Habitat-Island Effects on the Avian Community in Cypress Ponds[1]

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Abstract: Breeding season bird communities were sampled using point counts on 12 cypress-pond habitat islands in central Florida during May and June 1983. Habitat islands studied ranged from 7 to 229 ha in size. Of 38 species of birds detected, none was restricted to islands larger than 20 ha. Contrary to theoretical predictions, total species richness did not increase with island area. Both species richness and total counts on the sample points were negatively correlated with island area parameters and distance from island perimeter. Both species richness and total counts were positively correlated with snag density and spatial heterogeneity of overstory trees. Individual species responded to different vegetation characteristics in the islands. The negative correlation between island area and species richness was attributed to edge-effect and the paucity of neotropical migrants in the Southeast. A system of cypress ponds at least 10 to 20 ha in size was adequate to maintain the avian community using this vegetation type in central Florida.

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Numerous authors have correlated bird species richness with habitat island area in the United States (Forman et al. 1976, Robbins 1979, 1980, Anderson and Robbins 1981, Coleman et al. 1982). The tendency for bird species richness to increase with increasing habitat island size is apparently the result of different processes for different groups of species. In small islands (<10 ha), species occurrence is primarily a function of territory size, with species colonizing islands that meet their minimum territory size requirements (Galli et al. 1976, Rusterholz and Howe 1979, Harris and McElveen 1981, Martin 1981, Harris and Wallace 1984). These species tend to be "edge" species, permanent residents or short-distance migrants, and graminivorous or omnivorous in their feeding habits (Lynch and Whitcomb 1978). Birds that are restricted to larger island sizes (>10 ha) because of minimum territory

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requirements tend to be nonpasserines and carnivores (Galli et al. 1976, Harris and Wallace 1984). However, many of these species, such as the barred owl, red-tailed hawk, and pileated woodpecker can utilize small islands if they are part of a larger system of islands that contains, overall, an area sufficient for the species' habitat requirements (Whitcomb et al. 1977).

A second group of species is apparently not limited by territory size requirements, yet occurs only in larger areas of contiguous forest. These species may require forested areas 30 to >100 ha in size (Robbins 1979, 1980), areas much greater than their minimum territory sizes (Ambuel and Temple 1983). Species in this group are primarily neotropical migrants that require forest habitat and build open nests on or near the ground (Whitcomb et al. 1981).

Knowledge of forest fragmentation effects in the Southeast may be critical to designing forest management plans or selecting conservation areas to preserve avian communities. Habitat-island-area effects also will be critical to designing man-made wildlife habitats. This is especially applicable to phosphate-mine reclamation in Florida where reclamation regulations require that 10% of mined areas be returned to forests and that wetlands be reclaimed on a hectare-for-hectare basis. Habitat island effects could be important in planning the distribution of forests and wetlands on reclaimed phosphate mines to maximize avian diversity.

The purpose of this study was to examine effects of habitat island size and vegetative characteristics on an avian community in the Southeast. Cypress (*Taxodium distichum*) ponds in central Florida were chosen as examples of habitat islands. Moderate- to large-size ponds (7 to 229 ha) were studied, as smaller ponds had previously been examined by Harris and McElveen (1981).

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Methods

Study Area

Study areas were selected on a portion of Deseret Ranches of Florida, Inc., in Osceola County, Florida. Vegetation on the area was originally pine flatwoods, primarily open longleaf pine (*Pinus palustris*) woodlands with interspersed cypress swamps (Davis 1967). Approximately 40 to 50 years prior to this study, the pine forests were harvested and converted to improved or native pastures. Cypress areas were retained but were periodically logged since the turn of the century. Most recent logging in cypress areas occurred in the 1960s. At the time of this study, the area was characterized by habitat islands of cypress swamps surrounded by improved pastures. Approximately

25% of the area was composed of cypress ponds in the form of domes or strands of varying sizes distributed over the landscape.

Twelve of these cypress islands, including sizes of 7, 8, 10, 15, 16, 20, 41, 48, 92, 96, 215, and 229 ha, were selected for study. Dominant tree species, based on frequency of occurrence in point-quarter samples (described below) were pond cypress (*T. distichum* var. nutans), loblolly bay (*Gordonia lasianthus*), and blackgum (*Nyssa sylvatica*) in both the overstory and understory layers. Fetterbush (*Lyonia lucida*) was dominant in the shrub layer (48% frequency), followed by wax myrtle (*Myrica cerifera*, 13%), and loblolly bay (13%). Tree heights averaged 17 m and total shrub cover averaged 46% on the areas (Table 1).

Bird Sampling

Relative indices of bird numbers were obtained on each island using point counts (Blondel et al. 1970, Dawson 1981). Between 2 and 4 sample points were located in each island, depending on island size, for a total of 40 points over the 12 islands. Points were spaced along a transect perpendicular to the edge and extending into the middle of each island with the first point 80 m from the edge and subsequent points spaced at 160-m intervals. Each point was sampled 5 mornings during May and June 1983. For each bird sample, the

Table 1. Mean, standard error, and range of vegetation variables and island characteristics averaged across 40 sample points.

Variable[a]	$\bar{X}$	Units	SE	Range
BASAREA	39	m^2/ha	2	9–76
FHD	0.55	(H′)	0.01	0.46–0.60
FORMDIV	0.38	(H′)	0.01	0.20–0.59
GRNDCOV	41	%	3	2–94
HEIGHT	17	m	1	12–21
NOVER	2.9	*N*	0.2	1.0–6.0
NSHRUB	4.7	*N*	0.3	2.0–10.0
NUNDER	3.9	*N*	0.2	2.0–7.0
OVCOVAR	54	%	2	36–91
OVDENS	810	*N*/ha	50	174–1,494
OVERCOV	53	%	3	15–93
OVERDIV	0.30	(H′)	0.03	0.00–0.58
UNDCOV	60	%	3	23–100
UNDCOVAR	58	%	2	33–103
UNDENS	1,421	*N*/ha	181	222–4,882
UNDERDIV	0.43	(H′)	0.03	0.10–0.75
SHRBCOV	46	%	8	4–287
SHRBCOVAR	64	%	3	36–144
SHRBDENS	4,339	*N*/ha	655	406–17,485
SHRBDIV	0.51	(H′)	0.03	0.16–0.93
SNAGDENS	166	(index)	50	6–1,773
EDGEDIST	124	*N*	7	70–260
EDGEINDX	1.7	(index)	0.2[b]	1.2–2.7

[a] Variables are defined in table 2.
[b] $N = 12$.

observer stood at a sample point for 8 minutes and recorded all birds detected aurally or visually within a distance of approximately 75 m. All samples were taken by the same observer to minimize possible biases in bird detection and distance estimation. Birds detected outside the count circles or count periods were recorded to augment species lists. Counts were restricted to mornings with favorable weather conditions and were within 4 hours after sunrise to minimize variation due to weather and time of day. The order in which points were sampled was rotated to further minimize time-of-day differences.

Vegetation Sampling

The point-quarter technique (Cottam and Curtis 1956) was used to characterize vegetation on each bird census plot during October 1983. One vegetation sampling point was located at a distance of 25 m from the center of each plot along perpendicular axes, resulting in 4 point-quarter samples per plot. Distances to the nearest woody plant <5 m tall and to the nearest overstory (>15 cm dbh, >5 m tall) and understory (<15 cm dbh, >5 m tall) trees were measured in each quadrant. Plant species were recorded. Distance to the snag (>15 cm dbh) standing closest to each point also was measured as an index of snag density. Minimum and maximum crown diameters were measured for woody plants <5 m tall and dbh was measured for all overstory trees sampled. Canopy height was measured with a rangefinder and percent cover of overstory and understory trees was ranked on a scale of 1–10 at each vegetation sampling point. Percent cover of herbaceous vegetation was estimated on 0.5 x 0.5 m plots located 4 m from each point-quarter sample point along each of the perpendicular axes. Presence or absence of vegetation above these 0.25 m^2 plots also was noted for the 3 woody plant classifications for subsequent calculation of growth form diversity (Yahner 1983). In addition, contiguous forested area and perimeter length of each island were measured on U.S. Geological Survey quadrangle maps.

Data Analysis

Numbers of birds detected during sample counts were tabulated by species for each sample point. Twenty-one vegetation variables and 3 variables related to island characteristics also were calculated for each sample point ($N = 40$, Table 2). Principal components analysis was used with a varimax rotation to reduce the vegetation and island variables to orthogonal components describing physical and physiognomic characteristics of the sample points (Ray 1982). The minimum number of components was derived that resulted in components that were biologically interpretable in terms of the variable loadings. Principal component scores were calculated for each of the sample points and bird sample counts were regressed, using multiple regression, with these scores to determine the effects of vegetation and island charactristics on bird populations. Use of principal components as independent variables in multiple regression eliminated problems of multicolinearity in the vegetation and island

Table 2. Vegetation variables and island characteristics measured in 12 cypress habitat islands in central Florida.

Vegetation variables

- BASAREA = basal area of overstory trees (m^2/ha)
- FHD = $-\Sigma p_i \log p_i$, where p_i = proportion of TOTCOV in each of the height strata (GRNDCOV, SHRBCOV, UNDCOV, OVERCOV)
- FORMDIV = $-\Sigma P_i \log p_i$, where p_i = percent frequency/100 based on presence or absence of each height strata (herbaceous, shrubs, understory trees, overstory trees) in 0.25 m^2 plots
- GRNDCOV = average estimated percent cover of grass and forbs
- HEIGHT = average maximum height of the overstory canopy (m)
- NOVER = number of overstory species
- NSHRUB = number of shrub species
- NUNDER = number of understory species
- OVCOVAR = coefficient of variation of overstory distances (%)
- OVDENS = number of overstory trees (>5 m, >15 cm dbh)/ha
- OVERCOV = average estimated percent cover of overstory trees
- OVERDIV = $-\Sigma p_i \log p_i$, where p_i = percent frequency/100 of each overstory tree species
- UNDCOV = average estimated percent cover of understory trees
- UNDCOVAR = coefficient of variation of understory distances (%)
- UNDENS = number of understory trees (>5 m, <15 cm dbh)/ha
- UNDERDIV = $-\Sigma p_i \log p_i$, where p_i = percent frequency/100 of each understory tree species
- SHRBCOV = shrubcover (%)
- SHRBCOVAR = coefficient of variation of shrub distances (%)
- SHRBDENS = number of shrubs (<5 m)/ha
- SHRBDIV = $-\Sigma p_i \log p_i$, where p_i = percent frequency/100 of each shrub species
- SNAGDENS = index of number of dead overstory trees

Island characteristics

- EDGEDIST = distance of sample point from island perimeter
- EDGEINDX = perimeter length/$(2\sqrt{\text{area} \cdot \pi})$
- LNAREA = natural log of island area (ha)

variables (Freund and Littell 1981). Multiple regression was done for all small- to medium-sized birds with moderate-sized home ranges (i.e., Cuculidae, Picidae, and Passeriformes) that also were detected at least a total of 10 times on all points. Number of species detected per sample point and total number of detections (all species) also were regressed with principal component scores to determine gross numerical community responses. The significance level for entering variables in the regression models was set at 0.1. Pearson product-moment correlation also was used to compare number of species and total numbers per point with island areas.

Results

Thirty-eight bird species were detected in the habitat islands (Table 3). All but 4 of these species were recorded on the sample plots during 1 of the count periods, accounting for 877 detections. Ten species were recorded in islands 15 to 20 ha in size but not in islands 7 to 10 ha in size. Of these species,

Table 3. Number of birds detected in 12 cypress habitat islands grouped by size, May–June 1983, Osceola County, Florida.

Species	Island size groupings				
	7–10 ha	15–20 ha	41–48 ha	92–96 ha	215–229 ha
Great egret (*Casmerodius albus*)	1	3	1		
Little blue-heron (*Egretta caerulea*)		2		1	
Green-backed heron (*Butorides striatus*)		P	P		P
Yellow-crowned night heron (*Nyctanassa violaceus*)	10	2			
White ibis (*Eudocimus alba*)	7	P		1	
Wood duck (*Aix sponsa*)		1			
Black vulture (*Coragyps atratus*)	P[a]				
Turkey vulture (*Cathartes aura*)	3	1	P		
American swallow-tailed kite (*Elanoides forficatus*)		5	P		1
Red-shouldered hawk (*Buteo lineatus*)	6	6	2	3	2
Mourning dove (*Zenaida macroura*)		1	2	P	1
Yellow-billed cuckoo (*Coccyzus americanus*)	1	4	2	8	2
Barred owl (*Strix varia*)	P	1		1	
Ruby-throated hummingbird (*Archilochus colubris*)		P			
Red-bellied woodpecker (*Melanerpes carolinus*)	15	18	11	6	8
Downy woodpecker (*Picoides pubescens*)	2	4	1	2	2
Pileated woodpecker (*Dryocopus pileatus*)	1	3	5	6	1
Great crested flycatcher (*Myiarchus crinitus*)	13	22	15	4	6
Blue jay (*Cyanocitta cristata*)	P	3	7	2	5
American crow (*Corvus brachyrhynchos*)	7	4	2	5	P
Carolina chickadee (*Parus carolinensis*)	1	1	1		4
Tufted titmouse (*Parus bicolor*)	12	23	6	2	8
Carolina wren (*Thryothorus ludovicianus*)	31	45	54	61	26
Blue-gray gnatcatcher (*Polioptila caerulea*)	7	9	7	1	2
Northern mockingbird (*Mimus polyglottos*)				1	
Brown-thrasher (*Toxostoma rufum*)		P		1	

Species	Island size groupings 7–10 ha	15–20 ha	41–48 ha	92–96 ha	215–229 ha
White-eyed vireo (*Vireo griseus*)	2	17	21	18	9
Red-eyed vireo (*Vireo olivaceus*)		1		6	
Northern parula (*Parula americana*)	22	37	12	28	5
Yellow-throated warbler (*Dendroica dominica*)	1	1			
Pine warbler (*Dendroica pinus*)	7	1	1		1
Prothonotary warbler (*Protonotaria citrea*)	1	1			
Common yellowthroat (*Geothlypis trichas*)	2	1	4		10
Summer tanager (*Piranga rubra*)			1		
Northern cardinal (*Cardinalis cardinalis*)	5	14	17	5	5
Rufous-sided towhee (*Pipilo erythrophthalmus*)		1	2	1	P
Bachman's sparrow (*Aimophila aestivalis*)		P			
Common grackle (*Quiscalus quiscula*)	6	24	6	5	12
TOTAL	163	256	180	168	110
Number of species	26	35	25	23	22
Number of islands	3	3	2	2	2
Number of sample points	6	10	8	8	8

[a] P = detected outside of sample points or count periods.

the little blue heron, green-backed heron, wood duck, ruby-throated hummingbird, brown thrasher, and Bachman's sparrow were counted infrequently. Therefore, no conclusions could be drawn from the data concerning limitation of these species by island size. American swallow-tailed kites were restricted to islands >15 ha. Sprunt (1954) suggested that this species may be limited by too much open country. Red-eyed vireos have been recorded in habitat islands <5 ha in size in other studies (Whitcomb et al. 1981, Robbins 1979), and McElveen (1977) and Harris and McElveen (1981) have reported rufous-sided towhees in cypress domes <8 ha in size. Mourning doves, although occurring only in the larger islands, do not require deep woods for nesting (Hamel et al. 1982).

Fourteen principal components were derived for regression with bird species abundances (Table 4). Components 1, 5, and 10 were interpreted as coverage of overstory trees, shrubs, and herbaceous vegetation, respectively. Understory density and cover were negatively correlated with components 8 and 9, which represented conditions with high growth-form diversity and greater tree height, respectively. Components 2, 3, and 4 were correlated with measures of species diversity for the shrub, overstory, and understory layers.

Table 4. Rotated principal components analysis of vegetation variables and island characteristics in cypress habitat islands in central Florida. Only significant ($P < 0.01$, $r > 0.40$) component loadings are shown.

				Component loadings					
Component	Eigenvalve	$\%\delta^2$	Cumulative $\%\delta^2$	Variable	r	Variable	r	Variable	r
1	2.53	10.4	10.9	BASAREA	0.90	OVDENS	0.86	OVERCOV	0.75
2	2.12	9.5	20.4	NSHRUB	0.94	SHRBDIV	0.94		
3	2.10	9.5	29.9	NOVER	0.93	OVERDIV	0.93		
4	2.03	9.2	39.1	NUNDER	0.94	UNDERDIV	0.94		
5	2.02	9.1	48.2	SHRBCOV	0.88	SHRBDENS	0.80		
6	1.92	8.6	56.8	EDGEINDX	0.96	LNAREA	0.85		
7	1.07	7.3	64.1	UNCOVAR	0.88	SHRBCOVAR	0.75		
8	1.07	5.8	69.9	FORMDIV	0.77	UNDCOV	−0.47	UNDENS	−0.42
9	1.04	5.6	75.5	HEIGHT	0.89	UNDENS	−0.42		
10	1.04	5.2	80.7	GRNDCOV	0.92				
11	1.02	4.9	85.6	SNAGDENS	0.89				
12	1.01	4.9	90.5	OVCOVAR	0.89				
13	0.97	4.7	95.2	EDGEDIST	0.84				
14	0.96	4.7	99.9	FHD	0.87				

Table 5. Stepwise multiple regression of number of birds detected with principal components describing vegetation and island characteristics.

Species	Regression equations, β (principal component)	$\beta 0$	r^2	F
Yellow-billed cuckoo	0.20(5)+0.13(6)+0.17(7)−0.14(9)	0.37	0.34	4.59**[a]
Red-bellied woodpecker	−0.20(1)−0.18(6)+0.20(11)−0.22(13)	1.00	0.34	4.57**
Downy woodpecker	−0.17(9)+0.16(11)−0.12(14)	0.25	0.31	5.44**
Pileated woodpecker	0.23(3)−0.17(8)+0.11(10)+0.16(11)+0.12(12)	0.35	0.49	6.46***
Great crested flycatcher	−0.20(2)−0.22(6)	0.96	0.08	3.44*
American crow	−0.20(6)−0.17(10)	0.28	0.18	4.10*
Tufted titmouse	−0.23(5)−0.25(6)	0.85	0.21	4.94*
Carolina wren	−0.25(1)+0.22(4)+0.21(7)−0.18(8)−0.16(9)	2.24	0.47	6.21***
Blue-gray gnatcatcher	−0.17(2)−0.19(6)+0.14(11)+0.14(12)−0.23(13)	0.55	0.44	5.40***
White-eyed vireo	−0.30(2)+0.19(10)+0.20(12)	1.04	0.27	4.52**
Northern parula	−0.23(6)+0.27(8)+0.24(9)−0.30(10)	1.35	0.34	4.54**
Pine warbler	−0.11(1)−0.12(3)−0.13(5)−0.13(6)+0.13(8)	0.20	0.36	3.80**
Common yellowthroat	−0.23(1)−0.16(3)−0.12(4)+0.21(6)−0.20(7)+0.12(12)	0.29	0.56	7.12***
Northern cardinal	0.24(10)−0.32(13)	0.80	0.19	9.41**
Common grackle	0.20(2)−0.43(3)−0.20(4)−0.18(5)+0.22(10)+0.23(11)+0.24(12)	0.74	0.57	6.00***
Number of species	0.73(1)−0.88(6)+1.29(11)+0.78(12)−0.92(13)	9.13	0.61	10.67***
Total count (all species)	−1.44(1)−1.55(6)+2.00(11)+0.91(12)−1.23(13)	13.23	0.63	11.45***

[a] $*P < 0.05$, $**P < 0.01$, $***P < 0.001$; $N = 40$.

Spatial heterogeneity or "patchiness," as indexed by the coefficient of variation of distance measurements (Roth 1976), was represented by component 7 for the understory and shrub layers and component 12 for the overstory layer. Components 11 and 14 loaded high on snag density and foliage-height diversity, respectively. Components 6 and 13 represented variables associated with island characteristics. Component 6 was correlated with island area and island edge-to-area ratio; component 13 was correlated with distance from island perimeter.

The dependent variables, species richness and total count, were correlated ($r^2 = 0.63$, $P = 0.0001$), and both included the same principal components in regression equations (Table 5). These regressions showed decreasing numbers of species and individuals per point with increasing overstory (component 1), increasing area and edge/area ratios (component 6), and increasing distance from the island perimeter (component 13). Species richness and total count increased with increasing snag density (component 11) and overstory patchiness (component 12).

Number of species and total counts per point were both negatively correlated with island area ($r = -0.49$, $P = 0.0014$; and $r = -0.62$, $P = 0.0001$, respectively) and both were negatively correlated with distance from island perimeters ($r = -0.45$, $P = 0.0035$; and $r = -0.32$, $P = 0.0436$). Both parameters also were negatively correlated with island area when only points >120 m from island perimeters in islands >15 ha were considered ($r = -0.62$, $P = 0.0309$; and $r = -0.77$, $P = 0.0034$, respectively).

Individual species varied in their responses to vegetation and island characteristics. For example, 9 components (2 through 10) had both positive and negative coefficients with different species. Component 6, representing island characteristics, entered into regression equations for the most species but was positively correlated with only 2 species. All 3 species of woodpeckers detected, as well as the blue-gray gnatcatcher and common grackle, were correlated with component 11, representing snag density. Three species, red-bellied woodpecker, blue-gray gnatcatcher, and northern cardinal, showed decreasing numbers with increasing distance from the island perimeter (component 13). No species were positively correlated with foliage-height diversity (component 14), and only the blue jay was not correlated with any of the principal components.

Discussion

Harris and McElveen (1981) showed that species richness increased with habitat island area in small (0.6 to 7.9 ha) cypress ponds in Florida; they attributed this increase to minimum territory size requirements. Little evidence, however, of increases in species richness in cypress islands 7 to 229 ha in size was found in this study. In fact, total species counts were greater in islands 7 to

10 ha in size than in island groups of 41 to 48 ha, 92 to 96 ha, or 215 to 229 ha, despite larger sample sizes in the larger-island groups (Table 3). Only 2 species were restricted to habitat islands >20 ha in samples of this study. Both species were probably accidental as the northern mockingbird requires open country and the summer tanager prefers dry woodlands (Hamel et al. 1982).

Not only did species richness not increase with island size within the range of island sizes studied, but species numbers and total counts per plot were negatively correlated with island size parameters. These negative correlations apparently were due both to edge-effect and the paucity of forest-interior, neotropical-migrant species on the study areas. Species richness and bird densities tend to be greater in island edges than island interiors (Harris and McElveen 1981) and smaller islands have more characteristics of edge habitats than larger islands (Forman and Godron 1981, Noss 1983). As a result, smaller islands with greater edge-to-area ratios tend to have more species and greater densities as a result of edge-effect.

Declines in species richness and total counts, however, apparently were not attributable solely to decreasing edge-effect with increasing island size. Edge-effect has been shown to occur primarily within 25 m of the edge (Gates and Gysel 1978, Strelke and Dickson 1980). Yet species richness and total counts per point were still negatively correlated with island area when only points >120 m from the edge in larger islands were considered.

Lynch and Whigham (1984) found that, in many cases, short-distance migrants and permanent resident species attained higher densities in smaller tracts. They attributed this phenomenon to these species' abilities to use disturbed and edge habitats, in contrast to neotropical migrants which often required interior forest habitats. The southern latitude at which the areas in this study occurred apparently limited use of the larger islands by forest-interior, neotropical-migrant species, contributing to the negative correlation with island size. Thirteen species of neotropical migrants that use cypress habitats reach their southern limit north of these central Florida study areas (Hamel et al. 1982).

Forest fragmentation may affect breeding-season communities differently in different regions as a result of species distribution limits, especially neotropical migrant species. Southeastern states characteristically have lower breeding-bird diversities than the more northerly states where most habitat island studies have been conducted (MacArthur and Wilson 1967, Tramer 1974). Many of the breeding species that drop out along a north-to-south latitudinal gradient are the same neotropical migrants identified as area-sensitive species in northeastern and northcentral states (Fig. 1) (Robbins 1979, 1980, Whitcomb et al. 1981, Hamel et al. 1982), suggesting that the magnitude of change in bird communities resulting from forest fragmentation may differ with latitude. Optimal landscape management strategies for maintenance of avian communities may differ in the Southeast from those in other regions of

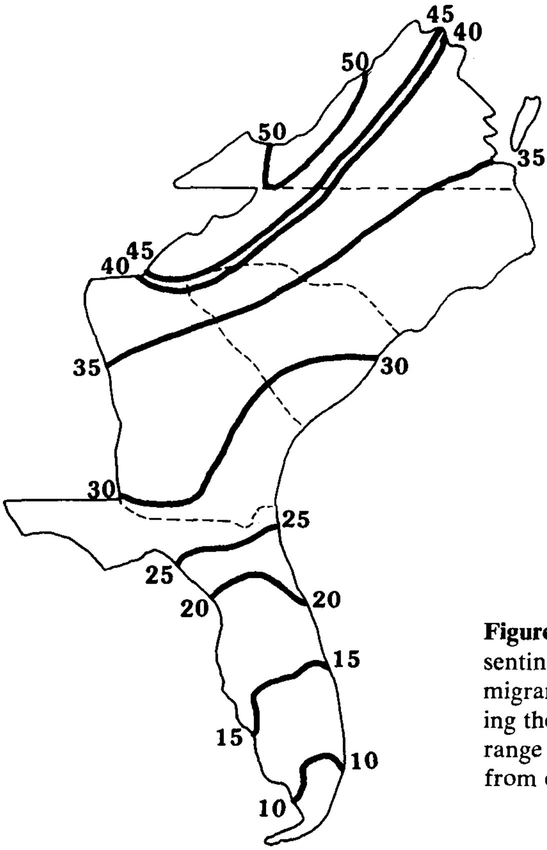

Figure 1. Contour intervals representing the number of neotropical-migrant woodland bird species reaching the southern limit of their breeding range in the Southeast. Compiled from data in Hamel et al. (1982).

the country as a result of this phenomenon. This is particularly true in Florida where the southern decline in species richness is accentuated southward in the Florida peninsula (Robertson and Kushlan 1974).

In central Florida, cypress ponds 10 to 20 ha in size retained the complement of breeding-season bird species using this vegetation type. Wide-ranging species may be maintained with small-size islands by interspersing the islands throughout the landscape (Harris 1984). Raptors and woodpeckers persisted in these areas because cypress ponds, many individually smaller than the birds' home ranges, were proximately located.

Island area effects may vary with habitat type as well as with latitude, however. Harris and Wallace (1984) found only 64% of the bird species known to breed in mesic hardwood forests in north Florida in hardwood islands ≤30 ha in size. Also, some species, although occurring on smaller islands, may not be present in sufficient numbers or have sufficient production to build up stable, self-sustaining populations (Whitcomb et al. 1981, Mader 1984).

In selection of management strategies for nongame birds, the regional species pool, as well as species' habitat requirements, should be considered. Proceeding north through the southeastern states, forest fragmentation may impact an increasingly greater percentage of the breeding-season bird population as the southern range limits of area-sensitive species are crossed.

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