is primarily agricultural and becoming more developed. In addition, wetland destruction on SRS was slowed greatly relative to the surrounding landscape. Most of the intact Carolina bays in South Carolina are on the SRS (S. Bennett, pers. comm.). The creation of the Par Pond reservoir unintentionally created a refuge for American alligators at a time when the species was in danger of extinction throughout its range (Brandt 1991a, b; Brisbin et al. 1997).

Some species that have apparently disappeared from the surrounding landscape have managed to persist on the SRS, including the green water snake and pine woods snake. Although unquantified, large snake species such as pine snakes and canebrake rattlesnakes appear to be encountered more frequently on the SRS than in the surrounding landscape, perhaps as a result of fewer roads and the lack of human residents who kill them. Southern hognose snakes are disappearing from throughout their range in the southeastern United States. For example, no southern hognose snakes have been seen in Alabama in over twenty years despite extensive survey efforts (Tuberville et al. 1999). Habitat destruction and degradation, road mortality, and the introduction and spread of red imported fire ants (*Solenopsis invicta*) are possible factors leading to the species' perceived decline in much of its range. The southern hognose snake appears to be more common on the SRS than in the surrounding landscape.

Timber rotation lengths on portions of the SRS (see chapter 3) do not allow for establishment of mature native habitat and therefore may not be in the best interest of all herpetofaunal species. However, considerable habitat restoration is occurring, and opportunities for applied research, restoration, and conservation of natural habitats (e.g., isolated wetlands and longleaf pine forests), as well as reintroductions of historically occurring species, are excellent on the SRS. The herpetofaunal diversity on the SRS is unrivaled anywhere else in the state of South Carolina. Nowhere else are the prospects and opportunities greater for long-term conservation of Southeastern Coastal Plain biodiversity than on the SRS.

Nongame Birds

John C. Kilgo and A. Lawrence Bryan, Jr.

The Savannah River Site (SRS) provides habitat for an impressive array of avian species. During its fifty-year existence, 259 bird species have been recorded there (Mayer et al. 1997 and unpublished data). This figure

represents more than two thirds of the 379 species on the South Carolina state list (McNair and Post 1993). Explanations for SRS's diverse avifauna include its location along the Savannah River migratory flyway, its predominantly forested landscape (in stark contrast to the surrounding counties; see figure 1.7), and the great diversity of habitat types on the site. SRS habitats span a continuum from xeric longleaf pine–turkey oak (see appendix for scientific names of plants) sandhills to hydric cypress-tupelo forests and from early successional pine regeneration stands to mature bottomland hardwood forests. The urban or developed habitats of the facilities areas and the lacustrine habitats of the cooling reservoirs add to the habitat diversity and support many species.

Since its inception, the SRS has been the subject of intensive avian study. In 1951, Dr. Eugene Odum and a team of scientists from the University of Georgia initiated avian surveys to establish baseline ecological information for the Department of Energy and to identify patterns of old-field succession. As this early research program grew into the Savannah River Ecology Laboratory, its avian research focus shifted toward radioecology, waterfowl, and endangered species studies. Meyers and Odum (2000) have described early ornithological work on the SRS. In recent years, the U.S. Forest Service has initiated considerable avian research and monitoring efforts. In 1996, the Forest Service symposium on long-term avian research on the SRS produced the publication *Avian Research at the Savannah River Site: A Model for Integrating Basic Research and Long-Term Management* (Dunning and Kilgo 2000). This valuable resource includes contributions from most ornithologists who worked on SRS in the 1980s and 1990s.

This section focuses on nongame forest and wading birds. Sections of chapters 5 and 6 cover endangered species and game birds.

Factors Controlling Bird Distribution

Many factors, both temporal and spatial, control the distribution and occurrence of birds on SRS. These factors include season, habitat type, and landscape structure.

Season

A species' seasonal occurrence depends on its migratory habits. Most species on SRS fall into one of three categories: resident, Neotropical migrant, or Nearctic migrant. Resident species (e.g., northern cardinal, Carolina wren) occur on SRS year-round (see table 4.22, which appears at the end of this section, for scientific names of birds not given in text). Neotropical migrants (e.g., hooded warbler, wood thrush) breed on SRS but winter south of the Tropic of Cancer, primarily in the Caribbean and Central America. Finally, Nearctic migrants (e.g., hermit thrush, white-throated sparrow) breed in North America and migrate southward to winter in southern North America. Nearctic migrants include species that do not breed at SRS but do winter here, as well as species (e.g., white-eyed vireo, common yellowthroat) that do breed here but migrate short distances (relative to Neotropical migrants) to winter along the South Atlantic Coast or in Florida.

Each group is highly varied, and some species are difficult to categorize even according to these broad definitions. Even within a species, not all individuals necessarily follow the same pattern. For example, white-eyed vireos are abundant breeders at SRS but are much less common during the winter. Whether the individuals at SRS during the winter are breeders that have remained or are birds that bred to the north is unknown, but it is possible that some SRS breeding white-eyed vireos are resident even if most are short-distance Nearctic or even Neotropical migrants. Other species, like brown thrashers, are resident at SRS, but during the winter an influx of migratory individuals from more northerly breeding populations augments SRS populations. Thus, some brown thrashers at SRS could be considered Nearctic migrants. Despite such difficulties, these designations help characterize major migratory patterns. The general migratory habits of a species provide insight as to when it most likely occurs at SRS.

Habitat

The relationship between bird communities and vegetation structure has long been recognized, and most species are associated with specific habitats or habitat features. For many species, habitat associations may be quite predictable, so that habitat types can often categorize bird communities. Table 4.22 predicts habitat-specific suitability for nongame and nonendangered species that breed or winter at SRS. The degree to which the avian communities of various habitats are distinct depends on the habitat preferences of each species in a community. Many species that are habitat specialists are closely tied to the narrow range of habitat conditions met in one or a few particular habitat types. Habitat generalists, which prefer a broader range of features that may be present in many

different habitats, are not as closely associated with a particular type. Thus, a community that includes many specialists will be more distinct from other communities than one that includes many generalists.

Generally, species-habitat associations are most pronounced during the breeding season; most species have specific nesting requirements, and birds tend to use habitats that meet those requirements. During breeding, birds are most vocal and detectable. In fall and winter, when birds sing much less, it is more difficult to determine their habitats, particularly those of small cryptically colored, secretive birds that use dense vegetation. Finally, given the importance of nesting in the life history of birds, research has emphasized nesting habitat requirements. Therefore, our understanding is greatest of species-habitat associations during the breeding period.

Many parameters describe a habitat. Two primary factors for birds are vegetation cover type and successional (seral) stage. Thus, our discussion of community and species distribution refers to these habitat attributes.

Cover Type

Managed pine forests occupy a large proportion of the SRS land area. The avian communities of these forests range from depauperate to species-rich, depending on the structure of individual stands. Just as birds select particular habitat types, they also may prefer certain structural configurations within a habitat. Habitat structure refers to the relative density and composition of ground cover (grasses and forbs), understory (shrubs and seedlings), midstory (saplings and small trees), and canopy layers (dominant and codominant trees). Each habitat layer can be subdivided any number of times, depending on the complexity of the forest.

With few exceptions, the species of pine per se does not seem important to birds at SRS, except to the extent that tree species dictates management alternatives and, hence, the structure of the stand. Because loblolly pine has been planted across the SRS on a variety of site types, and because managers often tailor silvicultural practices in established stands as much to site-specific conditions as to a particular species, later successional loblolly and longleaf pine forests on SRS often are quite similar in vegetation structure. Thus, bird communities are similar in longleaf and loblolly pine. Presettlement avian communities may have differed substantially between longleaf and loblolly forests, because in the absence of management intervention, these species occupied and shaped different site types.

Contrary to the general theory that bird species diversity is a function of foliage height diversity, the habitat structure that tends to support the most diverse bird community in mid- to late-successional southern pine forests includes a well-developed grass-forb understory, a sparse midstory, and a canopy of large pines, i.e., the structure found in mature, fire-maintained pine forests and savannas (Wilson, Masters, and Bukenhofer 1995; White et al. 1999; Krementz and Christie 1999). The bird community typical of such sites at SRS consists of a diverse array of species that nest on the ground, in the understory (i.e., shrub-scrub birds), and in the canopy, as well as a few midstory-nesting species. This community of breeding birds is among the most diverse of any habitat at SRS (table 4.23, 60-year pine forest).

Generally, when understory development is enhanced in SRS pine forests, bird diversity and abundance increase. Thinning, for example, stimulates the development of the understory by opening the forest canopy and allowing more sunlight to reach the ground (although understory development may be limited by prior land-use effects on the seed bank). Conversely, when the understory is diminished, bird diversity and abundance decline. Both canopy closure in young stands and hardwood midstory encroachment in older stands shade out the understory. Unthinned old-field pine stands on many SRS sites frequently have little to no midstory or understory, and the only ground cover may be pine straw. Such species-poor stands lack birds that nest in the understory. They are occupied almost exclusively by canopy-nesting species such as the great crested flycatcher, blue jay, pine warbler, and woodpeckers (see table 4.23, 25-year pine stand). Similarly, pine stands with well-developed hardwood midstories often lack understory and ground-nesting birds because the lower layers have been shaded out. Such stands may support a few additional species, such as wood thrush and red-eyed vireo, that use the midstory, but still lack the suite of species associated with the ground and understories of the mature pine forest (i.e., the shrub-scrub community).

Manipulating the frequency and timing of prescribed fire can control midstory encroachment (see chapter 3). Frequent burning, particularly during the growing season, suppresses the growth of hardwood trees and thus limits midstory development and enhances ground and understory development. Stands that escape burning for more than five years, especially if recently thinned, often develop a hardwood midstory and support a bird community with few ground nesters. In some stands at SRS,

Table 4.23 Typical avian communities associated with six common habitats on the Savannah River Site (nesting species only)

Pine plantation (4-yr)	Pine forest (25-yr)	Pine forest (60-yr)	Upland hardwood	Bottomland hardwood	Cypress-tupelo
Mourning dove	Yellow-billed cuckoo	Yellow-billed cuckoo	Yellow-billed cuckoo	Yellow-billed cuckoo	Yellow-billed cuckoo
Common ground dove	Red-bellied woodpecker	Red-headed woodpecker	Red-bellied woodpecker	Red-bellied woodpecker	Red-bellied woodpecker
Eastern kingbird	Eastern wood-pewee	Red-bellied woodpecker	Downy woodpecker	Downy woodpecker	Pileated woodpecker
Great crested flycatcher	Great crested flycatcher	Red-cockaded woodpecker	Northern flicker	Pileated woodpecker	Acadian flycatcher
Carolina chickadee	Blue jay	Northern flicker	Pileated woodpecker	Acadian flycatcher	Great crested flycatcher
Tufted titmouse	Carolina chickadee	Pileated woodpecker	Great crested flycatcher	Great crested flycatcher	Carolina chickadee
Carolina wren	Tufted titmouse	Eastern wood-pewee	Blue jay	American crow	Tufted titmouse
Eastern bluebird	Brown-headed nuthatch	Great crested flycatcher	American crow	Carolina chickadee	White-breasted nuthatch
Gray catbird	Carolina wren	Carolina chickadee	Carolina chickadee	Tufted titmouse	Carolina wren
Northern mockingbird	Blue-gray gnatcatcher	Tufted titmouse	Tufted titmouse	Carolina wren	Blue-gray gnatcatcher
Brown thrasher	Pine warbler	Brown-headed nuthatch	Carolina wren	Blue-gray gnatcatcher	Yellow-throated vireo
White-eyed vireo	Summer tanager	Carolina wren	Blue-gray gnatcatcher	Wood thrush	Red-eyed vireo
Prairie warbler		Eastern bluebird	Wood thrush	White-eyed vireo	Northern parula
Common yellowthroat		Pine warbler	Red-eyed vireo	Yellow-throated vireo	Yellow-throated warbler
Yellow-breasted chat		Prairie warbler	Northern parula	Red-eyed vireo	American redstart
Northern cardinal		Summer tanager	Summer tanager	Northern parula	Prothonotary warble
Blue grosbeak		Northern cardinal	Northern cardinal	American redstart	Summer tanager
Indigo bunting		Blue grosbeak		Prothonotary warbler	Northern cardinal
Eastern towhee		Indigo bunting		Swainson's warbler	
Bachman's sparrow		Eastern towhee		Louisiana waterthrush	
Field sparrow		Bachman's sparrow		Kentucky warbler	
		Chipping sparrow		Hooded warbler	
				Summer tanager	
				Northern cardinal	

Sources: Pine plantation, Irby et al. (1995, 1996), Krementz and Christie (1999), J. Dunning, unpublished data; pine forest (25-yr), Kilgo, unpublished data, Droge et al. (1993); pine forest (60-yr), Krementz and Christie (1999), Droge et al. (1993); upland hardwood, Kilgo et al. (1997), Plissner et al. (1993c); bottomland hardwood, Kilgo et al. (1998), Plissner et al. (1993a); cypress-tupelo, Plissner et al. (1993b).

mechanical and chemical means are required to control hardwood encroachment (see chapter 5). Whether by fire, mechanical, or chemical means, midstory control and the enhanced understory development benefit birds that nest and forage in the understory, such as prairie warbler, blue grosbeak, indigo bunting, and Bachman's sparrow, yielding a more diverse avian community (Burger, Hardy, and Bein 1998).

Other aspects of forest structure that affect the avian community of SRS pine stands include the size of overstory trees and the presence and size of coarse woody debris (i.e., large dead wood), both standing snags and downed logs (Lohr, Gauthreaux, and Kilgo 2002). The size of trees and snags primarily affects cavity-nesting species. Many primary and secondary cavity-nesting species, including great crested flycatcher, brown-headed nuthatch, and eastern bluebird use dead branches and malformations in the crotches of large living trees. Similarly, population levels of many cavity-nesting birds are related to the number of snags present in a stand; stands with snags experimentally removed supported fewer cavity-nesting birds (figure 4.23; Lohr, Gauthreaux, and Kilgo 2002). Rotation length limits the size that trees and snags are able to attain. The shortest for pines on SRS is 50 years, and many stands are on 100- or 120-year rotations. Assuming snags are not removed, nearly all pine stands on SRS can potentially produce enough trees and snags of sufficient size to support all cavity-nesting species. Large cavity nesters such as red-headed, red-bellied, and pileated woodpeckers are common in mature pine forests of SRS (Droge et al. 1993; Lohr 1999).

In contrast to pines, most hardwood forests at SRS receive little direct forest management (but see chapter 3); many are reserved from management in set-aside areas (Davis and Janecek 1997; chapter 1). However, as site type has a greater effect on the composition of the overstory (as well as the under and midstories) than in pine forests, there is considerable variation in the avian communities of these forests. The primary site factor affecting the bird communities of hardwood forests is slope position: upland or bottomland. As in pine stands with poorly developed understories, canopy-nesting species generally dominate the avian communities of upland hardwood forests (table 4.23). These forests lack the dense understory preferred by most shrub-nesting birds; northern cardinal is the only true shrub-nesting species common in these forests. There seems to be little difference between the avian communities of mesic and xeric upland sites; however, two species characteristic of mesic deciduous forests throughout their range, the ovenbird and the black-and-white warbler, seem to occur more frequently in xeric scrub oak forests of SRS

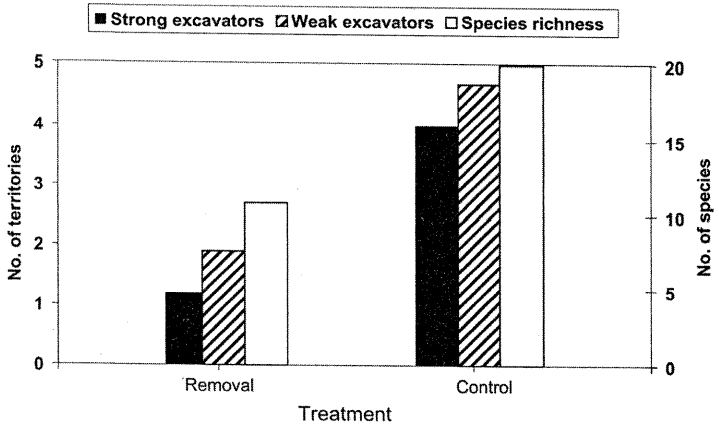

Figure 4.23. Abundance of strong- and weak-excavating cavity-nesting birds and total bird species richness on 9.3-ha (23-ac) experimental plots with all coarse woody debris removed (snags and logs) and with none removed (controls) on the Savannah River Site, 1997–1999 (Lohr et al. 2002). Strong excavators included woodpeckers, and weak excavators included great crested flycatcher, eastern bluebird, brown-headed nuthatch, tufted titmouse, and Carolina chickadee.

(pers. obs.). The reason is unclear, though it is likely related to differences in the forest floor between site types, as both species are ground nesters.

On bottomland sites, the most important factor affecting bird occurrence is flooding regime. Infrequent and shallow flooding, characteristic of most stream and some Savannah River bottomland sites on SRS, results in forests dominated either by oaks and sweetgum or by red maple, swamp gum, and yellow poplar. Both types support a similar suite of species (see table 4.23, bottomland hardwood). The avian community of most SRS bottomland hardwoods is more diverse in ground, understory, midstory, and canopy-nesting species than any other habitat on SRS, as each of these layers generally is well developed. Kilgo et al. (1998) recorded fifty-six species in twenty bottomland forests in or near SRS. The understory of these forests is denser than that of upland hardwoods and is often dominated by switchcane, an important nesting substrate for species such as hooded, Kentucky, and Swainson's warblers and northern cardinals. Some species such as Acadian flycatcher, yellow-throated vireo, and American redstart, all midstory or canopy nesters, seem to prefer these moister forests over dryer upland sites, whereas others, such as prothonotary warbler and Louisiana waterthrush nest exclusively near water.

Bald cypress and water tupelo generally dominate bottomland sites that experience deeper and more prolonged flooding, which occurs throughout much of the Savannah River swamp. Deep flooding reduces the understory, so species that nest on drier bottomland sites do not occur as frequently in cypress-tupelo swamps. Instead, as in other habitats lacking a dense understory, canopy-nesting species dominate the avian community. The white-breasted nuthatch and yellow-throated warbler, two canopy nesters that are uncommon at SRS, reach their greatest abundance in cypress-tupelo swamps.

In addition, several species of wading birds may use cypress-tupelo swamps for nesting or foraging. These include anhinga, cattle egret, green heron, great blue heron, great egret, little blue heron, white ibis, and wood stork (*Mycteria americana*). Foraging, the greater use of SRS swamps by these species, occurs after breeding. However, three wading-bird breeding colonies exist in the Savannah River swamp at Beaver Dam Creek (1990–present), at the Pen Branch delta (1989–present), and west of the Steel Creek delta (1989–present). These three colonies, typically thirty to sixty nests each, are mixed heronries of great blue herons, great egrets, and anhingas. Great blue herons (twenty-five to fifty nests) also nested in the Fourmile Branch delta from 1983 to 1989. Nesting there may have ceased in response to the hydrologic and vegetative changes following the shutdown of C Reactor in the mid-1980s; water no longer surrounded nest trees because of reduced stream flows. Generally, there appears to be a gradual increase in numbers of nesting wading birds on the SRS, although this possible trend is clouded by inconsistent monitoring efforts.

The high variability of such habitats complicates discussion of avian use of nonriparian wetland habitat at SRS. The vegetation of Carolina bays, for example, may be forested, herbaceous, shrubby, or any combination thereof, and the hydroperiod ranges from a few days to permanently. Thus, the opportunities that Carolina bay habitat affords to birds depends on the specific bay. Generally, regularly flooded forested bays (cypress-tupelo), if large enough, may support an avian community similar to that of cypress-tupelo riparian wetlands, whereas herbaceous bays may support an avian community similar to that of early-successional swamp forests (e.g., the Pen Branch delta; see below). Wading birds may use reservoirs, Carolina bays, and depression wetlands for foraging and occasionally for breeding. Breeding colonies of great blue herons and/or anhingas, containing two to ten nests, have been observed in Peat Bay, Eagle Bay, Dunbarton Bay, and a beaver pond near Upper Three Runs. Green herons, approximately twenty pairs, currently nest in ponds associated with the D Area ash basins and have nested historically on the

periphery of Par Pond and an island in Pond B. Great blue herons and great egrets frequently forage on the periphery of the major reservoirs.

The lawns, shrubbery, parking lots, and buildings of SRS facilities provide nesting, roosting, or foraging habitat for many species, several of which occur nowhere elsewhere at SRS. Urban birds such as rock dove, house finch, and house sparrow are locally abundant in these areas. Many other species with limited habitat availability elsewhere on SRS, such as black vultures, barn owls, and purple martins, use these areas as well. Mayer and Wike (1997) list urban birds at SRS.

Successional Patterns

Most early-successional habitat at SRS is in regenerating pine stands. In pine forests, avian diversity and abundance are greatest in young plantations (before canopy closure) and mature forests and lowest in mid-rotation plantations (Dickson and Segelquist 1979; Meyers and Johnson 1978; Johnson and Landers 1982). The first peak in bird diversity and abundance occurs in young plantations around age three to six. Shrub-scrub species dominate the avifauna of such sites at SRS (table 4.23, 4-year pine plantation) until canopy closure (Krementz and Christie 1999). Many forest-nesting species also heavily use young plantations for foraging and cover, bringing in recently fledged broods from the adjacent stands where they nested (Krementz and Christie 1999). Including these forest species, the avian communities of young plantations are among the most diverse of any habitat on SRS, second only to bottomland hardwood forests. J. Dunning et al. (Purdue University, unpublished data) recorded fifty-four species during the breeding season in two- to seven-year-old pine regeneration stands at SRS. In contrast, from the time the understory begins to diminish from canopy shading (usually around six or seven years in loblolly stands and eight or ten years in longleaf stands) until the canopy thins and the understory begins to redevelop (age twenty-five to forty or later, depending on site conditions and management actions), bird abundance and species richness of SRS pine plantations are extremely low. A few forest species invade, but most shrub-scrub species abandon closed-canopy plantations and do not return until much later in the rotation (see above discussion of mid- and late-rotation pine forests).

As in older stands, structural features of early-successional pine habitat that attract birds include understory development and residual snags and coarse woody debris. Site-preparation technique and manipulation of tree density affect these habitat components. Several workers (O'Connell 1993; Sparling 1996; Branch 1998, reviewed by Kilgo, Miller, and Moore 2000) have investigated the effects of site-preparation methods on birds in pine plantations at SRS. Although the overall composition of avian communities is similar, bird abundance and diversity are greater on chemically treated sites than mechanically treated sites (O'Connell 1993). Where snags and other coarse woody debris are piled into windrows on mechanically prepared sites, cavity-nesting species such as eastern bluebird are less abundant. However, species that use these slash piles and windrows for nesting or cover, such as Carolina wren and yellow-breasted chat, are more abundant on mechanically prepared sites (O'Connell 1993). Bird use apparently does not differ among sites prepared with either of three common herbicides—imazapyr, hexazinone, or a picloram + triclopyr mixture (Sparling 1996; Branch 1998).

Tree density in young plantations affects understory structure through its effects on timing of canopy closure; the fewer the trees, the longer it takes for the canopy to close and the longer the period of high habitat quality will persist. When longleaf stands were experimentally thinned at age eight to ten and competing hardwoods were controlled with herbicide and fire, some shrub-scrub species (e.g., prairie warbler, blue grosbeak, Bachman's sparrow) persisted as late as eleven to fourteen years after planting (Johannsen 1998). Loggerhead shrikes occurred in eight- to ten-year-old stands similarly treated, whereas they normally are restricted to one- to three-year-old stands (J. Dunning, unpublished data). Presumably, the same pattern occurs in stands planted at lower densities or where the trees suffer high mortality.

Less is known of successional patterns in avian communities of bottomland forests on SRS. Apparently, few old fields existed on bottomland sites at the time of acquisition, and little forest management has occurred on them since, so there has been less opportunity to observe early-successional bottomland communities. Buffington et al. (1997) studied the avifauna of SRS sites recovering from deforestation caused by the increased temperature and flow associated with reactor discharge (figure 4.24). Total bird abundance was greater in the early-successional bird community of the Pen Branch floodplain (two to three years recovery time) than in that of the mid-successional Steel Creek (twenty-seven to twenty-eight years recovery time) and late-successional Tinker Creek (more than sixty years since last timber harvest). However, species richness and diversity were greatest in Tinker Creek and lowest in Pen Branch, which was dominated by a few common species (red-winged blackbird, common yellowthroat, white-eyed vireo, and indigo bunting

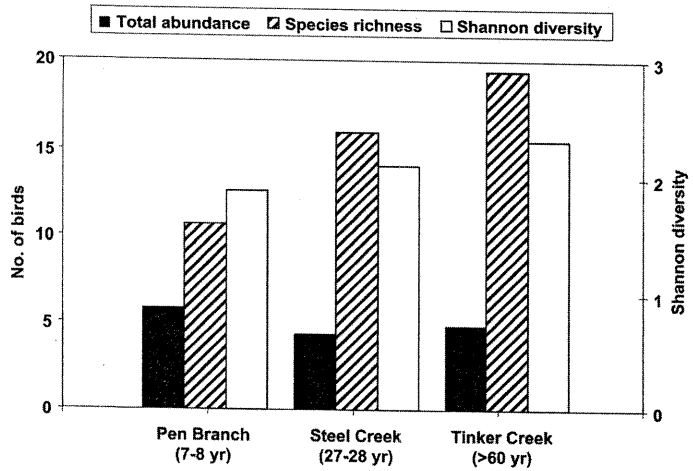

Figure 4.24. Abundance, species richness, and diversity (Shannon-Weaver index) of birds on 50-m (164-ft) radius plots in three successional stages of bottomland hardwood forest on the Savannah River Site, 1995–1996 (Buffington et al. 1997).

equaled 70 percent of the birds detected). In small patches (0.1–0.5 ha, or 0.3–1.25 ac) of early-successional bottomland habitat created by group selection timber harvest, according to Moorman and Guynn (2001), the same species, with the exception of red-winged blackbird, dominated two to four years post-harvest. However, they also noted use of these habitats by foraging family groups of forest-edge species such as northern parula and hooded warbler during mid to late summer.

Other early-successional habitats at SRS include road, railroad, and utility rights-of-way and old fields. Old fields, which dominated the SRS landscape during the 1950s and 1960s, were the focus of intensive study on old-field succession by Odum (1960) and other Savannah River Ecology Lab (SREL) researchers. Savannah sparrows, common during winter, were studied intensively (Norris and Hight 1957; Odum and Hight 1957; Norris 1960). However, by 1990 only 640 ha (1,581 ac) of old-field habitat remained at SRS (Workman and McLeod 1990). Rights-of-way are extensive at SRS, amounting to approximately 2,671 ha (6,600 ac), and may provide habitat similar to old fields, depending on vegetation control schedules. Although area-sensitive grassland species, such as Savannah and vesper sparrows, do not winter at SRS in the numbers seen during the 1950s and 1960s, these species do winter in rights-of-way and roadside corridors at SRS. During winter, the Henslow's sparrow, a sensitive species on SRS (see chapter 5), prefers utility rights-of-way, and Bachman's and grasshopper sparrows also use those habitats frequently (P. Champlin, U.S. Forest Service, and J. Kilgo, unpublished data). The breeding bird communities of old fields and rights-of-way are similar to those found during the first one to two years following planting in pine regeneration stands, when grasses and forbs still primarily dominate.

Seasonal Habitat Shifts

Although patterns of breeding-season habitat use generally persist throughout the year, many species relax their habitat preferences outside of the breeding season and use a greater diversity of habitats. For some species, such habitat shifts may be dramatic. During late summer and fall migration, many migrant species that use only mature bottomland hardwood forest during the breeding season move into the dense understory of early-successional bottomland habitat created by selection timber harvest (Kilgo, Miller, and Smith 1999). Lohr (1999) reported that red-headed woodpeckers were absent during the winter from pine forests in which they regularly bred, but Christmas Bird Count data indicate that they are common during the winter in bottomland hardwood forests on SRS. During the winter, foraging flocks of forest birds may use habitats that individual species in the flock (e.g., chickadees, titmice, woodpeckers) would not use during the breeding season. We need much more information on habitat-use patterns of birds outside of the breeding season.

Landscape Structure

Landscape structure and composition can have dramatic influences on bird communities. Although much of the landscape of the upper coastal plain surrounding the SRS is highly fragmented, the SRS landscape is nearly continuous forest (see chapter 1). Clear-cut timber harvests constitute a potential fragmenting effect, but those disturbances are temporary, and intensive research on SRS has documented few of the negative effects of forest fragmentation (e.g., increased nest depredation and brood parasitism). Brown-headed cowbirds do occur commonly throughout the SRS during the breeding season, and Moorman, Guynn, and Kilgo (2002) determined that parasitism of hooded warbler nests by brown-headed cowbirds did increase the closer a nest was to a habitat edge. However, the rate of brood parasitism was so low that it did not affect overall nesting success. Other studies have documented similarly low rates of brood parasitism on SRS (Sargent et al. 1998; Moorman 1999;

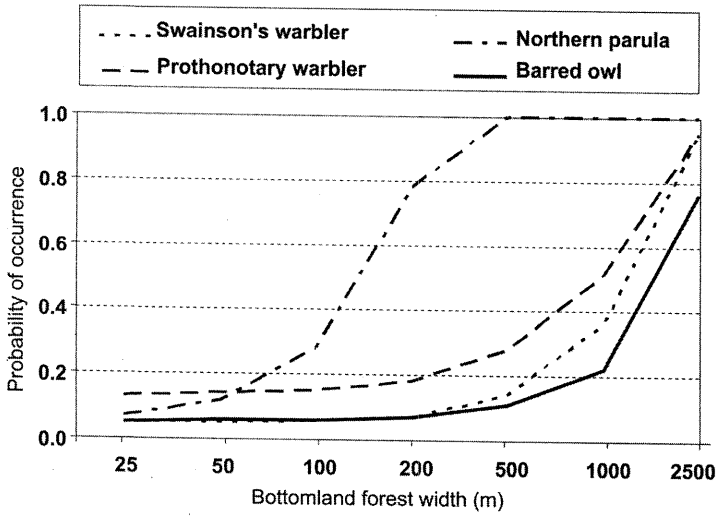

Figure 4.25. Probabilities of occurrence of four area-sensitive birds in bottomland hardwood forests of various widths on the Savannah River Site, 1993–1995 (Kilgo et al. 1998).

Stober and Krementz 2000, reviewed by Kilgo and Moorman 2003), and these rates are far below those reported for other regions of the country. Presumably, this trend results from the lower abundance of brown-headed cowbirds on SRS than in the surrounding landscape (Kilgo, Franzreb et al. 2000), which itself apparently is due to the general unsuitability of the forested SRS landscape as foraging habitat for cowbirds.

The landscape structure of SRS has resulted in a greater diversity of forest birds that breed on SRS than in the adjacent fragmented landscape of the upper coastal plain of Georgia and South Carolina but a lower diversity of field or open-habitat birds (Kilgo, Franzreb et al. 2000). Seventeen species were more abundant on SRS than off. Of these, nearly all were forest-interior species that prefer mature pine or bottomland hardwood forest. Thirty-two species were less abundant on SRS than off. These primarily included urban-suburban species and those characteristic of open fields.

The number of species in a given stand is positively related to size of the stand. In bottomland hardwood forests on SRS, the number of species increases as the width of the riparian zone (a correlate of stand size) increases (Kilgo et al. 1998). Area-sensitive species—those that occur only in large stands—include Swainson's warbler, prothonotary warbler, northern parula, barred owl, and Mississippi kite (figure 4.25; Kilgo et

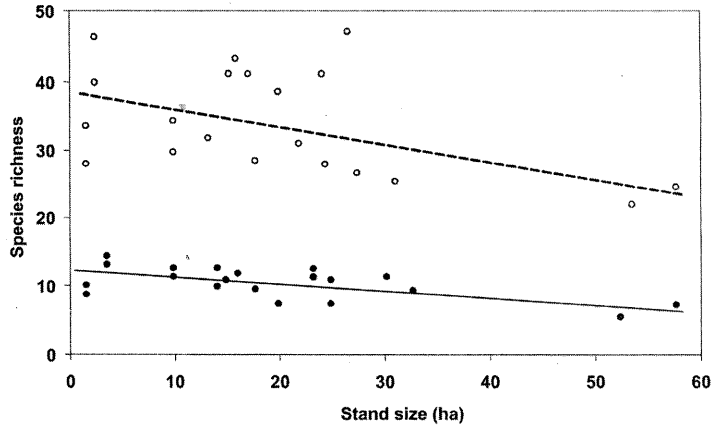

Figure 4.26. Number of shrub-successional bird species (closed circles) and total number of bird species (open circles) in clear-cuts of various sizes on the Savannah River Site, 1995–1996 (Krementz and Christie 2000).

al. 1998). Similarly, species richness is positively associated with stand size in SRS upland hardwood forests (Kilgo et al. 1999) and two- to seven-year-old longleaf and loblolly stands (J. Dunning, unpublished data). However, Krementz and Christie (2000) reported the opposite effect in two- to six-year-old longleaf pine stands (figure 4.26).

The habitat adjacent may affect the occurrence of some species in a given stand. For example, wood thrushes, red-eyed vireos, and ovenbirds do not occur in small upland hardwood stands surrounded by open habitat but do occur in stands of similar size and habitat surrounded by closed-canopy pine forest (Kilgo et al. 1997). The presence of forested habitat surrounding a woodlot, even if of a different type and age, may increase the functional size of the woodlot and allow certain area-sensitive species to persist there.

Isolation of a stand from other stands of similar habitat can affect the ability of some species to occupy a site. Kilgo et al. (1997) reported that the more isolated a stand of upland hardwoods, the lower the abundance of red-eyed vireos. Similarly, Dunning et al. (1995) reported that Bachman's sparrows were less likely to colonize isolated patches of suitable habitat (pine plantations one to five years old) than to colonize connected patches of habitat. Among unconnected patches, the greater the distance between a patch and a source population, the less likely the sparrows were to colonize the patch (figure 4.27). Therefore, Bachman's sparrows are absent from some areas of seemingly suitable, but isolated,

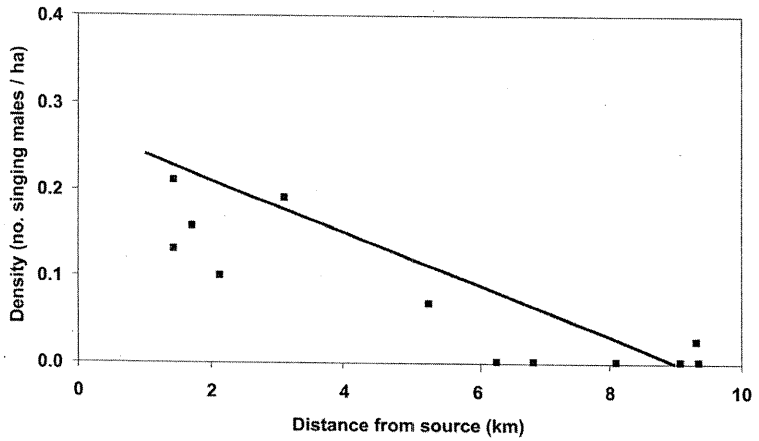

Figure 4.27. Densities of Bachman's sparrows in clear-cuts isolated by various distances from areas with source populations on the Savannah River Site in 1992 (reprinted by permission from Dunning et al. 1995, © 1995 Blackwell Publishing Ltd.).

habitat (Dunning and Watts 1990). Liu, Dunning, and Pulliam (1995) provided a model of the long-term impact of timber management on Bachman's sparrow populations by tracking their ability to use the temporally ephemeral and spatially scattered clear-cut habitat over a fifty-year time frame.

Historical Trends and the Effect of SRS Establishment

Bird censusing techniques have changed markedly over the fifty-year history of the SRS, making assessment of historical trends in bird abundance highly problematic. Fortunately, however, the SRS is one of the few sites with at least some form of long-term bird population data. The early surveys by Odum and Norris provide a rough baseline to compare species occurrence, if not abundance, over time. Three species that neither Odum (1952–1953) nor Norris (1957, 1963) reported as breeding on SRS, American redstart, black-and-white warbler, and ovenbird, now occur on site regularly during the breeding season, and breeding has been documented for the latter two. All three are forest-interior Neotropical migrants that have expanded their breeding ranges southward in recent years. Odum, Allen, and Pulliam (1993) noted similar southward range expansions in the vicinity of Athens, Georgia, approximately 161 km (100 mi) northwest of SRS. Whether these range expansions represent recolonization of once occupied habitat or new expansions is unclear. Nevertheless, habitat conditions during the 1950s likely were not as suitable because of the highly fragmented nature of the landscape at the time, whereas present habitat conditions seem favorable. American redstart and ovenbird still do not breed or are extremely rare breeders in the landscape surrounding the SRS (Kilgo, Franzreb et al. 2000). Conversely, once common species of open fields, particularly wintering birds such as Savannah and Henslow's sparrows, are rare or uncommon; Norris (1963) considered Savannah sparrows to be the most common species inhabiting old fields, a habitat nearly gone from SRS.

Although the counties surrounding the SRS underwent considerable reforestation during the latter half of the twentieth century, the landscape still has a significant agricultural component (Tansey and Hutchins 1988). This landscape may approximate habitat conditions available for birds on the SRS in 1950 better than its current reforested landscape. Thus, the abundance of forest birds and the rarity of open-field and suburban birds on the SRS relative to the surrounding counties (Kilgo, Franzreb et al. 2000) are likely representative of the changes in the SRS avifauna over the past fifty years.

McCallum, Leatherman, and Mayer (2000) identified raptors, aerial foragers, and nocturnal birds as groups that have "fallen between the cracks" in research and monitoring, and we know little of their ecology on the SRS. The habitat associations of these species, some of which are common, appear in table 4.22, at the end of this section. However, some species in these groups are either uncommon or are the subject of regional concern (e.g., American kestrel: Beheler and Dunning 1998; chapter 5), so monitoring of these groups on site is warranted.

Christmas Bird Count data (available at www.audubon.org/bird/cbc/index.html) indicate that king, Virginia, and sora rails occur regularly in the Pen Branch delta during winter. King rails reportedly nested in Craig's Pond and possibly other Carolina bays in 1956 (Norris 1963), but no recent breeding records exist, perhaps due to a lack of survey effort. Norris (1963) reported only a few records of Mississippi kites during the 1950s. The species currently is common during the breeding season along the Savannah River and in late summer across the SRS. Swallow-tailed kites, listed as endangered by the state of South Carolina, apparently did not occur on SRS during the 1950s (Norris 1963). They are now observed regularly during the breeding season, and one nest has been documented on SRS.

More work is needed to determine the status of many species on SRS (McCallum, Leatherman, and Mayer 2000).

Table 4.22 Bird habitat matrix for the Savannah River Site

This matrix presents predictions of the suitability of four successional stages of seven vegetation types as habitat for birds that use the SRS during the breeding season and the winter. The matrix, condensed and adapted from Hamel (1992), includes just those habitats that occur at SRS. However, this matrix differs somewhat from Hamel's. Predictions for some species, as footnoted, reflect our perceptions of SRS-specific habitat-use patterns. Where known, we include information on the validity of the predictions (see below). Finally, we have added information on the migratory status of each species.

After species, the first column of the matrix, labeled "Migrant," contains a code for the migratory status of each species. "R" represents resident, "T" represents Neotropical migrant, and "A" represents Nearctic migrant. See the text for definitions of these classifications. The matrix does not include species that migrate through the SRS annually during the spring and fall, as no adequate information is available on the habitat-use patterns of migrating birds. Mayer et al. (1997) present information on the status of these species on SRS. The column labeled "Season" indicates whether the species is present at SRS during the breeding season ("B"), defined as May–August; during the winter ("W"), defined as November–March; or both (indicated when information is given in both rows). Generally, species with predictions during the breeding season nest at SRS but not always. For example, only three species of wading birds nest on SRS, but several more use the site during the breeding season for foraging and so have habitat predictions for the breeding season.

The remaining columns represent habitats and particular successional stages. The vegetation types considered here, as defined by Hamel (1992), are longleaf pine–slash pine (LLSL), loblolly pine–shortleaf pine (LBSH), mixed pine-hardwood (MPHW), oak-hickory (OKHK), southern scrub oak (SOSO), oak-gum-cypress (OGCY), and bay swamp–pocosin (BSPO). LLSL includes longleaf and slash pine forests and is equivalent to USFS types 21 (longleaf pine) and 22 (slash pine). LBSH includes loblolly pine forest (shortleaf pine is rarely dominant at SRS) and is equivalent to USFS type 31 (loblolly pine). MPHW includes forests in which hardwoods (usually oaks) and pines (usually loblolly) each constitute at least 25 percent of the stocking. MPHW is equivalent to USFS types 13 (loblolly pine–hardwood), 44 (southern red oak–yellow pine), and 46 (bottomland hardwood–yellow pine). OKHK includes forests in which "a plurality of the stocking comprises upland oaks and hickories, singly or in combination, and where pines make up less than 25% of the stocking" (Hamel 1992). It is equivalent to USFS type 53 (white oak–red oak–hickory). SOSO includes forests of sandy, upland topography in which various species of scrub oaks make up at least 75 percent of the stocking. It is equivalent to USFS type 57 (scrub oak). OGCY includes bottomland forests in which water tupelo, black gum, sweetgum, oaks, or cypress dominate the canopy. It is equivalent to USFS types 61 (swamp chestnut oak–cherrybark oak), 62 (sweetgum–Nuttall oak–willow), 64 (laurel oak–willow oak), and 67 (bald cypress–water tupelo). BSPO includes forests of boggy, poorly drained soils in which various species of broadleaf "bay" trees dominate the canopy. Primary species are swamp tupelo, red maple, red bay, and sweet bay. BSPO is equivalent to USFS type 68 (sweet bay–swamp tupelo–red maple). Under each vegetation type are listed four successional stages: 1 (grass/forb), 2 (shrub/seedling), 3 (sapling/poletimber), and 4 (sawtimber).

The suitability ratings given in the body of the matrix are marginal ("M"), suitable ("S"), and optimal ("O"). Blank cells indicate unsuitable habitats. According to Hamel (1992, 12), "Optimal habitats are those in which the species occurs in highest frequency, greatest numbers, or both. Similarly, suitable and marginal habitats are those in which the species occurs in successively lower numbers and frequency." These designations imply nothing about relative productivity in various habitats. Kilgo et al. (2002) tested the ability of Hamel's matrix to predict presence or absence by considering predictions of "S" or "O" as habitats in which a species should be present and predictions of "M" or absent (i.e., blank cells) as habitats in which a species should be absent. Those species for which presence or absence was predicted well, when compared to actual field data, are footnoted.

			Habitat suitability by vegetation type and successional stage																									
			LLSL				LBSH				MPHW				OKHK				SOSO				OGCY				BSPO			
Species	Migrant	Season	1	2	3	4	1	2	3	4	1	2	3	4	1	2	3	4	1	2	3	4	1	2	3	4	1	2	3	4
Double-crested cormorant	A	B																							M	O				
Phalacrocorax auratus		W																												
Anhinga[a]	R	B																					M	M	M	O				
Anhinga anhinga		W																												
Great blue heron	R	B																								O		M	M	S
Ardea herodias		W																					M	M	M	M				

(continued)

Table 4.22 *(continued)*

			Habitat suitability by vegetation type and successional stage																									
			LLSL				LBSH				MPHW				OKHK				SOSO				OGCY				BSPO			
Species	Migrant	Season	1	2	3	4	1	2	3	4	1	2	3	4	1	2	3	4	1	2	3	4	1	2	3	4	1	2	3	4
Great egret[a]	A	B																					S	S	O	O		M	S	S
Ardea albus		W																												
Snowy egret[a]	A	B																					S	S	O	S		M	S	M
Egretta thula		W																												
Little blue heron[a]	A	B																					S	S	O	S		M	S	M
Egretta caerulea		W																												
Tricolored heron[a]	A	B																					S	S	S	S		M	S	M
Egretta tricolor		W																												
Cattle egret	A	B																					S	S	O	S		M	S	M
Bubulcus ibis		W																												
Green heron	R	B																					M	O	O	S		S	S	M
Butorides striatus		W																												
Black-crowned night heron[a]	A	B																					S	S	S	S		M	S	M
Nycticorax nycticorax		W																												
Yellow-crowned night heron[a]	A	B																						M	O	O		M	S	S
Nycticorax violacea		W																												
White ibis[a]	A	B																					M	S	O	S		M	S	S
Eudocimus albus		W																												
Black vulture	R	B		M	M	M		M	S	S		M	O	O		M	S	S		S	O		M	M	O	O		S	O	O
Coragyps atratus		W	M	M	M	M	M	M	M	M	M	M	S	S	M	M	M	M	M	S	O		M	M	O	O	M	S	O	O
Turkey vulture	R	B		M	S	S		M	S	S		M	O	O		M	O	O		S	O		M	M	O	O		M	S	S
Cathartes aura		W	M	M	S	S	M	M	M	M	M	M	S	S	M	M	M	M	M	S	O		M	M	O	O	M	M	S	S
Osprey	A	B				M			M	M															M	O			M	S
Pandion haliaetus		W																							M	O			M	S
Swallow-tailed kite	T	B				M								M												O				M
Elanoides forficatus		W																												
Mississippi kite[b]	T	B								M				M												O				M
Ictinia mississippiensis		W																												
Northern harrier	A	B																												
Circus cyaneus		W	M				M				S				S				M				S				M			
Sharp-shinned hawk[a]	A	B																												
Accipiter striatus		W			M	M			S	S			O	O			M	M			S				M	M			S	S
Cooper's hawk	A	B							M	M			M	O			M	O			M				M	M			M	M
Accipiter cooperii		W			M	M			S	S			O	O			M	M			S				M	M			S	S
Red-shouldered hawk	R	B			M	M																			M	O			M	O
Buteo lineatus		W	M	M	M	M																	M	M	S	O	S	M	S	O
Broad-winged hawk[a]	T	B															O													M
Buteo platypterus		W																												
Red-tailed hawk	R	B								M				O			O													M
Buteo jamaicensis		W	M	M	M	M	S	M	M	S	S	M	S	O	S	M	S	O	M	M	M		M				M	M	M	M
American kestrel	R	B	M				S				S				S				M											
Falco sparverius		W	M	M	M	M	O	M			O	M			O	M			S	M							M	M		
King rail	R	B																					M							
Rallus elegans		W																					M							

(continued)

Table 4.22 *(continued)*

Species	Migrant	Season	Habitat suitability by vegetation type and successional stage																									
			LLSL				LBSH				MPHW				OKHK				SOSO				OGCY				BSPO			
			1	2	3	4	1	2	3	4	1	2	3	4	1	2	3	4	1	2	3	4	1	2	3	4	1	2	3	4
Virginia rail	A	B																												
Rallus limicola		W																					M							
Sora	A	B																												
Porzana carolina		W																					M							
Common moorhen	R	B																					M	M	M	M				
Gallinula chloropus		W																					M	M	M	M				
Killdeer	R	B					M								M								M							
Charadrius vociferus		W					M																M							
Rock dove	R	B	M				M				M				M				M											
Columba livia		W	M				M				M				M				M											
Common ground-dove	R	B					O	M				M								O	S									
Columba passerina		W					S	M			M	M							O	O	S									
Yellow-billed cuckoo[b,c]	T	B											M	S			S	S			M				O	O			O	O
Coccyzus americanus		W																												
Eastern screech-owl	R	B			M	S			M	O			M	O			M	O			M				M	S			M	S
Otus asio		W			M	S			M	O			M	O			M	O			M				M	S			M	S
Great horned owl	R	B				S				O				O				S								M				M
Bubo virginianus		W			M	S			M	O			M	O			M	S							M	M			M	M
Barred owl	R	B																M							S	O				S
Strix varia		W																M							S	O				S
Common nighthawk	T	B	M	M	M	M													S	O	S									
Chordeiles minor		W																												
Chuck-will's-widow[b]	T	B			M	M			S	O			S	O			M	S			S								M	S
Caprimulgus carolinensis		W											S	S							S									
Whip-poor-will	T	B							S	S			S	O			S	S											M	M
Caprimulgus vociferus		W																												
Chimney swift	T	B																M								M				
Chaetura pelagica		W																												
Ruby-throated hummingbird[a]	T	B		M								M	M	M		M	S	S		M	M			M	S	S		S	S	S
Archilochus colubris		W																												
Belted kingfisher	R	B															M	M							M	S				
Ceryle alcyon		W															M	M							M	S				
Red-headed woodpecker[b]	R	B			M	O			M	S			M	S				M												
Melanerpes erythrocephalus		W			M	S			M	M			M	M				M							S	O			M	S
Red-bellied woodpecker[b]	R	B			M	S			M	S			S	O			S	O			M				M	O			M	O
Melanerpes carolinus		W			M	S		M	S	S		M	S	S		S	S	O		M	S				M	O			M	O
Yellow-bellied sapsucker	A	B																												
Sphyrapicus varius		W			M	M			M	S			S	O			S	O			S				M	S			M	M
Downy woodpecker[b,c]	R	B			M	M			M	S			S	O			S	O			S			M	S	O			M	S
Picoides pubescens		W			M	M		S	S	S		S	S	O		S	S	O		S	S			M	S	O			M	S
Hairy woodpecker[b]	R	B			M	M			M	M			M	S			M	O			S				M	O			M	S
Picoides villosus		W			M	M		M	M	M		M	M	S		S	S	O			S				M	O			M	S
Northern flicker[b]	R	B			M	S			M	S			S	O			M	S			S				S	S			M	M
Colaptes auratus		W	S		M	S	M	M	S	S	M	M	S	S	S	S	S	S	S	S	S		M		S	S	M		S	S
Pileated woodpecker[b,c]	R	B			M	S			M	S			M	S				O							M	O				S
Dryocopus pileatus		W			M	M			S	S			S	S			S	O							M	O				S

(continued)

Table 4.22 *(continued)*

			Habitat suitability by vegetation type and successional stage																									
			LLSL				LBSH				MPHW				OKHK				SOSO				OGCY				BSPO			
Species	Migrant	Season	1	2	3	4	1	2	3	4	1	2	3	4	1	2	3	4	1	2	3	4	1	2	3	4	1	2	3	4
Eastern wood-pewee[c]	T	B			M	O		M	M	O			M	O			M	O			M			M	M	M			M	O
Contopus virens		W																												
Acadian flycatcher[b,c]	T	B											M	M			M	M			M				O	O			M	S
Empidonax virescens		W																												
Eastern phoebe	R	B															M	M							M	M				
Sayornis phoebe		W	M	M	M	M	S	S	S	M	S	S	S	M	S	O	S	M	M	M	M		S	O	S	S	S	S	S	M
Great crested flycatcher[a,b]	T	B			M	O		M	M	S		M	S	O		M	M	S			M			M	S	S			M	S
Myiarchus crinitus		W																												
Eastern kingbird[b]	T	B	S			M	S				M				M				M											
Tyrannus tyrannus		W																												
Horned lark[a]	A	B																												
Eremophila alpestris		W					M				M				M								M							
Purple martin	T	B	M				M				M				M				M				M				M			
Progne subis		W																												
Barn swallow	T	B	M				M				M				M								M				M			
Hirundo rustica		W																												
Blue jay	R	B			M	S			M	S			M	O			M	O			S				M	S			M	M
Cyanocitta cristata		W		M	M	S		M	M	S		M	S	O		M	S	O		M	S			M	M	S		M	M	M
American crow	R	B			M	M			M	O			S	O			M	S			M				M	M			M	M
Corvus brachyrhynchos		W	S	M	M	M	S	M	M	O	S	M	S	O	S	M	M	M	S	M	M		S	M	M	M	S	M	M	M
Fish crow	R	B			M	M			M	O			M	S						M	S				M	M		M	S	S
Corvus ossifragus		W	M	M	M	M	S	M	M	S	S	M	M	S					M	M	S		S	M	M	M	S	M	S	S
Carolina chickadee[b]	R	B	M	M	S	S		S	S	S		S	S	O		M	M	S			S		M	M	S	S	M	M	S	S
Poecile carolinensis		W	M	M	S	S		S	S	O		S	S	O	M	S	S	S		S	S		M	M	S	S	M	M	S	S
Tufted titmouse[b,c]	R	B			M	S			M	S			S	O			S	O			S				S	O			M	S
Baeolophus bicolor		W		M	M	M		M	S	S		M	S	O		M	S	O		M	S			M	S	O		M	M	S
Red-breasted nuthatch	A	B																												
Sitta canadensis		W		M	S	S		M	O	O		M	S	O																
White-breasted nuthatch	R	B			M	M			M	M			M	M			M	O							M	S			M	M
Sitta carolinensis		W			M	M			M	M			M	M			M	O							M	S			M	M
Brown-headed nuthatch[c]	R	B			S	O			S	O			M	M																
Sitta pusilla		W		M	S	O		M	S	O			M	M																
Brown creeper	A	B																												
Certhia americana		W			S	S			S	O			S	O			S	S			M				S	S			M	M
Carolina wren[b,c]	R	B		M	S	S		M	S	S		S	O	O		S	O	O		S	O			M	O	O		S	O	O
Thryothorus ludovicianus		W		M	S	S		M	S	S		S	O	O		S	O	O		S	O			M	O	O		S	O	O
House wren	A	B																												
Troglodytes aedon		W	M	S	S	S	M	M			M	M			M	M			M	O	S		M	M			M	S		
Winter wren	A	B																												
Troglodytes troglodytes		W							M	S			S	S			S	S							O	O			O	O
Golden-crowned kinglet	A	B																												
Regulus satrapa		W		M	S	S		M	O	O		M	O	O			M	M							M	S			M	M
Ruby-crowned kinglet	A	B																												
Regulus calendula		W		S	S	S		S	O	O		S	O	O		S	S	S		M	S			M	S	O		S	S	S
Blue-gray gnatcatcher[c]	A	B			M	M							M	S			M	S			M				M	O			M	O
Polioptila caerulea		W						M	S	S		M	O	O						M	S		M	M	M	M		M	O	O
Eastern bluebird[c]	R	B	S	M	S	S	M		M	M	M		M	M	M		M	M	S	M	S									
Sialia sialis		W	S	S	S	S	S	M	S	S	M	M	M	M	M	M	M	M	S	M	S									

(continued)

Table 4.22 *(continued)*

			Habitat suitability by vegetation type and successional stage																									
			LLSL				LBSH				MPHW				OKHK				SOSO				OGCY				BSPO			
Species	Migrant	Season	1	2	3	4	1	2	3	4	1	2	3	4	1	2	3	4	1	2	3	4	1	2	3	4	1	2	3	4
Hermit thrush	A	B																												
Catharus guttatus		W			M	M			S	S			O	O			S	S			M				S	S			O	O
Wood thrush[b,c]	T	B							M	M			M	S			S	O			S				M	O			M	S
Hylocichla mustelina		W																												
American robin	R	B						M	M	M		M	M	M		M	M	M												
Turdus migratorius		W										M	M	M		M	M	M		M	M		M	M	S	O		S	O	O
Gray catbird[b]	R	B		M				S				S	M			M								M	M			M	M	
Dumatella carolinensis		W		S				S	M			S	M			S	M			S	S			S	S	M		O	O	S
Northern mockingbird[b]	R	B		S				S			M	M			M	M			M											
Mimus polyglottos		W	M	S			M	S			M	M			M	M			M											
Brown thrasher[b]	R	B		S	M	M		S	M	M		O	S	S		O	O	S		O	S			S				S	M	M
Toxostoma rufum		W		S	M	M		S	M	M		O	S	S	S	O	S	S	S	O	S			S	S	S		M	M	M
Cedar waxwing	A	B															M	M												
Bombycilla cedrorum		W										M	M	M		M	S	S		M	M			M	M	M		M	O	O
Loggerhead shrike	R	B					M																							
Lanius ludovicianus		W					M																							
European starling	R	B									M	M	M	M	M	M	M	M												
Sturnus vulgaris		W						M	M	M	M	M	M	M	M	M	M	M						M	S	S		M	S	S
White-eyed vireo[b,c]	A	B		S				S				S				S				S	M			S	S	O		O	S	O
Vireo griseus		W																		O	S			S	M	M		O	S	M
Blue-headed vireo[b]	A	B							M	M			M	M			M	M												
Vireo solitarius		W			M	S			S	O			S	O							S				M	M			S	O
Yellow-throated vireo[b,c]	T	B												S			O								O				M	
Vireo flavifrons		W																												
Red-eyed vireo[c]	T	B							M	M			M	S			S	O							M	O			M	S
Vireo olivaceous		W																												
Orange-crowned warbler	A	B																												
Vermivora celata		W								M	M	M	M	M					M	S	M		M	S	S	S	M	O	S	M
Northern parula[a,b,c]	T	B											M	S			S				S				S	O				S
Parula americana		W																							M	M				
Yellow-rumped warbler	A	B																												
Dendroica coronata		W		M	M	M		M	S	S		S	O	O		M	M	M		S	S			S	O	O		O	O	O
Yellow-throated warbler[a,c]	T	B			M	M			M	S			M	S			M	M							M	O			M	S
Dendroica dominica		W																												
Pine warbler[b,c]	R	B		S	S	O		M	M	S	O	M	M	S	S					M	M									
Dendroica pinus		W	S	S	S	O		M	S	S	O	M	S	S	S					M	M									
Prairie warbler[a,b]	T	B		O		S		O		S		S				M														
Dendroica discolor		W																												
Palm warbler	A	B																												
Dendroica palmarum		W	M	M	M			S	O	M		M	S	M		M	M	M		S	O	M						M	S	M
Black-and-white warbler	T	B											M	S			S	O			S				S	S			M	M
Mniotilta varia		W											M	S			M	M			M				S	O			S	O
American redstart[a,b,c]	T	B																							O	S			O	S
Setophaga ruticilla		W																												
Prothonotary warbler[c]	T	B																							S	O			M	S
Protonotaria citrea		W																												
Swainson's warbler[c]	T	B																							S	O			S	O
Limnothlypis swainsonii		W																												
Ovenbird[b]	T	B							M	M			S	O			S	O							M	S			M	S
Seiurus aurocapillus		W																												

(continued)

Table 4.22 *(continued)*

			Habitat suitability by vegetation type and successional stage																							
			LLSL				LBSH				MPHW				OKHK				SOSO				OGCY				BSPO			
Species	Migrant	Season	1	2	3	4	1	2	3	4	1	2	3	4	1	2	3	4	1	2	3	4	1	2	3	4	1	2	3	4
Louisiana waterthrush[b,c]	T	B												M											M	O			M	O
Seiurus motacilla		W																												
Kentucky warbler[b,c]	T	B												M											S	O			S	S
Oporornis formosus		W																												
Common yellowthroat[b,c]	A	B	M	S	M	M	S	M			S	S			S	S				M			S	O	M	S	M	O		
Geothlypis trichas		W	M	M			M	M			M	M			M	M			M	S			M	M			S	O		
Hooded warbler[b,c]	T	B											M	S											S	O			S	O
Wilsonia citrina		W																												
Yellow-breasted chat[a,b,c]	T	B		S			M	O	M		M	S			M	S								S						
Icteria virens		W																												
Summer tanager[b]	T	B			M	S			M	S			S	O			S	O			S				M	S			M	M
Piranga rubra		W																												
Northern cardinal[b,c]	R	B		S	S	S		S	S	S		S	S	O		O	O	S		S	S		M	S	S	S	M	S	S	S
Cardinalis cardinalis		W	M	S	S	S	S	S	S	S	S	O	O	O	S	S	S	S		S	S		M	S	S	S	M	S	S	S
Blue grosbeak[b]	T	B		S			M	S			M	S			M	M				M			M	M				M		
Guiraca caerulea		W																												
Indigo bunting[a,b,c]	T	B		S	M	S	M	O		M	M	S	M	M	M	S	M	M		M	M		M	S	M	S		S	M	M
Passerina cyanea		W																												
Painted bunting[b]	T	B						S																S						
Passerina ciris		W																												
Eastern towhee[b,c]	R	B		O	O	S		S	S	S		O	O	S		O	S	S		O	O			S	M	M		S	S	M
Pipilo erythrophthalmus		W		O	O	S		S	S	S		O	O	S		O	M	M		O	O			S	M	M		S	S	M
Bachman's sparrow[b,c]	R	B	O	S	M	O	S	O	M	S	M	S																		
Aimophila aestivalis		W	O	S	M	O	S	M	M	S	M	M																		
Chipping sparrow[b,c]	R	B			M	S	M	M	M	S	M	M	M	S			M	M												
Spizella passerina		W	M	M	M	M	S	M	M	S	M	M	M	M	M				S	M	M									
Field sparrow[c]	R	B		S			S	O			S	O				O														
Spizella pusilla		W	S	S			O	S			O	S			O	S			S	M										
Vesper sparrow	A	B																												
Pooecetes gramineus		W					S				S				S				M											
Savannah sparrow	A	B																												
Passerculus sandwichensis		W	M				S				S				S				M				S				M			
Grasshopper sparrow	A	B																												
Ammodramus savannarum		W	S	M			S	M			M	M			M				M				M				M			
Henslow's sparrow	A	B																												
Ammodramus henslowii		W	M			M	M			M																	O			
Fox sparrow	A	B																												
Passerella iliaca		W		M	M	M		M	S	O		M	S	O		M	M	M					M	M	M	M		M	S	O
Song sparrow	A	B										M																		
Melospiza melodia		W	M	M			S	M			S	M			S	M							M	M			S	M		
Swamp sparrow[b]	A	B																												
Melospiza georgiana		W	M								M												S	O			S	O		
White-throated sparrow	A	B																												
Zonotrichia albicollis		W	M	M	M	M	M	M	M	M	M	M	S	S	M	M	S	S	M	M	M		M	M	S	O	M	S	S	O
Dark-eyed junco	A	B															M	M												
Junco hyemalis		W	M	M	S	S	M	S	S	O	M	S	S	O	M	M	M	M									M	M	M	M
Red-winged blackbird	R	B	M				S				S				S				M				O	O			O	O	M	
Agelaius phoeniceus		W	M				M				M				M				M				O	O	S	M	O	O	S	M
Eastern meadowlark[b]	R	B	S	M			O	M			O	M			O	M			M				M							
Sturnella magna		W	M	M			O	M			O	M			O	M			M				M							

(continued)

Table 4.22 *(continued)*

Species	Migrant	Season	Habitat suitability by vegetation type and successional stage																					
			LLSL				LBSH				MPHW				OKHK				SOSO				OGCY				BSPO			
			1	2	3	4	1	2	3	4	1	2	3	4	1	2	3	4	1	2	3	4	1	2	3	4	1	2	3	4
Rusty blackbird	A	B																												
Euphagus carolinus		W											M	M			M	M					M	M	S	O	M	M	S	O
Brewer's blackbird	A	B																												
Euphalus cyanocephalus		W					M				M				M															
Common grackle	R	B			M	M			S	S			S	S									S							
Quisculus quiscula		W							M	M			M	M			M	M			M	M	M	M	S	S		M	S	S
Brown-headed cowbird[b]	R	B	M	O	M	S	M	O	M	S	M	M	M	M	M	M	M	M	M	M	M		M	M	M	O	M	M	M	O
Molothrus ater		W	M	M	M	M	M	M	M	M	M	M	M	M	M	M	M	M	M	M	M		M	M	M	M	M	M	S	S
Orchard oriole[b]	T	B	M	S		M		S	M	M					M			M												
Icterus spurius		W																												
Purple finch	A	B																												
Carpodacus purpureus		W			M	M			M	S			S	O			M	S							M	S			M	S
House finch	R	B																												
Carpodacus mexicanus		W					M				M	M			M	S	M	M												
Pine siskin	A	B																												
Carduelis pinus		W		M	M	M	M	S	S	O	M	S	S	O	M	M	M	M					S	S	S			M	M	M
American goldfinch[b]	R	B					M	M			M	M				S														
Carduelis tristis		W	M	M	M	M	O	S	S	S	O	S	S	S	S	S	S	S	M	M	M		M	M	S	S	M	M	M	M
Evening grosbeak	A	B																												
Hesperiphona vespertina		W			M	M			S	O			M	O			M	M											M	M
House sparrow	R	B					M				M				M				M											
Passer domesticus		W					M				M				M				M											

[a] Hamel's (1992) matrix modified to reflect SRS-specific seasonal occurrence.

[b] Hamel's (1992) matrix modified to reflect SRS-specific habitat associations.

[c] Hamel's (1992) matrix adequately predicted presence/absence (Kilgo et al. 2002).