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
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).

Nongame Mammals

Susan C. Loeb, Lynn D. Wike, John J. Mayer, and Brent J. Danielson

Fifty-four species of mammals inhabit (or have recently inhabited) the Savannah River Site (SRS; Cothran et al. 1991; table 4.24). Although far fewer in number than other taxa (see the previous five sections of this chapter), the mammals of SRS represent a wide diversity of body sizes, life histories, habitat affinities, and food habits. They range in body size from approximately 5 g (0.2 oz; the least shrew; see table 4.24 for scientific names) to 200 kg (441 lbs; black bear). They feed on herbaceous material, acorns, mushrooms, insects, other invertebrates, and vertebrates. Various mammals on SRS use underground tunnels, semi-aquatic environments, terrestrial habitats, and trees. They also employ a wide variety of locomotory modes, including burrowing, swimming, running, gliding, and flying.

Other than the eastern cougar, which has been extirpated regionally, no mammals on the SRS are on the federal list of threatened and endangered species. However, the South Carolina Department of Natural Resources has designated Rafinesque's big-eared bat as endangered, the southeastern bat as threatened, and the star-nosed mole, hoary bat, northern yellow bat, little brown bat, swamp rabbit, fox squirrel, eastern woodrat, spotted skunk, and black bear as species of special concern (table 4.24).

The SRS has been a center of mammal research since its establishment in the early 1950s (Cothran et al. 1991). Extensive studies conducted by Drs. Eugene P. Odum, Frank B. Golley, and Michael H. Smith of the University of Georgia and the Savannah River Ecology Laboratory (SREL), along with their students, have contributed greatly to our knowledge of SRS mammals, as well as to the field of mammalogy generally. Cothran et al. present a cross-indexed bibliography of the 304 references published between the mid-1950s and 1991 on mammals of the SRS, which is an invaluable reference for anyone working on mammals of the southern coastal plain. Because the SRS was primarily in old fields and cleared areas in the 1950s (White and Gaines 2000), much of the initial research focused on early-successional species such as the old-field mouse, cotton rat, and southern short-tailed shrew, as well as their mammalian predators (Cothran et al. 1991). To aid management, extensive work has been conducted on the population dynamics, biology, and genetics of white-tailed deer and wild hog populations. Much of the mammal

Table 4.24 Taxonomic listing and conservation status of the mammals of the Savannah River Site

Order	Family	Scientific name	Common name	Status[a]
Marsupialia	Didelphidae	***Didelphis virginiana***	**Virginia opossum**	
Insectivora	Soricidae	***Blarina carolinensis***	**Southern short-tailed shrew**	
		Cryptotis parva	**Least shrew**	
		Sorex longirostris	**Southeastern shrew**	
	Talpidae	***Scalopus aquaticus***	**Eastern mole**	
		Condylura cristata	**Star-nosed mole**	SC
Chiroptera	Vespertilionidae	***Corynorhinus rafinesquii***	**Rafinesque's big-eared bat**	SE
		Eptesicus fuscus	**Big brown bat**	
		Lasionycteris noctivagans	**Silver-haired bat**	
		Lasiurus borealis	**Red bat**	
		Lasiurus cinereus	**Hoary bat**	SC
		Lasiurus intermedius	**Northern yellow bat**	SC
		Lasiurus seminolus	**Seminole bat**	
		Myotis austroriparius	**Southeastern bat**	ST
		Myotis lucifugus	**Little brown bat**	SC
		Nycticeius humeralis	**Evening bat**	
		Pipistrellus subflavus	**Eastern pipistrelle**	
		Tadarida brasiliensis	**Brazilian free-tailed bat**	
Xenarthra	Dasypodidae	***Dasypus novemcinctus***	**Nine-banded armadillo**	
Lagomorpha	Leporidae	*Sylvilagus floridanus*	Eastern cottontail	
		Sylvilagus aquaticus	Swamp rabbit	SC
		Sylvilagus palustris	Marsh rabbit	
Rodentia	Sciuridae	*Sciurus carolinensis*	Gray squirrel	
		Sciurus niger	Fox squirrel	
		Glaucomys volans	**Southern flying squirrel**	
	Castoridae	*Castor canadensis*	Beaver	
	Cricetidae	***Oryzomys palustris***	**Marsh rice rat**	
		Reithrodontomys humulis	**Eastern harvest mouse**	
		Peromyscus polionotus	**Old field mouse**	

(continued)

Table 4.24 *(continued)*

Order	Family	Scientific name	Common name	Status[a]
Rodentia	Cricetidae	***Peromyscus leucopus***	**White-footed mouse**	
		Peromyscus gossypinus	**Cotton mouse**	
		Ochrotomys nutalli	**Golden mouse**	
		Sigmodon hispidus	**Hispid cotton rat**	
		Neotoma floridana	**Eastern wood rat**	SC
		Microtus pinetorum	**Pine vole**	
		Ondatra zibethicus	**Muskrat**	
	Muridae	***Rattus norvegicus***	**Norway or brown rat**	
		Rattus rattus	**Roof or black rat**	
		Mus musculus	**House mouse**	
Carnivora	Canidae	*Canis latrans*	Coyote	
		Canis familiaris	Feral dog	
		Urocyon cinereoargenteus	Gray fox	
		Vulpes vulpes	Red fox	
	Felidae	*Felis catus*	Feral cat	
		Felis concolor	Cougar	FE
		Lynx rufus	Bobcat	
	Mustelidae	*Lontra canadensis*	River otter	
		Mephitis mephitis	Striped skunk	
		Spilogale putorius	Eastern spotted skunk	SC
		Mustela vison	Mink	
		Mustela frenata	Long-tailed weasel	
	Procyonidae	*Procyon lotor*	Raccoon	
	Ursidae	*Ursus americanus*	Black bear	
Artiodactyla	Cervidae	*Odocoileus virginianus*	White-tailed deer	
	Suidae	*Sus scrofa*	Wild hog	

Note: Species in bold type are discussed in this chapter. Others are discussed in other chapters in this volume. Common and scientific names follow Wilson and Reeder (1993).

[a] SC = state species of concern; ST = state threatened; SE = state endangered; FE = federally endangered.

Table 4.25 Primary habitats of nongame mammals of the Savannah River Site

Common name	Old fields/ clear-cuts	Upland pine	Mesic pine-hardwood	Upland hardwoods	Bottomland hardwoods	Aquatic/ semi-aquatic
Short-tailed shrew	X	X	X	X	X	
Least shrew	X	X				
Southeastern shrew	X	X	X	X	X	
Eastern mole	X	X		X		
Star-nosed mole						X
Big brown bat				X	X	
Silver-haired bat			X			
Red bat				X	X	
Hoary bat				X		
Northern yellow bat			X		X	
Seminole bat		X				
Southeastern bat					X	
Little brown bat					X	
Evening bat		X	X		X	
Eastern pipistrelle			X	X	X	
Big-eared bat					X	
Nine-banded armadillo		X	X	X		
Southern flying squirrel		X	X	X	X	
Marsh rice rat					X	X
Eastern harvest mouse	X	X				
Old field mouse	X	X				
Cotton mouse	X	X	X	X	X	
Golden mouse			X	X	X	
Hispid cotton rat	X	X				
Eastern wood rat			X	X	X	
Pine vole	X	X	X	X		
Black rat	X					
Norway rat	X					
House mouse	X					

Three types of open habitats occur on the SRS: old fields, clear-cuts, and rights-of-way. Old fields are dominated by perennial grasses and patches of short, semi-woody shrubbery such as blackberry (*Rubus* spp.). Clear-cuts contain mixtures of annual, biennial, and perennial plants. Utility rights-of-way are frequently mowed, burned, or sprayed for woody vegetation control and contain mixtures of perennial plants and blackberry. Species found primarily in these habitats include the least shrew, southern short-tailed shrew, southeastern shrew, old-field mouse, harvest mouse, cotton rat, eastern mole, and pine vole (table 4.25). However, because the three open habitats differ in amount of woody vegetation; amount of downed, woody debris; and specific vegetation, they may also differ in the relative abundance of small mammal species (e.g., Golley, Gentry et al. 1965). For example, the least shrew and the southern short-tailed shrew are common in old fields, but the southern short-tailed shrew is rarely captured in clear-cuts or rights-of-way (Danielson, pers. obs.). Clear-cuts, the most common open habitat on the SRS, are similar to power line rights-of-way; cotton rats and old-field mice strongly dominate small-mammal communities in both habitats (Anderson 1995; Danielson and Anderson 1999). Blackberry thickets and shrubs provided dense cover ideal for cotton rats (Bowne, Peles, and Barrett 1999; Lidicker et al. 1992). Cotton mice may also be found in early-successional habitats but are most common in older successional stages (Golley, Gentry et al. 1965; Loeb 1997).

Open habitats are also important as foraging sites for some species of bats. Big brown bats, evening bats, eastern red bats, and Seminole bats commonly feed over open habitats at SRS (Menzel, Menzel, Kilgo et al. 2003). Menzel et al. detected bat activity at 75 percent of "grass/brush" survey points on SRS, a level exceeded only at wetland survey points (table 4.26). Similarly, Menzel (1998) found higher levels of foraging and feeding activity by bats in open areas within bottomland forest, such as skidder trails and small forest gaps created by a group selection harvest, than in the mature, intact bottomland hardwood forest.

Forested habitats make up more than 80 percent of the SRS. Both physiography and land-use history strongly influence their distribution (White and Gaines 2000). Imm and McLeod (see the first section, "Vegetation Types," in this chapter) use many forest-type classifications to describe the forests of SRS. For this section, we chose to classify forests as upland pine (including longleaf, loblolly, and slash pines; see appendix for scientific names of plants), mesic pine-hardwood, upland hardwood, and bottomland hardwood-swamp forests. In 1997, 70 percent of the forested

Table 4.26 Levels of foraging bat activity (percent of sampling points with bat activity, all species combined) over nine habitats on the Savannah River Site

Habitat	Activity level (%)
Lakes and ponds	88
Carolina bays	80
Grass/brush	75
Forest gaps	71
Bottomland hardwoods	67
Upland hardwoods	64
Longleaf pine	59
Pine/hardwood	57
Slash/loblolly pine	49

Source: Menzel, Menzel, Kilgo et al. 2003.

area was in upland pines, 3.5 percent in mesic pine-hardwood, 3.4 percent in upland hardwood, and 23.2 percent in bottomland hardwood–cypress tupelo forests (White and Gaines 2000).

Few nongame mammals are restricted to one forest type. Rice rats occur predominantly in bottomland hardwoods associated with wetlands and swamps (Wolfe 1982), but they also occupy pine stands with a dense understory (Mitchell et al. 1995) or clear-cuts near marshes or swampy areas (Sparling 1996). Star-nosed moles are semi-aquatic and usually live in close proximity to swamps, lakes, and Carolina bays (Petersen and Yates 1980). Occasional captures in upland pine forests on the SRS probably represent dispersal movement (McCay, Komoroski, and Ford 1999). Seminole bats apparently prefer to roost in pine foliage, whereas red bats prefer to roost in the foliage of hardwoods (Menzel et al. 1998). Pipistrelles may also rely on hardwood foliage for roost sites (Carter et al. 1999). Most of the other species associated with forests occupy a wide cross-section of forest types. For example, southern short-tailed shrews, southern flying squirrels, and cotton mice commonly occur in all of the forest types on the SRS (table 4.25) but probably prefer forests containing abundant hardwood mast, particularly during fall and winter (e.g., Heiterer 1994). The eastern woodrat is also a habitat generalist (Wiley 1980; Whitaker and Hamilton 1998), found in both upland and bottomland hardwood forests, open sites, near abandoned structures (Cothran et al. 1991), and in mature longleaf pine stands (Loeb 1999).

Physical Factors

Factors other than vegetation type and age may also affect the distribution of mammals. For example, soil type is an important factor governing the distribution of fossorial mammals. Thus, species that require well-drained soils, such as the eastern mole and the pine vole, are absent from areas such as bottomland hardwoods, with their heavy soils (Yates and Schmidly 1978; Smolen 1981). The presence and amount of coarse woody debris within a habitat may affect the abundance of some mammalian species. Snags and stumps are important roost and nest sites for a number of mammals (Loeb 1996b). For example, cotton mice use stumps as their primary day refuge in upland pine forests on the SRS (McCay 2000), southern flying squirrels commonly use cavities in snags (Muul 1974), and eastern woodrats occasionally use large stumps and snags for nesting (Fitch and Rainey 1956). Cavities and the loose bark of snags are also important roosting sites for evening bats (Menzel 1998; Menzel, Carter et al. 2001) and silver-haired bats (Whitaker and Hamilton 1998). Although cotton mice do not require coarse woody debris, they are more abundant (figure 4.29) and have higher reproductive and survival rates in longleaf pine stands with abundant coarse woody debris than in areas with almost no coarse woody debris (Loeb 1999). The characteristics of coarse woody debris may also be important. Cotton mice in upland loblolly pine stands on the SRS preferentially select longer logs over shorter logs for travel (McCay 2000).

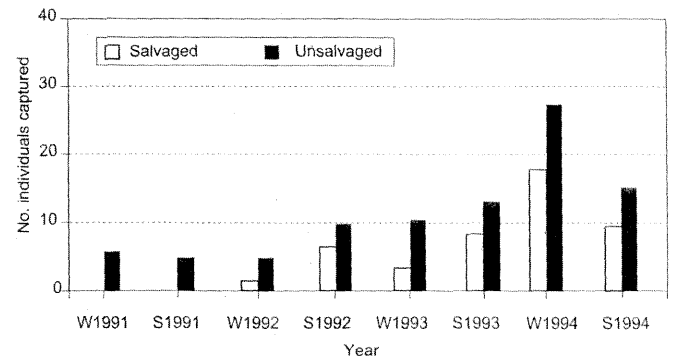

Figure 4.29. Number of cotton mice captured during winter (W) and spring (S) 1991–1994 on plots where tornado damage created a pulse of dead wood in 1989 on the Savannah River Site (adapted from Loeb 1999). Salvaged plots had dead wood removed within the first year; unsalvaged plots did not.

with many habitats and is considered at spatial scales from hectares to many square kilometers (Turner 1989). Each habitat or patch within a landscape may be characterized by its size, shape, isolation, and juxtaposition to other patch types. All of these factors may have a large effect on the plants and animals that inhabit a patch. In particular, as patches get smaller and more isolated, they will likely support fewer species, and the populations of organisms within those patches will be more vulnerable to local extinction (Harris 1984).

The field of landscape ecology is relatively new, but extensive studies on the SRS have tested the effects of habitat fragmentation on abundance and distribution of small mammals. For example, Yates, Loeb, and Guynn (1997) found that clear-cut size had a significant effect on small mammal species richness and diversity (figure 4.30). The greatest impact was on cotton rats. The relative density of cotton rats increased with clear-cut size, and no cotton rats were captured in clear-cuts of less than 6 ha (15 ac). Although this suggests that clear-cuts must be of a minimum size to support cotton rat populations, Menzel et al. (in press) found cotton rats

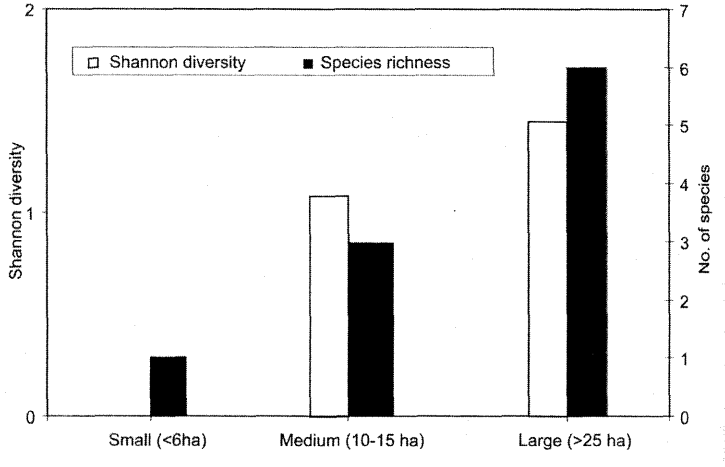

Figure 4.30. Diversity (Shannon-Weaver index) and species richness of small mammals in three sizes of clear-cuts on the Savannah River Site, 1991–1992 (Yates et al. 1997).

old-field mice and cotton rats, must disperse to and colonize the sites quickly. Because travel corridors increase connectivity among patches within a habitat mosaic, they may be important for colonization of newly created sites such as clear-cuts (Harris 1984). Menzel et al. (in press) found that species richness and diversity of small mammals that colonized gaps or small clear-cuts in bottomland hardwood forest were inversely related to distance to other open areas. Skidder trails created during harvesting operations probably acted as important travel corridors. In contrast, Anderson (1995) did not find a correlation between colonization of clear-cuts and distance to the nearest open site, and there was little correlation between the numbers of animals captured in clear-cuts and adjacent power line rights-of-way on SRS (Anderson 1995; Danielson and Anderson 1999). Further, in an experimental landscape designed specifically to test the effects of corridors on animal movement patterns, corridors had no effect on dispersal of old-field mice (Danielson and Hubbard 2000) and little effect on the dispersal patterns of cotton rats (Bowne, Peles, and Barrett 1999). Thus, corridors may not be particularly important for early-successional small mammal species on SRS, perhaps due to its extensive road system. In areas where there are fewer roads, however, such as in bottomland hardwood forests, the creation of corridors such as skid trails may facilitate the colonization of newly created open areas. Forested corridors may be important for species such as flying squirrels, which require a forest canopy for movement. Lack of forested corridors may restrict their movements and prevent dispersal among forested patches. The juxtaposition of habitats may also determine the suitability of a habitat for a species. For example, cotton rats living near Carolina bays prefer blackberry thickets bounded by tall grassland over blackberry thickets bounded by water (Lidicker et al. 1992). These observations highlight the need for more information on the effects of landscape structure and dynamics on the long-term viability of mammal populations.