

FIFTY YEARS OF ORNITHOLOGICAL COVERAGE AT SRS: WHAT SPECIES AND GROUPS HAVE FALLEN THROUGH THE CRACKS?

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Abstract. Over the past 50 years, SRS has been the site of numerous ornithological studies, both applied and basic. Although monitoring the entire avifauna has never been the goal of these studies, the spatial, temporal, and taxonomic coverage have nevertheless been extensive. In this paper, we attempt to distill published review papers and others in this volume into a single assessment of coverage. In addition to showing the successes of this body of work, our compilation shows the temporal periods, species, and higher taxonomic groups that have received little or no coverage. We found that waterfowl and other waterbirds have been well-covered throughout the half-century. Three endangered species (Wood Stork, *Mycteria americana*, Bald Eagle, *Haliaeetus leucocephalus*, and Red-cockaded Woodpecker, *Picoides borealis*) have received considerable attention for the past 2–3 decades. Upland gamebirds were a focus principally during the early years, and landbirds in general received little attention between the 1950s and the early 1990s, when extensive terrestrial censusing was initiated. Two groups that are frequently singled out for study, raptors and cavity nesters, have not been studied at SRS as guilds, and aerial foragers and nocturnal species have received little attention. While overall coverage has been good, we suggest that the status of SRS as a National Environmental Research Park calls for a more proactive attempt at comprehensive long-term monitoring of the avifauna on and off site, which could be accomplished through partnerships already in place.

Key Words: bird populations, contaminants, Department of Energy (DOE), Forest Service, long-term monitoring, National Environmental Research Park (NERP), radionuclides, Savannah River Ecology Laboratory (SREL), Savannah River Institute (SRI), Savannah River Site (SRS), silvicultural impacts, South Carolina, thermal impacts.

Seen from space, the Savannah River Site (SRS) is a vast patch of nearly continuous forest green in a surrounding matrix of agricultural fields, ditches, woodlots, and human residences (White and Gaines *this volume*). The current distribution of habitats on the SRS was created through the long-term land management of the SRS by the U.S. Forest Service, funded through the Department of Energy (DOE), and in response to the DOE's programmatic goals. One result of this management is that the avifauna on the SRS differs from that found in the agricultural lands and human residential areas that dominate the landscape matrix off-site (Kilgo et al. *this volume*). For instance, the SRS has a higher proportion of forest than do private lands in the region, and therefore supports more forest birds. The SRS offers at least potential source habitat for many forest-dwelling species that are uncommon in the surrounding landscape. Conversely, species typical of agricultural fields or other open habitats may be under-represented on the SRS (Kilgo et al. *this volume*).

Research on the birds of the SRS has been dominated by studies required to meet programmatic goals of DOE or the Forest Service. Thus, the research done to date is not completely representative of the whole avifauna. Programmatic emphases have varied since the creation of the SRS; thus different species have been studied at different times over the past 40-plus years. The

emphasis on certain species has been diminished somewhat by additional studies conducted for reasons extrinsic to the mission of SRS (e.g., by visiting faculty and students), and explicit attempts to monitor the entire avifauna (e.g., the annual Christmas Bird Count). Some species and higher taxa, however, remain poorly known on the site.

The purpose of this paper is to document how intensively and extensively this avifauna has been studied since the establishment of the site. The major focus is to identify those species and higher taxa that have fallen through the cracks in the extensive floor of coverage on the site. We address this goal by documenting in tabular form the species that have received coverage, both intentional and coincidental. Both published sources (from this volume and the open literature) and unpublished in-house reports have been consulted. The result is a compilation of taxa and ecological associations that allows us to identify which groups have been studied least and are not currently under study.

METHODS

Our data were species listed in tables or text in formal reports, both published in the open literature and in-house. These included journal articles, Savannah River Ecology Laboratory (SREL) documents, and SRS documents. These were not consulted, but were reviewed recently by Mayer et al. (1997). Original analysis of raw data, such as field notes, banding re-

cords, and museum specimens was beyond the scope of this study. We did, however, use raw Christmas Bird Count data compiled by K. F. Gaines, C. Eldridge, and L. L. Eldridge (unpubl. data).

We constructed a spread-sheet in which the rows were all the species recorded on SRS (Mayer et al. 1997), and each source document was represented by a column. To add some temporal depth to the tabulation, each decade since 1950 was represented in the appropriate cell by a numeric code (e.g., 50 for 1950–59, 60 for 1960–69, etc.). To save space, we combined data from studies that covered only one or a few species into a single column (Table 1, column 10). We used this coverage table to identify species and higher taxonomic groups that have received no or little coverage. We complemented the table with results of a discussion group at the symposium to identify, in a second table, taxa that may need more intensive coverage in the future (Table 2).

RESULTS AND DISCUSSION

Table 1 shows 254 species recorded by Mayer et al. (1997) as occurring on SRS. We found 192 species (99 nonpasserine, 93 passerine), representing 50 families (26 nonpasserine, 24 passerine) and 17 orders (following the taxonomy of Post and Gauthreaux 1989) that have received some coverage (Table 1). Despite the large number and percentage (76% of site list from Mayer et al. 1997) of species tabulated as covered, inspection of the table reveals strong taxonomic and temporal biases in coverage. Noteworthy omissions are listed in Table 2 and discussed below.

SRS has always had a programmatic interest in impoundments and wetlands (Table 1, columns 3, 4). The coverage of open-water habitats, and the mostly nonpasserine birds using them, has been extensive temporally and intensive methodologically. In winter, waterfowl and American Coots (scientific names of all species appear in Table 1) have been the main subjects of these studies (Brisbin et al. 1973, Brisbin 1974, Mayer et al. 1986, Brisbin and Kennamer *this volume*; R. A. Kennamer, unpubl. data); while the major breeding anatid, the Wood Duck, has been studied continuously from 1981 to the present (Kennamer and Hepp *this volume*). Ciconiiform waders were studied as their habitat was being flooded by the impoundment of L Lake in the 1980s (Table 1, column 2; Bildstein et al. 1994) and during the drawdown of Par Pond in 1991 (Bryan et al. 1996). Two endangered species that use aquatic habitats, the Bald Eagle and particularly the Wood Stork, have been the subjects of study (Table 1, column 2; Bryan et al. 1996, *this volume*).

Terrestrial birds, on the other hand, have received much less attention. Upland habitats were not a major programmatic concern, and following the pioneering studies of E. P. Odum and

students on old-field succession in the 1950s (Table 1, column 1; Meyers and Odum *this volume*), these birds received little attention until neotropical migrants became a focus of conservation efforts in the 1980s. In the early 1990s the Forest Service's Savannah River Institute (SRI) initiated extensive annual breeding bird censusing effort in terrestrial habitats (Table 1, columns 6–8; Kilgo et al. *this volume*). This added considerably to the scope of previously existing studies of forest birds, which were mostly associated with management of the endangered Red-cockaded Woodpecker (Franzreb and Lloyd *this volume*). Terrestrial coverage focused on communities was supplemented by intensive work on the Bachman's Sparrow and its associates in mature pine forest and early successional habitats (Table 1, column 5; Dunning et al. *this volume*).

Because of the conversion of the landscape from agricultural to forested land uses (White and Gaines *this volume*), coverage of open-country birds declined after the initial studies of succession directed by Odum (Meyers and Odum *this volume*). As the short-rotation pine plantations responsible for most of the increase in forest coverage matured, clear-cuts offered open-country birds, at least the ones with small home ranges (mostly passerines), extensive if temporary footholds throughout the site. Dunning et al. (*this volume*) have studied the impacts of this landscape-level ephemerality on Bachman's Sparrows and other open-country passerines (Table 1, column 5).

Falling under the rubric of open-country birds are two gamebirds (Mourning Dove and Northern Bobwhite), which were studied intensively in the 1950's. The Northern Bobwhite has declined drastically because of habitat conversion, on SRS as well as in the piedmont of the state (J. Cely, pers. comm.). Recently, the Mourning Dove has become the subject of intensive metal uptake and radioecology studies (Burger et al. 1997, 1998; Kennamer et al. 1998), but its basic biology was not studied during the shift from open to forested habitat, 1960–1990.

Another gamebird, the Wild Turkey, was present in small numbers in the Savannah River Swamp in the 1950s. In 1973–1974 the South Carolina Department of Natural Resources introduced 48 turkeys to SRS for propagation and, as of 1997, 728 turkeys had been relocated to other areas in the state and beyond (Halverson et al. 1997). Turkeys have been the subject of telemetry studies in the 1990s (I. L. Brisbin, pers. comm.; J. C. Kilgo, pers. comm.).

Given the intensive silvicultural management of the site, the lack, until recently, of explicit coverage and/or management of upland cavity-

TABLE 1. BIRD SPECIES OF SRS, WITH THOSE WHICH HAVE RECEIVED SOME COVERAGE AND ASSESSMENT INDICATED IN BOLD TYPE

Species	Sources (see footnotes)									
	1	2	3	4	5	6	7	8	9	10
Common Loon, <i>Gavia immer</i>		80, 90		50, 60, 70, 80					70, 80, 90	
Red-throated Loon, <i>Gavia stellata</i>									70, 90	
Pied-billed Grebe, <i>Podilymbus podiceps</i>	50	80, 90	70	50, 60, 70, 80				70, 90		
Horned Grebe, <i>Podiceps auritus</i>		80, 90	70	50, 60, 70, 80					70, 80, 90	
Double-crested Cormorant, <i>Phalacrocorax auritus</i>		80, 90							70, 80, 90	
Anhinga, <i>Anhinga anhinga</i>		80, 90							70, 80, 90	
American Bittern, <i>Botaurus lentiginosus</i>		80, 90							70, 80, 90	
Least Bittern, <i>Ixobrychus exilis</i>	50	80, 90							70, 80, 90	
Great Blue Heron, <i>Ardea herodias</i>		80, 90				90			70, 80, 90	
Great Egret, <i>Ardea alba</i>		80, 90							70, 80, 90	
Snowy Egret, <i>Egretta thula</i>		80, 90							80, 90	
Little Blue Heron, <i>Egretta caerulea</i>		80, 90							80, 90	
Tricolored Heron, <i>Egretta tricolor</i>		80, 90								
Cattle Egret, <i>Bubulcus ibis</i>									80	
Green Heron, <i>Butorides striatus</i>	50	80, 90				90			70, 80	
Black-crowned Night-Heron, <i>Nycticorax nycticorax</i>		80, 90							70, 80	
Yellow-crowned Night-Heron, <i>Nycticorax violaceus</i>	50								80	
White Ibis, <i>Eudocimus albus</i>		80, 90								80, 90 ¹⁰
Wood Stork, <i>Mycteria americana</i>										
Tundra Swan, <i>Cygnus columbianus</i>				50, 60, 70, 80					80, 90	
Greater White-fronted Goose, <i>Anser albifrons</i>										
Snow Goose, <i>Chen caerulescens</i>				50, 60, 70, 80					80, 90	
Canada Goose, <i>Branta canadensis</i>	50			50, 60, 70, 80						
Wood Duck, <i>Aix sponsa</i>	50	80, 90		50, 60, 70, 80		90			70, 80, 90	80, 90 ¹¹

TABLE 1. CONTINUED

Species	1	2	3	4	5	6	7	8	9	10
Killdeer , <i>Charadrius vociferus</i>	50	80, 90					90		70, 80, 90	
American Oystercatcher, <i>Haemastopus palliatus</i>										
Greater Yellowlegs, <i>Tringa melanoleuca</i>		80, 90								
Lesser Yellowlegs , <i>Tringa flavipes</i>										
Solitary Sandpiper, <i>Tringa solitaria</i>										
Spotted Sandpiper , <i>Actitis macularia</i>		80, 90							70	
Sanderling, <i>Calidris alba</i>										
Western Sandpiper, <i>Calidris mauri</i>										90
Least Sandpiper , <i>Calidris minutilla</i>										
White-rumped Sandpiper, <i>Calidris fuscicollis</i>										
Pectoral Sandpiper, <i>Calidris melanotos</i>										90
Dunlin , <i>Calidris alpina</i>										
Short-billed Dowitcher, <i>Limnodromus griseus</i>									70	
Long-billed Dowitcher, <i>Limnodromus scolopaceus</i>										
Common Snipe , <i>Gallinago gallinago</i>									80, 90	
American Woodcock , <i>Scolopax minor</i>	50								70, 80, 90	
Red-necked Phalarope, <i>Phalaropus lobatus</i>										
Laughing Gull , <i>Larus atricilla</i>		80, 90							70, 80	
Bonaparte's Gull , <i>Larus philadelphia</i>									70, 80, 90	
Ring-billed Gull , <i>Larus delawarensis</i>		80, 90							70, 80, 90	
Herring Gull , <i>Larus argentatus</i>		80, 90							80, 90	
Caspian Tern , <i>Sterna caspia</i>		80, 90								

Sources (see footnotes)

TABLE 1. CONTINUED

Species	Sources (see footnotes)									
	1	2	3	4	5	6	7	8	9	10
Common Tern, <i>Sterna hirundo</i>			70						90	
Forster's Tern, <i>Sterna forsteri</i>		80, 90								
Least Tern, <i>Sterna antillarum</i>		80, 90								
Sooty Tern, <i>Sterna fuscata</i>			70				90		70, 80, 90	
Black Tern, <i>Chlidonias niger</i>										
Rock Dove, <i>Columba livia</i>										
White-winged Dove, <i>Zenaida asiatica</i>					90	90	90	90	70, 80, 90	
Mourning Dove, <i>Zenaida macroura</i>	50					90	90			
Common Ground-Dove, <i>Columbina passerina</i>	50					90	90			
Black-billed Cuckoo, <i>Coccyzus erythrophthalmus</i>								90		
Yellow-billed Cuckoo, <i>Coccyzus americanus</i>	50				90	90	90	90		
Common Barn-Owl, <i>Tyto alba</i>										
Eastern Screech-Owl, <i>Otus asio</i>									70, 80, 90	
Great Horned Owl, <i>Bubo virginianus</i>	50								70, 80, 90	
Barred Owl, <i>Strix varia</i>	50					90			70, 80, 90	
Short-eared Owl, <i>Asio flammeus</i>	50								70, 80, 90	
Northern Saw-whet Owl, <i>Aegolius acadicus</i>										
Common Nighthawk, <i>Chordeiles minor</i>	50					90				
Chuck-will's-widow, <i>Caprimulgus carolinensis</i>										
Whip-poor-will, <i>Caprimulgus vociferus</i>						90	90		90	
Chimney Swift, <i>Chaetura pelagica</i>	50									
Ruby-throated Hummingbird, <i>Archilocus colubris</i>	50							90		
Belted Kingfisher, <i>Ceryle alcyon</i>		80, 90								
Red-headed Woodpecker, <i>Melanerpes erythrocephalus</i>	50				90	90	90	90	70, 80, 90	70, 80, 90

TABLE I. CONTINUED

Species	Sources (see footnotes)									
	1	2	3	4	5	6	7	8	9	10
Red-bellied Woodpecker, <i>Melanerpes carolinus</i>	50				90	90	90	90	70, 80, 90	
Yellow-bellied Sapsucker, <i>Sphyrapicus varius</i>									70, 80, 90	
Downy Woodpecker, <i>Picoides pubescens</i>	50				90	90	90	90	70, 80, 90	
Hairy Woodpecker, <i>Picoides villosus</i>	50				90	90	90	90	70, 80, 90	
Red-cockaded Woodpecker, <i>Picoides borealis</i>	50				90	90	90	90	70, 80, 90	70 ¹⁴ ; 80, 90 ¹⁷
Northern Flicker, <i>Colaptes auratus</i>	50				90	90	90	90	70, 80, 90	
Pileated Woodpecker, <i>Dryocopus pileatus</i>	50				90	90	90	90	70, 80, 90	
Eastern Wood-Pewee, <i>Contopus virens</i>	50				90	90	90	90		
Acadian Flycatcher, <i>Empidonax virescens</i>	50				90	90	90	90		
Willow Flycatcher, <i>Empidonax traillii</i>										
Least Flycatcher, <i>Empidonax minimus</i>							90	90	70, 80, 90	
Eastern Phoebe, <i>Sayornis phoebe</i>										
Great Crested Flycatcher, <i>Myiarchus crinitus</i>	50				90	90	90	90		
Western Kingbird, <i>Tyrannus verticalis</i>										
Eastern Kingbird, <i>Tyrannus tyrannus</i>	50				90	90	90	90		
Gray Kingbird, <i>Tyrannus dominicensis</i>										
Horned Lark, <i>Eremophila alpestris</i>							90	90	80, 90	
Purple Martin, <i>Progne subis</i>										90
Tree Swallow, <i>Tachycineta bicolor</i>							90	90		90
Northern Rough-winged Swallow, <i>Stelgidopteryx serripennis</i>							90	90		90

TABLE 1. CONTINUED

Species	Sources (see footnotes)									
	1	2	3	4	5	6	7	8	9	10
Nashville Warbler, <i>Vermivora ruficapilla</i>										
Northern Parula, <i>Parula americana</i>	50				90	90	90	90		
Yellow Warbler, <i>Dendroica petechia</i>										
Chestnut-sided Warbler, <i>Dendroica pensylvanica</i>										
Magnolia Warbler, <i>Dendroica magna</i>										
Cape May Warbler, <i>Dendroica tigrina</i>										
Black-throated Blue Warbler, <i>Dendroica caerulescens</i>										
Myrtle Warbler, <i>Dendroica coronata</i>								90	70, 80, 90	
Black-throated Green Warbler, <i>Dendroica virens</i>										
Blackburnian Warbler, <i>Dendroica fusca</i>										
Yellow-throated Warbler, <i>Dendroica dominica</i>						90	90		70, 80, 90	
Pine Warbler, <i>Dendroica pinus</i>	50				90	90	90	90	70, 80, 90	
Kirtland's Warbler, <i>Dendroica kirtlandii</i>										
Prairie Warbler, <i>Dendroica discolor</i>	50				90	90	90	90		
Palm Warbler, <i>Dendroica palmarum</i>									70, 80, 90	
Bay-breasted Warbler, <i>Dendroica castanea</i>										
Blackpoll Warbler, <i>Dendroica striata</i>										
Cerulean Warbler, <i>Dendroica cerulea</i>										
Black-and-white Warbler, <i>Mniotilta varia</i>						90	90	90	70, 80, 90	

TABLE 1. CONTINUED

Species	1	2	3	4	5	6	7	8	9	10
American Redstart, <i>Setophaga ruticilla</i>	50					90	90	90		
Prothonotary Warbler, <i>Protonotaria citrea</i>	50					90	90			
Worm-eating Warbler, <i>Helminthos vermivorus</i>						90				
Swainson's Warbler, <i>Limnolophus swainsonii</i>	50					90	90			80 ¹⁸
Ovenbird, <i>Seiurus aurocapillus</i>						90	90	90		
Northern Waterthrush, <i>Seiurus noveboracensis</i>						90	90			
Louisiana Waterthrush, <i>Seiurus motacilla</i>	50					90	90			
Kentucky Warbler, <i>Oporornis formosus</i>	50					90	90			90 ¹⁸
Connecticut Warbler, <i>Oporornis agilis</i>										
Common Yellowthroat, <i>Geothlypis trichas</i>					90	90	90	90	70, 80, 90	
Hooded Warbler, <i>Wilsonia citrina</i>	50				90	90	90			80, 90 ¹⁸
Wilson's Warbler, <i>Wilsonia pusilla</i>										
Canada Warbler, <i>Wilsonia canadensis</i>										
Yellow-breasted Chat, <i>Icteria virens</i>	50				90	90	90	90		
Summer Tanager, <i>Piranga rubra</i>	50				90	90	90	90		
Scarlet Tanager, <i>Piranga olivacea</i>										
Northern Cardinal, <i>Cardinalis cardinalis</i>	50				90	90	90	90	70, 80, 90	
Rose-breasted Grosbeak, <i>Pheucticus ludovicianus</i>										
Blue Grosbeak, <i>Guiraca caerulea</i>	50				90	90	90	90		
Indigo Bunting, <i>Passerina cyanea</i>	50				90	90	90	90		

TABLE 1. CONTINUED

Species	Sources (see footnotes)									
	1	2	3	4	5	6	7	8	9	10
Rusty Blackbird, <i>Euphagus carolinus</i>									70, 90	
Brewer's Blackbird, <i>Euphagus cyanocephalus</i>									90	
Common Grackle, <i>Quiscalus quiscula</i>					90	90	90		70, 80, 90	
Brown-headed Cowbird, <i>Molothrus ater</i>	50				90	90	90	90	70, 80, 90	
Orchard Oriole, <i>Icterus spurius</i>	50				90	90	90	90		
Baltimore Oriole, <i>Icterus galbula</i>										
Purple Finch, <i>Carpodacus purpureus</i>					90	90	90		70, 80, 90	
House Finch, <i>Carpodacus mexicanus</i>							90		90	
Pine Siskin, <i>Carduelis spinus</i>									70, 80	
American Goldfinch, <i>Carduelis tristis</i>					90	90	90	90	70, 80, 90	
Evening Grosbeak, <i>Coccothraustes vespertinus</i>										80
House Sparrow, <i>Passer domesticus</i>							90			

Notes: Digits in rows indicate decades of twentieth century in which studies were executed. For Christmas Bird Count data (column 9), these digits indicate that the species was recorded once in the decade. Column 10 collates studies that recorded a small number of species, but coverage may have been intensive.

1 Meyers and Odum *this volume*.

2 Bidstein et al. 1994, Bryan et al. 1996.

3 Brisbin et al. 1973.

4 Mayer et al. 1986.

5 Unpubl. species list compiled by Dunning et al. in pine and clearcut habitats in connection with studies of Bachman's Sparrow (Dunning et al. *this volume*).

6 Unpubl. species lists compiled by J. C. Kilgo, K. E. Franzreb, and S. A. Gauthreaux.

7 Kilgo et al. *this volume*.

8 J. B. Dunning, unpubl. data from New Production Reactor site.

9 Christmas Bird Count data.

10 Bryan et al. *this volume*.

11 Kennamer and Hepp *this volume*.

12 R. A. Kennamer unpubl. data.

13 Beheler and Dunning 1998.

14 White and Gaines *this volume*.

15 M. Caudell, pers. comm.; Mayer et al. 1997.

16 Brisbin and Kennamer *this volume*.

17 Franzreb and Lloyd *this volume*.

18 Moorman *this volume*.

19 Dunning et al. *this volume*.

TABLE 2. ECOLOGICAL GUILDS AND TEMPORAL PERIODS THAT ARE UNDER-REPRESENTED IN PAST AND CURRENT RESEARCH, AND PROBABLE REASONS FOR THEIR UNDER-REPRESENTATION

Under-represented group	Probable reason
Night birds (owls, goat-suckers)	Require specific census techniques
Aerial foragers (swifts, swallows)	Require specific census techniques
Raptors (hawks, owls, shrikes)	Spatial scale too large for point counts
Cavity nesters (except Wood Ducks)	Current focus is on neotropical migrants
Stopover populations	Current focus is on breeding populations
Winter populations	Current focus is on breeding populations

nesters is surprising. Short rotations may prevent the build-up of an inventory of snags, which are used by eight primary cavity-nesters (Table 1: seven woodpeckers and Brown-headed Nuthatch) for excavation of new cavities. These cavities are then used by up to twelve species of small secondary cavity nesters found on the SRS species list (Table 1: Eastern Screech-Owl, Chimney Swift, Great Crested Flycatcher, Purple Martin, Carolina Chickadee, Tufted Titmouse, White-breasted Nuthatch, Carolina Wren, Eastern Bluebird, European Starling, Prothonotary Warbler, and House Sparrow). Recent comparisons of chemical and mechanical site preparation (Kilgo et al. *this volume*) begin to address silvicultural impacts on these small cavity-nesters. Additionally, a large-scale experimental study of the role of coarse woody debris in structuring communities of cavity-nesting birds in loblolly pine forests was initiated by SRI just prior to this symposium (J. C. Kilgo, pers. comm.).

Short rotations also prevent the buildup of an inventory of large and old trees that eventually would provide natural cavities for larger, facultative cavity-nesters such as vultures and owls. These species are probably limited to bottomland situations, where large trees persist, or nest in alternative sites such as buildings.

Studying the impacts of the site's shifting landscape pattern on metapopulation dynamics of cavity nesters could be even more productive than studies of non-cavity nesters in clearcuts have been, because the former's nests are so much easier to find than cup nests in shrubs and on the ground. Moreover, the site's limited human access also makes it seemingly ideal for studies of the mitigative effects of nest boxes on secondary cavity nesters in managed environments. The feasibility of the latter suggestion is

compromised somewhat by the failure of American Kestrels (Beheler and Dunning 1998) and small passerines (D. A. McCallum, pers. obs.) to use boxes erected for their use. On the other hand, boxes erected for Wood Ducks have been used repeatedly, by nontarget as well as the target species (Kenamer and Hepp *this volume*). Erection of boxes for barn-owls in developed parts of the site could be especially effective.

A surprising omission in explicit coverage, given the level of interest on other federal lands, is raptors, both diurnal (falconiforms, shrikes) and nocturnal (strigiforms) (Table 2). Because of their large size and home ranges, many raptors require targeted surveys for adequate sampling. Fortunately, although raptors have not been studied as a group, several species have been studied individually. Once-a-year estimates of winter populations of all diurnal raptors (Christmas Bird Counts) and of Bald Eagles (Bryan et al. 1996) help identify trends. The SRI has augmented nesting structures for both Bald Eagles and Ospreys (W. L. Jarvis, pers. comm.). The American Kestrel was studied intensively for two years, 1995–1996 (Beheler and Dunning 1998). Loggerhead Shrikes were covered in studies of clearcuts (Dunning et al. *this volume*), and in urban areas (Mayer and Wike 1997).

Other nocturnal birds, primarily caprimulgi-forms, are likely to be under- or undetected with the point count methodology used in many research and monitoring projects (Table 2; Kilgo et al. *this volume*). Swallows (Hirundinidae) and swifts (Apodidae) are aerial foragers whose numbers are not well estimated without methods specific to their habits, but nests of species that breed locally (Purple Martin, Barn Swallow, Northern Rough-winged Swallow) are monitored in the developed/urban areas (J. B. Dunning, unpubl. data; J. J. Mayer, unpubl. data). Purple Martins may be valuable as sentinel species around waste sites, but attempts to establish colonies have met with only limited success (I. L. Brisbin, pers. comm.).

The focus on breeding birds has left terrestrial birds largely unstudied during winter and migration for the entire half century of SRS's existence (Table 2). This is an unfortunate omission, because several resident or wintering species recorded in the 1950s (Meyers and Odum *this volume*: Table 8) are no longer present on the site (e.g., Short-eared Owl) or in the state (e.g., Bewick's Wren). The major exception to the absence of winter landbird coverage is the annual Christmas Bird Count (Table 1, column 9), sponsored by the National Audubon Society (with recent co-sponsorship by the American Birding Association). This one-day count of all species in a 15-mi diameter circle is in fact the major

winter population monitoring scheme in North America, and the SRS count has provided invaluable data since 1979. But, this is a volunteer effort, with variable participation. A more rigorous and extensive approach to winter population monitoring is desirable. Data obtained in the pre-operational monitoring study for the proposed New Production Reactor (Ercolano 1992) provided a limited survey of these species. The inclusion of winter bird studies in recent master's theses (Kilgo et al. *this volume*) is a step in the right direction.

Winter studies are needed because the effect of land management practices may be just as significant for the many short-distance migrants that winter in South Carolina as it is for breeding species. For example, declines in populations of sparrows and other species that breed in mid-continent grasslands have recently aroused concerns. These are mostly "short-distance" migrants, some of which, e.g., Henslow's Sparrow, winter in South Carolina. Henslow's Sparrow is a species of concern for most land-management agencies in South Carolina and Georgia.

The importance of stopover sites for migratory species should also be recognized (Table 2). SRS, which lies athwart the northward route of many neotropical migrants, may be a stopover site of immense value for these dwindling populations, but the use of the site by migratory passerines has only recently received attention. A study of spring and fall migrant use of early successional bottomland hardwood habitat was initiated just prior to this symposium (J. C. Kilgo, pers. comm.).

CONCLUSIONS AND RECOMMENDATIONS

SRS was the first National Environmental Research Park, and the presence of a DOE operation on the site seems likely well into the future. The opportunity afforded by this tenure for comprehensive monitoring and study of all bird populations on the site has not, however, been exploited fully. The programmatic emphasis on wetlands has resulted in excellent coverage of nonpasserine aquatic birds, and many publications in the open, peer-reviewed literature. A recent emphasis on risk assessment has resumed an early focus on upland game birds, and additional work in this area may expand coverage somewhat. Indeed, the programmatic emphasis on fate and effects of contaminants seems to have led to underutilization of terrestrial birds as subjects by SREL, DOE's chief provider of ecological research (Meyers and Odum *this volume*).

Another contractor, the USDA Forest Service, has begun to fill this void in the past decade with a variety of census projects. Although many of

these have specific applied goals, Kilgo et al. (*this volume*) show how such results can be amalgamated into an approximation of comprehensive basic research on the breeding birds of forested lands. Nevertheless, comparison of census results on and immediately off the site show that onsite bird communities are not representative of the regional matrix (Kilgo et al. *this volume*), and suggest that SRS is a regional center of abundance for 13 species of neotropical migratory passerines, some of which are experiencing range-wide population declines. These authors conclude that 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. As Forest Service research and policy emphases understandably change over time, we conclude that unless DOE makes long-term monitoring of bird populations on SRS a programmatic emphasis, coverage will continue to be piecemeal, and the opportunity to acquire a priceless data set on avifaunal change may well be lost.

Moreover, despite the excellent coverage of terrestrial breeding bird populations fostered by Forest Service initiatives in the past decade, nonbreeding populations of terrestrial birds have received no intensive study. A 78,000-ha site with controlled access and a managed landscape has high potential as a major wintering and stopover site for nonbreeding birds. Assessing and maintaining this potential should go hand in hand with maintenance of breeding bird populations.

During the first half century of SRS's existence, DOE's environmental mission for SRS focused on minimizing and mitigating impacts caused by local operations. Although this mission will remain important in perpetuity, the next 50 years will see great changes in industrial focus at the former "bomb plant." A more inclusive mission could make this NERP a world leader in adaptive management for biodiversity, which would compliment its well-deserved reputation in contaminant studies and environmental monitoring. This potential leads us to recommend that DOE undertake the following programmatic goals and objectives for the next half-century:

Explicit commitment to 50 years of year-round monitoring of bird populations in upland, bottomland, aquatic, and urban habitats on site, and in the off-site matrix. This will permit correlation with global as well as local environmental variation.

Continued focused study on the impact of industrial operations and silviculture on these bird populations.

Restoration and maintenance at sustainable levels of populations of endangered and threatened species; maintenance at sustainable levels of populations of species with declining global habitat availability.

Specific objectives that would help implement these goals include: continuation of excellent studies of Wood Ducks and Wood Storks; continued encouragement and study of Bald Eagle and Osprey nesting on site; initiation of intensive study of cavity-nester metapopulation dynamics under stand-level, short-rotation timber management (including a site-wide nestbox program); continuation and expansion of intensive study of early-successional-species metapopulation dynamics under stand-level, short-rotation timber management; continuation and expansion of study of migratory forest-nesting birds; initiation of year-round monitoring of visiting and resident bird populations; active management of

industrial fringes, rights-of-way, and early successional forest compartments for wintering sparrows and other regionally declining open country birds, such as Northern Bobwhite and Loggerhead Shrike.

Expand leadership in the field of contaminant uptake and fate in birds by focusing on impacts on unexploited populations, in addition to impacts on humans.

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