Longleaf Pine Restoration: Implications for Landscape-Level Effects on Bird Communities in the Lower Gulf Coastal Plain

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ABSTRACT: *The longleaf pine (*Pinus palustris*) ecosystem of the southeastern United States is among the most heavily degraded of all ecosystems. Less than 1% of the original longleaf pine forests remain as old-growth stands. Eglin Air Force Base (Eglin) in northwest Florida contains the largest remaining extent of longleaf pine, but much of this habitat has been degraded through fire suppression, selective logging, and planting off-site species of pines. We examined the distribution of bird species among habitats during spring and fall 1994–1995 to assess the influence of large-scale habitat restoration on bird communities across the landscape. During both spring and fall, species richness and relative abundance of neotropical migrants were greatest in oak hammocks and riparian habitats. During spring, the abundance of resident species was greatest in barrier island scrub and flatwoods, but species richness of residents also was high in oak hammocks. During fall, both species richness and abundance of residents were greatest in oak hammocks and flatwoods. Analyses of abundance for individual species (both neotropical migrants and residents) suggested that each habitat examined was important for ≥1 species. An analysis examining the importance of habitats for conservation found that oak hammocks and riparian habitats were important for species of high management concern, but burned sandhills along with oak hammocks and riparian habitats were very important for species of the greatest management concern. Our results suggest that habitat modifications resulting from restoration of the longleaf pine ecosystem will benefit many species of management concern. Bird species negatively affected by habitat modifications for longleaf pine restoration were abundant in other habitats. South. J. Appl. For. 27(2):107–121.*

Key Words: Longleaf pine restoration, *Pinus palustris*, bird communities, neotropical migrants, prescribed burning, Gulf Coastal Plain, oak hammocks, riparian zones, barrier islands, Partners in Flight concern scores.

The longleaf pine (*Pinus palustris*) ecosystem once dominated the landscape of the southeastern Coastal Plain and extended from Virginia to Texas (Chapman 1932, Wahlenberg 1946, p. 45). This ecosystem was characterized by large, widely spaced longleaf pine with a dense herbaceous ground cover of perennial grasses and forbs (Harper 1943, p. 34, Wahlenberg 1946, p. 46-47). The composition and structure of longleaf pine forests resulted from frequent fires that regularly swept through the region (Chapman 1932, Platt et al. 1988). The longleaf pine ecosystem changed dramatically after European colonization as a result of exploitation for forest products, fire suppression, and conversion to agricultural lands including pine plantations (Croker 1979, Frost 1993, Simberloff 1993). Most of the original longleaf pine forests have been converted to either slash (*P. elliottii*) or loblolly pine (*P. taeda*) plantations (Frost 1993). Less than 1% of the original longleaf pine forest remains as old-growth stands, and the longleaf pine ecosystem is among the most heavily degraded of all ecosystems (Noss 1988, Simberloff 1993).

Eglin Air Force Base (Eglin) in northwest Florida represents one of the largest areas of public ownership along the

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Gulf Coast of the United States and contains part of the largest remaining area of contiguous longleaf pine (see Outcalt and Sheffield 1996). Eglin has recently developed an ecosystem management approach to address concerns for biodiversity (U.S. Department of Defense 1993, Jacobson and Marynowski 1997). Most habitats at Eglin are fire-dependent communities and, unless burned regularly, change drastically in structure and species composition (Engstrom et al. 1984, Waldrop et al. 1992). Several bird species that are endangered (e.g., red-cockaded woodpecker, *Picoides borealis*) or otherwise of special concern (e.g., Bachman's sparrow, *Aimophila aestivalis*) depend on fire-maintained communities with little hardwood midstory (Jackson 1988). Therefore, effort is being made at Eglin to restore natural habitat through prescribed burning and, when necessary, mechanical removal of midstory hardwoods. Although Provencher et al. (2002) examined the effect of these activities on wintering birds, the effects on most neotropical migrant and resident bird species are mostly unstudied (but see Brennan et al. 1995, Wilson et al. 1995, Plentovich et al. 1998). We studied the distribution of bird species among habitat types at Eglin to examine landscape-level effects that might result from restoration of the longleaf pine ecosystem. Specifically, we compared birds among habitats and assumed that species most abundant in frequently burned longleaf stands would benefit from restoration, species most abundant in fire suppressed longleaf stands would suffer from restoration, and species most abundant in habitats not targeted for restoration would be unaffected by restoration.

Methods

Study Area

Study sites were located at Eglin Air Force Base in northwest Florida. Eglin is bounded by Choctawhatchee Bay and the Gulf of Mexico to the south and the Yellow and Shoal Rivers to the north. Eglin covers about 188,000 ha and contains a wide diversity of habitats ranging from coastal dunes and scrub to bottomland hardwoods and pristine old-growth sandhills (Hardesty et al. 1995). About 78% of Eglin consists of sandhills dominated by longleaf pine. Most of these forests were heavily logged during the early 1900s, but about 900 ha of old-growth longleaf pine forest remains (U.S. Department of Defense 1993). Early logging practices left 7–15 longleaf pines per hectare for seed production. Thus, old-growth trees remain scattered throughout the sandhills at Eglin, and as a result, one of the largest populations of the endangered red-cockaded woodpecker exists at Eglin (U.S. Department of Defense 1993). The major impediment to natural recovery of sandhills habitats at Eglin has been fire suppression, which has caused the development of a dense hardwood midstory. The remaining old-growth sandhills are largely those located adjacent to bombing ranges where frequent wildfires have occurred (Hardesty et al. 1995). Eglin has recently adopted an ecosystem management approach with the primary objective of restoring and maintaining the ecological integrity of natural communities (U.S. Department of Defense 1993).

Study Site Selection

An extensive sampling effort was required to cover the large area at Eglin. To accommodate such large-scale surveys, we divided the base into major habitat types following the Florida Natural Areas Inventory (1990) with some further subdivision by stand age and burn history. We limited our counts to plots that could be unambiguously assigned to a habitat category and avoided areas that contained more than one habitat type or that were hard to classify by habitat. We recognized nine habitat types:

1. Young sandhills—planted longleaf pines approximately 8–12 yr old.
2. Mature unburned sandhills—naturally seeded longleaf pine >50 yr old with no evidence of burning for several decades.
3. Mature burned sandhills—naturally seeded longleaf pine >50 yr old with recent (≤3 yr) burning and at least one growing season since burning.
4. Flatwoods—mature flatwoods with recent (≤5 yr) burning (unburned flatwoods become very similar to some riparian habitat, and we did not sample unburned flatwoods).
5. Sand pine plantation—planted sand pine (*Pinus clausa*) >20 yr old.
6. Riparian habitats—included a variety of vegetation types ranging from floodplain forest and floodplain swamp to baygall.
7. Oak hammock—included both maritime and xeric hammocks.
8. Natural sand pine scrub—inland scrub occupying relict dunes.
9. Barrier island scrub—habitats on Santa Rosa Island containing an interspersion of coastal scrub, beach dune, and flatwoods.

We divided the area into 24-km^2 blocks to randomly distribute surveys among potential habitat patches. We randomly selected 20 of these blocks and, using aerial photographs and ground searches, attempted to locate patches of all habitat types (excluding barrier island scrub) within each block. For a patch of habitat to be suitable for surveying, it had to be large enough to contain a counting circle with a radius of 50 m. Counting points in different habitat types were separated by ≥200 m and, except for barrier island scrub (see below), points within the same habitat type were separated by >1 km. For habitat types that were missed in one or more blocks, we randomly drew additional blocks until 20 patches of each habitat type were located. Using this method, we located 20 plots of all habitat types except natural sand pine scrub; only 10 natural sand pine scrub plots could be located. We did not sample natural sand pine scrub as a habitat until fall 1994. Because of logistic constraints, we dropped 10 sand pine plantations in fall 1994 to enable us to sample natural sand pine scrub. We resumed

sampling in these 10 sand pine plantations and continued sampling natural sand pine scrub in spring and fall 1995. To sample barrier island scrub, we ran a transect along the long axis of Santa Rosa Island and systematically located plots every 1.2 km.

Point Counts

To sample birds, we conducted point counts (Bibby et al. 1992) in all plots within each habitat type. Spring counts were conducted April 4–May 29, 1994 and March 17–May 24, 1995. Fall counts were conducted September 8–November 3, 1994 and September 7–October 28, 1995. To conduct counts, an observer walked to the center of counting circles, waited 1 minute, and then for 5 minutes recorded all species seen or heard within 50 m. We chose a 50 m radius counting circle because patches of some habitat types (e.g., barrier island scrub and oak hammocks) often were only about 100 m wide. We did not count shorebirds, wading birds, or species flying overhead. Counts were conducted during the first four daylight hours, and the order in which points were sampled was rotated so that sampling time and date were unbiased among habitats. Before returning to a point for an additional count, a complete rotation (all sites counted) was made for the base. Using this technique, we completed 3.5 rotations in Spring 1994 (half rotations consisted of 10 points within each habitat), 4 rotations in Fall 1994, 6.5 rotations in Spring 1995, and 4 rotations in Fall 1995.

Migration Categories

In the Gulf Coast of northern Florida, it is useful to recognize four groups of birds based on migratory status: (1) residents—species both breeding and wintering in the southeast (e.g., brown-headed nuthatch, *Sitta pusilla*); (2) short-distance (wintering) migrants—species breeding to the north but wintering in the southeastern United States (e.g., yellow-rumped warbler, *Dendroica coronata*); (3) breeding neotropical migrants—species breeding in the southeastern United States but wintering south of the U.S. border (e.g., summer tanager, *Piranga rubra*); and (4) transient neotropical migrants—species breeding to the north and wintering to the south but using habitats in the southeast during migration (e.g., Cape May warbler, *D. tigrina*). We classify birds by migratory status as they occur along the Gulf Coast (Appendix A). To compare habitat use by birds, we divided species into three groups based on migratory status: resident, neotropical migrant, and wintering species. Because this study was designed to assess habitat use by breeding and migrating birds, the count periods did not adequately sample wintering birds; therefore, we did not analyze wintering species separately but did include them in analyses of overall bird species richness and bird abundance. In addition, few transient neotropical migrants were observed in this study, so we pooled them with breeding neotropical migrants for presentation and do not examine transients as a group. We did not observe obvious changes of any neotropical migratory species during spring surveys and, therefore, believe our analysis of birds in spring reflect abundance of breeding birds.

Analysis

We analyzed habitat use by birds using three measures of abundance: (1) mean number of individuals recorded (number/count), (2) cumulative number of species recorded (bird species richness, BSR), and (3) mean number of species recorded (BSR/count). None of these measures of abundance was normally distributed across plots, so we used nonparametric statistics to compare among habitats. Two-factor ANOVA on ranks of measures of bird abundance by year and habitat type were conducted following procedures in Zar (1984, p. 219–222). Multiple comparisons were conducted using Scheffe's test, because it is robust to heterogeneity, it can be used with unequal group sizes, and it is one of the most conservative of the multiple comparison procedures (Abacus Concepts 1992). For analyses of data from spring, we excluded natural sand pine scrub because it was sampled only in 1995. Because data for spring did not differ between years (see Results), we pooled years, included natural sand pine scrub, and compared among habitats using standard Kruskal-Wallis procedures (Zar 1984, p. 176–179). For both spring and fall, data were too sparse to compare abundance of individual species and importance scores (see below) among habitats by year, so we pooled these data across years and used standard Kruskal-Wallis procedures for analysis. When differences were found among habitats in analyses of data from spring, and for abundance of individual species and importance scores from both seasons, the Q-statistic which allows unequal group sizes and corrects for tied ranks was used for multiple comparison testing (Zar 1984, p. 200).

In all analyses of BSR, analysis of cumulative BSR and BSR/count yielded similar results. Cumulative BSR gave slightly better separation of group means in multiple comparison tests, so we only report results for analysis of cumulative BSR. Analysis of individual species was restricted to those species detected at ≥50% of the sites within at least one habitat type. To explore further the importance of habitats for conservation, we developed an index of habitat importance (importance scores) for each habitat (e.g., Carter and Barker 1993, Hunter et al. 1993*a*, *b*). We calculated importance scores for each site by multiplying Partners in Flight concern scores for each species (W.C. Hunter, U.S. Fish and Wildlife Service unpublished data, see Hunter et al. 1993*b*) by the mean number of individuals of the species detected and then summing the products for each site. These indices of importance are preferable to summation of concern scores, because they give greater weight to sites with more detections of a species and less weight to sites with few detections. We ran separate analyses for species of high concern (concern scores = 19–23) and very or extremely high concern (concern scores ≥24), because a large number of high concern species could potentially mask relationships of fewer very and extremely high concern species (e.g., Carter and Barker 1993).

Results

Spring Counts

We conducted 553 point counts in spring 1994 and 1,110 point counts in spring 1995. Five of our burned sites were

reburned in 1994 after we had begun our spring counts. Three of these sites were burned after being counted twice, and two were burned after being counted only once. We did not count these sites again until fall 1994. We detected 951 individual birds comprising 65 species in spring 1994 and 3,611 individuals comprising 70 species in spring 1995 (Appendix B presents pooled data for each species). Excluding natural sand pine scrub (see Methods), both total number of individuals and total number of species differed between years and also among habitats (Table 1). There was no interaction between year and habitat in either analysis (Table 1), and we concluded that, although more birds were detected in 1995, differences among habitats were consistent between years. Therefore, years were pooled, data for natural sand pine scrub were included, and habitats were compared using univariate Kruskal-Wallis tests.

Total number of individuals (Kruskal-Wallis statistic, H = 58.715) and total number of bird species (H = 50.575) differed among habitats during spring ($P < 0.001$). Barrier island scrub, oak hammocks, and flatwoods had the greatest number of individuals (Figure 1A), and oak hammocks, riparian habitats, and barrier island scrub had the greatest number of species (Figure 1C).

Both the number of individuals and the number of species of neotropical migrants (Figure 2A and Figure 2C, respectively) differed among habitats during spring ($H \geq 63.226$, $P < 0.001$) and were greatest in oak hammocks and riparian habitats.

The number of individual resident birds (H = 53.770, $P < 0.001$) and the number of resident bird species (H = 25.258, P = 0.001) differed among habitats during spring at Eglin (Figure 3). The number of individuals for resident species was greater at barrier island scrub and flatwoods than at young sandhills, mature unburned sandhills, and riparian habitats ($Q \geq 3.406$, $P < 0.05$; Figure 3A), and the number of individuals at barrier island scrub also was greater than the number at sand pine plantations (Q = 3.695, $P < 0.01$; Figure 3A). The number of resident bird species was greater at oak hammocks, than at sand pine plantations, mature unburned sandhills, and young sandhills ($Q \geq 3.338$, $P < 0.05$) but did not differ among other habitat types ($Q \leq 2.742$, $P > 0.20$; Figure 3C).

Twenty-two species, 7 neotropical migrants, and 15 residents were detected with sufficient frequency during spring at Eglin for species specific analysis (Appendix B). Although the blue jay (see Appendix A for scientific names of bird species) was marginal (H = 15.612, P = 0.048), and multiple comparisons failed to separate habitats for this species ($Q \leq 3.174$, $P > 0.05$), the other 21 species discriminated among habitat types ($H \geq 20.556$, $P \leq 0.008$; Appendix B). Each habitat had a few of these 21 species that tended to be most abundant within that habitat; however, the largest number of species appeared to prefer oak hammocks (Appendix B).

Thirty-four of 75 bird species detected at Eglin during spring were of high concern (24 species) or of very to extremely high concern (10 species, Appendix B). For the

Table 1. Results of 2-factor ANOVA by habitat and year on ranks of individual birds per count (*Num*) and cumulative number of bird species (*BSR*) for all species combined (*Total*), neotropical migrants (*Neotrops*), and resident species at Eglin Air Force Base, Florida during spring 1994 and 1995.

Variable	Source	DF	Sum of squares	H*	P
Num-Total	Habitat	7	498,743.025	58.329	< 0.001
	Year	1	758,356.512	88.691	< 0.001
	Habitat*Year	7	42,003.713	4.912	> 0.500
	Total	319	2,727,611.000		
BSR-Total	Habitat	7	311,298.200	36.588	< 0.001
	Year	1	1,193,894.113	140.321	< 0.001
	Habitat*Year	7	26,437.087	3.107	> 0.750
	Total	319	2,714,145.000		
Num-Neotrops	Habitat	7	742,481.725	92.932	< 0.001
	Year	1	169,188.012	21.176	< 0.001
	Habitat*Year	7	48,524.213	6.074	> 0.500
	Total	319	2,548,666.500		
BSR-Neotrops	Habitat	7	610,404.512	77.955	< 0.001
	Year	1	340,018.003	43.423	< 0.001
	Habitat*Year	7	44,456.259	5.677	> 0.500
	Total	319	2,497,887.500		
Num-Residents	Habitat	7	405,620.438	47.488	< 0.001
	Year	1	865,176.003	101.291	< 0.001
	Habitat*Year	7	16,367.884	1.916	> 0.950
	Total	319	2,724,743.000		
BSR-Residents	Habitat	7	207,667.562	24.573	< 0.001
	Year	1	1,232,188.903	145.801	< 0.001
	Habitat*Year	7	15,585.784	1.844	> 0.950
	Total	319	2,695,932.500		

* Kruskal-Wallis test statistic corrected for tied ranks (Zar 1984, p.219–222).

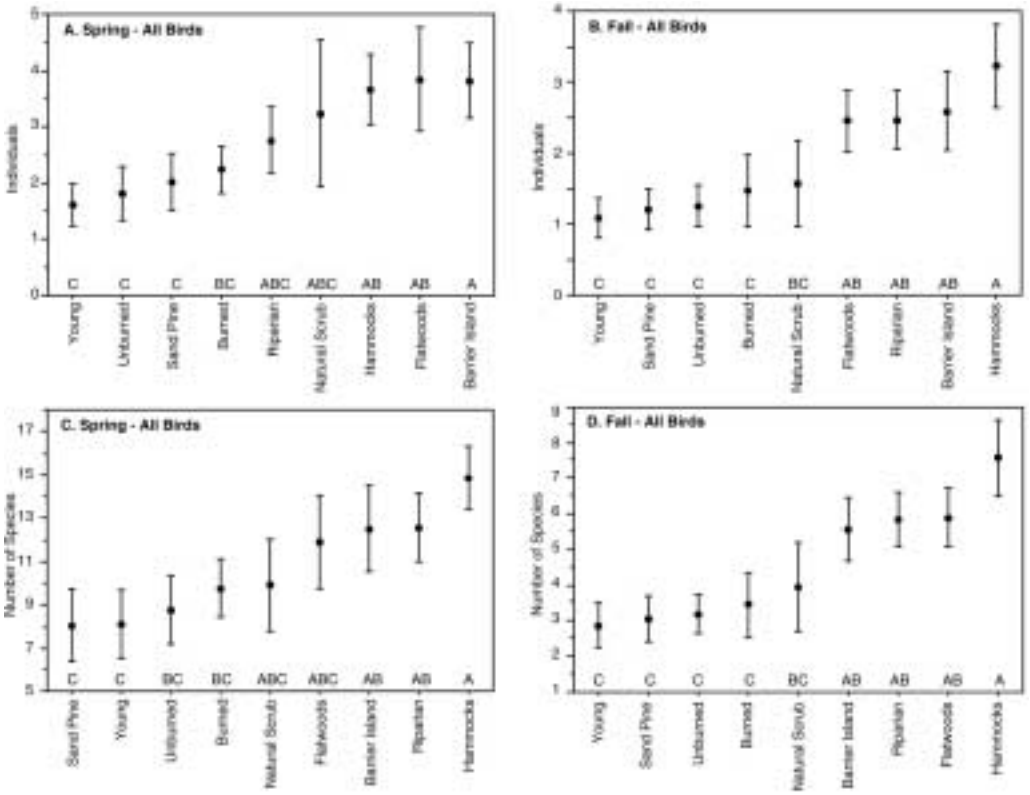

Figure 1. Means and 95% confidence intervals for number of individuals during (A) spring and (B) fall and number of species during (C) spring and (D) fall for all birds recorded within habitats at Eglin Air Force Base, Florida during 1994 and 1995. Within graphs, means not subscripted by a letter in common are different ($P < 0.05$).

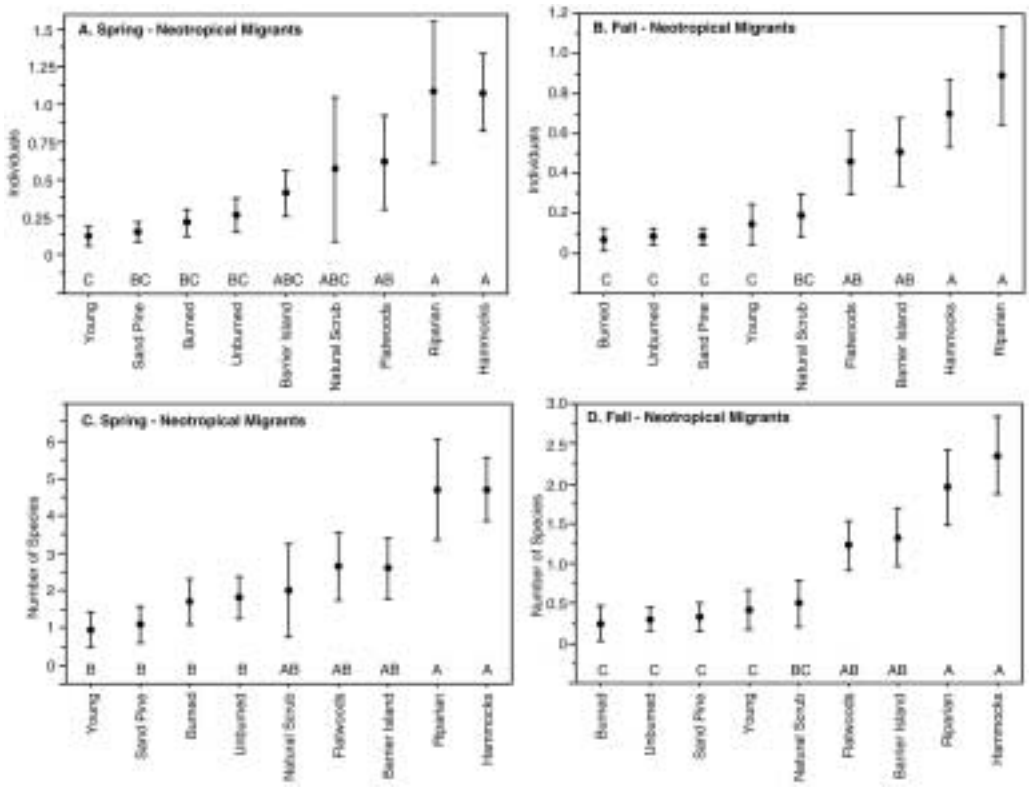

Figure 2. Means and 95% confidence intervals for number of individuals during (A) spring and (B) fall and number of species during (C) spring and (D) fall for neotropical migratory birds recorded within habitats at Eglin Air Force Base, Florida during 1994 and 1995. Within graphs, means not subscripted by a letter in common are different ($P < 0.05$).

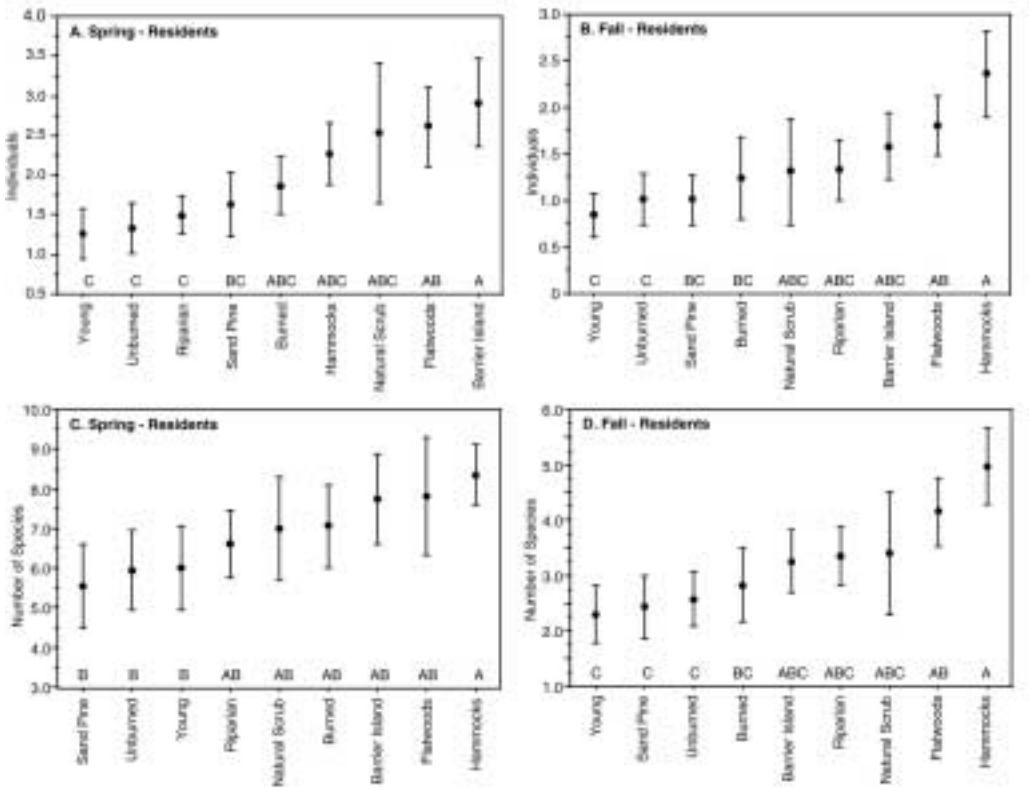

Figure 3. Means and 95% confidence intervals for number of individuals during (A) spring and (B) fall and number of species during (C) spring and (D) fall for resident bird species recorded within habitats at Eglin Air Force Base, Florida during 1994 and 1995. Within graphs, means not subscripted by a letter in common are different ($P < 0.05$).

group of high concern species, riparian habitats and oak hammocks had greater importance scores than mature burned sandhills, young sandhills, mature unburned sandhills, sand pine plantations, and barrier island scrub ($Q \geq 3.495$, $P < 0.02$) but did not differ among other habitats ($Q \leq 2.776$, $P > 0.10$, Figure 4A). Importance scores for the group of very to extremely high concern species were greater at mature burned sandhills, oak hammocks, and riparian habitats than at young sandhills and sand pine plantations ($Q \geq 3.784$, $P < 0.01$) but did not differ among other habitats ($Q \leq 3.167$, $P > 0.05$, Figure 4C).

Fall Counts

We conducted 640 point counts in fall 1994 and 680 point counts in fall 1995. Nine hundred and ninety-six individual birds composed of 63 species were recorded during fall 1994, and 1,506 individual birds composed of 64 species were recorded during fall 1995 (Appendix C presents pooled data for each species). Both the number of individual birds and the number of bird species differed between years and also among habitats, but there was no interaction between year and habitat in either analysis (Table 2). Both the number of individuals and the number of bird species was greater at oak hammocks, flatwoods, barrier island scrub, and riparian habitats than they were at young sandhills, sand pine plantations, mature unburned sandhills, and mature burned sandhills ($P \leq 0.011$), and both were greater in oak hammocks than they were in natural sand pine scrub ($P \leq 0.009$, Figures 1B and 1D).

Both the number of individuals and the number of species of neotropical migratory birds differed among habitats and also between years during the fall at Eglin, but there was no interaction between year and habitat in either analysis (Table 2). Both the number of individuals (Figure 2B) and the number of species (Figure 2D) of neotropical migratory birds was greater in riparian habitats and oak hammocks than in all habitat types ($P < 0.003$) except flatwoods and barrier island scrub ($P \geq 0.333$), and both the number of individuals and the number of species in flatwoods and barrier island scrub were greater than the number in all other sites ($P \leq 0.008$) except for natural sand pine scrub ($P \geq 0.237$).

For resident bird species, both the number of individuals and the number of species differed between years and also among habitats, but there was no interaction between year and habitat in either analysis (Table 2). Both number of individuals and species of resident birds were greater in oak hammocks than in young sandhills, mature unburned sandhills, sand pine plantations, and mature burned sandhills ($P \leq 0.002$, Figures 3B and 3D), and both number of individuals and species of residents were greater in flatwoods than in young sandhills and mature unburned sandhills ($P \leq 0.040$, Figures 3B and 3D). The number of resident species also was greater in flatwoods than in sand pine plantations ($P = 0.037$, Figure 3D).

Five species of neotropical migratory birds and 10 species of resident birds were detected with sufficient frequency during fall at Eglin to meet our criterion for species specific

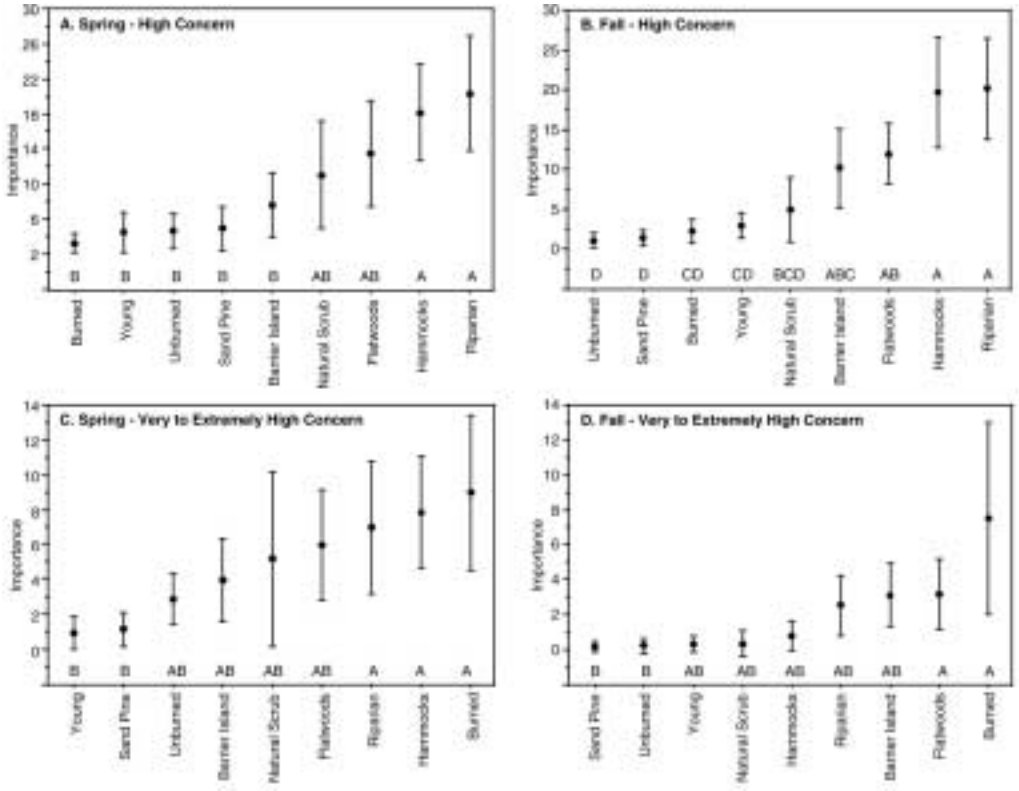

Figure 4. Means and 95% confidence intervals for importance scores of habitats for bird species of high management concern during (A) spring and (B) fall and very to extremely high management concern during (C) spring and (D) fall at Eglin Air Force Base, Florida during 1994 and 1995. Within graphs, means not subscripted by a letter in common are different (*P* < 0.05).

Table 2. Results of 2-factor ANOVA by habitat and year on ranks of individual birds per count (*Num*) and cumulative number of bird species (*BSR*) for all species combined (*Total*), neotropical migrants (*Neotrops*), and resident species at Eglin Air Force Base, Florida during fall 1994 and 1995.

Variable	Source	DF	Sum of squares	*H**	*P*
Num-Total	Habitat	8	824,645.459	91.044	< 0.001
	Year	1	98,516.801	10.877	< 0.001
	Habitat*Year	8	72,137.880	7.964	> 0.250
	Total	329	2,979,961.000		
BSR-Total	Habitat	8	878,591.231	97.860	< 0.001
	Year	1	91,096.215	10.146	< 0.005
	Habitat*Year	8	61,047.475	6.800	> 0.500
	Total	329	2,953,787.000		
Num-Neotrops	Habitat	8	1,016,762.147	125.625	< 0.001
	Year	1	67,945.152	8.395	< 0.005
	Habitat*Year	8	20,810.447	2.571	> 0.950
	Total	329	2,662,796.000		
BSR-Neotrops	Habitat	8	1,013,229.630	126.829	< 0.001
	Year	1	68,212.515	8.538	< 0.005
	Habitat*Year	8	31,639.865	3.961	> 0.750
	Total	329	2,628,353.000		
Num-Residents	Habitat	8	503,773.690	55.810	< 0.001
	Year	1	108,530.362	12.023	< 0.001
	Habitat*Year	8	95,749.103	10.607	> 0.100
	Total	329	2,969,774.000		
BSR-Residents	Habitat	8	470,862.494	53.124	< 0.001
	Year	1	55,189.072	6.227	< 0.025
	Habitat*Year	8	109,663.189	12.372	> 0.100
	Total	329	2,916,069.500		

* Kruskal-Wallis test statistic corrected for tied ranks (Zar 1984, p.219–222).

analysis (Appendix C). Each of these 15 species discriminated among habitats ($H \geq 22.717$, $P \leq 0.004$; Appendix C). Although each habitat appeared to contain a few species that were most abundant within that habitat, oak hammocks appeared to be preferred by the greatest number of species (Appendix C).

Thirty-two of 75 bird species detected at Eglin during fall were of high concern (23 species) or of very to extremely high concern (9 species, Appendix C). For the group of high concern species, riparian habitats and oak hammocks had greater importance scores ($Q \geq 3.197$, $P \leq 0.05$) than the other habitats except for barrier island scrub and flatwoods ($Q \leq 2.063$, $P > 0.50$, Figure 4B). Also, barrier island scrub and flatwoods had greater importance scores than mature unburned sandhills and sand pine plantations ($Q \geq 3.887$, $P < 0.005$), and flatwoods had greater importance scores than both mature burned sandhills and young sandhills ($Q \geq 3.438$, $P < 0.05$, Figure 4B). For the group of very to extremely high concern species, both mature burned sandhills and flatwoods had greater importance scores than sand pine plantations and mature unburned sandhills ($Q \geq 3.224$, $P < 0.05$), but differences were not found among other habitats ($Q \leq 3.168$, $P > 0.05$, Figure 4D).

Discussion

Few transient neotropical migrants were recorded during spring or fall at Eglin Air Force Base with our point-count methods. Although some of the breeding neotropical migrants we observed could have been transients, we did not observe obvious changes in numbers for any of these species during spring. We believe our data from spring reflect the relative abundances of breeding neotropical migrants at Eglin. However, many of the breeding neotropical migrants we recorded during fall probably were not breeders but were transients. For example, gray catbirds were relatively uncommon when we began the fall counts but soon became one of the most common species. Moore et al. (1993, 1995) stressed the importance of stopover habitat along the northern Gulf Coast for conservation of trans-Gulf migrants.

Moore et al. (1990) found that spring migrants stopping over on a barrier island in Mississippi utilized shrub/scrub, pine forest, and relic dune habitats more than expected based on habitat availability. Similar studies examining inland habitats along the northern Gulf Coast are lacking. Most of the transient migrants that we observed during both spring and fall were in barrier island scrub, oak hammocks, and riparian habitats, and few were observed in habitats targeted for restoration (Appendix B and C). Thus, our limited data suggest that restoration of longleaf pine communities at Eglin will have very little influence on transient neotropical migrants.

We found the largest number of neotropical migrants during spring in oak hammocks and riparian habitats (Figures 2A and 2C). These habitats consisted largely of deciduous vegetation and were structurally more diverse than other habitats we examined. Several species (e.g., northern parula and red-eyed vireo) were most abundant within these habitats (Appendix B). Great crested flycatcher was one of the most abundant neotropical migrants observed and was most abundant in oak hammocks (Appendix B). Hooded warbler was most abundant in riparian habitats and was one of the most frequent neotropical migrants detected in riparian habitats (Appendix B).

Neotropical migrants were distributed similarly during spring and fall. Both the number of individuals and number of species were greater in riparian habitats, oak hammocks, barrier island scrub, and flatwoods than they were in mature burned sandhills, mature unburned sandhills, young sandhills, and sand pine plantations (Figures 2B and 2D). Gray catbird was the most frequent neotropical migrant during fall and was more abundant in riparian habitats and barrier island scrub than in all other habitats except flatwoods and oak hammocks (Appendix C). Common yellowthroat was more abundant in flatwoods and barrier island scrub than in all other habitats, and both American redstart and hooded warbler were most abundant in oak hammocks (Appendix C). Blue-gray gnatcatcher was more abundant in oak hammocks than in flatwoods and riparian habitats but was equally abundant among other habitats (Appendix C).

The absence of many early successional neotropical migrants within sandhills (including both young and burned) at Eglin was notable. Many early successional bird species are shrub specialists and are commonly found in periodically burned pine stands that have a relatively open canopy (see Engstrom et al. 1984, Brennan et al. 1995, Wilson et al. 1995). The xeric conditions produced by deep sandy soils and heavy disturbance from site preparation at young sandhills are factors contributing to the development of a relatively sparse shrub layer at sandhills. In contrast to sandhills, flatwoods generally have moist soils and more shrubs in the understory (Glitzenstein et al. 1995). We found White-eyed vireo and common yellowthroat most frequently within burned flatwoods (Appendix B), and a yellow-breasted chat was found nesting at a flatwoods site.

The relatively subtle differences among habitats observed for resident birds during spring (Figures 3A and 3C) were probably produced by the high abundance of a few species that differed in their habitat preferences (Appendix B). For example, pine warbler was common in most habitats except barrier island scrub, and eastern towhee was very common in barrier island scrub and flatwoods but was relatively less common in other habitats. Resident birds were distributed similarly during spring and fall but were relatively more abundant in riparian habitats and relatively less abundant in mature burned sandhills during fall (Figures 3B and 3D). Overall, species distributions of resident birds were similar in spring and fall (Appendix C).

Analyses of importance scores for species of management concern were insightful. We found the index useful in identifying habitats of high conservation value and recommend its use in studies utilizing site-specific data to assess the relative contributions of habitats to conservation. Partners in Flight concern scores have been used to rank importance of habitats within geographic regions based on species-habitat associations (e.g., Carter and Barker 1993, Hunter et al. 1993b, Thompson et al. 1993), but our analysis differs

because we examined a specific management area and were able to utilize site-specific data. Using our index of importance, we were able to ascertain that mature burned sandhills are most important for species of the greatest management concern (Figures 4C and 4D), whereas analyses of standard measures of community composition (i.e., species richness and relative abundance) suggested mature burned sandhills ranked relatively low among habitats (Figures 1–3).

Hunter et al. (1994) reviewed habitat associations for bird species of the greatest management concern for the East Gulf Coastal Plain and concluded the following: (1) resident bird species of the greatest management concern are largely associated with mature open pine forests, and (2) neotropical migratory bird species of the greatest management concern are largely associated with bottomland hardwood (riparian) forests. Our results largely concur with Hunter et al. (1994), but we also found that oak hammocks and barrier island scrub were important for several bird species of great management concern.

Overall, prescribed burning and conversion of what has become dense pine–oak forest back to open pine stands at Eglin appeared beneficial. Several species of very high management concern (e.g., Bachman's sparrow, brown-headed nuthatch, and red-cockaded woodpecker) were more abundant in burned stands than similar stands that were unburned. In addition, bird species that appeared negatively influenced by prescribed burning (e.g., northern cardinal) were equally or more abundant in other habitats. Prescribed burning and other techniques for restoration of longleaf pine sandhills at Eglin have been found to benefit both native vegetation (Provencher et al. 2001) and herpetofauna (Litt et al. 2001).

The major objective of prescribed burning in pine-dominated habitats is to prevent midstory hardwood development and maintain the herbaceous ground cover (see Platt et al. 1991, Streng et al. 1993). Although we did not collect vegetation data for this study, anecdotal observations suggest that the maintenance of scattered live oaks (*Quercus virginiana* and/or *Q. geminata*) within these pine-dominated habitats will benefit several bird species. For example, most observations of blue-gray gnatcatcher, orchard oriole, and eastern kingbird within pine stands were in association with a live oak. Live oaks are relatively fire tolerant species, and we recommend leaving them scattered within pine stands.

We can draw few conclusions concerning the importance of natural sand pine scrub at Eglin. Small sample sizes and high variances among sites most likely resulted in low statistical power in multiple comparison tests involving this habitat. Several bird species, especially residents, were common within this habitat. Great crested flycatcher, Carolina wren, and brown thrasher are species of high management concern that were fairly abundant within natural sand pine scrub (Appendix B and C).

Ecosystem management efforts at Eglin include plans to remove all sand pine plantations and to replant them with longleaf pine (C.J. Petrick, Eglin Air Force Base, 1995, pers. comm.). Overall, we found relatively few birds within sand pine plantations, and sand pine plantations ranked among the lowest of habitats in all group analyses (Figures 1–4). In addition, analysis of individual species found most species among their lowest abundance within sand pine plantations (Appendix B and C). No species was significantly most abundant at sand pine plantations, and only summer tanager and pine warbler were more abundant at sand pine plantations than at any other single habitat. During spring (Appendix B), summer tanager was equally abundant at sand pine plantations and all other habitats except barrier island scrub. Also during spring, pine warbler was equally abundant in sand pine plantations and other habitats except young sandhills, riparian habitats, oak hammocks, and barrier island scrub. During fall (Appendix C), pine warbler was equally abundant in sand pine plantations and all other habitats except young sandhills, riparian habitats, and barrier island scrub. Thus, there will be few negative consequences from removal of sand pine plantations at Eglin, and the recovery of natural sandhills communities will benefit several bird species of very or extremely high management concern. Provencher et al. (2000) found that removal of sand pine followed by burning was an effective approach for restoring native ground cover in longleaf pine sandhills that had been heavily invaded by sand pine.

Literature Cited

Abacus Concepts. 1992. Statview. Abacus Concepts, Inc., Berkeley, California.

American Ornithologists' Union. 1998. Check-list of North American birds. Ed. 7. American Ornithologists' Union, Washington, DC.

Bibby, C.J., N.D. Burgess, and D.A. Hill. 1992. Bird census techniques. Academic Press, London.

Brennan, L.A., J.L. Cooper, K.E. Lucas, B.D. Leopold, and G.A. Hurst. 1995. Assessing the influence of red-cockaded woodpecker colony site management on non-target forest vertebrates in loblolly pine forests of Mississippi: Study design and preliminary results. P. 309–319 *in* Red-cockaded woodpecker: Recovery, ecology and management, Kulhavy, D.L., et al. (eds.). Center for Appl. Studies in For., Coll. of For., Stephen F. Austin State Univ., Nacogdoches, TX.

Carter, M.F., and K. Barker. 1993. An interactive database for setting conservation priorities for western neotropical migrants. P. 120–144 *in* Status and management of neotropical migratory birds, Finch, D.M., and P.W. Stangel (eds.). USDA For. Serv. Gen. Tech. Rep. RM-229.

Chapman, H.H. 1932. Is the longleaf type a climax? Ecology 13:328–334.

Croker, T.C., Jr. 1979. The longleaf pine story. J. For. Hist. 23:32–43.

Engstrom, R.T., R.L. Crawford, and W.W. Baker. 1984. Breeding bird populations in relation to changing forest structure following fire exclusion: A 15-year study. Wilson Bull. 96:437–450.

Florida Natural Areas Inventory. 1990. Guide to the natural communities of Florida. Florida Natural Areas Inventory and Florida Department of Natural Resources, Tallahassee.

Frost, C.C. 1993. Four centuries of changing landscape patterns in the longleaf pine ecosystem. Proc. of the Tall Timbers Fire Ecol. Conf. 18:17–43.

Glitzenstein, J.S., W.J. Platt, and D.R. Streng. 1995. Effects of fire regime and habitat on tree dynamics in north Florida longleaf pine savannas. Ecol. Monogr. 65:441–476.

Hardesty, J.L., R.J. Smith, C.J. Petrick, B.W. Hagedorn, and H.F. Percival. 1995. Status and distribution of the fourth largest population of red-cockaded woodpeckers: Preliminary results from Eglin AFB, Florida. P. 494–502 *in* Red-cockaded woodpecker: Recovery, ecology and management, Kulhavy, D.L., et al. (eds.). Center for Appl. Studies in For., Coll. of For., Stephen F. Austin State Univ., Nacogdoches, TX.

Harper, R.M. 1943. Forests of Alabama. Geological Survey of Alabama, Monogr. 10. Wetumpka Printing Co., Wetumpka, Alabama.

Hunter, W.C., M.F. Carter, D.N. Pashley, and K. Barker. 1993a. The partners in flight species prioritization scheme. P. 109–119 *in* Status and management of neotropical migratory birds, Finch, D.M., and P.W. Stangel (eds.). USDA For. Serv. Gen. Tech. Rep. RM-229.

HUNTER, W.C., D.N. PASHLEY, AND R.E.F. ESCANO. 1993b. Neotropical migratory landbird species and their habitats of special concern within the southeast region. P. 159–171 *in* Status and management of neotropical migratory birds, Finch, D.M., and P.W. Stangel (eds.). USDA For. Serv. Gen. Tech. Rep. RM-229.

HUNTER, W.C., A.J. MUELLER, AND C.L. HARDY. 1994. Managing for red-cockaded woodpeckers and neotropical migrants—Is there a conflict? Proc. Annu. Conf. Southeast. Assoc. Fish and Wildl. Agencies 48:383–394.

JACOBSON, S.K., AND S.B. MARYNOWSKI. 1997. Public attitudes and knowledge about ecosystem management on Department of Defense land in Florida. Conserv. Biol. 11:770–781.

JACKSON, J.A. 1988. The southeastern pine forest ecosystem and its birds: Past, present, and future. P. 119–159 *in* Bird conservation 3, Jackson, J.A. (ed.). Univ. Wisconsin Press, Madison.

LITT, A.R., L. PROVENCHER, G.W. TANNER, AND R. FRANZ. 2001. Herpetofaunal responses to restoration treatments of longleaf pine sandhills in Florida. Restor. Ecol. 9:462–474.

MOORE, F.R., S.A. GAUTHREAUX, JR., P. KERLINGER, AND T.R. SIMONS. 1993. Stopover habitat: Management implications and guidelines. P. 58–69 *in* Status and management of neotropical migratory birds, Finch, D.M., and P.W. Stangel (eds.). USDA For. Serv. Gen. Tech. Rep. RM-229.

MOORE, F.R., S.A. GAUTHREAUX, JR., P. KERLINGER, AND T.R. SIMONS. 1995. Habitat requirements during migration: Important link in conservation. P. 121–144 *in* Ecology and management of neotropical migratory birds: A synthesis and review of critical issues, Martin, T.E., and D.M. Finch (eds.). Oxford Univ. Press, New York.

MOORE, F.R., P. KERLINGER, AND T.R. SIMONS. 1990. Stopover on a Gulf Coast barrier island by spring trans-gulf migrants. Wilson Bull. 102:487–500.

NOSS, R.F. 1988. The longleaf pine landscape of the Southeast: Almost gone and almost forgotten. Endangered Spec. UPDATE 5(5):1–8.

OUTCALT, K.W., AND R.M. SHEFFIELD. 1996. The longleaf pine forest: Trends and current conditions. USDA For. Serv. Res. Bull. SRS-9.

PLATT, W.J., G.W. EVANS, AND S.L. RATHBUN. 1988. The population dynamics of a long-lived conifer (*Pinus palustris*). Am. Natur. 131:491–525.

PLATT, W.J., J.S. GLITZENSTEIN, AND D.R. STRENG. 1991. Evaluating pyrogenicity and its effects on vegetation in longleaf pine savannas. Proc. Tall Timbers Fire Ecol. Conf. 17:143–161.

PLENTOVICH, S., J.W. TUCKER, JR., N.R. HOLLER, AND G.E. HILL. 1998. Enhancing Bachman's sparrow habitat via management of red-cockaded woodpeckers. J. Wildl. Manage. 62:347–354.

PROVENCHER, L., B.J. HERRING, D.R. GORDON, H.L. RODGERS, G.W. TANNER, L.A. BRENNAN, AND J.L. HARDESTY. 2000. Restoration of northwest Florida sandhills through harvest of invasive *Pinus clausa*. Restor. Ecol. 8:175–185.

PROVENCHER, L., B.J. HERRING, D.R. GORDON, H.L. RODGERS, K.E.M. GALLEY, G.W. TANNER, J.L. HARDESTY, AND L.A. BRENNAN. 2001. Effects of hardwood reduction techniques on longleaf pine sandhill vegetation in northwest Florida. Restor. Ecol. 9:13–27.

PROVENCHER, L., N.M. GOBRIS, AND L.A. BRENNAN. 2002. Effects of hardwood reduction on winter birds in northwest Florida longleaf pine sandhill forests. Auk 119:71–87.

SIMBERLOFF, D. 1993. Species-area and fragmentation effects on old-growth forests: Prospects for longleaf pine communities. Proc. Tall Timbers Fire Ecol. Conf. 18:1–13.

STRENG, D.R., J.S. GLITZENSTEIN, AND W.J. PLATT. 1993. Evaluating effects of season of burn in longleaf pine forests: A critical literature review and some results from an ongoing long-term study. Proc. Tall Timbers Fire Ecol. Conf. 18:227–263.

THOMPSON, F.R., S.J. LEWIS, J. GREEN, AND D. EWERT. 1993. Status of neotropical migrant landbirds in the Midwest: Identifying species of management concern. P. 145–158 *in* Status and management of neotropical migratory birds, Finch, D.M., and P.W. Stangel (eds.). USDA For. Serv. Gen. Tech. Rep. RM-229.

U.S. DEPARTMENT OF DEFENSE. 1993. Natural Resources Management Plan Eglin Air Force Base, 1993–1997. Air Force Development Test Center, Eglin Air Force Base, Florida.

WAHLENBERG, W.G. 1946. Longleaf pine: Its use, ecology, regeneration, protection, growth, and management. Charles Lathrop Pack Forestry Foundation, Washington, DC.

WALDROP, T.A., D.L. WHITE, AND S.M. JONES. 1992. Fire regimes for pine grassland communities in the southeastern United States. For. Ecol. Manage. 47:195–210.

WILSON, C.W., R.E. MASTERS, AND G.A. BUKENHOFER. 1995. Breeding bird response to pine-grassland community restoration for red-cockaded woodpeckers. J. Wildl. Manage. 59:56–67.

ZAR, J.H. 1984. Biostatistical analysis. Ed. 2. Prentice-Hall, Inc., Englewood Cliffs, NJ.

APPENDIX A. Common name, scientific name, and migratory status (M-S) of bird species recorded at Eglin Air Force Base, Florida during spring and fall of 1994 and 1995.

Common name*	Scientific name*	M-S†
Acadian flycatcher	*Empidonax virescens*	NM-B
American crow	*Corvus brachyrhynchos*	R
American goldfinch	*Carduelis tristis*	W
American kestrel	*Falco sparverius*	R
American redstart	*Setophaga ruticilla*	NM-T
American robin	*Turdus migratorius*	W
Bachman's sparrow	*Aimophila aestivalis*	R
Baltimore oriole	*Icterus galbula*	NM-T
Black-and-white warbler	*Mniotilta varia*	NM-T
Blackburnian warbler	*Dendroica fusca*	NM-T
Blackpoll warbler	*Dendroica striata*	NM-T
Black-throated blue warbler	*Dendroica caerulescens*	NM-T
Black-throated green warbler	*Dendroica virens*	NM-T
Blue grosbeak	*Guiraca caerulea*	NM-B
Blue jay	*Cyanocitta cristata*	R
Blue-gray gnatcatcher	*Polioptila caerulea*	NM-B
Blue-headed vireo	*Vireo solitarius*	W
Blue-winged warbler	*Vermivora pinus*	NM-T
Broad-winged hawk	*Buteo platypterus*	NM-B
Brown creeper	*Certhia americana*	W
Brown thrasher	*Toxostoma rufum*	R
Brown-headed cowbird	*Molothrus ater*	R
Brown-headed nuthatch	*Sitta pusilla*	R
Canada warbler	*Wilsonia canadensis*	NM-T
Cape May warbler	*Dendroica tigrina*	NM-T
Carolina chickadee	*Poecile carolinensis*	R
Carolina wren	*Thryothorus ludovicianus*	R
Cedar waxwing	*Bombycilla cedrorum*	W
Chipping sparrow	*Spizella passerina*	W
Common grackle	*Quiscalus quiscula*	R
Common ground-dove	*Columbina passerina*	R
Common yellowthroat	*Geothlypis trichas*	NM-B
Downy woodpecker	*Picoides pubescens*	R
Eastern bluebird	*Sialia sialis*	R
Eastern kingbird	*Tyrannus tyrannus*	NM-B
Eastern meadowlark	*Sturnella magna*	R
Eastern phoebe	*Sayornis phoebe*	W
Eastern towhee	*Pipilo erythrophthalmus*	R
Eastern wood-pewee	*Contopus virens*	NM-T
Fish crow	*Corvus ossifragus*	R
Gray catbird	*Dumetella carolinensis*	NM-B
Golden-crowned kinglet	*Regulus satrapa*	W
Great crested flycatcher	*Myiarchus crinitus*	NM-B
Hairy woodpecker	*Picoides villosus*	R
Hermit thrush	*Catharus guttatus*	W
Hooded warbler	*Wilsonia citrina*	NM-B
House wren	*Troglodytes aedon*	W
Indigo bunting	*Passerina cyanea*	NM-B
Kentucky warbler	*Oporornis formosus*	NM-T
Loggerhead shrike	*Lanius ludovicianus*	R
Magnolia warbler	*Dendroica magnolia*	NM-T
Merlin	*Falco columbarius*	NM-T
Mourning dove	*Zenaida macroura*	R
Northern bobwhite	*Colinus virginianus*	R
Northern cardinal	*Cardinalis cardinalis*	R
Northern flicker	*Colaptes auratus*	R
Northern mockingbird	*Mimus polyglottos*	R
Northern parula	*Parula americana*	NM-B
Northern waterthrush	*Seiurus noveboracensis*	NM-T

APPENDIX A. (continued)

Common name*	Scientific name*	M-S†
Orchard oriole	*Icterus spurius*	NM-B
Ovenbird	*Seiurus aurocapillus*	NM-T
Palm warbler	*Dendroica palmarum*	W
Pileated woodpecker	*Dryocopus pileatus*	R
Pine warbler	*Dendroica pinus*	R
Prairie warbler	*Dendroica discolor*	NM-T
Prothonotary warbler	*Protonotaria citrea*	NM-B
Red-bellied woodpecker	*Melanerpes carolinus*	R
Red-cockaded woodpecker	*Picoides borealis*	R
Red-eyed vireo	*Vireo olivaceus*	NM-B
Red-headed woodpecker	*Melanerpes erythrocephalus*	R
Red-shouldered hawk	*Buteo lineatus*	R
Red-winged blackbird	*Agelaius phoeniceus*	R
Rose-breasted grosbeak	*Pheucticus ludovicianus*	NM-T
Ruby-crowned kinglet	*Regulus calendula*	W
Ruby-throated hummingbird	*Archilochus colubris*	NM-B
Savannah sparrow	*Passerculus sandwichensis*	W
Scarlet tanager	*Piranga olivacea*	NM-T
Sedge wren	*Cistothorus platensis*	W
Summer tanager	*Piranga rubra*	NM-B
Swainson's thrush	*Catharus ustulatus*	NM-T
Swainson's warbler	*Limnothlypis swainsonii*	NM-B
Swamp sparrow	*Melospiza georgiana*	W
Tennessee warbler	*Vermivora peregrina*	NM-T
Tufted titmouse	*Baeolophus bicolor*	R
Veery	*Catharus fuscescens*	NM-T
White-eyed vireo	*Vireo griseus*	NM-B
White-throated sparrow	*Zonotrichia albicollis*	W
Wood thrush	*Hylocichla mustelina*	NM-B
Worm-eating warbler	*Helmitheros vermivorus*	NM-T
Yellow warbler	*Dendroica petechia*	NM-T
Yellow-bellied sapsucker	*Sphyrapicus varius*	W
Yellow-billed cuckoo	*Coccyzus americanus*	NM-B
Yellow-breasted chat	*Icteria virens*	NM-B
Yellow-rumped warbler	*Dendroica coronata*	W
Yellow-throated vireo	*Vireo flavifrons*	NM-B

* Common and scientific names follow American Ornithologists' Union (1998).

† Migratory status classification: NM-B = Neotropical Migrant - Breeding, NM-T = Neotropical Migrant - Transient, R = Resident, W = Wintering.

APPENDIX B. Total number of individuals detected (number of sites where present) within habitats for bird species recorded at Eglin Air Force Base, Florida during spring 1994 and 1995.

Species†	Con-cern††	Habitat*									
		Burned	Flatwoods	Hammocks	Island	Scrub	Riparian	Sand Pine	Unburned	Young	All
Neotropical migrants											
Broad-winged hawk	H	0	0	1(1)	0	0	1(1)	0	0	0	2(2)
Merlin		0	0	0	1(1)	0	0	0	0	0	1(1)
Yellow-billed cuckoo	V	1(1)	1(1)	7(6)	0	1(1)	10(6)	1(1)	1(1)	0	22(17)
Ruby-throated hummingbird		0	0	0	4(3)	0	0	0	1(1)	0	5(4)
Acadian flycatcher	H	0	0	1(1)	0	0	5(5)	0	0	0	6(6)
Great crested flycatcher§	V	11(9)^{AB}	15(9)^{AB}	45(16)^{A}	15(6)^{B}	14(5)^{AB}	20(13)^{AB}	8(5)^{B}	21(11)^{AB}	7(5)^{B}	156(79)
Eastern kingbird	H	0	0	1(1)	3(3)	0	0	0	0	0	4(4)
Blue-gray gnatcatcher§		12(9)^{ABC}	13(6)^{ABC}	31(11)^{AB}	6(5)^{BC}	13(7)^{A}	4(4)^{BC}	1(1)^{C}	9(9)^{ABC}	6(4)^{BC}	95(56)
Wood thrush	V	0	0	2(1)	0	0	2(2)	0	0	0	4(3)
Gray catbird	H	0	5(3)	0	18(6)	0	1(1)	1(1)	0	0	25(11)
White-eyed vireo§	H	0^{B}	31(10)^{A}	11(7)^{AB}	5(5)^{AB}	5(2)^{AB}	18(6)^{AB}	1(1)^{B}	1(1)^{B}	1(1)^{B}	73(33)
Yellow-throated vireo	H	0	2(2)	1(1)	0	0	6(5)	2(2)	0	1(1)	12(11)
Red-eyed vireo§		2(2)^{BC}	0^{C}	37(14)^{A}	0^{C}	1(1)^{BC}	24(9)^{AB}	0^{C}	2(1)^{C}	0^{C}	66(27)
Blue-winged warbler	H	0	0	0	0	0	1(1)	0	0	0	1(1)
Northern parula§	H	0^{B}	0^{B}	56(13)^{A}	0^{B}	0^{B}	45(9)^{A}	0^{B}	0^{B}	0^{B}	101(22)
Yellow warbler		0	0	0	1(1)	0	0	0	0	0	1(1)
Prairie warbler	V	1(1)	0	0	9(7)	0	0	0	1(1)	1(1)	12(10)
Blackpoll warbler		0	0	0	1(1)	0	0	0	0	0	1(1)
Prothonotary warbler	V	0	0	1(1)	1(1)	0	18(5)	0	0	0	20(7)
Worm-eating warbler	H	0	0	3(3)	1(1)	1(1)	1(1)	0	0	0	6(6)
Swainson's warbler	V	0	0	0	1(1)	0	4(1)	0	0	0	5(2)
Ovenbird	H	0	0	2(1)	0	0	0	0	0	0	2(1)
Kentucky warbler	H	0	0	0	0	0	3(3)	0	0	0	3(3)
Common yellowthroat	H	0	43(6)	0	7(5)	0	3(2)	0	1(1)	0	54(14)
Hooded warbler§	H	0^{C}	2(2)^{BC}	13(9)^{B}	0^{C}	4(2)^{BC}	52(16)^{A}	0^{C}	1(1)^{BC}	0^{C}	72(30)
Yellow-breasted chat	H	0	4(3)	0	1(1)	0	2(1)	0	0	0	7(5)
Summer tanager§	H	6(5)^{AB}	5(5)^{AB}	6(6)^{AB}	1(1)^{B}	1(1)^{AB}	3(2)^{AB}	17(10)^{A}	13(8)^{AB}	3(2)^{AB}	55(40)
Scarlet tanager	H	0	1(1)	0	1(1)	0	0	0	0	0	2(2)
Rose-breasted grosbeak		0	0	1(1)	0	0	0	0	1(1)	0	2(2)
Blue grosbeak		7(5)	3(2)	1(1)	1(1)	0	0	0	0	3(3)	15(12)
Indigo bunting		0	3(2)	0	0	0	1(1)	1(1)	0	2(1)	7(5)
Orchard oriole	H	0	1(1)	0	4(1)	0	0	0	0	1(1)	6(3)
Baltimore oriole	H	0	0	0	1(1)	0	0	0	0	0	1(1)
Total neotropical migrants		40(15)	129(17)	220(20)	82(18)	40(7)	224(20)	32(14)	52(18)	25(12)	844 (141)
Residents											
Red-shouldered hawk	H	0	3(3)	2(2)	0	0	7(6)	1(1)	0	3(3)	16(15)
American kestrel	V	1(1)	1(1)	0	0	0	0	0	1(1)	0	3(3)
Northern bobwhite	H	7(5)	4(2)	0	0	0	0	0	1(1)	4(2)	16(10)
Mourning dove§		5(5)^{B}	6(5)^{B}	2(2)^{B}	51(16)^{A}	4(3)^{B}	5(3)^{B}	1(1)^{B}	1(1)^{B}	3(3)^{B}	78(39)
Red-headed woodpecker	H	10(5)	4(2)	0	2(2)	0	0	0	1(1)	0	17(12)
Red-bellied woodpecker§		19(9)^{ABCD}	46(16)^{AB}	51(18)^{A}	5(3)^{D}	5(2)^{CD}	30(14)^{ABC}	11(5)^{CD}	15(10)^{BCD}	3(3)^{D}	185(80)
Downy woodpecker		4(4)	5(3)	8(7)	0	2(2)	5(2)	4(4)	2(2)	2(2)	32(26)
Hairy woodpecker		0	1(1)	0	0	0	0	1(1)	0	0	2(2)
Red-cockaded woodpecker	E	11(5)	1(1)	0	0	0	0	0	0	0	12(6)
Northern flicker		5(3)	0	2(2)	0	2(2)	3(3)	1(1)	4(2)	0	17(13)

APPENDIX B. (continued)

Species†	Con-cern††	Habitat*									
		Burned	Flatwoods	Hammocks	Island	Scrub	Riparian	Sand Pine	Unburned	Young	All
Pileated woodpecker	H	2(2)	6(5)	5(5)	0	1(1)	8(6)	2(2)	0	3(2)	27(23)
Blue jay§		21(9)^{A}	19(10)^{A}	58(17)^{A}	30(13)^{A}	15(5)^{A}	31(12)^{A}	39(12)^{A}	17(9)^{A}	22(14)^{A}	252(101)
American crow§		18(10)^{A}	2(2)^{B}	4(3)^{AB}	2(1)^{B}	0^{B}	4(3)^{AB}	19(9)^{AB}	9(7)^{AB}	13(7)^{AB}	71(42)
Fish crow		4(2)	3(2)	3(2)	5(3)	0	2(2)	0	2(1)	1(1)	20(13)
Carolina chickadee§		19(11)^{ABC}	19(8)^{ABC}	21(13)^{ABC}	5(3)^{C}	17(7)^{AB}	16(8)^{ABC}	17(10)^{ABC}	41(16)^{A}	7(6)^{BC}	162(82)
Tufted titmouse§		15(9)^{BC}	23(13)^{ABC}	53(18)^{A}	0^{C}	29(9)^{A}	33(14)^{AB}	25(12)^{ABC}	40(18)^{AB}	25(14)^{AB}	243(107)
Brown-headed nuthatch	V	8(3)	23(8)	9(4)	6(2)	0	2(2)	1(1)	0	0	49(20)
Carolina wren§	H	2(2)^{C}	20(11)^{ABC}	74(18)^{A}	15(7)^{BC}	20(10)^{A}	45(14)^{AB}	22(11)^{ABC}	19(11)^{ABC}	11(6)^{BC}	228(90)
Eastern bluebird		6(5)	2(2)	0	0	0	0	0	0	0	8(7)
Northern mockingbird§		0^{B}	1(1)^{B}	2(1)^{B}	118(20)^{A}	1(1)^{B}	0^{B}	0^{B}	0^{B}	0^{B}	122(23)
Brown thrasher§	H	3(3)^{AB}	4(3)^{AB}	8(7)^{AB}	16(9)^{AB}	6(4)^{AB}	0^{B}	3(2)^{AB}	7(4)^{AB}	17(10)^{A}	64(42)
Pine warbler§		118(20)^{A}	165(20)^{A}	31(13)^{BC}	7(4)^{C}	35(10)^{AB}	24(12)^{BC}	141(18)^{A}	69(20)^{AB}	37(18)^{BC}	627(135)
Northern cardinal§		10(6)^{C}	28(11)^{BC}	80(20)^{A}	60(19)^{AB}	9(6)^{ABC}	62(20)^{AB}	24(12)^{BC}	25(9)^{BC}	76(18)^{A}	374(121)
Eastern towhee§		45(9)^{B}	125(19)^{A}	34(11)^{B}	144(20)^{A}	30(7)^{AB}	18(8)^{B}	19(9)^{B}	16(6)^{B}	21(10)^{B}	452(99)
Bachman's sparrow§	V	29(11)^{A}	8(3)^{B}	0^{B}	0^{B}	0^{B}	0^{B}	0^{B}	0^{B}	0^{B}	37(14)
Red-winged blackbird§		0^{B}	0^{B}	0^{B}	58(11)^{A}	0^{B}	2(2)^{B}	0^{B}	0^{B}	1(1)^{B}	61(14)
Eastern meadowlark		0	0	0	3(3)	0	0	0	0	0	3(3)
Common grackle		0	4(2)	2(1)	12(3)	1(1)	4(1)	0	0	0	23(8)
Brown-headed cowbird§		0^{B}	3(2)^{B}	4(3)^{B}	46(16)^{A}	0^{B}	0^{B}	0^{B}	0^{B}	0^{B}	53(21)
Total residents		362(20)	526(20)	453(20)	585(20)	177(10)	301(20)	331(20)	270(20)	249(20)	3,254 (170)
Wintering											
House wren		0	5(4)	0	2(2)	0	2(2)	1(1)	0	0	10(9)
Sedge wren		0	2(2)	0	2(1)	0	0	0	0	0	4(3)
Ruby-crowned kinglet		5(3)	7(7)	17(10)	6(6)	3(3)	14(9)	16(9)	11(7)	22(10)	101(64)
Hermit thrush		0	0	0	0	0	2(2)	2(2)	1(1)	1(1)	6(6)
American robin		0	2(1)	0	0	0	0	0	0	0	2(1)
Cedar waxwing		0	97(6)	8(1)	27(3)	0	5(1)	1(1)	0	0	138(12)
Blue-headed vireo		0	0	8(6)	0	0	2(2)	3(3)	2(1)	1(1)	16(13)
Yellow-rumped warbler		12(7)	1(1)	16(5)	22(12)	7(6)	5(3)	18(6)	28(8)	12(5)	120(53)
Palm warbler		3(2)	0	0	2(1)	0	0	3(2)	0	2(1)	10(6)
Chipping sparrow		3(2)	3(2)	1(1)	1(1)	0	0	0	1(1)	2(1)	11(8)
Swamp sparrow		0	0	0	3(2)	0	0	0	0	0	3(2)
White-throated sparrow		5(2)	6(2)	2(1)	27(8)	0	0	0	0	1(1)	41(14)
American goldfinch		1(1)	0	1(1)	0	0	0	0	0	0	2(2)
Total wintering		28(8)	123(15)	53(14)	92(18)	10(7)	30(11)	44(13)	43(12)	41(14)	464(112)
Total all species		430(20)	778(20)	726(20)	759(20)	227(10)	555(20)	407(20)	365(20)	315(20)	4,562 (170)

* Each habitat contained 20 sites except for scrub which contained 10 sites. Habitat types were as follows: Burned = sandhills with mature longleaf pines and recently (≤ 3 yr) burned; Flatwoods = mature, open flatwoods burned within 1–5 yr; Hammocks = both maritime and xeric hammocks; Island = interspersion of coastal scrub, beach dune, and flatwoods; Scrub = inland sand pine scrub occupying relic dunes; Riparian = largely deciduous forest types bordering streams and rivers; Sand Pine = sand pine plantations ≥ 20 yr old; Unburned = sandhills with mature longleaf pines and no evidence of recent burning; Young = sandhills planted with longleaf pine and 8–12 years old.

† Scientific names in Appendix A.

†† Ranking of species based on concern scores of Partners in Flight prioritization scheme (W. C. Hunter unpublished data, see Hunter et al. 1993a): H = species of high concern, V = species of very high concern, and E = species of extremely high concern. Other species are of low or moderate concern.

§ Abundance of species did not differ ($P > 0.05$) between habitats with same superscripts.

APPENDIX C. Total number of individuals detected (number of sites where present) within habitats for bird species recorded at Eglin Air Force Base, Florida during fall 1994 and 1995.

Species[†]	Con-cern[††]	Habitat*									
		Burned	Flatwoods	Hammocks	Island	Scrub	Riparian	Sand Pine	Unburned	Young	All
Neotropical migrants											
Broad-winged hawk	H	0	0	0	0	0	0	0	1(1)	0	1(1)
Yellow-billed cuckoo	V	0	0	2(2)	0	0	1(1)	1(1)	0	1(1)	5(5)
Ruby-throated hummingbird		0	0	1(1)	0	2(1)	0	0	0	0	3(2)
Eastern wood-pewee	H	1(1)	1(1)	1(1)	0	0	0	0	0	0	3(3)
Acadian flycatcher	H	0	0	1(1)	0	0	5(2)	0	0	0	6(3)
Great crested flycatcher	V	0	0	0	1(1)	0	0	0	0	0	1(1)
Eastern kingbird	H	0	0	0	1(1)	0	0	0	0	0	1(1)
Blue-gray gnatcatcher[§]		7(6)^{AB}	4(3)^{B}	20(13)^{A}	5(5)^{AB}	6(5)^{AB}	2(2)^{B}	5(5)^{AB}	9(8)^{AB}	6(6)^{AB}	64(53)
Veery	H	0	0	3(3)	0	0	8(4)	0	0	1(1)	12(8)
Swainson's thrush		0	0	0	1(1)	0	3(3)	0	0	0	4(4)
Wood thrush	V	0	1(1)	0	0	0	15(7)	0	0	0	16(8)
Gray catbird[§]	H	1(1)^{B}	25(9)^{AB}	13(10)^{AB}	32(11)^{A}	0^{B}	70(12)^{A}	2(2)^{B}	1(1)^{B}	2(1)^{B}	146(47)
White-eyed vireo	H	0	8(4)	8(6)	2(2)	3(2)	7(4)	0	0	0	28(18)
Red-eyed vireo		0	0	2(2)	0	2(1)	2(2)	0	0	1(1)	7(6)
Tennessee warbler		1(1)	0	0	0	0	0	0	0	0	1(1)
Northern parula	H	0	0	3(1)	0	0	1(1)	0	0	0	4(2)
Magnolia warbler		0	1(1)	2(2)	1(1)	0	2(2)	0	0	0	6(6)
Cape May warbler		0	0	3(2)	0	0	0	0	0	0	3(2)
Black-throated blue warbler	H	0	1(1)	0	0	0	0	0	0	0	1(1)
Black-throated green warbler		0	0	0	0	0	0	0	0	3(2)	3(2)
Blackburnian warbler	H	0	0	0	0	0	0	0	1(1)	5(1)	6(2)
Prairie warbler	V	0	0	1(1)	13(7)	0	1(1)	0	0	1(1)	16(10)
Black-and-white warbler		1(1)	0	4(4)	0	0	4(3)	0	0	0	9(8)
American redstart[§]		0^{B}	1(1)^{B}	18(14)^{A}	4(2)^{B}	2(1)^{B}	8(5)^{B}	1(1)^{B}	0^{B}	1(1)^{B}	35(25)
Worm-eating warbler	H	0	0	0	0	0	1(1)	0	0	0	1(1)
Ovenbird	H	0	0	5(4)	0	0	1(1)	0	0	0	6(5)
Northern waterthrush		0	0	1(1)	0	0	0	0	0	0	1(1)
Common yellowthroat[§]	H	0^{B}	31(15)^{A}	1(1)^{B}	19(11)^{A}	0^{B}	4(3)^{B}	0^{B}	0^{B}	0^{B}	55(30)
Hooded warbler[§]	H	0^{B}	0^{B}	19(11)^{A}	0^{B}	0^{B}	6(5)^{B}	0^{B}	0^{B}	0^{B}	25(16)
Canada warbler	H	0	0	0	1(1)	0	0	0	0	0	1(1)
Yellow-breasted chat	H	0	0	0	1(1)	0	0	0	0	0	1(1)
Summer tanager	H	0	0	1(1)	0	0	1(1)	1(1)	1(1)	0	4(4)
Rose-breasted grosbeak		0	0	2(2)	0	0	0	0	0	0	2(2)
Blue grosbeak		0	0	1(1)	0	0	1(1)	0	0	0	2(2)
Indigo bunting		0	0	0	0	0	0	0	0	1(1)	1(1)
Baltimore oriole	H	0	0	0	0	0	0	0	0	1(1)	1(1)
Total neotropical migrants		11(7)	73(18)	112(20)	81(20)	15(8)	143(20)	10(10)	13(10)	23(10)	481(123)
Residents											
Red-shouldered hawk	H	1(1)	0	0	0	0	4(3)	0	0	1(1)	6(5)
American kestrel	V	4(4)	1(1)	0	1(1)	0	0	0	0	0	6(6)
Mourning dove		0	0	1(1)	32(8)	1(1)	0	0	0	0	34(10)
Common ground-dove		0	0	0	0	0	0	0	2(1)	0	2(1)
Red-headed woodpecker	H	12(7)	3(1)	2(1)	0	0	0	0	0	1(1)	18(10)

APPENDIX C. (continued)

Species†	Con-cern††	Habitat*									
		Burned	Flatwoods	Hammocks	Island	Scrub	Riparian	Sand Pine	Unburned	Young	All
Red-bellied woodpecker§		12(9)^{BC}	17(10)^{ABC}	40(17)^{A}	4(3)^{C}	6(2)^{BC}	28(16)^{AB}	2(2)^{C}	6(6)^{C}	3(3)^{C}	118(68)
Downy woodpecker		10(5)	7(7)	7(5)	0	6(3)	6(6)	4(3)	7(5)	1(1)	48(35)
Red-cockaded woodpecker	E	13(6)	3(2)	0	0	0	0	0	1(1)	0	17(9)
Northern flicker		5(3)	3(3)	8(6)	2(1)	0	17(7)	0	3(3)	1(1)	39(24)
Pileated woodpecker	H	1(1)	4(3)	4(4)	0	1(1)	4(3)	1(1)	2(1)	1(1)	18(15)
Blue jay§		15(8)^{B}	19(11)^{B}	90(19)^{A}	22(11)^{B}	21(6)^{AB}	34(13)^{B}	14(8)^{B}	36(17)^{AB}	28(15)^{B}	279(108
American crow		9(4)	1(1)	2(2)	0	0	3(3)	3(2)	5(4)	4(2)	27(18)
Fish crow		1(1)	0	0	0	0	0	0	0	0	1(1)
Carolina chickadee§		13(7)^{AB}	15(7)^{AB}	23(11)^{A}	0^{B}	4(4)^{AB}	9(4)^{AB}	18(9)^{AB}	26(12)^{A}	18(12)^{A}	126(66)
Tufted titmouse§		16(8)^{ABC}	9(7)^{BC}	36(16)^{A}	1(1)^{C}	10(5)^{ABC}	11(5)^{BC}	12(8)^{ABC}	29(13)^{AB}	28(12)^{AB}	152(75)
Brown-headed nuthatch	V	15(4)	14(7)	2(1)	4(2)	1(1)	0	0	0	0	36(15)
Carolina wren§	H	0^{B}	18(9)^{AB}	57(16)^{A}	8(5)^{B}	8(4)^{AB}	34(17)^{A}	4(3)^{B}	3(2)^{B}	3(2)^{B}	135(58)
Eastern bluebird		2(1)	6(4)	0	0	0	0	0	0	0	8(5)
Northern mockingbird§		0^{B}	4(3)^{B}	5(2)^{B}	94(19)^{A}	1(1)^{B}	0^{B}	0^{B}	0^{B}	1(1)^{B}	105(26)
Brown thrasher§	H	0^{C}	3(3)^{BC}	38(15)^{A}	17(12)^{AB}	8(7)^{AB}	11(8)^{ABC}	2(2)^{BC}	0^{C}	9(6)^{BC}	88(53)
Loggerhead shrike	V	3(3)	0	0	1(1)	0	0	0	0	0	4(4)
Pine warbler§		51(18)^{AB}	87(20)^{A}	19(12)^{BC}	4(3)^{C}	26(7)^{ABC}	7(3)^{C}	43(17)^{AB}	35(16)^{BC}	15(8)^{C}	287(104
Northern cardinal§		1(1)^{C}	20(12)^{AB}	36(18)^{A}	17(8)^{BC}	7(3)^{BC}	30(12)^{AB}	13(5)^{BC}	7(5)^{BC}	16(9)^{ABC}	147(73)
Eastern towhee§		7 4)^{C}	56(17)^{A}	8(6)^{BC}	45(14)^{AB}	5(2)^{BC}	13(6)^{BC}	5(3)^{C}	0^{C}	5(4)^{C}	144(56)
Bachman's sparrow	V	8(4)	0	0	0	0	0	0	0	0	8(4)
Red-winged blackbird		0	0	0	1(1)	0	0	0	0	0	1(1)
Total residents		199(20)	290(20)	378(20)	253(20)	105(9)	211(20)	121(20)	162(20)	135(20)	1,854 (169)
Wintering											
Yellow-bellied sapsucker		1(1)	5(4)	1(1)	0	0	5(3)	1(1)	3(3)	1(1)	17(14)
Eastern phoebe		5(4)	4(4)	1(1)	5(4)	0	10(9)	4(4)	3(3)	0	32(29)
Brown creeper		0	0	0	1(1)	0	0	0	0	0	1(1)
House wren		8(5)	13(10)	0	6(5)	0	0	0	0	0	27(20)
Golden-crowned kinglet		0	0	0	0	0	3(1)	0	0	0	3(1)
Ruby-crowned kinglet		2(2)	3(2)	4(4)	3(3)	1(1)	4(4)	3(3)	5(5)	3(3)	28(27)
Hermit thrush		0	0	1(1)	0	0	2(2)	0	0	0	3(3)
Blue-headed vireo		0	0	1(1)	0	0	2(2)	0	0	0	3(3)
Yellow-rumped warbler		0	0	2(2)	21(9)	0	1(1)	0	1(1)	0	25(13)
Palm warbler		2(1)	0	0	15(8)	0	0	1(1)	0	2(2)	20(12)
Chipping sparrow		0	0	0	1(1)	0	0	0	1(1)	0	2(2)
Savanna sparrow		0	0	0	4(3)	0	0	0	0	0	4(3)
White-throated sparrow		0	1(1)	0	1(1)	0	0	0	0	0	2(2)
Total wintering		18(9)	26(15)	10(8)	57(17)	1(1)	27(14)	9(9)	13(9)	6(6)	167(88)
Total all species		228(20)	389(20)	500(20)	391(20)	121(10)	381(20)	140(20)	188(20)	164(20)	2,502 (170)

* Each habitat contained 20 sites except for scrub which contained 10 sites. Habitat types were as follows: Burned = sandhills with mature longleaf pines and recently (≤ 3 yr) burned; Flatwoods = mature, open flatwoods burned within 1–5 yr; Hammocks = both maritime and xeric hammocks; Island = interspersion of coastal scrub, beach dune, and flatwoods; Scrub = inland sand pine scrub occupying relic dunes; Riparian = largely deciduous forest types bordering streams and rivers; Sand Pine = sand pine plantations ≥ 20 yr old; Unburned = sandhills with mature longleaf pines and no evidence of recent burning; Young = sandhills planted with longleaf pine and 8–12 years old.

† Scientific names in Appendix A.

†† Ranking of species based on concern scores of Partners in Flight prioritization scheme (W. C. Hunter unpublished data, see Hunter et al. 1993a): H = species of high concern, V = species of very high concern, and E = species of extremely high concern. Other species are of low or moderate concern.

§ Abundance of species did not differ ($P > 0.05$) between habitats with same superscripts.