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BREEDING BIRDS OF LATE-ROTATION PINE HARDWOOD. STANDS: COMMUNITY CHARACTERISTICS AND SIMILARITY TO OTHER REGIONAL PINE FORESTS

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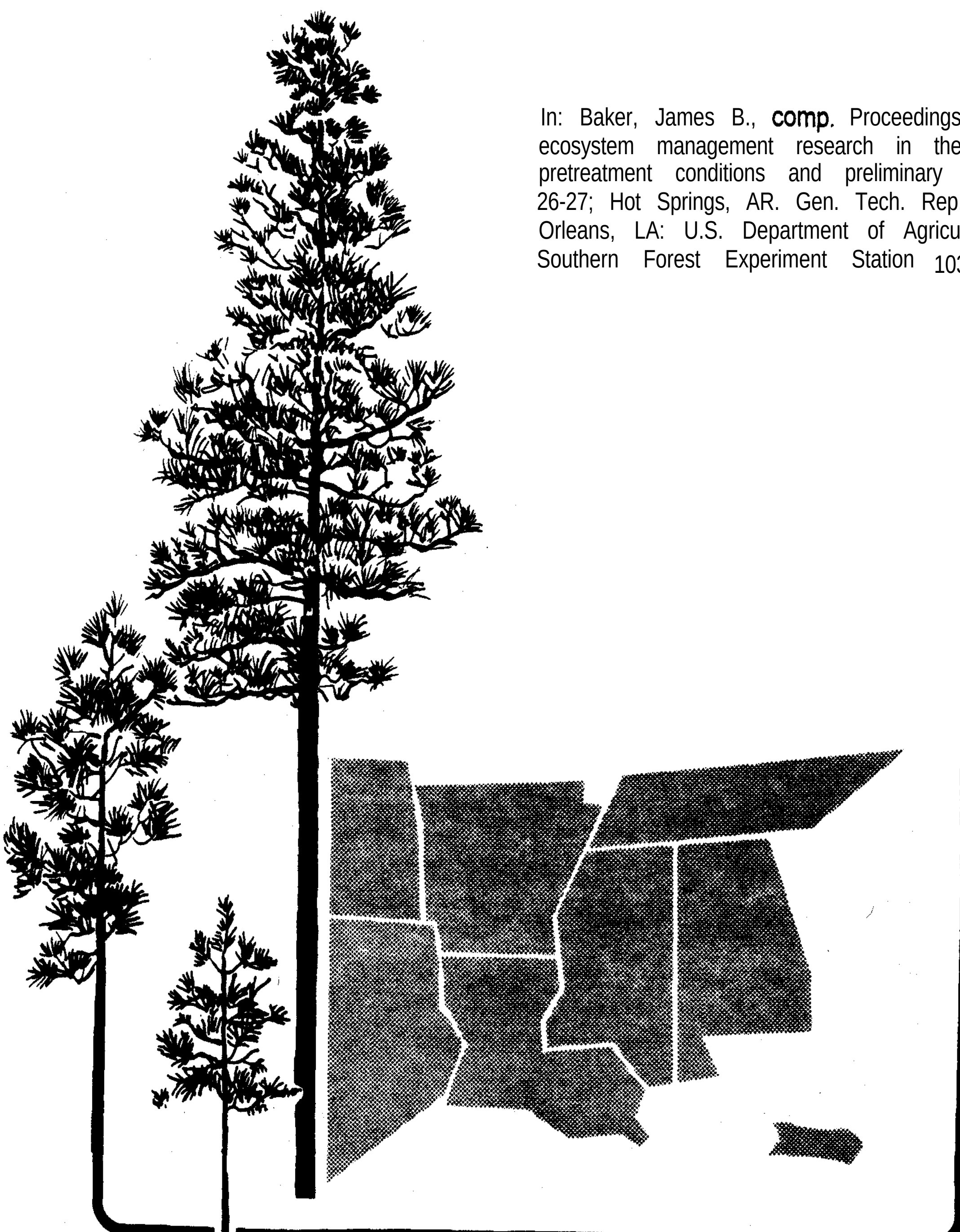

Southern Forest Experiment Station

1994

Breeding Birds of Late-Rotation Pine-Hardwood Stands: Community Characteristics and Siiilarity to Other Regional Pine Forests[1]

Daniel R. Petit, Lisa J. Petit, Thomas E. Martin, Ronald E. Thill, and James F. Taulman[2]

ABSTRACT

The relative abundances of bird species and the ecological characteristics of the overall avian community were quantified within 20 late-rotation pine-hardwood sites in the Ouachita and Ozark National Forests in Arkansas and Oklahoma during 1992 and 1993. In addition, similarities in species composition and guild representation were compared with those of forest types in other areas of the Southeastern United States to assess the possible extent of generalizations to be made from this Ecosystem Management research. A total of 55 bird species was recorded within survey plots during 1992 and 1993, but only 10 species accounted for more than 80 percent of all individuals detected. Pine warblers comprised approximately 40 percent of all individuals. Rank abundances of the 55 species were relatively consistent between years, especially for the most common species. Numbers of species and individuals detected during point count surveys were different between 1992 and 1993, although some of that discrepancy may be due to interobserver variation. No significant differences were detected in bird species richness, abundance, or diversity among the four geographic zones or among future harvesting treatments. Bird communities were dominated by species that nest and forage in the canopy. Similarity was relatively low between bird assemblages characterized on the Ouachita Mountain sites and assemblages in other studies. Representation of nesting and foraging guilds, however, was more closely aligned with guild structure found in other forests. In general, results from Ecosystem Management Research should be most applicable to loblolly-shortleaf pine and oak-hickory forest types in the Southeast.

INTRODUCTION

The Ecosystem Management Research Program of the USDA Forest Service was designed to assess the effects of traditional and nontraditional cutting and regeneration techniques on the flora, fauna, ecosystem function, and esthetic and cultural properties of our national forests as well as the economic costs associated with each harvesting program. The philosophy behind the ecosystem-level approach to managing federal lands is based on the perception that to serve the long-term, multiple interests of society, preservation of biodiversity and sustainability of natural resources must be viewed in a holistic fashion (Salwasser 1991, 1992). This "new perspective" suggests that neither societal (monetary and cultural) considerations nor ecosystem integrity (including sustainability) can be viewed independently of the other, and that management units must be viewed simply as components within the scope of larger-scale watershed processes and functions. The interactions of these complex, and often controversial, issues (e.g., Frissell and others 1992) are being investigated in a series of demonstration projects within National Forests.

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Ecosystem Management Research in the Ouachita and Ozark National Forests in western Arkansas and eastern Oklahoma is comprised of three phases: Phase I provided a demonstration of the logistical aspects and feasibility of different harvesting treatments. Phase II and Phase III are designed to assess the economic effectiveness of different harvesting treatments as well as treatment effects on the biological, chemical, physical, and esthetic properties of pine-hardwood ecosystems at the stand and watershed levels, respectively (Baker, this volume).

Natural pine forests and pine plantations often support fewer species of birds compared with mature deciduous stands in the Southeastern United States (Hamel 1992, Smith and Petit 1988). Mixed pine-hardwood forests, on the other hand, often equal or exceed pure hardwood forest types in speck richness (Dickson and others 1980, Hamel 1992, Meyers and Johnson 1978). Yet, both pine and mixed-pine forest types represent critical habitats for economically and socially important game birds, declining neotropical migratory bird populations, and threatened/endangered species (Evans 1978, Hamel 1992, Jackson 1988). The value of pine-associated habitats to bird and wildlife populations, coupled with increasing demands on these lands for timber production and urban development (Jackson 1988, Knight 1987), has created an urgency among wildlife biologists to better understand bird-habitat relationships and the impact of different management practices on bird populations in the Southeast (Childers and others 1986, Harris and others 1974, Johnson 1987, Noble and Hamilton 1975). Critical in this research is documentation of bird species that are associated with mature, naturally regenerated pine forests, 'controls' against which to compare different stand ages and management techniquea.

This report summarizes information oo the relative abundances and community characteristics of breading birds associated with late-rotational pine-hardwood forests before stand-level ecosystem management harvesting treatments were applied (Phase II). Bird assemblages occupying these sites were compared with assemblages inhabiting mature pine and pine-hardwood stands in other areas of the Southeastern United States. The degree of similarity among the different regional bird communities allowed projection of the generality of the harvesting treatments on Southeastern pine/pine-hardwood bird communities.

METHODS

Study Sites

In 1991, nine late-rotation pine-hardwood stands were selected in the Ouachita (7) and Ozark (2) National Forests of northwestern Arkansas (table 1) to establish bird and vegetation sampling protocols to be used once Phase II treatment plots were selected (sea below). (At that time, these sites were targeted to represent pretreatment controls. However, timing of Phase II timber harvesting allowed pretreatment data to be collected within the actual 20 Phase II sites. Consequently, these nine sites provided only supplemental information on late-rotation pine-hardwood bird assemblages.) South-facing slopes (including southeast and southwest) predominated on most sites. Stands had not been harvested for 75 to 90 years, and pine and hardwood basal areas averaged approximately 7.7 m^2/ha (range: 7.0 to 8.1 m^2/ha) and 3.8 m^2/ha (range: 2.5 to 4.3 m^2/ha), respectively. Canopies were largely closed (percent canopy cover, mean = 84 percent; range = 79 to 88 percent, N = 9), with mean canopy heights between 15 and 23 m (overall mean = 18 m). Most sites had well-developed understories and midstories comprised mainly of *Vaccinium corymbosum* L., *Cornus florida* L., *Nyssa sylvatica* Marsh., *Quercus marilandica* Muenchh., and *Q. stellata* Wangenh. *Quercus wlutina* Lam., *Q. rubra* L., *Carya* spp., and *Pinus echinata* Mill. were the primary overstory trees. All sites encompassed 16 to 25 ha.

In 1992 and 1993, bird surveys were conducted oo 20 additional sites on which 5 different Phase II harvesting treatments were to be applied during summer and autumn 1993. All stands had predominantly south-facing aspects (including southwest and southeast) with slopes that ranged between 0 to 15 percent. Stand age (> 70 years), vegetative structure (mean canopy cover = 82 percent, range = 78 to 87 percent; mean canopy height = 17 m, range = 15 to 20 m), and tree species composition were similar to the late-rotational tracts studied in 199 1 (Thill and others [this volume] provide additional details of sites used in 1992 and 1993). The 20 Phase II sites were loosely grouped (based upon possible edaphic and climatic differences (Baker, this volume]) into four geographic zones (five stands per zone) primarily in the Ouachita National Forest in Arkansas and Oklahoma, but several sites were located in the southernmost district of the Ozark National Forest (table 1). Each group of five sites included one replicate of each of the four harvesting treatments (clearcutting, shelterwood, group selection, and single tree selection) that were to be performed in 1993, in addition to an untreated control site (Thill and others, this volume). AU sites were 14 to 16 ha.

Table 1.– *Locations of late-rotation pine-hardwood stands studied in 1991-93 in the Ouachita and Ozark National Forests in Arkansas and Oklahoma*

Year	National Forest	Zone*	Compartment	Stand
1991	Ozark		2	25
	Ozark		2	16
	Ouachita		1601	11
	Ouachita		1610	11
	Ouachita		1614	24
	Ouachita		603	17
	Ouachita		1457	ACEF†
	Ouachita		473	11
	Ouachita		462	11
1992-93	Ouachita	North	458	16
	Ouachita	North	457	12
	Ozark	North	46	la
	Ozark	North	70	10
	Ouachita	North	284	11
	Ouachita	East	1067	15
	Ouachita	East	1119	21
	Ouachita	East	1124	11
	Ouachita	East	609	9
	Ouachita	East	605	5
	Ouachita	South	1658	5
	Ouachita	South	27	1
	Ouachita	South	35	42
	Ouachita	South	1649	13
	Ouachita	South	23	10
	Ouachita	West	1292	2
	Ouachita	West	a33	I
	Ouachita	West	62	6
	Ouachita	West	248	17
	Ouachita	West	a96	7

* Geographic zone used in the Ecosystem Management experimental design. No designation of zone is appropriate for preliminary data collected on the nine sites in 1991.

† Alum Creek Experimental Forest.

Bird Surveys

Bird abundance was estimated in five or six (depending on size of the site) 40-m radius (0.5 ha) circular plots spaced evenly over each site. Bird survey plots (hereafter "plots") were usually more than 150 m apart, but size or shape of some stands permitted only 130 to 150 m of separation. Plots were more than 90 m away from edges (e.g., roads, younger successional growth, different forest types). On 3 different days (= 3 visits) between 5 to 24 May 1991.28 April to 2 June 1992 (75 percent of surveys completed before 15 May), and 1 to 14 May 1993, all birds seen or heard within plots on each site were recorded. Ten minutes were spent at each plot. Individuals detected beyond 40 m, but within the site boundaries were also noted. Birds seen flying or soaring above canopy trees and species that do not breed in the region (transients) were excluded. Surveys were conducted between 06:00 and 12:00 (> 90 percent were completed before 11:00) on days without strong winds or prolonged precipitation. (On several days, surveys were continued when light rainfall began after initiation of bird counts on a site.) Bird surveys were conducted by four observers in 1991, three in 1992, and three in 1993. Only one observer (Taulman) surveyed birds during all 3 years. With the exception of Taulman, the bird censusers in 1992 were different from those in 1993.

Guild Analysis

Species were grouped into the following foraging and nesting guilds to examine the relative contributions of these groups to the overall bird community inhabiting late-rotation pine-hardwood stands: (1) open-cup, canopy (> 3 m); (2) open-cup, shrub (< 3 m); (3) ground; (4) cavity; and (5) other (e.g., rock faces). Foraging/trophic guilds were based on breeding season diets/foraging tactics and designated as either: (1) foliage-gleaning insectivore, canopy (> 3 m); (2) foliage-gleaning insectivore, shrub (<3 m); (3) ground-foraging insectivore; (4) aerial flycatcher; (5) bark insectivore; (6) carnivore; (7) granivore; (8) nectarivore; and (9) omnivore. Classifications were based upon Ehrlich and others (1988) and Hamel (1992).

Breeding bird community composition on sites in the Ouachita and Ozark National Forests was compared with that of 12 other studies conducted within mature (> 40 years) pine-associated forest types in the Southeastern United States. Raptors and waterbirds were not included in this analysis because populations are not easily quantified using fixed-radius point counts (e.g., raptors); presence of a species on a given site may be highly dependent upon water (e.g., waterfowl); and many studies reported only terrestrial landbirds. Similarity in bird community composition was calculated by Sorensen's Index (SI): 200C/(A + B), where A = number of species in forest type A, B = number of species in forest type B, and C = number of species shared between two forests (Mueller-Dombois and Ellenberg 1974). Sorensen's Index can range from 0 percent (no species in common) to 100 percent (identical species composition).

Similarity indices may not accurately reflect the actual overlap in species composition in two areas because species assemblages quantified at local levels may be strongly influenced by the intensity of sampling (e.g., number of sites, number of years). Hamel (1992) presented complete bird species lists for different forest types in the Southeastern United States. Those data were used to provide some indication of the "potential" similarity in bird community composition between mature mixed-pine hardwood stands (forest type represented by Ouachita and Ozark National Forest research) and six other forest types in the Southeast: loblolly-shortleaf pine (*Pinus taeda* L.-P. *echinata*), Virginia-pitch pine (*P. virginiana* Mill. -*P. rigida* L.), longleaf-slash pine (*P. palustris* Mill.-*P. elliottii* Engelm.), sandhills longleaf pine, longleaf pine-scrub oak (*Quercus* spp.), and oak-hickory (*Carya* spp.). Similarity indices were calculated as described above.

Data Analysis

The bird survey technique allowed calculation of an index of density for each species rather than a measure of absolute density. Relative abundance of each species on a site was presented as the average number of individuals detected per survey point (based upon three visits). Species richness was based upon: (1) only those individuals detected within survey plots on each of the 20 sites (S_p); and (2) all species detected on the site, i.e., both within and outside survey plots (S_t). The Shannon-Weiner diversity index (H') was calculated as $H' = -\Sigma p_i \ln p_i$, where p_i was the proportion of all individuals detected that were represented by species i (Pielou 1969). Data from 1992 and 1993 were analyzed separately because of between-year differences in species richness and abundance (see below). Comparisons of bird community metrics (i.e., abundance, diversity, richness) across future treatments and geographic zones were made with two-way analysis of variance (ANOVA). Only the main effects model for each bird community metric was repotted here because no interactions existed among the factors (Neter and Wasserman 1974, p. 582). Other statistical tests are included in the text. Differences were considered to be significant if $P \leq 0.05$.

RESULTS

Adequacy of Bird Sampling Effort

Thoroughness of bird surveys is difficult to assess without extraordinary effort (e.g., by spot-mapping) to determine all species breeding on sites and their relative densities. However, when estimating species richness, for example, adequate sampling intensity can be achieved when species-effort curves become asymptotic. Bird surveys in 1991 demonstrated that, on average, one visit to a site (cumulative sum from all plots on a site during a given day) detected nearly three-fourths of the species, and that two visits registered more than 90 percent of the species recorded within survey plots after three visits. Data from 1992 and 1993 revealed species-effort curves similar to those found in 199 1, especially for results after two visits (fig. 1).

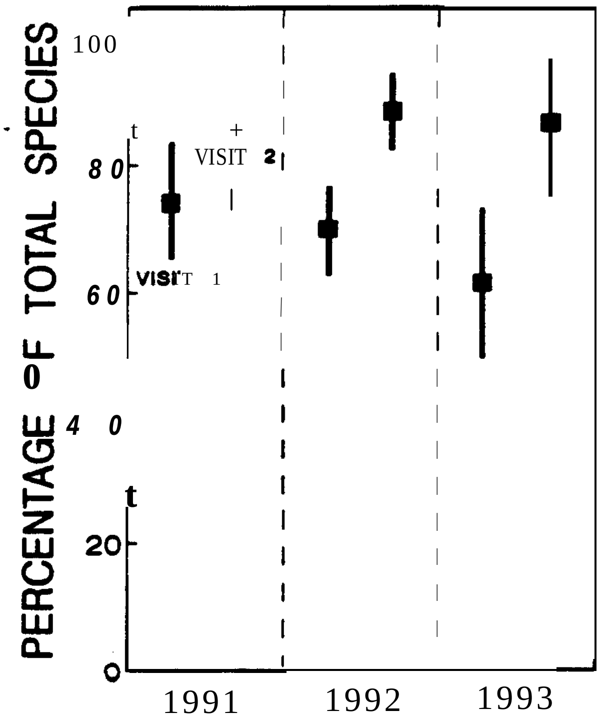

Figure 1.– *Effect of number of visits on estimates of species richness during 1991-93. Squares represent the mean percentage of species detected after one and two visits compared with the total number of species recorded after three visits (N = 9 sites in 1991, and 20 sites in 1992 and 1993). Vertical bars represent one standard deviation.*

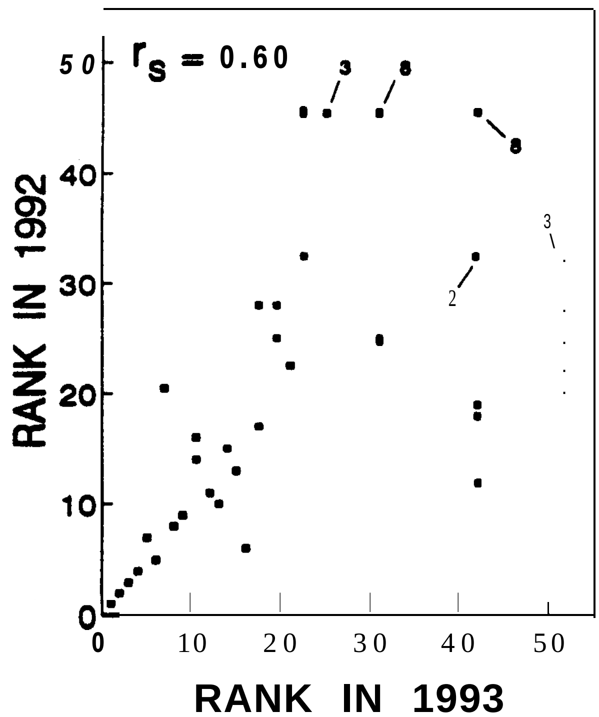

Figure 2.– *Relationship (Spearman's correlation coefficient) between rank-order abundance of 55 species observed in 1992 and/or* 1993. *Numbers within graph represent multiple points.*

Bird Community Characteristics

Species Richness, Abundance, and Diversity

Few of the 55 specia detected within Ouachita and Ozark survey plots in 1992 and 1993 were common (table 2). Pine warblers (scientific names are listed in table 2) and red-eyed vireos comprised half of all individuals detected withia plots; 10 species accounted for 82 percent of tho 2,248 individuals counted in 1992 and 1993. The rank-order of abundance of these 55 species was generally stable between years (Spearman's rank correlation coefficient; r_s = 0.60, df = 53, P <0.001), although abundances of relatively rare spacia were much less consistent (fig. 2). Hence, when the 29 rarest (ranked higher than median rank) species were removed from the analysis (including those that were recorded in only one year), the relationship became stronger (r_s = 0.77, df = 24, P <0.001).

Relative abundance was compared between years for each of the 11 species that comprised more than 2 percent of the bird community in 1992-93. When analyzed within regions, only 4 of the 44 comparisons (11 species x 4 regions) showed significant differences (pine warbler, north; scarlet tanager, south; worm-eating warbler, south and west). Over all 20 sites, only these 3 specia showed significant (paired t-tats; P <0.05) between-year variation.

Table 2.— *Relative abundances (percentage of total) of bird species recorded within 40-m radius circular plots in 1992 and 1993. Species are arranged according to their rank abundance (in parentheses) in 1992. In cases of ties, average ranks were assigned to species*

Common name	Scientific name	Percentage of total (rank)	
		1992	1993
Pine warbler	*Dendroica pinus*	40.1 (1)	311.2 (1)
Red-eyed vireo	*Vireo olivaceus*	12.9 (2)	11.9 (2)
Summer tanager	*Piranga rubra*	5.8 (3)	7.2 (3)
Black-and-white warbler	*Mniotilta varia*	4.6 (4)	6.9 (4)
Ovenbird	*Seiurus aurocapillus*	4.5 (5)	4.S (6)
Scarlet tanager	*Piranga olivacea*	4.4 (6)	0.8 (16)
Carolina chickadee	*Parus carolinensis*	4.1 (7)	4.8 (5)
Tufted titmouse	*Parus bicolor*	3.4 (8)	2.7 (8)
Blue jay	*Cyanocitta cristata*	2.5 (9)	2.4 (9)
Carolina wren	*Thryothorus ludovicianus*	2.1 (10)	1.9 (13)
Pileated woodpecker	*Dryocopus pileatus*	1.8 (11)	2.1 (12)
Brown-headed cowbird	*Molothrus ater*	1.6 (12)	0.1 (42)
American crow	*Corvus brachyrhynchos*	1.6 (13)	I.2 (15)
Blue-gray gnatcatcher	*Polioptila caerulea*	1.5 (14)	2.3 (10.5)
Great crested flycatcher	*Myiarchus crinitus*	1.4 (15)	1.8 (14)
Indigo bunting	*Passerina cyanea*	1.2 (16)	2.3 (10.5)
Acadian flycatcher	*Empidonax virescens*	1.1 (17)	0.7 (17.5)
Northern cardinal	*Cardinalis cardinalis*	0.8 (18)	0.1 (42)
Hairy woodpecker	*Picoides villosus*	0.7 (19)	0.1 (42)
Worm-eating warbler	*Helmitheros vermivorus*	0.5 (20.5)	4.2 (7)
Chuck-will's widow	*Caprimulgus carolinensis*	0.5 (20.5)	0.0 (52)
White-breasted nuthatch	*Sitta carolinensis*	0.4 (22.5)	0.5 (21)
Yellow-billed cuckoo	*Coccyzus americanus*	0.4 (22.5)	0.0 (52)
Mourning dove	*Zenaida macroura*	0.3 (25)	0.0 (52)
Red-bellied woodpecker	*Melanerpes carolinus*	0.3 (25)	0.2 (31)
Wood thrush	*Hylocichla mustelina*	0.3 (25)	0.6 (19.5)
Downy woodpecker	*Picoides pubescens*	0.2 (28)	0.7 (17.5)
Eastern wood-pewee	*Contopus virens*	0.2 (28)	0.0 (52)
Kentucky warbler	*Oporornis formosus*	0.2 (28)	0.6 (19.5)
Barred owl	*Strix varia*	0.1 (32.5)	0.1 (42)
Northern flicker	*Colaptes auratus*	0.1 (32.5)	0.0 (52)
Gray catbird	*Dumetella carolinensis*	0.1 (32.5)	0.1 (42)
Prairie warbler	*Dendroica discolor*	0.1 (32.5)	0.0 (52)
Rufous-sided towhee	*Pipilo erythrophthalmus*	0.1 (32.5)	0.0 (52)
Yellow-throated vireo	*Vireo flavifrons*	0.1 (32.5)	0.4 (22.5)
Broad-winged hawk	*Buteo platypterus*	0.0 (45.5)	0.2 (31)
Great-horned owl	*Bubo virginianus*	0.0 (45.5)	0.1 (42)
Northern bobwhite	*Colinus virginianus*	0.0 (45.5)	0.1 (42)
American goldfinch	*Carduelis tristis*	0.0 (45.5)	0.2 (31)
American redstart	*Setophaga ruticilla*	0.0 (45.5)	0.1 (42)
Black-billed cuckoo	*Coccyzus erythropthalmus*	0.0 (45.5)	0.1 (42)
Brown-headed nuthatch	*Sitta pusilla*	0.0 (45.5)	0.1 (42)
Chipping sparrow	*Spizella passerina*	0.0 (45.5)	0.2 (31)
Common grackle	*Quiscalus quiscula*	0.0 (45.5)	0.3 (25)
Cooper's hawk	*Accipiter cooperii*	0.0 (45.5)	0.4 (22.5)
Hooded warbler	*Wilsonia citrina*	0.0 (45.5)	0.2 (31)
Louisiana waterthrush	*Seiurus motacilla*	0.0 (45.5)	0.2 (31)
Northern parula	*Parula americana*	0.0 (45.5)	0.2 (31)
Red-shouldered hawk	*Buteo lineatus*	0.0 (45.5)	0.2 (31)
Ruby-throated hummingbird	*Archilochus colubris*	0.0 (45.5)	0.2 (31)
Swainson's warbler	*Limnothlypis swainsonii*	0.0 (45.5)	0.3 (25)
Cedar waxwing	*Bombycilla cedrorum*	0.0 (45.5)	0.3 (25)
Red-headed woodpecker	*Melanerpes erythrocephalus*	0.0 (45.5)	0.1 (42)
White-eyed vireo	*Vireo griseus*	0.0 (45.5)	0.1 (42)
Yellow-throated warbler	*Dendroica dominica*	0.0 (45.5)	0.1 (42)
Wild turkey	*Meleagris gallopavo*	+[*]	+
Red-tailed hawk	*Buteo jamaicensis*	.[†]	+
Belted kingfisher	*Megaceryle alcyon*		+
Yellow-breasted chat	*Icteria virens*		+

[*] Detected oo sites, but only outside of bid survey plots.

[†] Not detected on sites in 1992.

Thirty-seven percent more species were recorded within plots in 1993 (S_p [Total] = 48) than in 1992 (S_p [Total] = 35). On average, the number of species recorded within survey plots per site in 1993 (mean S_p = 13.40, SD = 3.07, N = 20) exceeded that of 1992 (mean S_p = 12.35, SD = 2.41) by one, but this difference was not significant (paired t-test; t = 1.60, P = 0.12). Likewise, when all species detected oa sites were considered (i.e., both within and beyond survey plot boundaries), more species were documented in 1993 (S_s [Total] = 57) than in 1992 (41). On average, approximately 4 more species were recorded on each site in 1993 (mean S_s = 22.70, SD = 2.96, N = 20) than in 1992 (mean S_s = 18.10, SD = 2.99; paired t-test, t = 8.93, $P<0.001$). In contrast to species richness, relative abundance of birds within survey plots was significantly greater (t = 3.54, P = 0.002) in 1992 (number of individuals per survey point; mean = 3.63, SD = 0.56, N = 20) than in 1993 (mean = 3.04, SD = 0.63). Species diversity (H') at the site level averaged 1.92 (SD = 0.28) in 1992 and 2.04 (0.35) in 1993 (paired t-test; t = 1.66, df = 18, P = 0.11). (Annual differences in bird species richness, abundance, and diversity were corroborated with ANOVA -- see Methods).

Discrepancies in bird community metrics betweea years could reflect either ml differences in bird community characteristics or interobserver variation. Some insight into these alternatives can be obtained by comparing results of the only observer to survey birds in both 1992 and 1993 (Taulman). The number of individuals per survey poiat declined 16 percent between yam for both the overall results (see above) and when analyses were restricted to the single observer, although the latter difference was not significant (paired t-test; t = 1.67, P = 0.11). Species richness also did aot differ between yam at either the plot or site level for the single observer (S_p, t = 0.91, P = 0.37; S_s, t = 1.23, P = 0.23). These results suggest that, although bird abundance may have been lower in 1993 compared with 1992, observer variation was partly responsible for the recorded differences in species richness during that same period.

Nesting and Foraging Guilds

Canopy nesters comprised approximately two-thirds of the individuals recorded in both 1992 md 1993. The high densities of two canopy-nesters, piae warbler and red-eyed vireo, accounted largely for that domination (fig. 3a). At the species level, canopy-nesters still were the best represented nesting guild, but cavity-, shrub-, md ground-nesters also contributed substantially to species richness (fig. 3b). Shrub-nesters represented approximately 18 percent of the species detected but only 3 percent of the individuals. Representation of nesting guilds within the community did aot vary significantly between years (log-likelihood ratio test; G = 0.72, df = 4, P = 0.95).

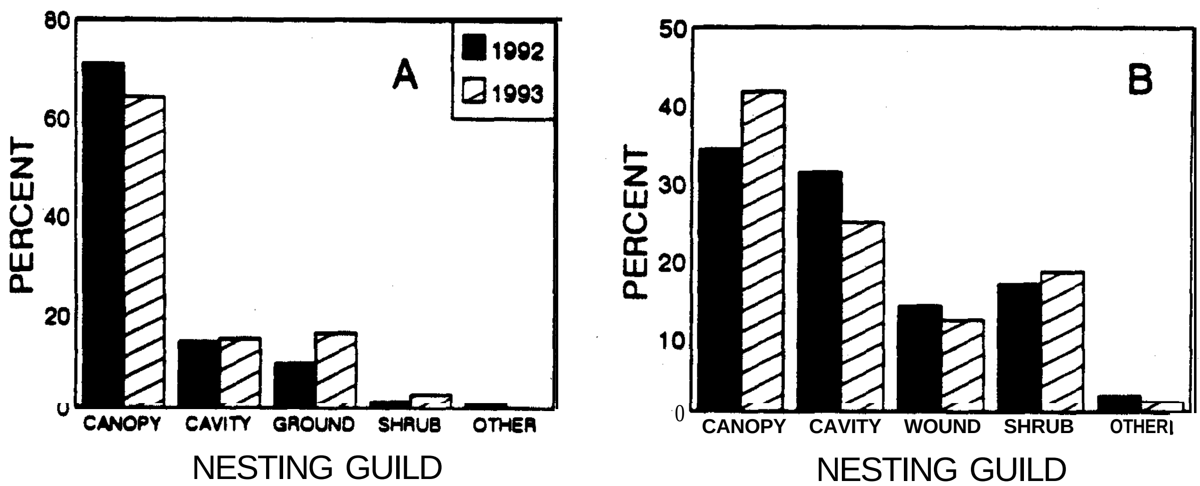

Figure 3.-- *Representation of different nesting guilds on late-rotation pine-hardwood sites in 1992 and 1993. Bars represent the percentage of (A) individuals and (B) species that comprised each of the five guilds. Nesting guilds are open-cup, canopy (CANOPY); tree cavity (CAVITY); ground; open-cup, shrub layer (SHRUB); and other.*

Canopy foliage-gleaning insectivores, Of which **pine warblers and red-eyed vireos were the most abundant, accounted** for **approximately two-thirds** of the individuals **detected,** but **only** one-fourth of the **species** (fig. **4a). No other foraging** guild comprised more than 11 **percent** of tho individuals detected in **either** year. When **species were equally** weighted (Lo., no **measure** of **abundance),** however, **bark-, ground-, and shrub-foraging insectivores,** in addition to **canopy foragers, were** comparable in **their representation** (fig. 4b). **Carnivores were** represented by 3 percent and 10 percent of the species in 1992 and **1993,** respectively, although less than 1 percent of the individuals detected each year **were raptors. Granivorous** and **nectarivorous species** were scarce on **Ecosystem** Management sites. No significant shifts occurred **between years** in tho **relative** structure of **trophic** guilds ($G = 3.69$, df = 6, $P = 0.72$).

Differences Among Geographic Zones

No **significant differences** oxistod in bii species richness (S, **[1992]:** $F = 0.77$; df = 3, 12; $P = 0.53$; S, (1993): $F = 0.95$, $P = 0.45$; *S*, [1992]: $F = 0.45$, $P = 0.72$; *S*, [1993]: $F = 2.13$, $P = 0.15$), **relative abundance** (1992: $F = 0.10$, $P = 0.96$; 1993: $F = 3.31$, $P = 0.06$), or species diversity (1992: $F = 1.03$, $P = 0.41$; **1993:** $F = 0.62$, $P = 0.62$) **among** tho four **geographic zones** in either **year** (fig. **5).**

Differences Among Future Treatments

No significant differences were detected in bird species richness (S, **[1992]:** $F = 0.18$; df = 3, 12; $P = 0.94$; *S*, [1993]: $F = 0.16$, $P = 0.96$; *S*, **[1992]:** $F = 0.83$, $P = 0.53$; S, **[1993]:** $F = 1.26$, $P = 0.34$), **relative abundance** (1992: $F = 0.21$, $P = 0.93$; 1993: $F = 1.43$, $P = 0.28$), or species diversity (1992: $F = 0.17$, $P = 0.95$; 1993: $F = 0.49$, $P = 0.75$) **among** the five **future** harvesting **treatments** in either **year** (fig. 6).

Similarity to Other Southeastern Forest Types

The overall bird community (terrestrial **landbirds** only) recorded on Ecosystem **Management** Research sites was **compared** to bird communities from 12 other studies conducted within **pine** and mixed pine-hardwood forests **of the** Southeast. **In general,** similarity indices **(SI)** were relatively low (mean = 55 **percent, range** = 36 to 78 **percent)** and showed no **clear** relationship with forest type, number of sites sampled, or geographic proximity to the **Ouachita** and Ozark National Forests (table 3). However, SI was highly correlated with total number of bird species recorded in each of the **studies** ($r = 0.87$, $P < 0.01$).

Analysis of 'potential" similarity in bird communities using **Hamel's** (1992) data showed that the pool of species in mixed pine-hardwood forests in the Southeastern United States was most similar to those of loblolly-shortleaf **(SI** = 78 **percent)** and oak-hickory (SI = 85 **percent)** forest types. Bird communities in forests dominated by slash, Virginia, pitch, and/or **longleaf** pines showed less similarity (mean = 62 percent, range = 57 to 67 **percent,** N = 4) to communities occupying mixed **pine-hardwood** forests, tho **pine** component of which is usually loblolly or shortleaf. **Percent** similarity was significantly **correlated** with tho hypothetical number of species occurring in each of the six **forest types** ($r = 0.89$, $P < 0.01$). **Furthermore,** tho ratio of SI to SI_{max} (tho maximum value possible given **the** number of **species occurring** in each of two forest types) ranged between 0.85 **and** 0.98 for the six forest types, suggesting that the less **speciose** bird communities (all but o&-hickory) were nearly perfect subsets of that found in **mixed-pine** hardwood forests, and that **the** mixed pine hardwood bird community **was** a subset of the oak-hickory bird community.

Nesting and **foraging** guild composition of **the** Ecosystem Management sites in **the Ouachitas** and **Ozarks was** comparable to that of other sites and **forest types** in the Southeastern United States, but only when species **were** equally woighted (fig. 7). When species were weighted by **relative** abundance, canopy insectivores and canopy nesters clearly dominated the guild structure on **the Ouachita/Ozark** sites **(see** figs. 3 and **4),** whereas guild representation did not change appreciably in the other **areas.**

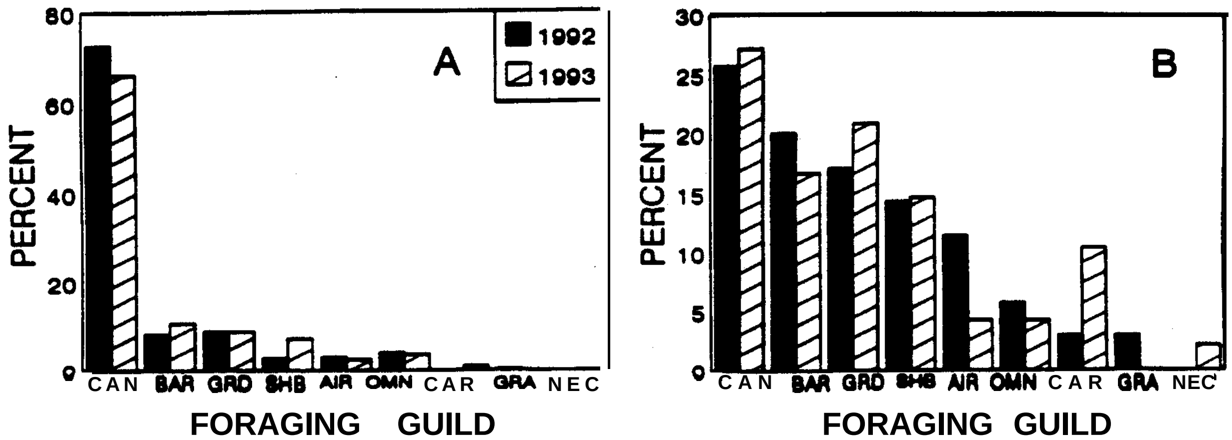

Figure 4.– Representation of different foraging guilds on late-rotation pine-hardwood sites in 1992 and 1993. Bars represent the percentage of (A) individuals and (B) species that comprised each of the nine guilds. Foraging guilds are foliage-gleaning insectivore, canopy (CAN); bark insectivore (BAR); ground insectivore (GRD); foliage-gleaning insectivore, shrub layer (SHB); aerial insectivore (AIR); omnivore (OMN); carnivore (CAR); granivore (GRA); and nectarivore (NEC).

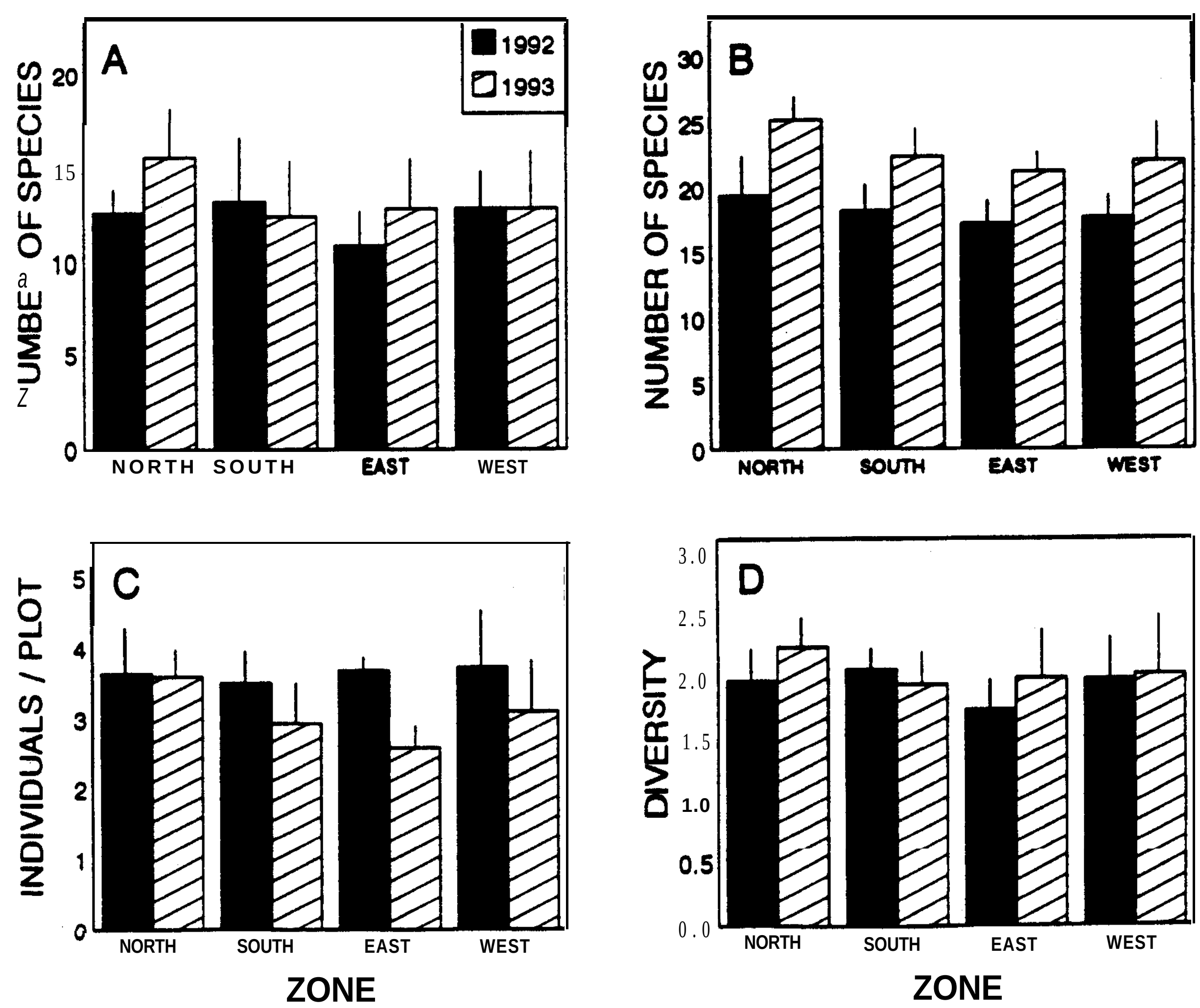

Figure 5.– Comparison of bird community metrics across different geographic zones in late-rotation pine-hardwood stands in 1992 and 1993. Bars represent the mean value (vertical lines equal 1 SD) across five sites for (A) species richness within bird survey plots, (B) species richness of entire site, (C) number of individuals detected per 40-m radius plot per survey, and (D) Shannon-Weiner diversity index (H').

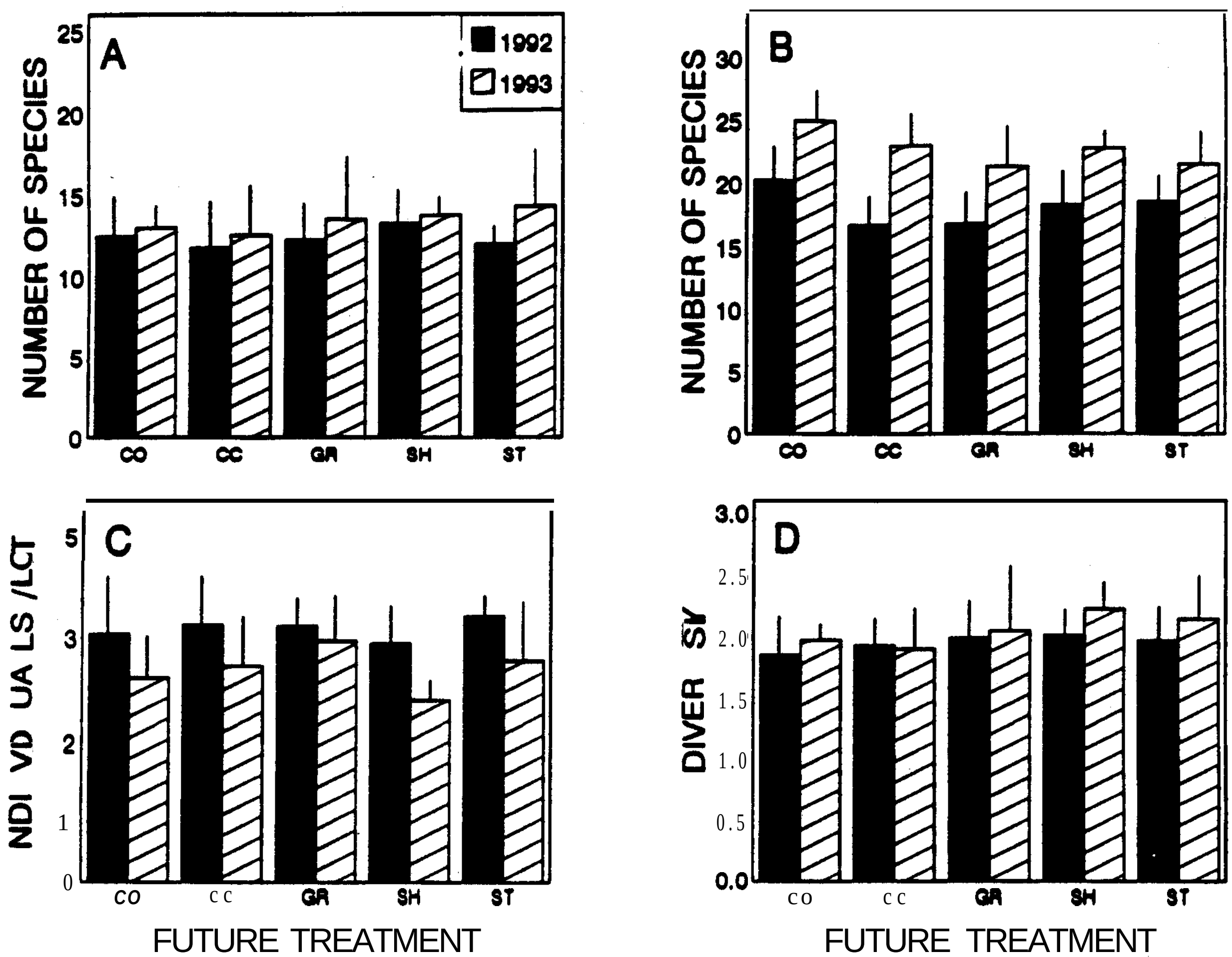

Figure 6.– *Comparison of bird community metrics on late-rotation pine-hardwoods stands that will be subjected to different silvicultural treatments. Bars represent the mean value (+ 1 SD) across five sites for (A) species richness within bird survey plots, (B) species richness on entire site, (C) number of individuals detected per 40-m radius plot per survey, and (D) Shannon-Weiner diversity index (H'). CO = control, CC = clearcut, GR = group selection, SH = shelterwood, and ST = single-tree selection.*

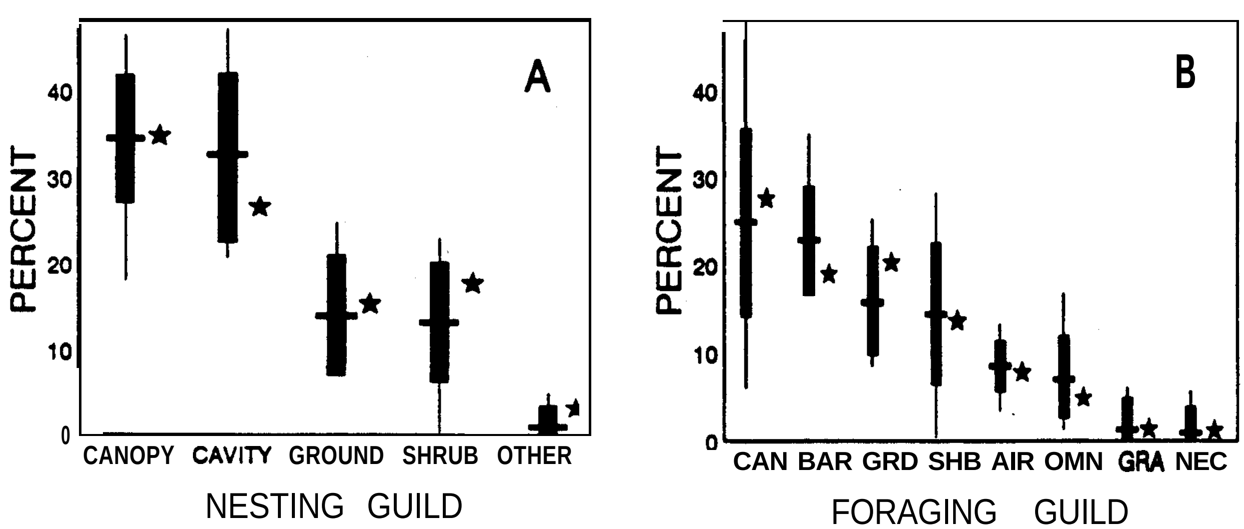

Figure 7.– *Comparison of the distribution of different* avian (A) *nesting* and *(B) foraging guilds* in *mature pine-hardwood stands in the Ouachita and Ozark National Forests (stars) and pine forests in other locations* in the *Southeastern United States. Figures are based* upon *the number* of specie8 *comprising* each *guild. Horizontal* bon *represent* the mean value *calculated from 12 different* studies (table *3), thick bars equal ± 1* SD. *and thin vertical lines represent* the *range* of *values.* Nesting *guilds are open-cup, canopy (CANOPY); tree cavity (CAVITY); ground;* open-cup, *shrub layer* (SHRUB); and other. *Foraging guilds are foliage-gleaning insectivore,* canopy *(CAN);* bad *insectivore (BAR); ground insectivore (GRD); foliage-gleaning insectivore, shrub* layer *(SHB); aerial insectivore* (AIR); *omnivore (OMN); granivore (GRA);* and *nectarivore (NEC).*

Table 3.– *Sorensen's Index (SI) of bird community similarity between late-rotation, pine-hardwood stands in the Ouachita and Ozark National Forests and other pine-associated forest types and areas in the Southeastern United States*

Forest type	Location	Number of sites	SI	Author
Longleaf-slash pine	Multiple States	3	36	Dickson and others 1980
Longleaf pine	Florida	3	39	Repenning and Labisky 1985
Slash pine	Florida	3	39	Repenning and Labisky 1965
Loblolly pine	V i i	3	48	Childers and others 1986
Loblolly pine	Louisiana	I	53	Noble and Hamilton 1975
Loblolly-shortleaf pine	Texas	1	53	Dickson and Segelquist 1979
Mixed pine-hardwood	Texas	I	53	Dickson and Segelquist 1979
Pitch pine	NoWJersey	6	53	Kerlinger 1983
Pitch pine-oak	v i i	I	65	Conner and others 1979
Mixed pine-hardwood	Louisiana	1	73	Noble and Hamilton 1975
Loblolly-shortleaf pine	Multiple States	ca 5	75	Dickson and others 1980
Mixed pine-hardwood	Multiple States	4	n	Dickson and others 1980

DISCUSSION

Fixed-radius point couats appeared to be an appropriate means for estimating relative bird abundance in mature pine-hardwood forests. Three visits to each site were probably sufficient to detect nearly all species that would be recorded within survey plots with a moderate increase in effort (perhaps, five visits), because in all 3 years detection of aew species slowed dramatically after the second visit (fig. 1). Similarly, Twedt sad others (1993) conducted unlimited-distance point couats in Mississippi Alluvial Plain forests sad found that the number of species recorded after four visits did not differ significantly from the number detected after five visits. In the Ouachita and Ozarks, however, 30 to 40 percent of the total number of species recorded oa a site were aot detected within survey plots. Thus, by restricting survey plots to 0.5 ha, relative abundances of many species that occurred on each site were underestimated. Those species that were not detected withia plots were extremely rare (each species comprised < 1 percent of the total individuals), often being detected.00 oaly oao occasion. This rarity is evident in that, over three visits, rate of accumulation of species on the entire site (S_t) closely paralleled that found for species detected oaly within survey plots. Because these unlimited-distance counts covered a much luger area than the 40-m fixed-radius survey plots, a more rapid rate of species accumulation should have been exhibited if most species were at last moderately common (and detectable). Unlimited-distance couats, as used in this study, will improve estimates of species richness compared to fixed-ndius plots, although estimates of relative abundance may be more tenuous. Therefore, to maximize the information gained from general bird surveys in forests, wildlife biologists should incorporate both fixed-radius and unlimited-radius methods into survey protocols (Petit sad others, in press).

The ramifications of underestimation of rare species are probably aot significant in the scope of this research. Difficulty in quantifying abundance of M species is common to all bird survey techniques (Ralph sad Scott 1981). Furthermore, underestimation of abundance of rare species within fixed-radius plots should not hinder assessment of Ecosystem Management harvesting treatments, particularly if those rare species become, more abundant after treatments are applied because of changes in successional stage or vegetative structure. In sdditioa, although all species were not detected by the fixed-radius bird sampling technique, limited resources necessitated examination of relative differences among treatments. Thus, harvesting treatments that result in increases in abundance of species should be (statistically) detectable even though some of those species were underestimated during pretreatment surveys. In sdditioa, several of those rare species (e.g., owls, hawks, sad some woodpeckers) characteristically occupy large (> 10 ha) breeding territories, such that say survey technique focussed on stand-level populations would detect relatively few individuals. For those species, the effects of harvesting and management practices oa breeding ecology might be most effectively assessed during the watershed-level manipulations of Phase III Ecosystem Management R-h.

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