Birds and Land Classes in Young Forested Landscapes

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Abstract: In the Mississippi Coastal Plain of the southeastern United States, we explored relationships among bird species and vegetation types and landscape characteristics at four different scales. We modeled abundance of priority avian species from Breeding Bird Surveys using land class metrics at 0.24, 1, 3, and 5-km extents. Our modeling method was logistic regression and model selection was based on Akaike's Information Criteria and validation with reserved data. Northern bobwhite (*Colinus virginianus*), red-headed woodpecker (*Melanerpes erythrocephalus*), northern parula (*Parula americana*), Swainson's warbler (*Limnothlypis swainsonii*), prairie warbler (*Dendroica discolor*), hooded warbler (*Wilsonia citrina*), and brown-headed cowbird (*Molothrus ater*) had models containing positive area or core area variables. White-eyed vireo (*Vireo griseus*) and gray catbird (*Dumetella carolinensis*) had models with a combination of area and edge associations at different scales. Acadian flycatcher (*Empidonax virescens*), red-bellied woodpecker (*Melanerpes carolinus*), wood thrush (*Hylocichla mustelina*), and yellow-breasted chat (*Icteria virens*) had positive edge density models. Modeling at different scales produced more complete habitat associations for most species and landscape variables were more influential at larger extents than the smallest extent. Although Mississippi is heavily forested, the landscape is unexpectedly fragmented, with small areal extents of vegetation types. Managers should seek to provide large extents of a variety of habitats, including historically representative vegetation types such as low density pine, to support persistence of a complete suite of avian species.

RH: Mississippi birds and land classes

Keywords: Conservation, core area, edge effects, habitat, landscape.

INTRODUCTION

When land use transforms a landscape, smaller patches of original vegetation types generally lose characteristic species. Studies have shown that landscape characteristics such as area and isolation affect interior bird presence, as well as pairing and reproductive success, in eastern and mid-western forests fragmented by agriculture and urbanization [1, 2]. Some area-sensitive species will occupy smaller patch sizes, but may incur high demographic penalties through brood predation and parasitism [3] or reduced food abundance [4]. Landscape changes that elevate nest predator abundance probably contribute to the processes that produce avian declines [5] because 1) predation is the primary source of nest mortality for most songbirds [6] and 2) previous reproductive success ultimately influences habitat selection at local [7] and landscape scales.

Any type or state of forest, when not containing agricultural and developed lands that support generalist predators and brood parasites (e.g., brown-headed cowbirds, *Molothrus ater*), may alleviate some fragmentation issues, including nest predation and parasitism [5, 8] as opposed to other land uses. Some studies in forests of the southeastern United States have shown mitigating effects of managed forests on nest predation and parasitism. Sargent *et al*. [9] found that nest predation in South Carolina was greater in hardwood stands enclosed by agricultural fields than in hardwood stands enclosed by mature pine forests, where predation rates did not differ between edge and interior nests between or within stand types. They observed that the low edge contrast in pine-enclosed stands appeared to attract fewer nest predators. In managed pine forests of South Carolina, Wigley *et al*. [10] reported little brood parasitism for two species and Hazler *et al*. [11] found that edge did not depress Acadian flycatcher (*Empidonax virescens*) nest survival. In regenerating site-prepared pine plantations (2 to 6 years old; 2 to 57 ha) of South Carolina, Krementz and Christie [12] discerned no area effect on species richness or juvenile to adult ratios in birds captured in mist nets. Also in South Carolina, in hardwoods of differing areal extents enclosed within a managed pine matrix, Turner *et al*. [13] found most avian species were present in all hardwood areal classes, regardless of size. Turner *et al*. [13] concluded that pine plantations with some hardwood midstory and interspersed hardwood patches sustained bird species normally associated with hardwood forests.

In contrast, other studies have demonstrated relationships between characteristics of forest landscapes (e.g. stand size, edge) and measures related to bird reproductive success (e.g. nest predation and parasitism). In northern Mississippi of the southeastern United States, Aquilani and Brewer [14] found

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that wood thrush (*Hylocichla mustelina*) nest success was greatest in large, mature oak-pine mixed patches enclosed by pine plantations and other forest types and lowest near clear-cut edges. Predation appeared to cause all but one nest failure, which was due to parasitism. In northeastern Alabama hardwood and mixed forest fragments, Keyser *et al*. [15] also reported that predation rates decreased with increasing stand size. In South Carolina pines, edge increased nest predation and negatively affected indigo bunting (*Passerina cyanea*) nesting success [16].

Landscape composition and configuration potentially affect specialists, including species of early- and late-successional vegetation and open (i.e., fire-dependent) ecosystems, more than generalists, or edge and adaptable species [17, 18]. Also, land use that results in loss of type or structure may affect avian presence. For example in the southeastern United States, loss of mature pine forests that generally contain specific stand elements (e.g. cavity trees, open midstory) negatively can impact foraging opportunities and dispersal of federally endangered Red-cockaded Woopeckers (*Picoides borealis*), and ultimately group size and reproduction [19, 20]). Woodpecker habitat isolation, combined with population isolation, can make it difficult for woodpeckers to locate breeding clusters. Likewise, patch isolation may prevent declining Bachman's sparrows (*Aimophila aestivalis*) from detecting of suitable habitat, resulting in consequent physiological or reproductive costs, in South Carolina's managed pine woodlands [21].

Avian abundance may be connected to areal extent, abundance, or age of vegetation types. In addition, habitat selection involves hierarchical choices at different scales [22, 23], and the selection process may alter with geographic variation [24]. Identification of avian habitat relationships at different scales and regions is needed, both for management guidelines and for research, particularly in areas such as Mississippi, a young forested landscape in the southeastern United States where there has been little research at larger extents.

Our aim was to develop models at multiple scales to predict abundance of avian species of concern in Coastal Plain Mississippi. We explored 1) relationships between bird abundance and landscape (i.e., land type and edge and area associations) variables and 2) how scale affects these relationships. We extracted landscape information at 0.24, 1, 3, and 5-km extents from a land cover layer developed by MS-GAP and then used FRAGSTATS to calculate landscape metrics. We then developed logistic regression models for bird abundance from Breeding Bird Surveys using landscape variables at different scales.

METHODS

Study Area

Most of Mississippi is part of the Coastal Plain, the largest physiographic region in the Southeastern United States. The Coastal Plain is characterized as humid subtropical, with mild winters, hot summers, long growing seasons of 180 to 320 days [25], and high annual precipitation of 114 to 162 cm [26]. Natural disturbances include fire, wind, hurricanes and tornados, flooding, and ice storms.

Forestlands cover 7.5 million ha, or 62% of Mississippi [27], and the state's forest base continues to grow [28]. About 2.5 million ha are softwoods, half established in pine plantations, and most planted with loblolly pine (*Pinus taeda*). Approximately 2.8 million ha, or 37% of Mississippi's forested area, is in the seedling-sapling stage (less than 12.7 cm diameter; [28]). Pine tracts in later seral stages are limited, and land use conversion and pine plantation management likely will continue this situation; 94% of southern planted pine is less than 33 years old, whereas 53% of natural pine is less than 33 years old [28].

Overview of Analysis Steps

For our analysis, we correlated bird species abundance from Breeding Bird Surveys (BBS; [29]) with landscape metrics, such as amount of edge and area, for six different vegetation classes at 0.24, 1, 3, and 5-km extents. We extracted vegetation classes at four scales from a land cover layer produced by Mississippi Gap Analysis Project (MS-GAP; [30]). We used a common modeling approach, logistic regression, to model low and high abundance for each of 22 bird species of concern using the land class metrics as predictor variables. We selected final models based on 1) Akaike's Information Criteria, a measure of goodness of fit and 2) predictive performance by models of bird abundance for reserved data that was not used in development of models.

Data Sets

The BBS routes are approximately 40-km long and consist of 50 points that are 0.8 km apart. Volunteers record birds within a 400-m radius of points during three minutes. From the BBS database, we selected all routes, totaling 17, in or bordering the Mississippi Coastal Plain with 3-5 survey years from 1989 to 1995 [31]. Most routes had 5 years of data from 1991-1995. Only surveys conducted during acceptable conditions were included [29]. We divided each of 17 routes into 5, 10-stop partial route segments about 8 km in length. From each route, we selected the straightest (i.e. non-overlapping) 2 partial routes that were separated by at least 2 segments, approximately 16 km apart. We did this to increase our sample sizes and provide distance in time and space among samples.

The MS-GAP classified Landsat Thematic Mapper satellite imagery from 1991-1993 using 30 m resolution. There are 38 thematic classes with 76.6% classification accuracy for vegetation classes, based on a 1996 accuracy assessment. We reclassified the MS-GAP into 6 vegetation classes for use in analysis: 1) hardwoods (high density, medium density, and bottomland hardwoods), 2) mixed forest, 3) low density pine (low density pine with open canopy and pine savannah), 4) medium density pine (12 to 20 year old pole-sized pine, typically thinned with increasingly more understory vegetation), 5) high density pine (5 to 12 year old pine, little ground layer vegetation), and 6) herbaceous (low herbaceous vegetation, grassy/pasture/range, and recently clearcut forests). We clipped the reclassified grid with buffered extents of 0.24, 1, 3, and 5-km around each partial BBS route, creating grids of each partial route at 4 buffer distances. At the 3 and 5-km extents, we excluded one partial route that extended beyond Mississippi's borders. We chose these buffer distances because a buffered extent of 0.24 km is similar in area to stand-scale studies, whereas a 5 km buffer was the maximum extent before losing information off the Mississippi border.

We used FRAGSTATS [32] to calculate 10 spatial metrics for each class type (Appendix **A**), producing means for each buffered partial route extent. Primary metrics for each class included mean patch area (AREA; depends on patch size and number), mean core area (CORE; mean core area of patch, excluding 90 m buffer from edge), core percentage landscape (CPLAND; proportional abundance of class type core area, excluding 90 m buffer from edge), and mean area edge density (ED; edge length of patch standardized by area). Supporting factors consisted of patch density (PD; patch number of class type, standardized by area), percentage of landscape (PLAND; proportional abundance of class type, standardized by area), cohesion (COHESION; connectivity of class type), interspersion and juxtaposition index (IJI; class type intermixing), shape index (SHAPE; average patch shape, compared to maximally compact square standard equal to one), and contiguity (CONTIG; patch boundary configuration).

We chose 22 bird species to model, all scoring 19 or greater for the East Gulf Coastal Plain by Partners in Flight ([33]; Appendix **B**). Partners in Flight formulated a system to assess conservation status of North American bird species, which allows for identification of priority species for conservation [34]. Species were eliminated if they were poorly sampled by point count methods (e.g., waterfowl, seabirds, shorebirds, raptors, nocturnal birds), or if they were extremely rare. We also included brown-headed cowbird, a nest parasite, and blue jay (*Cyanocitta cristata*), a nest predator, because of their possible impact on declining species, for a total of 24 species.

We averaged BBS counts for each species by partial routes and years to calculate a species mean (Appendix **B**). We then categorized routes as either low abundance for less than the mean and high abundance for greater than or equal to the mean for each species. However, 0.5 was the minimum value that we allowed for the high abundance category, in cases where the mean was below 0.5.

Statistical Analyses

Our predictor variables were land cover class variables at each extent and our response variable was lesser and greater bird abundance of every species. We used 24 partial routes extents for modeling, while holding 10 routes in reserve for validation. First, we ran *t*-tests (PROC TTEST; SAS software, v. 9.1, Cary, NC, USA) between land cover class variables of lesser and greater bird abundance to reduce the number of spatial metrics. We retained variables with *P*-values up to 0.1. We removed variables with ≥ 70% correlation, keeping in the following order: CORE**,** CPLAND, AREA, ED, COHESION, PLAND, IJI, PD, CONTIG, and SHAPE. Then we identified the 5 best, one to 5 variable models, for each species based on logistic regression with score selection (PROC LOGISTIC). We assessed these candidate models with Akaike's Information Criteria corrected for small sample size (AIC_c). We ranked the models from least to greatest AIC_c values, and kept as competing models all models that had an AIC_c value within 2.0 of the least value model. We also removed models if standard error for parameter estimates was ≥ values for parameter estimates.

To evaluate model accuracy and select the most accurate models of the competing models, we used the competing models to predict lesser or greater abundance in 10 model validation routes not used in model formulation (PROC LOGISTIC). We classified model fit as correct for a route if predicted probability was greater than or equal to 50% and bird abundance mean fell within the higher abundance category, or alternatively if probability was less than 50% and bird abundance mean was within the lesser abundance category. Final best model selection included models with the best prediction rate, with at least 7 out of 10 routes correct. For each extent, we removed larger models if a nested smaller model predicted equally well, and removed smaller model subsets of larger models that had better prediction rates.

RESULTS

Seven species had models that primarily indicated habitat area or core associations (Table **1**). Greater abundance of northern bobwhite was associated with herbaceous vegetation core areas at 3 and 5 km extents. Red-headed woodpecker greater abundance was related to medium density pine area at the 0.24 km extent. Models for northern parula incorporated hardwood core areas at 1 and 3 km. Swainson's warbler was associated with hardwood core metrics at 3 km. Prairie warbler greater abundance involved medium density pine core area. The model for hooded warbler encompassed medium density pine core area. Brown-headed cowbirds were tied to herbaceous vegetation area.

A mixture of area and edge variables developed for two species. White-eyed vireo abundance related to high density pine edge density at 1 and 3 km, as well as medium density pine area and hardwood core area. The best models for gray catbird included low density pine and medium density pine for all scales and variables of core area, percent of landscape, and edge density.

The four species that had positive edge density models, unmixed with positive area or core variables, were associated with hardwood or medium density pine. Models for red-bellied woodpecker incorporated hardwood edge density. For Acadian flycatcher, hardwood edge density was a positive model variable. Wood thrush greater abundance was linked to hardwood edge density. Medium density pine edge density and hardwood patch density were model variables for yellow-breasted chats.

Two species did not have models with area or edge metrics directly. The model for Carolina chickadee (*Poecile carolinensis*) was hardwood patch density. Kentucky warbler (*Oporornis formosus*) greater abundance was tied to medium density pine patch density. Models for yellow-throated vireo (*Vireo flavifrons*), prothonotary warbler (*Protonotaria citrea)*, and summer tanager (*Piranga rubra*) only contained negative variables. Great crested flycatcher (*Myiarchus crinitus)*, eastern wood-pewee (*Contopus virens)*, and blue jay did not have models that met the minimum 70% validation rate, whereas models for brown-headed nuthatch (*Sitta pusilla*), orchard oriole (*Icterus spurius*), and field sparrow

Table 1. Models, with AICc Value and Prediction Rate for Validation Routes, for Avian Species in Coastal Plain Mississippi During 1991-1995.

Species	Buffer (km)	Best Model(s)[ab]	β (SE)	Prediction Rate
Northern Bobwhite	3	(+) T6CORE	10.8 (5.6)	7/10
	5	(+) T6CORE	8.2 (4.8)	7/10
Red-headed Woodpecker	0.24	(-) T1AREA (+) T4AREA	2.9 (1.6), 7.9 (3.3)	9/10
Northern Parula	1	(+) T1CPLAND	1.0 (0.6)	9/10
	3	(+) T1CPLAND	0.4 (0.2)	9/10
Swainson's Warbler	3	(+) T1CPLAND	0.5 (0.4)	10/10
Prairie Warbler	5	(+) T4CORE_MN	133 (77)	9/10
Hooded Warbler	5	(+) T3AREA (-) T6ED	6.5 (4.3), 0.08 (0.04)	9/10
Brown-headed Cowbird	1	(+) T6AREA	0.7 (0.3)	7/10
White-eyed Vireo	1	(+) T1CPLAND (-) T2IJI (+) T5ED	0.8 (0.5), 0.04 (0.02) 0.09 (0.04)	8/10
	3	(-) T2SHAPE (+) T5ED (-) T6ED	2.7 (1.2), 0.04 (0.03) 0.05 (0.03)	8/10
	5	(+) T1COHESION (+) T4AREA	0.2 (0.1), 3.1 (1.6)	8/10
Gray Catbird	all	(+) T3, T4 many variables	N/A	9/10
Red-bellied Woodpecker	1	(+) T1ED (-) T5IJI	0.04 (0.02), 0.1 (0.06)	8/10
Acadian Flycatcher	0.24	(+) T1ED (-) T5AREA	0.03 (0.02), 7.1 (5.4)	10/10
Wood Thrush	0.24	(+) T1ED (+) T4IJI	0.12 (0.06), 0.6 (0.3)	8/10
Yellow-breasted Chat	1	(+) T4ED	0.04 (0.02)	7/10
	3	(+) T1PD	0.2 (0.1)	7/10
	5	(+) T1PD	0.2 (0.1)	7/10
Carolina Chickadee	1	(+) T1PD	0.19 (0.09)	9/10
Kentucky Warbler	5	(+) T4PD	0.24 (0.12)	10/10

[a]T1 = Hardwoods, T2 = Mixed Forest, T3 = Low Density Pine, T4 = Medium Density Pine, T5 = High Density Pine, T6 = Herbaceous

[b]AREA = mean patch area, COHESION = connectivity, CONTIG = patch boundary configuration, CORE = mean core area, CPLAND = proportional abundance of class type core area, ED = edge length density, IJI = class type intermixing, PD = patch density, PLAND = proportional abundance of class type, SHAPE = average patch shape

(*Spizella pusilla*) did not have reasonable parameter estimates.

DISCUSSION

The most common land classes, which were herbaceous, hardwood, and medium density pine at 65% of the landscape, also had high edge density (Appendix **A**). Only the hardwood and herbaceous vegetation types contained unfragmented areas, whereas the hardwoods alone retained at least some minor core area. Therefore, these spatial metrics were either common (i.e. edge) or rare (i.e. core), and associations could have reflected relative availability. Despite this, area was important for northern bobwhite, red-headed woodpecker, northern parula, Swainson's warbler, prairie warbler, and hooded warbler, corroborating previous research [35-37]. There is evidence that white-eyed vireo is area-sensitive [36] although our models also indicated that scale and vegetation type influenced spatial metric relationships, and that edge may play a role in habitat for these species that often use shrub borders. Likewise, red-bellied woodpecker, Acadian flycatcher, and wood thrush may be area-sensitive [36,38], nonetheless our study suggested that edge also may be part of their habitat at some scales. Conversely, brown-headed cowbirds were linked with herbaceous vegetation area, which is their feeding zone, although edges and core areas may provide breeding opportunities [39].

Model variables incorporated both vegetation type and spatial metrics, which prevents direct interpretation of either variable. However, the relative weight of vegetation type may increase when area and edge density of the identical vegetation type are present, particularly in the same model or at least at the same scale. For example, gray catbird models contained low density and medium density pine variables at different scales, strengthening the overall importance of the pine vegetation type.

The models correctly identified most bird-vegetation types associations, nevertheless there were some vegetation types missing from models. For instance, rather than herbaceous vegetation type for species that use shrub, such as prairie warbler, white-eyed vireo, yellow-breasted chat, hooded warbler, or gray catbird, or open lightly-treed areas for red-headed woodpecker, high and medium pine densities were model vegetation types. If these types represent regenerating stands before canopy closure or non-treed borders then they are an appropriate match, but it is not clear that either high or medium pine density represents that structure, according to Gap documentation. In any event, although the models predicted well without the more likely vegetation type, the absence of the characteristic vegetation type may indicate errors in classification, spurious results from modeling, or bias in the BBS.

The models do have limitations, beginning with the data sets on which they are based. The primary drawback with BBS is that they occur alongside roads, which may limit inferences. However, there are roads throughout Mississippi, where there may be only 1200 ha of roadless areas [40]. Road effects also may be contained within 50-100 m [41], whereas the point count stations extend to 450 m. In addition, even though each variable went through a 4 step process to stay in the model, remaining variables may match bird abundance without actually influencing bird abundance. We did not examine reproductive success, and thus density may be uncoupled from habitat quality in some cases. Nevertheless, density can be correlated with reproductive success [42].

Scale selection influenced the importance of variables. In this study, all extents were well-represented, except the more local 0.24 km extent associated with woodpeckers and a flycatcher, perhaps reinforcing that stand elements and microhabitat gain importance at the smaller site scale [43]. In addition, the nature of modeling is that variables that best match the scale of the study extent will become more influential. In contrast to our models, using buffers of 50, 100, 500, 1,000, 2,500, and 5,000 m, Mayer and Cameron [44] found that the narrowest and broadest scales explain greater variance than intermediate scales.

Model variables for some species persisted throughout the extents, supporting their importance, but in most cases the inclusion of all four extents contributed to a more complete habitat picture than would one extent alone. Desrochers *et al*. [45] also found varying area sensitivity by scale, with increasing area-sensitivity at regional scales of 12-24 km, which was beyond the extents of this study. Area sensitivity is emergent at the landscape scale and therefore, should become more apparent at larger scales.

The landscape metric variables used in this study may explain avian habitat selection equally well as stand elements, given a large enough study extent. Howell *et al*. [46] detected strong landscape variable associations with bird species in both fragmented (340-880 ha) and continuous Missouri forests. Landscape metrics best predicted abundance of 70% of bird species compared to 30% for local variables. Mitchell *et al*. [47, 48] determined that landscape models generally are as effective as stand-scale models, especially for migrants and specialists, in southeastern managed forests. Late-successional and area-sensitive species as well as class type specialists potentially are more affected by landscape than other avian species, for which stand-scale variables may determine species composition [49, 50]. Indeed, the species without models, great crested flycatcher, eastern wood-pewee, and blue jay, are all generalists [51-53].

CONCLUSION

In the Coastal Plain of the southeastern United States, there are declining bird species as well as habitat conversion due to land use [54]. Areal extent of land classes was an influential variable in bird abundance models but core and areal extents for all vegetation types were low or nonexistent, indicating that heavily-forested Mississippi may be surprisingly fragmented. Fragmentation can increase interspecific interactions, including competition with edge and generalist species, predation of adults and young, and avian nest parasitism by brown-headed cowbirds, although surrounding lands may buffer these effects. Land planners should focus on increasing the patch size of vegetation types while minimizing high contrast borders.

Vegetation types now common, such as medium density pine, were positively associated with numerous species of conservation concern. However, low density pine savannas, which historically covered the Coastal Plain, provide primary habitat for vulnerable species, including some of the modeled species and species too rare to model in this study but of extreme management concern, such as red-cockaded woodpecker (*Picoides borealis*) and Bachman's sparrow (*Aimophila aestivalis*). Regional land management goals should include increasing abundance of rare vegetation types, such as low density pine, to ensure long-term stability of plant and animal communities.

CONFLICT OF INTEREST

The authors confirm that this article content has no conflicts of interest.

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APPENDIX

APPENDIX A. Summary Statistics for Primary Metrics[a] of Each Class Type[b] for All Selected Partial Breeding Bird Survey Routes in Coastal Plain Mississippi During 1991-1993

		T1		T2		T3		T4		T5		T6	
Metric	**Buffer (km)**	**Mean**	**SE**	**Mean**	**SE**	**Mean**	**SE**	**Mean**	**SE**	**Mean**	**SE**	**Mean**	**SE**
PLAND (%)	0.24	15.9	2.3	3.3	0.6	3.2	0.7	11.1	1.6	5.5	1.1	35.1	2.3
PLAND (%)	1	19.2	2.5	3.9	0.7	3.5	0.8	12.5	1.7	6.9	1.2	31.9	2.3
PLAND (%)	3	20.8	2.4	3.5	0.7	3.4	0.7	13.2	1.7	7.3	1.3	29.9	2.2
PLAND (%)	5	21.4	2.4	3.5	0.6	3.5	0.7	13.4	1.6	7.2	1.2	29.4	2.1
AREA (ha)	0.24	1.1	0.2	0.2	0.0	0.3	0.0	0.5	0.1	0.5	0.1	3.1	0.4
AREA (ha)	1	2.2	0.5	0.3	0.0	0.3	0.0	0.8	0.1	0.8	0.1	3.7	0.4
AREA (ha)	3	3.2	0.7	0.3	0.0	0.3	0.0	0.9	0.1	0.9	0.1	3.7	0.4
AREA (ha)	5	3.7	0.9	0.3	0.0	0.4	0.0	1.0	0.1	0.9	0.1	3.7	0.4
CORE (ha)	0.24	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
CORE (ha)	1	0.2	0.1	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.2	0.0
CORE (ha)	3	0.6	0.2	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.2	0.0
CORE (ha)	5	0.9	0.3	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.2	0.0
CPLAND (%)	0.24	0.1	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.4	0.1
CPLAND (%)	1	1.1	0.3	0.0	0.0	0.0	0.0	0.0	0.0	0.1	0.1	1.3	0.3
CPLAND (%)	3	2.3	0.5	0.0	0.0	0.0	0.0	0.1	0.0	0.2	0.1	1.7	0.3
CPLAND (%)	5	2.8	0.7	0.0	0.0	0.0	0.0	0.1	0.0	0.1	0.0	1.7	0.3
ED (m/ha)	0.24	69.8	6.9	41.4	6.0	32.5	5.7	69.8	8.1	34.0	5.1	131.4	6.0
ED (m/ha)	1	73.8	6.7	47.0	6.4	33.5	5.9	75.2	7.9	38.0	5.3	115.0	5.7
ED (m/ha)	3	72.4	6.2	43.1	6.0	31.9	5.5	75.3	8.0	39.3	5.3	104.5	5.6
ED (m/ha)	5	73.1	5.9	43.1	5.8	32.4	5.1	76.4	7.9	39.8	5.0	103.1	5.6

[a]AREA = mean patch area, CORE = mean core area, CPLAND = proportional abundance of class type core area, ED = edge length density, PLAND = proportional abundance of class type
[b]T1 = Hardwoods, T2 = Mixed Forest, T3 = Low Density Pine, T4 = Medium Density Pine,
T5 = High Density Pine, T6 = Herbaceous

APPENDIX B. Common and Scientific Name, 2005 East Gulf Coastal Plain Partners in Flight Conservation Score, Significant Population Trend During 1966-2005 for the Coastal Plain[a], and Partial Breeding Bird Survey Route mean Abundance

Common Name	Scientific Name	Conservation Score	Trend	Mean
Northern Bobwhite	*Colinus virginianus*	21	-	4.20
Red-headed Woodpecker	*Melanerpes erythrocephalus*	21	0	0.35
Red-bellied Woodpecker	*Melanerpes carolinus*	19	0	2.80

Appendix B. contd….

Common Name	Scientific Name	Conservation Score	Trend	Mean
Eastern Wood-pewee	*Contopus virens*	19	-	0.80
Acadian Flycatcher	*Empidonax virescens*	19	+	0.38
Great Crested Flycatcher	*Myiarchus crinitus*	20	+	1.00
White-eyed Vireo	*Vireo griseus*	21	0	3.10
Yellow-throated Vireo	*Vireo flavifrons*	20	0	0.15
Blue Jay	*Cyanocitta cristata*	17	-	5.10
Carolina Chickadee	*Poecile carolinensis*	20	-	1.40
Brown-headed Nuthatch	*Sitta pusilla*	26	-	0.15
Wood Thrush	*Hylocichla mustelina*	22	-	2.20
Gray Catbird	*Dumetella carolinensis*	19	-	0.28
Northern Parula	*Parula americana*	19	0	0.50
Prairie Warbler	*Setophaga discolor*	24	-	0.22
Prothonotary Warbler	*Protonotaria citrea*	26	-	0.33
Swainson's Warbler	*Limnothlypis swainsonii*	28	+	0.05
Kentucky Warbler	*Oporornis formosus*	23	0	0.45
Hooded Warbler	*Wilsonia citrina*	20	0	1.00
Yellow-breasted Chat	*Icteria virens*	19	+	6.00
Summer Tanager	*Piranga rubra*	19	0	1.40
Field Sparrow	*Spizella pusilla*	22	-	0.20
Brown-headed Cowbird	*Molothrus ater*	11	-	1.60
Orchard Oriole	*Icterus spurius*	22	0	1.20

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