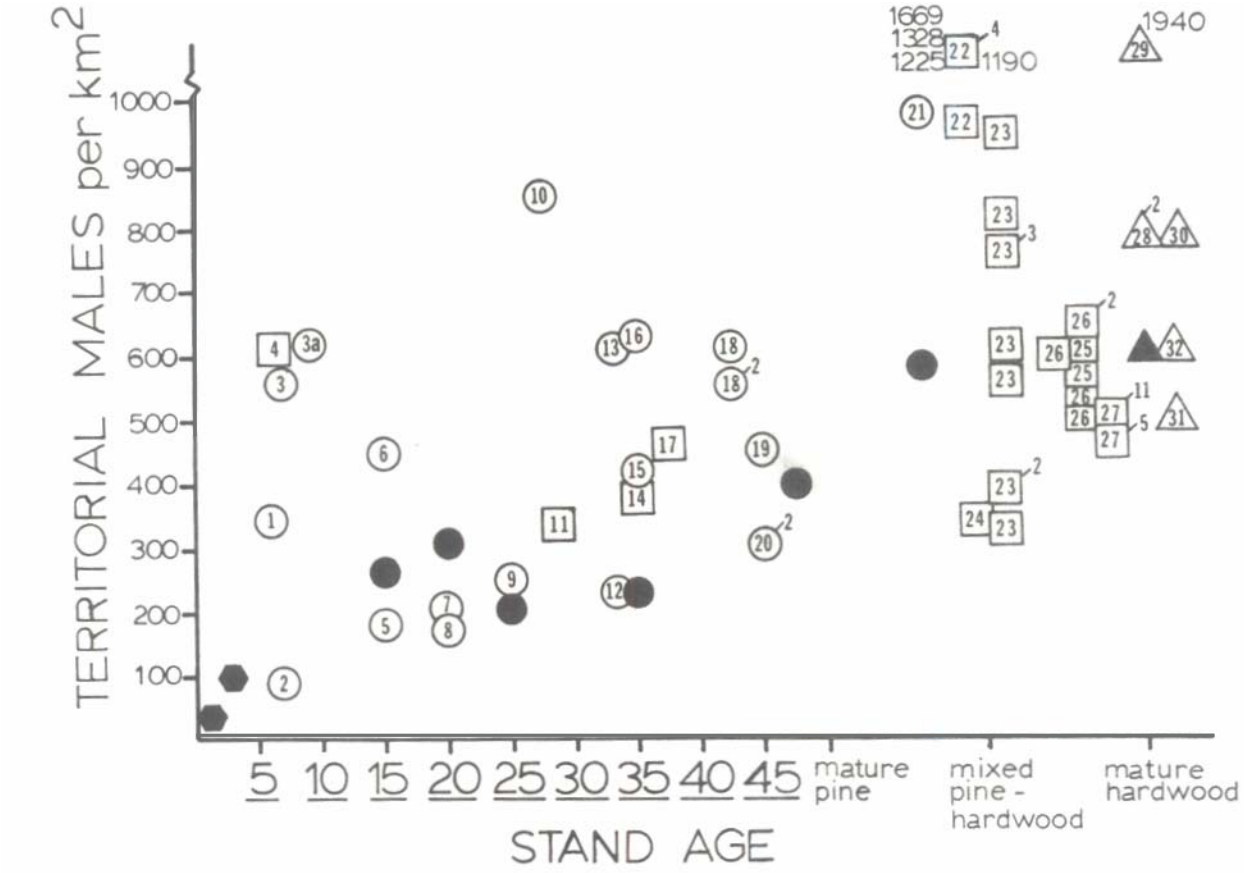


Figure 6.--The relationship of breeding bird density with succession of loblolly-shortleaf pine forests. See figure 5 for interpretation of symbols.

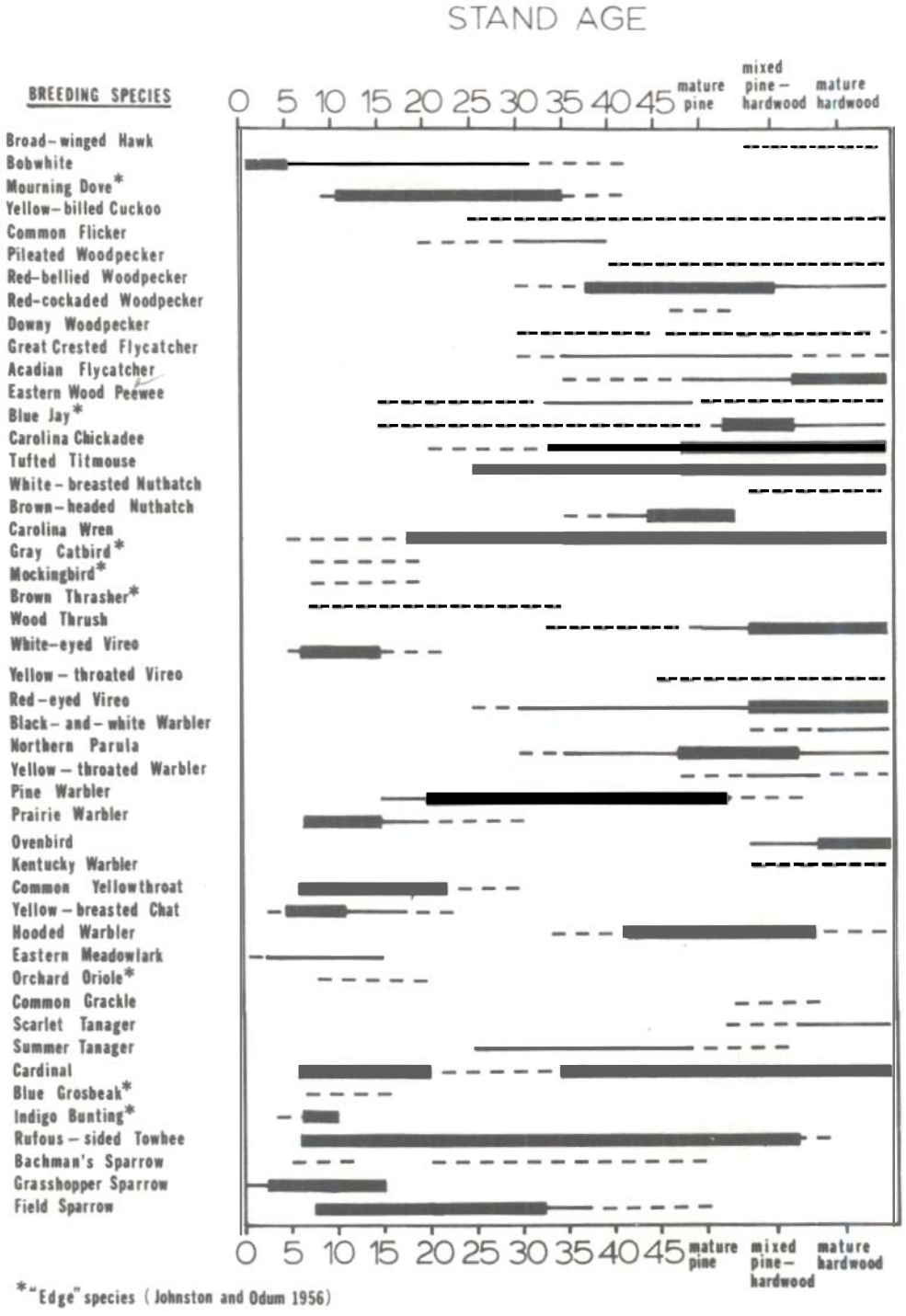


Figure 7.--The approximate density of selected breeding birds in the seral stages of loblolly-shortleaf pine and oak-hickory forests. Dashed line = < 5 pairs per 40 ha, solid line = > 5 < 10 pairs per 40 ha, and solid bar = > 10 pairs per 40 ha. Data from table 2 and Johnston and Odum 1956.

Grasshopper Sparrow and Meadowlark are true grassland species and the only breeding species found in large uniform fields without shrubs or trees (Johnston and Odum 1956). Two other uncommon species not presented in figure 7 are Killdeer and Horned Lark (Eremophila alpestris). Both of these birds feed and nest on essentially bare ground and are pioneer species in the successional series. Horned Larks have been extending their breeding range eastward from the prairies (Johnston and Odum 1956).

The shrubland habitat (age 5-15) is important to "edge species," which require two or more plant communities usually of widely separated ages (Johnston and Odum 1956). These species are common in shrubland and usually also common at forest-shrub boundaries in older stands (fig. 7). A few other species are most abundant only in the shrubland stage and rapidly decrease in forest stands. Prairie warbler (Dendroica discolor), Yellow-breasted Chat (Icteria virens), Indigo Bunting (Passerina cyanea), White-eyed Vireo (Vireo griseus), Common Yellowthroat (Geothlypis trichas), and Field Sparrow are common breeding species only in shrubland. Mourning Doves, an edge species, become fairly abundant in the latter part of the shrub stage. Edge and shrubland species are a major component of bird communities. Possibly more than 30 to 40 percent of common breeding birds in the Georgia Piedmont belong to this category (Johnston and Odum 1956). These species are also some of the most widely recognized birds found in low density residential areas.

By age 20 most pine stands have closed canopies with shrub and grass cover significantly reduced. However, in natural succession poorly seeded areas and eroded or wet areas often create a patchiness of habitats with clumps of pines interspersed with small openings of earlier seral stages. These openings increase the bird diversity and density in pine stands which otherwise would have low densities.

The Pine Warbler, Brown-headed Nuthatch (Sitta pusilla), and rare Red-cockaded Woodpecker (Picoides borealis) are the only breeding birds restricted to the southern pine forest (Johnston and Odum 1956). Pine Warblers are most abundant in pure stands of pines, and their density decreases significantly with the invasion of hardwood species (fig. 7). The uncommon Brown-headed Nuthatch, a cavity nester, is generally a breeding bird of mature pine stands. The Red-cockaded Woodpecker breeds in mature pine stands with infections of red heart disease and is generally more common in the Coastal Plain than Piedmont.

In southeastern pine forests birdpopulations are determined mainly by the under-story (Johnston and Odum 1956). Grasses under mature pine forests create breeding habitat for Bobwhite and Bachman's Sparrow (Aimophila aestivalis). Thick patches of shrubs or well developed understory in mature pine forests are good breeding habitat for the Carolina Wren (Thryothorus ludovicianus), Great Crested Flycatcher (Myiarchus crinitus), Summer Tanager (Piranga rubra), Yellow-throated Vireo (Vireo flavifrons), Eastern Wood Peewee (Contopus virens), Hooded Warbler (Wilsonia citrina), Northern Parula (Parula americana), Cardinal, Rufous-sided Towhee, and many other less common species (fig. 7 and data from sources in table 2). Many of these species also occur in hardwood forests which usually have a well developed understory.

As pine forests mature, hardwood species replace pines and produce a mixed pine-hardwood stand (fig. 2). These mixed forest types have highly diverse bird populations. Woodpeckers and other cavity nesters, such as the Carolina Chickadee, Tufted Titmouse, Great Crested Flycatcher, and White-breasted Nuthatch (Sitta carolinensis), are fairly abundant at this stage. Some of these species also are found in younger pure pine stands with dead standing trees (Noble and Hamilton 1976). In addition, many predominantly hardwood forest birds, such as the Broad-winged Hawk (Buteo platypterus), Acadian Flycatcher (Empidonax virescens), Wood Thrush (Hylocichla mustelina), Red-eyed Vireo (Vireo olivaceus), Black-and-white Warbler (Mniotilta varia), Ovenbird (Seiurus aurocapillus), and Scarlet Tanager (Piranga olivacea), begin to breed commonly in mixed pine-hardwood stands (fig. 7).

Endangered Species

The only endangered species closely associated with upland loblolly-shortleaf pine is the Red-cockaded Woodpecker. Considerable research is being done on management of this species' habitat (Hooper et al. 1977, Baker 1977, Jackson 1977). The Red-cockaded Woodpecker breeds in open, mature pine stands. The nest trees are almost always infected with red heart disease.

This woodpecker usually occurs in clans of 2-10 birds, with only 1 pair breeding and the remaining birds acting as helpers. Cavities are almost always in mature, living pines and are readily identified by the glaze of white resin surrounding the entrance. The home range of a pair is 14 to 20 ha, and clans of 8 birds utilize up to 65 ha.

Management of this species is achieved by providing suitable nest and roost trees, which include loblolly, shortleaf, longleaf, slash, and pond pines (Pinus serotina) at least 80 years old. Stands for nest sites should have

an average density of 110-124 stems/ha with a basal area of 11 to 14 m^2/ha. Understory should be no more than 4.5 m tall and preferably less than 2 m. The exact stand size necessary for the preservation of the clan is not known, but is in the range of 14-65 ha (Chamberlain 1974).

TIMBER MANAGEMENT IN RELATION TO BIRD HABITAT

Management Trends

Forest management trends have accelerated within the last 20 years. Land ownership, management objectives, and multiple use management are the major areas of change. For instance, forest industrial land holdings in the Georgia Piedmont increased 26 percent from 1961 to 1969, and in 1973 20 percent of the Georgia Piedmont forest was managed by forest industries, mostly for production of pulpwood (Brender 1973). Management of loblolly-shortleaf pine types, has become more intense and mechanized. Rotation lengths are shorter with intensive management.

Maintenance of forest stands in earlier successional stages by shorter rotations is eliminating mature pine and hardwood forests. One can readily recognize that compartmental control of a loblolly-shortleaf pine forest with no stands older than 35 years would eliminate many breeding bird species (fig. 7). Short rotation stands lack (1) suitable cavities for nests, (2) an understory nesting stratum, (3) high energy fruits and mast, and (4) deciduous foliage necessary for many songbirds (Johnson et al. 1975). More intensive management, with elimination of hardwoods by herbicides or burning and row planting of pines, further reduces breeding habitat for ephemeral bird species in the grass and shrub stages.

Multiple resource management is now the policy on most publicly owned forests, where a diversity of age classes are maintained. Timber, water, wildlife, and recreation are the major resources of these forests. However, deliberate nongame bird management has not been widely practiced. Much of what happens is incidental to timber and game management.

Only a few studies have been completed on bird populations and the effects of site treatments in the early stages of succession of pine plantations (see tables 1, 2). Obviously shorter rotation lengths in managed pine forests will produce more forest in early stages of succession. More research is needed on bird populations during the first 35 years of managed and unmanaged pine forests.

Succession is predictable only on a macroscopic level (Margalef 1968). Many sites of the same stage of succession will be phytologically different because of past land uses, soil fertility, soil moisture, or microclimate. Local site characteristics are important when overall management decisions are made for songbird habitat.

Harvest and Regeneration

Harvest methods can greatly affect bird communities. Southern pine forests generally are managed in even-aged stands, harvested by clear cutting, seed-tree, or shelterwood cutting. Much of the literature on the effects of even-aged timber management on bird populations concerns clearcutting. Clearcutting with intensive site preparation eliminates the overstory and reduces the site to mineral soil. When soil preparation and planting are done during the fall and winter, the spring vegetation is sparse and all forest breeding birds are eliminated. Killdeers would be the only bird breeding in this habitat (Johnston and Odum 1956, Perkins 1973). However, if the site is not intensively prepared and "whips," shrubs, and logging slash are present, the breeding bird populations are considerably higher, possibly higher than populations in uncut loblolly-shortleaf forest (Perkins 1973). This would be true also for non-breeding bird populations. Snags left in harvested areas are important to cavity-nesting birds such as bluebirds (Sialia sialis) (Conner and Adkisson 1974), woodpeckers, and other nesting birds; and they hardly affect timber production goals. Conner and Crawford (1974) found that one-year-old oak clearcuts with slash and debris were excellent foraging areas for Downy Woodpeckers and Hairy Woodpeckers (Picoides villosus); however, the source of insect prey was much less abundant in 5- and 12-year-old clearcuts. Perkins' (1973) data on bird species richness of mist blown-injected and bedded (with burned windrows) sites indicated that mist blown-injected sites have more than twice as many species during spring and summer as uncut forests. Many early successional bird species are common in these habitats, as the greater volume of vegetation in the lower strata significantly increases the number of species. Windrows often support plant communities quite different from the adjacent treatment area (Perkins 1973). Shrubs and hardwood saplings in windrows create an "edge effect," which usually increases breeding bird species diversity and density.

Clearcut size and shape, and juxtaposition of different age classes are important in bird management. Arner (1972) reported that the average size of clearcuts in southern forests was 92 ha (range 20-600 ha) on commercial land and 26 ha (Piedmont) to 36 ha (Coastal Plain) on public land. Clearcuts of 20 to 40 ha are

acceptable units for nongame bird management. This range coincides with clearcut sizes suggested for many game species. Clearcuts larger than 40 ha are less important to "edge" bird species, but, if rotations are long (6080 years), these clearcuts could provide more habitat for forest interior species.

Long narrow clearcuts clearly benefit "edge" species. However, a more important harvest treatment is the undulating boundary (scalloped edge), which is the natural edge of mature systems (Margalef 1968). Meyers (unpublished data) has found significantly higher bird densities on scalloped forest edges of transmission line corridors. It is quite possible that clearcuts with undulating boundaries rather than straight boundaries are higher in bird density and diversity. Undulating boundaries have more edge and also create patchiness of habitat types. Further research on this phenomenon is needed before we make management recommendations. Johnston and Odum (1956) state that boundaries separating habitats of widely different age classes (e.g. grassland and forest) are most important to forest edge bird species. Clearcuts, by maximizing mature forest-grassland edge usually increase densities of edge bird species and bird species diversity. But, we caution against exclusive use of the "edge effect" as a management objective. Many of the edge species are common, whereas forest birds, particularly those of mature pine and hardwoods, are less common, and current forest management trends could further reduce their populations.

Narrow spacing of trees on intensely managed sites usually causes early crown closure, while wider spacing of planted pines results in a delay in crown closure. The delayed crown closure benefits early seral stage birds. Clumping from natural or aircraft seeding and seedling mortality from climatic or edaphic conditions both increase the variety of breeding birds. Regular spacing of trees possibly reduces bird species diversity (Roth 1976).

High breeding bird densities (1800 pairs/km^2) in an intensively managed plantation interplanted with Norway spruce (Picea abies) and European beech (Fagus sylvatica) were reported by Williamson (1970). The plantation was bounded by a fringe of mature beech and oak, field hedgerows, and grassland access roads and firebreaks. The fringe of mature trees was used to screen the new plantation from the public roads. Although southern pine management currently does not include inter-planting of hardwoods, birds would most likely benefit greatly by this management.

The other methods of regenerating even-aged stands--shelterwood and seed-tree harvests--do not produce the very low bird diversity and density during the first year after harvest. The presence of overstory trees during the early stages of succession encourages both forest and field or shrubland breeding birds. Also, natural mortality of residual trees associated with these methods (Brender 1973), provides bird habitat for nesting and foraging.

Selection harvesting of loblolly and shortleaf pine is controversial. It is useful for managing small holdings where the landowners expect a regular income at short intervals. Sawtimber and veneer stock are the principal products of uneven-age management (Brender 1973). Since selection harvesting is not a widely used method in the South, there have been no bird studies in uneven-aged loblolly-shortleaf pine. Research on all silvicultural systems as they relate to bird habitat in southern pine forests is scarce.

Intermediate Treatments

At mid-rotation (about 15 years) pine stands, especially on dry sites, are devoid of groundstory vegetation. If there is a pulp market available, stands should be thinned, especially on average to poor sites (Brender 1973). Thinning dense stands can significantly increase timber volume and provide improved bird habitat. Natural thinning encourages a patchier habitat than mechanical thinning and therefore may support more breeding bird species. However, if management of birds is of particular interest, mechanical methods that create non-uniform habitat are suitable, especially on poor to average sites that do not thin naturally.

Burning is commonly prescribed in the management of loblolly-shortleaf pine forests for timber and game. Prescribed burning at 3-to 4-year intervals is useful in hardwood control and can create a patchiness in the understory that may increase bird species and densities. A few species, such as Bachman's Sparrow, benefit from more frequent prescribed burning. However, a vast majority of the breeding birds nest between ground level and 3 m (Preston and Norris 1947); therefore without understory, significant numbers of breeding species are eliminated. Annual burning is not desirable for management of most songbirds, and for timber management generally is unnecessary. Noble and Hamilton (1976) concluded that burning at intervals of 3 to 4 years provided the same results for forest management as annual burning in a 46-year-old stand of loblolly pine. Research is needed on burning rotations greater than 4 years, spot-burning, and other techniques of prescribed burning for non-game bird management.

NATURAL AGENTS MODIFYING BIRD HABITAT

Two animals, the beaver (Castor canadensis) and the southern pine beetle, have a significant impact on forests by creating openings. Reese and Hair (1977) examined birds associated with beaver pond habitat in South Carolina and found highly diverse communities. Dead standing trees, wetland habitat, forest edge, and abundant shrub cover are prominent components of beaver ponds. All of these structures contribute to the increased species diversity in the pond area.

The southern pine beetle is one of the most damaging forest insects in the South (U. S. Forest Service 1969). Damage is within a well-defined area from the Piedmont in central Alabama to south-central Virginia with scattered areas reported on the Coastal Plain. The boundaries of the damage-prone area have changed little since the late 1800's (U. S. Forest Service 1969). Southern pine beetles are natural agents that set back succession. Dead standing trees in damaged areas are valuable woodpecker foraging areas and nest sites for cavity-nesting species. Small, scattered infested areas are important bird habitat; however, large areas are not as valuable to birds.

Lightning strikes, damaging tropical storms, glaze storms, and wild fires are significant agents modifying bird habitat in the loblolly-shortleaf pine type. Before the arrival of European man they were very important to bird species of earlier successional stages. Lightning-struck and wind-damaged trees are readily used by foraging woodpeckers and also are used as nest sites. Large wind-thrown areas create forest openings that are useful demonstration and management areas for the effects of natural habitat modifications on bird populations. Wildfires are of less importance today because of fire control technology. Large burned areas obviously benefit early seral stage birds, but the loss in lives, timber, and property would be great if these fires were not controlled. Man replaces the effects of wildfires by harvesting and other silvicultural practices.

LAND USE TRENDS AND BIRD HABITAT

Regional land use trends can significantly modify bird populations (Dambach and Good 1940, Warbach 1958). In the Southern Piedmont a trend of increased timberland and decreased farmland has been evident for the last 5 decades. Small farms are being displaced by large agribusinesses employing highly mechanized and more intensive practices with fertilization, irrigation, and large open fields without hedgerows. High operation costshave eliminated diverse habitat that is valuable to many wildlife species on farmland. More land is used in crop production on today's highly mechanized farms that depend heavily on outside energy sources (e.g. fertilizer, irrigation, pesticides).

Private lands in relatively small holdings make up a significant percentage of the land area but receive relatively little attention from wildlife biologists. These lands usually are not available for management by wildlife biologists; but, *we* should make information available to landowners interested in bird management and recommend that they consider management of the entire bird community and not individual species (except in the case of endangered species).

Rapid human population growth in the South is causing large increases in subdivisions and corresponding loss of forest bird habitat. Few studies have been completed on the effects of subdivisions on summer and winter bird communities. None have been done in the loblolly-shortleaf pine type. Commonly subdivisions are thought to provide only House Sparrow (Passer domesticus) and Starling (Sturnus vulgaris) habitat; however, with proper management and initial subdivision planning, these habitats should produce diverse bird communities with very high densities. Subdivisions may be an important factor in the breeding range extensions of many songbird species.

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