Studies in Avian Biology No. 21:81–86, 2000.

EFFECTS OF LONG-TERM FOREST MANAGEMENT ON A REGIONAL AVIFAUNA

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Abstract. We compared breeding bird populations on and off of the Savannah River Site (SRS), South Carolina, to determine whether management practices on SRS have affected abundance and composition of the resident avifauna. We assessed relative abundance by comparing Breeding Bird Survey (BBS) data from six routes off SRS with three surrogate routes generated using point-count data from four research projects on SRS. Total number of species per route did not differ on- and off-site. Total number of birds per *route* was greater off SRS than on. Twenty-three species were more abundant on than off SRS, and 33 species were more abundant off than on SRS. Species more abundant off SRS primarily were those that prefer agricultural or urban habitats, whereas those more abundant on SRS primarily prefer mature forest habitat. We conclude that management practices on SRS have resulted in a landscape that supports many species not otherwise common in the region.

Key Words: Breeding Bird Survey, forest management, landscape effects, point counts, Savannah River Site, South Carolina.

The Savannah River Site (SRS) is a 78,891-ha tract in Aiken, Barnwell, and Allendale counties in the upper coastal plain of South Carolina. Prior to acquisition by the U.S. Department of Energy in the early 1950s, the land was largely in agricultural production. Subsequent to acquisition, open areas were reforested by plantings and natural succession (White and Gaines this *volume*). Forest resources currently are managed by the U.S. Forest Service (USFS) for timber production and wildlife habitat needs (see White and Gaines this *volume* for more detailed discussion of SRS management). Approximately 89% of SRS is in closed canopy forest, primarily managed pine (loblolly, longleaf, and slash; see Table 1 for scientific names) and bottomland hardwood (Table 1). In contrast, only 62% of the southern portion of South Carolina's coastal plain is forested, whereas 23% is in agriculture and 9% is urban (Tansey and Hutchins 1988). Thus, the degree of forest cover, and therefore overall landscape structure, differs considerably between SRS and the surrounding lands. We compared breeding bird populations on and off of SRS to determine whether management practices on SRS have affected abundance and composition of the resident avifauna. If those practices have not affected bird populations, off-site monitoring programs should be sufficient to track populations on-site. However, if SRS management practices have affected bird populations, on-site monitoring also may be necessary.

METHODS

The North American Breeding Bird Survey (BBS) is the most comprehensive bird census database available for nearby off-site areas. The BBS, a program of the Biological Resources Division of the U.S. Geological Survey, uses volunteer labor to survey permanently established routes once per year during the breeding season in early June (Robbins et al. 1986). An observer drives a 39.4-km route (24.5 mi), stopping every 0.8 km (0.5 mi) for a total of 50 stops. At each stop, all birds detected within 0.4 km (0.25 mi) of the observer during a 3-min count are recorded. Surveys begin at 0.5 h before official sunrise and are conducted only during acceptable weather (good visibility, little or no precipitation, and no more than light winds). We used data from the six BBS routes that at least partially fell within 80 km of the SRS boundary and were in the same physiographic province; three were in Georgia and three were in South Carolina.

No BBS routes existed on SRS. Therefore, we used point-count census data from four recent studies conducted on SRS (Kilgo 1996, Buffington et al. 1997; K. E. Franzreb, unpubl. data; S. A. Gauthreaux, Jr., unpubl. data) to generate three surrogate "BBS" routes. Although objectives and habitat types sampled in each study differed, all used standard point-count methodology (Ralph et al. 1995). Sampling occurred between 5 May and 25 June. Counts were conducted from sunrise to 3.5 h post-sunrise. For this reason, night birds were less likely to be detected on point counts than on BBS routes, which began at 30 min before sunrise. Therefore, we eliminated the goatsuckers (Common Nighthawk, ***Chordeiles minor,*** Chuck-will's-widow, ***Caprimulgus carolinensis,*** and Whip-poor-will, *C. vociferus*) and the Barred Owl ***(Strix varia)*** from analysis (no Eastern Screech-Owls, ***Otus asio,*** were recorded). All birds detected from a point were recorded in distance intervals of <50 and >50 m. Birds flying over the point were recorded separately by Franzreb (unpubl. data) and Gautbreaux (unpubl. data) but were not recorded by Kilgo (1996) or Buffington et al. (1997). Consequently, birds such as crows and vultures, most commonly recorded when flying over a point, may be slightly underrepresented in the SRS data. Buffington et al. (1997) and Kilgo (1996) conducted 5-min point counts, subdivided into intervals of 1-3 min and 4-5 min, whereas Franzreb (unpubl. data) and Gautbreaux (unpubl. data) conducted 10-min counts, subdivided

TABLE 1. HABITAT TYPES ON THE SAVANNAH RIVER SITE AND THE U.S. FOREST SERVICE CODES FROM WHICH THEY WERE DERIVED

Habitat type	USFS forest type code	Code description
Longleaf pine	21	Longleaf pine (*Pinus palustrus*)
Loblolly-slash pine	22	Slash pine (*P. elliottii*)
	31	Loblolly pine (*P. taeda*)
	32	Shortleaf pine (*P. echinutu)*
	34	Sand pine (*P. clausa*)
	35	Eastern red cedar (*Juniperus virginianus*)
Pine-hardwood	12	Shortleaf pine-oak (Quercus spp.)
	13	Loblolly pine-hardwood
	14	Slash pine-hardwood
	26	Longleaf pine-hardwood
	44	Southern red oak (*Q falcata*)-yellow pine (*P.* spp.)
	46	Bottomland hardwood-yellow pine
	47	White oak (Q. *alba*)-black oak (Q *velutina*)-yellow pine
Upland hardwood	53	White oak-red oak (Quercus spp.)-hickory (*Carya* spp.)
	56	Yellow poplar (*Liriodendron tulipifera*)-white oak-red oak
	57	Scrub oak (*Quercus* spp.)
	82	Black walnut (*Juglans nigru)*
Bottomland hardwood	58	Sweet gum (*Liquidambur styraciflua*)-yellow poplar
	61	Swamp chestnut oak (Q. *michauxii*)-cherrybark oak (*Q.f.* var. pagodaefolia)
	62	Sweet gum-Nuttall oak (Q. *nuttallii*)-willow (*Salix* spp.)
	63	Sugarberry (*Celtis laevigata*)-American elm (*Ulmus americana*)-green ash (*Fraxinus pennsylvunicu)*
	64	Laurel oak (Q. *laurifolia*)-willow oak (*Q. phellos*)
	67	Bald cypress (*Taxodium distichum*)-water tupelo (*Nyssa aquatica)*
	68	Sweet bay (*Magnolia virginiana*)-swamp tupelo (*N.s.* var. *biflora*)-red maple (*Acer rubrum)*
	72	River birch (*Betula nigra*)-sycamore (*Platanus occidentalis*)

into intervals of l-3, 4-5, and 6-10 min. We included all birds detected from each point, regardless of distance, during the first 3-min period. No point counts were conducted along roadsides.

Although some studies sampled multiple points per stand, we randomly selected only one point from each stand. Buffington et al. (1997) sampled one stand in each of three successional stages of bottomland hardwood forests during 1994. Kilgo (1996) sampled 20 upland hardwood sawtimber stands, 20 pine sawtimber stands, and 20 bottomland hardwood sawtimber stands, all during 1994. Franzreb (unpubl. data) sampled all stands within Red-cockaded Woodpecker (see Table 3 for scientific names) buffer zones (N = 86 points) during 1995. Gauthreaux [unpubl. data) sampled 75 points during 1994-95 that were established by the USFS Forest Inventory and Analysis program using an approximately 1,000 X 2,000-m grid overlaid on the site. Thus, 224 stands of all major forest types and ages occurring on SRS were sampled.

We classified habitats on SRS using the USFS Continuous Inventory of Stand Condition (CISC) database, which contains information on the entire land base of SRS, by stand. This information includes forest type, according to USFS codes, and age of each forest stand. We condensed the USFS forest types into five habitat types: (1) longleaf pine forest; (2) loblolly and/or slash pine forest; which also included insignificant acreages of shortleaf pine and Eastern redcedar; (3) mixed pine-hardwood forest; (4) upland hardwood forest; and (5) bottomland hardwood forest (Table 1). Six percent of the area of SRS was classified as nonforested. Nonforested areas, which included industrial facilities, rights-of-way, and bodies of water, were excluded from consideration in determining proportional area of habitats on site because no census data were available for those habitats. For this reason, we eliminated wetland birds (waterfowl, wading birds, and kingfishers) from the analysis. We used stand age to subdivide the six types into four successional stages similar to the procedure developed by USFS Region 8 biologists for use in the BIRDHAB GIS program, which is based on Hamel (1992). These types were regeneration (O-2 yr), seedling/sapling (3-9 yr), pole timber (10–30 yr), and sawtimber (>30 yr). We included with the regeneration stage the small amount of acreage classified as grass (USFS forest type 96) and brush (USFS forest type 99). Thus, 20 habitats were delineated: four successional stages of five habitat types.

We selected 50 point counts from SRS databases for each surrogate BBS route. To produce routes representative of habitat conditions occurring on SRS, we used the proportional area of each habitat type on site as the expected proportion of the routes (i.e., 50 points) that each habitat type should occupy. We used a random number generator to determine number of points expected in each habitat type for each route if 50 points were randomly located on SRS based on the expected proportions (Table 2). This approach simulated the expected composition of a randomly placed 39.4-km section of road (or BBS route) on SRS. We randomly selected from the datasets the number of point counts needed for each habitat type. When an insufficient number of point counts were available for a habitat type, we substituted point counts from the most similar habitat type with excess points. For example, three point counts from longleaf pine regeneration stands were substituted for three point counts from loblolly pine regeneration stands, because the bird communities of these types did not differ (J. B. Dunning, unpubl. data).

We compared the total number of individuals of each species counted per route (i.e., summed over the

TABLE 2. NUMBER OF POINT COUNTS WITHIN EACH HABITAT TYPE ON THE SAVANNAH RIVER SITE USED TO GENERATE THREE "BREEDING BIRD SURVEY" ROUTES

Forest type	Successional stage	Area (ha)	Percent	Number of points		
				Rt 1	Rt 2	Rt 3
Longleaf pine	Regeneration	858	1.1	2	0	1
	Seedling/Sapling	4,364	5.8	2	2	1
	Poletimber	2,070	2.7	3	0	1
	Sawtimber	9,235	12.4	8	4	6
Loblolly/slash pine	Regeneration	2,788	3.7	2	3	2.
	Seedling/Sapling	7,962	10.6	3	7	8
	Poletimber	5,781	7.7	2	2	3
	Sawtimber	20,315	27.2	15	12	18
Pine-hardwood	Regeneration	0	0.0	0	0	0
	Seedling/Sapling	189	0.2	0	1	0
	Poletimber	289	0.4	0	0	0
	Sawtimber	2,105	2.8	3	2	0
Upland hardwood	Regeneration	0	0.0	0	0	0
	Seedling/Sapling	55	0.1	0	0	0
	Poletimber	724	1.0	0	0	2
	Sawtimber	1,740	2.3	0	1	2
Bottomland hardwood	Regeneration	126	0.2	0	0	0
	Seedling/Sapling	1,675	2.2	1	2	0
	Poletimber	2,615	3.4	0	2	0
	Sawtimber	11,877	15.9	9	12	6
Total		74,768	100.7	50	50	50

50 stops or points) between the SRS routes and the BBS routes using two-sample t-tests. We tested the assumption of equal variances using the F-test for equality of variance. When this test indicated that variances were not equal ($P < 0.05$), we used unequal variance t-tests. We felt justified in comparing BBS data (i.e., roadside counts) with point count data (i.e., off-road counts) because the detection of forest species is similar between roadside and off-road counts (Keller and Fuller 1995). Small roadside openings apparently are not avoided by area-sensitive birds (Keller and Fuller 1995).

A potential bias inherent in our approach may exist because habitat conditions along the BBS routes might not have represented those in the region. For example, if more forested habitat existed in the region than occurred within the detection distance from roads, forest interior species would be under-represented and edge species would be over-represented on the BBS routes. However, if the habitat conditions along the BBS routes did not differ from overall habitat conditions in the off-site areas (i.e., on- and off-road), an accurate assessment of birds occurring off-site was achieved by the BBS methodology.

To address that potential bias, we used satellite imagery and a Geographic Information System to compare the landscape composition of areas surrounding the BBS routes. Habitat-classified data (LANDSAT Multi Spectral Scanner, 80 X 80 m pixels) were available for portions ($\bar{x}$ = 82.4% coverage) of the three routes in east-central Georgia. Five cover types were defined from the data: open water, pine forest, hardwood forest, scrub forest (including turkey oak, successional [5–15 yr old], and residential open forests), and open habitats (including bare soil, row crop agriculture, and herbaceous fallow fields and pastures). We superimposed buffer strips of two widths (140 m [Bart et al. 1995] and 1 km) along the portions of the routes covered by the satellite image and tallied the total number of cells of each type that fell within or were intersected by the strips. We calculated percent composition by type for each route and averaged over the three routes.

RESULTS

Eighty species that were detected among the six BBS routes in Georgia and South Carolina and the three constructed routes on SRS were included in analysis. Total number of species per route did not differ ($t = 0.84$, $P = 0.21$) on ($\bar{x} = 53.0$, SE = 1.9) and off SRS ($\bar{x} = 55.5$, SE = 1.7). Eight species were detected on SRS that were not detected off SRS, whereas 20 species were detected off SRS that were not detected on SRS (Table 3).

Total number of birds per route was greater ($t = 3.77$, $P = 0.004$) off SRS ($\bar{x} = 661.2$, SE = 50.6) than on SRS ($\bar{x} = 372.0$, SE = 31.2). Including species that were detected only on SRS, 17 species were more abundant on SRS than off ($P < 0.05$; Table 3). Including those detected only off SRS, 32 species were more abundant off SRS than on ($P < 0.05$; Table 3). Thirty-one species did not differ in abundance ($P > 0.05$) on and off SRS.

Distribution of habitat types near (within 140 m) the three BBS routes in Georgia generally was similar to that in the larger landscape (within 1 km of BBS routes; Table 4). Forested types

TABLE 3. COMPARISON OF BIRD ABUNDANCE (MEAN ± SE) ON THE SAVANNAH RIVER SITE (SRS) AS INDEXED USING THREE "BREEDING BIRD SURVEY" (BBS) ROUTES GENERATED FROM POINT COUNT DATA, WITH BIRD ABUNDANCE OFF THE SRS, AS INDEXED USING SIX ACTUAL BBS ROUTES

Species	Abundance[a]		
	On SRS	Off SRS	t-test (P)
Species detected only on SRS			
Wild Turkey ***(Meleagris gallopavo)***	2.0 ± 0.6	*0.0 ± 0.0*	0.074[b]
Ruby-throated Hummingbird ***(Archilochus colubris)***	0.7 ± 0.3	*0.0 ± 0.0*	0.184[b]
Red-cockaded Woodpecker ***(Picoides borealis)***	2.0 ± 1.0	*0.0 ± 0.0*	0.184[b]
White-breasted Nuthatch ***(Sitta carolinensis)***	0.3 ± 0.3	*0.0 ± 0.0*	0.423[b]
American Redstart ***(Setophaga ruticilla)***	1.3 ± 0.7	*0.0 ± 0.0*	0.184"
Ovenbird ***(Seiurus aurocapillus)***	1.7 ± 0.3	*0.0 ± 0.0*	0.038[b]
Louisiana Waterthrush ***(Seiurus motacilla)***	1.7 ± 0.3	*0.0 ± 0.0*	0.038[b]
Hooded Warbler ***(Wilsonia citrina)***	7.0 ± 1.5	*0.0 ± 0.0*	0.049
Species more abundant on SRS			
Pileated Woodpecker ***(Dryocopus pileatus)***	6.0 ± 0.6	1.2 ± 0.3	*0.000*
Tufted Titmouse ***(Baeolophus bicolor)***	24.7 ± 5.8	9.5 ± 1.6	0.011
Brown-headed Nuthatch ***(Sitta pusilla)***	5.3 ± 1.9	1.2 ± 0.7	0.03 1
Yellow-throated Vireo ***(Vireo flavifrons)***	1.3 ± 0.3	0.2 ± 0.2	0.009
Red-eyed Vireo ***(Vireo olivaceus)***	7.7 ± 1.7	2.0 ± 0.7	0.008
Northern Parula ***(Parula americana)***	8.7 ± 1.2	2.0 ± 0.8	0.002
Pine Warbler ***(Dendroica pinus)***	27.3 ± 5.9	8.0 ± 2.3	0.007
Prairie Warbler ***(Dendroica discolor)***	4.7 ± 0.3	0.5 ± 0.2	0.000
Kentucky Warbler ***(Oporomis formosus)***	1.7 ± 0.3	0.3 ± 0.2	0.010
Species detected only off SRS			
Turkey Vulture ***(Cathartes aura)***	0.0 ± 0.0	4.2 ± 1.6	0.050[b]
Mississippi Kite ***(Ictinia mississippiensis)***	0.0 ± 0.0	0.2 ± 0.2	0.363[b]
Killdeer ***(Charadrius vociferus)***	0.0 ± 0.0	3.0 ± 1.1	0.058[b]
Rock Dove ***(Columba livia)***	0.0 ± 0.0	1.8 ± 1.5	0.278[b]
Chimney Swift ***(Chaetura pelagica)***	0.0 ± 0.0	11.2 ± 3.2	0.017[b]
Eastern Phoebe ***(Sayomis phoebe)***	0.0 ± 0.0	0.7 ± 0.5	0.235[b]
Homed Lark ***(Eremophila alpestris)***	0.0 ± 0.0	0.8 ± 0.8	0.363[b]
Purple Martin ***(Progne subis)***	0.0 ± 0.0	19.3 ± 8.7	0.077[b]
Rough-winged Swallow ***(Stelgidopteryx serripennis)***	0.0 ± 0.0	0.2 ± 0.2	0.363[b]
Barn Swallow ***(Hirundo rustica)***	0.0 ± 0.0	5.7 ± 2.4	0.065[b]
American Robin ***(Turdus migratorius)***	0.0 ± 0.0	2.8 ± 0.9	0.030[b]
Gray Catbird ***(Dumetella carolinensis)***	0.0 ± 0.0	2.5 ± 0.9	0.037[b]
Loggerhead Shrike ***(Lanius ludovicianus)***	0.0 ± 0.0	2.7 ± 0.6	0.007[b]
European Starling ***(Stumus vulgaris)***	0.0 ± 0.0	12.7 ± 6.6	0.115[b]
Yellow-throated Warbler ***(Dendroica dominica)***	0.0 ± 0.0	1.0 ± 0.6	0.175[b]
Eastern Meadowlark ***(Sturnella magna)***	0.0 ± 0.0	7.0 ± 2.6	0.044[b]
Boat-tailed Grackle ***(Quiscalus major)***	0.0 ± 0.0	0.2 ± 0.2	0.363[b]
Common Grackle ***(Quiscalus quiscula)***	0.0 ± 0.0	44.8 ± 15.8	0.036"
House Finch ***(Carpodacus mexicanus)***	0.0 ± 0.0	1.3 ± 0.6	0.082[b]
House Sparrow ***(Passer domesticus)***	0.0 ± 0.0	12.8 ± 7.0	0.126[b]
Species more abundant off SRS			
Northern Bobwhite ***(Colinus virginianus)***	5.7 ± 0.7	24.7 ± 3.6	0.003[b]
Mourning Dove ***(Zenaida macroura)***	15.0 ± 4.0	66.0 ± 7.1	0.002
Eastern Kingbird ***(Tyrannus tyrannus)***	1.3 ± 1.3	14.7 ± 1.4	0.001
Blue Jay ***(Cyanocitta cristata)***	10.3 ± 1.8	30.3 ± 3.7	0.009
Northern Mockingbird ***(Mimus polyglottos)***	1.0 ± 1.0	44.0 ± 9.6	0.007[b]
Brown Thrasher ***(Toxostoma rufum)***	1.0 ± 0.0	9.8 ± 2.9	0.030
Northern Cardinal ***(Cardinalis cardinalis)***	14.0 ± 4.5	47.5 ± 4.7	0.003
Indigo Bunting ***(Passerina cyanea)***	9.3 ± 1.8	18.7 ± 1.8	0.014
Blue Grosbeak ***(Guiraca caerulea)***	3.3 ± 1.2	14.5 ± 2.0	0.008
Red-winged Blackbird ***(Agelaius phoeniceus)***	0.7 ± 0.7	14.2 ± 4.6	0.03 1[b]
Brown-headed Cowbird ***(Molothrus ater)***	1.3 ± 0.3	8.1 ± 1.7	0.009[b]
Orchard oriole ***(Icterus spurius)***	0.3 ± 0.3	11.8 ± 2.7	0.008[b]
Species for which abundance did not differ on and off SRS			
Black Vulture ***(Coragyps atratus)***	0.7 ± 0.7	7.3 ± 3.5	0.117
Red-shouldered Hawk ***(Buteo lineatus)***	1.3 ± 0.7	0.8 ± 0.5	0.598
Red-tailed Hawk ***(Buteo jamaicensis)***	0.3 ± 0.3	0.8 ± 0.3	0.351
Common Ground-Dove ***(Columbina passerina)***	0.3 ± 0.3	2.2 ± 1.4	0.411

TABLE 3. CONTINUED

Species	Abundance[a] On SRS	Off SRS	t-test (P)
Yellow-billed Cuckoo (Coccyzus *americanus)*	3.3 ± 0.3	2.7 ± 0.9	0.640
Red-headed Woodpecker *(Melanerpes erythrocephalus)*	6.7 ± 2.3	1.0 ± 0.5	0.133[b]
Red-bellied Woodpecker *(Melanerpes carolinus)*	15.0 ± 1.5	15.5 ± 2.4	0.894
Downy Woodpecker *(Picoides pubescens)*	2.3 ± 0.7	4.2 ± 0.9	0.247
Northern Flicker *(Colaptes auratus)*	3.0 ± 1.5	0.8 ± 0.5	0.119
Eastern Wood-Pewee *(Contopus virens)*	7.7 ± 1.8	3.8 ± 0.9	0.066
Acadian Flycatcher *(Empidonax virescens)*	6.7 ± 1.5	1.5 ± 0.3	0.067[b]
Great Crested Flycatcher *(Myiarchus crinitus)*	23.0 ± 4.0	6.5 ± 1.0	0.05 1[b]
Fish Crow (Corvus *ossifragus)*	3.0 ± 1.5	15.0 ± 8.7	0.228[b]
Carolina Chickadee *(Poecile carolinensis)*	9.0 ± 1.0	6.8 ± 1.3	0.318
Carolina Wren *(Thryothorus ludovicianus)*	17.7 ± 1.9	18.8 ± 5.5	0.890
Blue-gray Gnatcatcher *(Polioptila caerulea)*	7.3 ± 0.9	3.8 ± 1.1	0.076
Eastern Bluebird *(Sialia sialis)*	3.3 ± 1.2	4.7 ± 1.1	0.486
Wood Thrush *(Hylocichla mustelina)*	4.3 ± 0.9	4.0 ± 1.3	0.873
White-eyed Vireo *(Vireo griseus)*	7.3 ± 3.0	4.7 ± 1.0	0.471
Black-and-white Warbler *(Mniotilta varia)*	1.0 ± 0.6	0.2 ± 0.2	0.106
Protbonotary Warbler *(Protonotaria citrea)*	0.6 ± 0.3	1.8 ± 0.9	0.398
Swainson's Warbler *(Limnothlypis swainsonii)*	0.3 ± 0.3	0.2 ± 0.2	0.626
Common Yellowthroat *(Geothlypis trichas)*	3.7 ± 1.2	2.2 ± 0.5	0.222
Yellow-breasted Chat *(Icteria virens)*	2.0 ± 2.0	4.7 ± 2.0	0.435
Summer Tanager *(Piranga rubra)*	12.0 ± 2.0	7.2 ± 1.4	0.084
Painted Bunting *(Passerina ciris)*	0.3 ± 0.3	1.8 ± 0.8	0.244
Eastern Towhee *(Pipilo erythrophthalmus)*	14.0 ± 4.7	25.3 ± 3.3	0.090
Bachman's Sparrow *(Aimophila aestivalis)*	5.0 ± 1.5	0.3 ± 0.3	0.089[b]
Chipping Sparrow *(Spizella passerina)*	2.3 ± 0.3	1.0 ± 0.7	0.234
Field Sparrow *(Spizella pusilla)*	1.7 ± 0.9	5.8 ± 1.7	0.147
American Goldfinch *(Carduelis tristis)*	0.7 ± 0.3	0.7 ± 0.5	1.000

[a] Expressed as number of individuals detected per route.
[b] Unequal variance t-test.

(pine and hardwood) accounted for a slightly greater proportion of the area within 1 km (36.4%) than within 140 m (32.5%) of the routes. Conversely, open habitats accounted for a slightly greater proportion of the area within 140 m (58.6%) than within 1 km (55.3%).

DISCUSSION

The relative abundance of birds in the region surrounding SRS was nearly twice that of birds on SRS. The most probable explanation for the greater abundance of birds detected off SRS is that a greater diversity of land use practices, including agriculture and urban/suburban development, was present off-site. Areas under these land uses provided habitat for more species. For example, Killdeer, Homed Lark, Eastern Meadowlark, Eastern Kingbird, Blue Grosbeak, and Brown-headed Cowbird commonly are associated with field, pasture, or edge habitats, and Rock Dove, Chimney Swift, Purple Martin, House Finch, and House Sparrow commonly are associated with urban or residential habitats. Developed areas were present on SRS that were not sampled, and these areas supported populations of urban birds; all of the above-mentioned species have been documented to occur on SRS (Mayer and Wike 1997). Developed areas comprised <5% of the area of SRS, so their impact on abundance comparisons likely would have been minimal had we data to include them in analysis. However, inclusion of these areas may have impacted the species richness estimates for SRS, and the number of species detected only off SRS may have been reduced considerably. Additionally, J. B. Dunning (unpubl. data),

TABLE 4. COMPARISON OF RELATIVE DISTRIBUTION (% COMPOSITION) OF HABITAT TYPES NEAR (WITHIN 140 M) THREE BREEDING BIRD SURVEY ROUTES WITH THAT IN THE BROADER LANDSCAPE (WITHIN 1000 M OF THE ROUTES) IN EAST-CENTRAL GEORGIA

Cover type	Distance from road 140 m	1,000 m
Open water	0.6	0.8
Pine forest	6.4	7.6
Hardwood forest	26.1	28.8
Scrub forest[a]	8.2	7.6
Open ground[b]	58.6	55.3

[a] Includes turkey oak (*Quercus laevis*), successional, and residential open forest.
[b] Includes bare soil, row crop agriculture, herbaceous fallow field, and herbaceous pasture.

working in forest regeneration stands on SRS, documented the presence of several species reported herein as occurring only off SRS. These species, present but only locally common or uncommon on SRS, included Mississippi Kite, Rough-winged Swallow, Barn Swallow, Gray Catbird, Loggerhead Shrike, and Common Grackle, in addition to some of the urban birds mentioned above. As with any sampling methodology, species were missed. For this reason, Table 3 should not be viewed as a comprehensive list with regard to SRS birds, but rather as a representative sample of the species occurring in non-developed habitats on SRS. Similarly, species recorded off SRS likely are only a representative sample.

The difference in land-use patterns on- and off-site also explains the greater abundance of forest birds on SRS. Of the species that were more abundant on-site, most were species that preferred mature forested habitats of either bottomland hardwood or longleaf pine. These included Red-cockaded Woodpecker and Prairie Warbler in longleaf pine forest, and American Redstart, Louisiana Waterthrush, Hooded Warbler, and Kentucky Warbler in bottomland hardwoods. Both mature longleaf pine and bottomland hardwood forests are more prevalent on SRS than off. Both are considered by Partners In Flight to be ecosystems of high priority for bird conservation (W. C. Hunter, in prep.). Furthermore, many species more abundant on SRS were forest-interior species (e.g., Pileated Woodpecker, Red-eyed Vireo, American Redstart, Kentucky Warbler; Robbins et al. 1989, Kilgo et al. 1998). Apparently, the continuously forested landscape of the SRS increased the effective size of suitable habitat patches (i.e., stands) for these species, and thus supported greater densities (Kilgo et al. 1997).

A potential bias that may have contributed to the differences we observed relates to the different sampling methodologies of the BBS and point counts. When compared with off-road counts, roadside counts such as the BBS may over-represent species that prefer edge habitats (Keller and Fuller 1995), apparently because of the greater amount of edge habitat (i.e., that created by the right-of-way) that is sampled. However, such a bias was not a concern in our study if the roadside counts sampled the habitat actually available in the region. That is, if the region was dominated by edge or brushy habitat, more of these habitats were expected to be sampled by the BBS routes, and therefore more edge or brush birds were expected. Our GIS analysis of landscape composition indicated that the strip within 140 m of the BBS routes generally was similar to the larger landscape in both forested habitat (32.5 vs. 36.4%, respectively) and open habitat (58.6 vs. 55.3%, respectively). If these differences are not merely attributable to sampling error, the relative abundance of birds in the off-site areas that prefer open or brushy habitat may be slightly over-estimated, whereas that of forest birds may be slightly under-estimated. However, we believe that, due to the magnitude of the differences in bird populations on and off of SRS, this bias had minimal impacts on our analysis.

We conclude that SRS provides the habitat conditions necessary to support a large suite of forest birds not otherwise common in the region. Eleven of the species that were either more abundant or occurred only on site are ranked as "high priority" or higher for the area by the Partners In Flight prioritization scheme (Hunter et al. 1993; W. C. Hunter, in prep.), and one, Red-cockaded Woodpecker, is an endangered species whose population on site is increasing (Franzreb and Lloyd this volume). This situation exists because of the presence of rare habitats on SRS (longleaf pine and bottomland hardwood forest) and the overall landscape composition and configuration of SRS. However, forest management conducted at the expense of other land uses (agriculture and urban development) also precludes the presence of habitat conditions for many species. The conservation needs of each group (i.e., forest versus non-forest birds) should be considered in large-scale land use planning.

The differences in bird populations on and off SRS necessitate a monitoring program on site to supplement ongoing regional monitoring programs such as the Breeding Bird Survey. However, we demonstrated that if such on-site information is lacking, long-term research projects may provide useful comparative information in lieu of standard monitoring programs if the research data are collected following standardized guidelines such as those of Ralph et al. (1995) for point counts.

ACKNOWLEDGMENTS

This work was funded by the U.S. Department of Energy's National Environmental Research Park program, the USFS Savannah River Natural Resource Management and Research Institute's Biodiversity Program, the USFS Southern Research Station, the University of Georgia, and Clemson University. We thank J. M. Buffington, C. Irby, l? A. Johnston, J. Plissner, and R. A. Sargent for assistance with point counts, B. G. Peterjohn for providing BBS data as well as helpful discussion, J. E. Pinder for providing satellite imagery, and M. M. Davalos for conducting the GIS analysis.