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INTRODUCTION

Mammals constitute an important part of most terrestrial ecosystems. Because they tend to be nocturnal or crepuscular, fossorial or semifossorial, and all are cryptic either in their behavior or markings, most mammals are not conspicuous. Detection and study of mammals involves knowledge of activity and habitat preference, plus a heavy measure of patience and persistence. The continued well-being of the mammalian species of an area should be of prime interest to people charged with the management of our natural resources. When the mammalian fauna declines in abundance and/or local populations are exterminated, we may have serious environmental problems with potential or already occurring effects for man. Some mammals are part of the human food chain, and therefore, may be possible sources for contaminants in the diet. These considerations make it likely that mammals will continue to be a focal point of interest for the general public and for scientific research.

Our objective in writing this report is to provide information on the taxonomy, distribution, habitat preference, population biology and ecology of mammals occurring on the U.S. Department of Energy's Savannah River Site (SRS), which is located on the Atlantic coastal plain near Aiken, South Carolina. The primary purpose of this report is to give professional biologists, students, and other interested people an initial familiarity with the mammals of the SRS. We include lists and keys to the pertinent species, as well as descriptions of collecting methods, ecological relationships of the species, and a cross-indexed bibliography to the available literature for the SRS mammals. This report should allow interested people to pursue in depth various biological topics concerning SRS mammals by identifying pertinent literature. Certain species that are particularly well-known on the SRS are highlighted and their biology is discussed in greater detail. In addition, where applicable, a brief outline of how a particular mammal has been involved in research on the SRS is provided. This report is not a definitive document on the taxonomy of these species. The keys are designed to identify distinctive characteristics of most species, however, for some species of bats, canids (especially dogs and coyotes), and for the three *Peromyscus* species, we refer the reader to more detailed accounts such as (Golley, 1962; Hall, 1981). The general format of this report follows that of Gibbons and Semlitsch (1991) for the reptiles and amphibians of the SRS.

Fifty-four species of mammals might reasonably be expected to occur on the SRS. This is a majority of the 57 species listed for the state of South Carolina by Golley (1966). However, these numbers are small compared with the approximately 800 species listed for North America by Hall (1981). The 54 species of mammals include 41 of the 233 genera, 17 of the 45 families, and eight of the 11 orders listed for North America.

The study of mammals in South Carolina has had a long history, but prior to the extensive collections of R. H. Coleman from 1919 to 1954 (Golley, 1966) few papers on the taxonomy, distribution, and general natural history of mammals in

the state were published. During this early period, F. W. Sherman of Clemson College and E. B. Chamberlain, former Curator of Vertebrate Zoology at the Charleston Museum, made substantial contributions to the knowledge of South Carolina mammals. In the early 1950's mammal research on the upper coastal plain region in South Carolina was accelerated. With the acquisition of the SRS property in 1951 by the then United States Atomic Energy Commission, extensive areas of land formerly under cultivation were suddenly abandoned. At the time Dr. E. P. Odum of the University of Georgia, along with graduate students, initiated a series of integrated ecological investigations of the old-field ecosystems on these abandoned farm lands. Much of this work established Dr. Odum's preeminence in this area of research and formed a foundation for his later election to the National Academy of Science and his receipt of the Presidential Science Medal.

The initial studies were surveys to establish the kinds and relative abundance of mammals present. As the vegetation on the site has succeeded, different species have been studied more extensively than others partly because they have become more abundant. Thus, one of the first species to be emphasized was the old-field mouse, *Peromyscus polionotus,* the most conspicuous species in the sparsely vegetated fields. Associated with the old-field mouse was the house mouse, *Mus musculus*, which formed feral field populations when the human inhabitants departed from the site in 1951. Because some people thought that rodent populations would increase dramatically at this time and that their predators would also increase, a long term trapping study of the furbearers was initiated in 1954 by J. E. Wood of the United States Public Health Service. The annual furbearer census based on this trapping technique eventually provided over 29 consecutive years of data. As succession proceeded toward a grass-shrub stage, *P. polionotus* and *M. musculus* populations declined, and emphasis was placed on studies of the cotton rat, *Sigmodon hispidus*, which had started dispersing out of the hedgerows and fencerows and establishing dense populations in the old fields. *Mus musculus* populations gradually disappeared from the natural areas, became quite rare by the late 1960's, and currently are considered extinct as feral field populations in the central part of the SRS. Field studies of these species were frequently followed by in-depth investigations of their growth and reproductive biology, behavior, energetics, mineral cycling, and genetics.

The progress of succession was not the only factor which influenced the direction of mammal research on the SRS. The level of funding by government agencies had a profound effect, as well as did the interest of the principal scientists involved in the work. The level of funding was not very high to begin with and much of the work was conducted by students who used the data for completion of graduate degrees. These students were supervised by faculty who commuted to the site, frequently on the weekends. The early studies by students dealt with population structure and dynamics (Davenport, 1964; Caldwell, 1964; Gentry, 1964; Caldwell and Gentry, 1965a and 1965b; Gentry, 1966). Such studies were ideal for low research budgets since the major equipment required was a few mammal traps and cages. Several small mammal enclosures were constructed at this time and used to

observe interactions between species. These enclosures were later used to study radiation effects on small mammal populations. Enclosure studies have been an important part of the mammal research program on the SRS since the construction of the first enclosure. At present there are seven small mammal enclosures on the SRS.

Following the early basic studies of population dynamics, the interest shifted to the effects of ionizing radiation on natural populations and studies were conducted on a variety of species (Golley et al., 1965b; Williams et al., 1968; Pelton and Provost, 1969; Selander, 1970) including furbearers (Golley et al. 1965c, d). At about the same time, studies were being conducted on the physiological ecology of mammals. These studies were concerned with excretion rates of radioactive isotopes (Golley et al., 1965e; Orr, 1967), food intake and assimilation (Golley et al., 1965d), and energy flow (Buechner and Golley, 1967; Petrides et al., 1968). Frank Golley of the University of Georgia became the on-site Director of the Savannah River Ecology Laboratory (SREL) in 1962 and the growth of research in this area stemmed from his basic interests and the development of supporting laboratory facilities for this type of work. These facilities supported research in the early 1970's involving elemental cycling in small mammal populations. By substituting the amount of either a stable or radioactive element for the energy unit of biomass, the concepts of energy flow could be applied to elemental flow in populations. Much of the research on elemental cycling is summarized in Gentry et al. (1975).

Michael H. Smith arrived at SREL in 1966 and renewed the interest in the ecology of *P. polionotus*. Dr. Smith had just completed his dissertation on *P. polionotus* in Florida and was interested in the evolutionary biology of populations. After arriving at SREL he continued his studies as part of a National Science Foundation grant, utilizing a series of *P. polionotus* populations across a latitudinal gradient from South Carolina to Florida. Later, in 1971, Smith spent a year at the University of Texas learning electrophoretic techniques in the laboratory of Robert K. Selander. Upon returning he established an electrophoresis laboratory at SREL for comparing genetic variability within and across populations. This facility greatly broadened the research horizons geographically, as populations across the county were sampled and analyzed at SREL. Initially only small mammal populations were studied (Selander et al., 1971; Johnson et al., 1972; Patton et al., 1972; Smith et al., 1973, 1975a, b, 1978; Kaufman et al., 1971; Bowers et al., 1973; Garten, 1976a, 1977; Straney et al., 1976) but later, studies of game populations were included (Manlove et al., 1975, 1976; Smith et al., 1976). Extensive investigations into the population genetics of the SRS deer herd continue at present.

Communication with other research groups working on similar problems is essential to good scientific research and the impact of interacting with such groups can significantly affect the direction of a research program. In September 1966 the International Biological Program (IBP) section concerned with the productivity of terrestrial communities, in collaboration with the Polish Academy of Sciences, Institute of Ecology, held a technical meeting in Jablonna, Poland. One of the

research programs organized by the working group at that meeting was designed to develop research methods concerned with measuring energy flow in mammal populations. One of the special concerns was the development of methods to more accurately determine the density of mammal populations. The meeting was attended by Frank Golley, who, upon his return, expressed enthusiasm for the proposed research. He was particularly impressed by the work of several Polish investigators who had proposed and tested the "Standard-Minimum" method (Grodzinski et al., 1966) to estimate numbers in small rodent populations based on removal trapping. In 1967 researchers at SREL used the same method and compared results obtained from a hardwood forest at SRS with those obtained from a similar forest habitat in Poland. The results (Gentry et al., 1968) were not comparable and the search for answers to questions generated from these differences was the main focus of small mammal research at SREL for the next several years. Up to this time most of the small mammal research on the SRS dealt with species of the old field; now, with emphasis on the forest habitat, the cotton mouse (*Peromyscus gossypinus*), golden mouse (*Ochrotomys nuttalli*), and the short-tailed shrew (*Blarina carolinensis*) began receiving more attention.

The new research effort was oriented toward developing a sampling method that would not only produce reliable density estimates of small mammal populations, but could also serve as a standard method useful to different investigators over a wide geographic area. Various sampling designs involving removal trapping were tested in replicate forest habitats at SRS and in desert habitats of the southwestern United States (Southern California and Nevada). Over a million trap nights were accumulated by SREL investigators in testing the various sampling methods. The results of these studies were incorporated into nine papers presented at the Third Meeting of the IBP Working Group on Small Mammals in Helsinki, Finland in 1970. At the end of the Helsinki meetings, various investigators from several countries were asked to prepare a summary paper dealing with the major projects proposed by the working group at the 1966 Jablonna meeting. SREL researchers were responsible for two papers, one on small mammal density estimations (Smith et al., 1975a) and the other with elemental cycling in small mammal populations (Gentry et al., 1975). Each invited paper was discussed at the Fourth Meeting in Dziekanow Lesny, Poland, in November 1973 and upon revision was published in a synthesis volume of the IBP (Golley et al., 1975).

In addition to research groups and individuals previously mentioned, others played significant roles in the development of mammal research on the SRS. Mentioned earlier were the surveys to determine the status of certain mammal groups. Of particular interest were commonly trapped and hunted, furbearer and game species. Such surveys were conducted on SRS by James H. Jenkins, Ernest E. Provost, and students from the University of Georgia's School of Forest Resources. These basic surveys led to studies on the ecology of bobcats and raccoons, effects of radiation on furbearer species and the cotton rat, and uptake and excretion of radioactive fallout isotopes in game and furbearer species. Later, Robert L.

Marchinton supervised studies of movement patterns in deer and feral hog populations at the SRS.

SREL has made significant contributions to the advancement of mammalogy through publications in recognized journals, papers presented at national meetings, and personal contacts. This is reflected in the number of requests from researchers outside the University of Georgia system to spend their sabbaticals at SREL. This visitor research program led to the establishment of research projects that would not have otherwise been feasible given the time constraints on the resident staff. John A. Selander of the University of Arkansas studied the effects of gamma radiation on old-field mouse populations; Dr. Howard Orr, St. Olaf College, Minnesota, investigated excretion rates of zinc-65 by the cotton rat; Richard W. Dapson, University of Michigan in Flint, studied the age structure of old-field mouse populations and developed accurate techniques to determine age in small mammals; and William Z. Lidicker, Jr. and Jerry O. Wolff studied habitat use by cotton rats. Phyllis Kennedy has conducted a number of genetic analyses for mammal populations throughout the southeast. Michael Kennedy spent a sabbatical year at the laboratory. Steve Buskirk, Lee McClenaghan, Earl Zimmerman, Robert Warren, Teresa Pope and Jan Murie have worked in the laboratory on a variety of projects. Other visiting researchers have contributed to the SREL mammal research efforts and appear as authors on publications listed in the bibliography. Many visiting faculty contributed further by later sending students to SREL to work toward advanced degrees.

Interactions with scientists at other institutions have also proved valuable to mammal research at SRS. Robert K. Selander, formerly at the University of Rochester, New York, Robert J. Baker, Texas Tech University, and James Joule, University of Colorado in Denver, have collaborated in population genetics research on small mammal populations. David F. Urbston of the U.S. Forest Service and Nils Ryman of the University of Stockholm have contributed to population genetic studies of the SRS deer herds. During the summer of 1970 census on small mammals in the desert of the southwestern United States, interactions with Norman R. French, Clive D. Jorgensen, and Bernardo G. Maza resulted in cooperative research projects on small mammal census techniques. Discussions with John B. Calhoun and Gerald G. Wheeler at the National Institute of Mental Health in Bethesda, Maryland, and John J. Christian at the Albert Einstein Medical Center in Philadelphia, Pennsylvania, aided significantly in the selection and design of census methods for sampling small mammal populations.

A number of students from other universities who worked as technicians or research associates have gone on to graduate school to finish their Ph.D.'s or are currently working on their degrees. John C. Avise finished his degree at the University of California at Davis and is currently on the faculty at the University of Georgia. Donald Straney went to the University of California at Berkeley and is now on the faculty of Michigan State University. Others include Ramone Baccus who went to the University of California at Berkeley and now is a research geneticist

with the U.S. Fish and Wildlife Service, Ronald Chesser who attended the University of Oklahoma is now on the senior staff of SREL, Gus Cothran from the University of Oklahoma is now at the University of Kentucky, Michael Wooten is now at Auburn University, and Michael Manlove went on to do graduate work at the University of Florida. None of these students worked at SREL as part of the laboratory's formal fellowship program, but all contributed directly to the program of research on the genetics of natural mammal populations.

The ability to attract and provide funds for good students has been central to the success of the mammal research program at SREL. One hundred and forty-nine theses and dissertations have been completed since 1962 (see Dissertations and Theses, page 109). Over 300 papers involving mammal research on the SRS have been published, 50% of which have at least one student author. Students are encouraged to present their research at scientific meetings. Since 1962, over 200 papers have been presented at the annual meeting of the American Society of Mammalogists (ASM). Nine papers based on SREL mammal research were presented at the New York meeting in 1969 and eight papers were presented at the Texas A&M meeting the next year. The large number of students who contributed to the success of the mammal research program at the SRS precludes the mention of individuals here. Their contributions via theses and dissertations are listed later in this document and their names appear as authors on the appropriate references presented in the bibliography. Five of these students further distinguished themselves by winning awards for papers presented at annual ASM meetings. Charles T. Garten, Jr., Donald W. Kaufman, Paul L. Leberg, and C. Kenyon Wagner each were presented the American Society of Mammalogists Award for their research papers, and David W. Foltz was given the A. Brazier Howell Award for a paper presented at an annual ASM meeting.

In June 1978, SREL was host to the Fifty-eighth Annual Meeting of the American Society of Mammalogists (ASM) at the University of Georgia in Athens. This was the first time the Society had convened at the University of Georgia. A total of 252 papers covering a broad spectrum of mammalian biology was presented to the approximately 600 scientists and students in attendance. The choice of SREL as host to the annual ASM meeting is considered as recognition of its contributions to the field of mammalogy. Michael H. Smith was awarded the Merriam Award in 1985 by the ASM for his research and other contributions to the field of mammalogy. The 1985 paper on white-tailed deer by Kim T. Scribner, Michael C. Wooten, Michael H. Smith and Paul E. Johns was selected by the Wildlife Society as the best research paper of the year.

Looking at the bibliography of SREL mammal literature, it is apparent that the focus of mammal research on the SRS site has changed over its 30 year history. Beginning with basic natural history and population studies, the research has proceeded through investigations of bioenergetics, radiation effects, accumulation and excretion of radioactive isotopes, mineral nutrient relationships, census techniques, population ecology, and genetics. It is hoped that future investigators

will be able to fill in some of the gaps by orienting their research toward unanswered questions as well as generating new ideas by the research conducted on the SRS and summarized in this report.

TAXONOMIC CHECKLIST OF MAMMALS OF THE SAVANNAH RIVER SITE

Class Mammalia
- Subclass Theria
  - Infraclass Metatheria
    - Order Marsupialia
      - Family Didelphidae
        - *Didelphis virginiana virginiana* Kerr-Opossum
  - Infraclass Eutheria
    - Order Insectivora
      - Family Soricidae
        - *Blarina carolinensis carolinensis* (Bachman) - Southern short-tailed Shrew
        - *Cryptotis parva parva* (Say) - Least Shrew
        - *Sorex longirostris longirostris* Bachman - Southeastern Shrew
      - Family Talpidae
        - *Condylura cristata parva* Paradiso - Star-nosed Mole
        - *Scalopus aquaticus howelli* Jackson - Eastern Mole
    - Order Chiroptera
      - Family Vespertilionidae
        - *Eptesicus fuscus fuscus* (Palisot de Beauvois) - Big Brown Bat
        - *Lasionycteris noctivagans* (Le Conte) - Silver-haired Bat
        - *Lasiurus borealis borealis* (Müller) - Red Bat
        - *Lasiurus cinereus cinereus* (Palisot de Beauvois) - Hoary Bat
        - *Lasiurus intermedius floridana* Miller - Northern Yellow Bat
        - *Lasiurus seminolus* (Rhoads) - Seminole Bat
        - *Nycticeius humeralis humeralis* (Rafinesque) - Evening Bat
        - *Myotis austroriparius* (Rhoads) - Southeastern Bat
        - *Myotis lucifugus lucifugus* (Le Conte) - Little Brown Bat
        - *Pipistrellus subflavus subflavus* (F. Cuvier) - Eastern Pipistrelle
        - *Plecotus rafinesquii macrotis* Le Conte - Big-eared Bat
    - Order Xenarthra
      - Family Dasypodidae
        - *Dasypus novemcinctus mexicanus* Peters - Nine-banded Armadillo
    - Order Lagomorpha
      - Family Leporidae
        - *Sylvilagus aquaticus aquaticus* (Bachman) - Swamp Rabbit

Sylvilagus floridanus mallurus (Thomas) - Eastern Cottontail
Sylvilagus palustris palustris (Bachman) - Marsh Rabbit

Order Rodentia

Family Cricetidae

Neotoma floridana floridana (Ord) - Eastern Wood Rat
Ochrotomys nuttalli nuttalli (Harlən) - Golden Mouse
Oryzomys palustris palustris (Harlan) - Marsh Rice Rat
Peromyscus gossypinus gossypinus (Le Conte) - Cotton Mouse
Peromyscus leucopus leucopus (Rafinesque) - White-footed Mouse
Peromyscus polionotus lucubrans Schwartz - Old-field Mouse
Reithrodontomys humulis humulis (Audubon and Bachman) - Eastern Harvest Mouse
Sigmodon hispidus komareki Gardner - Hispid Cotton Rat
Microtus pinetorum pinetorum (Le Conte) - Woodland Vole
Ondatra zibethicus zibethicus (Linnaeus) - Muskrat

Family Muridae

Mus musculus brevirostris Waterhouse - House Mouse
Rattus norvegicus norvegicus (Berkenhout) - Norway Rat
Rattus rattus rattus) - Black Rat

Family Castoridae

Castor canadensis carolinensis Rhoads - Beaver

Family Sciuridae

Glaucomys volans saturatus Howell - Southern Flying Squirrel
Sciurus carolinensis carolinensis Gmelin - Gray Squirrel
Sciurus niger niger Linnaeus - Fox Squirrel

Order Carnivora

Family Canidae

Canis latrans frustror Say - Coyote
Canis familiaris Linnaeus - Feral Dog
Urocyon cinereoargenteus cinereoargenteus (Schreber) and *U. c. floridanus* (Rhoads) - Gray Fox
Vulpes vulpes fulva (Desmarest) - Red Fox

Family Felidae

Felis catus Linnaeus - Feral Cat
Felis concolor coryi Bangs - Mountain Lion
Felis rufus floridanus Rafinesque - Bobcat

Family Mustelidae

Lutra canadensis lataxina F. Cuvier - River Otter
Mephitis mephitis elongata Bangs - Striped Skunk

Mustela frenata olivacea Howell - Long-tailed Weasel
Mustela vison mink Peale and Palisot de Beauvois - Mink
Spilogale putorius putorius (Linnaeus) - Eastern Spotted Skunk

Family Procyonidae
Procyon lotor solutus Nelson and Goldman - Raccoon

Family Ursidae
Ursus americanus americanus Pallas - Black Bear

Order Artiodactyla

Family Cervidae
Odocoileus virginianus virginianus (Zimmerman) - White-tailed Deer

Family Suidae
Sus scrofa Linnaeus - Feral Swine

*Adapted from Honacki et al. (1982) and Jones et al. (1986).

WHOLE BODY KEY FOR ADULT MAMMALS OF THE SAVANNAH RIVER SITE

Four common external dimensions used as key characteristics for species are depicted in Fig. 1.

1a. Armour-like exterior with rows of keratinized plates ..... XENARTHRA ..... (Dasypodidae) *Dasypus novemcinctus*

1b. Exterior surface haired and with no keratinized plates 2

2a. Fingers on the forelimbs longer than the forearm, membrane between fingers forming wing ..... CHIROPTERA (Vespertilionidae) 3

2b. Fingers on the forelimbs shorter than the forearm, no wing-like structure formed between the fingers of the forelimb 13

3a. Ears large, greater than 25 mm in length ..... *Plecotus rafinesquii*

3b. Ears small, less than 25 mm in length 4

4a. Dorsal surface of uropatagium heavily furred 5

4b. Dorsal surface of uropatagium naked or only lightly furred 9

5a. Uropatagium completely furred above 6

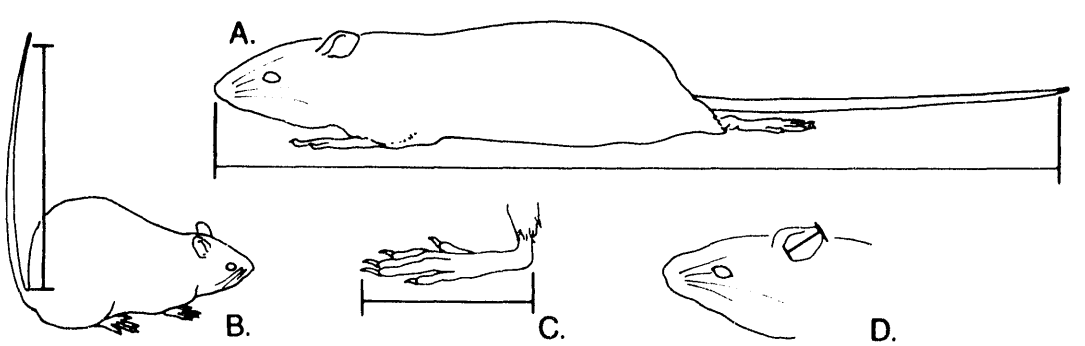


Figure 1. Standard external body measurements: A. total length (Tip of nose to tip of last caudal vertebra) B. Tail length (Base of tail to tip of last caudal vertebra) C. Hind foot length (Heel to tip of claws) D. Height of ear (From base of notch to most distal edge of pinna).

5b. Uropatagium heavily furred only next to body 8

6a. Fur strongly frosted to tip of interfemoral membrane, total length greater than 120 mm ..... *Lasiurus cinereus*

6b. Fur not frosted to tip of interfemoral membrane, total length less than 120 mm 7

7a. Pelage yellowish brick red to rusty red ..... *Lasiurus borealis*

7b. Pelage dark mahogany and slightly frosted with white . *Lasiurus seminolus*

8a. Pelage yellowish tan ..... *Lasiurus intermedius*

8b. Pelage dark reddish brown, hairs tipped with white .... *Lasionycteris noctivagans*

9a. Total length greater than 100 mm, tan to dark brown ..... *Eptesicus fuscus*

9b. Total length usually less than 100 mm 10

10a. Pelage distinctly tricolor (hairs with dark base, light middle, and brown tip) ..... *Pipistrellus subflavus*

10b. Fur not tricolor 11

11a. Pelage dark brown, hairs short, tragus short and blunt . . . . *Nycticeius humeralis*

11b. Pelage light brown, hairs long, tragus long and pointed 12

12a. Fine silky glossy fur ..... *Myotis lucifugus*

12b Dense wooly dull fur ..... *Myotis austroriparius*

13a. Front and back feet with hoofs ..... ARTIODACTYLA 14

13b. Front and back feet without hoofs 15

14a. Body stocky, neck short and thick, short thick legs, tail thin .... (Suidae) *Sus scrofa*

14b. Body slender, legs long and thin, neck not short and thick, tail heavily furred and flag-like ..... (Cervidae) *Odocoileus virginianus*

15a. First toe on hind food nail-less and thumb-like, long prehensile tail, female with pouch on lower abdomen MARSUPIALIA(Didelphidae) ..... *Didelphis virginiana*

15b. First toe on hind foot with nail and not thumb-like, tail not prehensile, no abdominal pouch in females 16

16a. Only one or two incisors per upper jaw, incisors separated from cheek teeth by a diastema 17

16b. Incisors adjacent to other teeth forming a continuous row, no diastema .. 36

17a. Two pairs of incisors in upper jaw (Fig. 3), one large the other diminutive, ear longer than tail, tail cotton-like tuft LAGOMORPHA (Leporidae) ... 18

17b. One pair of incisors per upper jaw, tail longer than ear RODENTIA .. 20

18a. Underparts of tail and body pure white 19

18b. Underparts of tail and body gray or brown ..... *Sylvilagus palustris*

19a. Total length greater than 500 mm, tail large (67-71 mm) and narrow, ears large (68-72 mm) ..... *Sylvilagus aquaticus*

19b. Total length less 500 mm, tail small (39-65 mm) and fluffy, ears small (49-68 mm) ..... *Sylvilagus floridanus*

20a. Tail thickly furred and bushy, or scaly and flattened 21

20b. Tail not thickly furred and bushy, not flattened 24

21a. Tail with thick fur, feet not webbed ..... (Sciuridae) 22

21b. Tail broad, flat, and scaly, hind feet webbed . . . . (Castoridae) *Castor canadensis*

22a. Loose fold of skin present between fore and hind limbs ... *Glaucomys volans*

22b. Loose fold of skin between fore and hind limbs absent 23

23a. Upper parts uniform gray with touches of rufous, underparts white or gray, size small (total length 390-530 mm) ..... *Sciurus carolinensis*

23b. Upper parts variable (from fulvous, gray to black), underparts gray, size large (total length 530 to 726 mm) ..... *Sciurus niger*

24a. Upper molar teeth with tubercles in three longitudinal rows, tail dull colored, relatively long and sparsely haired; annulations of scales on tail easily visible ..... (Muridae) 25

24b. Upper molar teeth with tubercles in two longitudinal rows, tail of variable length and color and usually haired; annulations of scales covered by pelage (except *Ondatra*) ..... (Cricetidae) 27

25a. Total length less than 250 mm ..... *Mus musculus*

25b. Total length greater than 250 mm 26

26a. Tail usually longer than head and body and not bicolor, ears usually greater than 22 mm and naked ..... *Rattus rattus*

26b. Tail usually shorter than head and body and bicolor, ears usually less than 22 mm and slightly haired ..... *Rattus norvegicus*

27a. Tail flattened laterally ..... *Ondatra zibethicus*

27b. Tail not flattened laterally 28

28a. Tail length less than $\frac{1}{3}$ of head and body length ..... *Microtus pinetorum*

28b. Tail length greater than $\frac{1}{3}$ head and body length 29

29a. Adults less than 200 mm in total length 30

29b. Adults usually greater than 200 mm in total length 34

30a. Hairs on ventral surface of abdomen tipped with white 31

30b. Hairs on ventral surface not tipped with white ... *Reithrodontomys humulis*

31a. Pelage silky ochraceous color, ears same color as body . . . . *Ochrotomys nuttalli*

31b. Pelage not ochraceous, ears dusky or dusky edged with white 32

32a. Tail distinctly bicolor, hind foot usually less than 19 mm, tail less than 60 mm, total length less than 154 mm ..... *Peromyscus polionotus*

32b. Tail not distinctly bicolor, tail greater than 60 mm, total length greater than 154 mm 33

33a. Hind foot usually less than 21 mm* ..... *Peromyscus leucopus*

33b. Hind foot usually greater than 22 mm* ..... *Peromyscus gossypinus*

34a. Tail well haired ..... *Neotoma floridana*

34b. Tail sparsely haired or naked 35

35a. Dorsal pelage grizzled black and yellow, fur long ..... *Sigmodon hispidus*

35b. Dorsal pelage an even brownish gray ..... *Oryzomys palustris*

36a. Small size (total length less than 150 mm, weight less than 50 g); eyes diminutive, ears and canine teeth often not noticeable ..... INSECTIVORA 37

36b. Large size (total length greater than 150 mm, weight greater than 50 g); eyes, ears, and canine teeth distinctive ..... CARNIVORA 41

37a. Front feet at least twice as wide as hind feet ..... (Talpidae) 38

37b. Front feet not twice as wide as hind feet ..... (Soricidae) 39

38a. Snout with 22 fleshy lobes, eyes visible, tail haired ..... *Condylura cristata*

38b. Snout without fleshy lobes, eyes not visible, tail essentially naked ..... *Scalopus aquaticus*

39a. Tail length much less than $\frac{1}{2}$ head and body length 40

39b. Tail length greater than $\frac{1}{2}$ head and body length ..... *Sorex longirostris*

40a. Color slate gray, total length greater than 90 mm ..... *Blarina carolinensis*

40b. Color brown, total length less than 90 mm ..... *Cryptotis parva*

41a. Hind foot with five toes 42

41b. Hind foot with four toes 48

42a. Tail shorter than hind foot, body large and stocky . . . (Ursidae) *Ursus americanus*

42b. Tail longer than hind foot 43

43a. Tail conspicuously ringed ..... (Procyonidae) *Procyon lotor*

43b. Tail not ringed ..... (Mustelidae) 44

44a. Toes fully webbed, tail long, thick at base ..... *Lutra canadensis*

44b. Toes not webbed, tail not thickened at base 45

45a. Forehead usually with median white stripes or patch 46

45b. Forehead usually without median white stripes or patch 47

46a. One pair of dorsal white stripes, extent of white markings variable ..... *Mephitis mephitis*

46b. Two pairs of broken white stripes on dorsum ..... *Spilogale putorius*

47a. Ventral side of body brown occasionally with light patch on throat or belly ..... *Mustela vison*

47b. Ventral side of body white or yellow ..... *Mustela frenata*

48a. Claws non-retractable ..... (Canidae) 49

48b. Claws retractable ..... (Felidae) 52

49a. Face narrow and pointed, tail bushy, fur long and thick* 50

49b. Body size and form variable, fur variable, all characters not as in 49a* ..... *Canis familiaris*

50a. Tail length more than ½ total length of head and body 51

50b. Tail length less than ½ total length of head and body ..... *Canis latrans*

51a. Legs and feet reddish brown, tip of tail black ..... *Urocyon cinereoargenteus*

51b. Legs and feet black, tip of tail white ..... *Vulpes vulpes*

52a. Tail length less than ½ total length of head and body ..... *Felis rufus*

52b. Tail length greater than ½ total length of head and body 53

53a. Size small, less than 5 kg and less than 1 m total length, color variable ..... *Felis catus*

53b. Size large, color pale buff to deep gray brown dorsally and white to tan ventrally,tail long ..... *Felis concolor*

*Characteristics not always mutually exclusive. See other reference keys for further identifying features.

KEY TO THE SKULLS OF THE MAMMALS OF THE SAVANNAH RIVER SITE

Common skull dimensions and teeth are depicted in Fig. 2.

1a. Incisors absent from both jaws ..... XENARTHRA (Dasypodidae) *Dasypus novemcinctus*

1b. Incisors present on lower jaw 2

2a. Incisors absent from the upper jaw ..... ARTIODACTYLA (Cervidae) *Odocoileus virginianus*

2b. Incisors present in the upper jaw 3

3a. Canines present, no pronounced diastema between incisors and cheek teeth 23

3b. Canines absent, diastema between incisors and cheek teeth pronounced .. 4

4a. Only one pair of incisors per upper jaw ..... RODENTIA 7

4b. One pair of large and one pair of diminutive (peg like) incisor per upper jaw (Fig. 3) ..... LAGOMORPHA (Leporidae) 5

5a. Posterior portion of supraorbital process long and narrow, extending close to cranium and forming a slit-like opening when viewed from above ..... *Sylvilagus floridanus*

5b. Posterior portion of supraorbital process not long and narrow and completely fused to cranium 6

6a. Basilar length of skull greater than 63 mm ..... *Sylvilagus aquaticus*

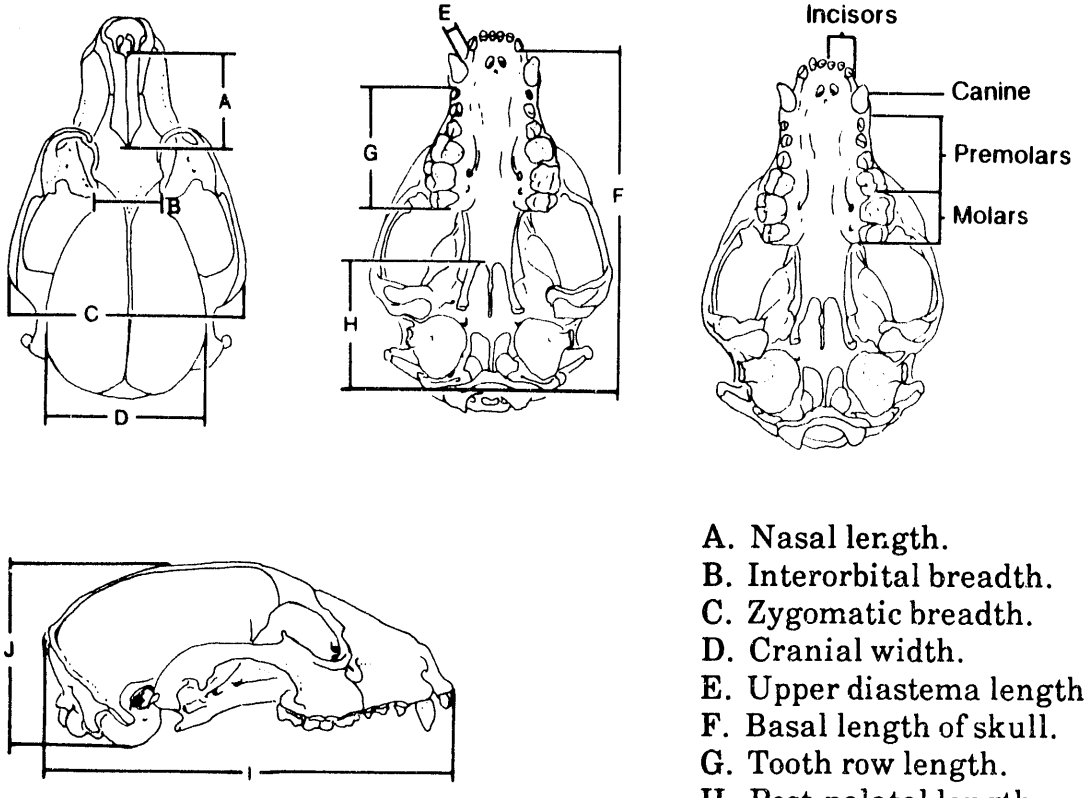
6b. Basilar length of skull less than 63 mm ..... *Sylvilagus palustris*

7a. Total number of teeth 20 to 22, infraorbital opening small to minute 8

7b. Total number of teeth 16 to 18, infraorbital opening vertically elongate . 11

8a. Molars with transverse enamel loops and flat grinding surface (Fig. 4); rostrum broad and deep ..... (Castoridae) *Castor canadensis*

8b. Molars without transverse enamel loops ..... (Sciuridae) 9



A. Nasal length.
B. Interorbital breadth.
C. Zygomatic breadth.
D. Cranial width.
E. Upper diastema length.
F. Basal length of skull.
G. Tooth row length.
H. Post-palatal length.
I. Greatest length of skull.
J. Skull depth.

Figure 2. Skull of *Procyon lotor* illustrating standard skull measurements.

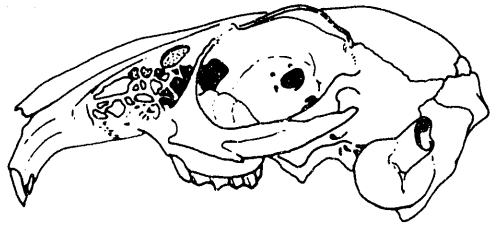


Figure 3. Skull of *Sylvilagus aquaticus* showing peg-like incisors.

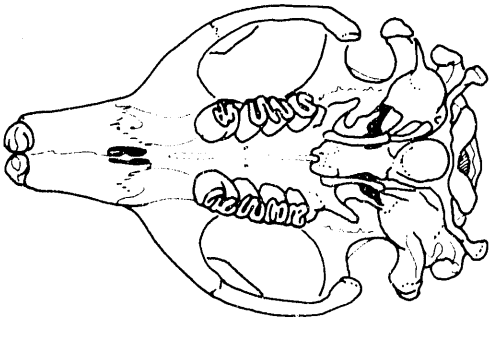


Figure 4. Skull of *Castor canadensis* illustrating transverse enamel loops of molars.

9a. Length of skull greater than 50 mm 10

9b. Length of skull less than 50 mm ..... (*Glaucomys volans*)

10a. Five cheek teeth present on each side of upper jaw (first premolar diminutive and peg-like) ..... *Sciurus carolinensis*

10b. Four cheek teeth present on each side of upper jaw ..... *Sciurus niger*

11a. Upper molars with cusps in three longitudinal rows (Fig. 5; Muridae) ... 12

11b. Upper molars with cusps in two longitudinal rows, lophs form prismatic pattern of dentine bordered with enamel ..... (Cricetidae) 14

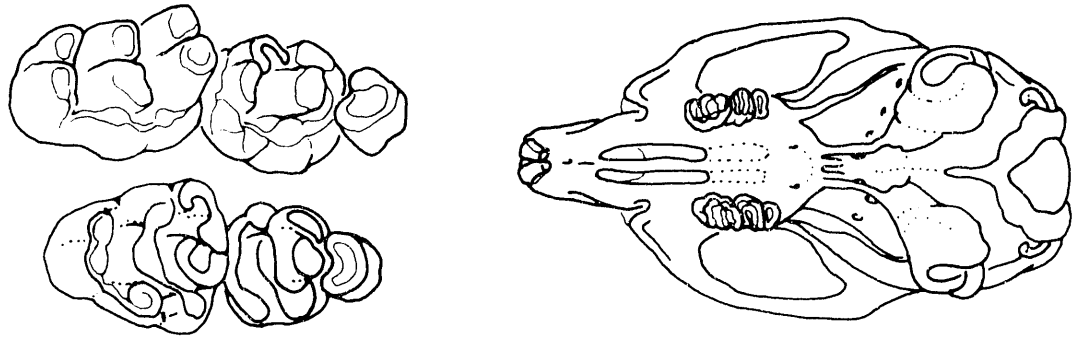


Figure 5. Skull of *Mus musculus* showing three rows of longitudinal cusps on molars.

12a. Length of skull less than 22 mm, upper incisors notched in side view ..... *Mus musculus*

12b. Length of skull greater than 30 mm, upper incisors not notched 13

13a. Length of parietal along temporal ridge less than distance between temporal ridges ..... *Rattus rattus*

13b. Parietal length along temporal ridge not less than distance between temporal ridges ..... *Rattus norvegicus*

14a. Cranium not abruptly constricted in front of braincase; molars with two rows of rounded cusps 15

14b. Cranium abruptly constricted in front of braincase; molar crowns with prismatic pattern (Fig. 7) 22

15a. Upper incisors with grooves on anterior surface (Fig. 6) .... *Reithrodontomys humulis*

15b. Upper incisors without grooves 16

16a. Supraorbital and temporal ridges form a distinct ridge on side of skull between and posterior to eye sockets; inner and outer rows of cusps on upper molars opposite ..... *Oryzomys palustris*

16b. No ridge on upper surface of skull between eye sockets; inner and outer rows of cusps on upper molars alternating 17

17a. Posterior palatine foramina closer to posterior edge of palate than to anterior palatine foramina ..... *Ochrotomys nuttalli*

17b. Posterior palatine foramina approximately midway between anterior palatine foramina and posterior edge of palate 18

18a. Least interorbital width 4 mm or less* ..... *Peromyscus polionotus*

18b. Least interorbital width 4 mm or greater* 19

19a. Greatest length of skull grater than 35 mm 21

19b. Greatest length of skull less than 35 mm 20

20a. Greatest length of skull usually 28-30 mm* ..... *Peromyscus gossypinus*

20b. Greatest length of skull usually less than 28 mm* .... *Peromyscus leucopus*

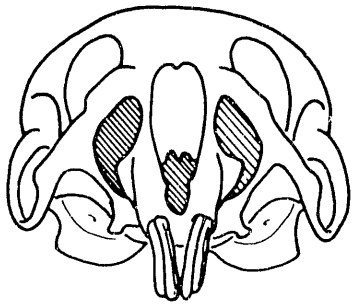


Figure 6. Grooved incisors of *Reithrodontomys*.

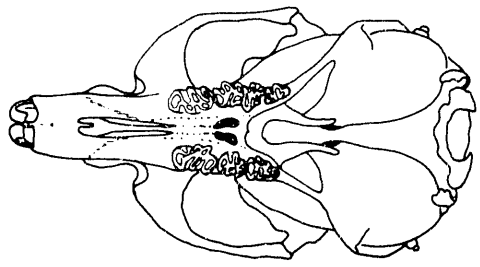


Figure 7. Skull of *Microtus pinetorum* illustrating prismatic triangular folds of enamel of molars.

21a. Cusps on molars elongated into transverse lophs forming a sigmoid pattern; supraorbital ridge prominent ..... *Sigmodon hispidus*

21b. Cusps on molars elongated into transverse lophs forming a letter E; supraorbital ridge not prominent ..... *Neotoma floridana*

22a. Greatest length of skull over 30 mm ..... *Ondatra zibethicus*

22b. Greatest length of skull less than 30 mm ..... *Microtus pinetorum*

23a. First upper incisor greatly enlarged ..... INSECTIVORA 24

23b. First upper incisor not noticeably larger than adjacent incisors 28

24a. Zygomatic arch incomplete (Fig. 8); tips of teeth with brown, red, or bluish pigment ..... (Soricidae) 25

24b. Zygomatic arch complete; pigment on teeth absent .. (Talpidae) 27

25a. Four unicuspid teeth in upper jaw ..... *Cryptotis parva*

25b. Five unicuspid teeth in upper jaw 26

26a. First 4 unicuspids arranged in 2 distinct pairs, first 2 teeth equal in size and much larger than 3rd and 4th; robust skull, distinct sagittal crest ..... *Blarina carolinensis*

26b. First 4 unicuspids not arranged in 2 distinct pairs; skull delicate, no distinct sagittal crest ..... *Sorex longirostris*

27a. Ten teeth in each upper jaw, bony palate extends posteriorly as far as last molar ..... *Scalopus aquaticus*

27b. Eleven teeth in each upper jaw, bony palate does not extend posteriorly as far as last molar ..... *Condylura cristata*

28a. Rostrum with U-shaped indention when viewed from above, one or two upper incisors per jaw, skull small, never exceeding 30 mm in length ..... CHIROPTERA (Vespertilionidae) 29

28b. Rostrum without U-shaped notch (Fig. 9), incisors more than two per jaw; skull large exceeding 30 mm 38

29a. Six cheek teeth on each side of upper and lower jaw, 38 total teeth, premolars 3/3 30

29b. Less than 6 cheek teeth on each side of upper and lower jaw, 36 or fewer total teeth, less than 3 upper premolars 31

30a. Sagittal crest absent, interorbital constriction greater than 4 mm ..... *Myotis lucifugus*

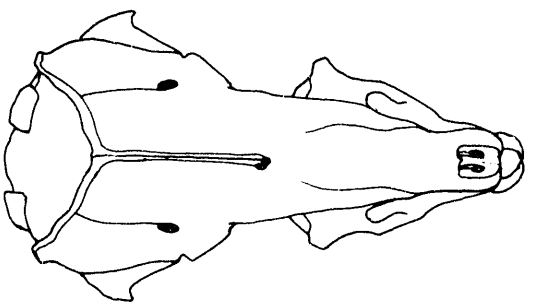


Figure 8. Incomplete zygomatic arch of Soricidae.

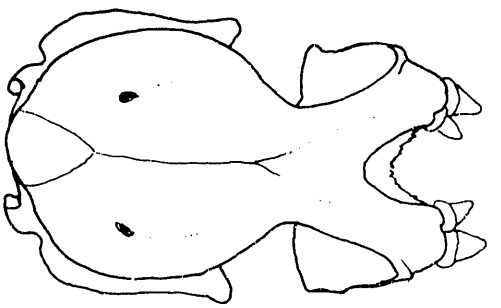


Figure 9. U-shaped rostrum of Chiroptera.

30b. Sagittal crest present, interorbital constriction less than 4 mm; incisors 2/3 ..... *Myotis austroriparius*

31a. Premolars 2/2 or 2/3 32

31b. Premolars 1/2 36

32a. Incisors 1/3, first upper premolar tiny and lying in angle between canine and second premolar 33

32b. Incisors 2/2 or 2/3 34

33a. Total length of skull less than 15.5 mm* . *Lasiurus borealis* and *L. seminolus*

33b. Total length of skull greater than 15.5 mm ..... *Lasiurus cinereus*

34a. Premolars 2/2 ..... *Pipistrellus subflavus*

34b. Premolars 2/3 35

35a. Rostrum broad and distinctly concave on each side dorsally ..... *Lasionycteris noctivagans*

35b. Rostrum narrow and convex on each side ..... *Plecotus rafinesquii*

36a. Incisors 2/3 ..... *Eptesicus fuscus*

36b. Incisors 1/3 37

37a. Upper incisor in contact with canine, skull large, greater than 18 mm ..... *Lasiurus intermedius*

37b. Upper incisors distinctly separated from canine, skull small, less than 15 mm ..... *Nycticeus humeralis*

38a. Five incisors per upper jaw, 50 teeth, angular process on the lower jaw turned inwards ..... MARSUPIALIA (Didelphidae) *Didelphis virginiana*

38b. Three incisors per upper jaw, fewer than 50 teeth, angular process on lower jaw not inflected inward 39

39a. Jaw teeth brachydont and with four cusps, canines project outward and are triangular in cross section ..... ARTIODACTYLA (Suidae) *Sus scrofa*

39b. Jaw teeth variable, canines projecting downward and are round or oval in cross section ..... CARNIVORA 40

40a. Less than 30 teeth ..... (Felidae) 41

40b. More than 30 teeth 43

41a. Three cheek teeth behind canines ..... *Felis rufus*

41b. Four cheek teeth behind canines 42

42a. Greatest length of skull greater than 135 mm ..... *Felis concolor*

42b. Greatest length of skull less than 135 mm ..... *Felis catus*

43a. Forty or more total teeth 44

43b. Thirty-eight or fewer total teeth ..... (Mustelidae) 49

44a. Teeth 40, zygomatic arch flaring when viewed from front .....
..... (Procyonidae) *Procyon lotor*

44b. Teeth 42, zygomatic arch not flaring 45

45a. Anterior end of nasal bones midway between orbit and incisors
..... (Ursidae) *Ursus americanus*

45b. Anterior end of nasals much closer to incisors than orbit . (Canidae) ... 46

46a. Post-orbital processes thin and concave above 48

46b. Post-orbital processes thick and convex above 47

47a. Distance from the anterior margin of the upper first premolar to the posterior margin of the last molar 3.1 times or greater the palatal width between the inner margins of the upper first premolars ..... *Canis latrans*

47b. Distance from the anterior margin of the upper first premolar to the posterior margin of the last molar 2.7 times or less the palatal width between the inner margins of upper first premolars ..... *Canis familiaris*

48a. Temporal ridges well-developed and widely separate, forming a U-shape
..... *Urocyon cinereoargenteus*

48b. Temporal ridges close together, not particularly well-developed, forming a V-shape ..... *Vulpes vulpes*

49a. Five cheek teeth per upper jaw ..... *Lutra canadensis*

49b. Four cheek teeth per upper jaw 50

50a. First upper molar squarish 51

50b. First upper molar nearly twice as wide as long, outline hour-glass shaped 52

51a. Interorbital area almost flat, infraorbital canal opening above anterior half of carnassials ..... *Spilogale putorius*

51b. Interorbital area strongly convex, infraorbital canal opening above posterior half of carnassials ..... *Mephitis mephitis*

52a. Greatest length of skull greater than 55 mm, auditory bulla approximately as long as upper premolar - molar series ..... *Mustela vison*

52b. Greatest length of skull less than 55 mm, auditory bulla longer than upper premolar - molar series ..... *Mustela frenata*

*Characteristics not always mutually exclusive. See other reference keys for further identifying features.

GLOSSARY OF TERMS

Agouti - A hair color with alternating light and dark bands on each hair.

Alisphenoid Canal - A canal on the ventral surface of the alisphenoid bone and anterior to the auditory bulla.

Altricial - A developmental state at birth in which young are born without hair, their eyes closed, and requiring considerable parental care for a period of time after birth. Opposite of precocial.

Alveolus - A socket in which the root of a tooth is set.

Auditory Bulla (Tympanic Bulla) - The inflated bony capsule that encases the middle and inner ear; located on the base of the skull.

Basilar Length - From the posterior border of median incisive alveolin to mid-ventral border of foramen magnum (Fig. 2F).

Body Measurements - Standard measurements of the body of a mammal taken before the specimen is skinned. These include: Total length, Tail length, Hind-foot length, and Ear length (Fig. 1).

Brachydont - Low crowned. Used in reference to premolar and molar teeth.

Canine - An enlarged tooth between the incisors and premolars; usually a large stabbing tooth, occasionally bladelike, but sometimes small and similar to the teeth preceding it.

Carnassials - An enlarged pair of shearing teeth found in carnivores; consists of the last upper premolar and first lower molar.

Cranium - The portion of the skull that encases the brain.

Crepuscular - Active during the twilight of dawn and/or dusk.

Cusp - A peak or rounded elevation on the crown of a tooth.

Cuspidate - Having cusps.

Dental Formula - The standard manner of designating the number and arrangement of mammalian teeth; e.g., i. 3/3, c. 1/1, p. 4/4, m. 3/3 is the full compliment for placental mammals. The letters indicate incisors, canines, premolars, and molars, respectively. The numerators give the number of each type of tooth in one half of the upper jaw and the denominator those in one half of the lower jaw. The total formula represents the number of teeth on one side of the skull.

Deciduous - Shed periodically. In mammals this term refers to the milk incisors, canines, and premolars that are shed once and replaced by permanent dentition.

Dentine - Ivory-like substances beneath the enamel, usually constituting the bulk of the tooth.

Diastema - A vacant space, or gap, between teeth.

Estrus - Period during which females both are receptive to copulation with males and have ova available for fertilization. Sometimes referred to as 'heat'.

Foramen - A perforation through a bone for the passage of a nerve or blood vessel.

Foramen Magnum - The opening in the rear of the skull through which the spinal cord emerges.

Friable - Easily crumbled or crushed. Used in describing soils.

Fundamental Number - The number of autosomal chromosome arms.

Incisors - Nipping or chiseling teeth at the front of the jaws. Upper incisors always root in the premaxillary bone.

Infraorbital canal - An opening in the skull in front of the orbit.

Interfemoral membrane - The fold of skin extending from hind limbs to tail in bats.

Interorbital Breadth - The least width between the orbits dorsally. (Fig. 2B).

Jugal - The bone that forms the mid-section of the zygomatic arch.

Keratinized - Composed of a horn-like substance.

Lyrate - Shaped like or suggestive of a lyre; U-shaped.

Mandible - The entire lower jaw.

Maxillary - The bone in the upper jaw that bears the canine, premolar and molar teeth.

Metapodials - Bones of the fore- and hind-feet between the carpals (wrist bones) or tarsals (ankle bones) and phalanges (finger or toe bones).

Molars - The posterior teeth in the upper and lower jaws that are non-deciduous.

Monestrous - Having a single period of estrus per year.

Orbit - The body socket that contains the eyeball.

Palate - The body roof of the mouth composed of part of the premaxillary, maxillary, and palatine bones.

Palatine - Paired bones that form the posterior part of the hard palate.

Parietal - Paired bones roofing the posterior part of the braincase.

Postorbital Process - A projection from either the jugal on the zygomatic arch, or the frontal bone, partially separating the orbit and the temporal fossa.

Premaxillary - Paired bones in the front of the upper jaw that bear the incisor teeth.

Premolars - Deciduous teeth posterior to the canines.

Prismatic - With a pattern consisting of sharply-angled triangles, or loops with sharp salient angles. Geometric in appearance.

Rostrum - The portion of the skull anterior to the orbits.

Sagittal Crest - A longitudinal median body ridge dorsal to the braincase.

Sectorial - Modified for cutting or shearing.

Squamosal - A fan-shaped bone on either side of the braincase above the auditory bulla.

Supraorbital Ridge - A bead-like ridge bordering the orbit dorsally.

Temporal Fossa - The large space behind the orbit enclosed by the zygomatic arch and the postorbital process.

Temporal Ridge - A ridge traversing the top or side of the braincase which marks the dorsal border of the insertion of the temporal muscle. They may be found on parts of the frontal, parietal or squamosal bones and may coalesce to form a sagittal crest.

Tragus - A leaf-like fleshy structure of the anterior border of the ear opening.

Tubercle - A small rounded eminence or nodule.

Unicuspid - Having one cusp.

Uropatagium - The membrane between the tail and the hind legs of bats.

Venter - The underparts or belly of a mammal.

Zygomatic Arch - The arch of bone that forms the lateral border of the orbit and temporal fossa.

HABITATS OF THE SAVANNAH RIVER SITE

The SRS is located in the west central portion of South Carolina and encompasses portions of Aiken, Barnwell, and Allendale counties (Fig. 10). The site's southwestern boundary is the Savannah River, a typical large southern river with extensive flood plains and oxbows. The northern boundary of the SRS is 20 to 30 miles (32 to 48 km) south of the Fall Line, and the influence of the Fall Line is evident in the representation of some species on the SRS. Throughout a major portion of the southeast the Fall Line represents the transitional zone between montane or piedmont and coastal plain environments. The Fall Line also forms a range boundary for numerous species found on the SRS and is a zone of intergradation for many others. The entire SRS lies within the Atlantic coastal plain geologic province. Two physiographic subregions are included within the site boundaries: The Aiken Plateau (82-122 m elev.) and three Pleistocene Coastal Terraces (30-82 m elev.) (Fig. 11; Shields et al., 1980).

The SRS encompasses a variety of habitats within its area of approximately 300 mi^2 (780 km^2). Predominant terrestrial habitats include old fields, sandhills (scrub oak-longleaf pine forest), pine forests, upland hardwoods, bottomland hardwoods, forest swamps, Carolina bays, and freshwater streams, ponds, and marshes (Workman and McLeod, 1990). Approximately 260 ha of abandoned pastures and croplands have remained in old-field vegetation, since the SRS was established 40 years ago.

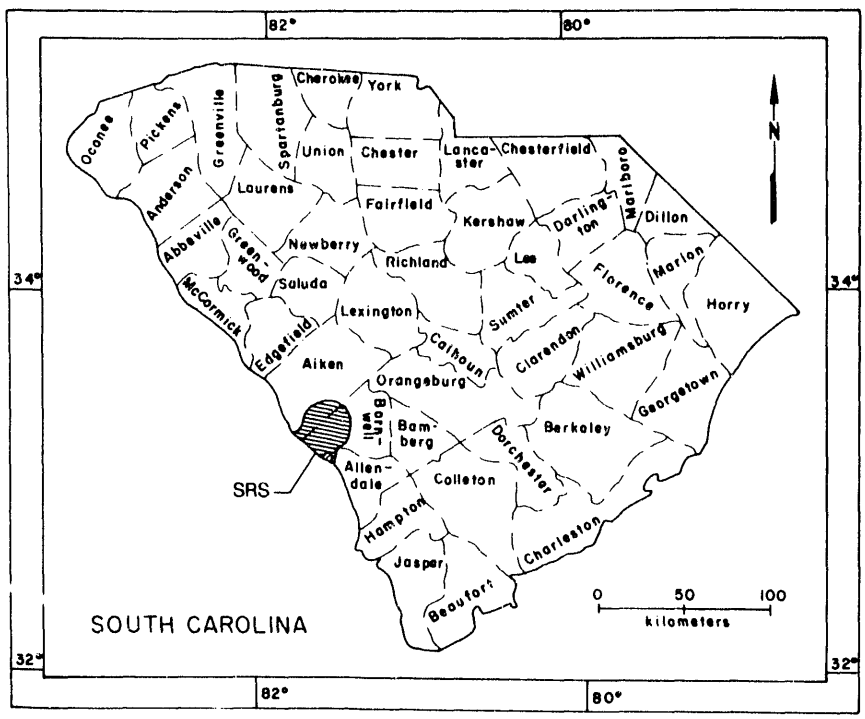


Figure 10. Location of the Savannah River Site (SRS) on a county map of South Carolina.

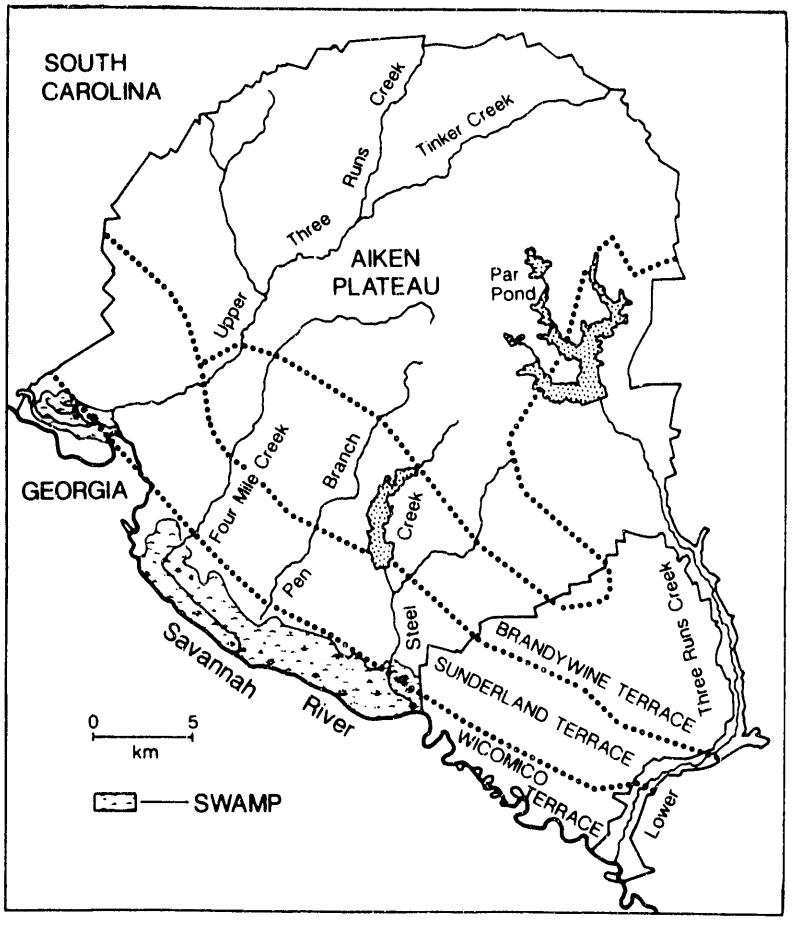


Figure 11. Location of the Pleistocene coastal terraces on the Savannah River Site (SRS). There are two physiographic regions on the SRS: Aiken Plateau and that represented by the three terraces combined. (Modified from Langley and Marter, 1973).

In old fields, herb and weed species, primarily horseweed (*Erigeron canadense*), yellow aster (*Haplopappus divaricatus*), purple cudweed (*Gnaphalium purpureum*), camphorweed (*Heterotheca subaxillaris*), crab grass (*Digitaria sanguinalis*) and sheep sorrell (*Rumex aetosella*) are typically dominant during the first five to seven years following old field abandonment. Broomstraw (*Andropogon ternarius*), broomsedge (*A. virginicus*) and other grasses (especially *Panicum* spp.) become most important community dominants during the fourth year. Blackberry (*Rubus* spp.) and loblolly pine (*Pinus taeda*) usually invade these sites after about 10 years. One large area of approximately 142 ha (Field 3-412) remains essentially an open field despite the gradual encroachment of shrubs and pines. Field 3-412 is the site of many early mammal studies (see references by Odum, Golley, Smith, and Gentry). Plant succession at 3-412 has proceeded to the present perennial grass dominated by panic grass (*Panicum aciculare* plus other *Panicum* spp.) and fall witch grass (*Leptoloma cognatum*). Broomsedge was dominant for several years and is now more widely scattered in its distribution as is poverty grass (*Aristida oligantha*) and long-awned aristida (*Aristida longespica*). Sericea lespediza (*Lespedeza cuneata*) and camphor weed are scattered and localized, whereas two other forbs, daisy fleabane (*Erigeron annuus*) and yellow aster are distributed more uniformly. Forest clearcut

areas quickly revert to old-field habitats for a short period until shaded out by the rapid growth of replanted pines.

The sandhills, or scrub oak-longleaf pine forest habitat, is an edaphic climax community that results from a specific soil type characteristic of remnant beaches and dunes of the upper coastal plain and fires that periodically sweep through the area. The forest is dominated by turkey oak (*Quercus laevis*) and longleaf pine (*Pinus palustris*), however pure stands of scrub oaks, including turkey oak, bluejack oak, and blackjack oak occur on deeper sands. The soil is very sandy, low in nutrients, and dry, and the productivity is the lowest of the forest habitats. Leaf litter accumulation is sparse with scattered open areas containing grasses and forbs similar to those of the old-field sites. Prickly pear cactus (*Opuntia compressa*) and cat's bells (*Baptisia perfoliata*) reflect the dry conditions and are common ground covers.

Pine plantations consist of monocultures of longleaf, slash (*P. elliottii*), or loblolly pines. The trees are planted in rows and the forest is relatively open, with little or no understory vegetation due to heavy accumulations of pine needles. With the application of periodic thinning operations the forest becomes more open and an understory soon develops. Understory species vary with age and location of the stand, but may include young pines, wild cherry (*Prunus serotina*), wild plum (*Prunus americana*), winged sumac (*Rhus copallina*), red maple (*Acer rubrum*), evergreen oaks (*Quercus* spp.), and wax myrtle (*Myrica cerifera*). Ground cover species include poison ivy (*Rhus radicans*), reindeer moss (lichen; *Cladonia* sp.), Japanese honeysuckle (*Lonicera japonica*), dog fennel (*Eupatorium capillifolium*), sericea lespideza, greenbrier (*Smilax* spp.) and goldenrod (*Solidago* spp.).

Hardwood forest communities can be divided into upland, lowland, and swamp habitats. The upland and lowland forests are associated with large coves or ravines within the watershed system of large streams such as Upper Three Runs Creek (Figs. 11 and 12). Small streams, intermittent in some cases, may meander along the cove bottom or floodplain and eventually empty into the larger stream. Surrounding the cove floodplain on the drier slopes is upland forest dominated by white oak (*Quercus alba*), mockernut hickory (*Carya tomentosa*), black oak (*Q. velutina*), scarlet oak (*Q. coccinea*), and southern red oak (*Q. falcata*). The understory may contain flowering dogwood (*Cornus florida*), black cherry, sassafras (*Sassafras albidum*) and several species of vines such as poison ivy, catbriars (*Smilax glauca* and *bona-nox*), and muscadine (*Vitis rotundiflora*). Tree species at the moister upland sites include tulip poplar (*Liriodendron tulipifera*), beech (*Fagus grandifolia*), red buckeye (*Aesculus pavia*), and witch hazel (*Hamamelis virginiana*). The more mesic bottomland is dominated by swamp gum (*Nyssa sylvatica* var. biflora), red maple, sweet gum (*Liquidambar styraciflua*), water oak (*Q. nigra*), laurel oak (*Q. laurifolia*), and red ash (*Fraxinus pennsylvanica* var. *subintegerrina*). Dominant species along stream banks include yellow poplar, sweet bay (*Magnolia virginiana*), river birch (*Betula nigra*), tag alder (*Alnus serrulata*), wax myrtle, willow (*Salix* spp.), and buttonbush (*Cephalanthus occidentalis*). The understory consists of holly, dogwood, and young beech trees. Dog hobble (*Leucothoe axillaris*) occurs as a dense tangle along sections of streams. Switch cane (*Arundinaria*

gigantea) forms dense patches in seepage areas. Grape (*Vitis* sp.) and greenbrier form dense tangles along the trunks and among the limbs of trees, especially in lowland hardwood areas. Dead limbs, logs, and stumps are common on the ground.

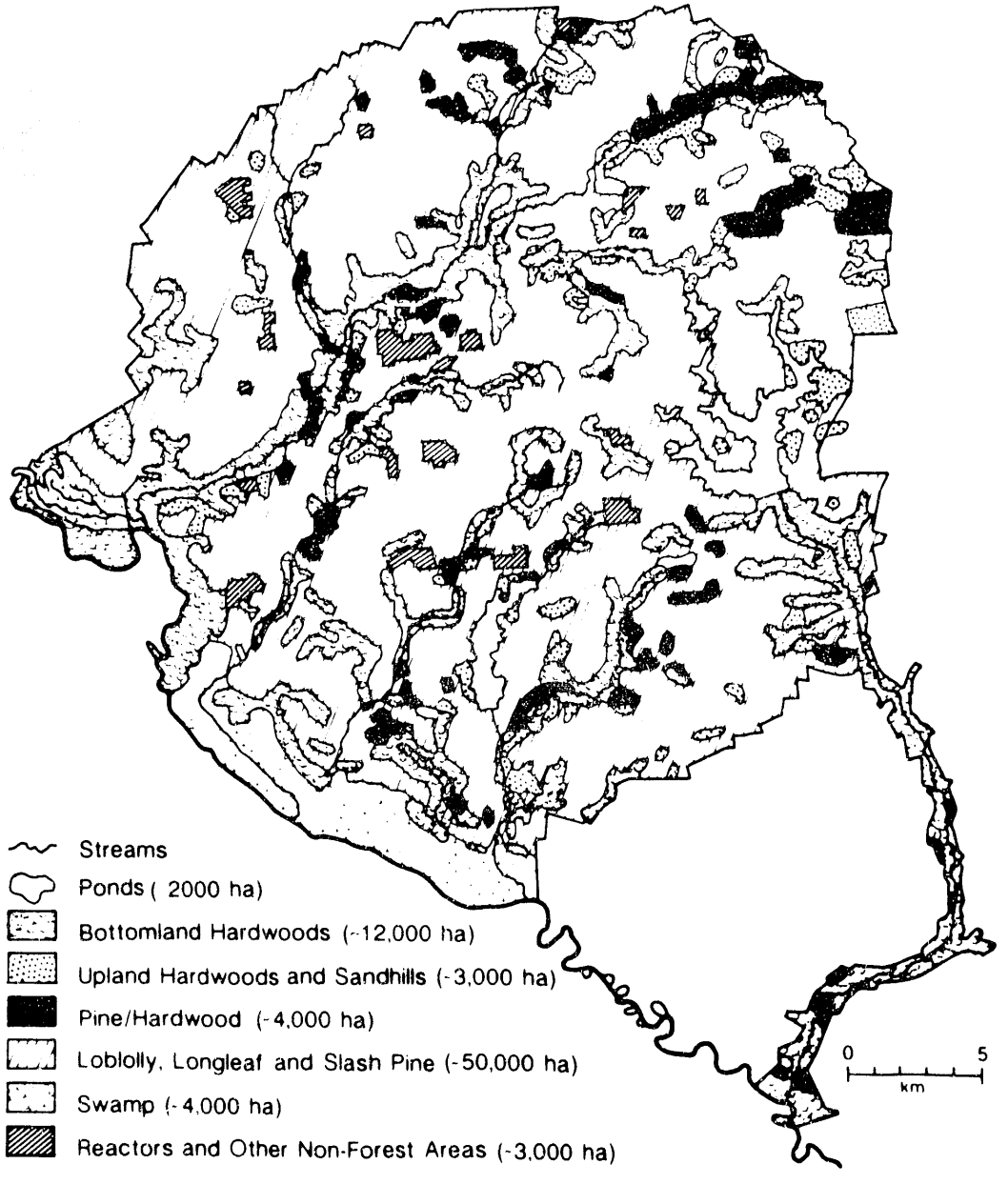


Figure 12. Distribution of vegetational types on the Savannah River Site. (From Workman and McLeod, 1990).

An extensive swamp forest system is associated with the Savannah River and the lower parts of tributary streams (Fig. 12). The swamp forest is dominated by water tupelo (*Nyssa aquatica*) and bald cypress (*Taxodium distichum*). A subcanopy of saplings may include water ash (*Fraxinus caroliniana*), red ash, and less frequently water tupelo, red maple, swamp gum, American elm (*Ulmus americana*),

and sycamore (*Platanus occidentalis*). During the growing season (April to October), the herbaceous understory consists of woolgrass (*Scirpus cyperinus*), arrowhead (*Sagittaria latifolia*) and, in open water areas, water lily (*Nymphaea odorata*); various forbs and grasses occupy drier sites. Extensive areas that are flooded less frequently may support dense stands of saw palmetto (*Serenoa repens*). The substrate is composed of organically enriched mud (silt) fortified near the surface with the roots of herbaceous plants and trees. Dead trees, snags and stumps are common and the forest floor is littered with fallen logs. During the winter and early spring the swamp forest may be flooded by water up to three meters in depth and during that period is essentially an aquatic habitat.

Major aquatic habitats on the SRS are small ponds, reservoirs, streams, the Savannah River and Carolina Bays. A number of small ponds ranging in surface area from 0.4 to 1.2 ha (1 to 3 acres) currently exists on the SRS. Some were farm ponds constructed while the areas were under private ownership, whereas others have resulted from the construction of cooling water ponds. Two large impoundments, Par Pond and Pond B, were constructed to provide additional water to cool nuclear production reactors. Par Pond is approximately 1,220 ha (2800 acres) in surface area, including the 64 ha pre-cooler, Pond C. The other reservoir, Pond B (118 ha), is in a post-thermal recovery state.

Five major tributaries of the Savannah River are located on the SRS (Fig. 11). The largest and least disturbed of these tributaries is Upper Three Runs, a deep, swift blackwater stream 39 km long. This is the only stream which originates and has a substantial portion of its watershed outside of the SRS boundary. Steel Creek and Lower Three Runs are post-thermal recovery streams. Both Four Mile Creek and Pen Branch received thermal effluents from nuclear reactors until fairly recently.

The Savannah River forms the southwestern boundary of the SRS (Fig. 11). Over the years several oxbow lakes have been formed as the river meandered toward the Atlantic Ocean. Small islands with typical lowland forest vegetation occur occasionally in the middle of the river. At flood stage the water overflows the channel to form a floodplain up to 3 km wide.

Carolina bays are small grassy or occasionally forested marshes found along the coastal plain regions of North and South Carolina and are scattered throughout the SRS. Although varying in size, Carolina bays characteristically are egg-shaped, oriented in a northwest-southeast direction and have highly fluctuating water levels. The bays frequently undergo annual fluctuations being dry in summer and wet in winter and early spring. The geologic origin of Carolina bays is unknown; see Wells and Boyce (1953) and Shields et al. (1980) for further description and theories concerning their origin.

Some Carolina bays are covered with a dense stand of panic grass (*Panicum hemitomon)* near their borders and water lilies in the deeper and more open pools. Black willows (*Salix nigra*) and button bush trees are widely scattered near the edge of the bay. Also scattered near the edge are small patches of woolgrass, common

rush (*Juncus effusus*), cattail (*Typha latifolia*), and giant plume grass (*Erianthus giganteus*). Surrounding the bay just beyond the high water mark usually is a narrow and very distinct band of broomsedge (*Andropogon virginicus*) and blackberry. Other Carolina bays are forested and dominated by bald cypress, swamp gum, sweet gum, and red maple.

The variety of aquatic, semi-aquatic, and terrestrial habitats are important to the maintenance of a diverse mammalian fauna. The distribution of 40 mammal species for which data are available by major SRS habitats is given in Table 1.

Table 1. The five major habitats of the Savannah River Site and the mammal species found there. An X indicates that a species is likely to be found in the habitat.

Mammals Species	Old-fields and clearcuts	Pine Plantations	Scrub oak-Longleaf Pine	Upland and Lowland Hardwoods	Aquatic and Semi-Aquatic
Blarina carolinensis	X	X	X		
Castor canadensis					X
Condylura cristata	X				X
Cryptotis parva	X	X		X	
Didelphis virginiana	X	X	X	X	
Felis rufus	X		X	X	
Glaucomys volans				X	
Lasionycteris noctivagans				X	
Lasiurus borealis	X	X		X	
Lasiurus intermedius				X	
Lasiurus seminolus		X		X	
Lutra canadensis					X
Mephitis mephitis	X	X		X	
Microtus pinetorum	X			X	
Mustela frenata	X			X	
Mustela vison				X	X
Neotoma floridana	X			X	
Nycticeius humeralis		X		X	
Ochrotomys nuttalli	X	X	X	X	
Odocoileus virginianus	X	X	X	X	
Ondatra zibethicus					X
Oryzomys palustris	X			X	X
Peromyscus gossypinus	X	X		X	
Peromyscus polionotus	X	X	X		
Pipistrellus subflavus		X		X	
Plecotus rafinesquii				X	
Procyon lotor	X	X	X	X	X
Reithrodontomys humilis	X	X			
Scalopus aquaticus	X		X	X	
Sciurus carolinensis		X	X	X	
Sciurus niger		X	X		
Sigmodon hispidus	X				
Sorex longirostris	X	X			
Spilogale putorius	X	X		X	
Sus scrofa	X	X		X	
Sylvilagus palustris				X	X
Sylvilagus floridanus	X	X	X	X	
Urocyon cinereoargenteus	X		X	X	
Ursus americanus				X	
Vulpes vulpes	X				

MAMMALS OF SPECIAL CONCERN

Several species of mammals on the SRS warrant special consideration. One such group is those species which potentially could occur on the site but whose presence is still questionable. Only seven species, the cougar (*Felis concolor*), the white-footed mouse (*Peromyscus leucopus*), the swamp rabbit (*Sylvilagus aquaticus*), and the bats, big brown bat (*Eptesicus fuscus*), hoary bat (*Lasiurus cinereus*), little brown bat (*Myotis lucifugus*), and the Southeastern myotis (*Myotis austroriparius*) fall into this category. A number of sightings of cougars on the SRS have been reported (Jenkins and Provost, 1964), however, none of the reports have been confirmed by evidence such as tracks or scat (feces). Cougars may occasionally range onto the site (Jenkins and Provost, 1964; Pelton et al., 1976), but no positive evidence for their presence exists. The SRS is at the southeastern limit of the range of *P. leucopus* (Hall, 1981; Golley, 1966). Only two records of this mouse exist from the plant site, and the specimens were identified from biochemical characteristics. Additional records of *P. leucopus* exist from Saluda County which borders Aiken County and Edgefield County (Golley, 1966) and from Richmond County, Georgia, (across the Savannah River from the SRS; Golley, 1962). The swamp rabbit has only been positively recorded from the extreme southwestern tip of South Carolina (Golley, 1966), however, it has been identified from Columbia County, Georgia, which is not far from the SRS. Further field work will probably confirm the presence of these species on the SRS.

The correct subspecific assignment of species on the SRS is a second potential problem area. The northern border of the SRS is only a few kilometers south of the Fall Line (the transition between the Piedmont and Coastal Plain). This area represents a zone of intergradation of several subspecies of mammals (Golley, 1966). Additionally, the Savannah River represents a subspecific boundary for some species (Hall, 1981). Most subspecific assignments were based on geographic range information following Hall and Kelson (1959) and Golley (1966). The species for which subspecific intergradation in the area of the SRS is possible are the opossum (*Didelphis virginiana*), old-field mouse (*Peromyscus polionotus*), and eastern mole (*Scalopus aquaticus*).

Game and/or edible species represent another group of mammals that merit special attention. The game species that occur on the SRS include deer, rabbit, squirrel, fox, bobcat, raccoon, opossum, bear, and feral swine. Additionally, mink, otter, beaver, and muskrat may be trapped for fur. Because of the protected status of the SRS, only deer and feral swine are now hunted by the public. Deer hunts were begun in 1965 due to a dramatic increase in deer-car accidents as the deer population increased. Hunts are conducted annually in late October through November with about 1,000 deer currently being harvested each year (see section on White-tailed Deer Studies). Hunters are also allowed to take feral swine to aid in the control of this species. Killed animals are checked for radioactive contaminants.

A number of the SRS mammals are introduced species. The feral dog, cat, and swine represent domestic species that now live free on the site. Only the feral swine occurs in large enough numbers to be of any concern at this time. The house mouse and the two species of *Rattus* are also introduced species. These rodents live primarily in association with man around buildings and settlements. In addition, western jackrabbits (*Lepus californicus*) were released in Aiken County about 40 years ago (Golley, 1966). One road-killed specimen was collected on the SRS in 1952. However, no other records from this release are known, and it is probable that jackrabbits no longer occur in this area.

A final source of problem species includes those that are on the federal or state endangered species list. Only the cougar, *F. concolor*, of the SRS mammals appears on the federal endangered species list. As indicated earlier, the status or even the presence of the cougar on the SRS, is not known. Additionally, the black bear (*Ursus americanus*) is on the South Carolina list of threatened species. At the present time, it is not likely that a permanent population of bears exists on the site. Any bears found on the SRS are probably transients traveling along the Savannah River. Finally, several species are listed by Pelton et al. (1976) as being of special concern in South Carolina because of unknown status, suspected low populations, or as species that are potentially threatened by man's activities. These species are represented on the SRS by *Condylura cristata*, *Lasiurus intermedius*, *Plecotus rafinesquii*, *Sylvilagus aquaticus*, *Lutra canadensis*, *Mustela frenata*, *Spilogale putorius*, and *Felis rufus* (see Pelton et al., 1976; for details on these species). Two of these species, *C. cristata* and *F. rufus*, have been consistently captured on the SRS and do not appear to be in danger of extinction on the site at this time. Additionally, *S. putorius* and *L. canadensis* are observed on the SRS fairly regularly. The status of the remaining species is not presently known.

FURBEARER CENSUS

Because of its protected status and large area, the SRS is ideally suited for long term studies. Such studies are an important aspect of research at SREL. The furbearer census was initiated in 1954 by E. P. Odum (Wood and Odum, 1965) and continued uninterrupted until 1982. Thus, 29 consecutive years of data were collected on furbearers on the SRS.

The trapping method employed in the census changed during the course of the study, although the basic format remained the same. In general, the technique followed that of Wood (1954, 1959). A series of 10, two-mile long traplines were established along secondary dirt roads. Ten traps were set at 0.2-mile intervals along each line. Five traplines were placed on the Coastal Terraces and five on the Aiken Plateau (Fig. 13). The same ten traplines were used throughout the study. Trapping was conducted for seven consecutive rain-free nights for a total of 700 trap nights per census period.

From 1954 through 1967, No. 2 double spring steel traps were used exclusively. Crippling injuries to animals from these traps presented a serious problem. In 1965, an attempt was made to reduce much of the self-damage suffered by steel trapped animals. Tranquilizer tabs were attached to the jaws of every other trap. In an attempt to free itself, the animal would chew the tab (containing tranimul) and ataxia was induced. Leg damage to trapped animals was significantly reduced at these traps (Payne et al., 1966a); however, the problem was not totally solved. In 1968, 1969 and 1970 a combination of steel and welded wire live traps (approximately 37.5 x 50 x 105 cm in size) were used. The trap type did not appear to affect the capture rate (Table 2), but it did change the species composition of the animals captured. Therefore, only live traps were used after 1971. The live traps required more work because they were set (with the door kept open) and prebaited for four days or more in advance, but they were a more humane way of conducting the census.

The survey was conducted in the spring and autumn for the first three years and only in autumn for the remainder of the study. Animals were more active and densities were higher in autumn than they were in spring. Consequently, spring

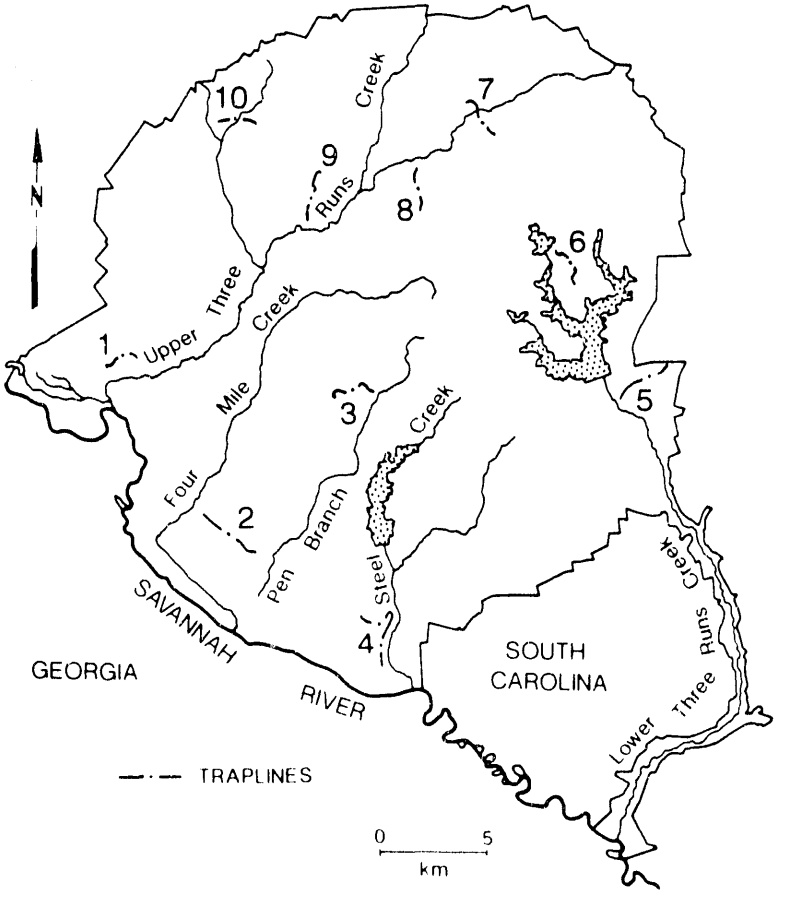


Figure 13. Location of the 10 furbearers census traplines.

Table 2. Comparison of trapping success for No. 2 double spring steel traps (steel) and welded wire live traps (live) for the 1969 and 1970 years of the annual furbearers census (Jenkins et al., 1980).

	Traps with captures	Traps without captures	Total*
Steel	26	298	310
Live	24	286	310
Total	50	570	620

*$X^2 = 0.081$, df = 1, and $0.7 < P < 0.8$ for a comparison of the results obtained from the two types of traps.

trapping was discontinued due to poor trapping success. The traplines were initially run in November, but with the advent of controlled deer hunting in 1965, the census was moved to late September or October to avoid possible conflicts with the hunts. Prior to 1975 animals were sacrificed and used for radionuclide analysis. After 1975 captured animals were ear-tagged and released. Some animals were taken for use in other projects, e.g., monitoring radioisotope concentrations in animal populations on the site. Steel traps were baited with a combination of bobcat and fox urine. Several baits were used with live traps including deer meat, bass, sardines, and urine.

The furbearer species most commonly taken were gray fox, raccoons, opossums, and bobcats. Other mammal species that were captured during the census included striped skunks, red foxes, cottontail rabbits, gray squirrels, feral dogs, and feral house cats (Table 3). In the following discussion we concentrate on the first six species mentioned.

The number of animals caught each year during the 29 year census fluctuated widely (Fig. 14). There appeared to be an initial expansion of furbearers following abandonment of the land. The largest numbers of animals caught were 123 in 1954 and 138 in 1980. Seventy or more animals were captured only six times (1954, 1956, 1965, 1968, 1979, and 1980). The lowest number of total captures was 18 in 1971.

Survey data indicated that species composition changed over the course of the census. The gray fox was the most common species in the first 11 years of the study. Since then gray fox numbers declined and approached their former abundance only in 1965 and 1980. The red fox, although n ever abundant, virtually disappeared.

Table 3. Yearly number of furbearers captured during the annual furbearers census.

Year	Total Number	Gray Fox	Bobcat	Raccoon	Opossum	Striped Skunk	Red Fox
1954	123	73	14	20	4	2	10
1955	48	24	5	13	1	5	0
1956	71	35	12	15	2	0	7
1957	47	32	2	7	1	2	3
1958	36	20	2	9	3	1	1
1959	38	21	3	10	12	1	1
1960	56	22	8	16	3	3	4
1961	45	19	7	12	0	0	7
1962	58	35	6	9	3	2	3
1963	35	26	3	4	0	1	1
1964	56	36	2	14	2	2	0
1965	70	41	3	18	6	0	2
1966	46	8	10	19	8	0	1
1967	39	18	10	5	6	0	0
1968	72	22	5	28	15	2	0
1969	49	18	7	10	4	9	1
1970	47	24	5	7	7	4	0
1971	18	6	2	1	8	1	0
1972	48	1	1	10	28	8	0
1973	29	5	3	6	15	0	0
1974	42	8	2	10	19	3	0
1975	40	16	0	8	16	0	0
1976	33	15	3	3	10	1	0
1977	47	5	0	11	30	1	1
1978	42	9	2	9	22	0	0
1979	77	18	4	12	41	2	0
1980	138	45	5	38	47	3	0
1981	50	9	8	8	25	0	0
1982	65	2	1	5	56	1	0
Total	1565	613	135	337	383	55	42

Only one individual was caught after 1969 and 50% of the total captures were obtained during the first five years of the census. On the other hand, the opossum became more common in later years. The opossum was rarely captured during the first 10 years, however, more than 50% of the animals taken in five out of the last

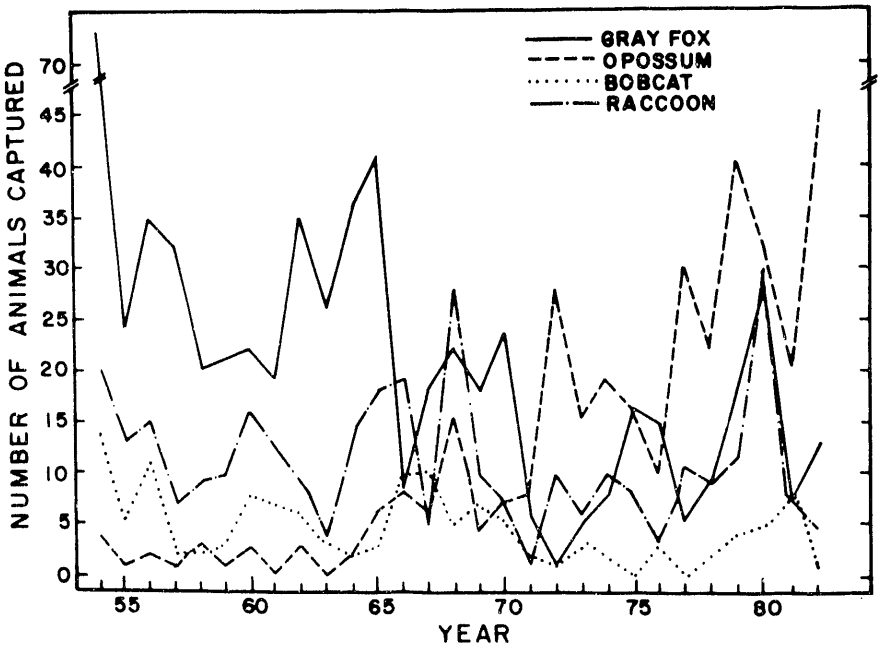


Figure 14. Numbers of furbearers captured yearly from 1954 through 1982.

seven years were opossums. Opossums are relatively easy to live trap and difficult to catch in leg-hold traps which may explain some of this trend. Bobcats and striped skunks rarely were numerous in the census. The number of raccoons caught decreased somewhat in the last few years of the study.

Wood and Odum (1965) suggested that the fox, bobcat, and raccoon were fluctuating through time as a unit. Their data which covered the first nine years of the census were reanalyzed by Jenkins et al., (1980). They found significant correlations among most species combinations except for a few involving raccoons. This result supported the contention of Wood and Odum. However, for the years 1963-1977, they found no significant correlation between gray fox versus bobcat, gray fox versus raccoon, fox and bobcat versus raccoon, and bobcat versus raccoon (Table 3). There were some correlations by year, but overall the fluctuation of species as a unit is no longer evident.

A number of factors can influence animal populations. Among these are habitat characteristics and food availability. Habitat changes on the SRS have been dramatic. At the time the area was closed to the public in 1951, about one-third of the land had been in cultivation. Cotton and corn were the chief crops. These fields quickly succeeded into the perennial grass stage. The old fields soon supported a

large number of rodents (particularly cotton rats), insects, and other prey species. With an abundance of prey items and a release from human population pressures, predator populations were expected to expand. The large numbers of gray foxes captured in 1954 might be indicative of this response.

The old fields were soon converted into pine plantations which may have had an effect on the furbearer population. Canopy closure of the pinelands resulted in the shading of much of the understory vegetation which reduced food and cover for predators and prey species alike. Except for the opossum and periodic increases in one species or another, the furbearer populations decreased in numbers. The red fox, an open field species, all but vanished except perhaps on the fringes of agricultural fields. Bobcats were also captured less frequently in recent years. With the elimination of many of the old fields, both cotton rat and rabbit populations, important prey species for the bobcat, were reduced. Evidence other than trapping success also indicated lower numbers of bobcats. Bobcat home ranges were smaller when population levels were high and food was plentiful (Young, 1958). Home ranges of bobcats on the SRS increased from about 1.5 mi^2 in 1965 to about 7.5 mi^2 in 1978 (Marshall and Jenkins, 1967; Jenkins et al., 1980) when preferred habitat and prey numbers declined. The more uniform pinewood habitat probably also affected raccoons which prefer swamps, old fields, and farmlands (Johnson, 1975).

Burning may result in some habitat improvement. Approximately 10,000 acres of pineland are subject to prescribed burning each winter. This is done primarily for disease control and seedbed preparation for pine regeneration as well as aiding in the prevention of wildfires. As pointed out by Jenkins et al. (1980), prescribed burning is a key to raising the carrying capacity for game on wildlife plantations of the coastal plain. Burning improves the habitat for quail, turkey, and rabbits by removing undergrowth and increasing the growth and nutritive value of legumes.

Disease can play a significant role in animal populations. Rabies may have had an effect on the decline of some of the furbearer species. From 1969 to 1972 blood samples were taken from animals caught during the census. The samples were tested by the serum virus neutralization procedure for rabies and four positives were found in raccoons and bobcats in 1970, and one each in raccoons and gray foxes in 1971 (Jenkins et al., 1980). Foxes and bobcats are considered to be the most vulnerable to the disease whereas raccoons, skunks, and especially opossums are more resistant (McLean, 1975). The number of opossums caught during this period increased dramatically and opossums were the most common species taken every year after that time except 1976. Only 12 gray fox were captured from 1971 to 1973 which is fewer than the number caught in any one year prior to this time except 1966. However, this was also the period when the change was made from steel to live traps. It is not possible to conclude whether the change in species number was a result of rabies, trap type, or some other factor. In any event, the representation of foxes and bobcats in the census did not regain the level held before 1971.

The rabies question points out one of the major problems of this type of census. This method does not employ the controls necessary to answer questions of actual numbers of individuals or species composition of an area. At best it can only give an estimate of the relative abundance of the species taken at that particular time. Several factors can influence the results obtained from this kind of census, particularly one of this length. Habitat change, species composition, population density, movement, home range sizes, trapability, and time of year, as well as the type of trap, bait, and personnel running the survey can affect results.

Many different investigators were involved in the census throughout the 29 years. Differences in levels of expertise and experience, and also different personal styles in setting the traps may well affect the results. The type of bait used may influence what species are taken, although no significant preference between fish and deer meat was found. In particular, the predator urine scent used every year except 1979 may repulse some species. The spotted skunk represents a possible example. Although 55 striped skunks were captured in the 29 years, no spotted skunks were recorded in the census. Yet spotted skunks are common on the SRS (Jenkins and Provost, 1964).

The habitats in which the traplines are set can also affect species composition and numbers. One hundred traps are not sufficient to sample all the habitats in 780 km^2 of area. However, except for the swamp, samples were taken from all of the major habitat types on the site.

As previously mentioned, the traps used in the census were changed from steel to live traps beginning in 1968. Analysis of the results for 1969 and 1970 did not show any significant difference in level of success for one trap over the other (Jenkins et al., 1980). However, it was at this time that the greatest decrease in the total number of animals caught occurred. Lower numbers of captures, with the exception of the opossum, continued throughout the 1970s. There is no way to substantiate whether this decline was due to an actual decrease in the furbearer populations or to the change in traps. Also, it is not clear whether the opossum population had increased or if this species simply was more susceptible to live traps. Jenkins and Provost (1964) suggested that at that time the opossum population was at least as large as that of the raccoon population. However, the first year when only live traps were used was also the first year that opossums outnumbered raccoons. More opossums than raccoons were captured in each succeeding year.

Considerably more time, effort, and expense would be required to adequately census the population. On the other hand, Jenkins et al. (1980) pointed out the value of the furbearer census. For large protected areas such as military bases, wildlife refuges, and parks, this type of census (or technique) provides data for disease surveillance, population trends, and development of cheap and quick index methods. This technique also provides animals that can be used in other research projects.

WHITE-TAILED DEER STUDIES

The white-tailed deer (*Odocoileus virginianus*) population on the SRS has been subject to an annual harvest since 1965 and has been intensively studied since early 1970's (Ramsey et al., 1975, Scribner et al., 1985). Deer of either sex and any age are taken during the harvest. These studies have resulted in over 80 publications that deal directly or indirectly with the SRS deer population. Most of these studies have dealt with the demographic and/or genetic structure of the herd and how this information may be used in developing management strategies for deer populations. This is arguably one of the most intensively studied ungulate populations in the world.

The initial impetus for the deer hunts on the SRS was the precipitous rise in car-deer accidents in the early 1960's. Thus, the initial management goal was merely to reduce the numbers of deer on the site and thereby reduce the number of deer-related automobile accidents. As the hunts developed over time, they became part of a good public relations program for the site and increased in popularity such that all applicants for hunts could no longer be accommodated. Because of the limited public access to the SRS, the number of hunters on any given hunt day is precisely known. The actual number of hunters allowed onto the site rapidly increased during the late 1960's, stabilized during the early seventies and then gradually increased, reaching a peak in the early 1980's. At that time the population size of the deer was declining (Fig. 15), and the number of hunts was reduced to allow the population to stabilize.

The main hunting technique over the years has been dog-hunting where the deer are moved through the woods using dog packs and are run past hunters at deer stands. Still hunting was also used in certain areas of the site during the period of 1969 through 1980. However, the relative success rate of dog hunters is much greater than still hunters (29% vs 11%), and thus still hunting has not been used on the site since 1980. Because of the efficiency and magnitude of the hunting pressure on the herd, it is clear that demographically and most likely genetically, the SRS deer population is a hunter driven system (Scribner et al., 1985; Novak et al., 1991). Novak et al. (1991) have estimated that the mortality risk of a deer from dog-hunting is over four times greater than all other mortality factors combined. although this may at first appear to be a problem when trying to generalize the results to other populations, that is not the case. Virtually all white-tailed deer populations are either hunted or managed populations, and the "natural" deer population may not exist, at least in the eastern United States.

Mean estimated prehunt population sizes of white-tailed deer on the SRS have varied from 2,591 to 5,368 during the time period 1965-1989 (Fig. 15). The temporal patterning of the estimated population sizes correlates very well with the hunter effort, as expected in a hunter driven system (Novak et al., 1991). Additionally, the number of car-deer accidents tracks the estimated population sizes very closely (Fig.

15). Because these are independently gathered data sets, confidence in the population estimates is increased. These estimates are currently being used to examine the effects of population size on other demographic and genetic processes in the population.

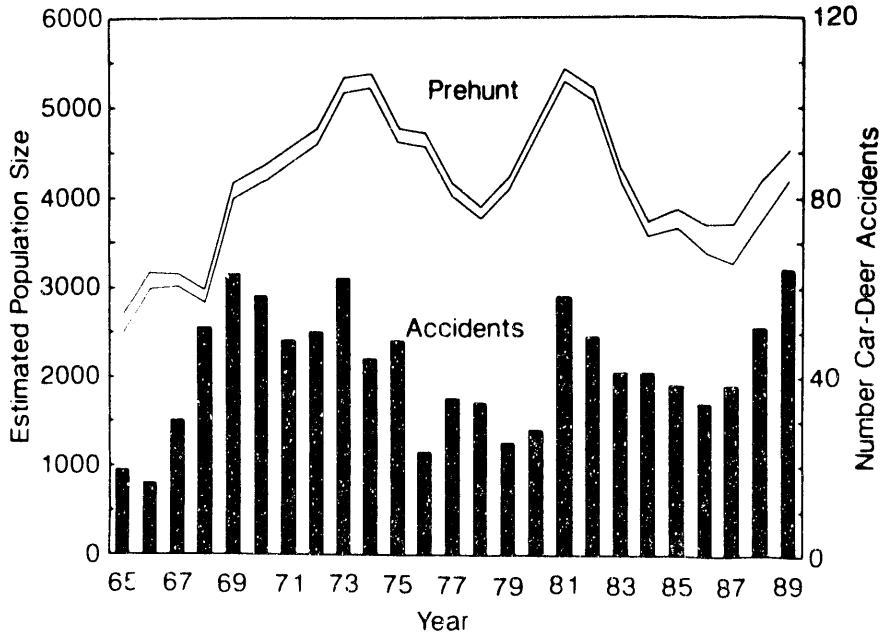


Figure 15. Estimated population size of deer on the SRS and the number of reported car-deer accidents. Population sizes were estimated as described in Novak et al. (1991).

The age structure of the population should be sensitive to the intensity and type of hunting applied to the population. The mean age of the population showed an initial rapid drop in the late 1960's followed by a slight rise and then a leveling off with minor variation until the present (Fig. 16). Although the decline in mean age appears to be slight this is somewhat deceptive. In most normally age structured populations that are demographically stable, the older age class animals make up a relatively small proportion of the total number of individuals in the population. However, to decrease the mean age by even the apparently small degree shown here requires that virtually no deer in this population live more than 4.5 years and that the numbers of deer in the 3.5 and 4.5 year age classes have been reduced by greater than 67% of their original frequency in the population. Therefore, this represents a significant demographic impact on the population and has implications for the overall productivity of the herd. As the age structure was truncated, the percentage of fawn breeding increased (Rhodes et al., 1986). The mean litter size of fawn females is significantly lower than that for adult females (1.06 vs 1.63; Rhodes et al.,

1985). Thus as percentage fawn breeding increased and the proportion of older females decreased, the overall productivity of the herd decreased.

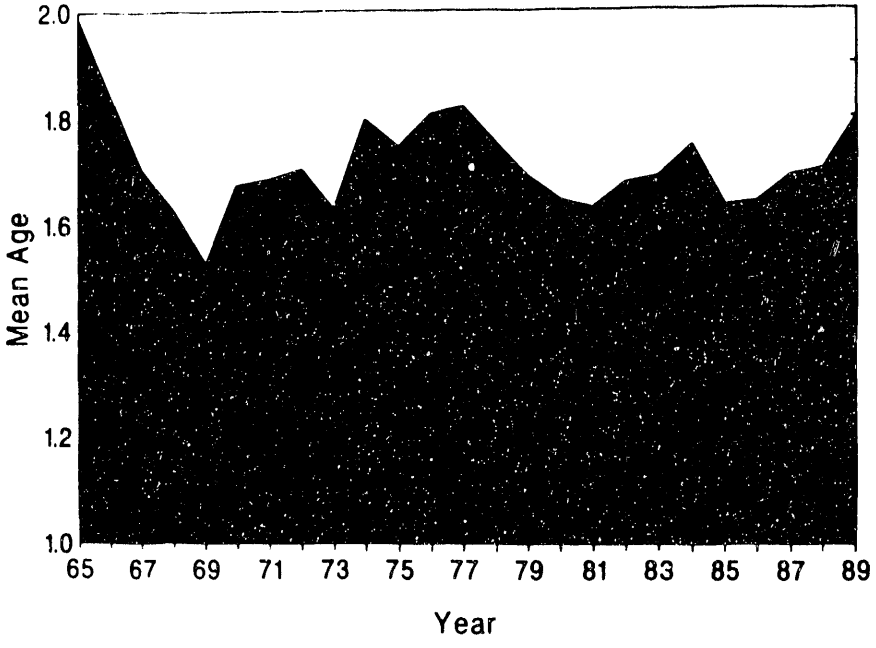


Figure 16. Mean age of deer killed on the yearly hunts during the time period from 1965-1989.

The sex ratio of the population is not expected to be as affected by the intensity of hunting as is the age structure because of the hunting technique used. Over the entire time span the sex ratio of the kill has been slightly skewed towards females in 19 of the 25 years (Fig. 17). There does not appear to be any discernible temporal trend changes in the sex ratio. However, since the number of hunts were reduced beginning in 1987, the sex ratio in the kill has exhibited a bias towards males (Fig. 17). This may have more to do with the timing of the hunts rather than an actual change in the population sex ratio. To reduce hunting pressure on the herd the early hunts during the late September and October were eliminated. The main part of the rutting season falls after this time period. Male deer are more active and more susceptible to hunting pressure during the rut. Thus, deleting the early portion of the season may effectively bias the kill towards bucks even though their relative representation in the population may be unchanged. Additional work needs to be done to clarify this situation. If the hunting mode is affecting the sex ratio this can have a dramatic effect on the population's productivity, perturbation response time, and effective population size.

A unique aspect of the scientific studies on the SRS deer population is that beginning in 1971 and continuing yearly from 1974 through 1989 the genetic characteristics of the population were surveyed using starch gel electrophoresis. Thus, changes in the genetic structure of the herd over time could be monitored with

respect to changes in demography. A comparable genetic time series does not exist for any other natural mammalian population. Mean multilocus heterozygosity is a

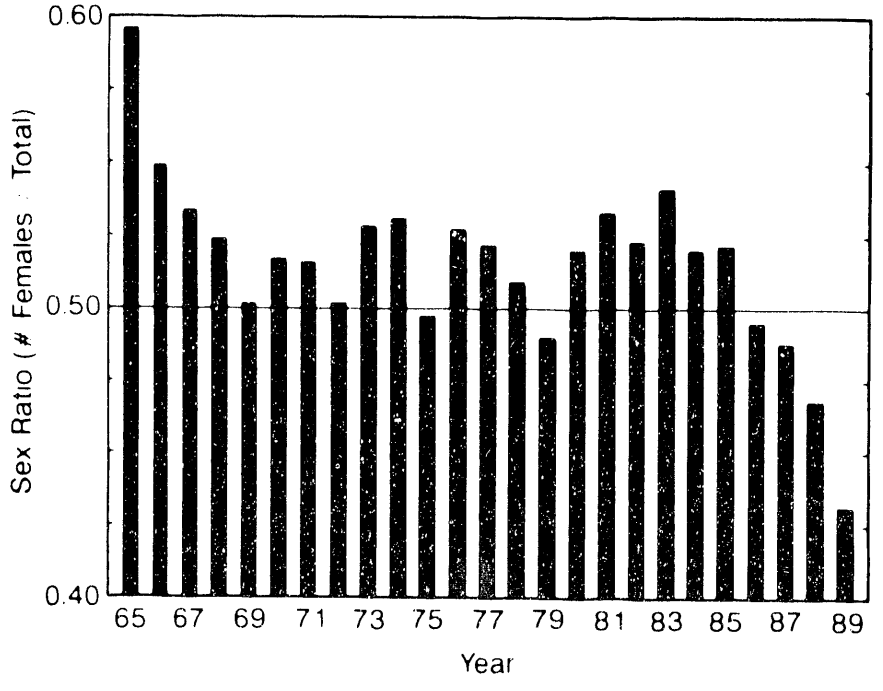


Figure 17. Sex ratio of the yearly deer kill for the period 1965-1989. The sex ratio is expressed as the proportion of females in the kill. Thus, 0.50 indicates an equal sex ratio for all deer 0.5 years or older.

good summary statistic to show how genetic variability has changed over time. There is no significant temporal trend in multilocus heterozygosity (Fig. 18). The low values from 1978-1979 may be a technical artifact or may represent a real phenomenon. The low values for 1980 are due to a lack of data for the highly variable beta-hemoglobin locus. In 12 out of the 16 years the deer from the swamp showed higher mean heterozygosity values than deer from the upland areas. Historically deer were scarce on the plant area due to agricultural practices and hunting except in the river swamp. When the SRS was started in the 1950's, the agricultural areas that were not to be used for plant operations reverted to old field habitats or were changed to pine plantations. It is hypothesized that these newly created habitats were colonized by deer from the river swamp area. The lower mean heterozygosity values may be a reflection of this historical founder event. Evidence from single locus analyses also indicates that deer in the swamp and upland areas may not be exchanging genes randomly and, thus, appear to be operating as semi-independent genetic units (K. Willis pers. comm.). The fact that no significant

change in genetic structure or level of variability has accompanied the demographic ichanges is interesting. It may ndicate that the genetic structure and variability of deer populations is buffered for some time period from demographic changes in the population. Recent analyses of the genetic data indicate that degree of isolation between the swamp and upland areas is related to population size, but there is a one year time lag in the relationship (J. Novak pers. comm.). That is, if the population increases in size from year i to year i + 1, the degree of genetic interchange decreases from i + 1 to year i + 2. This is not an intuitive result and may indicate changes in the herd's social structure related to population size.

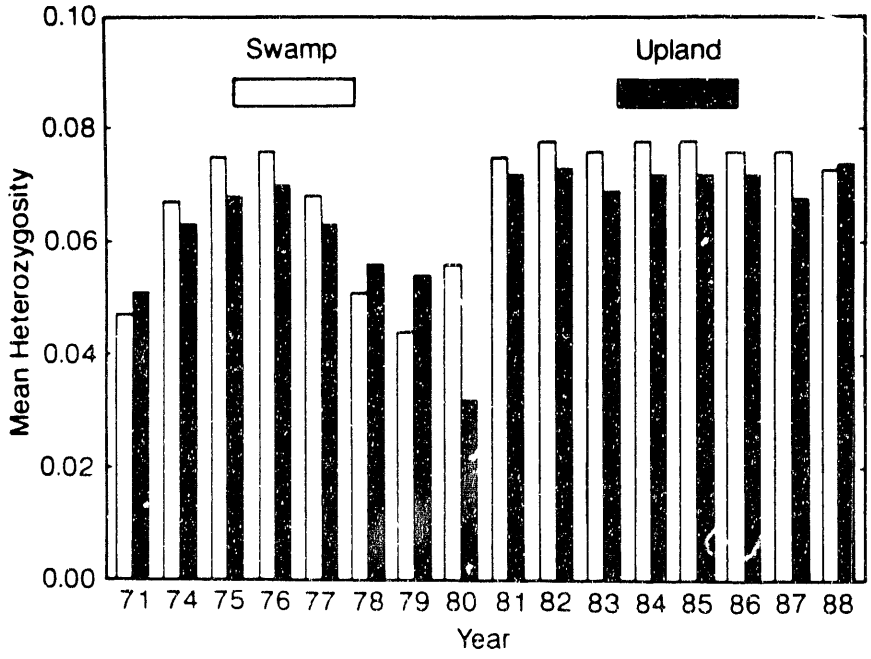


Figure 18. Mean multilocus heterozygosity of the deer from swamp and upland compartments for the period 1965-1988. Heterozygosity values are based on 31 loci of which 9 exhibit variability with the common allele frequency ≤ 0.99.

The SRS provides a unique site for the study of white-tailed deer. Because of their size and relatively long generation length, many of the studies undertaken here would not have been possible on a smaller spatial or temporal scale. The results of the studies of white-tailed deer on the SRS are testament to the necessity for long-term studies to investigate many population biological processes.

SPECIES ACCOUNTS

Introduction

The following section provides a brief account for 50 of the 55 mammal species recorded on the site. Each account includes a brief description and any unique feature of the species that will help in its identification. The dental formula is given for each species following the definition given in the glossary. Standard measurements, mean and (range) are presented in the format: total length, tail length, hind foot length, and weight. All measurements are in millimeters and grams unless otherwise designated. When possible, data are presented from animals caught on the SRS; otherwise data from other regions of South Carolina (Golley, 1966), Georgia (Golley, 1962), or the eastern United States (Hamilton, 1963) are given. An illustration of the tracks of the more common larger and conspicuous mammals is provided on page 107 and 108 (Fig. 19). The geographic distribution is given for each species and reference is made to historical and present distributions and abundance on the SRS. Some ecological, behavioral, and reproductive biology is provided including information on food habits, habitat preferences, home range sizes and movement patterns, mating system, breeding season, litter sizes, and other related information. For species that have been studied on the SRS, specific results and conclusions are provided along with the appropriate reference. General descriptions and basic background biology for the various species were obtained primarily from Golley (1962), Hamilton (1963), Golley (1966), Hall (1981) and Chapman and Feldhamer (1982). Species accounts are not provided for four species of bats that have not been caught on the Site, but have been recorded in areas near the SRS.

Didelphis virginiana virginiana (Kerr) - Opossum

The opossum is the only marsupial native to the United States. This species was formerly considered to be a subspecies of *Didelphis marsupialis*; however, Gardner (1973) separated *D. virginiana* and *D. marsupialis* based on distinctive karyotypic and morphological differences. Coloration of the opossum on the SRS is variable ranging from a grayish white to almost black. The under fur is relatively thick and is overlain by thinner guard hairs giving the animal a grizzled appearance. The tail is naked and is often darkly pigmented on the proximal half to two-thirds. The tail is prehensile and can be used in climbing or carrying nesting materials. Adult males have scent glands on their chests which produce a yellow to orange secretion with a distinctive musky odor; females lack sternal glands (Holmes-Meisner, 1987). The skull has a small brain case and a well-developed sagittal crest, and the mandible has an inflected angular process. Adult dentition is 5/4, 1/1, 3/3, 4/4 = 50. Males are slightly larger than females and their canines are longer and thicker. Measurements of six adult males from Georgia were: total length, 560 (513-692); tail length, 254 (224-313); hind foot length, 53 (48-63); and weight, 500 (467-541). Five adult females measured: total length, 583 (352-808); tail, 261 (222-321);

hind foot, 57 (49-71); and weight, 1137 (920-3700). Females possess a ventral marsupium or pouch for the development of young. Pouch young may be aged using snout to rump length and toothwear is a relatively reliable indicator of age up until adult size is attained (Petrides, 1949). The opossum has a complement of 22 chromosomes.

The opossum occurs throughout the eastern half of the United States and most of Mexico and Central America (Hall, 1981; McManus, 1974). Opossums have gradually extended their range northward and have been introduced on the west coast of the United States. The species utilizes a wide variety of habitats from arid to mesic environments and thrives in suburban areas (McManus, 1974). However, it typically is found in wetter areas particularly near water courses or swamps. Opossums are common throughout the SRS. This animal can be collected by using live traps with a meat or fish bait.

Little is known about numbers or densities of the opossums on the SRS. Young opossums apparently make up the majority of the population. Petrides (1949) found an Ohio population consisting of 75% young. Population turnover is probably rapid with an estimated average life expectancy of 1.3 years and a 4.8 year turnover (Petrides, 1949). Females rarely breed after their first year of sexual maturity.

Opossums have two breeding periods each year. In Georgia these are from mid-January to early March and from early April to mid-June (McKeever, 1958; Golley, 1962). Average litter size is between 6.8 and 8.9 although as many as 21 young have been observed (McManus, 1974). Birth occurs from 12 to 13 days after fertilization. The newborn are altricial but manage to crawl into the mother's pouch and attach themselves to a teat. Females typically possess 13 teats. The young remain attached to the teat for 50 to 65 days and are weaned at 95 to 105 days after birth (McManus, 1974).

The opossum is basically an opportunistic feeder, but typically consumes more animal than plant material. Insects make up the bulk of its diet but plant material and small vertebrates also are eaten (Golley, 1962; McManus, 1974). Opossums are often killed while foraging for carrion along roads. The success of the species is attributed to its omnivorous habits.

Home range estimates for the opossum vary widely. In Texas the estimates ranged from 0.12 ha to 23.47 ha with an average of 4.65 ha (Lay, 1942). The ranges typically are elongated rather than circular and may follow water courses. Home ranges of males are generally larger than those of females and may overlap ranges of several females. Opossums usually nest in abandoned underground dens of other animals or occasionally construct arboreal nests in tree hollows. Nesting material is passed from the mouth under the thorax to the tail which encircles the material and grasps it during transport (McManus, 1974).

Defensive behavior is highly developed in the opossum and consists of hisses, growls, and the baring of teeth. A greenish secretion is often extruded from two anal

glands when the animal is threatened. Feigning death may occur in the presence of a strong or persistent threat. In death feigning the animal becomes immobile with the mouth open and it lays with a ventral flexion of the body and tail (McManus, 1974). Apparent sensitivity to touch is greatly reduced but opossums exhibiting this behavior do respond weakly to a sudden low pitched sound.

The opossum has some economic importance. It is hunted and occasionally eaten in some part of its range. The opossum pelt is of low quality but is an abundant item on the fur markets.

Opossums were captured throughout the 29 years of the furbearer census although rarely during the first five years. Opossums were also included in a study of the effect of acute gamma radiation on wild animal species by Golley et al. (1965d). Steven Austad of Harvard University and postdoctoral fellow Donna Holmes are comparing aging rates and life histories of opossums on the SRS (a mainland population with a normal average lifespan of about 20 months) to longer-lived opossums on Sapelo, a barrier island off the Georgia coast. Holmes and Austad are currently beginning a study to determine if the differences in life histories seen in Sapelo and SRS opossums in the wild persist in captivity under controlled conditions.

Blarina carolinensis carolinensis (Bachman) - Southern Short-tailed Shrew

This short-tailed shrew, formerly recognized as *B. brevicauda* (George et al., 1982), is a small, short legged mammal with velvety fur. The eyes and ears are small and obscure. The tail is less than half the length of the head and body. Pelage color varies from slate gray to deep brown. The skull lacks a zygomatic arch and the teeth are tipped with brown pigment. The dental formula is 4/2, 1/0, 2/1, 3/3=32. The short-tailed shrew has five peg-like, unicuspid teeth, four of which are visible from the side. Mean standard measurements for 423 adults collect on the SRS were: total length, 92.6; tail, 18.8; hind foot, 11.6; and weight, 9.7. The sexes are difficult to distinguish as the genitals are borne internally. The diploid number of chromosomes is 50 (Meylan, 1967).

Blarina carolinensis is distributed throughout the southeastern United States from the Atlantic Coast to slightly west of the 100th meridian and from the Gulf Coast to Kentucky and southern Virginia (Hall, 1981). It is found primarily in moist deciduous forests and moist fields. The species is probably the most common mammal on the SRS. The greatest abundance appears to be in lespedeza fields (Golley et al., 1965a).

Faust et al. (1971) reported a mean home range size of 0.96 ha for short-tailed shrews on the SRS. Blair (1940) reported that males may have home ranges up to four times larger than those of females. Population levels are highest in autumn when they may exceed spring population levels by two to five times (Pearson, 1945). In lowland hardwood forests on the SRS, the density of *Blarina* was 11 per ha (Smith

et al., 1971). A density estimate made for a Florida population was also 11 per ha (Kale, 1972).

The breeding period appears to begin in February (Christian, 1969) with peaks in spring and autumn (Dapson, 1968; O'Farrell et al., 1977). The gestation period is 21 to 22 days (Hamilton, 1929). Litter size for 11 pregnant females collected on the SRS ranged from two to six with a mean of 4.0 (O'Farrell et al., 1977). Litter size was greater in the autumn (4.2) than in the spring (3.8). Young born in the spring may breed within two months (Pearson, 1945). The sex ratio of adults is 1:1 (Blair, 1940). Principle food items are earthworms, slugs, and snails (Fulk, 1972).

The short-tailed shrew has been investigated along with other small mammal species in relation to abundance and variety of small mammals on the SRS (Golley et al., 1965a; Gentry et al., 1971a, b, c; Briese and Smith, 1974; Smith et al., 1974) and effectiveness of various trapping and censusing techniques (Gentry et al., 1968; Kaufman et al., 1971; Smith et al., 1969, 1971). A genetic analysis of 30 individuals from the SRS revealed no variability in the allelic products of 12 loci (Tolliver et al., 1985).

Cryptotis parva parva (Say) - Least Shrew

The least shrew is similar in general appearance to *Blarina carolinensis*, however, the least shrew is somewhat smaller, less heavy bodied, and has grayish-brown fur. The dental formula is 3/1, 1/1, 2/1, 3/3=30. The species has four peg-like unicuspid teeth, three of which are visible from the side of the mouth. Mean standard measurements for four adult males collected on the SRS are: total length, 72.5; tail, 18.5; hind foot, 9.8;4.4; and for four females: total length, 74.8; tail, 16.0; hind foot, 9.7; and weight, 5.4. The diploid number of chromosomes is 52 (Hsu and Benirschke, 1970).

The least shrew is distributed from the Atlantic Coast of the United States to just west of the 100th meridian and from Panama to southern Canada (Hall, 1981). The least shrew is most often associated with grass and herbaceous vegetation (Hamilton, 1944; Davis and Joeris, 1945; Golley et al., 1965a).

The biology of the least shrew is not well known. Density estimates from an old field in Illinois were 25 to 37 individuals per ha (Hoffmeister and Mohr, 1957). The male:female sex ratio of 60 individuals collected on the SRS was 1.2:1. In northern parts of the species range, breeding extends from March to November (Golley, 1962). Litter size of five females from the SRS averaged 2.7 and Golley (1962) reported litter size of from five to six young. The gestation period is 21 to 23 days (Conaway, 1958).

The primary food of the least shrew is invertebrates such as earthworms, snails, centipedes, and insects. In captivity, least shrews may eat more than their

own body weight daily (Hamilton, 1944). Digestion is rapid and chitin from insect food can appear in the feces 95 minutes after ingestion (Hamilton, 1944).

The least shrew has not been specifically studied on the SRS, but can be locally abundant. It has been mentioned in studies involving a number of species of small mammals (Golley et al., 1965a; Gentry et al., 1968: 1971; Briese and Smith, 1974).

Sorex longirostris longirostris Bachman - Southeastern Shrew

The southeastern shrew is small, short-legged, and has a long snout. The fur is dark brown and velvet-like. The tail is about half as long as the body. The skull is less than 25 mm long, lacks a zygomatic arch, and has brown tipped teeth. The southeastern shrew has five pairs of peg-like, unicuspid teeth in the upper jaw, only four of which are visible from the side of the mouth. There is little difference in the size of the first four of these unicuspid teeth. The dental formula is 3/1, 1/1, 3/1, 3/3 = 32. The genitals are retained internally, making it difficult to distinguish the sexes. Mean standard measurements for seven adult males collected on the SRS were: total length, 82.2; tail, 29.6; hind foot, 10.1; weight, 3.7; and for 21 females were: total length, 92.9; tail, 30.7; hind foot, 10.9; and weight, 3.7.

The southeastern shrew is distributed from the Atlantic Coast westward to the Mississippi River and from the Gulf Coast northward to about the Mason-Dixon line (Hall, 1981). This shrew is primarily considered to be a forest species (Smith et al., 1971; Gentry et al., 1968). Little is known about the biology of the southeastern shrew. It probably feeds on insects, earthworms, and other invertebrates on the forest floor. The male:female sex ratio for 19 individuals collected on the SRS was 0.35:1. The peak number of individuals collected was in June (Briese and Smith, 1974). No estimates of density or home range size are available for the southeastern shrew. This shrew has not been well studied on the SRS, but has been reported in other small mammal studies.

Condylura cristata parva Paradiso - Star-nosed Mole

The star-nosed mole is the size of either a large mouse or a small rat. An elongate snout bearing 22 fleshy appendages on the nose is its most characteristic feature. The forefeet are hand-like, held along the side of the head with the palms facing laterally, and bearing long blunt claws. The head is elongate and appears to be neckless and earless; the eyes are small but discernable. The tail is about half as long as the body and is coarsely haired. The exposed skin on the feet has a scaly appearance. The velvety pelage may be brown or black. The dental formula is 3/3, 1/1, 4/4, 3/3 = 44. Measurements for seven specimens collected on the SRS were: total length, 132; tail, 48; hind foot, 22; front foot length x width, 18x12; and weight, 27.8. The diploid chromosome number is 34 (Yates and Schmidly, 1975).

The only mole other than the star-nosed mole occurring on the SRS is the eastern mole. The fleshy appendages on the snout, long hairy tail, and scaly

appearance of the skin on the feet all distinguish the star-nosed mole from the eastern mole. For the star-nosed mole, the width:length ratio of the skull is 1:3, there are 11 teeth in each upper tooth row, and the hard palate terminates anterior to the posterior border of the last molar. For the eastern mole, the width:length ratio of the skull is 1:2, there are 10 teeth in each upper tooth row, and the hard palate terminates posterior to the last molar. Mole skulls can be distinguished from shrew skulls by the presence of zygomatic arches and lack of color pigment on the teeth. All the shrews on the SRS lack a zygomatic arch and have brown tipped teeth.

The present distribution of the star-nosed mole appears to be centered around the Great Lakes and the St. Lawrence Seaway (Hall, 1981). The South Carolina-Georgia group seems to be a disjunct population. The star-nosed mole generally occurs in wet habitats. Some burrows terminate at or below the water table (Rust, 1966). Most of the specimens have been collected in general trapping for other species. Snap traps set in surface runways and in the burrows have been tried (Rust, 1966). Star-nosed moles have been caught in minnow traps (Eadie and Hamilton, 1956) and in quantity in muskrat sets (Hamilton, 1931). Specimens have been collected on the SRS in pitfall buckets associated with drift fences.

The biology of the star-nosed mole on the SRS has not been studied. Studies elsewhere in its range indicate that there is a single litter per year that averages 5.4 (range two to seven) young (Davis and Peek, 1970) with breeding occurring in the first year of life (Eadie and Hamilton, 1956). This species is evidently gregarious and active both day and night (Hamilton, 1931). The measurements reported by Hamilton (1931), Yates (1978) and Hall (1981) do not suggest any type of sexual dimorphism.

The star-nosed mole is not commonly collected on the SRS. Three individuals caught in pitfall traps on the SRS were included in a study of genetic variability of insectivores (Tolliver et al., 1985). No genetic variability has been found for *C. cristata* (Yates and Greenbaum, 1982; Tolliver et al., 1985) but further analyses are needed to substantiate the lack of genetic polymorphism in the species.

Scalopus aquaticus howelli Jackson - Eastern Mole

The highly adapted forefeet and short 'hairless' tail are the most characteristic features of the eastern mole. The forefeet are hand-like and oriented along the side of the head with the palms facing laterally, have broad blunt claws, and appear armless. Except for the movable, elongate snout, the head is featureless, as the eyes, ears, and neck are not evident. The velvet-like fur characteristically is slate gray, but appears silvery when smoothed down; all hairs are of nearly equal length. A cinnamon-brown staining on the chin and along the center midline is common in adults, and usually is more pronounced in males than in females. The tail is approximately the length of the hind foot and is scantily haired. The hind feet are small, bear short claws, and rotate in lateral planes.

The dental formula is 3/2, 1/0, 3/3, 3/3 = 36. Standard measurements for 13 adult males collected on the SRS during the summer of 1979 were: total length, 132.9 (123-142); tail, 18.1 (13-22); hind foot, 16.2 (15-19); front foot length-width, 19.5 to 19.8; weight, 40.2 (34-43); and for nine females were: total length, 131 (122-138); tail, 19.2 (17-20); hind foot, 16.2 (15-18); front foot length-width, 19.5 to 17.7; and weight, 33.8 (29-37). The diploid chromosome number is 34 (Yates and Schmidly, 1975).

Males are slightly larger in size than females (Jackson, 1915; Yates and Schmidly, 1977; Yates, 1978; Hartman and Gottschang, 1983), however, no single external body measurement is reliable for sexing moles. During the breeding season, sex sometimes can be determined using the method described by Hartman and Gottschang (1983). Using skull characteristics (Leftwich, 1972; Yates, 1978) and reproductive tract data (Conaway, 1959), two age classes can be identified during the spring and summer months. The parietal-occipital suture and the root canals of the upper molars are open in young of the year and closed in adults.

The star-nosed mole, which also occurs on the SRS, can be distinguished from the eastern mole by its flared snout with a cluster of 22 finger-like appendages and a long coarsely-haired tail. Skulls of adult eastern moles can be distinguished from those of shrews because they exceed 25 mm in length, have zygomatic arches, and possess white teeth instead of brown-tipped teeth. The skull of the eastern mole can be distinguished from that of the star-nosed mole by the number of teeth, the width x length ratio, and the point of termination of the bony palate (see star-nosed mole account).

The eastern mole currently is the most widely distributed American mole. It ranges from the east coast to slightly west of the 100th meridian and from the Gulf of Mexico to the southern parts of Minnesota (Hall, 1981). Suitable habitat appears to involve an abundant invertebrate soil fauna, and a substrate above the water table that is sufficiently thick and friable yet adhesive, so as to support a permanent burrow system. On the SRS, moles are most abundant on the Sunderland Terrace (Langley and Marter, 1973; p. 18) and least abundant in the sandy areas and the swamp. During the summer of 1979 the maximum density observed was five moles per ha (at road A-12 and the railroad). Density on the Aiken Plateau was 2.5 moles per ha which probably is more typical for the entire area. Home range size has not been determined for the SRS moles. Elsewhere in the range of the species, the tunnel system of the male usually is two or three times the length of that of the female (Harvey, 1967; Leftwich, 1972). The Victor Mole trap #750 is effective for collecting this species.

The SRS summer sample of 1979 showed a male:female ratio of 1:1 and a young of the year:adult ratio of 0.5:1. In Missouri, the adult sex ratio was 0.7:1 and the young:adult ratio 3.9:1 (Leftwich, 1972). Mean placental scar counts for nine adult moles taken during the summer of 1979 on the SRS were 2.7, and means from other areas range from 3.4 (Leftwich, 1972) to 3.9 (Conaway, 1959). A single annual litter

of about three to four young is born in the spring (Scheffer, 1909; Jackson, 1915), and young do not breed until the year following their birth (Scheffer, 1909; Conaway, 1959). The precise length of the gestation period is unknown but appears to be about four weeks (Conaway, 1959).

Stomach contents of SRS moles included earthworms, white grubs, and ants. Elsewhere in the range, white grubs and earthworms form the bulk of the diet (Dyche, 1903; West, 1910; Whitaker and Schmeltz, 1974). Laboratory maintained moles use 1 kcal/g/day (Leftwich, 1972). If this information is applicable to the SRS moles, they would need approximately 37 kcal/day. Translated into earthworms (0.74 kcal/g) or white grubs (0.98 kcal/g; Leftwich, 1972), this would involve a harvest of 50 g/day of earthworms or 38 g/day of white grubs. However, Jensen (1983) has noted that such experiments may not reflect actual food consumption of moles in the wild.

Specimens of *S. aquaticus* have been examined electrophoretically in two separate studies. Average heterozygosity ($\bar{H}$) at 18 presumptive loci of 15 moles from Kentucky, Massachusetts, Michigan, Tennessee, and Texas was 0.015 (Yates and Greenbaum, 1982). Tolliver et al. (1985) examined 18 loci of 32 moles from the SRS and 30 from Missouri and reported $\bar{H} = 0.05$ for both populations.

Lasionycteris noctivagans (Le Conte) - Silver-haired Bat

The silver-haired bat is a medium-sized bat with dark fur, strongly washed with silver dorsally. The ears are short, rounded, and naked. The interfemoral membrane is lightly furred dorsally but the wings are hairless. The skull is flattened, having a broad rostrum and interorbital region. The dentition is 2/3, 1/1, 2/3, 3/3 = 36. Typical measurements of adults were: total length, 92-113; tail, 38-48; hind foot, 9-12; and weight, 7-9. The only similar species on the SRS is the hoary bat, *Lasiurus cinereus*; however, the hoary bat is much larger and has a heavily furred interfemoral membrane. The diploid chromosome number is 20 (Baker and Patton, 1967).

The silver-haired bat is found from southern Canada south through all the states except Florida (Hall, 1981). It probably occurs statewide in South Carolina (Golley, 1966). The species is primarily associated with wooded areas near streams, rivers, and ponds. The silver-haired bat shelters in hollow trees, under bark or leaves, in woodpecker holes, in crevices, or buildings but rarely enters caves. In winter silver-haired bats hibernate in protected shelters. Silver-haired bats are insectivorous and frequently forage over water.

Lasionycteris noctivagans is a tree dweller that roosts individually or in small groups. The sexes apparently segregate after breeding and the females may form small nursery colonies (Barbour and Davis, 1969). Generally, two young are

produced in late June or early July. Little else is known regarding the species breeding habits.

Little work has been published on the bats of the SRS. In the summer of 1979, two week-long bat censuses were conducted by Stephen B. Childs and William M. Atkins from the University of Maryland, Eastern Shore (Anonymous, 1980). No *L. noctivagans* were taken during the census. One *L. noctivagans* from the SRS is in the mammal collection of the University of Georgia Museum of Natural History.

Lasiurus borealis borealis (Müller) - Red Bat

The red bat is a medium-sized species with long pointed wings, short rounded ears, and a heavily furred interfemoral membrane. The coat color distinguishes this species from the other bats of the SRS. The pelage is brick red to rusty red above and white underparts. Males are usually more brightly colored than are females. The skull is short and broad with a high rounded braincase. The dentition is 1/3, 1/1, 2/2, 3/3 = 32. Measurements for 26 males from South Carolina were: total length, 98 (57-109); tail, 47 (38-54); hind foot, 7.7 (6.5-9.0); forearm 39 (25-42); weight, 8.8 (7.3-10.6); and for 21 females were: total length, 108 (88-117); tail, 50 (38-58); hind foot, 7 (6-9); forearm 40 (32-43); and weight, 11.8 (9.6-14.0). The red bat has a diploid number of 28 chromosomes (Baker and Patton, 1967).

The red bat ranges from southwestern Canada south to Panama and east to the Atlantic coast. It also occurs on the Pacific coast (Hall and Kelson, 1959). In South Carolina red bats occur statewide in the warmer months (Golley, 1966). Red bats are predominately solitary, woodland inhabitants.

In many parts of its range, the red bat is one of the most abundant bat species. In Iowa, McClure (1942) estimated a density of 2.5 red bats per hectare. Females congregate in nursery areas in summer with few males occurring in that part of the range (Barbour and Davis, 1969). The gestation period is 80 to 90 days (Jackson, 1961); however, breeding takes place in the fall or winter and sperm is stored in the uterus until spring when fertilization occurs. Litter size averages 3.2 with a range of one to four (Barbour and Davis, 1969). The young are weaned at about one month of age and are able to fly at an age of five or six weeks (Hamilton, 1963; Jackson, 1961).

Red bats roost alone or in small groups in trees and shrubs. The bats choose leafy areas where they are concealed on all sides but have a clear path beneath them (Barbour and Davis, 1969). The species begins searching for insects in the early evening and usually hunts along water courses or near trees. Red bats migrate to warmer climates with the onset of cold weather or hibernate in underground refuges. The species is well adapted for surviving drastic temperature fluctuations (Barbour and Davis, 1969).

The red bat has not been studied on the SRS. One individual was recorded at Rainbow Bay in the August 1979 bat census (Anonymous, 1980).

Lasiurus intermedius floridana Miller - Northern Yellow Bat

This species is a relatively large bat with long wings, short pointed ears, and an interfemoral membrane that is furred only on the anterior half of the dorsal surface. The color is variable ranging from yellowish orange to yellow brown and gray. The tips of the hairs are often gray or brown. The skull is short, deep, and broad and has well-developed lambdoidal and sagittal crests. The yellow bat lacks the peglike second premolar of the other members of the genus. The dental formula is 1/3, 1/1, 1/2, 3/3=30. Typical measurements were: total length, 121-164; tail, 57-77; hind foot, 8-13; forearm, 45-63; and weight, 15-19. The diploid chromosome number is 26 (Baker and Patton, 1967).

In the United States, *L. intermedius* occurs along the coast from southern Virginia to eastern Texas. The species is closely associated with Spanish moss (Barbour and Davis, 1969). The sexes of the yellow bat are segregated during a major part of the year (Barbour and Davis, 1969). The females form nursery colonies. The mating season is unknown but young have been observed from late May through June. The average litter size is 3.4 (Barbour and Davis, 1979). Yellow bats characteristically forage 5 to 10 m above the ground over open areas with few shrubs and only scattered trees. Grassy areas such as pastures or lake edges are preferred (Jennings, 1958). The species roosts and bears its young in clumps of Spanish moss.

The yellow bat has not been studied on the SRS. The species was not recorded in the 1979 bat survey, however, one specimen was collected along Upper Three Runs Creek by Jerry Choate in the summer of 1978.

Lasiurus seminolus (Rhoads) - Seminole Bat

The seminole bat resembles the red bat, differing mainly in color. The upper parts of *L. seminolus* are rich mahogany brown lightly frosted with grayish white. The posterior part of the underside is slightly paler than the back. The throat and chest are whitish. The dentition is the same as that of *L. borealis*; 1/3, 1/1, 2/2, 3/3=32. Body measurements of 38 adult females from South Carolina were: total length, 105 (94-116); tail, 48 (41-53); forearm, 42 (39-44); and weight 10.4 (6.7-13.1). The diploid chromosome number is 28 (Hsu and Benirschke, 1969).

The seminole bat occurs from the southern tip of North Carolina along the coast through Texas into Mexico (Barbour and Davis, 1969). Its distribution closely coincides with that of Spanish moss. Seminole bats winter in the Deep South, but the northern limits of the species range are unknown (Barbour and Davis, 1969). Seminole bats roost in clumps of Spanish moss although there is no indication that they rear their young there (Jennings, 1958). These bats feeds on insects which are captured in flight in and around the tree canopy (Barbour and Davis, 1969). They

occasionally may capture insects on the ground. The seminole bat apparently shifts its range to the south in winter (Barkalow, 1948).

Young are born in June in Florida and litter size ranges from one to four with an average of 3.3 (Jennings, 1958). In younger age classes the sexes are nearly equal in number; however, females predominate the older age classes presumably due to higher male mortality (Jennings, 1958).

No research has been conducted on the seminole bat on the SRS. This species was one of the most common bats taken during the 1979 summer bat census on the SRS (Anonymous, 1980).

Nycticeius humeralis humeralis (Rafinesque) - Evening Bat

The evening bat is a small to medium-sized brown bat. The pelage is short, sparse, and medium to dark brown. The membranes of the wings and tail are thick and leathery and are not furred. The skull is short, broad and robust. The lateral profile of the skull from the nares to occiput is nearly straight. The dental formula is 1/3, 1/1, 1/2, 3/3 = 30. Measurements of 19 males from South Carolina were: total length, 88 (79-94); tail, 36 (31-39); hind foot, 7.1 (6-9); forearm, 36 (33-38); and weight, 8.2 (6.1-12.0); and for 50 females: total length, 92 (76-99); tail, 38 (33-43); hind foot, 6.9 (5.5-8); forearm, 36 (31-40); and weight, 8.8 (6.6-13.0). The evening bat has a diploid chromosome number of 46 (Baker and Patton, 1967).

The evening bat is found from eastern Texas and Kansas to the Atlantic Coast of the United States and from the Gulf of Mexico to the southern Great Lakes (Hall, 1981) and occurs statewide in South Carolina. Evening bats prefer trees and buildings as roosting sites and are rarely found in caves (Watkins, 1972).

Little is known about the population biology of the evening bat. The sexes generally segregate during the period when young are born. Males may be completely absent in parts of the species range (Watkins, 1969) although both sexes have been reported year around in South Carolina (Golley, 1966). The young are born in nursing colonies that range in size from 25 to 950 individuals (Watkins, 1969). Smaller groups have been taken from clumps of Spanish moss in Florida (Jennings, 1958). Pregnant females have been collected only in May in South Carolina (Golley, 1966). The usual number of young is two, although one to four have been found (Watkins, 1972). The young are born naked and blind. The eyes open within 12 to 30 hours after birth and fur is present on the dorsum by day five. Juveniles begin flying at approximately 20 days of age (Watkins, 1972).

Evening bats are insectivorous. The species is known to forage in the same area with other bat species. Evening bats are migratory; banded individuals have been recovered up to 547 km south of where they were marked (Watkins, 1969). The evening bat is probably a winter resident of South Carolina (Golley, 1966). The predators of *N. humeralis* are not well known but feral or domestic cats take a heavy

toll when the nursing colonies are located in buildings (Watkins, 1972). Raccoons and black rat snakes also may prey upon the species.

The evening bat has not been studied on the SRS. It was collected in the August, but not in the June bat survey conducted by Childs and Buchler during 1979 (Anonymous, 1980).

Pipistrellus subflavus subflavus (F. Cuvier) - Eastern Pipistrelle

The eastern pipistrelle is a small bat with tricolor fur. The base of the hair is dark, the middle band lighter, and the tip dark. The anterior third of the interfemoral membrane is furred. Pelage color is variable ranging from pale yellow to silver-gray, chocolate brown or black. The lateral profile of the skull is convex in the interorbital region. The dentition is 2/3,1/1, 2/2, 3/3 = 34. Measurements of 17 adults from South Carolina were: total length, 71-92; tail, 33-45; hind foot, 7-10, forearm, 32-36; and weight 4.2-6.1. The diploid chromosome number is 30 (Baker and Patton, 1967).

The eastern pipistrelle occurs throughout most of eastern North America (Hall, 1981). Its distribution is statewide in South Carolina (Golley, 1966), occurring primarily on the edge of wooded areas. Caves, mines, and rock crevices are used as winter hibernation sites and summer roosts.

Reproduction probably takes place in late fall with the young born from late May to late June (Barbour and Davis, 1969). Litter size is normally two although up to four embryos have been reported. The young are large at birth. The ratio of fetal weight to maternal weight is about 1:3 (Barbour and Davis, 1969). Growth is rapid and young *P. subflavus* are capable of flight at about one month of age. Males have a higher survival rate than do females (Davis, 1966).

Eastern pipistrelles emerge from their roosts early in the evening to forage. They often hunt over water courses or large open fields and tend to stay away from dense woods and small open areas (Davis and Mumford, 1962). Insects, particularly moths, are their principle prey. Eastern pipistrelles appear to be solitary hunters but small groups occasionally can be seen. In winter, eastern pipistrelles hibernate in colonies that consist of fewer than 50 individuals.

The eastern pipistrelle has not been studied on the SRS. During the summer bat census on the site in 1979, *P. subflavus* was recorded in both late June and late August (Anonymous, 1980).

Plecotus rafinesquii macrotis (Le Conte) - Big-eared Bat

The big-eared bat is medium-sized with large ears and two large lumps on the dorso-lateral surface of the snout. The pelage is gray above and nearly white below. The basal portion of the hairs is blackish and the tips are white. The wing

membranes are not furred. The dental formula is 2/3, 1/1, 2/3, 3/3 = 36. The first upper incisors are bicuspid. Measurements of 11 males from South Carolina were: total length, 98 (95-100); tail, 48 (44-52); hind foot, 9.6 (7-11); forearm, 41 (38-43); weight, 7.6 (6.9-9.5); and for 22 females: total length, 101 (96-105); tail, 49 (47-54); hind foot, 10 (8-12); forearm, 43 (41- 44); and weight, 7.4 (6.0-8.8). Female big-eared bats tend to be slightly larger than males. The diploid chromosome number is 32 (Baker and Mascarello, 1969).

Big-eared bats occur from southeastern Virginia westward to central Indiana and east Illinois south to east Texas (Jones, 1977). In South Carolina the species appears to be most common in forested regions on the coastal plain (Golley, 1966). Big-eared bats generally utilize partially lighted buildings, caves, trees and other natural places as roosting sites (Barbour and Davis, 1969). They frequently roost with other bat species. Foraging does not begin until after dark. The diet consists of insects. The flight of adult *P. rafinesquii* varies from swift to nearly hovering. If disturbed, females will carry their offspring to a new site (Jones, 1977). The species hibernates but the time when hibernation takes place is not known.

Big-eared bats apparently breed in late autumn and winter (Hoffmeister and Goodpaster, 1963). The gestation period is unknown. A single offspring is born in late May or early June. Females form nursery colonies from several to 100 individuals (Jones, 1977; Barbour and Davis, 1969). Newborn individuals are naked, but a dark juvenile pelage develops a few days after birth and persists until about three months of age (Jones and Suttkus, 1975).

Big-eared bats have not been studied on the SRS. The species was not collected during the 1979 summer bat census. Two specimens from the SRS are in the collection of mammals at the University of Georgia Museum of Natural History.

Dasypus novemcinctus mexicanus Peters - Nine-banded armadillo

This mammal is the only representative of the xenarthrans in the United States. It is characterized by a pointed nose and pointed tail and a body covered with a shell-like keratinized scaly skin (armour plates) with nine bands across the back. The animal has short legs, hairy toes, and long claws. The molars and premolars are peg-like, and there are no incisors or canine teeth. The dental formula is 0/0, 0/0, (premolars and molars combined) 7/7 = 28. The tongue is long and cylindrical, and the submaxillary saliva glands are well developed. The total length of the body and tail is approximately 600 to 800 mm, and weights range from 4 to 7 kg (Galbreath, 1982). Sexual dimorphism is evident with males being slightly larger than females. The diploid chromosome number is 64.

The armadillo has a South American origin and migrated northward and eastward to Texas and through the southeast. It was accidentally released in Florida earlier in the century and has just recently been reported as occurring in South Carolina (Mayer, 1989). The northern distribution of armadillos is probably limited

by temperature and rainfall (Humphrey, 1974; Galbreath, 1982). Preferred habitats include brushy areas and wastelands; however, armadillos also occur in pine plantations and hardwood bottomlands (Golley 1962; Hamilton 1963). Another habitat prerequisite is soil that permits easy digging where the animals can obtain insects, their larvae, and other soil and terrestrial invertebrates. Armadillos are fossorial, living in underground burrows and their activity patterns are crepuscular to nocturnal. Home range sizes range from 7.6 to 10.8 ha (Galbreath, 1982). Litter size ranges from two to six with four being typical. Litters always consist of genetically identical offspring developed from a single zygote. Breeding occurs in July and the young are born in November. Armadillos are susceptible to a leprosy-like disease and therefore have been a subject of biomedical research (Walsh et al., 1975).

Only two nine-banded armadillos, have been recorded on the SRS, both were road-killed specimens. One specimen was near the center of the site in 1985 (Mayer, 1989) and the other was on Highway 125 by Upper Three Runs Creek (J. W. Gibbons, pers. comm.). Several other records have been recorded from the southeastern portion of the state (Mayer, 1989). According to Humphrey (1974) the climatic limits of armadillos include a minimum of 380 mm annual precipitation and no more than nine freeze-days per year. Based on these physiological limits, armadillos could expand their range throughout most of south Carolina except for the western mountainous regions. A viable population of armadillos does not currently exist on the SRS.

Sylvilagus aquaticus aquaticus (Bachman) - Swamp Rabbit

The swamp rabbit or cane cutter is a large rabbit with large ears and a sparsely-haired slender tail. The coloration is rusty brown above and white below. The underside of the tail is pure white unlike the marsh rabbit which has brown hair on the underside of its tail. The large size of the swamp rabbit differentiates it from the eastern cottontail. The skull is large and robust. The posterior extensions of the supraorbital processes are joined to the braincase along their entire lengths. The dentition is 2/1, 0/0, 3/2, 3/3 = 28. Standard measurements of 58 adults from Georgia were: total length, 368-535; tail, 44-93; hind foot, 84-111; and weight, 1332-2535.

The swamp rabbit is found in the southeastern United States from eastern Texas to western South Carolina and from southern Illinois to the Gulf of Mexico (Hall, 1981). It is an inhabitant of the floodplains of rivers and creeks and is seldom found far from water. Swamp rabbits often are associated with cane thickets, and thus, are called cane cutters in many regions (Davis, 1966). It is not clear whether the swamp rabbit actually occurs on the SRS; however, Jenkins and Provost (1964) indicate that there might be some intergradation between *S. aquaticus* and *S. palustris* on the SRS.

In Texas, a census of swamp rabbits indicated that they occurred at a density of one rabbit per 2.8 ha (Davis, 1966). Densities as high as 1.2 rabbits per ha were

found in western Kentucky (Barbour and Davis, 1974). In bottomland habitat in northern Georgia a population density estimate was 0.14 rabbits per ha (Lowe, 1958). Breeding may occur throughout the year and two to five litters may be produced per year (Golley, 1962; Barbour and Davis, 1974). The gestation period is about 40 days (Hunt, 1959) and litter size averages 2.6 (Lowe, 1958). The young are born fully furred, but the eyes and ears are closed. The eyes open and the young begin to walk in two to three days. Nests are constructed from grass and the mother rabbit's fur, and often are built in logs and stumps. The mean home range size of swamp rabbits in northern Georgia was 7.6 ha (Lowe, 1958). Swamp rabbits feed on emergent aquatic vegetation, grasses, sedges, and cane (Golley, 1962). These rabbits are good swimmers and enter the water voluntarily and may even dive under the water when pursued by predators (Hamilton, 1963). Known predators include gray foxes, great horned owls, and alligators (Davis, 1966). Swamp rabbits are extensively hunted in parts of their range. No research has been conducted on swamp rabbits on the SRS.

Sylvilagus floridanus mallurus (Thomas) - Eastern Cottontail

The eastern cottontail is a medium-sized rabbit with relatively long ears. The pelage is generally grayish buff agouti in color but varies from gray to reddish. The nape of the neck is cinnamon red. The tail is large, well furred and fluffy, and is reddish brown above and white below. An anterior supraorbital process is present and is separated from the skull by a notch. The posterior supraorbital process is partially fused with the cranium forming a slit-like opening when viewed from above. The dental formula is 2/1, 0/0, 3/2, 3/3 = 28. Standard measurements of 33 adults from Georgia were: total length, 335-510; tail, 35-68; hind foot, 40-98; and weight, 568-1334. The diploid chromosome number is 42 (Holden and Eabry, 1970). The cottontail can be distinguished from the marsh rabbit by its smaller size and the white underside of the tail. The swamp rabbit is larger than the cottontail and it has a small narrow tail.

The eastern cottontail has the largest geographic range of any species of *Sylvilagus* in North America (Hall, 1981). This species occurs throughout the eastern United States and ranges from southern Canada to South America. Eastern cottontails are primarily associated with upland areas in both wooded and open habitats. Heavy grass and thickets or bushy farmland probably provide the optimal conditions for this species. The cottontail is abundant on the SRS, but their numbers are low in the sandhills and they are rare in the deep swamp (Jenkins and Provost, 1964).

Density of cottontails on the SRS has been estimated to be about 0.7 rabbits per ha (Jenkins and Provost, 1964). This estimate is lower than that reported by Allen (1954) of from 1.3 to 2.5 rabbits per ha but is comparable to the 0.8 rabbits per ha reported by Gerstell (1937) for Pennsylvania. There are no estimates of the age structure of the cottontail population of the SRS, but it probably favors the young due to the high fecundity and expected longevity of the species.

The breeding season is primarily from February to August (Golley, 1962). The gestation period is about 30 days and females breed immediately after producing a litter such that three or more litters may be produced per year (Ecke, 1955; Barbour and Davis, 1974). Individuals from early litters can produce young by late summer. The litter size averages four or five and ranges from three to eight (Barbour and Davis, 1974). The young are born lightly furred with their eyes closed, but are indistinguishable from adults by four to five months (Davis, 1966).

The home range size of eastern cottontails in Missouri has been estimated to be 0.56 ha for males and 0.48 ha for females with a range of 0.06 to 1.96 ha (Schwartz, 1941). The rabbits spend most of the day in packed-down grass or brush called a form. The female builds a nest by scraping out a shallow depression in the ground and lining it with grass and fur which she pulls from her belly and breast (Barbour and Davis, 1974). Cottontails are active primarily in the twilight hours. Peak activity of cottontails on the SRS in May 1961 was from 7 to 8 a.m. (Jenkins and Provost, 1974).

Cottontails are often found in urban areas, particularly around the edges of towns. They can cause some damage to gardens and flower beds. In many areas, cottontails are important game animals. An average of 950,000 rabbits was taken annually in Kentucky from 1964 to 1967 and 1970 to 1971 (Barbour and Davis, 1974).

The eastern cottontail has not been studied on the SRS. Cottontails were caught occasionally during the annual furbearer census (Wood and Odum, 1965) but they were not taken after 1969 when live traps baited with meat replaced scent-baited leg-hold traps.

Sylvilagus palustris palustris (Bachman) - Marsh Rabbit

The marsh rabbit is a small rabbit with short, broad ears and a small tail. The pelage is reddish brown dorsally and the underparts are white to buff. The underside of the tail is brownish or dingy gray, not white as in the other two species of rabbits on the SRS. The posterior and anterior extensions of the supraorbital processes are joined to the skull along most or all of their lengths. The dental formula is the same as that of *S. floridanus*: 2/1, 0/0, 3/2, 3/3 = 28. Standard measurements of 10 adults from Georgia were: total length 284-446; tail 20-52; hind foot, 59-97, and weight 858-1780.

The marsh rabbit is found in the coastal areas of the southeastern United Sates occuring from southeastern Virginia to extreme western Florida (Hall, 1981). This rabbit is most commonly associated with coastal lowlands, brackish marshes, and floodplain habitat (Golley, 1962). Marsh rabbits are not common on the SRS and only two specimens have been collected (Jenkins and Provost, 1964). This species is most likely to be found in the swamp on the SRS and possibly along some of the water courses.

Little is known about the population biology of the marsh rabbit. In favorable habitat it may be quite abundant. Tomkins (1955) observed 27, 30, and 42 rabbits over 2.1 km during three road censuses in Georgia. Marsh rabbits probably breed year around. Young have been observed in late February, and a nursing female was found in November (Tomkins, 1955). Two to four young per litter are produced (Hamilton, 1963). Nests are constructed of soft grass, and the mother's fur and may be built on the ground surface (Golley, 1966). A variety of foods are eaten including marsh grass, cane, forbs, leaves, shrubs, and woody materials. Blair (1936) reported that captive marsh rabbits consumed 29% of their body weight in green food daily. Marsh rabbits are primarily nocturnal. They are strong swimmers and have been observed swimming over 200 m from shore (Tomkins, 1935). Marsh rabbits seldom exert economic pressure on crops. This rabbit is considered a good game animal in some areas.

Marsh rabbits have not been studied on the SRS, however, a study has been conducted on growth, development, and ectoparasites of marsh rabbits from the area of Savannah, Georgia (Caldwell, 1966).

Neotoma floridana floridana (Ord) - Eastern Wood Rat

The eastern wood rat is large, with long naked ears, long vibrissae and a haired tail. The upper parts vary from pale cinnamon to buffy gray and the underparts are white to grayish. The tail is shorter than the head and body and not sharply bicolored. The dental formula is 1/1, 0/0, 0/0, 3/3=16. The enamel on the cheek teeth is arranged into a folded pattern of three or four loops. Mean body measurements of six adult male wood rats captured on the SRS were: total length, 321; tail, 158; hind foot, 35; weight, 202; and for nine females: total length, 340; tail, 162; hind foot, 36; and weight, 189. The diploid number of chromosomes is 52 (Hsu and Benirschke, 1970).

Eastern wood rats are sexually monomorphic and the major difference between juveniles and adults is body size and weight. The eastern wood rat is not likely to be confused with any other rodent on the SRS except possibly the Norway rat, *Rattus norvegicus*. The latter can be recognized by its brown color, coarse pelage, and naked, scaly tail. *Neotoma floridana* ranges from Pennsylvania south throughout the southeastern United States and as far west as Texas and Colorado. The

subspecies *N. f. floridana* found on the SRS occurs along the coastal plains of South Carolina and Georgia and the northern two-thirds of Florida.

On the SRS the wood rat is now found mainly in hardwood forest habitat and along extensive hardwood hedgerows (Teska, 1978). During the first few years following land abandonment, the wood rat was commonly found in open field situations associated with abandoned houses, barns, corn cribs, and hog pens. A colony on rare occasions may be discovered among the debris of former sites of human habitations.

Wood rats are somewhat omnivorous but their diet consists primarily of plant material including twigs, green leaves, fruits, berries and nuts. In the autumn they may hoard acorns and other seeds. Wood rats live in family groups which are widely dispersed. Consequently, wood rat populations are disjunct, and common line or grid trapping patterns may not give true estimates of its numbers or distribution. Also, because of their large body size, wood rats are not readily caught in conventional small mammal traps. As a result, the wood rat is likely to be much more common on the SRS than is reflected by the few miscellaneous captures associated with other small mammal studies.

Few data are available on the population biology or ecology of the wood rat on the SRS. From other studies in the southeastern states (Golley, 1966) breeding is known to occur throughout the year, at least along the coastal plain. Gestation presumably is 33 to 42 days with one to four young produced per litter.

Wood rats construct a nest or house of a large pile of sticks, leaves, and trash. The house is often located on the ground and supported by a log or sapling, but may also be in a stump, hollow log, under a large rock, in crevices of rocky outcrops or cliffs, in caves, in attics of buildings, or even several feet in the air in grapevines or greenbrier tangles (Chamberlain, 1928). The large house contains a nest and storage and defecation areas. The house may contain discarded trash items such as flash bulbs, shotgun shells, bits of glass and paper, bones, metal scraps and articles of clothing (Barbour and Davis, 1974). Wood rats seldom enter urban areas, but often build nests in outbuildings in rural areas or abandoned structures. Therefore, wood rats are considered of minor economic importance to man. Wood rats show little fear of man and are remarkably gentle in their behavior. They are easily handled and rarely bite even when just captured in the wild. They can be maintained in the laboratory where they readily breed and raise young.

Miscellaneous captures of wood rats were reported by Teska (1978) during a study of *Sigmodon hispidus* in young loblolly pine stands. A comparative electrophoretic study of the tissue proteins of wood rats from SRS and from Arkansas revealed many fixed protein differences. The possibility that there are at least two species of wood rats in the two areas needs further investigation. Researchers contemplating studies on wood rats will need to design trapping techniques to take into account the wood rats' nesting patterns, distribution, and large body size.

Ochrotomys nuttalli nuttalli (Harlan) - Golden Mouse

The golden mouse is easily distinguished from all other mice on the SRS by its uniformly rich, tawny yellow fur on the upper parts. The pelage underneath is soft and thick. The feet and underparts are creamy, often washed with yellow on the venter. The tail is pale golden brown above and creamy below. The dental formula is 1/1, 0/0, 0/0, 3/3 = 16. In body form the golden mouse resembles the cotton mouse. During preliminary field identification a juvenile golden mouse with wet fur may be confused with the harvest mouse, the juvenile cotton mouse, or the house mouse. The harvest mouse has a median groove in each upper incisor, the cotton mouse is darker, has a shorter tail, and slightly larger ears, and the house mouse has a naked tail. Adult golden mice continue to grow slowly throughout their life. Mean body measurements of 80 adult male and 149 adult nonpregnant female golden mice captured on the SRS were: total length, 158.6; tail, 75.5; hind foot, 18.0; and weight, 19.0. Measurements did not differ significantly between the sexes.

The golden mouse was originally placed in the genus *Peromyscus* (Osgood, 1909), but based on the peculiar characters of the skin, skull, and male phallus (Hooper, 1958; Blair, 1942; Manville, 1961) it was placed in its own genus. In addition, the diploid number of 52 chromosomes for *Ochrotomys* differs from that of 48 for *Peromyscus* (Patten and Hsu, 1967).

The golden mouse is found in all the southeastern states in forested areas as well as in brushy thickets, hedgerows, and along dense field borders. On the SRS the species is among the five most commonly trapped mammals. Its preferred habitat is the lowland hardwood forest where it is most often trapped with the cotton mouse and the short-tailed shrew. On the SRS, the lowland hardwood forest habitats associated with major streams and their tributaries are preferred golden mouse habitat. This species is primarily arboreal and makes use of vines (grape, greenbrier, poison ivy, and honeysuckle), spanish moss, and bamboo thickets in which to nest and use as foraging routes. The mouse may also nest in trees. Golden mice are relatively easy to capture with snap and live traps during years of high population numbers. Setting traps in trees may result in an increased capture rate (Gentry et al., 1968).

On the SRS the breeding season of the golden mouse begins in April and extends into October with spring and autumn peaks. A greater proportion of the females are pregnant in autumn than in the spring. Similar seasonal breeding patterns have been found in Kentucky (Goodpaster and Hoffmeister, 1954) and Tennessee (Linzey, 1966). Layne (1960) suggested that the breeding season of *Ochrotomys* in Florida encompassed approximately eight months from June to early February, however, McCarley (1958) reported that in Texas, breeding occurred from autumn through spring with an almost total cessation during the summer months.

Linzey (1966) reported gestation in *Ochrotomys* to range from 25 to 29 days for lactating females with shorter periods for nonlactating females. Goodpaster and

Hoffmeister (1954) suggested that seven to eight litters per year could be produced. On the basis of the known gestation period, *O. nuttalli* in South Carolina would be capable of producing three to five litters per year, but the actual number is likely lower than that. Based on 12 pregnant females, litter size for golden mice on the SRS ranges from two to four with a mean of 2.4 (O'Farrell et al., 1977). These data are similar to other values reported in the literature (Goodpaster and Hoffmeister, 1954; McCarley, 1958; Layne, 1960; Linzey, 1966). Linzey's data suggested that the young were weaned at around three weeks of age.

Population densities based on calculations using the assessment line method were 5.7 to 5.9 mice per ha for a late summer population (Smith et al., 1971) and 3.7 to 3.9 and 5.7 to 7.1 mice per ha, respectively, for a winter and late winter population (Kaufman et al., 1971). In a 13-year study on the SRS, late spring removal trappings from a 5.76 ha grid over an 18-day period produced from two to 47 golden mice per trapping period. Density estimates from other areas include 1.0 mouse per ha in Texas (McCarley, 1958), 0.08 mice per ha near Knoxville, Tennessee (Howell, 1954) and from 0.08 to 1.4 mice per ha over a two-year period in the Smoky Mountains (Linzey, 1966). Direct comparisons with population densities based on data collected by other investigators may not be valid because of the different trapping techniques.

Several investigators have reported on the home range sizes of *Ochrotomys*, but due to differences in methods of calculation, comparisons are difficult. Mean home range size estimates for golden mice on the SRS using five different methods of calculations varied from 0.4 to 8.5 ha for males and 0.23 to 3.3 ha for females (Faust et al., 1971). Mean home range size estimates in the Smoky Mountains based on the exclusive boundary strip method ranged from 0.04 to 0.4 ha for males and 0.1 to 0.4 ha for females (Linzey, 1966). Home range calculations for *Ochrotomys* are somewhat complicated by the added dimension of their vertical distribution in the habitat. The amount of time spent in vines and trees is likely determined by the overall features of the habitat (G. C. Smith et al., 1980).

Food habits of the golden mouse are expected to vary with food availability in a particular habitat. Linzey (1966) listed the main food items of *Ochrotomys* in the Great Smoky Mountains National Park as greenbrier (*Smilax*), wild cherry (*Prunus*), dogwood (*Cornus*), oak (*Quercus*), and insects. Blackberries (*Rubus*) were listed as important during the period when they were in fruit. In addition, Goodpaster and Hoffmeister (1954) listed sumac (*Rhus*), peppervine (*Ampelopsis*), bindweed (*Polygonum*), pokeweed (*Phytolacca*), and tick clover (*Desmodium*) as important food sources of the golden mouse. All of these species occur in or near the preferred habitat of the golden mouse on the SRS.

Oryzomys palustris palustris (Harlan) - Rice Rat

The rice rat is a small, slender rat with a long tail and relatively large hind feet. The pelage is grayish brown to ochraceous-tawny mixed with blackish hair above. The sides are paler with less black and the fur is white to pale buff below.

The tail varies from brownish above and whitish below to evenly dusky. Sex may be determined on the basis of external genitalia; juveniles and adults show no pelage differentiation. The dental formula is the same as that of most cricetids 1/1, 0/0, 0/0, 3/3 = 16. Mean body measurements for five adult males captured on the SRS were: total length, 205.4; tail, 98.0; hind foot, 17.0; weight, 51.0; and for four females: total length, 231.0; tail, 109.0; hind foot, 24.5; and weight, 54.8. The diploid number of chromosomes is 56 (Hsu and Benirschke, 1969).

Rice rats may be confused with young Norway rats, *Rattus norvegicus*. The young Norway rat has a heavier build, larger hind feet, and a stouter tail which is nearly uniform in color. The tail of the rice rat is bicolored. In addition, the molars of rice rats have only two rows of tubercles. The rice rat is easily distinguished from the much larger wood rat which has a furry tail. Another similar species is the cotton rat, *Sigmodon hispidus*, which appears heavier and darker and with a shorter tail. Cotton rats also exhibit characteristic pelage and sigmoid-shaped crowns on the upper molars.

Rice rats range widely throughout tidal marshes from Pennsylvania to Texas and are the only resident rodent species of the extensive salt water marshes along the Georgia Coast (Sharp, 1967). Six subspecies of the rice rat occur throughout the southeastern United States (Hall, 1981). The subspecies found on the SRS has the greatest range, occurring in 13 states from Pennsylvania to Mississippi and north to Missouri, Illinois and Kentucky. Preferred habitat of the rice rat is open, lowland marshes but it may be found equally abundant in drier habitats in certain parts of the country (Negus et al., 1961). On the SRS the rice rat is associated with roadside ditches, streams, ponds, lakes, and Carolina bays where grasses and shrubs provide sufficient cover. It also occurs in the forested swamp habitat, preferring to nest in the more open marsh areas.

On the SRS this rodent has proved difficult to trap, even with extensive trapping operations in or near preferred habitat. Sudden weather changes such as a winter cold front which produces ice on the vegetation have caused sudden increases in trapability. Due to low capture rates of rice rats, very little is known about their populations on the SRS. Based on live-trapping data, Negus et al. (1961) reported monthly densities ranging from 0.5 to 15 per ha during their 1957 to 1960 study in Louisiana. Seasonal variation in numbers was great, apparently related to the severity and duration of winter. The mean home range size for 23 adult males was 0.32 ha (range 0.1 to 0.9 ha) and the mean home range for 12 adult females was 0.2 ha (range 0.1 to 0.45 ha).

The breeding season of rice rats on the SRS is unknown, but in the southern coastal states it extends from February to November. Gestation period is 25 days and litter size averages three with a range of one to five (Svihla, 1931). Goodpaster and Hoffmeister (1952) reported a field nest in western Tennessee with seven young. Rice rats are blind and naked at birth but grow rapidly; their eyes open by the sixth day, and they are weaned at 11 to 20 days. Rice rats are sexually mature at 50 days

of age and are capable of mating within 10 hours after parturition. Rice rats can potentially have nine litters per year. In Svihla's (1931) experiments, one female produced six litters in one year. Another female gave birth to her first litter at 75 days of age and had a total of four litters during her first year.

The rice rat is essentially a semi-aquatic animal, although it may be encountered in dry uplands where the vegetation forms a dense cover. Rice rats are at home in the water where they swim and dive with ease. On the SRS rice rats are often associated with cotton rats which may become locally abundant in the dense grass around marshy areas.

In the salt marshes of the coastal states rice rats construct spherical nests of shredded grass placed about 30 cm or so above high-water level in the vegetation of the intertidal zone. When frightened the rats jump into the water and dive to safety. Rice rats in the Georgia salt marshes use modified nests of long-billed marsh wrens (Sharp, 1967). In inland regions nests are often in shallow burrows on higher ground a meter or so back from the water. Because of its nesting habits, the rice rat may be quite vulnerable to predation. Hawks, owls, minks, weasels, and foxes are known to prey on rice rats. Rice rats have also been found in the stomachs of cottonmouth moccasins on the SRS.

Rice rats feed on the succulent portions of grass and sedges, seeds, insects, crabs, mollusks, crayfish, fish, young turtles, bird eggs, and young birds. Kale (1965) reported that rice rats may be the major cause of nest failure in the long-billed marsh wren living in Georgia's salt marshes. He speculated that the 80% mortality rate of young marsh wrens observed in one study was due primarily to rice rat predation on the eggs and young birds.

In states where rice is not raised, the rice rat is of little economic importance. Goodpaster and Hoffmeister (1952) observed that in western Tennessee where baby turtles were raised commercially, the rice rat was considered of some economic importance as a predator. Svihla (1931) reported that Texas muskrat trappers occasionally complained of pelt damage to captured animals by rice rats.

Peromyscus gossypinus gossypinus (Le Conte) - Cotton Mouse

The cotton mouse is one of the most numerous species of mammals on the SRS. It is a large *Peromyscus* with brown fur on the upper body and a dark dorsal stripe. The belly is white and the tail is not distinctly bicolor. Juveniles are gray. The total length of the skull is usually greater than 26 mm and the interorbital width is greater than 4 mm (Golley, 1962). The cotton mouse is similar in appearance to *P. leucopus* but generally is larger. The dental formula is 1/1, 0/0, 0/0, 3/3 = 16. The range of measurements for 272 specimens from South Carolina were: total length 78-198; tail 47-90; hind foot, 19-24; and weight, 12.7-40.0. The diploid number of chromosomes is 48 (Hsu and Arrighi 1968).

The cotton mouse is found throughout the southeastern United States. In South Carolina it is an abundant species in the coastal plain and sandhill regions (Golley, 1966). The preferred habitat of *P. gossypinus* is bottomland hardwood forest often in areas subject to periodic flooding (Golley, 1962), however, they also are found in upland forests. On the SRS cotton mice have been found in habitats characterized by broomsedge, grassforbs, upland grass, pine-scrub oak, upland pine, upland hardwood, and lowland hardwood (Golley et al., 1965a, b). Nests are commonly built in hollow logs and cavities, under fallen logs, and in crevices. The diet of the cotton mouse consists of about 68% animal matter during the summer (Calhoun, 1941). Beetles, lepidopterans, spiders, and snails were the animals most often eaten. Cotton mice also feed on seeds and nuts especially during the winter.

Breeding activity of *P. gossypinus* on the SRS exhibits a bimodal pattern with little or no breeding activity during the summer and winter (O'Farrell et al., 1977). The gestation period ranges from 23 to 30 days depending upon whether or not the female is nursing young (Pournelle, 1952). Litter size on the SRS ranged from two to six with an overall mean of 3.6 (O'Farrell et al., 1977). A mean spring litter size of 3.1 was significantly lower than a mean autumn litter size of 4.3. The recruitment of juveniles was greatest (about 40% of the population) in late autumn and early winter.

The mean number of *P. gossypinus* caught on a 5.8 ha grid from 1967 to 1972 was 21.2 ± 4.4, however, significant fluctuations occurred between years (Smith et al., 1974). From 1967 through 1970, more males than females were captured (52 males, 37 females) but the ratio was not significantly different from 1:1 (Gentry et al., 1971c). The greatest numbers of cotton mice were caught in August and April and the fewest were caught in November and December (Briese and Smith, 1974). Estimates of density of *P. gossypinus* on the SRS range from 3.3 to 8.7 individuals per ha (Smith et al., 1971).

In addition to the above mentioned studies involving *P. gossypinus* from the SRS, the cotton mouse has been the subject of research concerning the effects of radiation on small mammals (Golley et al., 1965b; Golley et al., 1965e) and the use of radioactive isotopes in studies of small mammal population dynamics (Gentry et al., 1971a, b). The species has also been studied in relation to assessment of trapping or censusing techniques and population fluctuations, abundance, and habitat preference of small mammals on the SRS (see SRS bibliography).

Peromyscus leucopus leucopus (Rafinesque) - White-footed Mouse

The white-footed mouse is a small rodent with a tail that is less than one-half the total length of the animal and not particularly bicolored. The fur is generally brownish above and white below. In winter the pelage is grayish. In juveniles the dorsal pelage is gray. The interorbital width of the skull is generally greater than 4 mm, and the total length of the skull is usually less than 26 mm (Golley, 1962). The dental formula is the same as that of *P. gossypinus*, 1/1, 0/0, 0/0, 3/3 = 16. The range

of measurements for 156 specimens from South Carolina were: total length, 114-186; tail, 47-92; hind foot, 17-22; and weight, 13.3-30.8. The diploid number of chromosomes is 48 (Hsu and Arrighi, 1968).

The white-footed mouse is generally found in hardwood forests with dense undergrowth. Nests are most often located in hollow logs, tree cavities, and ground burrows. The diet of *P. leucopus* consists primarily of plant material such as insects, seeds, and berries (Wolff et al. 1985).

The behavior and ecology of white-footed mice has been studied in Virginia and is probably similar in south Carolina. Breeding occurs primarily in spring and autumn with 3 to 5 young born after a 24 day gestation period (Wolff, 1985a). Spring-born animals usually mature and breed in autumn except at high densities. During the breeding season males and females are intrasexually territorial (Wolff, 1985b). During winter, aggression is reduced and animals nest communally (Wolff and Durr, 1986). The mating system is polygynous and males do not provide parental care (Wolff, 1989; Wolff and Cicirello, in press). Juvenile males tend to disperse from their natal site, whereas females are philopatric and remain in or near their natal home range (Wolff et al., 1988). *Peromyscus* populations are normally stable at 10 to 20 mice per ha, but occasionally may reach greater than 50 mice per ha following years of high mast production (Wolff, 1986, and unpubl.).

Two specimens of white-footed mice have been captured in Aiken County on the northern part of the site east of the U.S. Forest Service headquarters. Representative tissue samples of these animals were processed by starch gel electrophoresis. The banding patterns of two proteins, transferrin and glucosephosphate isomerase were diagnostic of this species. The species has also been recorded from Richmond County, Georgia (Golley, 1962) and Saluda County, South Carolina (Golley, 1966). A viable population of white-footed mice is not known to exist on the SRS.

Peromyscus polionotus lucubrans Schwartz - Old-field Mouse

This is a small *Peromyscus* with fairly dark brown or buffy dorsal pelage and white underparts. Additionally, a pale brown phenotype occurs on the SRS (Smith et al., 1972). The tail is distinctly bicolored although indistinctly so in pale mice. The skull is generally less than 24 mm in total length and the interorbital width is usually less than 4 mm. The dental formula is the same as that in *P. gossypinus*: 1/1, 0/0, 0/0, 3/3 = 16. Measurements for 129 specimens from South Carolina were: total length, 113 (87-134); tail, 43 (17-52); hind foot, 16 (9-18); and weight, 13.5 (5.2-18.7). The diploid number of chromosomes is 48 (Greenbaum et al., 1978).

The range of the old-field mouse extends over the states of Florida, Georgia, Alabama, Mississippi, and South Carolina (Hall, 1981). Within South Carolina the species is found throughout the state except in the most northern areas, mountains, lowland swamps and barrier islands. The old-field mouse prefers sandy soils with

herbaceous vegetation. On the SRS, *P. polionotus* has been found in habitats characterized by aster, mixed forbs, broomsedge and forbs, broomsedge, broomsedge and vine, grass and forbs, upland grasses, and lespedeza (Golley et al., 1965a). The greatest numbers of individuals have been found in the lespedeza and the mixed forbs habitats. They also occur in low numbers in sandy areas with mixed turkey oak-long leaf pine forest.

The old-field mouse constructs characteristic burrows in well-drained, sandy soils. The burrow system is generally simple, and the entrance is marked by a mound of dirt. Burrows generally have an escape tube, and the exit of the escape route is plugged with a thin layer of soil. A variety of other animals use the burrows of the old-field mouse. Camel crickets and wolf spiders often share the burrow with the mouse as do six-lined racerunner lizards (Gentry and Smith, 1968). The old-field mouse is omnivorous, eating a wide variety of plants and insects (Gentry and Smith, 1968). The seeds of grasses and herbs are often utilized along with beetles, lepidopterans, grasshoppers, and crickets.

Breeding peaks for *P. polionotus* occur in the spring and autumn (Caldwell and Gentry, 1965b). Breeding activity in the summer is lower than that of the spring and autumn seasons, and there is essentially no breeding activity in January and February. The mean litter size for 172 females was 3.1 ± 0.86 with 52.3% of the litters being three in size. Larger females tended to have larger litters. Females greater than 126 mm in total length had a mean litter size of 3.4 ± 0.17 compared to 3.0 ± 0.10 for females less than 116 mm in total length (Caldwell and Gentry, 1965b). Litter size is greater in autumn and spring than in summer. The gestation period is about 22 days. Females become sexually mature at about 30 days of age and there may be a post-partum estrus. The mating behavior of *P. polionotus* has been described by Smith (1967a). Sex ratios of old-field mice on the SRS do not generally differ from 1. The percentage of males captured in three different studies ranged from 50.9% to 53.2% (Smith, 1967b). Fifty to 57.1% of the juveniles were males and 53% of newborn pups taken from excavated nests were males.

Old-field mice are nocturnal, however activity is usually subdued until after the moon has set (O'Farrell and Kaufman, 1975). The susceptibility of *P. polionotus* to predation by owls has been studied by Kaufman (1973, 1974). Kaufman found that the two pelage phenotypes differed in susceptibility to predation depending upon the color of their substrate. Mice were also more likely to be captured under high than low light intensities.

Densities of old-field mice on the SRS range from 9.5 to 13.0 mice per ha. The greatest densities of mice are in stands of *Lespedeza sericea*. Densities are greatest from November to March and least in June and July. Mortality rates of mice on the SRS were about 50% per month and 70% by the second month of life (Caldwell, 1960). Dispersal distances are not significantly greater for males than for females, although males may disperse into areas where mice are absent more often than do females (Smith, 1968). The average dispersal distance for males was 1117.3 ± 546.7

m and 417.3±98.3 m for females. The average home range size (estimated by the inclusive strip method) was 0.14 ha (Davenport, 1960).

The old-field mouse has been one of the most intensively studied mammalian species on the SRS. Over 50 papers involving *P. polionotus* have been published as well as several theses and dissertations (see SREL bibliography). Among the aspects of the biology of *P. polionotus* that have been examined are genetic variation (Selander et al., 1971), genetic variation and behavior (Garten, 1974, 1976a, b, 1977), population structure (Davenport, 1964), competition (Caldwell and Gentry, 1965a; Gentry, 1966; Briese and Smith, 1973), aging and age structure (Dapson and Irland, 1972; Dapson, 1972), body composition and elemental analyses (Angerman et al., 1974; D. Kaufman and G. Kaufman, 1975; G. Kaufman and D. Kaufman, 1975; Gentry et al., 1975), phenotypic variation (Smith et al., 1972; Smith, 1967c), and radiation effects (Golley et al., 1965b).

Reithrodontomys humulis humulis (Audubon and Backman) - Eastern Harvest Mouse

The eastern harvest mouse is a small rodent with short ears, small eyes, and a long tail. The upper parts of the pelage are brown, sometimes faintly washed with grayish, and usually with a dark mid-dorsal stripe. The color of the fur is paler on the sides and a clear lateral line often is present. The fur of the underparts is ash colored, often with a cinnamon or pinkish tint. The tail is bicolored, dark above and light below. The dental formula is 1/1, 0/0, 0/0, 3/3=16. The upper incisors of the harvest mouse are grooved (Fig. 6) which distinguishes them from other cricetids. Adults and juveniles have similar pelage coloration. Mean body measurements for 30 adult males captured on the SRS were: total length, 110.8; tail, 54.0; hind foot, 15.0; weight, 8.1; and for 15 adult females: total length, 109.8; tail, 54.0; hind food, 14.6; and weight, 8.0.

The harvest mouse may be confused with the house mouse which is gray rather than brown and does not have grooved incisors. Also, the house mouse is larger than the harvest mouse, and its fur has a greasy texture. The diploid number of chromosomes is 51 (Carleton and Meyers, 1979; Robbins and Baker, 1980).

Reithrodontomys humulis occupies a wide geographic range in the southeastern United States, west into Texas and Oklahoma and north into Ohio, West Virginia, and Maryland (Hall, 1981). Its preferred habitat is open, uncultivated fields, especially those with stands of relatively dense grass. On the SRS the harvest mouse occurs in old fields, along powerlines and roadsides, and around Carolina bays (Golley et al., 1965a).

Using standard Calhoun lines (60 snap traps set for three nights), the average rate of capture of harvest mice per line was 0.11 compared with 3.14 old-field mice on the SRS (Golley et al., 1965a). Rates of capture of 2.5 (Dunaway, 1968; Howell, 1954), and 0.75 harvest mice per 100 trap nights have been observed elsewhere

(Kaye, 1959). Large numbers of this species are seldom caught. It is not clear whether this indicates low density or low trapability. Briese and Smith (1974) found that drift fences with pit-fall traps were more successful in capturing harvest mice than were surface live traps. Caldwell (pers. comm.) also captured large numbers of *R. humulis* around a Carolina bay using the drift fence method. In both cases and in other instances utilizing conventional trapping methods, more mice were captured during winter than summer months.

Movements and home ranges of harvest mice are difficult to characterize. Using radioactive wire tags Kaye (1961b) observed that movements of harvest mice were oriented around several nest sites, and that the mice were not found in some of the areas between the nests. Dunaway (1968) reported that *R. humulis* were not strongly territorial in contrast to cotton rats occurring on the same areas.

The reproductive history of SRS harvest mice is not known, but breeding likely occurs throughout the year. This is the case in Florida (Layne, 1959) and Tennessee (Dunaway, 1968) except for during very severe winters. Mean litter sizes for laboratory colonies have averaged 2.2 (Layne, 1959) to 3.2 (Kaye, 1961a) with a range of one to five. Mean litter size of young born in live-traps was 3.5 (Dunaway, 1968). Excluded from this average was a litter of eight, the record litter size for the species (Dunaway, 1962). The gestation period for *R. humulis* is around 22 days and the number of days between successive litters averages 24 (Layne, 1959). Harvest mice attain adult body weight at approximately 45 days of age.

On the SRS the harvest mouse is associated with old fields and the other small rodents and shrews in that community. Harvest mice are likely to be captured in association with cotton rats which also prefer densely vegetated grass fields. There is, however, some suggestion that if one species is abundant, the other may be less common (Golley, 1966).

The nest of the harvest mouse is constructed of shredded plant fiber and is often placed above the ground in grass clumps, shrubs, or small trees. Nests constructed on the ground rest in small depressions that apparently are dug by the mice, or they may occur under a stone or dirt clod. Winter nests tend to be larger than spring and summer nests and may be located within burrows.

Food of harvest mice consists principally of seeds supplemented by green vegetation and insects. The mice are particularly fond of grass seeds and are known to bend a grass stem to the ground and then nip off the head of seeds. Harvest mice do not thrive on cultivated land and are of no great economic importance.

Sigmodon hispidus komareki Gardner - Cotton Rat

The cotton rat is a medium-sized rat with a slightly-haired tail of medium length. The upper body has a grizzled appearance with blackish or dark brownish hairs interspersed with buffy or grayish hairs. Sides are only slightly paler with

underparts pale to dark grayish sometimes with a faint buffy appearance. The tail is coarsely annulated with sparse hairs that do not totally obscure the scaly annulations. Juvenile pelage does not differ in appearance from that of adults. Animals less than 60 g are not sexually mature. The dental formula is the same as that of most cricetids: 1/1, 0/0, 0/0, 3/3 = 16. Cotton rats are not obviously sexually dimorphic, but mean body weight of adult males is slightly higher than that of adult females. On the SRS, males may reach a maximum weight of 241 g and females 220 g. Mean body measurements of 50 adult male cotton rats from the SRS were: total length, 230.2; tail, 96.5; hind food, 31.1; weight, 106.8; and for 50 adult nonpregnant females: total length, 229.5; tail, 96.4; hind foot, 30.0; and weight, 100.0. The diploid chromosome number is 52 (Hsu and Benirschke, 1968).

In the field juvenile cotton rats may be confused with rice rats, however, the rice rat neither has the grizzled appearance nor the sigmoid-shaped crown upper molars of the cotton rat. The tail of the rice rat is longer and more slender and does not have the scaly annulations seen in the cotton rat.

Two subspecies of the cotton rat live in South Carolina (Golley, 1966). *Sigmodon h. hispidus* is abundant in the lower coastal plain and *S. h. komareki* occurs over the remainder of the state. At present it has not been determined if both subspecies occur on the SRS, but *S. h. komareki* should be the sole or predominant form based on previous range descriptions (Hall, 1981). *Sigmodon hispidus* is found in the southeastern United States extending across the remaining southern states into southern California, Mexico, and throughout Central America. In the central part of the United States, the species has been slowly extending its range northward. On the SRS cotton rats are found wherever adequate cover, such as overgrown grass fields, hedgerows, and thickets is available. Cotton rats are seldom observed in early successional stages or in mature forests.

Cotton rats forage during both day and night and are easily caught in traps set in their runways. However, certain precautions must be taken when live trapping cotton rats. To keep the animals from dying in the traps, the traps either must be covered with boards or checked often during the hot summer days. Trapping the animals becomes much more difficult in winter and early spring due to a decrease in density (Schnell, 1964) and activity as animals seek refuge in various thickets and hedgerows, the only habitat left with adequate cover (Briese, 1973). Some habitats which provided refuge from avian predators during the summer and autumn no longer do so following the killing frosts of the late autumn. Habitat quality is a significant factor in the densities attained by cotton rat populations (Goertz, 1964). On the SRS, *S. hispidus* densities range from 0.15 to 19.5 animals per ha across habitats of differing vegetative types (Golley et al., 1965a).

The female reproductive cycle is characterized by a prolonged spring breeding period and a short autumn breeding period. Three age cohorts are apparently produced each year, one each in the early spring, early summer, and autumn (O'Farrell et al., 1977). At least 20% of the population continues to breed throughout

the summer months. Pregnant females are rare from November through January. All adult males retain large testes and are apparently capable of reproducing throughout the summer. The sex ratio is approximately 1.

Cotton rats have a high reproductive potential. Meyer and Meyer (1944) reported that litters could be produced every 27 days with up to nine litters per year. The average litter size on the SRS is 4.6 (O'Farrell et al., 1977), and means of 5.0 to 6.0 have been reported from other areas (Goertz, 1965). The average litter size of 16 pregnant females collected in South Carolina was six young ranging from two to 12 per litter (Golley, 1966).

The cotton rat is primarily an animal of older abandoned fields where it is associated with the old-field mouse and harvest mouse. In wet areas it commonly is found with the rice rat. Cotton rats are important food of both avian and mammalian predators. Cotton rats are active both day and night and are preyed upon by marsh, red-shouldered, and red-tailed hawks as well as short-eared, barn, and great-horned owls. Principle mammalian predators are foxes and bobcats. The cotton rat is able to survive under such intense predation through high reproductive potential and its ability to make effective use of vegetative cover.

The combined effects and interactions of vegetation, weather, interspecific competition, and predation are thought to be the principle factors affecting cotton rat movements and distribution (Gardner, 1975). The home range size is usually less than one-half hectare, which is rather small for an animal of this size. McNab (1963) suggested that animals which are "croppers", as is *S. hispidus*, have smaller home ranges than do those animals which hunt for their food. Odum (1955a) reported the average home range as 0.22 ha in a population studied for 11 years on the Georgia Piedmont. On the SRS, Gardner (1975) reported mean home range sizes that ranged from 0.45 to 1.12 ha across all seasons. The home range size of males was greater (1.02 ha) than that of females (0.47 ha).

The nest is constructed of leaves and grass and placed on the ground surface within a clump of vegetation or brush pile, or underground in a shallow burrow. Where these rodents are common, the ground surface may be traversed by numerous runways between nests and feeding areas. These runways are good indicators of the location of the rodents as are piles of cut grass stems and leaves located along the runways. Cotton rats are generally omnivorous eating plants (leaves, stems, roots, and seeds) and animal matter, including insects, crayfish, and the eggs of ground-nesting birds such as bobwhite quail. The rodents become more herbivorous during the summer when green plants are abundant, but may rely heavily on insects and seeds during the winter (Briese, 1973). In the southern part of its range the cotton rat may become destructive to sugar cane, cotton, sweet potatoes, and squash. At high densities cotton rats may girdle trees, eating the cambium at ground level and have reportedly caused damage to plantations of young pine trees on the SRS.

The cotton rat has been the object of a variety of studies at the SRS. Specific investigations have focused on population ecology (Schnell, 1964; Wiegert, 1972a, b;

Gardner, 1975; Teska, 1978), metabolism and elemental cycling (Wagner, 1968; Briese, 1973; Kaufman et al., 1976), radiation effects (Pelton, 1966; Pelton and Provost, 1969, 1971) and genetics (Johnson et al., 1972).

Microtus pinetorum pinetorum (Le Conte) - Woodland Vole

The woodland vole (also called pine vole) is a small mouse with a short tail and soft, dense mole-like fur. The eyes and ears are small and well-adapted for semi-fossorial existence; the ears are barely visible in the fur. The upper parts are bright russet brown to brownish chestnut, the under parts are dull buff to bright cinnamon, and the tail is indistinctly bicolor or even unicolor, usually the same color as the back. The dental formula is 1/1, 0/0, 0/0, 3/3 = 16. Mean measurements for eight adult males collected on the SRS were: total length, 126.2; tail, 18.5; hind foot, 16.0; weight, 18.1; and for eight females: total length 109.6; tail, 18.5; hind foot, 16.2; and weight, 18.6. The diploid number is 62 (Wurster and Benirschke, 1968).

Adults do not show sexual dimorphism and juveniles may be recognized by lighter weight and pelage. The woodland vole may be mistaken for a mole, however, the forelegs and digits of the woodland vole are not shovel-like as they are in moles. Juvenile woodland voles and meadow voles (*Microtus pennsylvanicus*) are similar in appearance, however the tail of the woodland vole is much shorter than that of the meadow vole.

The woodland vole occurs in all states of the eastern half of the United States with the possible exception of Maine, and it is rare or missing from the extreme coastal regions of the southeastern states. Woodland voles are particularly fond of hedgerows and apple orchards, but also live in a wide variety of woodland to grassland habitats wherever there is adequate cover, friable soil, and a good food supply. Woodland voles are found over the entire SRS area in old fields and hardwood forests where the soil is loose or where rich leaf mold is present. Woodland voles are also thought to inhabit pine plantations, but the necessary studies to substantiate this have not been conducted. Woodland voles burrow just beneath the soil surface or leaf mold and may extend their burrows several centimeters into the soil. Woodland voles also use mole tunnels in their subterranean travels. On the SRS woodland voles have been observed to use tunnels at depths of at least 60 cm (Gentry, 1968).

Woodland voles are very difficult to capture on the surface of the ground. The average number of *M. pinetorum* captured in standard Calhoun snap-trap lines (Calhoun and Cosby, 1958) over a 12-year period with 86,000 trap-nights (427 lines) in 13 different SRS habitat types was 0.01 animal per line (Golley et al., 1965a). Captures occurred only in the old fields, and their number averaged 0.04 per line in this habitat. Trapability apparently varies with season. For example, of 41 dated recorded captures in the state of South Carolina, only five were from a period

between May and September (Golley, 1966). Gentry (1968) also reported reduced probability of capture during the summer for one SRS population.

Woodland voles may be much more abundant on the SRS than is indicated by routine trap surveys. In one study conducted in the old-field habitat, woodland vole populations reached densities of 25 per ha in 0.8 ha enclosures (Gentry, 1968). Such densities are not unusually high for this species of microtine rodent. Benton (1955) reported densities of 625 woodland voles per ha in New York orchards. The numbers reached in the enclosures were greater than those observed in unenclosed areas at SRS. Because the animals were able to move out of the enclosures by deep tunnels beneath the enclosure walls, the large number of captures was not the result of the elimination of dispersal. More likely it was the result of the trapping technique which consisted of live-trap grids operated once weekly over a 28-month period. Each drop-door-live trap was covered by a large board and when not in operation was left upside-down with the door open allowing free access to bait left in the trap. Traps were baited each week with a total 8 to 10 kg of cracked corn and sunflower seeds added to each grid. Woodland voles spend the majority of their time underground and, as a result of well-covered traps with an abundant and reliable food source, each station became a regular part of the animals' home ranges. Close to 80% of the traps had well-used tunnel entrances at the back or front of the traps. Most of the remaining traps were within 1 m of a tunnel opening.

In Gentry's (1968) study the majority of animals entered the traps as juveniles and subadults. Thirty-five percent of the trapable population was juveniles, 29% was subadults and 36% was adults. Hamilton (1938) concluded from laboratory studies that woodland voles in the north leave the nest at about two weeks of age when they weigh approximately 8 g.

Breeding probably occurs throughout the year in SRS populations with the greatest activity occurring from October to April (Gentry, 1968). In New York the breeding season of woodland voles extends from January to October with a peak in March and April (Benton, 1955). Horsfall (1963) reported year-around breeding in Virginia orchards with a large number of pregnant females in the population during the summer with a peak in August. Average litter size of *M. pinetorum* is two with a range of one to three (Horsfall, 1963; Golley 1966). Nine females from Kansas and Arkansas had an average number of 2.9 (range two to five) embryos (Hall, 1981). At the SRS an average of 2.0 embryos was recorded from seven pregnant females. Twenty-five females were recorded as pregnant a total of 42 times for an average of 1.7 pregnancies per female. One female captured over an 18-month period was pregnant seven times. Benton (1955) reported that northern animals may have several litters during one season.

On the SRS the woodland vole is found in association with the shrews *Blarina carolinensis*, *Cryptotis parva*, and *Sorex longirostris*. Woodland voles have been captured in the same trap at the same subterranean tunnel exits following the previous days capture of a *B. carolinensis*. Woodland voles may also use tunnels

excavated by eastern moles. The home range is small with some animals living within the root system of a single tree. The mean distance traveled between captures for 83 animals on the SRS was 22 meters. Movement patterns did not differ between sexes (Gentry, 1968). Nests consisting of leaves, stems, or rootlets are located in stumps, under logs, or on the surface of the ground. Food consists of a wide variety of plant and animal material, but roots, tubers, cambium, and bulbs are preferred. Woodland voles often girdle trees and in orchards can become serious economic pests. *Microtus pinetorum* are more destructive to garden crops than is any other small rodent. Mole tunnels in the garden are often an avenue for the woodland vole to potatoes which they relish. The subterranean behavior of *M. pinetorum* probably affords it relative freedom from predation.

Although one intensive study of the woodland vole has been conducted on the SRS (Gentry, 1968), general and wider ranging investigations are needed. Due to the low probability of capture at the surface, other techniques such as drift fences with pitfall traps (Briese and Smith, 1974) or underground trapping may be required to study *M. pinetorum* populations in various SRS habitats.

Ondatra zibethicus zibethicus (Linnaeus) - Muskrat

The muskrat is a large aquatic rodent. The tail is flattened laterally, hind feet are large and webbed, and the ears are small. The pelage is dark brown above and pale brown below. The skull resembles that of *Microtus* but is larger and more massive. The dental formula is 1/1, 0/0, 0/0, 3/3 = 16. Range of body measurements of 11 adults from Georgia were: total length, 522-625; tail, 194-265; hind foot, 73-86; and weight, 975-1572. The diploid number of chromosomes is 54 (Hsu and Benirschke, 1971).

Muskrats occur throughout most of the United States, except the southwestern and extreme southeastern U.S., and Canada (Hall, 1981). The species is principally found in the Piedmont and Blue Ridge Mountain areas of South Carolina (Golley, 1966) and is rare on the SRS. Muskrats require a permanent body of water such as a stream, river, lake, or pond with an abundance of aquatic plants and animals. Marsh habitat is optimum for the species (Golley, 1962). Muskrats construct lodges of cattails and sedges or dig burrows into the banks along the edge of bodies of water. Muskrats probably breed at any time of year. Two litters of from one to 11 young are produced a year. The gestation period is 29 to 30 days (Golley, 1962). The young are able to care for themselves by the age of one month.

Population sizes of muskrats vary greatly depending on abundance of food, water level, and predators (Golley, 1962). In Alabama, as many as nine muskrats per pond were recorded. Up to 70% of the population may be young of the year. Muskrats eat both plant and animal food including roots, stems, leaves, and fruit of aquatic plants as well as clams, fish, and crayfish (Golley, 1966). Muskrats may

move between ponds and streams during the warm months, but their movements are restricted during the winter.

Muskrats are an important furbearing species. In North America, trappers receive more dollars for pelts from muskrats than from any other species (Hall, 1981). The species has not been studied on the SRS.

Mus musculus brevirostris Waterhouse - House Mouse

Mus musculus belongs to a group of Old World rats and mice in the family Muridae which has been introduced into North America. In wild or feral populations on the SRS the mouse is small; it usually weighs less than 20 g, and its head and body measures less than 75 mm. The pelage is gray-brown to yellow-brown, grading to buff or light brown underneath. The tail is long, equal to or longer than the head and body and is naked and scaly. The tail is not distinctly bicolored but is lighter below than above. The skull may be distinguished by its small size and three rows of tubercles on the molar teeth. Commensal stocks tend to be larger and darker in color, have longer tails, smaller molars, and a shorter molar tooth row than feral open-field forms. The dental formula is typical of murid rodents: 1/1, 0/0, 0/0, 3/3 = 16. Mean body measurements of 50 adult males collected on the SRS were: total length, 142.6; tail, 71.3; hind foot, 17.1; weight, 14.1; and for 50 females were: total length, 150.0; tail 73.9; hind foot, 17.5; and weight, 15.4. The diploid number of chromosomes is 40.

The house mouse is sometimes mistaken for the eastern harvest mouse in the field. The adult harvest mouse is somewhat smaller than the house mouse, but is very similar in color and body form. A deep longitudinal groove along the middle of each upper incisor distinguishes the harvest mouse. When captured in a live trap the house mouse leaves an unpleasant, musky odor characteristic of Murid rodents.

Mus musculus is found throughout North America. House mice are extremely adaptable and are most often thought of as commensal with man in houses, barns, and other manmade structures. However, house mice commonly establish feral populations in open field situations. Following the removal of human inhabitants from the SRS in 1951, feral house mouse populations became established in abandoned agricultural fields. Easily captured both by live and snap traps, these rodents were studied for several years. Eventually, the populations gradually disappeared from the fields becoming quite rare by the middle to late 1960's. House mice are considered extinct as feral populations at present, but still occur in buildings and other development sites on the SRS.

Feral house mouse populations on the SRS never reached high densities and rarely exceeded five mice per ha. Individuals were very mobile and capable of moving rather long distances over a short period of time. Populations were unpredictable, appearing and disappearing from season to season and site to site. Peak populations were restricted to the winter months. In California feral

populations of 750 mice per ha have been reported (Pearson, 1963; Lidicker, 1966), however, the populations crashed shortly after peak numbers were reached. The species has the potential for serious population outbreaks as illustrated by the estimated 175,000 animals per ha in Kern County, California in 1926 and 1927 (Hall, 1927).

Average sex ratios among SRS house mouse populations were 134 males/100 females. Higher percentages of males than females have been reported in a number of studies (e.g. 72.0%, Pearson, 1963; 67.7%, Evans, 1949; and 63.2%, Brown, 1953). In other studies (Pearson, 1963; Lidicker, 1966) a 1:1 ratio was reported.

Feral house mouse populations living in open fields may have a restricted breeding season, but when living as commensal populations under more favorable circumstances as in stacks of grain (Laurie, 1946) or human establishments (Smith, 1954), or at peak numbers (Pearson, 1963) breeding tends to occur throughout the year. The annual reproductive cycle of *M. musculus* on the SRS is not known because the species was not present on any one study area over an entire year. Breeding likely takes place all year with peak breeding during the late autumn or early winter, the period of greatest numbers. Litter size of SRS populations ranged from four to seven, averaging from 5.1 to 5.7 and agreed closely for that listed by Asdell (1946) for *Mus* under a wide variety of geographic locations. The gestation period is around 20 days. Female mice may breed as early as 39 days of age. The potential for producing large numbers under optimum environmental conditions is obvious.

The mammal species with which the house mouse is most often associated is man. It is in or near human establishments that large stable populations can be maintained. As long as optimum conditions continue to exist in a given area, the mouse will remain a serious pest, carry disease, and destroy stored foods. Continuous trapping and poisoning programs can be used to control the populations but these are often expensive. The only way to ensure the absence of house mice is to isolate all sources of food.

As a feral animal the house mouse often competes with native small mammals. House mice on the SRS were outcompeted by their major competitor, the old-field mouse, because they could not utilize the native seed resource as efficiently as did the old-field mouse. The house mouse may be unable to construct its own nest system to any degree and may have been forced to utilize abandoned *P. polionotus* burrows and mole runways. Because feral populations were normally made up of large numbers of transient animals, they were probably more vulnerable to predation. Thus, without the more direct influence of humans, house mice were not able to survive for long periods in natural situations on the SRS (Briese and Smith, 1973).

The house mouse was the subject of several studies during the first 15 years after the SRS was established. In addition to the population studies already mentioned, studies involving radiation effects were also conducted. Various

laboratory strains of *Mus* were also used in experiments on differential predation by owls (Kaufman and Wagner, 1973).

Rattus norvegicus norvegicus (Berkenhout) - Norway Rat

The norway rat is a large rat with a long naked tail, prominent naked ears, and coarse pelage. The upper parts are reddish or grayish brown to black, and the underparts are grayish or yellow white. White, black, or mottled specimens are occasionally found (Hall, 1981). The tail is indistinctly bicolored and is usually less than the length of the head and body. The ears are usually shorter than 20 mm and are covered with short, fine hair. The skull is narrower across the braincase than it is in *R. rattus*. The dentition is 1/1, 0/0, 0/0, 3/3 = 16. Range of body measurements of 17 individuals from Georgia were: total length, 167-595; tail, 122-214; hind foot, 32-45; and weight, 90.6-319.4. The diploid number of chromosomes is 42 (Hsu and Benirschke, 1967).

Norway rats are somewhat similar in appearance to several other rodents on the SRS. The rice rat is similar in appearance to a juvenile Norway rat but it is more slender and has a thinner tail, especially at the base. Furthermore, the skulls and teeth of the two species are distinctive (Hall, 1981; see account of *Rattus rattus*). The wood rat, *Neotoma floridana*, can be distinguished from Norway rats by its well-furred, bicolored tail, its gray pelage, and the sharp line of separation of the darker dorsal color from the white of the underparts.

The Norway rat seems to have arrived in North America about 1775 and has since spread over most of the continent (Hall, 1981). Unlike *R. rattus*, the distribution of the Norway rat is closely associated with human habitations. They are common in cities, villages, and on farms, and in many such areas they have replaced the native rodents. In comparison, *R. rattus* may be found in areas far from human developments.

None of the small mammal studies conducted on the SRS have resulted in the capture of *R. norvegicus*, but they have been captured in buildings on the site. A small population of Norway rats was probably present at the time the site was abandoned. Norway rats certainly could have been residents of Ellenton or Dunbarton, two small towns on the plant site at the time the land was purchased by the Federal Government in 1952.

Since the Norway rat is not presently a permanent resident of the natural habitats on the SRS its life history will not be discussed in any great detail. Anyone desiring further information on the behavior and life history of the Norway rat should see Calhoun (1963). Only a brief discussion of the rodents' economic impact on the human population will be presented here.

The reproductive potential of the Norway rat gives a clue to its potential as a pest. Norway rats first breed when they are three to four months old and have litters

of six to 22 young after a gestation period of 22 days. Six to eight litters are produced in a year. In North America, damage done by these rodents to gardens, farms, and stored food is estimated to run into the hundreds of millions of dollars each year. Just as important is the indirect damage caused by these pests by carrying diseases harmful to man and livestock. Control methods such as Warfarin poison have helped control populations, but some populations have developed an immunity to this agent.

The murid rodents which include the house mouse (*Mus musculus*) are such dreaded economic pests that it is rare for someone to make a favorable comment about them. However, it must be remembered that the common laboratory rat and mouse are strains of *R. norvegicus* and *M. musculus*, respectively. The value of the experimental laboratory strains in various phases of biological research may serve, in part, to offset the damage caused by their uncaged relatives.

Rattus rattus rattus (Linnaeus) - Black Rat

Rattus rattus is a large rat with a naked tail and prominent ears. The upper parts of its body range from black to tawny and underparts are slate-colored to white. The tail is not bicolor and is usually longer than the body. The ears are more than 20 mm long and naked. The skull of *R. rattus* has the following characters that distinguish it from that of the Norway rat: length of the parietal bone, when measured along the temporal ridge, is less than the greatest distance between the outbowed temporal ridges; and the diastema is much less than twice as long as the cheek tooth row. The dental formula is 1/1, 0/0, 0/0, 3/3 = 16. Ranges of body measurements for 14 adults from Georgia were: total length, 220-444; tail, 122-246; hind foot, 27-42; weight 75-441.

Rattus rattus probably came to North America on ships of early explorers (Hall, 1981). Black rats are found on ships far more commonly than are Norway rats, and therefore have been introduced and reintroduced to most seaports. In port areas, the larger Norway rat is dominant and in most cases has driven out the black rat. In South Atlantic and Gulf Coast ports, black rats are relatively common and in recent years have moved inland. In southern localities where both species of rats are found, the more aggressive Norway rat has forced the black rat into upper portions of buildings. Black rats are the better climbers than are Norway rats (Hall, 1981).

Two subspecies of *R. rattus* have been introduced in South Carolina. These are *R. r. rattus* (Linnaeus), the black rat, and *R. r. alexandrinus* (E. Geoffrey Saint-Hilaire), the roof rat (Golley, 1966). These forms freely interbreed and it is often impractical to separate individuals into the two subspecies.

Rattus rattus is not a resident of the SRS, and therefore, its life history is not discussed in detail here. The black rat probably was present on the SRS when it was abandoned by human inhabitants. Unlike the Norway rat, which depends upon a close relationship with humans for survival, the black rat may be found in areas far

from human developments. The black rat is occasionally found on neighboring farms on the edge of the SRS and in the city of New Ellenton.

Castor canadensis carolinensis Rhoads - Beaver

The beaver is the largest native North American rodent frequently weighing more than 27 kg. The body is thick and compact, the legs short, and the hind feet webbed. The tail vertebrae are flattened dorso-ventrally, and the tail is broad, flat, nearly hairless, and covered with large scales. The pelage is a glossy, dark brown. The rostrum is broad and deep, and the braincase is narrow. The basioccipital region has conspicuous pitlike depressions. The incisors are well developed, and the outer surface is a red-orange color. The dentition is 1/1, 0/0, 1/1, 3/3=20 (Hall, 1981). Typical body measurements average: total length 1000-1220; tail, 412; hind foot, 175; and weight 15-30 kg. The diploid number of chromosomes is 40 (Hsu and Benirschke, 1968).

The beaver is an aquatic mammal living in streams throughout most of North America. Beavers may also be found along rivers and lakes where suitable water and food are available. Beavers typically construct dams of sticks and mud to block the flow of water, thus creating a pond deep enough to forage, build a lodge, and avoid predation. Activity centers of beavers on the SRS include Upper and Lower Three Runs Creeks, the swamp along the Savannah River, and the area around Par Pond. Par Pond probably serves as a center of dispersal for the species (Jenkins and Provost, 1964). On the SRS, trapping has successfully been conducted in the autumn before extensive flooding allows animals to spread out over the area.

Beaver are not obviously sexually dimorphic, however males may be slightly larger than females. Juveniles are similar in appearance to the adults and the best criterion for age in young beaver (up to three years) is weight. Beaver apparently breed from October through march. The gestation period is about three months, and an average of two to four young are produced. Kits are born fully furred, eyes open, and with visible incisor teeth. Beaver do not normally mature sexually until their second year, although yearlings occasionally will breed. Established beaver colonies usually consist of an adult pair, two to four yearlings, and two to four kits.

Few quantitative data are available for beaver on the SRS. Beaver were not abundant in the 1950's and 60's, but at least 15 colonies were reported by Jenkins and Provost (1964). A major survey of the SRS beaver ponds and their ecological characteristics was undertaken in the late 1970's under the sponsorship of the Savannah River Forest Station. Although never completed for all stream systems, this report (Fitzgerald, 1979) contains thorough ecological surveys, maps and description of timber damage for at least 24 SRS beaver ponds, and partial information on a number of others. Several SRS stream systems have not been surveyed.

Beaver feed on a variety of vegetation. In the summer a number of herbaceous aquatic plants and sedges are consumed and the inner bark of trees (cambium) is an important part of their diet throughout the year. On the SRS, beaver feed on sweetgum, alder, dogwood, yellow poplar, blue beech, and red maple. Pines are occasionally girdled and barked, but it is not known if they actually are utilized as a major food source. Beavers store food by cutting tree parts into manageable lengths and anchoring them to the bottom of the body of water where they have their residence. In more northern areas, beaver build homes or lodges out of sticks and mud. On the SRS, most beaver dens are under the banks of streams or ponds. When startled, the beaver will dive under the water and produce a slap with its tail that may be heard over a considerable distance. This slap acts as a warning to other beaver in the area. The home range of a beaver includes the dam, lodge, pond, and surrounding foraging sites. Barbour and Davis (1974) reported that beavers seldom travel more than 100 meters from their homesite to gather food. Beavers are territorial and defend their homesites from intruding beavers.

The history of man's interactions with beaver is a long one. Beaver pelts have been valued since Europeans first began settling this continent. In the eighteenth and nineteenth centuries, trapping pushed the beaver to the brink of extinction. Management programs during this century have restored the beaver populations, and in some areas they are perhaps as numerous as they formerly were. Beaver ponds aid in soil and water conservation and provide homes for waterfowl and a variety of aquatic organisms. Abandoned ponds eventually silt in and form rich meadows. Beaver ponds can also be a nuisance to man by flooding roads, damaging irrigation systems, and destroying commercially valuable trees. Management practices often consist of live-trapping beaver and relocating them to areas where they will not be pests.

On the SRS, the feeding strategy and population biology of the beaver have been studied by Shipes (1979) and the genetics by Hoppe et al. (1984). The beaver is considered important on the SRS in regard to forest management and road maintenance.

Glaucomys volans saturatus Howell - Southern Flying Squirrel

The southern flying squirrel is a small squirrel with dense, soft, silky fur. The pelage is white below and soft gray on the back and head. The fore- and hind-limbs are connected from wrist to ankles by a loose fold of fully-furred skin. When the legs are extended this fold of skin forms a gliding membrane, the patagium. The tail is well-furred and flattened to form an additional gliding surface that is used both as a rudder and as a brake. The skull is delicately constructed and somewhat flattened. The skull is deeply notched in the interorbital region, the nasals are short and abruptly depressed at the tip, and the tympanic bullae are inflated. Dentition is 1/1, 0/0, 2/1, 3/3=22. Measurements for 52 males from South Carolina were: total length, 222 (192-239); tail, 99 (72-115); hind foot, 29 (23-32); weight, 60.5 (35.0-78.6); and for 71 females: total length, 228 (200-252); tail, 103 (89-116); hind foot, 30 (26-

33); and weight, 62.7 (24.0-82.3). The diploid chromosome number is 48 (Nadler and Sutton, 1967).

The southern flying squirrel is found in temperate to subtemperate pine-hardwood forests in most of the eastern United States and in scattered areas through Mexico to Honduras. Flying squirrels are most often found in deciduous forests, but also occur in mixed hardwood and conifer woodlands. On the SRS, they are apparently common in the pine-hardwood areas. This species can be collected by trapping, and meat-bait is usually very successful. During the day flying squirrels can be captured from their nests in old woodpecker holes by holding a clear plastic bag over the cavity entrance and pounding on the nest tree.

Sexual dimorphism is not evident in the species although at SRS 10 adult males averaged 69.9 g with a range of 54.9 to 80.7 g, while 10 adult females averaged 74.6 g with a range of 65.4 to 86.4 g . Juveniles can be differentiated from adults only by size. Two breeding periods are in April and May and August and September, but it is not known if a given female can bear a litter in both periods. It has also not been determined if females born in late winter reproduce during their first year. The gestation period is 40 days and generally two to four young are born. Six April and May litters on the SRS included three with two young and three with three young (J. Jackson, pers. comm.). Young are born blind, deaf, and hairless, and are weaned at six to eight weeks.

Flying squirrels feed primarily on nuts, seeds, berries, fruits, and cambium, but they also are quite carnivorous and feed on insects, eggs, birds, and carrion when they are available. The home range size has been estimated at 0.41 ha for females and 0.53 for males (Madden, 1974). Madden also reported that breeding females are territorial and will defend their entire home range. Territoriality was not observed for males.

Flying squirrels are the only nocturnal North American sciurid. They rarely have any direct interactions with man, although they often nest in buildings. Flying squirrels also may be considered pests because they raid the nests of songbirds. Golley (1966) reported evidence of flying squirrels preying on bluebird eggs and nestlings. On the SRS flying squirrels almost always are found in Red-cockaded woodpecker colony sites and may be a serious competitor/predator of this endangered bird (J. Jackson, pers. comm.). Potential predators of flying squirrels include bobcats, weasels, raccoons, hawks, owls, and snakes.

Flying squirrels are extremely social and tend to form winter aggregations. It is not known whether these represent family groups or if extra-familial individuals are included. This species is able to travel by gliding from tree to tree. This is accomplished by jumping from a high place and spreading the gliding membrane and using the tail as a rudder. Flying squirrels show great ability in being able to dodge branches in flight. Most glides are only 6 to 9 m, but much longer distances have been recorded.

The flying squirrel has not been well studied on the SRS. Golley et al. (1965a) attempted to include it in a study on the number and variety of small mammals on the SRS, however, no flying squirrels were captured during the course of the study. J. Jackson (Mississippi State University) studied a marked population of about 75 individuals associated with red-cockaded woodpecker colonies on the SRS (unpubl.).

Sciurus carolinensis carolinensis Gmelin - Gray Squirrel

The gray squirrel is a medium-sized tree squirrel with a long bushy tail. The pelage is generally a light gray on the back and sides, and the belly is white. The pelage of the gray squirrel extremely variable and albinism and melanism are common in some portions of the species range. Relative to other sciurids the skull is long with a shallow braincase. The postorbital process is short and stout. The dental formula is 1/1, 0/0, 2/1, 3/3=22; the first upper premolar in the skull is diminutive and peg-like. A good series of specimens from the SRS is not available but standard measurements for 18 adult males from Georgia were: total length, 452 (390-528); tail 204 (180-240); hind foot, 58 (45-66), and weight, 461 (358-610), and for 19 adult females: total length, 459 (410-533); tail, 221 (187-278); hind foot, 61 (45-67); and weight, 512 (450-623). The diploid chromosome number is 40 (Nadler and Sutton, 1967).

Gray squirrels can be found throughout the eastern half of the United States. The species is most commonly found in hardwood forests, particularly those of hickory and oak. Gray squirrels also occur in mixed pine-hardwood forests and are often abundant in urban areas where trees are plentiful. On the SRS, the gray squirrel is most common in areas where there are extensive hardwood stands and especially at old abandoned pecan groves maintained for them by the SRFS. Gray squirrels are also found in pinelands which are normally inhabited by fox squirrels. Jenkins and Provost (1964) estimated gray squirrel density at more than one per ha in the swamp bordering the Savannah River. Squirrels may be collected by trapping but the use of a shotgun would probably be more effective as squirrels can be quite difficult to trap at certain times.

Sexual dimorphism is not apparent in gray squirrels. Two peaks of breeding activity occur, one in late January with the young born in March or April, and a second peak occurs in early June with the young being born in September. Usually two or three naked and blind young are produced per litter following a 42 to 45 day gestation period. The young are weaned at about seven weeks and remain in the nest for about two months. Yearlings usually produce only one litter per year, whereas older females may have two litters. Early spring-born individuals may breed and bear a litter in their first summer. Population size may fluctuate considerably from year to year.

The primary food items of gray squirrels are hickory nuts and acorns, however, pecans, beechnuts, buds, roots, fruits, leaves, mushrooms, bird eggs, baby birds, carrion, and insects are also consumed. The home range size of this species probably

is slightly smaller than that of the fox squirrel. Territoriality is known in gray squirrels, but it occurs primarily in females defending the nursery nest.

The gray squirrel is a popular game species throughout most of its range. In Kentucky, a yearly average of 1,309,000 gray and fox squirrels was harvested by hunters in the 1964-65 through 1970-71 hunting seasons (Barbour and Davis, 1974). Gray squirrels can also become pests by robbing fruit and nut trees, damaging gardens, raiding bird nests, and stripping bark from trees. However, unless the squirrels occur in exceptionally high numbers within an area, damage is generally minimal.

Gray squirrels are diurnal and arboreal. They may serve as prey species for bobcats, foxes, and some of the larger predatory birds. For the most part, gray squirrels have low densities, however, if food is abundant, densities can increase until the food supply is depleted within that area. At such times vast migrations of squirrels may occur (Seton, 1920) usually resulting in mass mortality and population crashes. Migrations of gray squirrels were more common in the past than they have been in recent years and have not been reported for the SRS.

Until recently the gray squirrel has not been the subject of research at SREL. It had been noted only as an incidental species in studies directed towards other species (for example the furbearer census).

Sciurus niger niger Linnaeus - Fox Squirrel

The fox squirrel is larger than the gray squirrel. The color of the pelage is highly variable. In general, the coloration of the legs, feet, and underparts is rusty brown, gray, or black and the back and sides are agouti or gray. On the SRS fox squirrels often have a black head with a white nose. Melanistic forms have occasionally been observed on the SRS and in other areas in the southeast. The skull of the fox squirrel lacks the peg-like upper premolar found in the gray squirrel, the frontals are slightly elevated posteriorly, and the interorbital notch is distinct (Hall, 1981). The dentition is 1/1, 0/0, 1/1, 3/3 = 20. Standard measurements for 18 male specimens from Georgia were: total length, 615 (530-726); tail 313 (232-439); hind foot, 76 (70-83); and weight, 972; and for 19 females: total length, 613 (590-640); tail, 294 (290-300); hind foot, 79 (78-80); and weight, 821. The diploid chromosome number is 40 (Nadler and Sutton, 1967).

The fox squirrel occurs in hardwood and pine forests throughout the eastern half of the United States south of central Pennsylvania. Habitat requirements of the fox squirrel are essentially the same as those of the gray squirrel, although the fox squirrel appears to be more tolerant of open areas (Golley, 1966) and less common in urban areas. This species is found primarily on the terraces and plateaus of the SRS, but is not as common on the site as is the gray squirrel.

The sexes are not noticeably different in this species and juveniles differ from adults only in size. Two breeding seasons occur each year. The first begins in late November or early December and extends to March. Most two-year-old and yearling females breed at this time (Golley, 1962). The second breeding season is from May to October, and the older adult females and those born in early winter breed at this time. Two or three naked and blind young (range one to seven; Davis, 1966) are born after a 44 to 45 day gestation period. Young are weaned at about two and one-half to three months of age. No adequate data exist for population structure or density of fox squirrels on the SRS. Population sizes of fox squirrels in any given area may fluctuate considerably.

The staple foods are seeds and nuts, but a great variety of vegetable matter as well as some animal food is eaten. Some food is stored in underground caches and may be recovered by other animals that also bury food (Hall, 1981). Fox squirrels spend more time foraging on the ground than do gray squirrels. Barbour and Davis (1974) reported the home range of the fox squirrel at one to two hectares, but when food is scarce they may range over eight hectares.

In general, the fox squirrel's interactions with man and its ecological role are the same as those of the gray squirrel. Behaviorally, the fox squirrel tends to be quieter than the gray squirrel. Its barking and scolding notes are similar to those of the gray squirrel, but are used less frequently (Barbour and Davis, 1974). The fox squirrel has not been studied on the SRS.

Canis latrans frustror Say - Coyote

The coyote is similar in appearance to a German Shepherd dog but with a shorter and bushier tail, longer fur, thinner legs, and a more pointed snout. The color is variable from grayish tawny above with black-tipped dorsal hairs to white or light-colored on the throat and belly. The dental formula is the same as foxes and dogs: 3/3, 1/1, 4/4, 2/3 = 42. The diploid chromosome number is 74. Adults are approximately 1 to 1.5 m long including the 300 to 400 mm tail. Weights range from 10 to 15 kg. Females are slightly smaller than males. The skulls of coyotes can be distinguished form those of dogs by the ratio of the palatal width (distance between the inner margins of the upper first premolars) to length of upper molar tooth row (from the anterior margin of the first premolar to the posterior margin of the last molar; Howard, 1949). If the tooth row is 3.1 times the palatal width the specimen is a coyote; if the ratio is less than 2.7 the specimen is a dog (see skull key). Distinguishing features of the tracks of canids and felids are illustrated in Fig. 19 on page 107.

Mating occurs in late winter and five to 10 pups (average six) are born in spring after a 63-day gestation period (Bekoff, 1982). Young are weaned at five to seven weeks of age and reach adult size by nine months of age. Juveniles disperse from their natal site in autumn or early winter and may travel 80 to 160 km (Nellis and Keith, 1976). Coyotes are monogamous and both parents and occasionally older

siblings from previous litters help feed the young. Coyotes occur in male-female pairs, family groups, and occasionally in packs. Home ranges vary in size from 10 to 68 km^2 (Bekoff, 1982). Packs maintain and defend territories against neighboring packs, but individuals and pairs do not (Bekoff and Wells, 1980). Densities range from 0.1 to 2.3 individuals per km^2 (Bekoff, 1982).

Coyotes have expanded their range eastward with human settlement and the clearing of forested lands. Coyotes inhabit open country where they feed mostly on rodents. Their diet also includes wildfowl and other birds and eggs, insects, rabbits, reptiles, frogs, fruit, and carrion. Coyotes have been a concern to ranchers and farmers because of their alleged predation on domestic fowl, livestock (primarily sheep), and other farm animals. Detailed studies on coyote food habits and natural sheep mortality, however, have shown little evidence to support the notion that coyote predation is a primary limiting factor on population losses of big game or domestic livestock (Bekoff, 1977).

The first documented sighting of a coyote on the SRS was on Nov. 19, 1989 on the northern periphery of the site (I. L. Brisbin, pers. comm.). Since that time two road-killed specimens have been collected on the SRS and deposited in museums. A number of additional sightings have since been reported on the site and on lands on its periphery. Coyotes have adjusted well to settlements and urban environments, and their continued expansion into human environments should be closely monitored.

Canis familiaris Linnaeus - Feral Dog

Dogs are digitigrade mammals with non-retractile claws. They have either four or five front toes and four hind toes. Their tracks are considerably larger than those of foxes which they may closely resemble (Fig. 19). The rostrum of the skull is elongate and the carnassials are highly sectorial. The alisphenoid canal is well developed. The dental formula is 3/3, 1/1, 4/4, 2/3=42. The diploid number of chromosomes is 78 (Hsu and Benirschke, 1967).

Although domestic dogs may show a great deal of morphological variability among breeds, free-ranging dogs tend to show a conformity to a general "pariah-type" of body structure such as that typically shown by the Australian Dingo (Newsome and Corbet, 1985). Many of the dogs found on the SRS conform to these general characteristics as described in detail by Epstein (1971) and Brisbin (1977, 1989). Some of the dogs observed on the site, however, show morphological characteristics which would suggest that they are of relatively pure-bred domestic ancestry, particularly resembling the German shepherd dog, beagle, or other hound breeds.

As described in detail by Brisbin (1989), efforts to study dogs showing the basic primitive pariah (dingo) body morphotype, captured from on or near the SRS, have suggested that these animals also show unusual behavioral traits that have never

before been described for either wild or domestic canids. These studies have also revealed cranial features clearly distinguishing these dogs from domestic animals. Longman (1928) indicates that in the dingo, the antero-posterior length of the carnassial is more than 10 per cent of the basal (=condylobasal) length of the skull and that this characteristic may be used to distinguish the dingo skull from that of domestic breeds in which this ratio ranges from 8.06 to 9.85 (Longman, 1928). Measurements of this ratio in two male specimens which were collected along the northern boundary of the SRS produced corresponding ratios of 11.2 and 10.2 percent (I. L. Brisbin, pers. comm.).

Archaeological sites on the SRS have produced remains of *Canis familiaris* which lived in association with the paleoindians of the Woodland Period over 2,000 years ago (D. G. Anderson, South Carolina Institute of Archaeology and Anthropology). In present times, large numbers of deer hounds are released into the SRS woods during autumn hunts. Few if any of these hounds remain on the site for more than one month after the hunting season. The number of free-ranging dogs on the SRS seems to have decreased from the time of the closure of the area to the public in the early 1950's when many dogs may either have been intentionally or inadvertently left behind at the site. During the earlier days of the SRS, free-ranging dogs seemed to orient their activities around a waste dump, and the frequency with which persons were chased or otherwise threatened by packs of such dogs was greater than at the present time (Jenkins and Provost, 1964). There is no evidence that any truly feral dogs live on the SRS.

Urocyon cinereoargenteus cinereoargenteus (Schreber) - Gray Fox

The gray fox is a medium-sized canid with a slender muzzle and long, bushy tail. The pelage is gray above and white below. The tail has a black tip and the legs, side of neck, and back of ears are a dark rusty-yellow or brown. The temporal ridges are widely separated anteriorly, but approach each other posteriorly to form a U-shaped ridge of the braincase. The ventral border of the ramus of the lower jaw has a distinct step midway between the tip of the angular process and anterior border of the coronoid process. The dentition is the same as that of the red fox and dog: 3/3, 1/1, 4/4, 2/3=42. Standard measurements of four adults from Georgia were: total length, 935 (921-955); tail, 322 (280-351); hind food, 132 (120-150); and weight, 3,416 (2,519-4,458). The diploid chromosome number is 66 (Hsu and Benirschke, 1970).

The gray fox occurs throughout the eastern and southwestern United States south to South America (Hall, 1981). Gray foxes occur state-wide in South Carolina (Golley, 1966) and are abundant on the SRS (Table 3). Gray fox population density apparently has declined since the site was closed to the public in the early 1950's. In 1951, 40 percent of the land was in farm fields. These fields were soon planted with pine trees for timber production. Gray foxes were abundant in fields where their preferred diet of arthropods, fruits, and small mammals were readily available (Wood et al., 1958). The age structures of gray fox populations on the SRS were biased toward young individuals. Over 50 percent of the foxes were less than one

year old, and more than 80 percent were under two years of age (Wood, 1958). The sex ratio was not significantly different from 1 (Wood, 1958). Sexual maturity is reached during the first year. The peak of mating activity is in late January to early February (Wood, 1958). The gestation period is 53 days and the average litter size is 4.5. Juveniles reach adult size by five to six months of age (Golley, 1962).

Gray foxes are chiefly nocturnal. Den sites include hollow logs, rock piles, and the abandoned burrows of other animals. The average home range size of the gray fox on the SRS ranges from 8 to 14 km^2 for females and 26 to 62 km^2 for males (Griffith, 1985; see also Jeselnik, 1982). Males tend to have larger home ranges than do females. The home ranges of individual foxes may vary seasonally or by habitat (Jeselnik, 1982; Griffith, 1985). Home range overlap occurs between sexes, but there is little overlay within sexes, (Griffith, 1985). Daily movements range from 6 to 16 km.

The gray fox was the most common species captured during the annual furbearer census on the SRS. Wood (1958) examined the age structure of gray fox populations on the SRS and Jeselnik (1982) and Griffith (1985) conducted radiotelemetric studies of behavior, movement, and habitat utilization of gray foxes on the SRS.

Vulpes vulpes fulva (Desmarest) - Red Fox

The red fox is a medium-sized canid with a long, pointed muzzle, long ears and bushy tail. The fur is generally yellowish-red on the back and tail, and white on the belly and throat. The tip of the tail is white and the feet are black. Individuals may occasionally be black or silvery in color. The skull has an elongate muzzle and the temporal ridges of the braincase form a V-shaped crest. The dentition is 3/3, 1/1, 4/4, 2/3=42. Standard measurements for three Georgia specimens were: total length, 776 (639-940); tail, 282 (245-335); hind foot, 133 (117-150); and weight, 2,951. The red fox has a diploid chromosome number of 34 (Hsu and Benirschke, 1973).

The red fox can be found over much of the United States and Canada (Hall, 1981). The species probably was not originally a resident of South Carolina, but now occurs throughout the Piedmont and Coastal Plain (Golley, 1966). Data from the annual furbearer census indicate that the number of red foxes on the SRS has declined in recent years.

Red foxes are animals characteristic of open habitats and rarely occur in heavily wooded areas. The den is usually located just inside woodland bordering on a field (Barbour and Davis, 1974). The fox may dig its own den or modify one made by another animal. The den is used for a bedding site in cold weather or as a place for raising young. Breeding occurs in January or February (Barbour and Davis, 1974). The average litter size is five (range two to 10), and the gestation period is about 51

days. Young are weaned at about two months of age and may breed the following winter (Barbour and Davis, 1974). Red foxes are monestrous.

The home range of the red fox is usually within a radius of 1.5 km from the den site, but may vary seasonally (Barbour and Davis, 1974; Golley, 1962). Red foxes hunt primarily at night. They are more or less omnivorous, but their staple food is meat. Small mammals are the main prey items, but birds, reptiles, amphibians, fish, insects, and plants also are eaten. The food habits of the species depends mainly on prey availability.

Red foxes are probably beneficial to man because they help to control rodent populations. Fox hunting with hounds is a popular sport in some parts of the country and is widely practiced in Aiken County lands adjacent to the SRS. Red fox pelts also have commercial value. The red fox has not been studied on the SRS except in relation to the annual furbearer census. As might be expected, the decrease in small grain agriculture and open farmlands after closure of the SRS, decreased available habitat for this species. Consequently, the red fox may now be functionally extinct in the interior of the site (Table 3). The only red foxes which were viewed or taken on the furbearer census were found on the periphery of the SRS, areas in which the animals' home ranges could almost certainly extend beyond the site boundary and include adjoining agricultural lands. Red foxes are known to be abundant on the Woodside Plantation several miles north of the SRS. However, running two furbearer census lines per year at this site during 1980, 1981 and 1982, failed to produce any live-trap captures of this species (I. L. Brisbin, pers. comm.). Thus, the absence of this species from the furbearer census does not necessarily confirm its complete absence.

Felis catus Linnaeus - Feral House Cat

The house cat is a small felid that is extremely variable morphologically. Most of the variation is in length and color of hair. The basic colors are black, yellow, and white. These colors can be mixed or diluted in various combinations in individual cats. The species has retractable claws, a long tail, and sharp teeth. The dentition is 3/3, 1/1, 3/2, 1/1 = 30. Although the cat has been domesticated for over 3,000 years it has not developed into as many breeds as has the dog. Differences in size and shape of the different breeds are relatively minor. The diploid number of chromosomes is 38 (Hsu and Benirschke, 1967).

The distribution of the house cat is worldwide. Domestic cats were probably left behind when the residents of the SRS were moved in 1951 and 1952. Feral cats have probably continued to move onto the site from human habitations that border the SRS. Little is known about the state of feral house cats on the SRS, but they are occasionally caught in live traps set for furbearers. SRS site operations now include the live-trapping and removal of free-ranging house cats when they become numerous in the vicinity of reactors, waste burial sites or other areas of industrial activity. The SRS Central Shops area seemed to be the source of particularly large

numbers of such cats, where they were fed leftover food by site workers during the late 1970's.

Felis concolor coryi Bangs - Mountain Lion (Cougar)

The cougar is a large, deep gray to pale buff cat with a small rounded head and long tail. The distal 5 to 10 cm of the tail is black. The skull is short, broad, and the sagittal crest is convex in outline. The nasals are expanded distally and the palate is wide. The dentition is 3/3, 1/1, 3/2. 1/1 = 30. The total length may reach 2.1 m and weight up to 90 kg. Kittens are spotted with black on a buff background. The diploid number of chromosomes is 38 (Hsu and Benirschke, 1969). Tracks of cougars are easily distinguished from dogs and bobcats (Fig. 19).

The cougar has the broadest geographic distribution of any mammal native to the Western Hemisphere, occurring from British Columbia to Patagonia (Hall, 1981). However, it has been extirpated in many parts of its range. If the cougar lives in South Carolina it is probably confined to the swamps of the larger rivers (Golley, 1966) or in the northwestern mountains. Many sightings of this species on the SRS have been reported through the years but none has been confirmed.

The cougar reaches sexual maturity at about three years of age (Hall, 1981) and probably breeds throughout the year. The gestation period is 90 to 96 days (Hamilton, 1963). Litter size averages two with a range from one to six. Kittens develop teeth at about one month and are weaned by about three months of age. Cougars are nocturnal hunters that may range 30 to 50 km while hunting. The primary prey are deer and wild pigs, but other animals and some plant material may be consumed (Golley, 1962; Davis, 1966). The cougar is often considered an unwanted predator by man. The species is a potential threat to livestock; however, its present restriction to remote areas and its rarity in populated areas reduces the probablity of an interaction with man. The cougar is on the Federal and South Carolina State endangered species lists.

Felis rufus floridanus Rafinesque - Bobcat

The bobcat is a medium-sized cat with a short tail. The pelage is buffy, grayish, or reddish, usually with black spots, above and whitish with black spots on the underparts. The tail has indistinct black rings. The skull is robust, and the braincase is rounded, the sagittal crest is lyrate, and the tympanic bullae are large. The dentition is 3/3, 1/1, 2/2, 1/1 = 28. Standard measurements for bobcats from various regions in eastern United States are: total length, 838-1200; tail, 95-152; hind foot, 158-165; and weight, 7-16. Bobcats from the southeast usually average 7 to 8 kg (Hamilton, 1963). Bobcats have a diploid number of 38 (Hsu and Benirschke, 1970).

The range of the bobcat includes the entire continental United States, some of southern Canada, and most of Mexico (Hall, 1981). The preferred habitat of the

bobcat on the SRS appears to be the edges of swamps and streams, old fields, young pine plantations, and upland hardwoods (Kight, 1962; Buie, 1980). Eighty-three percent of the bobcats captured on the SRS before 1962 were captured less than 0.5 km from a swamp or stream. In the northern United States, the home range size of the bobcat is between 3.9 and 14.3 km^2 (Pollack, 1949). Bobcat home ranges on the SRS have been estimated to be 0.65 to 2.6 km^2 (Kight, 1962), 5.2 km^2 (Marshall and Jenkins, 1967), and 13.5 to 25.0 km^2 (Buie, 1980). Home range sizes are larger in areas where prey are sparse then where they are abundant. The density of bobcats on the SRS was once high relative to the rest of the southeastern United States. A density of two to three bobcats per 2.6 km^2 was estimated by Kight (1966). However, the number of bobcats captured in the annual furbearer census declined since 1970 (Fig. 14; Table 3), and the density of bobcats is probably lower now because of the conversion of old field habitat to mature pine forests (Buie, 1980). Based on home range/territory characteristics, the resident adult bobcat density is probably about one animal per 8 km^2 (T. Fendley, pers. comm.).

Adult SRS bobcats defend the entire home range from intrusion by other adults of the same sex (Buie, 1980). Thus, population size is apparently limited by the availability of suitable territories. The mechanism maintaining stable density is probably juvenile dispersal. Juveniles leave their natal areas in March at about nine months of age and embark on a nomadic journey in search of suitable unoccupied use areas (Griffith et al., 1980; Griffith and Fendley, 1982a). Dispersal duration and distances have ranged from three days to more than 100 days and from 7 to 32 km, respectively (Griffith et al., 1980; Griffith and Fendley, 1982b).

Bobcats may breed throughout the year with a peak of breeding activity on the SRS around February or March (Nelson, 1971). The gestation period is 50 to 60 days (Golley, 1962). Litter sizes range from one to four, and young bobcats weigh 283 to 340 grams at birth. The eyes open when the kittens are nine to 10 days old, and kits are weaned by about 70 days (Barbour and Davis, 1974).

SRS bobcats are usually crepuscular; however, they become more diurnal during colder periods of the year (Buie, 1980). Rabbits and cotton rats are the principle prey species of bobcats on the SRS (Kight, 1962; Bara, 1970). Birds, squirrels, snakes, woodrats, deer mice, mink, feral swine, opossum, raccoons, pine voles, and insects have also been identified in bobcat scats on the SRS (Kight, 1962). Under laboratory conditions, energy consumption of SRS bobcats averaged 138 kcal/kg/day (Golley et al., 1965c). Disposition of energy intake was as follows: feces, 9%; urine, 8%; weight gain, 6%; and metabolism, 77%.

Bobcats are secretive and rarely interact with man, although they may be found in close association. An occasional bobcat may kill young livestock or poultry. Although the pelt of the bobcat is commercially valuable, the species' greatest values probably are ecological and aesthetic. The SRS bobcat populations is probably among the most studied population in the eastern United States. In addition to the

work cited above, Golley et al. (1965c) studied the effects of acute gamma radiation, and Heller and Fendley (1982) characterized habitats for this species on the site.

Lutra canadensis lataxina F. Cuvier - River Otter

The otter is a large, aquatic mustelid with a flattened head, small ears, long neck, and long tapering tail. The legs are short, and the toes are webbed. The fur is dense and is dark brown above and a lighter brown below. The skull is large with a short rostrum and flattened auditory bullae. The dentition is 3/3, 1/1, 4/3, 1/2=36. The last upper molar has a square shape. Representative measurements for otters are: total length, 900-1100; tail, 300-400; hind foot, 100; and weight, 5-8. Females are slightly smaller than males. The diploid number 38 (Wurster and Benirschke, 1968).

Otters occur throughout most of the United States and Canada (Hall, 1981). Their distribution is statewide in South Carolina, and they are relatively common along the waterways of the SRS including Par Pond (Golley, 1966; Jenkins and Provost, 1964.

The otter is a strong swimmer and may cover 80 to 100 km of a waterway in a year. They also are able to swim long distances under water. Males are known to travel long distances overland during the breeding season. The otter reaches sexual maturity at about one year of age. Breeding probably occurs in February (Golley, 1962). Delayed implantation my occur followed by a gestation period of about eight or nine weeks. One to four altricial young are born in April or May. Offspring take to the water at an age of about two months (Barbour and Davis, 1974). Otters usually use burrows made by other animals as they do not dig their own dens.

The otter's diet consists mainly of fish but invertebrates, frogs, mammals, and birds are also eaten (Wilson, 1954). Carp, suckers, sunfish, and catfish are the fish most commonly eaten. Otters are secretive in nature and are rarely encountered by man. Their presence most often is detected by the observation of their mud slides along the banks of water courses. The pelt of the otter is high quality and desirable on the fur markets. Genetic characteristics of otters have been studied on the SRS (J. Novak pers. comm.).

Mephitis mephitis elongata Bangs - Striped Skunk

The striped skunk is a medium-sized mustelid with a bushy tail and short pointed snout. The fur is black with white dorsal stripes. The pattern of the stripes is usually white on the head dividing into two stripes that extend to the tail. The feet are semi-plantigrade with large claws on the forefeet. The posterior edge of the palate is nearly on a line with the posterior border of the molars. The dentition is 3/3, 1/1, 3/3, 1/2=34. Representative measurements reported for striped skunks from the southeast were: total length, 678 (598-719); tail, 293 (215-351); hind foot, 70 (64-76); and weight, 1,800-4,500. The skull of *Mephitis* is larger than that of

Spilogale, and the upper molar is approximately square. Female striped skunks are up to 15% smaller than males . The diploid number of chromosomes is 50 (Hsu and Benirschke, 1968).

The striped skunk occurs throughout most of the United States and Canada (Hall, 1981) and is found statewide in South Carolina (Golley, 1966). Striped skunks are fairly common on the SRS with greater concentrations in the lowland swampy areas than on the sandy highlands (Jenkins and Provost, 1964).

The breeding season of the striped skunk is in the early spring. Four to seven young are born after a gestation period of about 62 to 66 days (Verts, 1967). The young stay in the den for about two months and remain with the mother most of their first year (Barbour and Davis, 1974). The den is usually located in underground burrows which were dug and abandoned by other mammals. The primary food is insects, but small mammals, eggs, carrion, and fruit are also eaten. Striped skunks are essentially nocturnal, although they occasionally may be seen during the day. Skunks defend themselves by spraying a fluid with an over-powering odor from two scent glands located on either side of the anus. The striped skunk faces away from its target when spraying. Striped skunks become fat and sluggish as winter approaches. They do not hibernate but may be inactive for a week or more during the coldest winter days (Barbour and Davis, 1974).

For the most part, striped skunks are beneficial because of the number of insects and rodents they eat, and their pelts are used by the fur industry. On the detrimental side, they occasionally do damage to poultry or spray pets, and they carry rabies. Striped skunks have not been specifically studied on the SRS. The species has occasionally been taken during the annual furbearer census, but only in small numbers. They frequently present a problem by getting into buildings on the SRS.

Mustela frenata olivacea Howell - Long-tailed Weasel

The long-tailed weasel is a long, slender-bodied mustelid with short legs and a long, fully-furred tail. The tail is two-fifths to seven-tenths of the length of head and body and has a distinct black tip. The muzzle is relatively blunt and the ears are set low on the head. The pelage is dark brown above with light-colored underparts. The skull has a well developed sagittal crest and the last upper molar is hour-glass shaped. The dentition is 3/3, 1/1, 3/3, 1/2=34. Standard measurements for representative males are: total length, 320 to 510; tail 100 to 150; hind foot, 42 to 50; weight, 200 to 270; and for females: total length, 306 to 362; tail, 95 to 117; hind foot, 35 to 41; and weight, 71 to 126. Females are about two-thirds the size of males. The long-tailed weasel is smaller than the mink and is more lightly colored. The diploid number of chromosomes is 42 (Hsu and Benirschke, 1971).

The long-tailed weasel is distributed over most of the United States to South America (Hall, 1981). It occurs statewide in South Carolina (Golley, 1966), but it rarely is observed on the SRS (Jenkins and Provost, 1964).

No estimates of population density of the long-tailed weasel are available for the vicinity of the SRS. In Iowa, densities on farmlands were estimated to be from one per ha to one per 5.7 ha (Polderboer et al., 1941). Females mate when they are three to four months old, but males do not reach sexual maturity until they are about one year old (Golley, 1962). Breeding occurs in April or May and the embryos remain as unimplanted blastocysts in the uterus for 205 to 337 days (Golley, 1962). The embryos implant 21 to 28 days before birth. Parturition occurs in mid-April and the litter size varies from four to eight (Golley, 1962). The young remain with the mother until mid-summer.

Long-tailed weasels are found at forest edges, brushlands, fencerows, and stream banks. The den is generally located in a shallow burrow often under a stump or in a burrow made by another mammal (Golley, 1962). Leaves, moss, grass, and the fur of prey animals are used to make the nest. Small mammals such as cotton rats, mice, and shrews form the major food items; birds, snakes, and insects are also eaten. Weasels are extremely quick, and their long slender bodies are well adapted for entering the burrows of prey (Golley, 1962). The long-tailed weasel is rarely observed on the SRS, and no special attempts have been made to study them. Weasels were not captured in the annual furbearer census.

Mustela vison mink Peale and Palisot de Beauvois - Mink

The mink is a medium-sized mustelid with a long narrow body, long neck, short legs, and long bushy tail. The toes on the hind feet may be partially webbed. The dark brown fur is soft and water repellent. Occasionally, the fur under the chin or on the chest may be white. The adult skull is over 55 mm in total length. The brain case is expanded and the palate extends past the last molar. The dentition is the same as that of *M. frenata*: 3/3, 1/1, 3/3, 1/2 = 34. Total length ranges from 509 to 535 mm, and tail length from 149 to 175 mm (Hamilton, 1963). Body weight averages 0.6 to 1.0 kg. Males are slightly larger than females. The diploid chromosomes number is 30 (Hsu and Benirschke, 1968).

The mink occurs throughout the United States except in the southwest, north to the Arctic Circle and Alaska (Hall, 1981). It can be found statewide in South Carolina (Golley, 1966). The species is rarely observed on the SRS, although it is probably not uncommon (Jenkins and Provost, 1964).

The breeding season of the mink is in March, and there may be three estrus periods lasting about two days and occurring at intervals of about eight days (Golley, 1962). Coitus, which may last 30 to 40 minutes, induces ovulation which occurs 42 to 52 hours later. The gestation period averages about 50 days, but varies from 39 to 76

days (Golley, 1962). Litter size ranges from four to 10 young. Offspring are weaned at about five weeks and remain with their mother until mid-summer (Golley, 1962).

Mink are semi-aquatic and are generally found along streams or ponds and salt water marshes. Mink feed on a variety of organisms including small mammals, fish, frogs, insects, snakes, and birds. The mink also preys upon muskrat and often uses the abandoned burrow of this rodent for its den. Mink primarily are nocturnal but sometimes are observed during the day. The species is active during all seasons. Mink are excellent swimmers both at and below the surface of water.

In the wild, mink seldom interact with man. However, the mink is an extremely important furbearer. The species is trapped for its fur in some areas and is also raised for its fur on mink ranches. The mink has not been studied on the SRS. Four records of mink were obtained from bobcat scats collected over a two month period (Kight, 1962). The extermination of an insular population of cotton rats by a mink was reported by Schnell (1964). This cotton rat population was an experimental population set up on an island in Lake Lanier, Georgia, by Schnell while he was a graduate student at the University of Georgia and SREL.

Spilogale putorius putorius (Linnaeus) - Eastern Spotted Skunk

The eastern spotted skunk is a small to medium-sized mustelid having black fur with dorsal white stripes broken into patches on the hind quarters. The secondary palate of the skull extends to just past the last molar. The upper molars of *Spilogale* are more rectangular than are those of *Mephitis*. The dental formula is the same in both species of skunks: 3/3, 1/1, 3/3, 1/2=34. Mean total length of five adults from Alabama was 540 m, tail length 201 mm, and weight 1 to 2 kg (Hamilton, 1963). Spotted skunks are less robust and are more "weasel-like" in appearance and behavior than are striped skunks. The skull of the spotted skunk is slightly flattened dorso-ventrally. The diploid number of chromosomes is 64 (Hsu and Benirschke, 1967).

The eastern spotted skunk occurs over the central and southeastern portions of the United States (Hall, 1981). Records of the species in South Carolina are restricted to the western edge of the state (Golley, 1966). Spotted skunks are fairly common in the lowland swampy areas of the SRS (Jenkins and Provost, 1964).

Spotted skunks live primarily in open areas around farms and brushlands. Breeding probably occurs in early spring and two to six young are born in early summer (Hall, 1981). The gestation period is about 60 to 70 days (Barbour and Davis, 1974). A second litter may be born in late summer. The young are born hairless, and their eyes open in about 30 days. The offspring stay with their mother through the summer.

Spotted skunks den in underground burrows. They may use the abandoned burrows of other species of animals. *Spilogale* is an omnivore and eats invertebrates,

small mammals, birds, and vegetable material (Golley, 1962). The species appears to feed more heavily on vertebrates than does *Mephitis* (Selko, 1937). Spotted skunks, like striped skunks, use a strong scent as a defense. The scent of the spotted skunk is more pungent than that of the striped skunk (Hall, 1981).

The spotted skunk has little interaction with man. It is trapped for its fur in some areas and is also a carrier of rabies. The spotted skunk has not been studied on the SRS. Unlike the striped skunk, spotted skunks were never captured during the annual furbearer census.

Procyon lotor solutus Nelson and Goldman - Raccoon

The raccoon is a stocky, medium-sized mammal, easily recognized by its heavily furred, ringed tail and black facial markings (Golley, 1966). The animal has thick body fur and a conspicuous black mask across the eyes which is set off by white on the snout and above the eyes. The short muzzle is sharply pointed. The feet are plantigrade, with five toes on each foot. The tail is ringed with black and yellowish markings. Typically, the body appears grizzled agouti above, paler on the sides, and light gray below. Considerable variation in color may occur ranging from light tan or brown to dark gray. The skull is distinguished by the broadly flaring zygomatic arches and by the molar teeth with well developed cusps. The dentition is 3/3, 1/1, 4/4, 2/2 = 40. Mean body measurements for 93 male raccoons captured on the SRS were: total length, 779; tail, 255; hind foot 103; weight, 4800; and for 65 females: total length, 754; tail, 250; hind foot, 101; and weight, 4000 (Cunningham, 1962). The diploid number of chromosomes is 38.

The raccoon is found throughout the continental United States and nearby offshore islands, with the exception of the Rocky Mountain Range (Hall, 1981). They occur in many different habitats. Raccoons den in the woodlands where hollow trees are plentiful, but they often range for food over the more open uplands. Raccoons are plentiful in both fresh and salt water marshes. In the salt water marshes along the South Carolina and Georgia coasts, raccoons live in forested hammocks and move out into the marshes and banks of tidal creeks along well-used trails to feed on mussels and crabs. On the SRS, raccoons prefer the bottomland hardwood and swamp forest habitats where there is an abundance of hardwood den trees and water habitats for foraging sites. Raccoon scats are common in these habitats (Kinard, 1964), but at one time or another, raccoons have been observed in all habitats on the SRS. During autumn, family groups consisting of the female and two to five juveniles may be observed, often during daylight hours, moving through upland hardwoods, scrub oak forests, pine plantations, across open fields, power line right-of-ways, and four-lane highways in search of food. Based on 140 observations (Cunningham, 1962), activity peaks occur between 4 and 6 am and 8 and 10 pm.

In 1962 the total raccoon population on the SRS was estimated at roughly 13,000 animals. Density estimates were one animal per 4 ha in a 20,800 ha area considered optimal raccoon habitat and one animal per 8 ha in 61,600 ha in habitat

considered marginal for raccoons. The average home range, based on limited data from 28 recaptures, had a radius of 418 m. Further information on raccoon numbers on the SRS over 29 years may be found in the Furbearer Census section of this report.

Of 223 raccoons collected or handled on the SRS, 158 were adults and 65 were juveniles. Male/female sex ratios varied with age class and method of capture. The sex ratios of 119 raccoons captured with dogs were 1.4/1.0 for adults and 1.1/1.0 for juveniles. Of 61 animals taken in live traps the sex ratios were 2.1/1.0 for adults and 1.4/1.0 for juveniles. The sex ratios of 29 raccoons found resting or feeding were 1.0/1.0 for adults and 1.1/1.0 for juveniles.

Breeding activity may be evident throughout most of the year. However, the onset of breeding occurs about mid-January, is well-advanced by mid-February, peaks in March, and then declines. The gestation period is about 63 days (Llewellyn, 1953). Litter size of SRS raccoons ranges from two to four and averages 2.8 (Cunningham, 1932). Young were weaned at 10 to 12 weeks; however, they foraged with the mother well into autumn. Spring-born raccoons were ready to breed toward the end of their first winter. Based on this SRS study, it is estimated that 2.3 young were added to the population per adult female per year.

On the SRS the raccoon is found in association with other furbearing and game animals such as the bobcat, red and gray fox, opossum, and tree squirrels. Raccoons do not construct nests, however dens or refuge sites are usually located in a hole in a large limb or main trunk of a tree. Barns, abandoned buildings, mines, caves, and rock crevices may also be used as refuge or nests sites.

The raccoon is omnivorous, its food habits largely depending upon what is most readily available. According to Kinard (1964), scats from raccoons on the SRS contained animal material throughout the year. Insects were a part of the diet more frequently from March to December. Plant material was in highest concentration from May to November. Analysis of 198 raccoon scats collected throughout 1961 at the SRS revealed 30 different food items including 14 animal and 16 plant species. The seven most common food items in descending order of frequency, were plums, persimmons, beetles, insects (unidentified), mammals (unidentified), grasshoppers and grapes.

Raccoons are furbearers and are also considered game animals throughout much of their range. They are taken by traps for their fur and meat and are hunted using dogs, mainly for sport. Young raccoons are playful, intelligent and interesting animals and are favored as pets. However, as young raccoons get older they often become mischievous and hard to handle. The animals are generally considered beneficial, but can be harmful if they become too numerous. They may cause damage to vegetable or fruit gardens and may even eat eggs and/or domestic fowl. Raccoons are known to be carriers of rabies. In urban areas, they rely heavily on dump sites as well as garbage cans for food. Densities can become high in suburban

areas; periodic outbreaks of distemper appear to control such populations (Hoffman and Gottschang, 1977).

Ursus americanus americanus Pallus - Black Bear

The black bear is a large, heavily-built mammal. The feet are plantigrade with non-retractable claws. The tail is short, and the pelage may be brown or black. The tympanic bullae are not inflated, and the alisphenoid canal is present. The dentition is 3/3 1/1, 4/4, 2/3 =42. The molar teeth have crushing rather than cutting surfaces. Adults may weigh up to 140 kg. The diploid number of chromosomes is 74 (Hsu and Benirschke, 1967).

The historic range of the black bear covered most of the United States and Canada (Hall, 1981); however, the species has been extirpated in much of its former range. Black bears are rare in the mountain province and in the swamps of the large rivers in South Carolina (Golley, 1966). A few bears probably live along the floodplain of the Savannah River (Jenkins and Provost, 1964), and a plaster cast of a bear footprint has been made from an area along the SRS swamp. A sighting of two juvenile bears near Par Pond was made by the SRS security patrol in late 1969. Most bears sighted in the Aiken/Barnwell County area are most likely transients following seasonally ripening fruits and berries between the Piedmont and mountainous regions to the northwest and the more southern reaches of the Savannah River swamp delta.

Female bears are monestrous and breeding takes place during spring or early summer. The gestation period is six to eight months, but implantation of the embryo is delayed until fall, and the young are born during the winter (Barbour and Davis, 1974). Litter size ranges from one to four. The young weigh about 300 g at birth and their eyes open at about 25 days of age (Barbour and Davis, 1974). Females usually become sexually mature at three years of age and then breed every other year. Cubs remain with their mothers for about one and a half years.

Bears are forest-dwelling animals, but often wander over a variety of habitats covering a considerable area. Adult males commonly range over 15 km (Barbour and Davis, 1974). Bears are omnivorous and will eat almost any food available. Their diet may include berries, nuts, grasses, insects, fish, small mammals, and occasionally livestock and deer. During the winter, bears in colder areas become inactive, sleeping for long periods of time in windfalls at the base of trees, under shelving rock, or some other suitable site (Davis, 1966). During inactive periods bears subsist on fat stores accumulated during the summer and autumn. Bears are not, however, true hibernators. Bears generally avoid contact with civilization. On occasion, a bear may be a problem to livestock raisers. Bears on the SRS have not been studied, and there is no evidence of a permanent population on the SRS.

Odocoileus virginianus virginianus (Zimmerman) - White-tailed Deer

The white-tailed deer is a large, even-toed hoofed mammal. The pelage is tan with darker hair on the midline of the back. The large tail is bushy and is colored dark brown dorsally and white below. The young, or fawns, are reddish brown with white spots. Males have antlers which are shed after the breeding period each winter. The main beam of the antlers is directed forward. Tines appear to grow straight up from the main beam and rarely are forked. Mean weight of adult male and female deer on the SRS is 59.9±9.19 kg and 45.7±7.02 kg, respectively. The skull is long, and there are no incisors in the upper jaw. The diploid number of chromosomes is 70 (Wurster and Benirschke, 1967).

The white-tailed deer is found throughout most of North America, although it has been recorded from only a few localities in some of the western states (Hall, 1981). Its distribution is statewide in South Carolina, although the species was reintroduced into some parts of the state (Golley, 1966).

The white-tailed deer is found in all areas of the SRS including the river swamp. On the SRS, the deer that are found in the river swamp are genetically and demographically different from those in the upland region (Urbston, 1967; Ramsey et al., 1979). Optimum habitat appears to be the bushy stage of deciduous forest development, where young trees and shrubs provide food and cover. Deer eat a variety of plants. Green deciduous leaves are the major food item when they are available (Harlow and Hooper, 1971). Other plants in the diet include honeysuckle, blackberry, greenbrier, acorns, mushrooms, fruits, and forbs. The diet changes somewhat seasonally. For example, the succulent green woody stems of trees are eaten in the spring, and leaves are eaten in summer (Harlow and Hooper, 1971).

The breeding period of the white-tailed deer on the SRS extends from August through February (Payne et al., 1966b). Peak breeding activity occurs in October and November. The mean conception date for adult deer on the SRS is November 13±15 days (Rhoades et al., in press). Some male deer have sperm as fawns, but most become sexually mature at 1.5 years of age; young males may not be very successful in reproducing. The conception date is related to the age of the female with older deer breeding earlier than younger animals (Johns et al., 1970). Female deer are capable of breeding in their first year, and a minimal estimate of from 12 to 60% of female fawns breed in their first year. Deer in the swamp appear to breed one to two weeks before those in the uplands. The mean number of offspring is 1.61, but this number varies with age. For age classes 1.5, 2.5, and 3.5 yrs, the mean number of offspring was 1.59, 1..81, and 1.71, respectively. The gestation period is about 200 days. Estimates of the length of the lactating period on the SRS range from four to seven months (Scanlon and Urbston, 1978). The overall male/female fetal sex ratio is 1.12:1, however, fetal sex ratio varies with age of the female (Johns et al., 1977). Young deer tend to have male fetuses twice as often as female fetuses, but in the older age groups the sex ratio is close to 1:1 (Dapson et al., 1979).

The post-natal sex ratio on the SRS is approximately 1:1 in fawn and yearling deer, but is about 0.4:1 in the older age classes in the swamp and about 0.85:1 in the upland (Dapson et al., 1979). Mean fawn mortality has been estimated at 46% in the first nine months of life. The sex ratios indicate higher mortality in male than in female fawns possibly due to behavioral differences between the sexes, and the increased likelihood of a male fawn having a younger mother.

The history of the SRS white-tailed deer herd is discussed by Urbston (1967). When the site was closed to the public in 1952 perhaps no more than about 25 deer occurred on the site, primarily in the deep swamp (Jenkins and Provost, 1964). However, our conversations with older hunters in the area suggest that the number was higher than 25, and that the Upper Three Runs Creek area may have contained a second nucleus of deer. At any rate, the herd rapidly expanded when human hunting pressures were eliminated, and by 1963 the population size was estimated at about 1,400 animals (Jenkins and Provost, 1964). By the spring of 1965 the population was believed to be in excess of 7.7 deer per km^2 (Payne et al., 1966b), and Urbston (1967) estimated the herd density at 17.4 animals per km^2. Both of these estimates are likely too high (Fig. 15), and the estimate at the time they did their work should have been around 4 deer per km^2.

The increase in size of the herd resulted in the initiation of public hunts on the SRS in 1965 primarily to reduce the number of deer-car accidents. The hunts make the deer the most economically significant wild mammal on the SRS. Thousands of dollars are spent annually to conduct the hunts. Each year around 1,000 deer are now harvested providing both food and recreation.

The hunts have also provided an excellent opportunity for research. The white-tailed deer currently is one of the most intensively studied species of mammal on the SRS. One of the primary areas of research is the population genetics of the deer including the following papers: Baccus et al. (1979), Chesser et al. (1982), Cothran et al. (1983), Manlove et al. (1975, 1976), Ramsey et al. (1979), and Smith et al. (1984, 1991, in press). Other areas of research have included body condition and fat cycles (Finger et al., 1981; Johns et al., 1980; Johns et al., 1982, 1984), radioecology studies (Brisbin and Smith, 1975; Kirkham et al., 1979; Rabon, 1968, 1978), and body composition (Wiener et al., 1975) as well as many other studies. See the section on "White-tailed Deer Studies" for more information on deer research.

Sus scrofa Linnaeus - Feral Swine

Swine are large (up to 2.0 m in length), heavy bodied ungulates with a short tail. Males may weigh up to 200 kg and females up to 180 kg. Coloration is white to red/brown to black, and spotting is frequent. Individuals with white shoulder belts and points are also seen. The most common colors on the SRS are black and red/brown spotted, black and white spotted, and just black (Mayer et al., 1989). Color frequencies changed abruptly in the population with a decrease in all-black and an increase in spotted phenotypes occurring between 1976 and 1984 (Mayer et

al., 1989). The body is covered with stiff bristles and occasionally curly wool-like underfur. The snout is long and mobile with a disk-like cartilage in the tip. The skull has an elevated and backward sloped occipital crest formed by the union of the supraoccipital and the parietal bones. The dental formula is 3/3, 1/1, 4/4, 3/3 = 44. The canines are enlarged and evergrowing in the males (Mayer and Brisbin, 1988). The diploid chromosome number is 38 (Hsu and Benirschke, 1960; Barrett, 1971).

Domestic swine are found throughout the nonpolar regions of the world. Feral swine frequently are found as components of swamp and forest ecosystems in the southeastern United States (Brisbin et al., 1977a, b, c; Mayer, 1983; Mayer and Brisbin, in press). The population on the SRS has existed in a truly feral state for less than 30 years and was originally comprised of escaped domestic animals left behind when the site was closed to the public in the early 1950's (Jenkins and Provost, 1964; Mayer, 1983). In the mid 1970's, a small second population of feral swine was discovered along the Upper Three Runs Creek drainage area in the north central part of the site just below U.S. Highway 278. Since that time, this second population has increased in size and spread throughout the northern half of the SRS (Mayer and Brisbin, in press).

The density of feral swine on the SRS in the early 1960's varied from one pig per 24 to 80 ha (Jenkins and Provost, 1964) and in 1979 was one pig per 70 ha. The sex ratio is close to one, and the vast majority of swine on the SRS are less than a year old (Sweeney, 1970). Breeding occurs throughout the year. Females reach sexual maturity at about nine months of age, whereas males mature at between five and seven months of age. The average litter size on the SRS is 7.4. Thirty-one of 50 fetuses examined by Sweeney (1970) were males.

Feral swine apparently show little preference in feeding and eat whatever is available. Grasses, tubers, fruits, and acorns accounted for the majority of the volume of stomach contents of SRS hogs examined by Sweeney (1970); some animal material was also found. On the SRS, feral swine seem to prefer the swamps and adjacent bottomlands. The degree of direct association with water, however, is dependent on the season. The home range size of hogs on the SRS was estimated to be about 392 ha with a range of 121 to 747 ha (Kurz, 1971). Summer and autumn ranges were smaller than winter-spring ranges. Potential nonhuman predators of hogs on the SRS include bears, feral dogs, alligators, and bobcats. Bobcats probably are the most important predator, particularly for young swine.

Feral swine are hunted and eaten by man, and thus, are potential vectors of various environmental contaminants (Brisbin et al., 1977c). Feral swine also are taken during the annual SRS deer hunts and occasionally are harvested in high numbers. From 1964-1988, hunters removed a total of 1476 hogs from the site (Savareno and Fendley, 1989). Feral swine may also damage the habitat of more desirable wildlife species and have been a problem through their rooting of food plots planted for wild turkeys. As a result, a program of contract removal through trapping and shooting has been instituted and is managed by the Savannah River

Forest Station. From 1985 to 1988, this program resulted in the removal of 846 hogs from the Site (Savareno and Fendley, 1989).

Feral swine have been intensively studied on the SRS. The research program includes eight major disciplines: (1) studies of external morphology, (2) nutritional (fattening) studies, (3) studies of cranial morphology, (4) studies of population genetics, (5) radiotelemetric studies of movement and behavior, (6) reproductive biology, (7) feeding ecology and, (8) studies of contaminant distribution and cycling especially for radionuclides and heavy metals. These subjects are discussed in detail by Brisbin et al. (1977c). Principle attention so far has been given to studies of external body morphology (Brisbin et al., 1977b; Mayer, 1983) and population genetics (M. W. Smith et al., 1980).

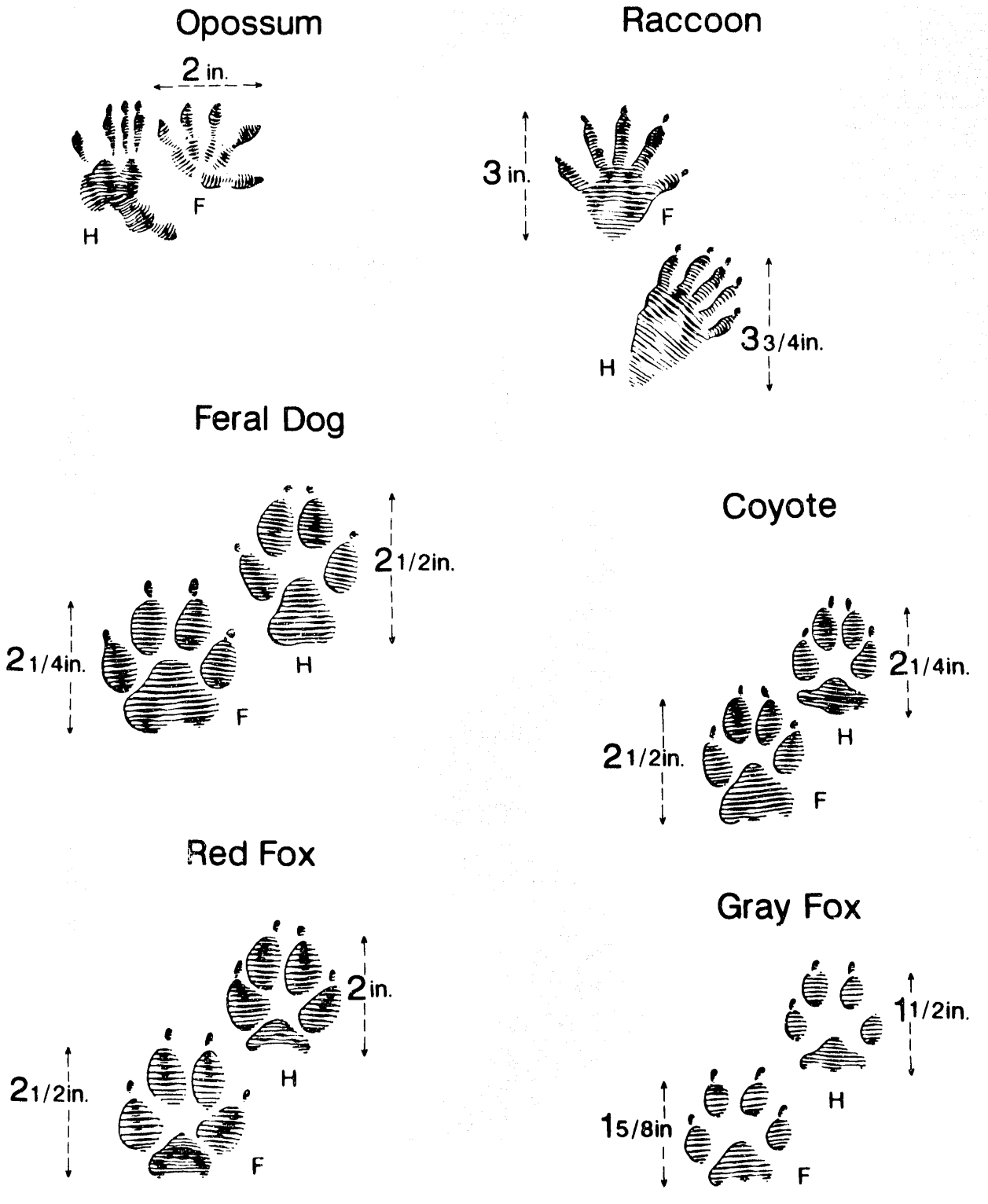


Figure 19. Front (F) and hind (H) tracks of selected mammal species from the SRS.

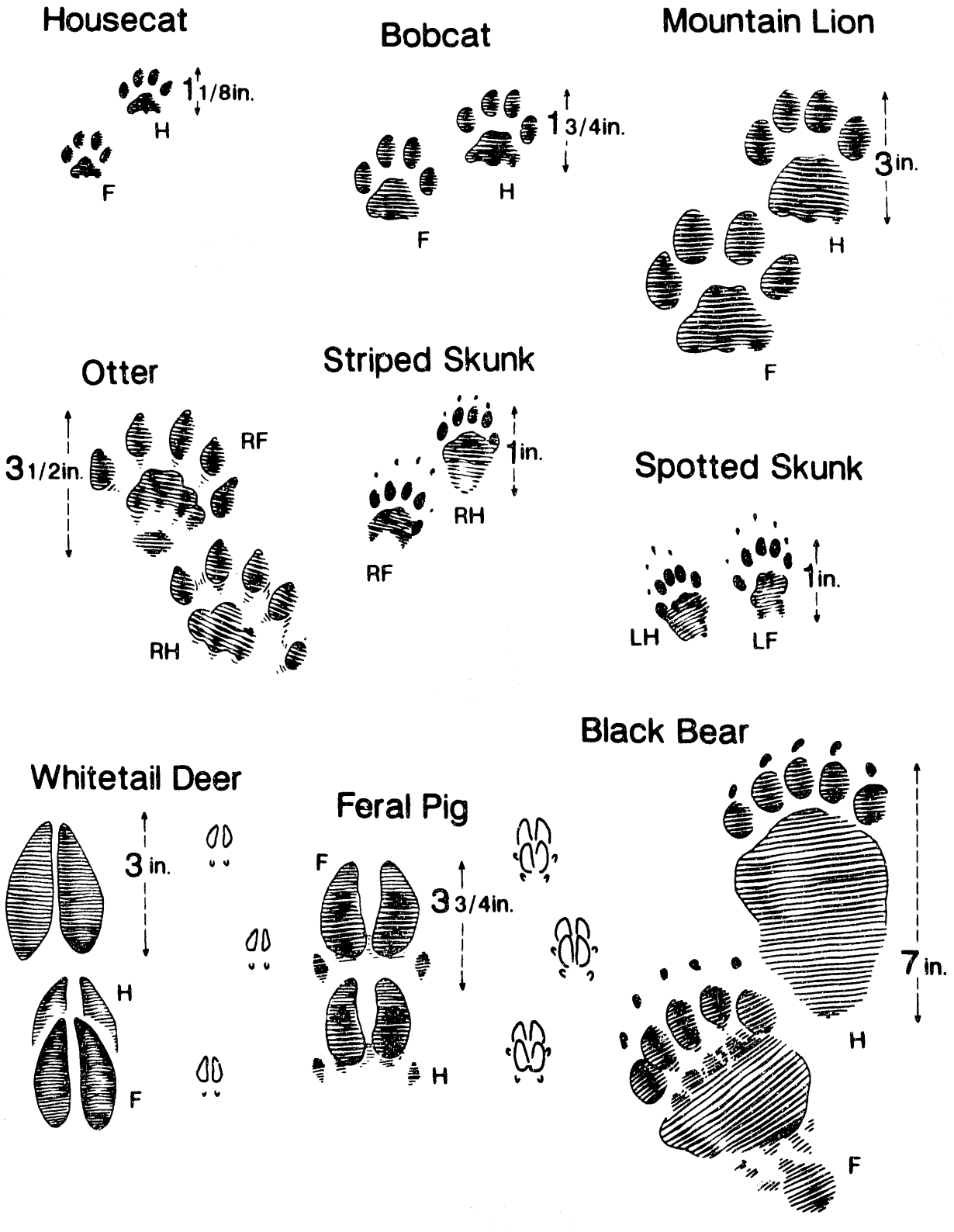


Figure 19. Continued.

DISSERTATIONS AND THESES

This is a list of dissertations and theses resulting from research conducted on mammals of the Savannah River Site by students working wholly or partially on the SRS. The list also includes those dissertations and theses conducted on mammals from elsewhere by students working at SREL. The references are also listed in the cross-indexed bibliography along with the subjects addressed within the document.

Bara, M. O. 1970. Some aspects of bioaccumulation of cesium-137 in the bobcat (*Lynx rufus*). M. S. Thesis, Univ. of Georgia, Athens. 53 pp.

Benke, S. S. 1970. Individual recognition in the old-field mouse, *Peromyscus polionotus*. M. S. Thesis, Univ. of Georgia, Athens. 63 pp.

Boize, B. J. 1970. Behavior and home range size in the old-field mouse, *Peromyscus polionotus*. M. S. Thesis, Univ. of Georgia, Athens. 51 pp.

Boone, J. L., Jr. 1990. Reassessment of the taxonomic status of the cotton mouse (*Peromyscus gossypinus anastasae*) on Cumerland Island, Georgia, and implications of this information for conservation. M.S. Thesis. Univ. of Georgia, Athens. 70 pp.

Borlase, B. C. 1976. Quantification of small mammal dispersal by genetic and demographic characters. M. S. Thesis, Univ. of Houston, Houston. 52 pp.

Branan, W. V. 1984. Ecology and management of deer in Suriname, South America. Ph.D. Diss., Univ. of Georgia, Athens. 154 pp.

Briese, L. A. 1973. Variations in elemental composition and cycling in the cotton rat, *Sigmodon hispidus*. M. S. Thesis, Univ. of Georgia, Athens. 71 pp.

Buie, D. E. 1980. Seasonal home range and movement patterns of the bobcat on the Savannah River Plant. M. S. Thesis. Clemson Univ., Clemson. 68 pp.

Caldwell, L. D. 1960. An investigation of competition in natural populations of mice. Ph.D. Diss., Univ. of Georgia, Athens. 49 pp.

Chesser, R. K. 1981. Genetic and morphologic variation within and among populations of the black-tailed prairie dog. Ph.D. Diss., Univ. of Oklahoma, Norman. 90 pp.

Connell, C. E. 1959. Seasonal lipid levels in three population groups of an old field ecosystem. Ph.D. Diss., Univ. of Georgia, Athens. 107 pp.

Cothran, E. G. 1982. Karyotypic, morphologic, and genic differentiation of hybridizing ground squirrels (*Spermophilus mexicanus* and *Spermophilus tridecemlineatus*). Ph.D. Diss., Univ. of Oklahoma, Norman. 186 pp.

Cunningham, E. R. 1962. A study of the eastern raccoon, Procyon lotor (L.) on the Atomic Energy Commission Savannah River Plant. M. S. Thesis, Univ. of Georgia, Athens. 55 pp.

Davenport, L. B. Jr. 1960. Structure and energy requirements of *Peromyscus polionotus* populations in the old-field ecosystem. Ph.D. Diss., Univ of Georgia, Athens. 102 pp.

Erickson, L. 1979. Genetics of white-tailed deer of South Texas. M. S. Thesis, Texas Tech Univ., Lubbock. 45 pp.

Farrell, M. P. 1977. The interaction between some ecological, physiological, and behavioral components of water metabolism in the cotton rat, *Sigmodon hispidus*. Ph.D. Diss., Mississippi State Univ., Starkville. 136 pp.

Foltz, D. W. 1979. Genetics and mating system of the old-field mouse (*Peromyscus polionotus*). Ph.D. Diss., Univ. of Michigan, Ann Arbor. 105 pp.

Gardner, R. H., Jr. 1975. Movement and distribution of confined and freely growing populations of cotton rats (*Sigmodon hispidus*). Ph.D. Diss., North Carolina State Univ., Raleigh. 71 pp.

Garten, C. T., Jr. 1974. Relationships between behavior, genetic heterozygosity, and population dynamics in the old-field mouse, *Peromyscus polionotus*. M. S. Thesis, Univ. of Georgia, Athens. 88 pp.

Gentry, J. B. 1961. The effect of old-field succession on small mammal populations. M. S. Thesis, Univ. of Georgia, Athens. 32 pp.

Griffith, M. A. 1985. Seasonal home range sizes, movement patterns, and dispersal behavior of the bobcat on the Savannah River Plant. M.S. Thesis. Clemson Univ., Clemson. 78 pp.

Heller, S. P. 1982. Characterization of bobcat habitat on the Savannah River Plant, South Carolina. M. S. Thesis, Clemson Univ., Clemson. 64 pp.

Hillestad, H. O. 1984. Stocking and genetic variability of white-tailed deer in the southeastern United States. Ph.D. Diss., Univ. of Georgia, Athens. 112 pp.

Hughes, T. W. 1985. Home range, habitat utilization and pig survival of feral swine on the Savannah River Plant. M.S. Thesis, Clemson Univ., Clemson. 67 pp.

Jeselnik, D. L. 1982. Comparative analyses of movement, behavior and habitat utilization of free-ranging gray foxes. M. S. Thesis, Univ. of Georgia, Athens. 104 pp.

Kaufman, D. W. 1971. Effects of pelage and substrate coloration on predation of mice by owls. Ph.D. Diss., Univ. of Georgia, Athens. 72 pp.

Kight, J. 1962. An ecological study of the bobcat, *Lynx rufus* (Schreber), in west-central South Carolina. M. S. Thesis, Univ. of Georgia, Athens. 52 pp.

Kinard, F. W., Jr. 1964. Food habits of the eastern raccoon, *Procyon lotor* (L.), in west-central South Carolina. M. S. Thesis, Univ. of Georgia, Athens. 95 pp.

Lovvorn, J. R. 1980. Factors limiting cotton rat populations in enclosed natural habitat during summer and fall. B. S. Thesis. Univ. of Georgia, Athens. 24 pp.

Manlove, M. N. 1979. Genetic similarity among contiguous and isolated populations of white-tailed deer in Michigan. M. S. Thesis, Michigan State Univ., East Lansing. 26 pp.

Markham, C. P. 1968. Dynamics and energy budgets of 30 populations of laboratory house mice. M. S. Thesis, Univ. of Georgia, Athens. 50 pp.

Marshall, A. D. 1969. Spring and summer movements and home ranges of bobcats in the coastal plain of South carolina. M. S. Thesis, Univ. of Georgia, Athens. 52 pp.

Mayer, J. J., II. 1983. The history, comparative morphology, and current status of wild pigs in the United States. Ph.D. Diss., Univ. Conn., Storrs. 368 pp.

Nelson, C. A., Jr. 1971. Preliminary investigations on reproduction in the bobcat (*Lynx rufus*) in the southeast. M. S. Thesis, Univ. of Georgia, Athens. 54 pp.

Payne, R. L. 1968. Preliminary investigations on reproduction in white-tailed deer (*Odocoileus virginianus*) of the Savannah River Plant, South Carolina. M. S. Thesis, Univ. of Georgia, Athens. 43 pp.

Pelton, M. R. 1966. The effects of radiation on survival and reproduction of wild cotton rats (*Sigmodon hispidus*) in enclosed areas of natural habitat. M. S. Thesis, Univ. of Georgia, Athens. 44 pp.

Provo, M. M. 1962. The role of energy utilization, habitat selection, temperature and light in the regulation of a *Sigmodon* population. Ph.D. Diss., Univ. of Georgia, Athens. 49 pp.

Ramsey, P. R. 1973. Spatial and temporal variation in genetic structure of insular and mainland populations of *Peromyscus polionotus*. Ph.D. Diss., Univ of Georgia, Athens. 103 pp.

Rhodes, O. E., Jr. 1987. Factors influencing reproduction of white-tailed deer on the Savannah River Plant. M.S. Thesis, Clemson Univ., Clemson. 45 pp.

Rowland, R. D. 1989. Population genetics of white-tailed deer on Cumberland Island, Georgia. M.S. Thesis. Univ. of Georgia, Athens. 42 pp.

Sawyer, D. T. 1988. Gray fox home range dynamics and validation of the scent station transect technique. M.S. Thesis, Clemson Univ., Clemson. 104 pp.

Schnell, J. H. 1964. An experimental study of carrying capacity based on the disappearance rates of cotton rats (*Sigmodon hispidus komareki*) introduced into enclosed areas of natural habitat. Ph.D. Diss., Univ. of Georgia, Athens. 45 pp.

Shipes, D. A. 1979. The feeding strategy and population biology of the beaver (*Castor canadensis carolinensis*) in the upper coastal plain of South Carolina. M. S. Thesis, Clemson Univ., Clemson. 86 pp.

Stribling, H. L. 1978. Radiocesium concentrations in two populations of naturally contaminated feral hogs (*Sus scrofa domesticus*). M. S. Thesis, Clemson Univ., Clemson. 57 pp.

Sweeney, J. M. 1970. Preliminary investigations of a feral hog (*Sus scrofa*) population on the Savannah River Plant, South Carolina. M. S. Thesis, Univ. of Georgia, Athens. 58 pp.

Sweeney, J. R. 1970. The effects of harassment by hunting dogs on the movement patterns of white-tailed deer on the Savannah River Plant, South Carolina. M. S. Thesis, Univ. of Georgia, Athens. 103 pp.

Teska, W. R. 1978. *Sigmodon hispidus* (Rodentia) in loblolly pine succession as influenced by supplemental food. Ph.D. Diss., Michigan State Univ., East Lansing. 95 pp.

Urbston, D. F. 1968. A comparison of several techniques for aging white-tailed deer. M.S. Thesis, Virginia Polytechnic Institute and State Univ., Blacksburg. 90 pp.

Urbston, D. F. 1976. Descriptive aspects of two fawn populations as delineated by reproductive differences. Ph.D. Diss., Virginia Polytechnic Inst. and State Univ., Blacksburg. 104 pp.

Wagner, C. K. 1968. Relationship between oxygen consumption, ambient temperature and excretion of 32-phosphorus in laboratory and field populations of cotton rats. M. S. Thesis, Univ. of Georgia, Athens. 37 pp.

Wiggers, E. P. 1979. Deer forage production and prediction in forest stands of the upper coastal plains, South Carolina. M.S. Thesis, Clemson Univ., Clemson. 134 pp.

BIBLIOGRAPHY OF THE MAMMALS OF THE SRS

Introduction

The mammal studies conducted on the SRS over the last 40 years have been more extensive than in any other region of South Carolina. In this bibliography, we draw together all of the information that has been published on mammal populations on the SRS primarily by scientists at or associated with the Savannah River Ecology Laboratory.

Papers included in this bibliography have been classified for each species and according to 22 different subject categories. Categories are listed and explained at the front of the bibliography. Citations are listed alphabetically along with appropriate category numbers. We have developed a computer program to search the data base and to print cross-indexed bibliographies. The search program and/or the complete data base can be made available to scientists currently working on these species. The reprints which apply to particular categories are listed at the back of the bibliography. These listings also give all of the references that apply to a particular species. For example, papers that deal with the old-field mouse are listed under category 55. Accession numbers are used to locate the reprint in the SREL library and refer to the number given in Wiener and Smith (1981); those listed with SREL numbers refer to publications on the laboratory's reprint distribution list. Theses and dissertations are catalogued in the SREL Library. Updated bibliographies will be maintained and made available upon request.

MAMMALS OF THE SRS

List of Categories

1. Habitat
2. Locality
3. Growth and Development
4. Body Composition
5. Reproduction
6. Mortality and Age Structure
7. Numbers or Density
8. Genetics
9. Movement Patterns
10. General Behavior
11. General Physiology
12. Metabolism and Energetics
13. Parasites and Diseases
14. External Morphology
15. Internal Morphology
16. Taxonomy

17. Paleontology
18. Radioecology
19. Evolution
20. Dissertations or Theses
21. Wildlife Management
22. Bibliography
32. *Didelphis virginiana virginiana* Kerr - Opossum
33. *Blarina carolinensis carolinensis* (Bachman)-Short-tailed Shrew
34. *Cryptotis parva parva* (Say)-Least Shrew
35. *Sorex longirostris longirostris* Bachman - Southeastern Shrew
36. *Condylura cristata parva* Paradiso - Star-nose Mole
37. *Scalopus aquaticus howelli* Jackson - Eastern Mole
38. *Lasionycteris noctivagans* (Le Conte) - Silver-haired Bat
39. *Lasiurus borealis borealis* (Müeller) - Red Bat
40. *Lasiurus intermedius floridanus* Miller - Northern Yellow Bat
41. *Lasiurus seminolus* (Rhoads) - Seminole Bat
42. *Nycticeius humeralis humeralis* (Rafinesque) - Evening Bat
43. *Pipistrellus subflavus subflavus* (F. Cuvier) - Eastern Pipistrelle
44. *Plecotus rafinesquii macrotis* Le Conte - Big-eared Bat
45. *Homo sapiens sapiens* Linnaeus - Modern Man
46. *Dasypus novemcinctus mexicanus* Peters - Nine-banded Armadillo
47. *Sylvilagus aquaticus aquaticus* (Bachman) Swamp Rabbit
48. *Sylvilagus floridanus mallurus* (Thomas) - Eastern Cottontail
49. *Sylvilagus palustris palustris* (Bachman) - Marsh Rabbit
50. *Neotoma floridana floridana* (Ord) - Eastern Woodrat
51. *Ochrotomys nuttalli nuttalli* (Harlan & Bachman) - Golden Mouse
52. *Oryzomys palustris palustris* (Harlan) - Marsh Rice Rat
53. *Peromyscus gossypinus gossypinus* (Le Conte) - Cotton Mouse
54. *Peromyscus leucopus leucopus* (Rafinesque) - White-footed Mouse
55. *Peromyscus polionotus lucubrans* Schwartz - Old-field Mouse
56. *Reithrodontomys humulis humulis* (Audubon & Bachman) - Eastern Harvest Mouse
57. *Sigmodon hispidus komareki* Gardner - Hispid Cotton Rat
58. *Microtus pinetorum pinetorum* (Le Conte) - Woodland Vole
59. *Ondatra zibethicus zibethicus* (Linnaeus) - Muskrat
60. *Mus musculus brevirostris* Waterhouse - House Mouse
61. *Rattus norvegicus norvegicus* (Berkenhout) - Norway Rat
62. *Rattus rattus rattus* (Linneaus) - Roof Rat or Black Rat
63. *Castor canadensis carolinensis* Roads - Beaver
64. *Glaucomys volans saturatus* Howell - Southern Flying Squirrel
65. *Sciurus carolinensis carolinensis* Gmelin - Gray Squirrel
66. *Sciurus niger niger* Linnaeus - Squirrel
67. *Canis latrans frustror* Say - Coyote
68. *Canis familiaris* Linneaus - Feral Dog
69. *Urocyon cinereoargenteus cinereoargenteus* (Schreber) - Gray Fox
70. *Vulpes vulpes fulva* (Desmarest) - Red Fox

71. *Felis catus* Linnaeus - Feral Cat
72. *Felis concolor coryi* Bangs - Mountain Lion (Cougar)
73. *Felis rufus floridanus* Refinesque - Bobcat
74. *Lutra canadensis lataxina* F. Cuvier - River Otter
75. *Mephitis mephitis elongata* Bangs - Striped Skunk
76. *Mustela frenata olivacea* Howell - Long-tailed Weasel
77. *Mustela vison mink* Peale and Palisot de Beauvois - Mink
78. *Spilogale putorius putorius* (Linnaeus) - Eastern Spotted Skunk
79. *Procyon lotor solutus* Nelson & Goldman - Raccoon
80. *Ursus americanus americanus* Pallas - Black Bear
81. *Odocoileus virginianus virginianus* (Zimmerman) - White-tailed Deer
82. *Sus scrofa* Linneaus - Feral Swine
83. General (not SRS species)

Explanation of Categories

Papers are assigned to one or more of 74 categories according to their subject content. An explanation of each category is given below.

1. Habitat: Papers describing the habitat and associated species for the SRS mammals. These include the effects of habitat on the biology of particular species.

2. Locality: Papers that give specific locations that can be used to describe a species range.

3. Growth and Development: Papers on age-specific changes in dimensions or other characteristics.

4. Body Composition: Papers that deal with attributes of body composition such as caloric value of body fat and protein.

5. Reproduction: Papers concerning reproductive characteristics such as percentage of pregnant females, litter size, embryo mortality, and parturition.

6. Mortality and Age Structure: Papers dealing with sources of mortality, amounts of mortality in relation to various factors, and resulting age structure and sex ratio.

7. Numbers or Density: Papers dealing with numbers of mammals in populations or number per unit area.

8. Genetics: Papers concerning determination of marker genes, gene frequencies and inheritance, or genetic similarity of various forms as indicated by electrophoretic or breeding studies.

9. Movement Patterns: Papers concerning movement of mammals within a home range, dispersal and dispersion.

10. General behavior: Papers concerning all behavior of mammals other than movement. These include copulatory behavior and burrow construction.

11. General Physiology: Papers dealing with all physiological attributes of mammals with the exception of those concerning metabolism or energetics.

12. Metabolism and Energetics: Papers dealing with oxygen consumption, carbon dioxide production, food consumption or caloric requirements.

13. Parasites and Diseases: Papers that identify or describe parasites or diseases of the various mammalian species.

14. External Morphology: Papers that include measurements of external dimensions or descriptions of external appearance not specifically related to changes with age.

15. Internal Morphology: Papers dealing with attributes of internal morphology such as internal anatomy, cytology, histology, and karyotypes.

16. Taxonomy: Papers dealing with nomenclature, placement of populations in higher taxonomic categories, and subspecific designations within the species.

17. Paleontology: Papers that describe fossil occurrence of SRS mammals or evaluate methods for identifying fossils of these species.

18. Radioecology: Papers that describe effects of radiation in the use of radioisotopes.

19. Evolution: Papers that discuss the evolutionary biology of particular species including modes of selection.

20. Dissertations or Theses: Dissertation or theses written to fulfill degree requirements.

21. Wildlife Management: Papers that present data of management interest or that present different management plans for mammalian populations on the SRS.

22. Bibliography: Papers that contain extensive literature cited section or that are primarily bibliographical compilations.

32-83. Specific Species: Papers that deal with specific species listed in each category.

1. Angerman, J.A., R. W. Dapson, and M. H. Smith. 1974. Effect of age on the indigestible component of a mouse. J. Mammal. 55:210.
   CATEGORIES: 3, 5, 55
   ACCESSION NUMBER: SREL 365

2. Anonymous. 1980. A biological inventory of the proposed site of the defense waste processing facility on the Savannah River Plant in Aiken, South Carolina. Ann. Report SREL-7. 179 pp.
   CATEGORIES: 1, 7, 32, 33, 34, 35, 36, 37, 39, 41, 42, 43, 48, 50, 51, 52, 53, 55, 56, 57, 58, 65, 66, 69, 70, 73, 75, 77, 78, 81
   ACCESSION NUMBER: None

3. Ashley, C. 1965. Effect of the Savannah River Plant on environmental radioactivity. 2. Savannah River Plant. July - December 1964. Radiol. Health Data 6:457-464.
   CATEGORIES: 18
   ACCESSION NUMBER: 235

4. Baccus, R., H. O. Hillestad, P. E. Johns, M. N. Manlove, R. L. Marchinton, and M. H. Smith. 1979. Prenatal selection in white-tailed deer. Proc. Ann. Conf. Southeast. Assoc. Fish & Wildlife Agencies. 31:173-179.
   CATEGORIES: 8, 19, 21, 81
   ACCESSION NUMBER: SREL 618

5. Baccus, R., N. Ryman, M. H. Smith, C. Reuterwall, and D. Cameron. 1983. Genetic variability and differentiation of large grazing animals. J. Mammal. 64:109-120.
   CATEGORIES: 8, 16, 81, 83
   ACCESSION NUMBER: SREL 830

6. Bara, M. O. 1970. Some aspects of bioaccumulation of cesium-137 in the bobcat (*Lynx rufus*). M. S. Thesis, Univ. of Georgia, Athens, GA. 53 pp.
   CATEGORIES: 18, 20, 73
   ACCESSION NUMBER: SREL Library

7. Benke, S. S. 1970. Individual recognition in the old-field mouse, *Peromyscus polionotus*. M. S. Thesis, Univ. of Georgia, Athens, GA. 63 pp.
   CATEGORIES: 10, 20, 54
   ACCESSION NUMBER: SREL Library

8. Bergan, J. F. 1990. Kleptoparasitism of a river otter, *Lutra canadensis*, by a bobcat, *Felis rufus*, in South Carolina (Mammalia: Carnivora). Brimleyana 16:63-65.

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ACCESSION NUMBER: SREL 1483

9. Beyers, R. J. and M. H. Smith. 1971. A colorimetric method for determining oxygen concentration in terrestrial situation. Ecology 52:374-375.
CATEGORIES: 12, 55
ACCESSION NUMBER: 420

10. Beyers, R. J., M. H. Smith, J. B. Gentry, and L. L. Ramsey. 1971. Standing crops of elements and atomic ratios in a small community. Acta Theriol. 14:203-211.
CATEGORIES: 7, 11, 33, 51, 53
ACCESSION NUMBER: 415

11. Blackwell, T. L. and P. R. Ramsey. 1972. Exploratory activity and lack of genotype correlates in *Peromyscus polionotus*. J. Mammal. 52:401-403.
CATEGORIES: 8, 9, 10, 55
ACCESSION NUMBER: 343

12. Boize, B. J. 1970. Behavior and home range size in the old-field mouse, *Peromyscus polionotus*. M. S. Thesis, Univ. of Georgia, Athens, GA. 51 pp.
CATEGORIES: 3, 9, 10, 12, 20, 55
ACCESSION NUMBER: SREL Library

13. Borlase, B. C. 1976. Quantification of small mammal dispersal by genetic and demographic characters. M. S. Thesis, Univ. of Houston, Houston, TX. 52 pp.
CATEGORIES: 6, 7, 8, 9, 20, 52, 57, 83
ACCESSION NUMBER: SREL Library

14. Branan, W. V. 1984. Ecology and management of deer in Suriname, South America. Ph.D. Diss., Univ. Georgia, Athens, GA. 154 pp.
CATEGORIES: 1, 2, 3, 5, 8, 14, 15, 16, 21, 81.
ACCESSION NUMBER: SREL Library

15. Breshears, D. D., M. H. Smith, E. G. Cothran, and P. E. Johns. 1988. Genetic variability in white-tailed deer. Heredity 60:139-146.
CATEGORIES: 2, 8, 81
ACCESSION NUMBER: SREL 1209

16. Briese, L. A. 1973. Variations in elemental composition and cycling in the cotton rat, *Sigmodon hispidus*. M. S. Thesis, Univ. of Georgia, Athens, GA. 71 pp.
CATEGORIES: 3, 4, 12, 18, 20, 57
ACCESSION NUMBER: SREL Library

17. Briese, L. A. and M. H. Smith. 1973. Competition between *Mus musculus* and *Peromyscus polionotus*. J. Mammal. 54:968-969.
CATEGORIES: 7, 55, 60
ACCESSION NUMBER: 315

18. Briese, L. A. and M. H. Smith. 1974. Seasonal abundance and movement of nine species of small mammals. J. Mammal. 55:615-629.
CATEGORIES: 7, 9, 33, 34, 35, 36, 51, 52, 53, 55, 56, 57, 58, 60
ACCESSION NUMBER: 314

19. Briese, L. A. and M. H. Smith. 1980. Body condition elemental balance, and parasitism in cotton rats. J. Mammal. 61:763-766.
CATEGORIES: 6, 11, 12, 13, 57
ACCESSION NUMBER: 643

20. Brisbin, I. L., Jr. 1977. The pariah - its ecology and importance to the origin, development and study of pure bred dogs. Am. Kennel Gaz. 94:22-29.
CATEGORIES: 10, 19, 68
ACCESSION NUMBER: SREL 526

21. Brisbin, I. L., Jr. 1989. Feral animals and zoological parks: conservation concerns for a neglected component of the world's biodiversity. Pages 523-530. *In* Amer. Assoc. Zool. Parks & Aquariums 1989 Regional Proceedings, Southern Regional Conference, Atlanta, GA, 2-4 April 1989.
CATEGORIES: 21, 67, 82
ACCESSION NUMBER: SREL 1353

22. Brisbin, I. L., Jr. and M. S. Lenarz. 1984. Morphological comparisons of insular and mainland populations of southeastern white-tailed deer. J. Mammal. 65:44-50.
CATEGORIES: 1, 6, 14, 81, 82
ACCESSION NUMBER: SREL 889

23. Brisbin, I. L., Jr. and M. H. Smith. 1975. Radiocesium concentrations in whole-body homogenates and several body compartments of naturally contaminated white-tailed deer. Pages 542-556, *In* Mineral Cycling in Southeastern Ecosystems, F. G. Howell, J. B. Gentry, and M. H. Smith (eds.). ERDA Symp. Series CONF-740513.
CATEGORIES: 4, 15, 18, 81
ACCESSION NUMBER: 351

24. Brisbin, I. L., Jr., D. E. Buie, H. O. Hillestad, R. R. Roth, and E. J. Cahoon. 1977. Natural resource inventory and characterization at the Savannah River National Environmental Research Park: An overview of program

goals and design. Pages 99-119, *In* National Environmental Research Park Symp., J. T. Kitchings and N. E. Tarr (eds.). ORNL-5304, Oak Ridge Nat. Lab., Oak Ridge, TN.
CATEGORIES: 1, 7
ACCESSION NUMBER: 239

25. Brisbin, I. L., Jr., R. A. Geiger, H. B. Graves, J. E. Pinder, III, J. M. Sweeney, and J. R. Sweeney. 1977. Morphological characterizations of two populations of feral swine. Acta Theriol. 22:75-85.
CATEGORIES: 8, 14, 82
ACCESSION NUMBER: 297

26. Brisbin, I. L., Jr., M. W. Smith, and M. H. Smith. 1977. Feral swine studies at the Savannah River Ecology Laboratory: An overview of program goals and design. Pages 71-90, *In* Research and Management of Wild Hog Populations, G. W. Wood (ed.), Belle W. Baruch Forest Sci. Inst. of Clemson Univ., Georgetown, SC.
CATEGORIES: 3, 5, 8, 9, 12, 14, 18, 19, 21, 82
ACCESSION NUMBER: 391

27. Brown, C. J. 1982. Genotypic and morphological comparisons of pariah house cat populations from the southeastern United States. M. S. Thesis, Univ. of Georgia, Athens, GA. 48 pp.
CATEGORIES: 18, 20, 45
ACCESSION NUMBER: SREL Library

28. Brown, C. J. and I. L. Brisbin, Jr. 1983. Genetic analysis of pariah cat populations from the southeastern United States. J. Hered. 74:344-348.
CATEGORIES: 2, 8, 9, 14, 19, 71
ACCESSION NUMBER: SREL 865

29. Butler, F. E. 1962. Sr 90 monitoring at the Savannah River Site. Health Physics 8:273-277.
CATEGORIES: 18, 45
ACCESSION NUMBER: 405

30. Caldwell, L. D. 1960. An investigation of competition in natural populations of mice. Ph.D. Diss., Univ. of Georgia, Athens, GA. 49 pp.
CATEGORIES: 6, 7, 10, 20, 55, 60
ACCESSION NUMBER: SREL Library

31. Caldwell, L. D. 1964. An investigation of competition in natural populations of mice. J. Mammal. 45:12-30.
CATEGORIES: 5, 6, 7, 10, 12, 55, 60
ACCESSION NUMBER: 498

32. Caldwell, L. D. 1966. Marsh rabbit development and ectoparasites. J. Mammal. 47:527-528.
CATEGORIES: 3, 13, 49
ACCESSION NUMBER: SREL 110

33. Caldwell, L. D. 1967. Attack behavior of a loggerhead shrike. Wilson Bull. 79:116-117.
CATEGORIES: 6, 55
ACCESSION NUMBER: 496

34. Caldwell, L. D. and C. E. Connell. 1968. A precis on energetics of the old-field mouse. Ecology 49:542-548.
CATEGORIES: 5, 10, 12, 55
ACCESSION NUMBER 399

35. Caldwell, L. D. and J. B. Gentry. 1965a. Interactions of *Peromyscus* and *Mus* in a one-acre field enclosure. Ecology 46:189-192.
CATEGORIES: 5, 6, 7, 55, 60
ACCESSION NUMBER: 500

36. Caldwell, L. D. and J. B. Gentry. 1965b. Natality in *Peromyscus polionotus* populations. Am. Midl. Nat. 74:168-175.
CATEGORIES: 5, 6, 55
ACCESSION NUMBER: 212

37. Carr, S. M., S. W. Ballinger, J. N. Derr, L. H. Blankenship, and J. W. Bickham. 1986. Mitochondrial DNA analysis of hybridization between sympatric white-tailed deer and mule deer in West Texas. Proc. Natl. Acad. Sci. USA 83:9576-9580.
CATEGORIES: 8, 19, 81
ACCESSION NUMBER: None

38. Chesser, R. K. and M. H. Smith. 1987. Relationship of genetic variation to growth and reproduction in the white-tailed deer. Pages 168-177, *In* Biology and Management of the Cervidae, C. M. Wemmer (ed.). Smithsonian Institution Press, Washington, DC.
CATEGORIES: 3, 4, 5, 8, 14, 81
ACCESSION NUMBER: SREL 1187

39. Chesser, R. K., M. H. Smith, and I. L. Brisbin, Jr. 1980. Management and maintenance of genetic variability in endangered species. Intl. Zoo Yearbook 20:146-154.
CATEGORIES: 8, 21, 81
ACCESSION NUMBER: SREL 735

40. Chesser, R. K., M. H. Smith, P. E. Johns, M. N. Manlove, D. O. Straney, and R. Baccus. 1982. Spatial, temporal, and age-dependent heterozygosity of beta-hemoglobin in white-tailed deer. J. Wildl. Manage. 46:983-990.
CATEGORIES: 6, 8, 19, 81
ACCESSION NUMBER: SREL 802

41. Conley, R. H. and J. H. Jenkins. 1969. An evaluation of several techniques of determining the age of bobcats (*Lynx rufus*) in the southeast. Proc. 23rd Ann. Conf. Southeast. Assoc. Game Fish Comm. 23:104-109.
CATEGORIES: 6, 14, 15, 73
ACCESSION NUMBER: 579

42. Connell, C. E. 1959. Seasonal lipid levels in three population groups of an old field ecosystem. Ph.D. Diss., Univ. of Georgia, Athens, GA. 107 pp.
CATEGORIES: 3, 4, 7, 12, 20, 55
ACCESSION NUMBER: SREL Library

43. Cothran, E. G. 1982. Karyotypic, morphologic, and genic differentiation of hybridizing ground squirrels (*Spermophilus mexicanus* and *Spermophilus tridecemlineatus*). Ph.D. Diss., Univ. of Oklahoma, Norman, OK. 186 pp.
CATEGORIES: 2, 8, 14, 15, 16, 19, 20, 83
ACCESSION NUMBER: SREL Library

44. Cothran, E. G. and M. H. Smith. 1983. Chromosomal and genic divergence in mammals. Syst. Zool. 32:360-368.
CATEGORIES: 8, 15, 16, 19, 50, 53, 54, 55, 60, 61
ACCESSION NUMBER: SREL 881

45. Cothran, E. G., R. K. Chesser, M. H. Smith, and P. E. Johns. 1983. Influences of genetic variability and maternal factors on fetal growth in white-tailed deer. Evolution. 37:282-291.
CATEGORIES: 3, 8, 14, 81
ACCESSION NUMBER: SREL 833

46. Cothran, E. G., R. K. Chesser, M. H. Smith, and P. E. Johns. 1987. Fat levels in female white-tailed deer during the breeding season and pregnancy. J. Mamm. 68:111-118.
CATEGORIES: 1, 3, 4, 5, 6, 8, 81
ACCESSION NUMBER: SREL 1122

47. Crawford, T. V. (compiler). 1976. Savannah River Laboratory Environmental Transport and Effects Research. Annual Report FY-1975. E. I. Dupont de Nemours and Co., Savannah River Lab., Aiken, SC. DP-1412. 41 pp.
CATEGORIES: 18, 69, 72, 79
ACCESSION NUMBER: 266

48. Crawford, T. V. (compiler). 1978. Savannah River Laboratory Environmental Transport and Effects Research. Annual Report FY-1977. E. I. Dupont de Nemours and Co., Savannah River Lab., Aiken, SC. DP-1489. 262 pp.
CATEGORIES: 18, 81
ACCESSION NUMBER: 644

49. Cunningham, E. R. 1962. A study of the eastern raccoon, *Procyon lotor* (L.) on the Atomic Energy Commission Savannah River Site. M. S. Thesis, Univ. of Georgia, Athens, GA. 55 pp.
CATEGORIES: 6, 7, 14, 20, 79
ACCESSION NUMBER: SREL Library

50. Cushwa C. T., R. L. Downing, R. F. Harlow, and D. F. Urbston. 1970. Importance of woody twig ends to deer in the Southeast. Forest Res. Paper SE-67. 12 pp.
CATEGORIES: 1, 21, 81
ACCESSION NUMBER; None

51. Dapson, R. W. 1972. Age structure of six populations of old-field mice, *Peromyscus polionotus*. Res. Popul. Ecol. 13:161-169.
CATEGORIES: 6, 55
ACCESSION NUMBER: 373

52. Dapson, R. W. and J. M. Irland. 1972. An accurate method of determining age in small mammals. J. Mammal. 53:100-106.
CATEGORIES: 3, 55
ACCESSION NUMBER: SREL 297

53. Dapson, R. W., P. R. Ramsey, M. H. Smith, and D. F. Urbston. 1979. Demographic differences in contiguous populations of white-tailed deer. J. Wildl. Manage. 43:889-898.
CATEGORIES: 6, 21, 81
ACCESSION NUMBER: SREL 626

54. Davenport, L. B., Jr. 1960. Structure and energy requirements of *Peromyscus polionotus* populations in the old-field ecosystem. Ph.D. Diss., Univ. of Georgia, Athens, GA. 102 pp.
CATEGORIES: 5, 6, 7, 20, 55
ACCESSION NUMBER: SREL Library

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CATEGORIES: 1, 5, 6, 9, 55
ACCESSION NUMBER: 216

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CATEGORIES: 8, 55
ACCESSION NUMBER: 440

57. Duever, A. J. 1967. Trophic dynamics of reptiles in terms of community food web and energy intake. M. S. Thesis, Univ. of Georgia, Athens, GA. 95 pp.
CATEGORIES: 1, 20, 33, 55, 56, 57, 58, 60, 66
ACCESSION NUMBER: SREL Library

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CATEGORIES: 8, 19, 20, 81
ACCESSION NUMBER: SREL Library

59. Evans, A. G. and J. W. Fenimore. 1960. Radioactivity in soil, vegetation, and ground water. E. I. Dupont de Nemours and Co., Savannah River Laboratory, Aiken, SC. DPSPU 60-33. 15 pp.
CATEGORIES: 18, 71
ACCESSION NUMBER: 276

60. Evans, A. G., W. L. Marter, and W. C. Reining. 1968. Guides limiting the release of radionuclides by the Savannah River Plant. Health Physics 15:57-65.
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ACCESSION NUMBER: 490

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ACCESSION NUMBER: 684

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CATEGORIES: 7, 9, 33, 51, 54
ACCESSION NUMBER: 413

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CATEGORIES: 22, 55
ACCESSION NUMBER: SREL 446

64. Fendley, T. T. and D. E. Buie. 1982. Seasonal home range and movement patterns of adult bobcats on the Savannah River Plant. Pages 237-259, *In* Cats of the World: Biology, Conservation and Management. 2nd Intl. Cat Symp. S. D. Miller and D. Everett (eds.). Caeser Kleberg Wildl. Res. Inst. and Nat. Wild. Fed. Kingsville, TX.
CATEGORIES: 1, 9, 10, 21, 73
ACCESSION NUMBER: None

65. Finger, S. E., I. L. Brisbin, Jr., M. H. Smith, and D. F. Urbston. 1981. Kidney fat as a predictor of body condition in white-tailed deer. J. Wildl. Manage. 45:964-968.
CATEGORIES: 4, 12, 81
ACCESSION NUMBER: SREL 754

66. Foltz, D. W. 1979. Genetics and mating system of the old-field mouse (*Peromyscus polionotus*). Ph.D. Diss., Univ. of Michigan, Ann Arbor, MI. 105 pp.
CATEGORIES: 8, 10, 20, 55
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ACCESSION NUMBER: 349

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Ondatra zibethicus zibethicus - CATEGORY 59: 145, 169

Mus musculus brevirostris - CATEGORY 60: 17, 18, 30, 31, 35, 44, 57, 67, 74, 76, 92, 93, 94, 98, 124, 125, 128, 129, 130, 136, 145, 158, 169, 184, 186, 187, 244, 260, 265, 304

Rattus norvegicus norvegicus - CATEGORY 61: 44, 93, 303

Rattus rattus rattus -CATEGORY 62: 93, 303

Castor canadensis carolinensis - CATEGORY 63: 110, 113, 169, 243, 303

Glaucomys volans saturatus - CATEGORY 64: 93, 145, 169, 172, 201

Sciurus carolinensis carolinensis - CATEGORY 65: 2, 113, 145, 169, 170, 171, 173, 174, 189, 190, 202, 203

Sciurus niger niger Linnaeus - CATEGORY 66: 2, 57, 113, 145, 157, 169

Canis latrans frustror - CATEGORY 67: 21, 302

Canis familiaris Linneaus - CATEGORY 68: 20, 113, 115, 145, 169, 277, 302

Urocyon cinereoargenteus cineroargenteus - CATEGORY 69: 2, 47, 97, 114, 115, 116, 122, 141, 145, 162, 169, 181, 195, 228, 302

Vulpes vulpes fulva - CATEGORY 70: 2, 113, 114, 115, 117, 141, 145, 169, 195, 302, 303

Felis catus - CATEGORY 71: 28, 59, 113, 169, 179, 302

Felis concolor coryi - CATEGORY 72: 47, 113, 145, 169

Lynx rufus floridanus - CATEGORY 73: 2, 6, 41, 64, 96, 97, 99, 100, 101, 102, 107, 108, 113, 115, 122, 141, 145, 159, 160, 162, 169, 181, 182, 195, 205, 267, 302

Lutra canadensis lataxina - Category 74: 8, 145, 169

Mephitis mephitis elongata - CATEGORY 75: 2, 113, 115, 145, 169, 302

Mustela frenata olivacea - CATEGORY 76: 81, 145, 169

Mustela vison mink - CATEGORY 77: 2, 145, 302

Spilogale putorius putorius - CATEGORY 78: 2, 145, 169

Procyon lotor solutus - CATEGORY 79: 47, 49, 97, 113, 115, 120, 122, 142, 145, 162, 169, 195, 202, 203, 265, 302, 303

Ursus americanus americanus - CATEGORY 80: 113, 145, 169, 303

Odocoileus virginianus virginianus - CATEGORY 81: 2, 4, 5, 14, 15, 22, 23, 37, 38, 39, 40, 45, 46, 48, 50, 53, 58, 65, 103, 104, 106, 109, 112, 113, 118, 119, 121, 122, 143, 145, 146, 147, 148, 149, 150, 153, 154, 155, 156, 157, 161, 162, 169, 170, 171, 173, 174, 175, 177, 178, 180, 183, 190, 193, 196, 202, 203, 206, 207, 208, 209, 210, 211, 212, 213, 214, 215, 217, 218, 219, 220, 221, 222, 223, 225, 226, 229, 230, 231, 232, 236, 238, 239, 240, 253, 257, 259, 264, 265, 266, 276, 277, 284, 285, 286, 287, 288, 289, 290, 298, 299, 300, 303

Sus scrofa - CATEGORY 82: 21, 22, 25, 26, 111, 113, 144, 145, 163, 165, 166, 167, 168, 169, 213, 227, 269, 270, 271, 272, 273, 274, 275, 303

General (not SRS species) - CATEGORY 83: 5, 13, 43, 60, 191, 192, 201, 202, 265, 296, 303

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