Effects of Silviculture on Neotropical Migratory Birds in Central and Southeastern Oak Pine Forests

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Abstract — Avian communities that are associated with forest habitat attributes are affected by silvicultural and other stand influences. Some species have specific habitat requirements, whereas others occupy a broad range of vegetative conditions. In general, bird species richness and density are positively related to stand foliage volume and diversity. Bird density and diversity are usually high in young brushy stands, decrease in dense pole stands as canopies close and shade out understories, and are highest in older stands with diverse foliage strata. Tree harvesting generally favors early successional species such as the Indigo Bunting, Prairie Warbler, and Yellow-breasted Chat, but some late successional forest species, such as the Black-and-white Warbler, persist with partial cutting. A few forest interior species, such as the Ovenbird, are less abundant in landscapes with cutting and forest fragmentation. Some species may have elevated nest parasitism and nest predation along forest edges. Recommendations for NTMB include: Maintain some large, old-growth stands; manage forest habitat for NTMB; employ special measures for endangered or sensitive species; implement long-term monitoring; and develop more complete information through research regarding NTMB, population viability, and their forest habitat.

Central hardwood, loblolly-shortleaf pine, longleaf-slash-pine, and bottomland hardwood forests dominate the central and southeastern United States. These forests are managed by both even-aged and uneven-aged silvicultural systems. We review the impacts of silvicultural practices on neotropical migratory birds (NTMB), in forests of this region. We approach this topic by (1) identifying general relationships between birds and forest habitats and landscapes in the region, (2) assessing effects of forest management on the NTMB in each ecosystem, and (3) conclude with some management strategies that extend across forest types.

Bird Habitat

Bird species and communities in forest stands have specific habitat requirements and any changes to stand characteristics influence stand suitability. Avian density and diversity generally increase with plant succession, and vegetation volume and structural diversity (Johnston and Odum 1956, Shugart and James 1973, Shugart et al. 1975). But breeding bird densities in regenerating oak-hickory or pine-hardwood stands are often similar to those in mature stands, with densities often lowest in mid-successional pole-sized stands with little sub-canopy foliage (Conner and Adkisson 1975, Conner et al. 1979, Dickson and Segelquist 1979, Yahner 1986, Thompson and Fritzell 1990).

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Tree harvesting drastically alters bird habitat and thus bird communities. Generally, clearcutting results in a near complete turnover of bird species while partial removal of a forest overstory results in decreases in some species, increases in others, and little change in relative abundance of other species (Webb et al. 1977, Crawford et. al. 1981, McComb et al. 1989, Thompson et al. 1992).

Landscape Level Impacts

NTMB populations are affected by factors at scales larger than habitats or forest stands such as landscape (Freemark et al. this proceedings). For instance many forest interior migrants are absent from small forest fragments, and their absence is likely due to lower reproductive success in edge-dominated forest fragments (Faaborg et al. this proceedings, Robinson et al. this proceedings). While edge-related declines in reproductive success in fragmented forests have been documented, the effects of edges created by timber harvest in predominately forested landscapes is unclear. Yahner and Scott (1988) reported higher nest predation rates of artificial nests in Pennsylvania forest with clearcutting than with no clearcutting. Many forest interior species remain abundant in managed forests (Thompson et al. 1992), but it is possible that such forests are population sinks where reproduction is insufficient to compensate for adult mortality (Pulliam 1988). Simulated populations of forest interior NTMB were lower in cut than in uncut forest landscape (Thompson In Press).

In uneven-aged stands, selection cutting maintains a mature tree component at all times and does not create a mosaic of different aged stands. This may benefit forest interior warblers because large tracts of forest with mature trees can be maintained. However, edge effects may occur in group selection openings which could be detrimental to local populations, since these openings can be widely dispersed throughout forests. Also, selection cutting will not provide habitat for species that require young stands, or a diversity of even-aged stands.

CENTRAL HARDWOOD FORESTS

Oak-hickory forests dominate the central hardwood forests but give way to mixed hardwoods in the east and oak-pine forests to the south (Eyre 1980, Sander and Fischer 1989). These forest have been predominantly managed by clearcutting in the past. However, recently there has been an increase in the use of shelterwood and selection cutting, particularly on public lands.

Effects of Even-aged Management

Regeneration Stands

The first year after harvesting these stands may have abundant herbaceous ground cover, but they quickly become dominated by tree regeneration from sprouting and advance regeneration resulting in as many as 25,000 stems/ha (Gingrich 1971). The first year after clearcutting there is usually a drastic reduction in total bird numbers and a nearly complete turnover in species (Table 1). American Goldfinches and Field Sparrows often prefer cuts at this age because of the abundant grass/forb vegetation. As tree regeneration dominates the site, Yellow-breasted Chats, Indigo Buntings, Prairie Warblers, Blue-winged warblers, Kentucky Warblers, Common Yellowthroats, White-eyed Vireos, Gray Catbirds, and Rufous-sided Towhees occupy the stands. To the east Chestnut-sided Warblers and Hooded Warblers also may be common. In shelterwood and seed-tree cuts, and clearcuts with residual live trees and snags, some mature-forest, canopy-dwelling species may continue to use the stands.

Sapling Stands

During age 10 to 20 the stands are dominated by tree saplings with a closed canopy. At age 20 the number of stems has been reduced through mortality to 3,400-6,200/ha and the larger trees on good sites have reached 18 cm dbh (Gingrich 1971). Many birds typical of regenerating stands persist at lower densities in these stands. Black-and-white Warblers, Worm-eating Warblers, and Kentucky Warblers seem to prefer the high stem densities and closed canopies this age class provides. Ovenbirds, Wood Thrushes, and Red-eyed Vireos may begin using stands at this age.

Poletimber Stands

From age 20 to 60 years 90% of the trees will die due to competition. The canopy remains closed and there is little understory development. As a result, common species tend to be canopy nesters such as Red-eyed-Vireos, Scarlet Tanagers, Eastern Wood Pewees, and Wood Thrushes, or ground nesters such as Ovenbirds and Black-and-white Warblers.

Mature Stands

The structure of mature forests varies widely throughout the region. Depending on soils, geology, climate, and geography; mature stands may have sparse to dense groundcover and understory. Decay and deaths of large trees result in cavities, snags, and tree fall gaps not present in short rotation stands.

Table 1. — Abundance of neotropical migratory birds in central hardwood forests.[1]

Species	Stand Age[2]					
	R	S	P	M	G	T
Whip-poor-will	U[3]	U	U	U	U	U
Ruby-throated hummingbird	C	N	N	N	?	N
Acadian flycatcher	N	N	C	A	N	A
Eastern wood-pewee	N	N	U	A	N	A
Eastern phoebe	N	N	U	U	N	U
Great-crested flycatcher	C	C	C	C	C	C
Carolina wren	C	C	U	N	?	?
Blue-gray gnatcatcher	A	C	C	C	C	C
Eastern bluebird	C	N	N	N	N	N
Wood thrush	U	C	C	C	U	C
Gray catbird	C	C	N	N	?	N
White-eyed vireo	C	C	N	N	?	N
Yellow-throated vireo	N	N	N	U	N	U
Red-eyed vireo	U	U	A	A	U	A
Blue-winged warbler	A	C	N	N	?	N
Golden-winged warbler	C	U	N	N	?	N
Northern parula	N	N	U	C	N	C
Chestnut-sided warbler	C	C	N	N	?	N
Yellow-throated warbler	N	N	U	U	N	U
Pine warbler	N	N	C	C	N	C
Prairie warbler	A	C	N	N	?	N
Black-and-white-warbler	C	C	C	C	C	C
Worm-eating warbler	U	C	C	C	C	C
Ovenbird	U	C	C	C	U	U
Louisiana waterthrush	N	U	C	C	C	C
Common yellowthroat	A	U	N	N	?	N
Kentucky warbler	A	C	U	U	A	C
Hooded warbler	C	C	U	U	C	C
Yellow-breasted chat	A	C	N	N	?	N
Orchard oriole	U	N	N	N	N	N
Summer tanager	C	C	C	A	C	C
Scarlet tanager	U	U	C	A	U	A
Indigo bunting	A	C	U	U	A	C
Rufous-sided towhee	A	U	N	N	C	N
Field sparrow	A	N	N	N	?	N
Brown-headed cowbird	A	C	C	C	C	C
American goldfinch	U	N	N	N	N	N
Blue jay	C	C	C	C	C	C
American crow	U	U	U	U	U	U

[1] *Includes oak-hickory, mixed hardwood, and oak-pine forest types. Habitat associations based on Conner and Adkisson 1975, Conner et al. 1979, Dickson and Segelquist 1979, Dickson et al. 1980, Evans and Kirkman 1981, Yahner 1986, Thompson and Fritzell 1990, Thompson et al. (1992), Whitehead unpubl. data, Robinson unpubl. data.*

[2] *R = regeneration, S = sapling, P = poletimber, M = mature, G = group selection, T = single tree selection.*

[3] *A = abundant, C = common or regular, P = present, U = uncommon, N = not present.*

Rotations for central hardwood stands managed for sawtimber are usually 60-120 years. At age 80 dominant trees will range from 30-46 cm dbh. If left undisturbed these stands will slowly become uneven-aged as they age and individual trees die. However, because of widespread logging, burning, and grazing of this region in the late 1800s and early 1900s much of the mature forest in the region is even-aged ranging from 60-100 years old. There are no known obligate old-growth NTMB in these forests. The most abundant species throughout the region in mature forests is the Red-eyed Vireo. Other abundant or common species in this age class include Eastern Wood Pewee, Acadian Flycatcher, Blue-gray Gnatcatcher, Ovenbird, Worm-eating Warbler, Scarlet and Summer tanager, and Blue Jay. In oak-pine stands Pine Warblers and Yellow-throated Warblers are common.

Changes in Stand Composition

Regeneration cuts do not usually greatly alter tree species composition in central hardwood stands because they are naturally regenerated largely from advance reproduction and stump sprouts. Small changes in tree species composition have little effect on breeding birds because it is generally believed most birds select breeding habitat by vegetation structure. Past practices of converting low quality hardwood stands to pine have been largely abandoned on public lands but may persist on some private lands. Pine plantations generally support a lower density and diversity of breeding birds because of their structural simplicity.

Uneven-aged Management

Single and Multi-tree Gaps

Canopy gaps resulting from the harvest of single trees or groups of trees provide habitat for a variety of migrant birds. Species such as the Hooded Warbler and Indigo Bunting appear to be able to make use of small gaps typical of single tree selection while other species such as Yellow-breasted Chats, Blue-winged Warblers, and Prairie Warblers require large openings more typical of clearcuts (F. Thompson pers. obsv.). There is a dearth of information on the area sensitivity of species requiring early successional forest or gaps. These canopy gaps also may be attractive to cowbirds and predators.

Change in Stand Structure

Uneven-aged stands have a well developed understory and sub-canopy because of frequent canopy gaps. The presence of several well developed vegetation levels and more complex habitat structure than similar aged even-aged stands could result in higher within-stand bird species diversity. For instance, in Illinois selectively cut stands contained NTMB associated with mature forest habitats as well as some young second growth species.

There are indications that uneven-aged stands may be poor habitat for some mature forest species. There were fewer ovenbirds in mature uneven-aged than in even-aged forests; and all red-eyed vireo males in a selectively cut stand in Missouri were unmated, compared to 80% mated in a nearby uncut mature forest (Ziehmer 1992).

LOBLOLLY-SHORTLEAF PINE FORESTS

he loblolly-shortleaf pine ecosystem of the rolling portions of the Gulf Coastal Plains, the Piedmont, and portions of Appalachian, Ouachita, and Ozark Mountains, is characterized by a species composition of at least 50 percent pines (either loblolly, shortleaf, or a mix). Associated species include oaks, hickories, sweetgum, blackgum, winged elm, and red maple (Garrison et al. 1977). The degree of hardwood inclusion in these forests is largely determined by past frequency and intensity of natural and prescribed fire.

Harvesting of loblolly and shortleaf pines and subsequent stand regeneration can be successfully accomplished with both even- and uneven-aged silvicultural techniques (Baker and Balmer 1983, Lawson and Kitchens 1983), In modern managed forests prescribed fire, intensive mechanical site preparation, pine seedling planting, and herbicides are used to enhance or maintain the pine component.

Bird Communities

The loblolly-shortleaf pine ecosystem provides habitat for a very diverse array of birds, many of which are neotropical migrants. Stand structure and the proportion of pines and hardwoods are important determinants of avian communities.

Even-aged Management

Early succession stands are structurally simple with little vertical foliage diversity. As stands develop different stages of stand development are attractive to different species of birds.

Seedling and Sapling Stands

Breeding season--Clearcutting today and over the past several decades has produced habitat conditions very similar to those created by large landscape level disturbances. An array of neotropical migrants (e.g., Prairie Warblers, Field Sparrows, Blue Grosbeaks,) are attracted to the youngest stands during the breeding season (Noble and Hamilton 1976; Meyers and Johnson 1978; Conner et al. 1979, 1983; Dickson and Segelquist 1979; Dickson et al. 1980, 1984; Childers et al. 1986). When the stands exceed three years old the number of neotropical migrants using them for breeding sites blooms. Indigo Buntings,

Table 2. — Abundance of neotropical migratory birds in Loblolly-shortleaf pine forests[1].

Species	Stand Age[2]				
	R	S	P	M	O
Whip-poor-will	N[3]	N	N	N	?
Ruby-throated hummingbird	U	U	U	U	U
Acadian flycatcher	N	N	U	C	C
Eastern wood-pewee	N	U	P	C	A
Eastern phoebe	N	N	N	N	?
Great-crested flycatcher	N	N	U	P	C
Blue-gray gnatcatcher	N	N	U	C	A
Eastern bluebird	U	U	N	N	P
Wood thrush	N	N	U	C	A
American robin	N	U	U	U	U
Gray catbird	U	U	N	U	U
White-eyed vireo	U	A	P	U	C
Yellow-throated vireo	N	N	U	A	C
Red-eyed vireo	N	U	C	A	A
Blue-winged warbler	N	N	N	N	N
Golden-winged warbler	N	N	N	N	N
Northern parula	N	N	U	U	C
Chestnut-sided warbler	N	N	N	N	N
Pine warbler	N	N	C	A	A
Prairie warbler	C	A	N	N	U
Black-and-white-warbler	N	U	C	C	C
Worm-eating warbler	N	N	C	C	C
Chuck-will's-widow	U	U	U	U	U
Ovenbird	N	N	U	C	C
Louisiana waterthrush	N	N	N	P	P
Kentucky warbler	N	U	C	P	P
Hooded warbler	N	U	C	A	C
Yellow-breasted chat	C	A	U	N	P
Summer tanager	N	N	U	C	C
Scarlet tanager	N	N	U	U	U
Indigo bunting	N	A	P	U	P
Rufous-sided towhee	N	P	C	C	P
Field sparrow	C	U	N	N	N
Brown-headed cowbird	P	C	P	P	N
American goldfinch	U	U	U	U	U
Blue grosbeak	C	U	N	N	N
Blue jay	U	U	C	A	C
American crow	U	U	P	C	C

[1] Includes oak-hickory, mixed hardwood, and oak-pine forest types. Habitat associations based on Conner and Adkisson (1975), Conner et al. (1979), Crawford et al. (1981), Yahner (1986), Thompson and Fritzell (1990), Thompson et al. (1992), Hammel (in Press), Robinson (unpubl. data), Whitehead (unpubl. data).

[2] R = regeneration, S = sapling, P = poletimber, M = mature, O = oldgrowth.

[3] A = abundant, C = common or regular, P = present, U = uncommon, N = not present.

Painted Buntings, White-eyed Vireos, Yellow-breasted Chats, and Common Yellowthroats are some of the more common species found in the well developed shrubby vegetation of young clearcuts.

As these even-aged stands develop, foliage patchiness in the 0-3 m layer increases and some trees grow to 4-5 m. A few additional species of neotropical migrants begin to occupy the older sapling loblolly-shortleaf stands. In the northern portion of the ecosystem Ovenbirds, Rufous-sided Towhees, Black-and-white Warblers, and American Redstarts begin to appear. Further south, only Black-and-white Warblers are added in any numbers. During this later sapling stage of succession some species, such as Field Sparrows and Blue Grosbeaks, begin to disappear as foliage over-grows bare ground and grasses.

Winter--Many neotropical migrants use young and older sapling aged loblolly-shortleaf pine stands as wintering habitat (Noble and Hamilton 1976, Dickson and Segelquist 1977). Winter Wrens, Brown Thrashers, American Robins, Hermit Thrush, Eastern Bluebirds, Ruby-crowned and Golden-crowned kinglets, Pine and Yellow-rumped warblers, Dark-eyed Juncos, and Field, Song, Lincoln's, and White-throated sparrows all use young pine plantations during winter.

Pole Stands

Breeding season--When young pines and hardwoods reach the pole stage (12-25 years) most of the early succession migrants are no longer found. The taller foliage gradually forms a canopy that reduces light penetration through to the understory. A few White-eyed Vireos and Yellow-breasted Chats remain in open areas, such as wind rows, (Noble and Hamilton 1976; Meyers and Johnson 1978; Conner et al. 1979, 1983; Dickson and Segelquist 1979; Dickson et al. 1980, 1984; Childers et al. 1986). Kentucky and Black-and-white warblers become fairly common. Red-eyed Vireos, Worm-eating, Pine, and Hooded warblers, Yellow-billed Cuckoos, and Summer Tanagers begin to appear. Occasionally, Wood Thrush and Brown Thrashers are detected in such stands.

Winter--Both pine and pine-hardwood pole sized stands are used during winter by neotropical migrants, such as Brown Creepers, Winter Wrens, Hermit Thrush, Eastern Bluebirds, Golden-crowned and Ruby-crowned kinglets, Black-and-white, Pine, and Yellow-rumped warblers, and White-throated Sparrows (Noble and Hamilton 1976, Dickson and Segelquist 1977).

Mature Loblolly-Shortleaf Pine Stands

Breeding season--After 35 to 50 years the developing stand begins to achieve a few characteristics of maturity. An overstory canopy is now present, but midstory and understory foliage can be present also, depending on how much light filters through the canopy. A few White-eyed Vireos and Indigo Buntings are the only early succession species that may persist into the more mature stages of forest growth, depending on the availability of open patches where sufficient light has penetrated to stimulate growth of understory foliage for nesting sites. Wood Thrush, Red-eyed Vireos, Black-and-white Warblers, Eastern Wood Pewees, Great Crested and Acadian flycatchers, Pine, Hooded, Kentucky warblers, Summer Tanagers, and Blue-gray Gnatcatchers are now abundant (Noble and Hamilton 1976; Meyers and Johnson 1978; Conner et al. 1979, 1983; Dickson and Segelquist 1979; Dickson et al. 1980, 1984; Childers et al. 1986). Yellow-throated Warblers, Northern Parulas, and Yellow-billed Cuckoos are also present. Pine Warblers are attracted to the pine foliage, whereas most of the other species are primarily dependant on deciduous foliage that has developed.

Winter--Mature loblolly-shortleaf pine and pine-hardwood forests provide winter cover and food for American Robins, Hermit Thrush, Golden-crowned and Ruby-crowned kinglets, Black-and-white Warblers, and White-throated Sparrows (Noble and Hamilton 1976, Dickson and Segelquist 1977).

Management Activities Affecting Bird Communities

Management activities such as site preparation, herbicide use, and thinning, affect stand structure and impact the avian fauna.

Site preparation--The intensity of mechanical site preparation prior to planting affects the amount of hardwood vegetation that regenerates with the pine seedlings. Intensive K-G blading (bull-dozer blade) and chopping of roots will reduce the amount of hardwood regeneration substantially. Less intensive site preparation, such as prescribed burning, permits more hardwood vegetation to survive and grow along with the pines. Bird species diversity will be reduced as the amount of hardwoods in all pine stands decreases. **Herbicides**--Herbicides sometimes are used to kill hardwoods that compete with pines in young pine plantations. Reduction of hardwood vegetation would set back stand development and associated bird communities.

Thinning--Thinning opens the canopy, releasing the remaining pines for increased diameter growth, and permits more light into the understory which promotes understory vegetation (Blair and Enghardt 1976, Blair 1982).

Thinning is beneficial to some neotropical migrants and has a significant positive influence on bird abundance and species richness during the breeding season (Chritton 1988). Indigo Buntings, Pine Warblers, and Brown-headed Cowbirds increased in abundance following thinning of a loblolly plantation in Texas. White-eyed Vireos, Worm-eating Warblers, and Hooded Warblers were negatively affected, whereas Black-and-white Warblers appeared to be unaffected by thinning.

Thinning also affects migrants that winter in the loblolly-shortleaf pine ecosystem in the South (Chritton 1988). During winter, bird abundance and species richness was higher

in thinned pine stands than in unthinned stands. Pine Warblers, Ruby-crowned and Golden-crowned kinglets, and Dark-eyed Juncos increased in numbers following thinning in Texas.

Rotation ages--Longer rotations of 70 to 80 years and longer permit some old-growth attributes to develop and provide habitat for species of neotropical migrants that prefer mature pine forest, such as Red-eyed Vireos, Northern Parulas, and Hooded, Pine, and Yellow-throated warblers. Shorter saw log rotations of 35 to 50 years would provide habitat for some mature forest species but probably at lower densities then the longer rotations. Pulp wood rotations of 20-30 years provide habitat for early successional species when the stands are young, but has limited suitability for neotropical migrants requiring stands beyond the pole timber stage.

Seed-tree and Shelterwood Harvesting

Seed-tree and shelterwood harvesting leave uncut mature pines to serve as seed sources and in shelterwood as shelter for the developing stands. These large residual pines can be of value to early and late successional neotropical migrant birds (Hall 1987).

Breeding Season--Neotropical migrants using seed-tree and shelterwood cuts during the breeding season are: Eastern Kingbirds, Acadian Flycatchers, Pine Warblers, Prairie Warblers, Yellow-breasted Chats, Wilson's Warblers, Hooded Warblers, Orchard Orioles, Indigo Buntings, and Chipping and Field sparrows.

Winter--During winter, seed-tree and shelterwood harvesting again provide habitat for both early and late succession bird species. Neotropical migrants using cuts included American Kestrels, Ruby-crowned Kinglets, Yellow-rumped Warblers, Common Yellowthroats, Red-winged Blackbirds, Purple Finches, Pine Siskins, American Goldfinches, and Grasshopper, Henslow's, Lark, Field, White-crowned, White-throated, Swamp, and Song sparrows (Hall 1987).

Unfortunately, the benefits for bird species richness gained by the presence of the residual pines is lost completely when the residuals are removed following the establishment of the new pine stand.

Uneven-aged Timber Management

There is extremely little published information on the bird communities that inhabit stands managed under single-tree or group selection harvesting, so currently we can only speculate based on data from seed-tree and shelterwood cuts, and heavily thinned stands. Species that use early successional stands, small gaps within forests, and "edge" would probably be favored by single tree selection harvesting. In group selection larger gaps up to 1 ha would have a similar but more pronounced effect on the avian community than single tree selection. Yellow-breasted Chats, Indigo Buntings, and Prairie Warblers, will probably be added to the overall bird community. But, cowbird parasitism may increase and the few mature forest species that prefer a continuous canopy may be negatively impacted.

LONGLEAF, SLASH, AND LONGLEAF-SLASH PINE FORESTS

The longleaf-slash pine ecosystem, a subclimax type maintained by fire, generally occurs along the lower coastal plain of the southeastern U.S. Agricultural conversion, intensive timber management, and substantial declines in frequency and intensity of fires have resulted in drastic reduction in the longleaf pine forests. The natural range of slash pine is more restricted (South Carolina to Central Florida and southeast Louisiana), although it has been planted extensively as far north as North Carolina and west to eastern Texas. Most of the typical longleaf-slash pine cover type is found in the flatwoods of Florida and Georgia. Slash pine seedlings are more shade tolerant than those of longleaf pine; hence, slash pine may begin as an understory and remain subordinate to the longleaf pine overstory. Slash pine regeneration is eliminated by fire and without fire the encroachment of hardwoods will progress until they predominate and exclude the pines. Longleaf pine seedlings in the grass stage can tolerate and benefit from prescribed burning for brownspot control. Both slash and longleaf pine seedlings growing in height are vulnerable to fire, but both species are somewhat immune when they attain a height of about 5m.

Bird Habitat

Younger forests tend to have moderate bird species diversity (BSD), the initial BSD tends to decrease by the time the forests are 16-20 years old, after which it increases to maturity (Childers et al. 1986, Noble and Hamilton 1976, Repenning and Labisky 1985).

Avifauna in pine forests is substantially influenced by the presence and extent of hardwoods (Johnston and Odum 1956, Dickson and Segelquist 1979). Pine stands normally contain numerous hardwood species and removal influences bird community composition. Burning to maintain pine forests can have deleterious effects on birds using the hardwood component for cover, nesting, or foraging. However, for ground foragers, the effects of burning may be beneficial as fire reduces the litter thereby exposing seeds that then become available for food. Slash pine sites in southeastern Georgia that contained hardwoods supported 17 species that either were absent or occurred in low densities in the pure slash pine and, therefore, hardwoods were important in maintaining the BSD (Johnson and Landers 1982).

Several studies have examined longleaf and slash pine stands of various ages to determine how avian community structure may change as the stands mature. In slash pine stands

Table 3. — Abundance of neotropical migratory birds in longleaf and slash pine forests[1].

Species	Stand Age[2]				
	R	S	P	M	O
Longleaf Pine					
Common nighthawk	P[3]	P	U	U	U
Chuck-will's-widow			U	U	U
Eastern wood-pewee			U	C	C
Acadian flycatcher				P	P
Great-crested flycatcher		U	P		
Eastern kingbird				P	P
Purple martin	U				
Barn swallow	U				
Prairie warbler	C				
Summer tanager		U	U	C	C
Blue grosbeak	P	P			
Slash Pine					
Yellow-billed cuckoo			U	U	U
Ruby-throated hummingbird	C	C			
Eastern wood-pewee			C		
Acadian flycatcher			C		
Great-crested flycatcher			P	C	C
Eastern kingbird		P			
Bewick's wren			C		
Blue-gray gnatcatcher			P	P	
White-eyed vireo			C		
Yellow-throated vireo				P	
Yellow-throated warbler		C			
Prairie warbler	U	U	U		
Common yellowthroat		C	P	P	P
Yellow-breasted chat		C			
Summer tanager	C		C	C	C
Blue grosbeak	P	P			
Indigo bunting	C	C	P	U	U
Longleaf-Slash Pine					
Osprey				U	U
American swallow-tailed kite				U	U
Yellow-billed cuckoo	P				
Common nighthawk	P	U	U	U	U
Chuck-will's-widow			U	U	U
Ruby-throated hummingbird	U				
Eastern wood-pewee			U	C	C
Great crested flycatcher	P		U	P	P
Eastern kingbird	U	U	U	U	U
Purple martin	U				
Barn swallow	U				
White-eyed vireo				C	C
Yellow-throated warbler		U	U	U	U
Prairie warbler	U	U	U	U	U
Common yellowthroat	U	P	P	C	C
Yellow-breasted chat	U	U			
Summer tanager		U	U	P	P
Blue grosbeak	P	P			
Indigo bunting	C	C	P	U	U

[1] From Hamel et at. (1982), Johnson and Landers (1982), O'Meara et al. (1985), Repenning and Labisky (1985), Dickson (1991), and Hamel (in press),

[2] R = regeneration, S = sapling, P = poletimber, M = mature, O = old growth.

[3] A = abundant, C = common or regular, P = present, U = uncommon

in southeastern Georgia in relation to stand age and regeneration method, Johnson and Landers (1982) found that bird numbers tended to be lowest in the 1-year-old slash pine plantations, increased in the 2-6-year-old stands, and then declined again until approximately mid-rotation (16 years). Once stands passed mid-rotation ages (16-28 years), the initial stand treatments such as site preparation or whether naturally regenerated or planted, had no detectable effect on the avifauna. Five species of breeding NTMB were found in the fallow areas, with only the Blue-gray Gnatcatcher being abundant, and five species were regularly observed in the regenerating areas. Of the seven species found in the seedling/sapling stage, the Indigo Bunting, Common Yellowthroat, and Ruby-throated Hummingbird were either abundant or common. The Common Yellowthroat, Blue-gray Gnatcatcher, and Eastern Wood Pewee were the most commonly observed of the 10 NTMB in the pole stage.

Also, regenerating longleaf pine/slash pine stands in the grass forb stage are year round habitat for the Bachman's Sparrow, Northern Bobwhite , Mourning Dove and Eastern Bluebird; breeding habitat for the Common Nighthawk; and wintering habitat for Henslow's and Leconte's sparrows. The sapling stage is suitable habitat for the Common Nighthawk, Common Yellowthroat, Indigo Bunting, and a number of permanent resident species.

The effects of prescribed burning on a 20 year-old slash pine stand resulted in a drastic decline in ground cover and shrub foliage in Everglades National Park, Florida (Emlen 1970). However no significant difference was detected in NTMB or foraging guilds after the fire, possibly because of individual attachments to home range and familiar foraging sites.

Harris et al. (1974) compared site preparation techniques in three 9-year old slash pine stands with a naturally regenerated slash pine stand and with a mature longleaf pine stand that had been prescribed burned the previous year. The average number of birds observed per transect sampled was higher in areas that had undergone low intensity site preparation than in mature slash pine; however, the number of species observed per transect was significantly lower. There were nine times more birds in mature longleaf pine stands than in the low intensity site prepared slash pine stands and 60 times more than in the high intensity treated site prepared stands.

Repenning and Labisky (1985) compared the avian community in 3 naturally regenerated longleaf pine stands (>50 years) to slash pine plantations of 4 different ages (1-, 10-, 24-, and 40-year-old stands) (3 stands per age group). Density of breeding birds was highest in the longleaf pine stands (288 birds/km^2) and oldest slash pine stands (149 birds/km^2). Longleaf pine stands supported more breeding birds, a higher biomass, and greater species richness than any of the slash pine stands. Cavity and ground nesters increased in both density and number of species from the youngest to oldest stands and were highest in the longleaf pine forests. Of the 7 species of neotropical migrant breeding birds, 2 species were found in 1-year old stands (13 birds per km^2), 4 in 10-year old stands (19 birds per km^2), 2 in 24-year old stands (22 birds per km^2),

4 in 40-year old (33 birds per km^2), and 5 in mature longleaf pine forest (33 birds per km^2). Wintering birds were most numerous in the youngest slash pine stands, perhaps the result of the abundance of seed-producing grasses and forbs (Repenning and Labisky 1985). They concluded that conversion of mature longleaf stands to slash pine plantations did not accommodate the bird community associated with the mature habitat.

O'Meara et al. (1985) and Rowse and Marion (1980) examined the same 3 areas of flatwoods in Florida containing slash and scattered longleaf pine trees. The areas had been harvested 35 years prior, allowed to regenerate naturally, and fire had been excluded for 20 years. Pine stands in 2 of the areas were clearcut and were monitored before cutting and for 3 years afterwards. Unharvested slash pine 35-years-old, regenerating slash pine (recently clearcut), cypress and edge areas (< 10 m from the interface of 2 other habitats) were compared. The Great-creasted Flycatcher, White-eyed Vireo, and Common Yellowthroat were the NTMB in the 35-year old stands. For the 3 years subsequent to clearcutting, harvested habitats contained low spring and summer densities with only a few species adapted to early-successional vegetation. Three NTMB species (Common Nighhawk, Common Yellowthroat, and Blue Grosbeak) were present at densities less than 7/km^2. Winter densities in clearcut habitat were higher resulting from the presence of wintering flocks of American Robins and Red-winged Blackbirds and mixed species flocks of sparrows. The findings of this study are similar to that of Repenning and Labisky (1985) in that an immediate result of clearcutting slash pine was a replacement of birds by species adapted to early successional stages, a lower density of breeding birds, reduced BSD, and a much larger wintering than breeding population.

The above studies evaluated the effects of even-aged management on the avifauna. However, little work has been done in relation to the response of birds to uneven-aged harvesting techniques. Single tree selection harvesting opens up the forest canopy, creating small gaps in the forest floor. In the group selection method, cuts are usually 0.2 to 0.8 ha in size and thus create numerous small gaps in the forest. In both cases, species that use edge habitats or small gaps will benefit. However, it is not clear if the habitat fragmentation created by this approach will be detrimental to birds requiring large tracts of undisturbed forest.

OAK-GUM-CYPRESS FORESTS

Oak-gum-cypress forests (also called bottomland hardwoods) occur on mesic to hydric sites along streams or rivers from Virginia to eastern Texas and up the Mississippi river to Indiana. Dominant vegetative communities of this complex are closely associated with sites which are determined mainly by soils, elevation, and hydroperiod. Oak-gum-cypress forest area has declined, especially in the Mississippi River Delta where land was converted to soybeans, cotton, and pasture. Recently there have been some efforts to restore bottomland forests that have been converted to agricultural uses and to protect what remains.

The avifauna of oak-gum-cypress forests is abundant and diverse. Habitat suitability for bird communities and species depends on stand structure and other factors.

Breeding Birds

There are a variety and abundance of breeding birds in the mature bottomland hardwood forests of the South. In a Louisiana floodplain forest about half of the number and species of breeding season birds were neotropical migrants and about half were permanent residents (Dickson 1978b). The proportion of neotropical migrant breeders was lower than in more northerly and seasonally harsher climates.

Oak-gum-cypress forests are special habitat for many species of birds (Dickson 1978a, 1988, Hamel et al. 1982). A survey of breeding bird censuses from seven mature stands (Dickson et al. 1980) showed that Yellow-billed Cuckoos, Acadian Flycatchers, and Red-eyed Vireos were consistently abundant in oak-gum-cypress habitat. Other species regularly inhabit these stands, and some have special affinities for this habitat (Table 4).

Table 4. — Neotropical migrant breeding bird species present in southeastern oak-gum-cypress forests (from Hamel et al. 1982 and other sources)

American anhinga	Blue-gray gnatcatcher
Green-backed heron	White-eyed vireo
Great blue heron	Yellow-throated vireo
Little blue heron	Red-eyed vireo
Cattle egret[1]	Black-and-white warbler
Great egret	Prothonotary warbler
Snowy egret	Swainson's warbler
Tricolored heron	Worm-eating warbler
Black-crowned night heron	Bachman's warbler
Yellow-crowned night heron	Northern parula
Wood stork	Black-throated green warbler
Glossy ibis	Yellow-throated warbler
White ibis	Prairie warbler[2]
Hooded merganser	Ovenbird
American swallow-tailed kite	Louisiana waterthrush
Mississippi kite	Kentucky warbler
Cooper's hawk	Common yellowthroat[2]
Bald eagle	Yellow-breasted chat[2]
Osprey	Hooded warbler
Purple gallinule	American redstart
Common moorhen	Eastern meadowlark[1]
Mourning dove[1]	Red-winged blackbird
Yellow-billed cuckoo	Brown-headed cowbird[1]
Chimney swift[1]	Orchard oriole
Ruby-throated hummingbird	Northern oriole
Belted kingfisher	Summer tanager
Great-crested flycatcher	Blue grosbeak[2]
Eastern phoebe[1]	Indigo bunting[2]
Acadian flycatcher	Painted bunting[2]
Eastern wood pewee	Rufous-sided towhee[2]
Barn swallow[1]	
Purple martin[1]Wood thrush	

[1] *Associated with human altered non-forest habitat.*

[2] *Associated with early successional stands.*

Many long-legged waders nest and forage in aquatic woodlands. Wood Storks, which are now endangered, nest in tall cypress and hardwoods and feed in associated aquatic systems.

Several migratory raptors inhabit bottomland hardwoods, such as the Mississippi and Swallow-tailed kites, Cooper's Hawks, Bald Eagles, and Ospreys. Also, Purple Gallinules and Common Moorhens are found in appropriate aquatic habitat.

Acadian Flycatchers are strongly associated with forested wetlands (Shugart and James 1973, Smith 1977), and Wood Thrushes are a common breeding bird in the mesic sites. White-eyed Vireos are common in this type in low, shrubby foliage and Red-eyed Vireos in canopy foliage. There are many warblers in this habitat, some with special affinities. Prothonotary, Swainson's, Northern Parula, Kentucky, and Hooded are strongly associated with this habitat. Prothonotary Warblers nest in cavities, often over water. Northern Parulas construct their nest with Spanish moss in moist woods. The Swainson's Warbler is primarily associated with understory thickets of southern river floodplains and the southern Appalachian Mountains (Meanly 1971). The habitat of the rare Bachman's Warbler is bottomlands and headwater swamps subject to disturbances (Hooper and Hamel 1977). Both Swainson's and Bachman's warblers are associated with cane thickets, which were once extensive in southern bottomland forests (Meanly 1971, Remsen 1986). Kentucky and Hooded warblers are usually found in the moist understory of bottomland hardwoods (Dickson and Noble 1978). Other warblers often found in mature stands include Black-and-white, Worm-eating, Yellow-throated, Ovenbird, American Redstart, and Louisiana Waterthrush (Hamel et al. 1982).

Bird communities are related to age and development of forest stands (Shugart and James 1973, Dickson and Segelquist 1979). Breeding birds discussed previously have been those associated with mature stands of mixed species, and these would also generally be present in middle-aged stands. Young stands would have mostly a different bird composition. In the earliest stages of hardwood stand development the Dickcissel and Red-winged Blackbird would be characteristic species (Weinell 1989). Neotropical migrant birds typifying the avian community in young brushy stands include the Yellow-breasted Chat, Indigo Bunting, Painted Bunting, Prairie Warbler, Common Yellowthroat, and White-eyed Vireo.

Winter Birds

Winter is an important period for many birds. Mature oak-gum-cypress forests provide critical habitat for wintering birds, and support very abundant wintering bird communities (1400 - 2000/ km^2, Dickson 1978b). Most of the species are permanent or winter residents, such as Common Grackle and White-throated Sparrow, that do not winter in the tropics. But these mature bottomland forests are regular habitat for several species that winter from southern forests into the tropics, including Yellow-bellied Sapsuckers, American Robins, Hermit Thrushes, Ruby-crowned Kinglets, and Orange-crowned Warblers.

Silviculture and Bird Communities

Although specific studies of bird community changes related to silvicultural practices in oak-gum-cypress forests are generally lacking, some information may be presented based on general habitat relationships of bird species and from study results of the other habitats in the South. Drastic habitat alteration in oak-gum-cypress forests will influence bird community composition. Conversion of mature bottomland forest stands to other land uses, of course, will drastically alter bird communities. Many bottomland stands and their associated bird communities have been lost to reservoirs. This conversion probably only benefits a few aquatic species such as cormorants and perhaps some cavity nesters in the short term if the trees are not cleared before inundation and water-killed snags are left. Conversion of bottomland forests to agricultural land also results in elimination of the forest associated avian community.

Tree harvesting and regeneration in bottomland forests is a habitat alteration that results in changes to the bird community. The replacement of mature stands of mixed hardwoods by hardwood plantations alters bird communities. These plantations and natural stands of pure black willow or cottonwood lack vegetative diversity and support fewer birds and a less diverse bird community than natural mixed stands (Wesley et al. 1976). But in areas where the majority of land is in mature mixed stands and the plantations represent a small land commitment, the overall beta (landscape) bird diversity of an area could be increased because of the birds associated with early successional stands that inhabit the plantations. In Mississippi, Red-winged Blackbirds, Common Yellowthroats, Yellow-breasted Chats, Northern and Orchard orioles, Rufous-sided Towhees, and Warbling Vireos were common in plantations, but not in natural stands (Wesley et al. 1976).

Clearcuts with natural regeneration generally would favor edge species such as Wood Pewees and early successional species such as Indigo Buntings, Prairie Warblers, White-Eyed Vireos, and Yellow-breasted Chats (Dickson and Segelquist 1979, McComb et al. 1989, Thompson et al. 1992).

Harvest regimes in which some trees are harvested and some left, such as improvement cuts or thinnings would have a less drastic effect on bird communities than clearcuts and would favor early successional and edge species. Partial cuts or small clearcuts usually result in higher bird diversity and most mature forest associated birds remain in forested stands where some mature trees or stands remain. Understory vegetation growth in the opened stands would favor understory associated species such as Kentucky and Hooded warblers (Dickson and Noble 1978, McComb et al. 1989, Thompson et al. 1992).

A few forest interior species associated with closed canopy forest would dwindle with tree harvest and stand opening. Studies have shown Ovenbird and Wood Thrush abundance were negatively correlated with stand harvest (Crawford et al. 1981, Webb et al. 1977).

Rotation age also would affect bird community composition in forest stands. Short rotations would favor early successional species, whereas long rotations should favor cavity using species such as the Great-crested Flycatcher and canopy associated species such as the Red-eyed Vireo, Yellow-throated Vireo, Northern Parula, and Summer Tanager (Dickson and Noble 1978).

MANAGEMENT RECOMMENDATIONS

NTMB communities are determined by local habitat factors as well as landscape composition. At a landscape level the single most important consideration is to maintain large areas in breeding and wintering forest habitats to provide for large NTMB populations and minimize numbers of cowbirds and predators associated with agricultural, suburban, and urban land uses. At the habitat level the most basic management step is to maintain native ecosystems. Management should promote rare ecosystems and habitats required by threatened or endangered species and regional species of high management concern. A high priority in southeastern forests is to protect existing old-growth stands and corridors, and to allow new old growth stands to develop. Restoration and maintenance of natural ecosystems that have been substantially reduced or altered, such as longleaf and oak-gum-cypress forests, should be accelerated. NTMB species exhibiting population declines and identified as species of high management concern breed in all stages of forest succession (Hunter In Press, Thompson et al. In Press), so a diversity of successional stages should be provided. Unless specific concerns dictate otherwise, both selection cutting and even-aged management should be used to create small openings for gap species, large openings for early successional forest migrants, and a balanced age-class distribution to maintain sufficient mature forest habitats. This range of opening sizes more closely imitates the range in size of natural openings or disturbances in forests (Hunter 1990) than the use of any one regeneration practice. Where late successional, area or edge-sensitive NTMBs are a concern (e.g. Red-eyed Vireo, Ovenbird, Pine Warbler, etc.) some blocks of unfragmented forest should be set aside from timber harvest, larger regeneration cuts on longer rotations used in even-aged systems, and single tree selection favored over group selection. Even-aged systems should be used to provide young forest habitats for early successional species (e.g. Prairie Warbler, Yellow-breasted Chat, Blue-winged Warbler, etc.) because openings created by selection cutting may be too small for many of these species. Other stand level practices that will maintain NTMB community viability include retaining live cavity trees and snags when stands are regenerated, and maintaining both coniferous and deciduous components of mixed stands. An extensive monitoring program should be implemented which tracks bird species abundance and viability over the long term.

Research of NTMB and their forest habitat should be expanded to develop more complete information for management of NTMB. The different forested ecosystems, their components and function, should be explored more fully. Species density may not always be a suitable measure of habitat quality (Van Horne 1983). A better understanding of species demographics, including productivity, cowbird parasitism, and nest predation is essential. Moreover, additional information relating avian communities to forest composition, distribution, fragmentation and various silviculture practices is needed to ensure the future of sensitive NTMB.

LITERATURE CITED

Baker, J. B., & W. E. Balmer. 1983. Loblolly pine. Pp. 149-152 in Silvicultural systems for the major forest types of the United States (R.M. Burns, tech. compl.). USDA For. Serv. Agric. Hdbk No. 445.

Blair, R. M. 1982. Growth and nonstructural carbohydrate content of southern browse species as influenced by light intensity. J. Range Manage. 35: 756-760.

Blair, R. M., & H. G. Enghardt. 1976. Deer forage and overstory dynamics in a loblolly pine plantation. J. Range Manage. 29: 104-108.

Childers, E. L., T. L. Sharik, & C. S. Adkisson. 1986. Effects of loblolly pine plantations on songbird dynamics in the Virginia Piedmont. J. Wildl. Manage. 50: 406-413.

Chritton, C. A. 1988. Effects of thinning a loblolly pine plantation on nongame bird populations in east Texas. M.S. Thesis. Stephen F. Austin State Univ., Nacogdoches, Texas.

Conner, R. N., & C. S. Adkisson. 1975. Effects of clearcutting on the diversity of breeding birds. J. For. 73: 781-785.

Conner, R. N., J. G. Dickson, B. A. Locke, and C. A. Segelquist. 1983. Vegetation characteristics important to common songbirds in east Texas. Wilson Bull. 95: 349-361.

Conner, R. N., J. W. Via, & I. D. Prather. 1979. Effects of pine-oak clearcutting on winter and breeding birds in southwestern Virginia. Wilson Bull. 91: 301-316.

Crawford, H. S., R. G. Hooper, & R. W. Titterington. 1981. Songbird population response to silvicultural practices in central Appalachian hardwoods. J. Wildl. Manage. 45: 680-692.

Dickson, J. G. 1978a. Forest bird communities of the bottomland hardwoods. Pp. 66-73 in Proceedings of the Workshop: Management of Southern Forests for Nongame Birds (R. M. DeGraff, tech. coord.). U.S. For. Ser. Gen. Tech. Rep. SE-14.

Dickson, J. G. 1978b. Seasonal bird populations in a south central Louisiana bottomland hardwood forest. J. Wildl. Manage. 42: 875-883.

Dickson, J. G. 1988. Bird communities in oak-gum-cypress forests. Pp. 51-62 in Bird Conservation 3. International Council for Bird Preservation (J. A. Jackson, Ed.). University of Wisconsin Press, Madison.

Dickson, J. G. 1991. Birds and mammals of pre-colonial southern old-growth forests. Natural Areas J. 11: 26-33.

Dickson, J. G., R. N. Conner, & J. H. Williamson. 1980. Relative abundance of breeding birds in forest stands in the southeast. South. J. Appl. For. 4:174-179.

Dickson, J. G., R. N. Conner, & J. H. Williamson. 1984. Bird community changes in a young pine plantation in east Texas. So. J. Appl. For. 8: 47-51.

Dickson, J. G., & R. E. Noble. 1978. Vertical distribution of birds in a Louisiana bottomland hardwood forest. Wilson Bull. 90: 19-30.

Dickson, J. G., and C. A. Segelquist. 1977. Winter bird populations in pine and pine-hardwood stands in east Texas. Proc. Annu. Conf. S.E. Assoc. Fish Wildl. Agencies. 31: 134-137.

Dickson, J. G., & C. A. Segelquist. 1979. Breeding bird populations in pine and pine-hardwood forests in Texas. J. Wildl. Manage. 43: 549-555.

Emlen, J. T. 1970. Habitat selection by birds following a forest fire. Ecology 51: 343-345.

Evans, K.E. and R.A. Kirkman. 1981. Guide to bird habitat of the Ozark Plateau U.S. For. Serv. Gen. Tech. Rep NC-68.

Eyre, F. H. (Ed.) 1980. Forest cover types of the United States and Canada. Society of American Foresters, Washington, DC.

Garrison, G. A., A. J. Bjungstad, D. A. Duncan, M. E. Lewis, & D. R. Smith. 1977. Vegetation and environmental features of forest and range ecosystems. U.S. Dept. Agric., Agric. Handbook 475.

Gingrich, S. F. 1971. Management of young and intermediate stands of upland hardwoods. U.S.D.A. For. Serv. Res. Paper NE-195.

Hall, S. B. 1987. Habitat structure and bird species diversity in seedtree and clearcut regeneration areas in east Texas. M.S. Thesis. Stephen F. Austin State Univ., Nacogdoches, Texas.

Hamel, P. B., H. E. LeGrand, Jr., M. R. Lennartz, & S. A. Gauthreaux, Jr. 1982. Bird-habitat relationships on southeastern forest land. U.S. For. Serv. Gen. Tech. Rep. SE-22.

Harris, L. D., L. D. White, J. E. Johnston, & D. G. Milchunas. 1974. Impact of forest plantations on north Florida wildlife and habitat. Proc. Southeastern Assoc. Game Fish Comm. 28: 659-667.

Hooper, R. G., & P. B. Hamel. 1977. Nesting habitat of Bachman's Warbler- A review. Wilson Bull. 89: 373-37979.

Hunter, M. L., Jr. 1990. Wildlife, forests, and forestry: principles of managing forests for biological diversity. Prentice Hall, Englewood Cliffs, N.J.

Hunter, W. C. In Press. Species and habitats of special concern within the southeast region in Proceedings of a workshop on the status and management of neotropical migratory birds. Rocky Mountain Forest and Range Experiment Station General Technical Report.

Johnson, A. S., & J. L. Landers. 1982. Habitat relationships of summer resident birds in slash pine flatwoods. J. Wildl. Manage. 46: 416-428.

Johnston, D. W., & E. P. Odum. 1956. Breeding bird populations in relation to plant succession on the Piedmont of Georgia. Ecology 37: 50-62.

Lawson, E. R., & R. N. Kitchens. 1983. Shortleaf pine. Pp. 157-161 in Silvicultural systems for the major forest types of the United States (R.M. Burns, tech. compl.). USDA For. Serv. Agric. Hdbk No. 445.

McComb, W. C., P. L. Groetsch, G. E. Jacoby, & G.A. McPeek. 1989. Response of forest birds to an improvement cut in Kentucky. Proc. SE Assoc. Fish and Wildl. Agencies 43: 313-325.

Meanly, B. 1971. Natural history of the Swainson's Warbler. North Am. Fauna No. 69.

Meyers, J. M., & A. S. Johnson. 1978. Bird communities associated with succession and management of loblolly-shortleaf pine forests. Pp. 50-65 in Proceedings of the workshop Management of southern forests for nongame birds. USDA For. Serv. Gen Tech. Rept. SE-14.

Noble, R. E., & R. B. Hamilton. 1976. Bird populations in even-aged loblolly pine forests of southeastern Louisiana. Proc. Southeast. Assoc. Game Fish Comm. 29: 441-450.

O'Meara, T. E., L. A. Rowse, W. R. Marion, & L. D. Harris. 1985. Numerical responses of flatwoods avifauna to clearcutting. Florida Scientist 48: 208-219.

Pulliam, H. R. 1988. Sources, sinks, and population regulation. Amer. Nat. 132: 652-661.

Remsen, J. V., Jr. 1986. Was Bachman's Warbler a bamboo specialist? Auk 103: 216-219.

Repenning, R. W., & R. F. Labisky. 1985. Effects of even-age timber management on bird communities of the longleaf pine forest in northern Florida. J. Wildl. Manage. 49: 1088-1098.

Rowse, L. A., & W. R. Marion. 1980. Effects of silvicultural practices on birds in a north Florida flatwoods. Pp. 349-357 in First Biennial Southern Silvicultural Res. Conf.(J. P. Barnett, Ed.). USDA Forest Service Gen. Tech. Rep. SO-34.

Sander, I.L. & B. C. Fischer. 1989. Central Hardwood forest types. Pages 1.021-1.022 in Central Hardwood Notes (F. B. Clark and J. G. Hutchinson Eds.). North Central Forest Experiment Station, St. Paul, Minnesota.

Shugart, H. H., Jr., & D. James. 1973. Ecological succession of breeding bird populations in northwestern Arkansas. Auk 90: 62-77.

Shugart, H. H., S. H. Anderson, & R. H. Strand. 1975. Dominant patterns in bird populations of the eastern deciduous forest biome. Pp. 90-95 in The management of

forest and range habitats for nongame birds Symp. Proc. U.S. Dep. Agric. Gen. Tech. Rep. WO-1. U.S. Dep. Agric. For. Serv., Washington, DC.

Smith, K. G. 1977. Distribution of summer birds along a forest moisture gradient in an Ozark watershed. Ecology 58: 810-819.

Thompson, F. R., III, W. D. Dijak, T. G. Kulowiec, & D. A. Hamilton 1992. Breeding bird populations in Missouri Ozark forests with and without clearcutting. J. Wildl. Manage. 56: 23-30.

Thompson, F. R., III, & E. K. Fritzell. 1990. Bird densities and diversity in clearcut and mature oak-hickory forest. U.S. For. Serv. Res. Pap. NC-293, St. Paul, Minnesota.

Thompson, F. R., III, W. D. Dijak, T. G. Kulowiec, & D. A. Hamilton. 1992. Breeding bird populations in Missouri Ozark forests with and without clearcutting. J. Wildl. Manage. 56(1): 23-30.

Thompson, F. R., III., S. J. Lewis, J. Green, and D. Ewert. In Press. Status of neotropical migrant birds in the midwest identifying species of management concern in Proceedings of a workshop on the status and management of neotropical migratory birds. Rocky Mountain Forest and Range Experiment Station General Technical Report.

Van Horne, B. 1983. Density as a misleading indicator of habitat quality. J. Wildl. Manage. 47: 893-901.

Webb, W. L., D. F. Behrend, & B. Saisorr. 1977. Effect of logging on songbird populations in a northern hardwood forest. Wild. Monographs. 55: 6-35.

Weinell, D. E. 1989. Initial effects of hardwood reforestation and plant succession upon avian richness at the Ouachita Wildlife Management Area, Louisiana. M.S. Thesis. Northeast Louisiana Univ., Monroe.

Wesley, D. E., C. J. Perkins, & A. D. Sullivan. 1976. Preliminary observations of cottonwood plantations as wildlife habitat. Pp. 460-476 in Proc. Symp. East. Cottonwood and Related Species. Greenville, Mississippi.

Yahner, R. H. 1986. Structure, seasonal dynamics and habitat relationships of avian communities in small even-aged forest stands. Wilson Bull. 98: 61-82.

Yahner, R. H., and D. P. Scott. 1988. Effects of forest fragmentation on depredation of artificial nests. J. Wildl. Manage. 49: 508-513.

Ziehmer, R. L. 1992. Effects of uneven-aged timber management of forest bird communities. M.S. Thesis, Univ. of Missouri, Columbia.