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Mammals of Fort A. P. Hill, Caroline County, Virginia and Vicinity

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ABSTRACT

Fort A.P. Hill (APH) is a 30,329 ha military training installation (U.S. Army) located in the upper Coastal Plain of Caroline County, Virginia. It was formed in 1941 and named in honor of Civil War Confederate Lt. General Ambrose Powell Hill. The current landscape includes a mosaic of habitats that range from old fields to hardwood forests. Forty species of mammals are known to exist on or near the installation. These include one marsupial, five insectivores, 9 chiropterans, one lagomorph, 12 rodents, 10 carnivores, and one cervid. We have studied many of the species on APH since 1997. In this paper we describe the physical environment of the area and 7 important habitats used by mammals. We also summarize the ecology and natural history of each species and provide statistical summaries of original measurements from mammals caught on the installation. The results of several recent studies on APH allow us to describe habitat affiliations and relative abundance of most of the mammals native to the mid-Atlantic region. Old fields and clearcuts support a total of 20 species, including several found predominately in this habitat. Pine stands and pine plantations support the fewest number of mammal species (17) of any habitat on the installation. Mixed pine and hardwood forests, hardwood forests, and riparian forests support the largest number of species (29-36). With the possible exception of pine plantations, the habitat mosaic found on APH provides abundant resources for mammal communities. We also include an evaluation of age and health attributes of the deer population and describe the hunting program on the base. Number of deer harvested annually 1985-2000 varied from 460 to 1765. Management activities since 1996 when the deer population exceeded carrying capacity have improved herd health. Because much of Caroline County and eastern Virginia is in extensive agriculture and the remaining hardwood forests are

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being clearcut, APH is becoming a valuable habitat island for the mammalian fauna of the upper Coastal Plain of Virginia and the mid-Atlantic region.

Key Words: Biotic Communities, Coastal Plain, Ecology, Hunting, Life History, Mammals, Management, Military, Natural History, Virginia.

INTRODUCTION

Mammals in the mid-Atlantic region of North America play key functional roles in terrestrial and freshwater ecosystems. They act as predators, prey, and consumers of vegetation and thus regulate many aspects of these ecosystems, including affecting the structure of forest and stream habitats and population regulation of some small vertebrates. Some are conspicuous and well known to most people, and others are secretive and only detected with specialized inventory techniques. Declines of populations of some mammal species can have serious effects on many other animals. Some mammals are part of the human food chain and are important economically. Active management is mandatory for some of these species, or else they become so overpopulated that they alter habitats and interfere with human endeavors. The many ecological and economic roles played by mammals create the need to know which species occur in an area of interest and how they may be managed effectively.

Many species of mammals interact with humans directly or indirectly. Some, like white-tailed deer and gray squirrels, are designated as game animals and their harvests are regulated. Others, like raccoon, mink, muskrat, and beaver, are harvested for their fur. Woodchucks and beavers indirectly influence humans because of their habitat-altering behaviors. For example, beaver activity can create and maintain of certain types of wetlands that support a wide diversity of plants and animals (Naiman et al., 1988; 1994). Beaver ponds are used extensively by amphibians and reptiles (Mitchell, 1994; 2000) and by waterfowl, such as wood ducks (*Aix sponsa*), black ducks (*Anas rubripes*), and mallards (*Anas platyrhynchos*) (Merendino et al., 1995). Some mammal predators help to control insect pests and mammal pests, such as some rodents (Godin, 1982; Samuel and Nelson, 1982; Toweill and Tąbor, 1982). Diseases such as rabies can be carried by any mammal and are potentially fatal to humans. Lyme disease transmitted by ticks carried on white-tailed deer and white-footed mice is a growing human health concern. The large number of people engaging in outdoor recreation has increased the value of many mammals as watchable wildlife. Thus, the aesthetic, economic, and ecological values of mammalian fauna the region cannot be underestimated.

Removal of old-growth stands during the 19th century and the beginning of the 20th century, and human activities since then, have transformed the landscape of the mid-Atlantic region into a mosaic of habitat types (Handley, 1992; Pagels et al., 1992; Sharitz et al., 1992). Because short-term and long-term disturbances played roles in the evolution of temperate mammals, the mosaic is advantageous for many species (Kirkland, 1988, 1990). In addition to anthropogenic activities, short-term factors, such as fire, wind storms, and floods have long reshaped the landscape creating ever-changing mosaics of successional habitats (Sharitz et al., 1992). Pleistocene glaciations brought on long-term shifts in climate and vegetation assemblages (Kirkland, 1990) and the concomitant introduction of many northern species to what is now Virginia

(Handley, 1992). The present statewide mammal community represents a mix of boreal and indigenous austral species (Handley, 1992).

Following Linzey's (1998) summary, 78 mammal species, exclusive of marine and domesticated species, occur in Virginia. They represent 8 orders, 18 families and 50 genera. For comparison, 40 species are known or suspected to occur on APH representing 7 orders, 14 families, and 31 genera. No federal or state threatened or endangered mammal species are known to occur on the base or in its vicinity.

The United States Department of Defense is the fifth largest landowner of the federal landholding agencies and currently manages over 25 million acres of land (>10.1 million ha) (Boice, 1997). Most of the land is contained in military installations that have large areas protected from activities that adversely affect local flora and fauna. As a result, military installations such as APH serve as islands of biodiversity (Mitchell and Roble, 1998) for native species and provide opportunities to study their ecologies and distributions. Such opportunities are becoming increasingly important as land-use practices on surrounding properties become more complex.

In this paper we summarize our observations on the ecology and natural history of the mammals of APH. We provide new data on morphometrics for many of the species and an assessment of their habitat affinities and relative abundance. We also summarize the literature pertinent to the mammals of the mid-Atlantic Coastal Plain.

FORT A.P. HILL AND ITS ENVIRONMENT

Fort A.P. Hill Military Reservation (APH), Caroline County, Virginia is located in the upper Coastal Plain Physiographic Province (Fig. 1). Northern and southern boundaries of APH are located at 38° 12' 46" and 38° 01' 5.6" N latitude, and eastern and western boundaries are at 77° 08' 13" and 77° 23' 11" W longitude, respectively. APH includes 30,329 ha, mostly in Caroline County, with fewer than 41 ha in Essex County. U.S. Route 301 divides the base into north and south sections (Fig. 1).

APH was established for military training in June 1941 and named in honor of Civil War Confederate Lieutenant General Ambrose Powell Hill. Lands available for direct access training and where our surveys were conducted are divided into 30 Training Areas; most are north of U.S. Rt. 301. An additional 28 Controlled Access Areas occur south of U.S. Rt. 301 around the periphery of the Impact Area. The Impact Area receives live ordnance from small arms, light artillery, and helicopter firing exercises. Controlled Access areas may be opened to hunters and other persons on a limited basis but few people enter the active Impact Area due to potential hazards of unexploded ordnance. Thus, much land south of U.S. Rt. 301 is unmanaged with restricted access by humans. Most of APH is now used for infantry-related training activities. The Controlled Access Areas and the Impact Area were off-limits to our field research. APH has hosted the Boy Scouts of America National Jamboree every four years since 1981.

Drainages

Two drainages divide APH into two watersheds. The Mattaponi River watershed includes about a third of the base in the western and southwestern portions of the installation. The rolling topography in the watershed includes the highest point on APH (76 m [249 ft]). Tributaries of the Mattaponi River on APH drain to the south and southwest. The remainder of APH is drained by the Rappahannock River. Tributaries

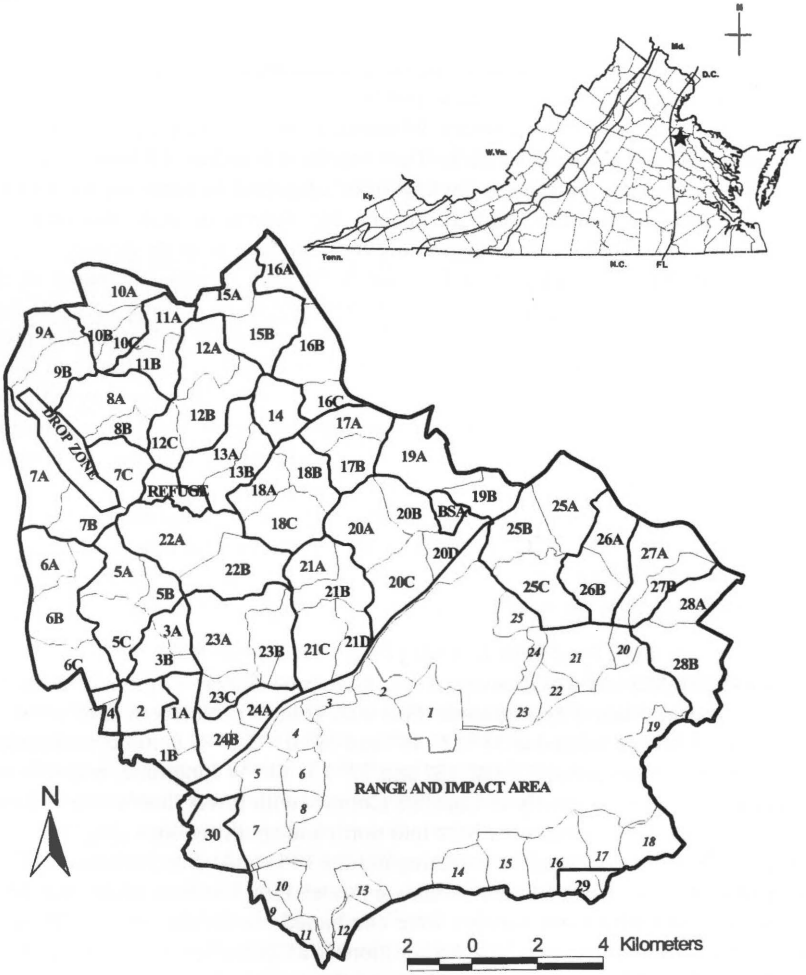

FIGURE 1. Map of Fort A. P. Hill, Caroline County, Virginia, illustrating major roads, training areas (large numerals), and controlled access areas (small italicized numerals). Boundaries of Virginia's physiographic regions are indicated on the insert map (FL = fall line).

of the Rappahannock drain to the northeast. Some of the topographic relief in this area is steep, especially around Devil's Bottom where highest and lowest elevations are separated by 46 m (151 ft).

Climate

Climate of APH and vicinity is humid subtropical and similar to the rest of Virginia east of the Blue Ridge Mountains (Woodward and Hoffman, 1991). Summers are warm to hot (maximum temperature reaches 38.3 C) and winters are cool to cold (minimum temperature reaches –18.3 C) (1997-1999, NOAA) (Fig. 2). Temperature extremes are ameliorated by the proximity of APH to the Chesapeake Bay.

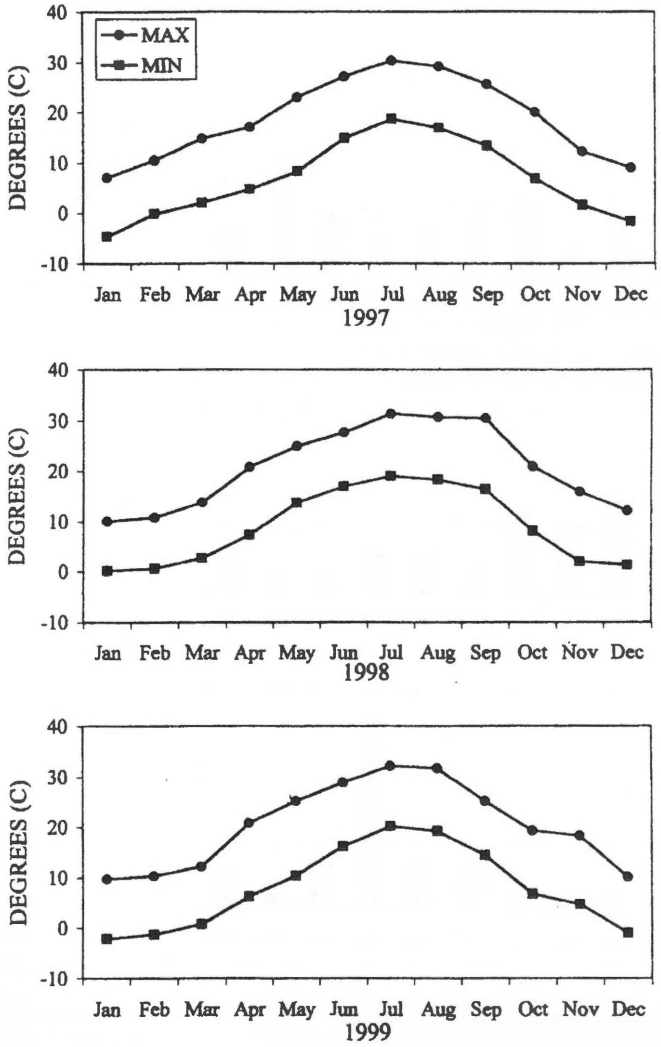

FIGURE 2. Average minimum and maximum monthly temperatures (°C) for 1997 through 1999 for Corbin, Virginia (U.S. Route 17, adjacent to training area 9a) (from NOAA Climatological Data).

Precipitation is usually in the form of rain but some snow accumulates during winter months. Average annual precipitation is 108.2 cm (42.6 inches) (based on 30-yr average, 1961-1990, NOAA). Monthly precipitation is generally higher in winter and spring than in summer and fall (Fig. 3). Droughts occasionally affect surface moisture. A drought in 1999 peaked in May with only 1.3 cm (0.5 inches) of rainfall, and continued through August. Precipitation in September 1999 from hurricanes Dennis

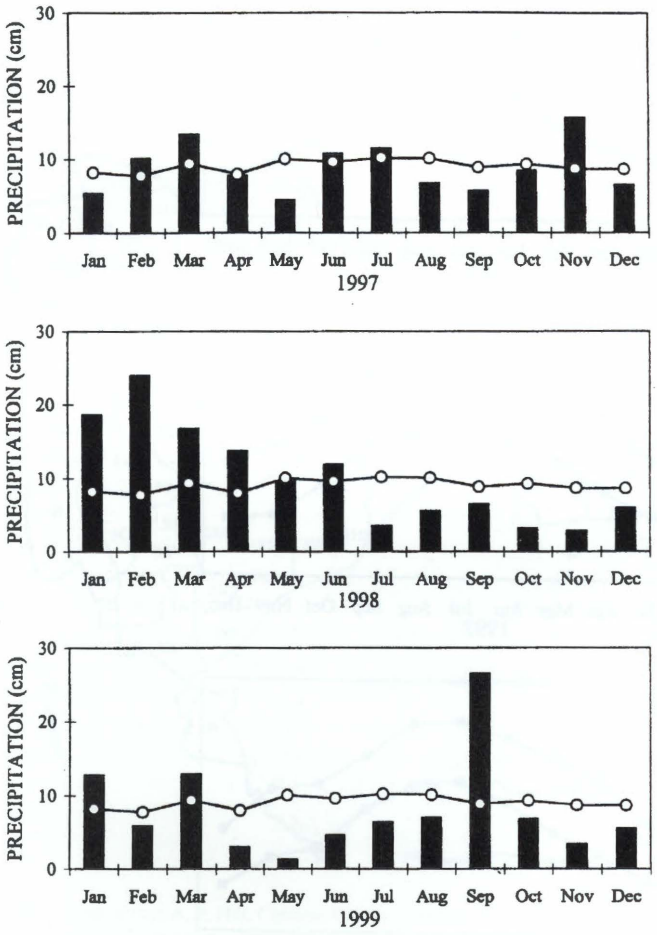

FIGURE 3. Average monthly precipitation (cm) for 1997 through 1999 for Corbin, Virginia (U.S. Route 17, adjacent to training area 9a). Thirty-yr averages (1961-1990) are indicated by the line. (taken from NOAA Climatological Data).

and Floyd replenished many ponds and vernal pools that had become dry. Total rainfall that month was 26.5 cm (10.4 inches). Such events modify the average monthly precipitation pattern illustrated in Fig. 3.

Habitats

Prior to 1941 the lands of APH were used primarily for farming and timber harvesting. APH is currently about 80% forested from natural re-growth and forestry management. The present landscape of APH is comprised of grasslands, pine forests,

mixed pine and hardwood forests, and hardwood forests, all in various stages of succession. Management has converted some of the pine and hardwood forests into loblolly pine (*Pinus taeda*) plantations. Riparian forests usually support more diverse flora and are more corridor-like than adjacent upland forests. Some grasslands are kept open by mowing operations and prescribed burns, usually for military training purposes, and, for example, wildlife food plots. Aquatic habitats include large to small impoundments, beaver ponds, vernal pools, streams, and seepages. For general description of plant communities and associated mammal communities, the habitats of APH can be grouped into 7 general habitat types.

Old fields

Perennial grasses, notably broomsedge (*Andropogon virginicus*) and redtop (*Agrostis alba*), characterize old-field habitats (Fig. 4). Other common herbs in old-fields are bushclover (*Lespedeza cuneata*), yarrow (*Achillea millefolium*), spotted knapweed (*Centaurea maculosa*), goldenrod (*Solidago* spp.), thistle (*Cirsium* spp.), and partridge pea (*Chamaecrista fasciculata*). Common vines include Japanese honeysuckle (*Lonicera japonica*), common greenbrier (*Smilax rotundifolia*), bullbrier (*Smilax bona-nox*), Virginia creeper (*Parthenocissus quinquefolia*), and less often, poison ivy (*Rhus radicans*). Bramble (*Rubus* spp.) was abundant in more mature old fields, often forming thick mats that provide important cover for small mammals. An exotic, Russian olive (*Elaeagnus augustifolia*), was the most abundant shrub found in old-field habitats on APH. Young *Pinus taeda* was the most common tree species found in this habitat, but winged sumac (*Rhus copallina*), persimmon (*Diospyros virginiana*), and saplings (e.g., oak [*Quercus* spp.], sweetgum [*Liquidambar styraciflua*], black cherry [*Prunus serotina*]) were also frequent and abundant inhabitants. Early successional stages (grasslands) were abundant under maintained (mowed regularly) and unmaintained (unmowed) management programs. Some of the latter are managed extensively by burning and disking to provide wildlife food plots.

Pine Forests

Virginia (scrub) pine (*Pinus virginiana*), was the primary tree in naturally occurring pine forests, however, in many locations *P. taeda* was also abundant (Fig. 5). Understory trees were generally a mix of saplings of overstory species (e. g., pines [*Quercus* spp.], *Liquidambar styraciflua*, *Fagus grandifolia*) and understory species like American holly (*Ilex opaca*) and less frequently flowering dogwood (*Cornus florida*) and sassafras (*Sassafras albidum*). Common shrubs in these habitats were blueberry (*Vaccinium* spp.) and huckleberry (*Galussacia* spp.). *Lonicera japonica* and *Smilax rotundifolia* were the most common vines in the pine forests. Except for partridgeberry (*Mitchella repens*), ground-level herbs were sparse in pine forests.

Pine Plantations

Pine plantations were almost all comprised of *Pinus taeda*. Recent plantings are usually thick and impenetrable (Fig. 6) but older stands that have been thinned mechanically or naturally have an open understory and a carpet of pine needles (Fig. 7). Trees associated with these plantations included sapling *Quercus* spp., hickories (*Carya* spp.), tulip-tree (*Liriodendron tulipifera*), *Liquidambar styraciflua*, and understory species such as *Ilex opaca*. Vines sometimes common in pine plantations included *Lonicera japonica* and *Smilax rotundifolia*. Ground-level herbs were scarce.

Mixed Pine and Hardwood Forests

Mixed pine and hardwood communities dominated the forest types on APH (Fig. 8). Pines (*Pinus taeda* and *P. virginiana*), southern and northern red oaks (*Quercus falcata* and *Q. rubra*), *Liquidambar styraciflua*, red maple (*Acer rubrum*), *Liriodendron tulipifera*, and princess tree (*Ailanthus altissima*) generally comprised the canopy. Saplings of overstory tree species, especially hardwood saplings, were abundant in older stands, but *Ilex opaca* was usually the dominant understory tree species in this habitat, with *Cornus florida* less common. Vine and shrub communities were similar to those found in naturally occurring pine stands. Common herbs included *Mitchella repens*, spotted wintergreen (*Chimaphila maculata*), and hog-peanut (*Amphicarpa bracteata*).

Hardwood Forests

Two tree species, white oak (*Quercus alba*) and *Liriodendron tulipifera* (Fig. 9), dominated hardwood forest communities on APH. Less frequently the dominant tree species was *Acer rubrum*, *Liquidambar styraciflua*, or American beech (*Fagus grandifolia*). More mature upland stands tended to be dominated by *Q. alba* or *F. grandifolia* and younger upland stands by *L. tulipifera* or *L. styraciflua*. Mesic stands were often dominated by *A. rubrum*. Other important overstory tree species are pignut hickory (*Carya glabra*), mockernut hickory (*C. tomentosa*), *Q. rubra*, *Q. falcata*, and black gum (*Nyssa sylvatica*). Understory tree species in hardwood forest communities were often comprised of saplings of overstory species. Other understory tree species included *Ilex opaca*, *Cornus florida*, and less frequently ironwood (*Carpinus caroliniana*). Shrub communities were primarily comprised of *Vaccinium* spp. and *Gaylussacia* spp., which in general were less abundant in older stands. Vines were less frequent in this habitat than other habitats, but common species included *Lonicera japonica*, *Smilax rotundifolia*, *S. bona-nox*, *Parthenocissus quinquefolia*, *Rhus radicans*, and less frequently groundnut (*Apios americana*). Common ground-level herbs included *Mitchella repens*, *Chimophia maculata*, *Amphicarpa bracteata*, tree clubmoss (*Lycopodium obscurum*), ebony spleenwort (*Asplenium platyneuron*), and Christmas fern (*Polystichum acrostichoides*).

Riparian Corridors

Overstory trees that occurred in these corridors were primarily hardwood species (Fig. 10). Several overstory tree species commonly observed in the riparian corridors (e.g., *Acer rubrum*, river birch [*Betula nigra*], sycamore [*Platanus occidentalis*], and *Nyssa sylvatica*) were classified as facultative wetland species in this region by Reed (1988). Other common overstory trees in riparian corridors (e.g., *Quercus alba*, chestnut oak [*Q. prinus*], and *Fagus grandifolia*) were classified as facultative upland species in this region. *Ilex opaca*, *Cornus florida*, *Carpinus caroliniana*, and sweetbay (*Magnolia virginiana*), and saplings of overstory trees comprised the understory tree community. Common shrubs in APH wetland habitats were *Vaccinium* spp., *Gaylussacia* spp., coast pepperbush (*Clethra alnifolia*), and spicebush (*Lindera benzoin*). Common forbs included obligatory wetland species (e. g., royal fern [*Osmunda regalis*], Lizard's tail [*Saururus cernuus*], skunk cabbage [*Symplocarpus foetidus*], golden club [*Orontium aquaticum*], and broad-leaved arrowhead [*Sagittaria latifolia*]). Facultative wetland forb species common in riparian corridors were cinnamon fern

(*Osmunda cinnamomea*), netted chain fern (*Woodwardia areolata*), sensitive fern (*Onoclea sensibilis*), and false nettle (*Boehmeria cylindrica*). *Mitchella repens* was the only facultative upland forb we observed in riparian corridors at APH.

Wetlands

Tributaries of the Mattaponi River in APH tended to be broad and shallow with a slow flow rate, whereas those of the Rappahannock River tended to be narrow, deeper, and faster. Exceptions were the marshes and ponds created by beaver activity (Fig. 11). Aquatic vegetation was well established in the marshes, ponds, and floodplains associated with slow streams. Yellow pond lily (*Nuphar variegatum*), golden club, swollen bladderwort (*Utricularia inflata*), fragrant water lily (*Nymphaea odorata*), pickerelweed (*Pontederia cordata*), arrow arum (*Peltandra virginica*), and arrowhead (*Sagittaria latifolia*) were common emergent vegetation in most ponds. Cattails (genus *Typha*) were less commonly observed. Impoundments usually lacked emergent vegetation except along shallow margins or in the upstream portion of the drainage where *N. variegatum* was common. There are 19 named impoundments on APH and most are stocked with game fish. Other often temporary wetlands on APH include naturally acidic vernal pools in hardwood forests, water-filled depressions in old fields, and road ruts and depressions.

Structures

There are relatively few buildings on APH and most occur in clusters. They vary from old structures of World War II vintage to modern brick buildings that serve as offices and barracks. Occupied buildings have not been surveyed for mammals but undoubtedly some species use them for shelter.

TAXONOMIC CHECKLIST OF THE MAMMALS OF APH, VIRGINIA

Class Mammalia
- Order Didelphimorphia (Marsupialia)
  - Family Didelphidae
    - *Didelphis virginiana* (Kerr)—Virginia opossum
- Order Insectivora
  - Family Soricidae
    - *Blarina brevicauda* (Say)—northern short-tailed shrew
    - *Cryptotis parva* (Say)—least shrew
    - *Sorex hoyi* (Baird)—pygmy shrew
    - *Sorex longirostris* (Bachman)—southeastern shrew
  - Family Talpidae
    - *Condylura cristata* (Linnaeus)—star-nosed mole
    - *Scalopus aquaticus* (Linnaeus)—eastern mole
- Order Chiroptera
  - Family Vespertilionidae
    - *Eptesicus fuscus* (Palisot de Beauvois)—big brown bat
    - *Lasionycteris noctivagans* (LeConte)—silver-haired bat
    - *Lasiurus borealis* (Müller)—eastern red bat
    - *Lasiurus cinereus* (Beauvois)—hoary bat
    - *Myotis austroriparius* (Rhoads)—southeastern myotis

FIGURE 4. Example of an old-field habitat on Fort on Fort A. P. Hill. (Photo by A. S.Bellows)

FIGURE 5. Example of a pine forest habitat on Fort A. P. Hill. (Photo by J. C. Mitchell)

FIGURE 6. Example of a young pine plantation on Fort A. P. Hill. (Photo by A.S. Bellows)

FIGURE 7. Example of an older pine plantation on Fort A. P. Hill. (Photo by A. S. Bellows)

FIGURE 8. Example of a mixed hardwood-pine forest on Fort A. P. Hill. (Photo by A. S. Bellows)

FIGURE 9. Example of a hardwood forest on Fort A. P. Hill. (Photo by J. C. Mitchell)

FIGURE 10. Example of a riparian corridor on Fort A. P. Hill. (Photo by A. S. Bellows)

FIGURE 11. Example of a wetland (beaver pond) on Fort A. P. Hill (Photo by A. S. Bellows)

Myotis lucifugus (LeConte)—little brown myotis
Myotis septentrionalis (Trouessart)—northern myotis
Nycticeius humeralis (Rafinesque)—evening bat
Pipistrellus subflavus (F. Cuvier)—eastern pipistrelle

Order Lagomorpha
Family Leporidae
Sylvilagus floridanus (Allen)—eastern cottontail

Order Rodentia
Family Sciuridae
Glaucomys volans (Linnaeus)—southern flying squirrel
Marmota monax (Linnaeus)—woodchuck
Sciurus carolinensis (Gmelin)—gray squirrel
Tamias striatus (Linnaeus)—eastern chipmunk
Family Castoridae
Castor canadensis (Kuhl)—beaver
Family Muridae
Microtus pennsylvanicus (Ord)—meadow vole
Microtus pinetorum (LeConte)—woodland vole
Mus musculus (Linnaeus)—house mouse (introduced)
Ondatra zibethicus (Linnaeus)—muskrat
Oryzomys palustris (Harlan)—marsh rice rat
Peromyscus leucopus (Rafinesque)—white-footed mouse
Rattus norvegicus (Linnaeus)—Norway rat (introduced)
Rattus rattus (Linnaeus)—black rat (introduced)
Reithrodontomys humulis (Audubon and Bachman)
eastern harvest mouse
Family Zapodidae
Zapus hudsonius (Zimmermann)—meadow jumping mouse

Order Carnivora
Family Canidae
Canis latrans (Say)—coyote
Urocyon cinereoargenteus (Baird)—gray fox
Vulpes vulpes (Linnaeus)—red fox
Family Procyonidae
Procyon lotor (Linnaeus)—raccoon
Family Mustelidae
Lontra canadensis (Schreber)—river otter
Mephitis mephitis (Schreber)—striped skunk
Mustela frenata (Lichtenstein)—long-tailed weasel
Mustela nivalis (Linnaeus)—least weasel
Mustela vison (Schreber)—mink
Family Felidae
Lynx rufus (Schreber)—bobcat

Order Artiodactyla
Family Cervidae
Odocoileus virginianus (Rafinesque)—white-tailed deer

SPECIES ACCOUNTS

INTRODUCTION

The following provides a brief account for all 40 mammal species that occur on APH. Although some species were not captured in our study (e.g., long-tailed weasel, *Mustela frenata*), published records (e.g., Handley and Patton, 1947, and others) indicate that each species should be present on APH. These accounts provide basic descriptions and diagnostic characteristics that aid field identification. Morphometric measurements are presented in a consistent format. Dental formulae should be interpreted as follows: (i.) incisors, (c.) canines, (p.) premolars, and (m.) molars; upper jaw dentition is presented over lower jaw dentition (i.e., 3/3). Whenever possible, measurements provided are from animals collected on APH. For these data, we provide minimum and maximum values with means (avg.) ±1 standard deviation in parentheses. When local data were not available, measurements were included from populations as near to APH as possible. In some instances where sample size from APH was small, we provided measurements from other regional populations for comparison. We note the geographic distribution of each species, as well as the subspecies present at APH. Order of species accounts follows the taxonomic checklist.

Order Didelphimorphia (Marsupialia)

Didelphis virginana Kerr (Virginia Opossum)

The Virginia opossum is North America's only marsupial. It is a relatively recent arrival, not appearing in North America until the late Pleistocene (Whitaker and Hamilton, 1998). Thick underfur, white basally and black at the end, and long white guard hairs give the pelage a grizzled appearance. The tail is prehensile and is used for grasping and carrying various items including nesting materials (Pagels, 1996). Weights of 9 adults captured on APH ranged from 1.6 to 3.2 kg (avg.=2.0 ±0.4). Means and ranges of measurements for 10 adults from Indiana, New York, North Carolina, and Pennsylvania were: total length 686-836 mm (avg.=767); tail length 290-348 mm (avg.=321); length of hind foot 60-74 mm (avg.=68.5) (Whitaker and Hamilton, 1998). Dentition: i. 5/4, c. 1/1, p. 3/3, m. 4/4 =50 (Gardner, 1982).

The range of the Virginia opossum extends northward into southern Ontario and British Columbia, west to the central Great Plains, and southward to Costa Rica, except central and northern Mexico (Hall, 1981). All populations within our region are the subspecies *D. v. virginiana* (Cothran et al., 1991).

Virginia opossums are not particularly selective about habitat, but streams associated with deciduous forests appear to be preferred. This habitat generalist has been observed in marshlands and a variety of forest, grassland, suburban, and agricultural habitats (Gardner, 1982; Hallett et al., 1991). We captured Virginia opossums in both riparian and upland habitats; upland habitats include pine-hardwood and hardwood forests. All 30 individuals taken by trappers on APH during the 1998/1999 Virginia trapping season were captured in riparian habitats. The omnivorous diet consists of carrion, human refuse, fungi, insects, worms, snakes, and a diversity of plant matter (Lay, 1942; Gardner, 1982). Few predators eat Virginia opossums, but raptors may contribute to the mortality of young of the year (Fitch and Shirer, 1970).

Food and sport values of Virginia opossums are limited. Management concerns often stem from this species being mislabeled as a nuisance by farmers and sportsmen (Gardner, 1982).

Order Insectivora

Blarina brevicauda Say (Northern Short-tailed Shrew)

The northern short-tailed shrew is the largest shrew in the United States. The snout is somewhat elongate, eyes minute, ears inconspicuous, and its short, noticeably hairy tail is less than half the total body length. Pelage is soft, mole-like in winter and color is slate to nearly black; it is lighter in summer. Dorsal pelage is generally darker than ventral pelage. External body measurements for 50 adults captured on APH were: total length 91-113 mm (avg.=101.3 ±4.9), tail length 15-25 mm (avg.=20.8 ±1.8), length of hind foot 13-15 mm (avg.=13.9 ±0.5). Dentition: i. 4/2, c. 1/0, p. 2/1, m. 3/3 =32 (Hall, 1981).

Northern short-tailed shrews occur from southern Canada throughout much of the eastern United States except that in the southeastern portion of its range it occurs only at higher elevations (George et al., 1986). They range throughout Virginia, except south-central and southeastern areas and the eastern portion of the Northern Neck Peninsula and Gwynn's Island, where the smaller southern short-tailed shrew (*B. carolinensis*) occurs (Tate et al., 1980; Pagels and French, 1987). Of 11 recognized subspecies, three (*B. b. churchi*, *B. b. telmalestes*, and *B. b. kirtlandi*) occur in Virginia; only *B. b. kirtlandi* is known from the northern Coastal Plain, including APH (George et al., 1986).

Northern short-tailed shrews occur in deciduous and coniferous forests and exhibit little affinity for any vegetation type (Jameson, 1949; Wrigley et al., 1979). This species occurs in somewhat higher numbers in forests than in clearcuts in Virginia's Piedmont (Pagels et al., 1992), and has been described as a habitat generalist (George et al., 1986). On APH, they were abundant in old fields and in riparian and upland forests. They were found in relatively low abundance in shelterwood treated forests. Habitat selection was positively associated with downed woody debris (Bellows et al., in press). Diet consists primarily of earthworms and myriapods, but also includes insects, snails, plant material, and occasionally small mammals, such as meadow voles (Hamilton, 1941; Eadie, 1952; Linzey and Linzey, 1973). Predators of the northern short-tailed shrew that occur on APH include Great Horned Owls (*Bubo virginianus*), Eastern Screech-Owls (*Otis asio*), Barred Owls (*Strix varia*), Barn Owls (*Tyto alba*), American Kestrels (*Falco sparverius*), Northern Harriers (*Circus cyaneus*), Red-tailed hawks (*Buteo jamaicensis*), black rat snakes (*Elaphe obsolete*), mole kingsnakes (*Lampropeltis calligaster*), copperheads (*Agkistrodon contortrix*), foxes, mustelids, and domestic free-ranging and feral cats (*Felis catus*) (Jackson et al., 1976; Mumford and Whitaker, 1982; Mitchell and Beck, 1992; Mitchell, 1994; Johnston, 2000).

Cryptotis parva Say (Least Shrew)

The least shrew is a short-tailed shrew similar in appearance to the northern short-tailed shrew, but smaller and lighter in color. Dense, almost velvety, pelage is brownish dorsally and paler ventrally. Measurements of 14 adults captured on APH were: total length 61-84 mm (avg.=74.7 ±5.6), tail length 12-17 mm (avg.=15.5 ±1.7),

length of hind foot 9-11 mm (avg.=9.9 ±0.5). Dentition: i. 3/1, c. 1/1, p. 2/1, m. 3/3 =30 (Cothran et al., 1991).

The distribution of the least shrew is centered in southeastern to south-central United States and extends southward through Mexico. It occurs statewide in Virginia (Handley and Patton, 1947), except rarely at high elevations (elevation record, 1,524 m) (Pagels, 1991). Of 9 recognized subspecies, only *C. p. parva* is found in Virginia (Hall, 1981).

Least shrews are most commonly found in open grassy or brushy habitats with dense herbaceous vegetation (Whitaker, 1974). They are also found in edge habitats such as power lines and along roadsides (Golley et al., 1965). Pagels et al. (1992) described this shrew as an old-field/edge form. We captured them on APH most frequently in old fields, but some were taken in forested habitats, including very low numbers in shelterwood-treated forests. Diet consists of insects, spiders, earthworms, and myriapods, and they have been known to eat more than their body weight daily (Whitaker, 1974; Whitaker and Mumford, 1972). Owls, including Barn Owls, Eastern Screech Owls, Short-eared Owls (*Asio flammeus*), and Great Horned Owls, are primary predators of the least shrew, however, hawks (e.g., Northern Harriers, Red-tailed Hawks), copperheads, predatory mammals, and domestic free-ranging cats, will eat it opportunistically (Whitaker, 1974; Linzey and Linzey, 1971; Jackson et al., 1976; Deibler, 1988; Mitchell and Beck, 1992; Mitchell, 1994; Whitaker and Hamilton, 1998; Johnston, 2000).

Sorex hoyi Baird (Pygmy Shrew)

The pygmy shrew is North America's smallest mammal. Pelage is reddish or grayish brown dorsally and paler ventrally, and the tail is bicolored. Measurements for 44 adults captured on APH were: total length 62-82 mm (avg.=75.0 ±3.8), tail length 20-30 mm (avg.=24.6 ±1.9), length of hind foot 8- 9 mm (avg.=8.1 ±0.3). Dentition: i. 3/1, c. 1/1, p. 3/1, m. 3/3 =32 (Long, 1974).

The pygmy shrew is a boreal species found throughout most of Canada and the northern United States southward into the Appalachians (Hall, 1981). Of 7 recognized subspecies, only *S. h. winnemana* occurs in Virginia (Hall, 1981). The pygmy shrew was once considered to be extremely rare in Virginia. As recently as 1980 this shrew was known from only 7 locations and a total of 8 specimens (Handley et al., 1980). Results from pitfall trapping techniques have shown that it is widely distributed and common in Virginia (Pagels, 1987; Pagels et al., 1992; Erdle and Pagels, 1995). Our trapping efforts at APH yielded 107 captures during the period of 1997-2000.

Wrigley et al. (1979) observed pygmy shrews in marsh, bog, shrub thicket, deciduous and coniferous forest habitats. They have been captured in a range of habitats, including riparian situations, upland sites, and old fields (Long, 1974; Pagels, 1987; Mitchell et al., 1993). This species was described by Pagels et al. (1992) as a habitat generalist. We captured them on APH more often in forested habitats than in old fields. Pygmy shrew populations on APH are positively associated with downed woody debris and dense forest canopies (Bellows et al., in press). Diet consists of insects, earthworms, spiders, carrion, and other small mammals (Long, 1972; Ryan, 1982; Webster et al., 1985). Predation on this little shrew is rarely reported, but Long (1974) reported that raptors and domestic cats may take this species opportunistically.

Sorex longirostris Bachman (Southeastern Shrew)

The southeastern shrew is a long-tailed shrew with reduced ears, an elongated rostrum, and brown-tipped teeth. Pelage is brown dorsally and cinnamon to tawny ventrally. Measurements for 50 individuals captured on APH were: total length 73-88 mm (avg.=80.1 ±2.9), tail length 23-31 mm (avg.=27.0 ±1.8), length of hind foot 9-10 mm (avg.=10.0 ±0.1). Dentition: i. 3/1, c. 1/1, p. 3/1, m. 3/3 =32 (French, 1980a).

The geographic range of the southeastern shrew centers in the southeastern United States and extends westward into Missouri, Arkansas, and Louisiana, and northward into Iowa and Illinois (Hall, 1981). They are found throughout Virginia except in higher elevations (Pagels and Handley, 1989). Two of the three recognized subspecies (*S. l. fisheri* and *S. l. longirostris*) occur in Virginia. The larger *Sorex. l. fisheri* (the Dismal Swamp southeastern shrew) is restricted to the Great Dismal Swamp and surrounding suitable habitat in the Coastal Plain of southeastern Virginia and adjacent North Carolina (Handley, 1991; Jones et al., 1991); only *S. l. longirostris* is known from APH.

Southeastern shrews occur in a diverse range of habitats but most frequently in moist areas (French, 1980a; 1980b). Pagels et al. (1992) captured them in Cumberland County, Virginia, more frequently in three- and six-year-old clearcuts than in 40-year-old hardwood forests. Pagels and Handley (1989) captured them most frequently in edge habitats. At APH, we captured southeastern shrews in all habitats, including old fields and riparian zones. It was the most frequently captured insectivore in forests treated with the shelterwood silvicultural technique—32% of all small mammal captures in that habitat. Presence of southeastern shrews was positively associated with ground-level shrub density (Bellows et al., in press). They feed on insects, myriapods, snails, spiders, and some herbaceous vegetation (Whitaker and Mumford, 1972). Known predators include Barn Owls and Barred Owls, snakes, Virginia opossums, and feral cats (French, 1980a; French, 1980b; Whitaker and Hamilton, 1998).

Condylura cristata Linnaeus (Star-nosed Mole)

The star-nosed mole is characterized by its elongate snout that bears 22 fleshy appendages (11/nostril) that contain sensitive tactile organs called Eimer organs (Petersen and Yates, 1980). The tail is scaled, hairy, and roughly equal to its body length. Forelimbs are short and powerful and its forefeet are greatly enlarged, an adaptation for a fossorial or burrowing lifestyle. Pelage is brown to black and velvety. We captured 7 individuals on APH but external measurements were not obtainable on three of them. Measurements of four remaining specimens were: total length 149-165 mm (avg.=156.8 ±7.1), tail length 48-53 mm (avg.=51.5 ±2.4), length of hind foot 25-27 mm (avg.=25.8 ±1.0). For comparison, adult measurements from 9 individuals from the southern Appalachians and southern coastal areas were: total length 158-170 mm (avg.=165), tail length 57-63 mm (avg.=60), length of hind foot 24-26 mm (avg.=25) (Whitaker and Hamilton, 1998). Dentition: i. 3/3, c. 1/1, p. 4/4, m. 3/3 =44 (Petersen and Yates, 1980).

Star-nosed moles occur throughout most of eastern Canada and northeastern United States (Petersen and Yates, 1980). Two of the three recognized subspecies (*C. c. cristata* and *C. c. parva*) occur in Virginia, and marginal records from Hall (1981) suggest that both subspecies may occur at APH. Measurements of the four specimens captured on APH fall within the range Handley and Pagels (1991) reported for *C. c. parva.*

Star-nosed moles are most commonly found in or near marshy habitats or streams, and rarely in dry situations (Hamilton, 1931; Handley, 1991). At APH, one was captured in a 5-10- year-old clearcut, three were captured in upland mixed or hardwood forests, one was in an upland pine forest, and two were captured in upland forests modified by shelterwood treatment. As with eastern moles, star-nosed moles may be more common on APH than our capture data indicate. Pitfalls and snap trap captures often misrepresent the abundance of fossorial species. Over 80% of their diet consists of insects and annelid worms (Handley, 1991). They are also known to eat minnows, mollusks, and crustaceans (Hamilton, 1931). Raptors, including the Red-Tailed Hawks, Great Horned Owls, and Barn Owls, are major predators on the star-nosed mole (Hamilton, 1931). Snakes and skunks will also consume this species (Mitchell, 1994; Linzey, 1998). Mitchell (1994) found a star-nosed mole in a copperhead from Giles County, Virginia.

Scalopus aquaticus Linnaeus (Eastern Mole)

The eastern mole can be easily distinguished from the star-nosed mole by its plain nose and relatively short, scantily haired tail. As in other moles, the eyes are tiny and concealed in the pelage and ear pinnae are absent. Pelage is thick and velvety, with color ranging from silver to black dorsally and paler ventrally. Males are generally larger than females (Whitaker and Hamilton, 1998). Two individuals were captured on APH, however, one specimen was partially eaten and measurements could not be taken. External measurements for the one individual were: total length 134 mm, tail length 20 mm, length of hind foot 16 mm. For comparison, body measurements for 15 adult males and 8 adult females, respectively, from Washington D.C. were: total length 154 to 175 mm (avg.=163.4), 146 to 168 mm (avg.=152.6); tail length 22 to 29 mm (avg.=26.5), 21 to 28 mm (avg.=26.0); length of hind foot 18 to 21 mm (avg.=19.8), 18 to 20 mm (avg.=19.0) (Jackson, 1915). Dentition: i. 3/2, c. 1/0, p. 3/3, m. 3/3 =36 (Hall, 1981).

The eastern mole has the broadest distribution of any North American mole, occurring throughout much the eastern and central United States (Yates and Schmidly, 1978). It is more abundant in southern than in northern portions of its range (Whitaker and Hamilton, 1998). Two of the 16 recognized subspecies (*S. a. aquaticus* and *S. a. howelli*) occur in Virginia (Hall, 1981), however, only *S. a. aquaticus* occurs on APH.

Eastern moles occur in most environments where the soil is well drained and relatively free of clay and gravel, especially open fields and pastures (Whitaker and Hamilton, 1998). One of two individuals captured on APH inhabited an oak-pine upland forest; the other was collected in a shelterwood-treated forest. Diet consists primarily of earthworms, insects, and other invertebrates, although some plant matter is eaten (Whitaker and Hamilton, 1998). Home ranges are relatively large compared to other fossorial mammal species, probably due to a demanding diet. Male home ranges (average 1.1 ha) are generally larger than those of females (0.3 ha) (Harvey, 1976). Their fossorial habits prevent predation from many species; however, Barn Owls and domestic free-ranging cats will take it opportunistically (Jackson et al., 1976; Mitchell and Beck, 1992; Whitaker and Hamilton, 1998). Mole kingsnakes and black racers (*Coluber constrictor*) probably enter its tunnels (Mitchell, 1994).

Order Chiroptera

Eptesicus fuscus Beauvois (Big Brown Bat)

This bat can be distinguished from all other bats of the region by its large size and coloration. The pelage is long, lax (>10 mm mid-dorsally), uniformly dark brown on the dorsal surface and paler on the ventral surface. Ears are rounded and short and just reach the nostrils when laid forward. The tragus is blunt and bends forward slightly at the tip. The calcar is keeled. Weights of big brown bats captured on APH ranged from 13.0 to 18.0 g for 11 males (avg.=15.7 ±1.5 g) and 18.0 to 24.0 g for 18 females (avg.=20.5 ±1.8 g). Measurements for the same individuals were: total length 107.0-120.0 mm (avg.= ±3.9), 108.0-124.0 mm (avg.=117.2 ±4.2); tail length 39.0-51.0 mm (avg.=45.1 ±3.2), 39.0-52.0 mm (avg.=46.3 ±3.1); wingspan 309.0-340.0 mm (avg.=324.1 ±9.5), 321.0-355.0 mm (avg.=334.5 ±8.8); forearm length 43.0-49.0 mm (avg.= ±1.6), 42.0-50.5 mm (avg.=47.0 ±2.2); length of hind foot 10-12 mm (avg.=11.0 ±0.6), 9.5-13.0 mm (avg.=11.0 ±0.9); ear length 11.0-17.0 mm (avg.=14.4 ±1.8), 11.0-18.0 mm (avg.=14.0 ±1.7); tragus length 3.5-8.0 mm (avg.=6.4 ±1.5), 3.0-8.0 mm (avg.=5.6 ±1.7). Dentition, i. 2/3, c. 1/1, p. 1/2, m. 3/3 =32 (Kurta and Baker, 1990).

The North American distribution of the big brown bats extends across southern Canada and throughout the contiguous United States (Hall, 1981). They occur statewide in Virginia (Handley and Patton 1947). Of the 11 recognized subspecies, only *E. fuscus fuscus* occurs in the mid-Atlantic region (Hall, 1981).

The big brown bat is frequently one of the last species to enter hibernation, which lasts from November until it emerges in March (Whitaker and Hamilton, 1998). Hibernacula are usually in old buildings and caves (Handley and Patton, 1947). They usually roost singly and often share hibernacula with *Myotis* and *Pipistrellus* (Whitaker and Hamilton, 1998). Big brown bats are partially migratory, but do not undertake long seasonal migrations between hibernating and summer sites (Paradiso, 1969). Summer roosts are usually located in old buildings, such as barns, churches, hollow trees, and houses (Barbour and Davis, 1969). They can also be found roosting in hollow trees (Padgett and Rose, 1991). This was one of the most common bat species on APH. We collected big brown bats in old fields and in upland and riparian forests.

Big brown bats forage throughout the night with most activity beginning about an hour after sunset (Kunz, 1973). Diet consists primarily of small beetles (Freeman, 1981). Known opportunistic predators include Common Grackles (*Quiscalus quiscula*), American Kestrels, long-tailed weasels, house cats, and bullfrogs (*Rana catesbeiana*) (Rysgaard, 1942; Mumford, 1969; Long, 1971; Black, 1974; Kirkpatrick, 1982).

Lasionycteris noctivagans LeConte (Silver-haired Bat)

This medium-sized bat can be distinguished from other bats of the region by its coloration. Pelage is generally blackish brown with white-tipped dorsal hairs that give it a slight silver-haired appearance. The frosting is more pronounced in young and older individuals may appear yellowish (Barbour and Davis, 1969). Wings, ears, and interfemoral membrane are black; and half of the dorsal surface of the interfemoral membrane is furred. The ears are short and rounded and the tragus is broad and blunt. The calcar is not keeled. Weight of three individuals captured on APH during April 2000 was 11.0 for a single male and 12.0 and 13.0 g for the two females, respectively.

Measurements for the same three individuals were: total length 103.0 mm (male), 97.0 and 97.0 mm (females); tail length 30.5 mm, 39.0 and 41.0 mm; wingspan 292.0 mm, 273.0 and 290.0 mm; forearm length 42.0 mm, 41.0 and 43.0 mm length of hind foot 8.0 mm, 8.0 and 10.0 mm; ear length 11.0 mm, 10.0 and 10.0 mm; tragus length 3.0 mm in all three individuals. Dentition, i. 2/2, c. 1/1, p. 2/3, m. 3/3 =36 (Kunz, 1982).

The geographic range of the silver-haired bat includes all of Virginia and extends over most of North America from southeastern Alaska to southern Canada and all of the contiguous United States except extreme southern regions (Kunz, 1982). There are no recognized subspecies.

Silver-haired bats are migrants, spending summers in the northern tier of states and in Canada (Handley and Patton, 1947). Based on Linzey's (1998) summary, there are no records of this bat in Virginia during the summer months. They occur in Illinois, Indiana, Ohio, Pennsylvania, Connecticut, and Rhode Island in spring and fall only during migration (Whitaker and Hamilton, 1998). Winters are spent hibernating in southern regions as far south as coastal Georgia. Padgett and Rose (1991) commonly observed them during winter in the Great Dismal Swamp. Winter roosts include caves, mines, hollow trees, and houses (Padgett and Rose, 1991). Silver-haired bats are usually solitary and there are no reports of large winter or summer colonies (Barbour and Davis, 1969; Whitaker and Hamilton, 1998). On APH, we captured them during migration in or near pine-hardwood and hardwood riparian forests during April 2000.

Kunz (1973) considered silver-haired bats to be relatively late flyers, emerging in the evening after other species have begun foraging. In contrast, Whitaker and Hamilton (1998) refer to them as early flyers. The individuals we captured on APH were netted well after sunset. Diet is variable. Kunz's (1982) summary of various studies includes records of more than a dozen insect orders, as well as some arachnids. Records of predation on silver-haired bats in the Commonwealth are few, however, Johnston (2000) provides a single record of a Great Horned Owl taking this bat in Virginia.

Lasiurus borealis Müller (Red Bat)

The red bat is a medium-sized bat that can be easily distinguished from other bats of the region by its coloration. Pelage is brick red to rusty red. Hairs on the back and chest are white-tipped resulting in a frosted appearance. The underparts are paler. The anterior portion of the shoulder has a whitish patch. This is one of the few mammals where coloration varies between the sexes; males are generally brighter red and less frosted than females. The dorsal surface of the interfemoral membrane is thickly furred. Ears are low, broad and rounded, and the tragus is triangular. The calcar is keeled. Weight of adults captured on APH ranged from 9.0 to 15.0 g for 34 males (avg.=10.9 ±1.5 g) and 10.0 to 20.0 g for 48 females (avg.=14.4 ±2.1 g). Measurements for the same individuals, male and females respectively, were: total length 95-115 mm (104 ±4.7), 99-117 mm (108±4.4); tail length 41.0-52.0 mm (48.0 ±2.5), 42.0-57.0 mm (49.5 ±3.2); wingspan 276-330 mm (300 ±10.6), 288-341 mm (314 ±11.0); forearm length 36.0-42.5 mm (40.2 ±1.5), 37.0-45.5 mm (42.1 ±1.9); length of hind foot 7.0-11.0 mm (8.6 ±0.8), 8.0-11.0 mm (9.1 ±0.7); ear length 8.0-12.0 mm (9.4 ±1.1), 8.0-13.0 mm (10.3 ±1.4); tragus length 3.0-6.0 mm (4.5 ±1.0), 3.5-6.5 mm (4.9 ±0.9). Dentition, i. 1/3, c. 1/1, p. 2/2, m. 3/3 =32 (Cothran et al., 1991).

Red bats occur throughout the midwestern and eastern United States, including all of Virginia, and throughout the south, along the Pacific Coast, and south through

Mexico and much of Central and South America (Shump and Shump, 1982a). Of the five recognized subspecies, only *L. b. borealis* is found in eastern North America.

Red bats are considered to be highly migratory and, although they are generally solitary, they may migrate in groups (Shump and Shump, 1982a). They generally travel south in winter but little is known about movement patterns or hibernacula selection. However, Padgett and Rose (1991) recorded the year-round presence of males in the Great Dismal Swamp. Whitaker et al. (1997) reported that male red bats were actively feeding, mostly on moths, during moderate winter evenings in the Great Dismal Swamp. Summer roosts are usually on trees or shrubs (Cothran et al., 1991).

Although red bats are generally solitary, Barbour and Davis (1969) reported that they are known to forage with big brown bats, hoary bats, silver-haired bats, evening bats, eastern pipistrelles, and little brown myotis. It was by far the most abundant of the 9 bat species that we collected on APH. We captured red bats in old fields and all forested, riparian and upland, habitats.

Kunz (1973) reported that red bats begin foraging 1 to 2 h after sunset. At APH, we have frequently captured them<1 h after sunset. Padgett and Rose (1991) found that daily emergence times changed with time of year, earliest in winter months, latest during summer, and around sunset in spring. Secondary foraging occurs throughout the night but with less intensity than during the initial period (Kunz, 1973). Diet includes moths, crickets, flies, bugs, beetles, and cicadas (Shump and Shump, 1982a). Predators include Virginia opossums, domestic cats, raptors, and most importantly (to young) Blue Jays (*Cyanocitta cristata*) (Elwell, 1962; Shump and Shump, 1982a).

Lasiurus cinereus Beauvois (Hoary Bat)

The hoary bat is the largest bat in the region. Pelage is dark brownish with hairs tipped in white, producing a frosted or hoary effect. Shoulder and wrist patches are whitish. The ears are edged in black and are short and rounded; the tragus is short and broad. The interfemoral membrane is heavily furred on the dorsal surface. The calcar is keeled. Adults usually weigh from 18 to 38 g (Whitaker and Hamilton, 1998). Weight of a single adult female captured on APH was 33.3 g. Weight of a single adult male captured on APH was 24.0 g. Measurements for the same two individuals, male and female respectively, were: total length 137.0 mm, 134.0 mm; tail length 61.0 mm, 60.0 mm; wingspan 415.0 mm, 408.0 mm; forearm length 55.0 mm, 54.0 mm; length of hind foot 15.0 mm, 12.0 mm; ear length 13.0 mm, 15.0 mm; tragus length 5.0 mm, 8.0 mm. For comparison, mean external measurements of 41 adult females from Indiana were: total length 135 mm, tail length 57 mm, wingspan 400 mm, forearm length 55 mm, tragus 8.0 mm (Whitaker and Hamilton, 1998). Dentition, i. 1/3, c. 1/1, p. 2/2, m. 3/3 =32 (Whitaker and Hamilton, 1998).

The hoary bat has the broadest distribution of all American bats. It occurs to the northern limits of trees in Canada and southward to Guatemala (Shump and Shump, 1982b). In South America, it ranges from Brazil south to Argentina and Chile; it is the only bat known from Hawaii. The hoary bat probably occurs throughout Virginia, at least seasonally, but is not common (Handley and Patton, 1947, and unpublished records). Of the three recognized subspecies, only *L. c. cinereus* occurs in North America (Shump and Shump, 1982b).

Although there is much evidence supporting the migratory habits of hoary bats, little is known about migration routes and wintering sites. They have been reported

passing through southern states (e. g., Florida) from late October to late November heading south to wintering sites and again from February to early May bound for northern summer roosting sites (Zinn and Baker, 1979). They are all but absent in the south the remainder of the year (Zinn and Baker, 1979). Findley and Jones (1964) suggested that they overwinter south of the United States. There have been a few observations of hoary bats overwintering in more northern areas of its range. The solitary summer roost is frequently located in foliage, especially in coniferous trees, 3 to 5 m above the ground (Whitaker and Hamilton, 1998). All three individuals captured on APH, one adult female, one subadult female and one adult male were netted in close proximity to or within riparian habitats.

Similar to red bats, hoary bats do not seem to associate with other bat species except when foraging. Shump and Shump (1982b) summarized reports that they forage with the red bats, big brown bats, Indiana bats (*Myotis sodalis*), eastern pipistrelles, silver-haired bats, and evening bats. They are often the last bat species to begin foraging, frequently not emerging until well after sunset. Hoary bats appear to prefer moths, but will also eat bugs, beetles, and flies, and are known to attack pipistrelles (Whitaker and Hamilton, 1998). Wiseman (1963) reported predation on this bat by a Texas rat snake (*Elaphe obsoleta linderheimi*). Hawks and owls probably take them opportunistically (Jackson, 1961; Barbour and Davis, 1969; Lowery, 1974).

Myotis austroriparius Rhoads (Southeastern Myotis)

The southeastern myotis is similar in appearance to the little brown bat but can be distinguished from this species by its shorter woolly pelage and pink face. Pelage is gray or drab brown dorsally and white or tan ventrally. The calcar is not prominently keeled. Weight of a single adult female captured on APH was 9.0 g. Measurements for the same individual were: total length 91.0 mm, tail length 41.0 mm, wingspan 269 mm, forearm length 39.0 mm, length of hind foot 10.0 mm, 14.0 mm, tragus length 7.0 mm. Dentition, i. 2/3, c. 1/1, p. 3/3, m. 3/3 =38 (Jones and Manning, 1989).

The range of this species is disjunct and centered in the southeastern United States (Jones and Manning, 1989). No subspecies are recognized.

Summer roosts and hibernacula are commonly located in caves, abandoned buildings, sewers, and hollow trees; and summer roosts are always near permanent bodies of water (Webster et al., 1985). The female collected on APH was captured over a gravel access road adjacent to a beaver pond. Southeastern myotis are occasionally found associated with other bats such as other *Myotis* spp., eastern pipistrelles, and Rafinesque's big-eared bats (*Corynorhinus rafinesquii*) (Jones and Manning, 1989).

Southeastern myotis emerge from day roosts at late in the evening. Common prey include beetles, moths, mosquitos, and crane flies (Whitaker and Hamilton, 1998). Known predators include Virginia opossums, black rat snakes, corn snakes, and owls (Jones and Manning, 1989).

Myotis lucifugus LeConte (Little Brown Myotis)

The little brown myotis is a medium-sized bat for this region. Pelage varies in color from dark sooty brown to paler golden brown with a glossy appearance. The face, ears, and membranes are dark brown. Young individuals are darker in color than adults. The interfemoral membrane is not furred, the calcar is not keeled, and the tragus is slender and pointed. Weight of 8 individuals captured on APH ranged from 7.0 to 9.0 g for

three males (avg.=8.3 ±1.2 g) and 8.5 to 10.5 g for five females (avg.=9.7 ±0.8 g). Measurements (ranges, means in mm) for the same individuals, males and females respectively, were: total length 85.0-90.0 mm (avg.=88.3 ±2.9), 85.0-93.0 mm (avg.=88.8 ±2.9); tail length 36.0-41.0 mm (avg.=38.7 ±2.5), 38.0-40.0 mm (avg.=39.6 ±0.9); wingspan 250.0-255.0 mm (avg.=253.3 ±2.9), 245.0-271.0 mm (avg.=259.6 ±11.4); forearm length 36.5-37.5 mm (avg.=37.0 ±0.5), 37.0-40.0 mm (avg.=38.7 ±1.2); length of hind foot 8.0-10.0 mm (avg.=9.2 ±1.0), 9.0-10.0 mm (avg.=9.8 ±0.4); ear length 10.0-14.0 mm (avg.=12.3 ±2.19), 6.0-7.5 mm (avg.=6.9 ±0.5); tragus length 3.5-7.0 mm (avg.=5.7 ±1.9), 6.0-7.5 mm (avg.=6.9 ±0.5). Dentition, i. 2/3, c. 1/1, p. 3/3, m. 3/3 =38 (Paradiso, 1969).

The species ranges from Alaska to eastern Canada, and it occurs in most of the east as far south as southern Alabama and Georgia (Fenton and Barclay, 1980). It is one of the most common bats in the Commonwealth and occurs throughout the state (Handley and Patton, 1947). Of six recognized subspecies, only *M. l. lucifugus* occurs in Virginia.

Roost preference is dependent on season and setting. Hibernacula (winter roosts) are usually located in caves and abandoned mines, and less frequently in buildings (Paradiso, 1969). Migration distances between hibernacula and summer roosts can be several hundred kilometers (Fenton and Barclay, 1980). Little brown myotis are gregarious, especially in winter when they have been found in colonies numbering 15,000 (containing several species) (Kurta and Teramino, 1994). Colonies generally have many fewer individuals. In the southern part of its range, little brown myotis enters hibernacula as late as November and emerges as early as mid-March (Fenton and Barclay, 1980). Day roosts and night roosts (spring, summer, and fall) are located in buildings, hollow trees, under the bark of trees, under bridges, and in caves (mostly males) (Whitaker and Hamilton, 1998). On APH, little brown bats have been captured most frequently in upland forests and less frequently in old-field and riparian habitats.

These bats emerge from a day roost at dusk to feed for an hour or two and continue to feed intermittently throughout the night, each time returning to night roosts. Diet, like all bats of the region, consists almost entirely of insects (Webster et al., 1985). Common prey are beetles, moths, and midges (Griffith and Gates, 1985). Size of prey generally falls between 3 and 10 mm in body length and 0.2 and 15.0 mg in weight (Gould, 1955; Anthony and Kunz, 1977). Small carnivores, birds, mice, and snakes opportunistically consume little brown bats (Gillette and Kimbrough, 1970).

Myotis septentrionalis Trouessart (Northern Myotis)

This bat was formally known as *Myotis keenii septentrionalis* (Keen's myotis), but based on morphological characteristics it is now considered to be a separate species (Jones et al., 1992). The species is similar in size and color to little brown myotis but lacks the glossy appearance and has longer ears, long for *Myotis*, that extend well beyond the muzzle when laid forward. Pelage is brown and darker dorsally than ventrally. The calcar is not keeled, and the tragus is long, pointed, and slightly curved. Weights of three individuals captured on APH were 7.0 g for a single male and 9.0 and 10.0 g for two females, respectively. Measurements of the same three individuals, male and females respectively, were: total length 95.0 mm, 87.0 and 92.0 mm, tail length 42.0 mm, 40.0 and 41.0 mm; wingspan 244.0 mm, 252.0 and 253.0 mm; forearm length 37.0 mm, 38.5 and 42.0 mm; length of hind foot 9.0 mm, 10.0 and 10.5 mm; ear length 17.5 mm, 17.0 and 18.0 mm; tragus length 9.5 mm, 9.5 and 9.5 mm. For comparison,

weights of 20 adults from various parts of the range were from 5 to 10 g (Whitaker and Hamilton, 1998). External body measurements for the same 20 individuals were: total length 79.2-87.8 mm (avg.=84.1), tail length 36.4-43.0 mm (avg.=41.7), forearm length 34.6-38.8 mm (avg.=36.7), length of hind foot 7.2-9.4 mm (avg.=8.4), ear length 17-19 mm, wingspan 228-258 mm. Dentition, i. 2/3, c. 1/1, p. 3/3, m. 3/3 =38 (Barclay, 2000).

Northern myotis range broadly in northeastern North America from portions of Canada to north Florida, although they are absent in the coastal areas of the South (Caceres and Barclay, 2000). They occur statewide in Virginia but vary from uncommon to locally abundant, making up 35 to 50% of late summer populations of *Myotis* inventoried at the mouths of caves (Handley, 1979). Northern myotis may be the least abundant species of those that hibernate in Virginia, but may be more abundant than winter cave inventories suggest (Dalton, 1987).

Northern myotis hibernate October or November through March or April. Winter hibernacula are usually in caves or mines (Caceres and Barclay, 2000). They often winter with other species, such as big brown bats, eastern pipistrelles, little brown myotis, and Indiana myotis (Whitaker and Hamilton, 1998). Favored summer roost sites are in trees; they will occasionally roost in man-made structures (Caceres and Barclay, 2000). We captured only three northern myotis during the 2000 APH bat survey. We captured them in riparian and upland habitats.

Northern myotis begin to forage shortly after dusk and probably use night roosts. They forage again before dawn and then retire to day roosts (Barbour and Davis, 1969). Diet consists primarily of moths, but beetles, flies, caddisflies and spiders are also taken (Whitaker and Hamilton, 1998). Typical of North American bats, northern myotis have few natural enemies, although many predators will take them opportunistically (Whitaker and Hamilton, 1998).

Nycticeius humeralis Rafinesque (Evening Bat)

The evening bat looks much like the larger big brown bat (*Eptesicus fuscus*), but can be distinguished from the latter by its smaller size. This bat also resembles bats of the genus *Myotis*, but can be distinguished from this group by its short, sparse pelage, which is dull brown dorsally with plumbeous bases, and paler on the ventral surface. Also in contrast with *Myotis*, the ears of the evening bat are short and the tragus is blunt. Interfemoral membrane is furred only at the base, and the calcar is not keeled. Ear and tail and wing membranes are leathery. The weight of a single adult male captured at APH was 9.5 g. Measurements for the same individual were: total length 86.0 mm, tail length 36.0 mm, 246.0 mm, forearm length 34.5 mm, length of hind foot 9.0 mm, ear length 11.0 mm, tragus length 5.0 mm. For comparison, weights of 19 males and 50 females from South Carolina were 6.1-12.0 g (avg.=8.2) for males and 6.6-13.0 g (avg.=8.8) for females (Cothran et al., 1991). Measurements for these males and females, respectively, were: total length 79-94 mm (avg.=88), 76-99 mm (avg.=92); tail length 31-39 mm (avg.=36), 33-43 mm (avg.=38); forearm length 33-38 mm (avg.=36), 31-40 mm (avg.=36); length of hind foot 6.0-9.0 mm (avg.=7.1), 5.5-8.0 mm (avg.=6.9) (Cothran et al., 1991). Dentition, i. 1/3, c. 1/1, p. 1/2, m. 3/3 =30 (Watkins, 1972).

Evening bats occur throughout the East as far north as Pennsylvania, west to Nebraska, and south into northeastern Mexico, and within these boundaries in all

regions except the Appalachians (Whitaker and Hamilton, 1998). Linzey (1998) summarized that they are found at lower elevations in Virginia and have not been reported from the mountains. Of the three recognized subspecies, only *N. h. humeralis* occurs in the mid-Atlantic region (Watkins, 1972).

Little is known about migration patterns of this primarily southern species, but it likely reaches the northern limits of its distribution (e.g., Pennsylvania, Michigan, Illinois) during summer (Whitaker and Hamilton, 1998). Summer colonies in Indiana usually disband by late September to October and reactivate by the beginning of May (Humphrey and Cope, 1968; Clem 1992; Clem, 1993). They migrate distances exceeding 500 km (Watkins, 1969), but where they actually hibernate is unknown. Summer roosts occur most frequently in buildings or hollow trees and uncommonly in caves (Watkins, 1972). We have captured this bat on APH in upland and riparian hardwood forests.

Evening bats leave daytime roosts to forage as darkness falls (Whitaker and Hamilton, 1998). Diet consists mainly of beetles, moths, and leafhoppers (Whitaker and Clem, 1992). Predation on evening bats is not well known. Domestic and feral cats are the most important predators in rural settings and raccoons and black rat snakes inhabiting the same buildings that serve as summer roosts would no doubt take them, especially young (Watkins, 1972).

Pipistrellus subflavus F. Cuvier (Eastern Pipistrelle)

The small size and light coloration of this bat distinguishes it from all other eastern bats. Pelage consists of tricolored hairs that are dark at the base, lighter and yellowish brown in the middle, and dark tipped. The anterior third of the interfemoral membrane is sparsely furred on the dorsal surface. The tragus is blunt, ears longer than they are wide, and reach the end of the nose when laid forward. The calcar is not distinctly keeled. Weights of bats captured on APH were 5.5 and 6.0 g for two males and 5.5 to 9.5 g for 10 females (avg.=7.3 ±1.3 g). Measurements for the same males and females, respectively, were: total length 78.0 and 85.0 mm, 77.0-92.0 mm (avg.=84.6 ±4.1); tail length 38.0 and 40.0 mm, 31.0-45.0 mm (avg.=39.2 ±3.7); forearm length 34.0 and 35.0 mm, 32.5-35.5 mm (avg.=34.3 ±0.9); length of hind foot 9.0 and 9.0 mm, 7.5-11.0 mm (avg.=9.0 ±1.1); ear length 10.5-11.0, 9.5 to 12.0 mm (avg.=11.3 ±0.8); tragus length 5.5 and 6.5 mm, 4.5-7.0 mm (avg.=5.9 ±0.8). Dentition, i. 2/3, c. 1/1, p. 2/2, m. 3/3 =34 (Fujita and Kunz, 1984).

Eastern pipistrelles occur throughout most of the eastern half of the United States and south into Central America (Hall, 1981). They occur throughout Virginia (Dalton, 1987). Of four recognized subspecies, only *P. s. subflavus* occurs in Virginia (Hall, 1981).

Eastern pipistrelles hibernate from late October until April and early May (Whitaker and Hamilton, 1998). Winter hibernacula include caves, mine shafts, rock crevices, and various other man-made structures (Handley and Patton, 1947; Jones and Pagels, 1968). They generally hibernate singly or in relatively small numbers. Eastern pipistrelles frequently share hibernacula with other species, such as little brown myotis, northern myotis, Indiana myotis, and big brown bats, but usually in side passages where other bats are absent (Whitaker and Hamilton, 1998). This is the least specialized cave bat in Virginia with regard to microhabitat requirements of the hibernaculum (e.g., temperature, humidity, and cave configuration) (Dalton, 1987). Winter and summer

roosts are in similar habitats and are geographically close (Cothran et al., 1991). On APH, we captured eastern pipistrelles in riparian and upland forests and in old-field habitats.

Eastern pipistrelles begin to forage relatively early in the evening. The erratic, slow flight often results in this species being mistaken for a large moth (Handley and Patton, 1947). Diet includes moths, tiny flies, beetles, and hymenopteran insects (Cothran et al., 1991; Whitaker and Hamilton, 1998). Little is known about predation on this bat. Hoary bats and northern leopard frogs (*Rana pipiens*) have been reported to prey on this species (Bishop, 1947; Creel, 1963).

Order Lagomorpha

Sylvilagus floridanus Allen (Eastern Cottontail)

The eastern cottontail is the only lagomorph on APH. Pelage is long and dense, brown to gray dorsally, and white ventrally, including the tail. Chapman and Morgan (1973) reported that average measurements for 35 males and 42 females, respectively, from western Maryland and West Virginia adult were: total length 427.0 mm, 433.2 mm; tail length 44.9 mm, 44.8 mm; length of hind foot 95.4 mm, 95.4 mm; length of ear 61.5 mm, 61.1 mm. Dentition, i. 2/1, c. 0/0, p. 3/2, m. 3/3 =28 (Chapman et al., 1980).

The distribution of the eastern cottontail includes portions of southern Canada, all of the central and eastern United States, and northwestern South America (Chapman et al., 1980). Of the 23 recognized subspecies of *S. floridanus*, only *S. f. mallurus* occurs throughout the Coastal Plain of the mid-Atlantic region (Handley, 1991).

Eastern cottontails occur in a variety of disturbed, early successional, and transitional habitats, but seem to prefer those with weedy forbs and bunch-type perennial grasses that provide thickly vegetated escape routes. On APH, eastern cottontails have been observed in old fields, clearcuts, grassy roadside firebreaks, forests with open canopy, and edges of pine-hardwood and hardwood forests. Diet consists mainly of herbaceous vegetation such as grasses and clover, fruits when available, and woody vegetation during winter (Chapman et al., 1982).

Eastern cottontails are prey of many predators within its range. Mammalian predators include raccoons, weasels (*Mustela* spp.), red and gray foxes, coyote, bobcats, and feral cats (Martin et al., 1961; Mitchell and Beck, 1992). Known snake predators of eastern cottontails that occur on the post include mole kingsnakes and black rat snakes (Mitchell, 1994). Other predators include hawks (e.g., Rough-legged Hawks [*Buteo lagopus*]), and owls (e. g., Barn Owls, Great Horned Owls) (Jackson et al., 1976; Johnston, 2000).

Eastern cottontails are the most widely hunted game species in the United States (Chapman et al., 1982). They sometimes causes damage to orchards and crops and can be a garden pest in suburban areas.

Order Rodentia

Glaucomys volans Linnaeus (Southern Flying Squirrel)

Southern and the northern flying squirrels are the only nocturnal North American squirrels (Dolan and Carter, 1977). Flying squirrels are easily identified by their furred gliding membrane, or patagium, which extends from the wrists to the ankles. Pelage

of the southern flying squirrel is dense and soft, slate gray dorsally and white below. Stapp (1992) found no differences in body weight between the sexes. Weights of three males captured on APH ranged from 59 to 68 g (avg.=63.0 ±4.6 g). Measurements for flying squirrels captured on APH, five males and three females, respectively, were: total length 217-239 mm (avg.=225.0 ±8.3), 210-240 mm (avg.=229.0 ±16.5); tail length 80-94 mm (avg.=87.6 ±6.2), 90-94 mm (avg.=91.7 ±2.1); length of hind foot 30-31 mm (avg.=30.8 ±0.4), 31 mm (avg.=31.0 ±0.0); ear length 18-19 mm (avg.=18.6 ±0.5), 18-20 mm (avg.=18.7 ±1.2). Dentition, i. 1/1, c. 0/0, p. 2/1, m. 3/3 (Hall, 1981).

Southern flying squirrels occur throughout the eastern United States, southeastern Canada, and in southern Mexico south into Honduras. Of the recognized subspecies, only *G. v. volans* is known from this region (Hall, 1981).

Southern flying squirrels occur most often in deciduous forests, but also inhabit mixed pine-hardwood and coniferous forests (Cothran et al., 1991). On APH, we found them in pine, mixed pine-hardwood, and hardwood forests, and in riparian and upland habitats. They are social, often forming winter aggregations of five to six individuals (Stapp et al., 1991). Such aggregations result in a form of social thermoregulation (Merritt et al., 2001). Diet consists primarily of nuts, seeds, and berries, but they will eat insects, carrion, birds, and eggs opportunistically (Dolan and Carter, 1977). Owls, domestic free-ranging cats, and black rat snakes are known predators of southern flying squirrels (Pearson, 1954; Mumford and Handley, 1956; Hall and Blewett, 1964; Mitchell and Beck, 1992). Other potential predators include mustelids, bobcats, raccoons, and hawks (Dolan and Carter, 1977).

Marmota monax Linnaeus (Woodchuck)

The woodchuck (groundhog) is the largest member of the squirrel family in the region. Pelage is gray to reddish brown dorsally and paler ventrally, feet and tail brown to black. Long white guard hairs over entire body give the woodchuck a grizzled appearance. Adult body measurements are: total length 418-665 mm, tail length 100-155 mm, length of hind foot 66-88 mm (location not provided, Hall, 1981). Dentition: i. 1/1, c. 0/0, p. 2/1, m. 3/3 =22 (Lee and Funderburg, 1998).

Woodchucks have the greatest distribution of any North American marmot (genus *Marmota*). They range from eastern Alaska, across southern Canada, and southward through the central and eastern United States, except many regions of the southeastern United States (Kwiecinski, 1998). Of the 9 recognized subspecies of *M. monax*, only *M. m. monax* is known from the mid-Atlantic region (Hall, 1981).

Woodchucks most frequently occur in woodland-field ecotones, rocky slopes, or clearings, preferring to hibernate in woodlands and to breed and forage in nearby fields (Lee and Funderburg, 1982; Kwiecinski, 1998). We observed them throughout APH, but they were especially abundant in all of the early successional habitats. We captured a subadult in an open canopy forest.

They are active from early spring until late fall, at which time they enter deep torpor until late February or early March (Webster et al., 1985). Periods of hibernation are generally longer in the northern regions of its range. Woodchucks are solitary and aggressively defend burrows, associating with conspecifics only to reproduce (Lee and Funderburg, 1982). Woodchuck burrows provide refuge for cottontails, skunks, Virginia opossums, raccoons, mice, chipmunks, weasels, and many bird and snake species (Grizzell, 1955). Woodchucks feed on a variety of plant materials, especially alfalfa,

clover, chickweed, and grasses, but will also eat invertebrates opportunistically (Grizzell, 1955; Lee and Funderburg, 1982; Kwiecinski, 1998). Woodchucks sometimes cause extensive damage to crops, but often the damage is only localized due to their solitary habits (Kwiecinski, 1998). Foxes are primary predators on young woodchucks, but owls, hawks and snakes sometimes take young (Grizzell, 1955).

Sciurus carolinensis Gmelin (Gray Squirrel)

The gray squirrel is a medium-sized tree squirrel. Pelage is gray in appearance due to alternating bands of brown, white, and black on the hairs. The mid-dorsal section and cheeks are slightly darker, and the chin, throat, and belly are white. Measurements for 179 adults from Indiana were: total length 404-530 mm (avg.=469), tail length 177-285 mm (avg.=210), length of hind foot 50-76 mm (avg.=65) (Whitaker and Hamilton, 1998). Dentition: i. 1/1, c. 0/0, p. 2/1, m. 3/3 =22 (Koprowski, 1994).

Gray squirrels range throughout the eastern United States and extend west to the limits of the deciduous forest and north to southeastern and south-central Canada (Hall, 1981; Koprowski, 1994). Of the five recognized subspecies, two (*S. c. carolinensis* and *S. c. pennsylvanicus*) are known from Virginia (Koprowski, 1994). Records from Handley and Patton (1947) indicate that that the range of *S. c. carolinensis* is to the south and east of APH.

Habitat of gray squirrels is primarily mature hardwood forests, but they also occur in mixed pine-hardwood forests and urban areas with abundant trees (Flyger and Gates, 1982; Cothran et al., 1991). On APH, we have observed them in numerous habitats, including pine, mixed pine-hardwood, and hardwood forests, riparian hardwood forests, and manicured areas around post facilities. Diet consists mainly of mast crops, such as acorns, hickory nuts, and walnuts (Brown and Batzli, 1984). They also eat fungi, herbaceous plants, tree bark, crops, and insects (Flyger and Gates, 1982; Koprowski, 1994). Predators are numerous, and include snakes (e.g., black rat snakes), owls (Barred Owls), hawks (e.g., Cooper's Hawks [*Accipiter cooperii*], Red-tailed Hawks), weasels, red and gray foxes, bobcats, coyotes, domestic and free-ranging cats and dogs (Koprowski, 1994; Mitchell and Beck, 1992; Mitchell, 1994; Johnston, 2000).

The gray squirrel is an important game species, especially in the southern part of its range. Adjustment of hunting regulations is the primary form of management. Gray squirrels can cause damage to gardens and ornamentals, particularly in urban areas, and are sometimes considered a pest (Flyger and Gates, 1982).

Tamias striatus Linnaeus (Eastern Chipmunk)

The eastern chipmunk is a small, stout-bodied, terrestrial squirrel. It is readily identified by five dark brown, longitudinal stripes. The two lateral pairs of dark stripes are separated by a yellowish stripe. Background pelage is reddish-brown and yellowish on the sides. Measurements for chipmunks we captured at APH, six males and 7 females, respectively, were: total length 180-204 mm (avg.=193 ±10.2), 178-235 mm (avg.=203 ±23.8); tail length 53-74 mm (avg.=66 ±7.2), 62-89 mm (avg.=62 ±9.2); length of hind foot 32-34 mm (avg.=33 ±0.8), 31-34 mm (avg.=32 ±1.2); ear length 12-18 mm (avg.=14 ±2.4). Dentition, i. 1/1, c. 0/0, p. 1/1, m. 3/3 =20 (Snyder, 1982).

Eastern chipmunks occur from southeastern Canada throughout much of the eastern United States, except most of Florida and lower areas of the Carolinas, Georgia, and Florida (Hall, 1981). Two of 11 recognized subspecies of *T. striatus* (*T. s. striatus* and

T. s. fisheri) occur in Virginia (Hall, 1981). *Tamias s. striatus* is found only in extreme southwestern Virginia and *T. s. fisheri* is uncommon in many coastal counties (Handley, 1991).

Eastern chipmunks most frequently occur in deciduous forests, especially areas that provide crevices for protection and elevated surveillance stations (Snyder, 1982). On APH, we observed them in upland forests. Chipmunks enter burrows and are largely inactive from late fall until spring. Hibernation is longer in the northern regions and sporadic in southern regions of its range (Webster et al., 1985). Important cool season foods are seeds, nuts, and acorns (Snyder, 1982). During the growing season, fungi, invertebrates, and mast leftover from winter caches are consumed (Wrazen and Svendsen, 1978; Snyder, 1982). Eastern chipmunks are prey for many predators, including snakes (e.g., black rat snakes, copperheads, black racers), hawks (e. g., Cooper's Hawks), weasels, foxes, bobcats, and domestic and free-ranging cats (Mitchell and Beck, 1992; Mitchell, 1994; Whitaker and Hamilton, 1998; Johnston, 2000).

Castor canadensis Kuhl (Beaver)

The beaver is the largest native North American rodent (Hall, 1981). Pelage is rich glossy brown. Coarse guard hairs are underlain with very dense fine underfur. Males tend to be slightly larger than females (Cothran et al., 1991). Weight of 58 individuals captured on APH during the 1998/1999 furbearer trapping season ranged from 5.0 to 25.0 kg for 36 males (avg.=11.3 ±4.2 kg) and 4.4 to 20.1 kg for 22 females (avg.=12.5 ±5.2 kg). External body measurements for the same males and females, respectively, were: total length 653-1,151 mm (avg.=903 ±124), 620-1,101 mm (avg.=924 ±155); tail length 155-320 mm (avg.=238 ±37), 178-295 mm (avg.=241 ±37); length of hind foot 130-207 mm (avg.=159 ±16), 117-187 mm (avg.=160 ±21); ear length 25-36 mm (avg.=31 ±3), 24-36 mm (avg.=31 ±3). Dentition: i. 1/1, c. 0/0, p. 1/1, m. 3/3 =20 (Jenkins and Busher, 1979).

The native beaver was extirpated from Virginia by 1911 due to unrestricted trapping (Echternach and Rose, 1987). Reestablishment began in 1932 and beavers have since become common in Virginia. The present range, inclusive of all 24 recognized subspecies, includes most of North America south to the most northern regions of Mexico and Florida. *Castor c. canadensis*, is the subspecies found in Virginia's Coastal Plain. *Castor c. carolinensis* occurs in mid- to southwestern Virginia and is the only other subspecies known from the mid-Atlantic region (Hall, 1981).

Good beaver habitat includes impoundments, rivers and streams, and lakes with relatively constant water levels, and small tributaries with enough flow for damming (Hill, 1982). On APH, beavers are present in a variety of wetland types, including impoundments, riparian swamps, and ponds created from seepages and creeks. The large number of beavers captured during the 1998/1999 furbearer trapping season on APH (n=157), in conjunction with the high captures per unit effort (13.0/100 trap nights), reflects the large population size on APH. Beavers feed on a diversity of seasonally abundant plant material. In winter, they rely primarily on the bark and twigs of trees, and in summer herbaceous vegetation becomes a major dietary component (Jenkins and Busher, 1979). Beavers have few predators due to its large size; however, Linzey (1998) summarized observations that dogs (*Canis familiaris*), foxes, bobcats, and otters occasionally eat young beavers.

Woodcutting and dam building by beavers modify hydrology and drainage network morphology by retaining organic matter and sediments (Naiman et al., 1994). These activities have a strong influence on plant and animal community composition and, thus, are responsible for the creation and maintenance of a wide diversity of wetland types and associated floras and faunas. Jenkins and Busher (1979) summarize effects of beaver activity on flora and other fauna.

Beavers are economically important for both positive and negative impacts. They are commercially valued for pelt quality. Activities such as woodcutting and damming often benefit native wildlife, however, these activities may result in the destruction of valuable timber and flooding of roads and pastures (Hall, 1981). Due to the relatively remote nature of much of APH, beaver activity has only a small economic impact (e.g., small-scale timber destruction and road damage).

Microtus pennsylvanicus Ord (Meadow Vole)

The meadow vole is a relatively large member of the genus *Microtus*. Pelage is chestnut brown dorsally and gray ventrally. Underhair is three-banded, gray at the base, orange to yellow brown in the middle, and black-tips. Guard hairs have gray bases with darker tips. Measurements for 11 males and 8 females, respectively, captured on APH were: total length 129-160 mm (avg.=146 ±8.8), 121-183 mm (avg.=159 ±21.0); tail length 31-41 mm (avg.=36 ±2.9), 19-40 mm (avg.=32 ±7.7); length of hind foot 20-22 mm (avg.=21 ±0.8), 20-44 mm (avg.=27 ±10.4); ear length 9-12 mm (avg.=10 ±1.0), 9-11 mm (avg.=10 ±0.8). Dentition: i. 1/1, c. 0/0, p. 0/0, m. 3/3 =16 (Johnson and Johnson, 1982).

The meadow vole has the broadest distribution of any American *Microtus*. This species ranges through Canada, most of Alaska, and southward through northern and eastern regions of the United States to South Carolina and northern Georgia (Reich, 1981). Of 26 recognized subspecies, two (*M. p. pennsylvanicus* and *M. p. nigrans*) are known from Virginia (Hall, 1981). Only *M. p. pennsylvanicus* occurs on APH.

Meadow voles are most commonly associated with grass-dominated habitats, in particular those with abundant perennial grasses and forbs that provide protective cover (Adler, 1985; Dooley and Bowers, 1996). The greatest numbers of this species observed on APH were in old fields; few individuals were taken in forested habitats. The presence of meadow voles in forested habitats is consistent with the observation of Pagels et al. (1992) that this species travels through "atypical environments" in the absence of old-field corridors and that the ephemeral nature of grassy habitats in the eastern United States drives this dispersal behavior (Kirkland, 1988). Diet consists primarily of grasses, sedges, and seeds, but fungi and insects are also eaten (Reich, 1981; Zimmerman, 1965). Although typically confined to ground-level runways, they have been captured above ground-level in traps attached to Japanese honeysuckle vines (Wright and Pagels, 1977). Meadow voles are important prey for many carnivorous forms (Whitaker and Hamilton, 1998). Known snake predators of meadow voles that are known to occur or may occur on APH include mole kingsnakes, black rat snakes, black racers, corn snakes (*Elaphe guttata*), eastern kingsnakes (*Lampropeltis getula*), eastern milk snakes (*L. triangulum*), and copperheads (Mitchell, 1994). Avian predators of meadow voles on APH include Barn Owls, Eastern Screech Owls, Great Horned Owls, Barred Owls, Long-eared Owls (*Asio otus*), Northern Harriers, Cooper's Hawks, Red-tailed Hawks, American Kestrels (Rageot, 1957; Jackson et al., 1976; Johnston,

2000). Mammalian predators found on APH include domestic free-ranging cats, raccoons, foxes, bobcats, weasels and mink (Mitchell and Beck, 1992; Linzey, 1998).

Microtus pinetorum LeConte (Woodland Vole)

The semi-fossorial lifestyle of the woodland vole (or pine vole) is reflected in its smooth silky mole-like pelage, reduced eyes and ears and short tail. Dorsal coloration of this small robust mouse is russet to chestnut brown, with a lighter ventral surface. Measurements of 11 males and 7 females, respectively, captured on APH were: total length 104-125 mm (avg.=112 ±7.8), 109-126 (avg.=116 ±6.2); tail length 17-23 mm (avg.=19 ±2.0), 14-24 mm (avg.=19 ±4.4); length of hind foot 15-17 mm (avg.=16 ±0.8), 15-21 mm (avg.=17 ±2.1); ear length 7-8 mm (avg.=7 ±0.5), 7-8 mm (n=4, avg.=8 ±0.5). Dentition: i. 1/1, c. 0/0, p. 0/0, m. 3/3 =16 (Smolen, 1981).

Woodland voles occur throughout most of the eastern United States, except most of Maine and Florida and coastal regions of other Gulf Coast states. Of 7 recognized subspecies, two (*M. p. pinetorum* and *M. p. scalopsoides*) occur in Virginia (Hall, 1981). Only the latter occurs on APH.

Woodland voles have been collected in most terrestrial habitats, including edge habitat (Rose et al., 1990). Whitaker and Hamilton (1998) remarked that few small mammals use such a variety of habitats. On APH, this species was captured primarily in forested habitats, but also in old fields. This vole was captured in relatively low numbers in all habitats we studied. Its semi-fossorial habits reduce its susceptibility to traps. However, its abundance is positively correlated with downed woody debris (Bellows et al., in press). Diet consists of bulbs, tubers, roots, seeds, fruit, bark, leaves, the fungus *Endogone*, and to a lesser degree, animal matter (Linzey and Linzey, 1973; Smolen, 1981). In Virginia, forbs and grasses comprise the major portion of the diet (Cengel et al., 1978). The largely fossorial habits of the woodland vole may provide some measure of protection from predation. Owls (e.g., Barn Owl, Barred Owls, Eastern Screech Owls), and hawks (e.g., Red-tailed Hawks, Northern Harriers) are primary predators (Jackson et al., 1976; Smolen, 1981). Other predators include snakes (e. g., black rat snakes, eastern milk snakes, copperheads), foxes, domestic and free-ranging cats, and Virginia opossums (Smolen, 1981; Mitchell and Beck, 1992; Mitchell, 1994). They are sometimes considered an agricultural pest due to damage to orchard trees, commercial bulbs, potatoes, and peanuts (Smolen, 1981).

Ondatra zibethicus Linnaeus (Muskrat)

The muskrat is a large semiaquatic rodent with relatively small eyes and a laterally flattened, nearly hairless tail. Pelage is brown to nearly black, thick and soft, with long guard hairs and waterproof underfur. Weight of 9 individuals captured on APH ranged from 1.1 to 1.5 kg for five males (avg.=1.3 ±0.2 kg) and 1.3 to 1.6 kg for four females (avg.=1.5 ±0.1 kg). Measurements for the same individuals, males and females respectively, were: total length 552-611 mm (avg.=576 ±26), 528-638 mm (avg.=579 ±45); tail length 238-257 mm (avg.=246 ±9), 227-253 mm (avg.=244 ±11); length of hind foot 81-86 mm (avg.=82 ±3), 75-85 mm (avg.=82 ±4); ear length 8-17 mm (avg.=13 ±4), 13-21 mm (avg.=18 ±3). Dentition: i. 1/1, c. 0/0, p. 0/0, m. 3/3 =16 (Willner et al., 1980).

The range of the muskrat includes most of North America and northern Mexico, although they are absent in Florida (Hall, 1981). There are 16 subspecies of *O. zibethicus* in North America; *O. z. zibethicus is* the only subspecies found on APH.

In the Chesapeake Bay drainage, muskrats are most abundant in low salinity and freshwater marshes along the Rappahannock, Piankatank, Mattaponi, Pamunkey, and James Rivers (Wass, 1972). Marshes provide optimum habitat for muskrats, although most permanent bodies of water are suitable (Cothran et al., 1991). All individuals captured on APH were in riparian habitats. The muskrat is herbivorous and in the southeastern United States feeds primarily on emergent aquatic vegetation, marsh grasses, and sedges (Wass, 1972; Perry, 1982). Aquatic invertebrates become important foods in winter when vegetation is scarce or in habitats with little aquatic vegetation (Neves and Odom, 1989). Major predators of muskrat are mink, raccoons, red foxes, Barn Owls, Barred Owls, Marsh Hawks, and largemouth bass (*Micropterus salmoides*) (Wass, 1972; Perry, 1982).

Muskrat exceed all other furbearers in numbers caught and marketed and, as a result, is the most valuable fur animal in North America. Muskrats are easily managed when compared to other furbearers, due mostly to prolific breeding and readily-met habitat requirements (Perry, 1982).

Oryzomys palustris Harlan (Marsh Rice Rat)

The marsh rice rat is a medium-sized generalized rat with a long, scantily haired tail and large hind feet. Pelage is gray to grizzled brown mixed with black dorsally and buff to white below. Underfur is dense, soft, and water repellent. Two adult males were collected on APH, but measurements for only one individual are available: total length 214 mm; tail length 102 mm; length of hind foot 29 mm; ear length 16 mm. For comparison, measurements for 7 adults from Chincoteague, Virginia were: total length 252 mm; tail length 121 mm; length of hind foot 30 mm (Whitaker and Hamilton, 1998). Dentition: i. 1/1, c. 0/0, p. 0/0, m. 3/3 =16 (Cothran et al., 1991).

The range of the marsh rice rat includes most of the south-central and southeastern United States and extends northward to southeastern Pennsylvania and southern New Jersey.

In Virginia, the marsh rice rat occurs as far west as the Piedmont in Cumberland County (Pagels et al., 1992) and throughout the Coastal Plain, including barrier islands (Moncrief and Dueser, 1994). Of 23 recognized subspecies, only *O. p. palustris* is known from the mid-Atlantic region (Wolfe, 1982).

Marsh rice rats are found in greatest numbers in wetland habitats, including swamps and freshwater marshes but most frequently in Gulf coastal marshes and tidal creek areas (Wolfe, 1982; Cranford and Maly, 1990). One adult male from APH was captured in a minnow trap set in shallow water in a thickly vegetated beaver pond; another was captured in a mixed pine-hardwood upland forest. We also captured a subadult male in an upland hardwood habitat in a pitfall trap. Because the marsh rice rat prefers riparian habitats, this individual could have been a transient, a scenario supported by Wolfe (1982). Marsh rice rats are excellent swimmers and divers (Esher et al., 1978). They feed on a wide range of plants and animals, but most predominately on seeds, succulent plant parts, mollusks, and arthropods such as insects, crayfish, and crabs (Sharp, 1967; Whitaker and Hamilton, 1998). Owls are the most commonly documented predators, especially Barn Owls (Blem and Pagels, 1973; Jackson et al., 1976).

Other predators include snakes (corn snakes), hawks, raccoons, red foxes, mink, weasels, and striped skunks (Svihla, 1931; Harris, 1953; Lowery, 1974; Brown, 1979; Whitaker and Hamilton, 1998).

Peromyscus leucopus Rafinesque (White-footed Mouse)

The white-footed mouse is a relatively small member of the genus *Peromyscus*. The tail is usually less than half the total body length. Pelage is brown to yellowish-brown dorsally, whitish ventral hairs are dark-based, and the feet are white dorsally. Juveniles are gray dorsally. Weight of mice captured on APH ranged from 12.7 to 24.4 g for 43 males (avg.=17.7 ±2.9) and 12.0 to 24.8 g for 30 females (avg.=17.2 ±3.3). Measurements for the same individuals, males and females respectively, were: total length 130-179 mm (avg.=150.9 ±8.9), 132-182 mm (avg.=148.2 ±12.1); tail length 56-80 mm (avg.=66.0 ±5.4), 55-81 mm (avg.=64.1 ±6.0); length of hind foot 12-20 mm (avg.=18.4 ±1.3), 17-20 mm (avg.=18.3 ±0.7); ear length 13-19 mm (avg.=16.2 ±1.2), 15-19 mm (avg.=17.1 ±1.1). Dentition: i. 1/1, c. 0/0, p. 0/0, m. 3/3 =16 (Cothran et al., 1991).

The white-footed mouse occurs in most of the eastern two-thirds of the United States and southward through eastern Mexico into the Yucatan Peninsula (Hall, 1981). Of the 17 recognized subspecies, two (*P. l. easti* and *P. l. noveboracensis*) occur in Virginia. Records from Hall (1981) indicate that only *P. l. noveboracensis* occurs on APH.

The white-footed mouse is the most common mammal in Virginia (Handley and Patton, 1947). It is found in a wide range of habitat types and considered a habitat generalist (Pagels et al., 1992). At APH, this mouse was abundant in all habitats, including old fields, clearcuts, pine plantations, shelterwood treatments, and pine, mixed pine-hardwood, hardwood, and riparian forests. Insects constitute the majority of its diet throughout the year but mast crops, seeds, fruits, and greens are seasonally important foods (Hamilton, 1941). Major predators are numerous and include owls (e.g., Eastern Screech Owls, Long-eared Owl), hawks (e.g., Northern Harriers), weasels, red foxes, domestic and free-ranging cats and snakes (Mitchell and Beck, 1992; Mitchell, 1994; Whitaker and Hamilton, 1998; Johnston, 2000). Known snake predators that occur or may occur on APH include black racers, black rat snakes, corn snakes, eastern kingsnakes, eastern milk snakes, mole kingsnakes, and copperheads (Mitchell, 1994).

Reithrodontomys humulis Audubon and Bachman (Eastern Harvest Mouse)

The eastern harvest mouse resembles the house mouse but is easily distinguished from it by the grooved upper incisors. Pelage is rich dark brown dorsally with a darker mid-dorsal stripe. Sides are lighter than the dorsum, and underparts are ashy with a cinnamon to pinkish suffusion. Weight of harvest mice captured in southeastern Virginia averaged 7.0 ± 0.1 g for 42 males and 8.2 ± 0.3 g for 35 females (Cawthhorne and Rose, 1989). Measurements for harvest mice captured on APH, 9 males and two females respectively, were: total length 111-134 mm (avg.=123 ±8.0), 117 and 118 mm; tail length 50-61 mm (avg.=56 ±3.7), 60 and 56 mm; length of hind foot 14-17 mm (avg.=15 ±1.0), 11 and 16 mm; ear length 7-10 mm (avg.=8 ±1.0), 9 and 11 mm. External measurements for 12 individuals from Louisiana were similar: males and females combined - total length 115-132 mm (avg.=120), tail length 52-65 mm

(avg.=56), length of hind foot 11-18 mm (avg.=16) (Lowery, 1974). Dentition: i. 1/1, c. 0/0, p. 0/0, m. 3/3 =16 (Stalling, 1997).

Eastern harvest mice are found throughout much of southeastern United States and portions of the south-central United States, except southern regions of Florida and Louisiana. Of the three recognized subspecies of *R. humulis*, only *R. h. virginianus* is known from the northern Coastal Plain of Virginia (Stalling, 1997).

Old fields are the preferred habitat of eastern harvest mice, especially the late herbaceous and early perennial grass stages of old-field succession (Stalling, 1997), including clearcuts (Pagels et al., 1992). We collected them on APH most frequently in old fields, however, some were collected 5 to10 year old clearcuts, upland hardwood forests, and in forests managed with the shelterwood treatment. Diet consists of seeds (particularly seeds of grasses), green shoots, and insects such as grasshoppers and crickets (Dunaway, 1968; Stalling, 1997; Whitaker and Hamilton, 1998). Reports of predation on eastern harvest mice are rare, but harvest mouse remains are regularly found in Barn Owl pellets (Handley, 1949; Wolfe and Rogers, 1969; Jackson et al., 1976). Johnston (2000) reported a harvest mouse in the stomach of a Great Horned Owl from Wythe County, Virginia.

Zapus hudsonius Zimmermann (Meadow Jumping Mouse)

Several characters of the meadow jumping mouse reflect their saltatory locomotion—hind limbs, legs, and feet are much longer and larger than forelimbs, arms, and feet, and the tail is very long. Pelage is coarse with a broad, longitudinal dorsal band of yellow-brown hairs darkened with brownish-black hairs. Sides are paler than the dorsum and underparts are buff to light yellow. Measurements for mice captured on APH, 26 males and 19 females respectively, were: total length 172-309 mm (avg.=193 ±8.5), 166-215 mm (avg.=190 ±11.7); tail length 99-126 mm (avg.=113 ±7.4), 102-125 mm (avg.=113 ±5.8); length of hind foot 25-30 mm (avg.=28 ±1.3), 23-29 mm (avg.=27 ±1.5); ear length 9-15 mm (avg.=13 ±1.9), 9-15 mm (avg.=11 ±2.0). Dentition, i. 1/1, c. 0/0, p. 0/0, 3/3 =16 (Whitaker, 1972).

The range of the meadow jumping mouse extends from southern Alaska to central and southern Canada and south through north-central and eastern United States, except the extreme southeastern regions (Hall, 1981). This mouse may be locally abundant throughout its range (Hamilton, 1935). Of the 11 recognized subspecies, only *Z. h. americanus* occurs in the mid-Atlantic region and APH.

The hibernation period of meadow jumping mice is longer than for most other hibernating mammals and in some parts of its range the duration may be as much as six months (Whitaker, 1972). No other species of small mammal found on APH hibernates. Meadow jumping mice most frequently occur in open meadows and grasslands, but also in forests with abundant herbaceous cover (Hamilton, 1935; Whitaker, 1972; Adler, 1985; Pagels et al., 1992). They are often abundant in thick brush bordering ponds, streams, and marshes (Whitaker, 1972). Most meadow jumping mice collected on APH were captured in old-field habitats, however, we captured 22 individuals in open canopy forests (e.g., shelterwood treatments), several in forest habitats, and one on the edge of a swamp. Diet consists primarily of seeds (especially of grasses), insects, and the fungus *Endogone* (Hamilton, 1935; Whitaker, 1963). Predators of meadow jumping mice are many, and include owls, (Barn Owls, Long-eared Owls, raptors (Red-Tailed Hawks), foxes, skunks, weasels, and snakes (e.g.,

copperheads) (Whitaker, 1963; Eaton and Grzybowski, 1969; Mitchell, 1994; Whitaker and Hamilton, 1998).

Order Carnivora

Canis latrans Say (Coyote)

The word "coyote" is taken from the Aztec word "Coyotyl," meaning "barking dog" (Bekoff, 1982). The coyote is often mistaken for other canids, such as gray wolf (*Canis lupus*), red wolf (*C. rufus*), and domestic dog. They hybridize successfully (but rarely) with those species and produce fertile offspring (Bekoff, 1982). Pelage is reddish, brown, and sometimes almost pure gray above, dorsal hairs are black-tipped, the head is grizzled gray, and the throat and belly are pale. An adult female from APH weighed 12 kg. Measurements were: total length 1295 mm, tail length not available, length of hind foot 184 mm, ear length 96 mm. Males are slightly heavier than females; males range from 8 to 20 kg, females 7 to 18 kg (location not provided, Bekoff, 1977). Measurements for adults were: total length 1,075-1,200 mm, tail length 300-390 mm, length of hind foot 175-220 mm (location not provided, Whitaker and Hamilton, 1998). Dentition, i. 3/3, c. 1/1, p. 4/4, m. 2/3 =42 (Cothran et al. 1991).

Coyotes range throughout the contiguous United States and most of Canada (Hall, 1981). They are becoming more common in the eastern United States as a result of natural range expansion due to land use changes and transplantations (e.g., Florida and Georgia) (Bekoff, 1982). There are 19 recognized subspecies of *C. latrans*, but only *C. l. latrans* is found in the mid-Atlantic region (Whitaker and Hamilton, 1998).

Coyotes inhabit a variety of grassland, desert, and montane habitats (Bekoff, 1982). Agricultural and rural land-use patterns of the mid-Atlantic region provide suitable habitat (Webster et al., 1985). They have been observed on APH in pine and hardwood upland forests. The adult mentioned above was killed by a hunter in an upland forest. Another killed by a car in the fall of 2000 near Smoot's Pond was a juvenile male, suggesting that a breeding population is present on or near APH. It is an opportunistic predator that feeds on a variety of prey; diet varies both seasonally and locally (Bekoff, 1977). Coyotes are often accused of killing livestock and have been considered a nuisance by ranchers and farmers (Cothran et al., 1991). There is little doubt that coyotes are responsible for some livestock mortality, but their diet consists primarily of wildlife (Whitaker and Hamilton, 1998). These authors summarized the results of the examination of 1,500 coyote scats collected in the Adirondacks and wild mammals were the most frequent component (78%), followed by fruits (21%), insects (10%), and birds (3%). The remaining components were reptiles, amphibians, and grasses. Carrion from large mammals such as deer is an important winter food source (Whitaker and Hamilton, 1998). Predation on young coyotes by dogs has been reported by Berg and Chesness (1978).

Movement patterns are generally within undefended territories, or home ranges, that vary geographically and seasonally (Bekoff, 1977). In western Tennessee, Babb and Kennedy (1988) reported that homes ranges averaged 31 km^2 for males and 60 km^2 for females.

Urocyon cinereoargenteus Schreber (Gray Fox)

The gray fox, a medium-sized canid, is slightly smaller than the red fox. Pelage has a "salt and pepper" appearance on the upperparts, a cinnamon neck and underparts, a

dorsal median black stripe on a black-tipped tail, and black-tipped ears. Measurements of four adults from Georgia were: total length 921-955mm (avg.=935), tail length 280-351 mm (avg.=322), length of hind foot 120-150 mm (avg.=132) (Cothran et al., 1991). Dentition, i. 3/3, c. 1/1, p. 4/4, m. 2/3 =42 (Fritzell and Haroldson, 1982).

The range of the gray fox extends into southern Canada, westward to the Pacific Coast, and southward to northern Venezuela and Columbia (Fritzell and Haroldson, 1982). There are 16 recognized subspecies of *U. cinereoargenteus*, but only *U. c. cinereoargenteus* is native to the mid-Atlantic region (Samuel and Nelson, 1982).

Gray foxes inhabit areas with a diversity of fields and woods, but are most common in areas that are mostly forested (Samuel and Nelson, 1982). All 18 individuals captured on APH were trapped in riparian forests; however, we have observed them in old fields and upland pine, mixed, and hardwood forests. Average home range size varies according to sex and geographic location. In West Virginia, male (n=3) home ranges averaged 97 ha and the home range of a single female was 75 ha (Yearsley and Samuel, 1980). Home ranges are stable throughout the year and do not shift as seasonal food becomes available (Greenburg and Pelton, 1994). Home ranges often include a heterogeneous group of habitat types that provides a wide range of foods in all seasons (Greenberg and Pelton, 1994). Mammals, primarily cottontails and rodents, comprise the bulk of the winter diet (Samuel and Nelson, 1982). Mammals remain important year-round as prey, but during summer insects and fruit predominate (Wood, 1958). Natural predators of gray foxes are few, but include raptors and bobcats (Mollhagen et al., 1972; Whitaker and Hamilton, 1998).

Like red foxes, gray foxes may sometimes kill game species and livestock (Samuel and Nelson, 1982). Gray foxes are economically important furbearers. Management plans for both gray and red foxes have shifted from "bounties" designed to reduce their numbers to regulation and maintenance of their populations for continued hunting and trapping.

Vulpes vulpes Linnaeus (Red Fox)

The soft dense pelage of the red fox is reddish-yellow on the head, back, and tail, darkest on the shoulders, and white on the tip of the tail, belly, and throat and the ears are often tipped in black. An adult male captured on APH weighed 4.9 kg. Measurements were: total length 970 mm, tail length 360 mm, length of hind foot 149 mm, ear length 79 mm. The average weight of three adults from Georgia was 3.0 kg (Cothran et al., 1991). Ranges of measurements for the same three adults were: total length 639-940 mm (avg.=776), tail length 245-335 mm (avg.=282), length of hind foot 117-150 mm (avg.=133) (Cothran et al., 1991). Dentition, i. 3/3, c. 1/1, p. 4/4, m. 2/3 =42 (Samuel and Nelson, 1982).

Red foxes have the broadest distribution of any carnivore in the world (Samuel and Nelson, 1982). They occur throughout Europe, all but the most northern regions of Asia, and they have been introduced to Australia. In North America, its range includes all of Alaska and Canada and extends south throughout most of the United States, except the extreme southwestern regions, southern Florida, and parts of the Great Plains (Hall, 1981). Of numerous subspecies (Larivière and Pasitschniak-Arts, 1996), only *Vulpes v. fulva* occurs in the eastern United States and APH (Samuel and Nelson, 1982).

Red foxes frequent open habitats, such as old fields, edges, and croplands, and unlike gray foxes they are seldom seen in heavily wooded areas (Samuel and Nelson,

1982). Five individuals captured on APH were trapped in riparian habitats, an impoundment, and forested streamside habitats. They have also been observed on APH in upland forests and old fields. Diet consists primarily of small mammals, but fish, reptiles, insects, garbage, carrion, and plant matter may be seasonally or locally important (Cothran et al., 1991; Mitchell, 1994). Various carnivores including raptors and coyotes occasionally eat young foxes; coyotes are known to kill adult red foxes (Whitaker and Hamilton, 1998).

Most current management of foxes involves hunting and trapping regulations, however, habitat management has been suggested (Samuel and Nelson, 1982). The red fox probably benefits from early successional habitats.

Procyon lotor Linnaeus (Raccoon)

The raccoon is one of the most recognizable mammals of the region due to its conspicuous facial mask and ringed tail. Weights of adult females generally average 10 to 15% less than males (Kaufmann, 1982). Weight of 16 individuals captured on APH ranged from 3.4 to 6.0 kg for 10 males (avg.=4.8 ±0.8 kg) and 3.4 to 6.0 kg for six females (avg.=4.5 ±1.0 kg). Measurements for the same males and females, respectively, were: total length 754-890 mm (avg.=819 ±38), 580-938 mm (avg.=758 ±144); tail length 199-284 mm (avg.=232 ±29), 200-290 mm (avg.=241 ±35); length of hind foot 104-114 mm (avg.=110 ±4), 98-116 mm (avg.=108 ±7); ear length 29-64 mm (avg.=50 ±11), 35-58 mm (avg.=48 ±9). Dentition: i. 3/3, c. 1/1, p. 4/4, m. 2/2 =40 (Lotze and Anderson, 1979).

The raccoon ranges from southern Canada through Central America (Kaufmann, 1982). Of the 25 recognized subspecies, only *P. l. maritimus* is known from the region (Hall, 1981).

Raccoons are generally associated with riparian habitats such as swamps, coastal salt marshes, and along the banks of streams and lakes, but it will readily frequent moist uplands, suburban neighborhoods, and agricultural areas (Wass, 1972; Webster et al., 1985). We captured raccoons on APH in upland and riparian habitats. We have also been observed in clearcuts, old fields, and roadside fire-breaks. Raccoons are opportunistic omnivores, however, preferred foods are arthropods (especially crayfish and crabs), small rodents, fish, berries, acorns, fruits, eggs and adults of freshwater turtles, and in agricultural areas, grains such as corn, wheat, and millet (Whitney, 1931; Lotze and Anderson, 1979; Mitchell, 1994). The raccoon is a major predator of young muskrats (Wass, 1972). Predation on adult raccoons is likely infrequent, however, bobcats, coyotes, dogs, foxes, and Great Horned Owls will occasionally consume them (Kaufmann, 1982).

Raccoons are often considered a vector for disease and in the southeastern United States are known to carry at least 13 pathogens that are transmittable to humans and their pets (Bigler et al., 1975). Among the most notable are leptospirosis, rabies, tularemia, and canine distemper (Lotze and Anderson, 1979). Raccoons harbor a wide variety of internal and external parasites. In southwestern Georgia, one of the most common external parasites is the tick *Dermacentor variabilis*, which is known to transmit tularemia (Lotze and Anderson, 1979).

Although the demand for pelts fluctuates, raccoons remain an important commercial fur species. Males tend to be more trappable than females, two to one in most studies or censuses, probably because males tend to move more and have larger home

ranges (Kaufmann, 1982). Results from the 1998/1999 trapping season on APH were consistent with this result, males (n=45) outnumbered females (n=19).

Lontra canadensis Schreber (River Otter)

Pelage of this large, semiaquatic mammal is brown on upperparts, paler below, with dense gray-tipped underfur. The lower jaw and throat are whitish. Females are slightly smaller than males. Weight of six individuals captured on APH ranged from 5.8 to 7.7 kg for three males (avg.=6.8 ±1.0 kg) and 4.6 to 9.5 kg for three females (avg.=6.9 ±2.5 kg). Measurements for these males and females, respectively, were: total length 999-1,120 mm (avg.=1,080 ±70), 963-1,170 mm (avg.=1,071 ±104); tail length 335-423 mm (avg.=397 ±54), 339-425 mm (avg.=376 ±44); length of hind foot 111-126 mm (avg.=120 ±7), 113-121 mm (avg.=116 ±4); ear length 12-25 mm (avg.=20 ±7), 14-24 mm (avg.=19 ±5). Dentition: i. 3/3, c. 1/1, p. 4/3, m. 1/2 =36 (Toweill and Tabor, 1982).

The historical distribution of the river otter encompassed most of North America. They were present in all waterways of the United States and Canada until at least the 18th century, however, overtrapping extirpated them from many states and portions of others (Toweill and Tabor, 1982). There are 7 recognized subspecies of *L. canadensis*, but only *L. c. lataxina* is known from the region (Hall, 1981).

River otters occur in a wide variety of aquatic habitats, especially those maintained by beavers (Newman and Griffin, 1994). In the mid-Atlantic region, they are present in coastal estuaries and the lower reaches of most river systems (Webster et al., 1985). Fish and crayfish are the most important dietary components, but they will consume mammals, especially muskrats, turtles, and amphibians (Gilbert and Nancekivell, 1982). No predator has been shown to seriously affect river otter populations (Toweill and Tabor, 1982).

Due to the thick and durable pelage, river otters have been commercially important furbearers since the European settlement of North America. In the past they has been erroneously accused of depleting game fish populations, in fact, otters are often a benefit to game fish through predation of non-game fish species that can potentially displace game fish (Toweill and Tabor, 1982).

Mephitis mephitis Schreber (Striped Skunk)

The striped skunk is readily identified by its odor and its pelage, which ranges from black with a large white patch that extend from the back of the head to the rump to all black. Females are roughly 15% smaller than males (Hall, 1981). Body measurements of 26 individuals from Indiana were: total length 447-635 mm (avg.=586), tail length 159-290 mm (avg.=221), length of hind foot 48-71 mm (avg.=63) (Whitaker and Hamilton, 1998). Dentition: i. 3/3, c. 1/1, p. 3/3, m. 1/2 =34 (Wade-Smith and Verts, 1982). This species was well represented on APH (n=11) during the 1998/1999 furbearer trapping season but weights and measurement data were not made available.

The distribution of the striped skunk includes southern Canada, northern Mexico, and all regions of the contiguous United States except some arid areas of the extreme southwest (Wade-Smith and Verts, 1982). There are 13 recognized subspecies of *M. mephitis* and both *M. m. nigra* and *M. m elongata* are known from Virginia. *Mephitis m. elongata* is most prevalent in the Piedmont and mountains (Hall, 1981) and *M. m. nigra* occurs on the Coastal Plain (Whitaker and Hamilton, 1998).

Striped skunks inhabit many habitat types, including old fields, forests, and croplands (Verts, 1967). On APH, they were frequently captured in beaver-maintained habitats and observed in upland forests. Striped skunks are omnivores that feed primarily on insects, but also eat fruits and crops in season (Verts, 1967). In spring and winter, when preferred insects are scarce, small mammals, snakes, bird eggs and nestlings, and freshwater turtles and their eggs become important dietary components (Wade-Smith and Verts, 1982; Mitchell, 1994). Great Horned Owls, Barred Owls, bobcats, foxes, coyotes, and dogs are known to prey on striped skunks (Godin, 1982).

Insect control, especially those insects that negatively affect crop production, is the primary economic value of striped skunks. They are commercially important fur-bearers, particularly in northern states where they are often protected within management guidelines (Godin, 1982).

Mustela frenata Lichtenstein (Long-tailed Weasel)

The long-tailed weasel has the typical tubular mustelid body with short legs. Its tail reaches 44-70% of body length (Sheffield and Thomas, 1997). Pelage is brown dorsally with underparts yellow or buff continuous from the chin to the inguinal area. Southern populations lack white winter pelage (Sheffield and Thomas, 1997). Females are approximately two-thirds the size of males (Cothran et al., 1991). Measurements for 20 adult males and 13 adult females from a population in New York, respectively, were: total length 374-447 mm (avg.=405), 306-362 mm (avg.=325); tail length 124-157 mm (avg.=135), 95-117 mm (avg.=108); length of hind foot 42-50 mm (avg.=45), 35-41 mm (avg.=37) (Whitaker and Hamilton, 1998). Dentition: i. 3/3, c. 1/1, p. 3/3, m. 1/2 =34 (Cothran et al., 1991).

Long-tailed weasels have the broadest distribution of any mustelid in the Western Hemisphere and occur in all life zones except desert (Sheffield and Thomas, 1997). They occur in North America in southern Canada, throughout the United States except the extreme Southwest, and throughout Mexico and Central America. Of 35 recognized North American subspecies, only *M. f. novaboracensis* occurs in Virginia (Hall, 1981). Long-tailed weasels have not yet been collected on APH, although they should be present (Handley and Patton, 1947; Whitaker and Hamilton, 1998).

As with least weasels, habitat use is primarily based on prey abundance, but ecotones, habitats with dense brush or vegetation, and those close to standing water seem to be preferred (Gamble, 1981). Diet consists mainly of small rodents (particularly *Microtus* and *Peromyscus* spp.), shrews, and young cottontails (Hamilton, 1933). Occasionally moles, bats, birds, bird eggs, and rarely snakes, lizards, and insects are eaten (Polderboer et al., 1941; Teer, 1964; Mumford, 1969). Predators of long-tailed weasels include snakes, raptors, and foxes (Hamilton, 1933).

Mustela nivalis Linnaeus (Least Weasel)

The least weasel is the smallest member of the order Carnivora. Summer pelage is brown above and white below; winter pelage is white in northern regions and brown above and below in southeastern regions (Sheffield and King, 1994). Males are larger than females. A single female collected on APH weighed 34.5 g; measurements were: total length 180 mm, tail length 32 mm, length of hind foot 21 mm, length of ear 10 mm (Bellows et al., 1999b). Weights of five males and two females from West Virginia and from the Piedmont and montane areas of Virginia ranged from 34 to 64 g (avg.=44

g) for males and 25 g for females (Handley, 1991). Measurements of these males and females, respectively, were: total length 184-217 mm (avg.=196); 174-175 mm; tail length 28-42 mm (avg.=34), 26-34 mm; length of hind foot 22-25 mm (avg.=23), 18-20 mm. Dentition: i. 3/3, c. 1/1, p. 3/3, m. 1/2 =34 (Sheffield and King, 1994).

The species has a circumboreal distribution, which in North America includes all of Alaska, Canada except extreme western areas, north-central United States, and southward down the Appalachian Mountains (Sheffield and King, 1994). Of the four recognized subspecies of *M. nivalis*, only *M. n. allegheniensis* occurs in the Eastern United States (Hall, 1981). The female captured at APH represented the first least weasel reported from Virginia's Coastal Plain (Bellows et al., 1999b). It is not clear whether this capture represents a recent range expansion or is the result of trapping this animal in an area previously unstudied. Other Virginia records for this species are from the mountains and Piedmont (Handley, 1991).

Least weasels are known to occupy many habitats, and home ranges are primarily determined by prey availability (Sheffield and King, 1994). The female collected on APH was captured in a mixed pine-hardwood forest (Bellows et al., 1999b). Small mammals comprise 50 to 80% of the diet, mostly rodents (over 90% in autumn and winter), birds, lizards, and insects are also eaten (Hamilton, 1933). Predators of the least weasel are similar to (and include) the long-tailed weasel (Hamilton, 1933; Handley, 1949; Jackson, 1961).

Mustela vison Schreber (Mink)

This medium-sized member of the weasel family is well known for its soft, lustrous pelage that in wild forms is primarily chestnut brown. Underparts are somewhat lighter than the dorsal surface. Underfur is dense, overlain with oily guard hairs that serve as waterproofing (Lowery, 1974). Females average 10% smaller in external body measurements and about 50% less in weight than males (Hall, 1981). Weight of a single adult male captured on APH was 1.8 kg. Measurements were: total length 641 mm, tail length 225 mm, length of hind foot 68 mm, ear length 19 mm. Weights from throughout its range for males range from 0.9 to 1.6 kg and females from 0.7 to 1.1 kg (Jackson, 1961). Adult measurements for these individuals, males and females, respectively, were: total length 580-700 mm, 460-575 mm; tail length 190-230 mm, 150-190 mm; length of hind foot 68-80 mm, 60-70 mm (Jackson, 1961). Dentition: i. 3/3, c. 1/1, p. 3.3, m. 1/2 =34 (Linscombe et al., 1982).

The range of the mink includes all of Canada south of the tree line and all of the lower 48 United States except portions of southwestern states. Of 16 recognized subspecies, two (*M. v. vison* and *M. v. mink*) occur in Virginia. *Mustela v. vison* is restricted to southwestern montane regions of Virginia and *M. v. mink* is found in the Piedmont and Coastal Plain (Hall, 1981)

Mink occur in all types of aquatic habitats, including human constructed habitats (e.g., drainage ditches and canals) (Clark et al., 1985; Linscombe et al., 1982). During the 1998/1999 trapping season on APH, mink were trapped in streamside riparian forests and forests surrounding impoundments. They are opportunistic carnivores that feed on most small aquatic and terrestrial animals; readily eating whatever prey is abundant (Gilbert and Nancekivell, 1982; Linscombe et al., 1982). Wilson (1954), who examined the stomach contents of 335 mink in northeastern North Carolina, recorded the following percentages: fish 61%, mammals 34%, arthropods 30%, birds 18%,

amphibians 13%, and reptiles 5%. Mink are occasionally eaten by red and gray foxes, bobcats, and Great Horned Owls (Linscombe et al., 1982).

Mink have long been considered one of the most desired furs on the commercial market, mostly due to the perceived prestige of owning a mink garment. Mink ranching practices that produce large quantities of perfectly matched pelts have reduced trapping pressure on wild populations (Linscombe et al., 1982).

Lynx rufus Schreber (Bobcat)

The bobcat is roughly twice the size of the domestic cat, but is readily distinguished by the very short tail, and otherwise taller and muscular build. Males are larger than females. Pelage is yellowish to reddish brown and is streaked or spotted with black to dark brown. Guard hairs are black-tipped. Underparts are black with white spots. One bobcat was collected on APH during the 1998/1999 trapping season, however, measurements for this individual were not made available. Adult measurements for 37 males and 51 females, respectively, from North Carolina were: total length 610-940 mm (avg.=823), 610-864 mm (avg.=728); tail length 113-178 mm (avg.=138), 90-152 mm (avg.=121); length of hind foot 137-178 mm (avg.=159), 127-165 mm (avg.=145) (Whitaker and Hamilton, 1998). Dentition: i. 3/3, c. 1/1, p. 2/2, m. 1/1 =28 (McCord and Cardoza, 1982).

Bobcats are distributed from southern Canada to most of Mexico. They were extirpated from much of the Ohio Valley, upper Mississippi Valley, and southern Great Lakes region. Two of 12 recognized subspecies (*L. r. floridanus* and *L. r. rufus*) are found in the mid-Atlantic region (Hall, 1981). Only *L. r. rufus* is present on APH.

Bobcats frequent a diverse array of habitats ranging from dry (xeric) to moist (mesic), however, the principal factor that defines habitat quality is prey abundance (Larivière and Walton, 1997; Koehler and Hornocker, 1989). A strict carnivore, bobcats are known to eat sciurids (squirrels) and microtines (voles and mice) opportunistically, but feed primarily on lagomorphs (rabbits and hares) (Whitaker and Hamilton, 1998). They will occasionally attack poultry and young livestock (Cothran et al., 1991). Adult bobcats are rarely victims of predation, however, kittens may be killed by foxes, coyotes, and owls (McCord and Cardoza, 1982).

Bobcats are secretive animals that avoid interaction with humans and are rarely seen even in areas where tracks are commonly observed. Bobcat pelts have remained commercially valuable since the European settlement of North America (McCord and Cardoza, 1982).

Order Artiodactyla

Odocoileus virginianus Rafinesque (White-tailed Deer)

The white-tailed deer is a large even-toed ungulate and the largest herbivore occurring in Virginia. Males have antlers that are grown annually and shed in winter following the breeding season. Summer pelage is thin and wiry, red-brown to bright tan dorsally, but underparts, including tail, inside of legs, belly, and chin are white. Pelage is longer and thicker in winter, with upperparts blue-gray to gray-grown. Weight and external adult measurements vary greatly depending on subspecies and location with high elevation and northern populations reaching generally larger sizes. Average dressed weights for aged adult deer (1.5 yrs and older) harvested on APH during three hunting seasons on APH were: bucks (1997/1998, n=502, 28.6 kg; 1997/1998, n=390,

37.2 kg, 1999/2000, n=286, 31.3 kg) (Table 1), and does (1997/1998, n=629, 28.7 kg; 1997/1998, n=480, 29.6 kg, 1999/2000, n=278, 29.8 kg) (Table 2). Average antler beam diameter for the same group of bucks was: 1997/1998, 24 mm; 1998/1999, 26 mm; 1999/2000, 23 mm (Table 1). Dentition: i. 0/3, c. 0/1, p. 3/3, m. 3/3 =32 (Hesselton and Hesselton, 1982).

In North America, the white-tailed deer is found from southern Canada throughout the contiguous United States (except some southwestern regions), and throughout Mexico and Central America (Hall, 1981). Of the 30 recognized, only *O. v. virginianus* occurs in Virginia (Smith, 1991). White-tailed deer are the only remaining native member of the deer family (Cervidae) occurring in the mid-Atlantic region (Webster et al., 1985). Another cervid, the elk or wapiti (*Cervus canadensis*) disappeared from Virginia in 1855 (Handley and Patton, 1947).

During the Colonial period, white-tailed deer were abundant throughout the state, but agricultural expansion and uncontrolled hunting severely reduced Virginia's deer herd, reaching lowest numbers by 1925 (Handley and Patton, 1947; Barick, 1951). Between 1930 and 1950 over 1,800 white-tailed deer were introduced into Virginia from nearby states (Engle, 1951). In conjunction with restocking programs, strict hunting laws, shorter hunting seasons, and abundant suitable habitat, the white-tailed deer has become abundant statewide. White-tailed deer distribution and abundance appears to positively correlate with the distribution of forest openings, riparian zones, and farmlands. As a result of abundant habitat, white-tailed deer are common throughout APH. Their diet tracks the seasonal availability of plant material. Succulent green plants and mushrooms are preferred in summer. In autumn, acorns are dominant, but Japanese honeysuckle, grapes (*Vitis* spp.), sumac, blueberries, and green brier are also important foods. Winter foods are primarily acorns, grasses, and honeysuckle (Hesselton and Hesselton, 1982). Most agricultural crops are readily eaten when available. Major predators of the white-tailed deer are feral dogs and the coyote.

Historically, counts of yearly buck and doe harvests were the only data available on the deer herd on APH. Wildlife biologists on APH were more interested in determining if deer have exceeded the carrying capacity of the installation's habitat than in an absolute estimate of the size of the herd. A primary indicator of the herd's relationship with carrying capacity is overall herd health. Therefore, in recent years, extensive data have been collected to determine the health of the deer herd on APH. The data collected on harvested deer include body weight/age class, evidence of hemorrhagic disease (splitting or sloughing hooves), antler beam diameter (ABD) and number of antler points (bucks), and evidence of lactation (does) (Tables 1-3). In more extensive health checks, complete necropsies were performed and bone marrow consistency, fat covering of body organs, and the number of fetal fawns per doe were also documented (Table 2). In 1996, the deer herd was determined to have exceeded the carrying capacity and the deer were in poor health.

To improve deer herd health, APH wildlife biologists increased the harvest, in particular the doe harvest, by increasing the number of days that does could be harvested and by adding a special muzzleloader season. After four years of intensive harvesting (1996-2000), improved health was realized in deer 2.5 yrs-old and younger. For a more detailed description of the current deer management plan refer to the "Hunting and Trapping Programs" section.

TABLE 1. Summary of age and three health attributes for a sample of white-tailed deer bucks harvested during three consectutive hunting seasons (1997/1998, 1998/1999, 1999/2000) on Fort A. P. Hill, Virginia. Hemmorhagic disease = HD. Antler beam diameter = ABD.

Mean	Aged (*n*)			Mean dressed weight (kg)			Individuals with HD			Mean ABD (mm)		
Age (yrs)	97/98	98/99	99/00	97/98	98/99	99/00	97/98	98/99	99/00	97/98	98/99	99/00
0.5	150	118	83	15.0	16.8	17.7	2	2	4			
1.5	211	119	104	29.5	29.9	31.3	3	4	8	14	15	15
2.5	87	101	65	39.5	39.5	40.4	4	4	5	22	22	23
3.5	43	45	28	43.1	42.2	44.5	0	1	1	26	24	26
4.5	9	3	6	47.6	49.9	50.8	0	0	0	31	32	30
5.5	2	3		49.0	49.9		0	0		28	36	
6.5		1			52.2			0			32	
Mean (all classes)				37.3	40.1	36.9						
Mean (≥ 1.5 yrs)				41.7	42.3	41.8				24	26	23
Total aged		502	390	286			9	11	18			
Total unaged		264	317	309								
Total harvest		766	707	595								

TABLE 2. Summary of age and four health attributes for a sample of white-tailed deer does harvested during three consectutive hunting seasons (1997/1998, 1998/1999, 1999/2000) on Fort A. P. Hill, Virginia. Hemmorhagic disease = HD. Data for mean number of fetuses/doe were not available for the 1997/1998 and 1998/1999 hunting seasons.

Mean	Aged (*n*)			Mean dressed weight (kg)			Individuals with HD			Lactating does (*n*)			Fetus/doe
Age (yrs)	97/98	98/99	99/00	97/98	98/99	99/00	97/98	98/99	99/00	97/98	98/99	99/00	98/99
0.5	177	117	66	14.5	15.9	16.3	4	6	3				
1.5	131	106	62	25.4	26.3	28.1	2	5	4	7	25	3	1.4
2.5	113	113	71	29.5	30.4	31.3	2	3	7	31	62	29	0.7
3.5	98	63	46	30.8	31.8	31.8	1	4	4	27	31	4	1.2
4.5	44	29	14	31.3	32.7	31.8	1	1	1	16	17	1	2.0
5.5	27	21	6	30.8	32.2	34.0	0	0	0	5	15		1.0
6.5	14	13	6	30.4	31.3	32.2	0	0	0	2	6		1.3
7.5	5	4	3	33.1	33.6	31.8	1	0	0	0	2		1.2
8.5	17	9	3	29.5	32.2	33.6	0	0	0	3	3		
9.5	1	2	1	29.5	33.1	27.2	0	0	0	1	2		
10.5	2	2		30.8	28.1		0	0		0	0		
12.5		1			27.2			0			0		
Mean (all classes)				28.7	29.6	29.8							
Mean (< 1.5 yrs)				30.1	30.8	31.3							1.3
Total aged	629	480	278				11	19	19	92	163	37	
Total unaged	293	382	295										
Total harvest	922	862	573										

TABLE 3. Description of health parameters for white-tailed deer.

Weight:	An indicator of the health and nutritional status. Low mean weights, or declines in weight, as evidenced by long-term data, is an indication that a population has exceeded the carrying capacity of the environment.
Antler Beam Diameter (ABD):	An indicator of the amount of food consumed and a deer's nutrition; ABD is positively correlated with nutrition.
Number of antler points:	For the most part, the number of antler points is only of interest to the hunter, the exception is that well nourished bucks may go from a button buck to a forked (four point) buck in a year. A high percentage of yearling (1.5 yrs-old) spike bucks (50% or more) and low body weights indicate a nutritional deficit that often results from a population too large for the amount of available forage (Coggin, 1987).
Hemorrhagic Disease (HD):	This disease is caused by two different strains of virus. Deer infected with more virulent strains die within 72 hours. Those that survive typically show lesions and/or sloughing and/or splitting of the hooves (Davidson and Nettles, 1997). If many deer with HD are harvested, the size of the deer harvest for the next year(s) may need to be reduced or modified.
Productivity:	Although possible, doe fawns (6-7 months) do not typically breed (Smith 1991). Yearling does usually produce one offspring and older does usually twin until they are about 7-8 years old, when they cease reproduction. However, reproductive status can be confounded by health. Triplets may be born to does receiving adequate nutrition, and fawns in excellent health have are known to produce a single offspring (Halls, 1974). Conversely, older does that are in poor health produce fewer offspring.

TABLE 4. Summary of the occurrence of 40 terrestrial mammal species in generalized habitat types on Fort A. P. Hill, Virginia. See text for descriptions of the habitat types. An "X" indicates an original capture or an observation for the species in these habitats.

	Habitat type				
Species	Old Field & Clearcut	Pine*	Pine-hardwood	Hardwood	**Riparian & Wetland
Didelphis virginiana			X	X	X
Blarina brevicauda	X	X	X	X	X
Cryptotis parva	X	X	X	X	
Sorex hoyi	X	X	X	X	X
Sorex longirostris	X	X	X	X	X
Condylura cristata	X	X	X	X	
Scalopus aquaticus			X		
Eptesicus fuscus	X		X	X	X
Lasionycteris noctivagans			X	X	X
Lasiurus borealis	X	X	X	X	X
Lasiurus cinereus				X	X
Myotis austroriparius			X	X	X
Myotis lucifugus	X		X	X	X
Myotis septentrionalis			X	X	X
Nycticeius humeralis				X	X
Pipistrellus subflavus	X		X	X	X
Sylvilagus floridanus	X		X	X	
Glaucomys volans		X	X	X	X
Marmota monax	X			X	X
Sciurus carolinensis		X	X	X	X
Tamias striatus		X	X	X	
Castor canadensis			X	X	X
Microtus pennsylvanicus	X		X	X	
Microtus pinetorum	X	X	X	X	X
Ondatra zibethicus			X	X	X
Oryzomys palustris			X	X	X
Peromyscus leucopus	X	X	X	X	X
Reithrodontomys humulis	X			X	
Zapus hudsonius	X	X		X	X
Canis latrans		X	X		X
Urocyon cinereoargenteus	X	X	X	X	X
Vulpes vulpes	X			X	X
Procyon lotor	X	X	X	X	X
Lontra canadensis				X	X
Mephitis mephitis		X	X	X	X
Mustela frenata					
Mustela nivalis			X		
Mustela vison				X	X
Lynx rufus				X	X
Odocoileus virginianus	X	X	X	X	X

* Includes pine plantations

** May be a subset of successional habitats that include beaver ponds, swamps, impoundments, and streamside floodplain

Introduced Species

In addition to domestic pets and livestock, several species of mammals closely associated with humans have been introduced into North America from the Old World. Two species, Norway rat and house mouse, likely occur from time to time in parts of the APH complex. Both species are most common in or near human-made structures but are sometimes found in more natural settings. The typical laboratory rat and laboratory mouse are albinistic forms of the Norway rat and house mouse, respectively.

Another introduced rat, the black rat or roof rat, *Rattus rattus* (Linnaeus), has been collected at widely scattered localities in the Commonwealth, but its occurrence at APH is unlikely. It can be distinguished from the Norway rat (*Rattus norvegicus*) by its somewhat darker coloration and from both *R. norvegicus* and native rats by its long slender and tapered tail, which is greater than half the total length. Jackson (1982) provides an overview of these introduced species.

Rattus norvegicus Linnaeus (Norway Rat)

Also sometimes called sewer or barn rat, Norway rats are well known for the damage they do to structures, and especially their consumption and contamination of stored dry goods, fruit, and grains. Although closely associated with human-made structures (e.g., garbage dumps and general trashy areas) they are sometimes found nearby in overgrown fields and stream banks. The Norway rat can be easily distinguished from other rats or rat-like forms in the study area by its prototypic rat form, which includes scruffy fur, small ears, and a heavy, long and nearly hairless scaly tail. It has a much thicker tail than the marsh rice rat or the hispid cotton rat, (see below), and adults are larger than adults of these native species. Young Norway rats that approximate the adult size of the rice rat and cotton rat will have the conspicuously large "puppy feet" that are characteristic of young mammals.

Mus musculus Linnaeus (House Mouse)

The house mouse is very much at home in human dwellings, granaries, barns, and other such dwellings, and yards and cultivated fields, but it is also found sometimes in more natural settings including meadows and marshes. This mouse has not been captured on APH but it is likely present in or near some of the buildings. The house mouse is easily distinguished from the somewhat similar eastern harvest mouse by the absence of the longitudinally grooved upper incisors. Adult white-footed mice are larger, have larger eyes and ears, body and tail are much more distinctly bicolored, and the species has a much sharper line of demarcation between dorsal and ventral coloration than is found in the house mouse. When viewed laterally, the incisors of *Mus musculus* reveal a distinct notch on the back near the tip. The notch is not present in other rodents of the area.

Species Recorded From The Vicinity of APH

Several species of mammals are known to occur in the mid-Atlantic region that encompasses APH. At least two of them may be found on the base in future research efforts.

Sigmodon hispidus Say and Ord (Hispid Cotton Rat)

Hispid cotton rats are small, native rodents found primarily in old field-habitats. In much of their range in the Commonwealth they are especially abundant in late-stage

old fields that include patches of honeysuckle and blackberries and oftentimes saplings of pioneer trees. As the name hispid suggests, elongate guard hairs in its dorsal pelage have a spiny appearance and are tipped with black; its hair is otherwise relatively long and coarse. It has relatively uniform gray pelage ventrally and its feet are dark brown to blackish. Adults are much smaller than adult Norway rats and their tails are much thinner. Hispid cotton rats superficially resemble marsh rice rats but tails on rice rats are much longer and the belly and feet of marsh rice rats are whitish.

Hispid cotton rats have expanded their range northward in much of North America. They were not collected in Virginia until the early 1940s (Patton, 1941). Subsequently, Pagels and Adleman (1971) reported this species from Chesterfield County, and later it was found in northern Powhatan County to the west and north of the James River in eastern Henrico County (Pagels, 1977). More recently, cotton rats were found farther north in the Piedmont in Cumberland County (Pagels et al., 1992), and they has been collected at relatively high elevations in the Blue Ridge in Nelson County (J. Cranford and J. Pagels, personal observations). Humans have played critical roles in the range expansion of the hispid cotton rat in their creation of an abundance of early successional habitat and the introduction of Japanese honeysuckle, an obvious component of old-field habitats at most Virginia sites (Wright and Pagels, 1977). If range expansion continues, it seems likely that the hispid cotton rat will be found at APH.

Ochrotomys nuttalli Harlan (Golden Mouse)

The golden mouse is known for its aboveground nesting and feeding. It occurs in many habitats but is most common in forest edge or disturbed areas in forests that include abundant vine growth. It has a typical mouse-like form and has a soft, thick pelage that ranges from a deep, goldish-yellow on the back, to yellowish on the sides and creamy white ventrally. Golden mice somewhat resemble white-footed mice but the above characters, as well as smaller eyes and ears and no distinct line of demarcation between dorsal and ventral coloration, easily separate the two species.

The golden mouse occurs across much of the southern half of Virginia but not as far north as APH (Handley and Patton, 1947; Webster et al., 1985). Although there is no evidence of range expansion as in the hispid cotton rat, the golden mouse may sometime in the future occur on APH.

HUNTING and TRAPPING PROGRAMS

A hunting program has been in place on APH since 1945. As a federal military installation, U.S. Army regulations require that recreational activities such as hunting, trapping, and fishing be allowed to the fullest extent possible where there are no conflicts with the military mission. Daily assessments by the Directorate of Plans, Training, Mobilization, and Security during the hunting and trapping seasons determine which areas will be open to recreational use. Areas with any type of military training activity are closed to hunting.

Thirty Training Areas are open to general hunting and 28 Controlled Access Areas are open to hunting with certain restrictions. The Wildlife Refuge and the Impact Area are closed to hunting (Fig. 1). After successfully completing the Virginia Hunter Safety Course (regulation #APH CIR 200-00-2), licensed hunters can hunt most of the training areas with an APH hunting permit. Controlled Access Areas are considered the buffer for the Impact Area. People hunting Controlled Access interiors must be familiar with

the areas through current or past employment or training and must pass yearly tests on local navigation and Installation, State, and Federal hunting regulations (regulation #APH CIR 200-00-3). Hunters can hunt locations along the perimeter of Controlled Access Areas after attending a briefing. There is currently a pilot program for disabled hunters (regulation #APH CIR 200-00-4, Disabled hunter pilot program regulations) with areas that have accessible stands designated for handicapped hunters.

Hunters are permitted to harvest deer with bow and arrow, muzzleloading rifles during special muzzleloader season, and shotguns. The use of dogs to hunt deer is prohibited, however, dogs may be used to hunt small game, quail, and waterfowl. In Controlled Access Areas, the use of dogs is permitted for waterfowl hunting only.

The installation sets its own hunting seasons. Most conform and run concurrent with state and federal seasons; differences are in accordance with base management needs. Although many game animals are pursued (e.g., gray squirrels, eastern cottontails, quail [*Colinus virginianus*], and wild turkey [*Meleagris gallopavo*]), the white-tailed deer is the primary focus of installation game managers. Harvest numbers for the 1999/2000 hunting season were typical for most years: 312 gray squirrels, 105 eastern cottontails, one red fox, one coyote, and 1,168 white-tailed deer.

In the hunting seasons 1985/1986 through 1999/2000, the deer harvest on APH ranged from 460 individuals (282 bucks and 178 does) in 1988 to 1,765 individuals (918 bucks and 847 does) in 1995 (Fig. 12). For the same time period, hunter effort (days in the field) ranged from 7,848 d in 1989 to 14,501 d in 1996 (Fig. 13). At the Savannah River Site, South Carolina, a comparably large federal facility, where dogs may be used, Cothran et al. (1991) reported 29% hunter success for hunting deer with dogs and 11% for still-hunting (without dogs). Still-hunter success was approximately 9% at APH, and is comparable to the success for still-hunters at the Savannah River Site.

In 1996 it was determined from data on deer health (Tables 1-3) that the deer population was exceeding the carrying capacity for APH. Does were then targeted in order to reduce the deer herd. To increase the overall harvest, while still focusing on increasing doe harvest, a special muzzleloader season was added and the number of doe days was increased. Bonus tag use for antlerless deer only was permitted three years before the state adopted a similar policy. Controlled Access Areas presented a special problem because they surround the Impact Area, a large area (10,925 ha) that cannot be hunted. To resolve this, the number of deer/day a hunter can harvest in Controlled Access Areas was increased from one to two—in Training Areas, the limit remained one deer/day. Deer of either sex may be harvested from Controlled Access Areas during the entire deer hunting season. In addition, APH enrolled the 28 Controlled Access Areas in the Commonwealth's Deer Management Assistance Program (DMAP). Through DMAP, the Virginia Department of Game and Inland Fisheries (VDGIF) provides antlerless deer tags in exchange for data collected (e.g., weight, indication of disease, reproductive status [evidence of lactation], age [using tooth wear], antler beam diameter) on harvested deer. These actions have collectively improved the health of the deer herd on APH.

The trapping program on APH is relatively small compared to the hunting program. It runs concurrently with the Virginia State trapping season, and most state and federal regulations are observed. Currently, 8 trappers participate in the program; all are employees or former employees of the post. Trapping is permitted in Training Areas

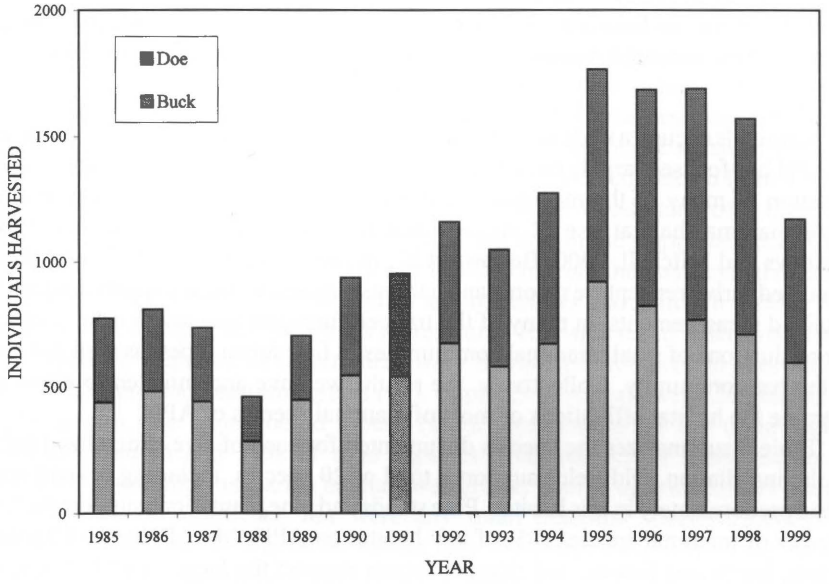

FIGURE 12. Summary of deer harvest for the 1985/1986 through 1999/2000 Virginia deer hunting seasons on Fort A. P. Hill, Virginia. Bars represent total harvest of bucks (light) and does (dark).

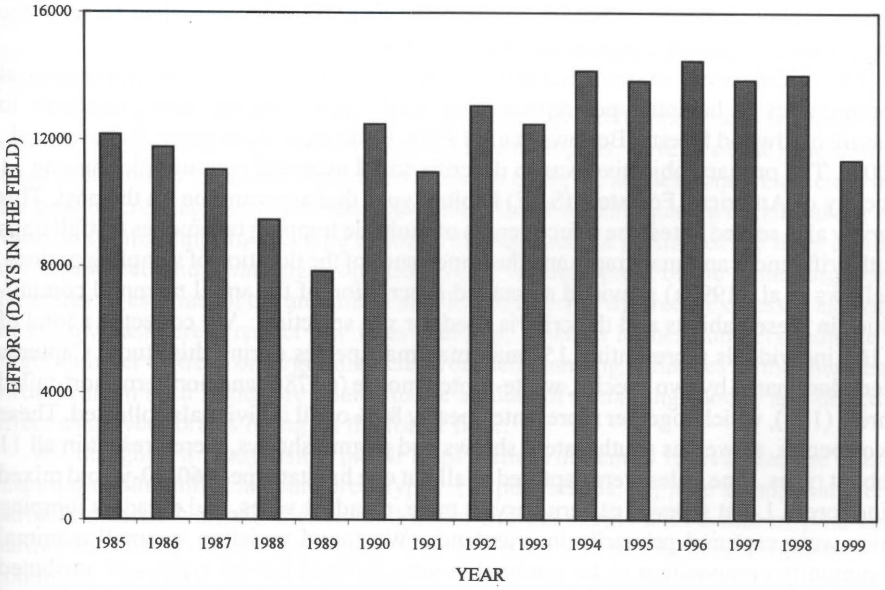

FIGURE 13. Summary of hunter effort (one day in the field = one day hunting for one hunter) for the 1985/1986 through 1999/2000 Virginia deer hunting seasons on Fort A. P. Hill, Virginia.

and Controlled Access Areas, and prohibited in the Impact Area. Most furbearer species are trapped but the beaver is targeted because it has a relatively high pelt value and because of the potential damage it can impose on the road system on the post.

DISCUSSION

Mammals occupy a wide variety of habitats in the mid-Atlantic region. Our research on APH has focused largely on habitat affiliations, community structure, and body size variation of many of the mammals on this military installation. We have evaluated small mammal habitat use of successional habitats, riparian, and upland habitats (Bellows and Mitchell, 2000; Bellows et al., in press ; Bellows et al., 2001). We also evaluated furbearer capture records and habitats targeted by local trappers, and we have obtained measurements on many of the trapped furbearer species. We are continuing our evaluations of small mammal communities in four forest types, as well our survey of the bat community. Collectively, the results we have accumulated to allow us to examine the habitat affiliations of most of mammal species of APH.

Table 4 summarizes the species documented for each of five generalized habitats on the installation. Old fields support a total of 20 species, including several species found predominately in this habitat. Pine stands and pine plantations support the fewest number of mammal species (15) of any habitat on APH. Mixed pine and hardwood forests, hardwood forests, and riparian forests support the largest number of species (27-34). Based on species richness, hardwood forests are the most important habitats for mammals on APH. With the possible exception of pine plantations, the habitat mosaic found on this installation provides abundant resources for mammal communities. This area should be representative of the upper Coastal Plain. However, much of Caroline County and eastern Virginia is in extensive agriculture and the remaining hardwood forests are being clearcut (A.S. Bellows and J.C. Mitchell, personal observations). Thus, APH is fast becoming a habitat island for the mammalian fauna of the upper Coastal Plain of Virginia and the mid-Atlantic region.

Our initial survey of small mammals on APH involved the study of small mammal communities in habitat types representing seral stages ranging from grasslands to mature hardwood forests (Bellows et al., 1999a; Bellows et al., in press; Bellows et al., 2001). The primary objective was to describe small mammal communities among 11 Society of American Foresters (SAF) habitat types that are common on the post. This survey also served to test the effectiveness of multiple trapping techniques (pitfall traps with drift fences and snap traps) and the importance of the duration of sampling periods. Bellows et al. (1999a) provided a detailed description of the small mammal communities in these habitats and the criteria used for site selection. We collected a total of 1,164 individuals representing 15 small mammal species during this study. Captures were dominated by two species, white-footed mouse (n=786) and northern short-tailed shrew (159), which together represented nearly 80% of all individuals collected. These two species, as well as southeastern shrews and pygmy shrews, were present in all 11 habitat types. Pine voles were captured in all but one habitat type—60-90-yr-old mixed pine forest. Least shrews, eastern harvest mice, meadow voles, and meadow jumping mice were captured primarily in grasslands. We found variation in small mammal community composition to be minimal among forested habitat types and attributed these results to the abundance of habitat generalist species, such as the white-footed mouse and the northern short-tailed shrew, that were present in all habitats.

We also studied small mammal communities in riparian and nearby upland habitats (Bellows and Mitchell, 2000). The primary objective was to compare small mammal communities between stream corridor and adjacent uplands in a forested ecosystem in the upper Coastal Plain of Virginia. Small mammal species richness and relative abundance were assumed to be higher in stream corridors because they frequently serve as dispersal corridors for many species. To test this possibility, we sampled 14 sites, 7 riparian sites and 7 upland sites, during 12 trapping sessions conducted from 9 April 1998 to 24 January 1999. Riparian sites were located in floodplains of 7 different tributaries, two in the Mattaponi River drainage and five in the Rappahannock River drainage. Upland sites were located between 150-250 m from their associated riparian site. Detailed descriptions of these habitats are in Bellows and Mitchell (2000). We collected a total of 162 small mammals representing four species of insectivores and three of rodents. Captures of insectivores were dominated by northern short-tailed shrews (n=23) and southeastern shrews (15). Captures of rodents were dominated by a single species, the white-footed mouse (115), representing all but three rodent individuals captured and 71% of total captures. The number of small mammals captured/100 trapnights in riparian habitats was greater than in upland habitats but the difference was not significant, nor were any small mammal species captured in significantly higher numbers in either habitat type. Although there was no significant difference in small mammal species richness between riparian (5 species) and upland habitats (6), Bray-Curtis ordination showed that there was more variation in small mammal community composition among riparian habitats than among adjacent uplands. This elevated variation in community composition was probably due to the isolated nature of the riparian sites compared to the contiguity of upland sites on the post and to the distribution of riparian sites between the two different river drainages. However, lack of a significant difference in average small mammal species richness and captures between riparian and upland trapping sites showed that both habitats are important to the long-term survival of the small mammal fauna in the upper Coastal Plain of Virginia.

Silvicultural treatment of forest stands to manage both timber and wildlife is a common approach used by foresters and wildlife biologists. Several of the pine-dominated stands on APH have recently been timbered using the shelterwood treatment with the goal of creating early successional habitat for bobwhite quail without having to resort to clearcutting. In this type of forest management, a portion of the trees on the site is removed and a varying proportion is left. Measurement of the remaining trees generates an estimate of the amount of area left covered by the trees, expressed as basal area. Low basal areas reflect few trees standing, whereas higher numbers indicate a larger number of trees or larger diameter trees left standing. Changes in the microenvironments in such stands are related to the amount of remaining canopy and directly affect small vertebrates living on the forest floor.

We designed a study using pitfall traps with drift fences to evaluate the small mammal communities in four forest types: (1) pine stands, (2) pine stands that were partially cleared with the shelterwood treatment, (3) stands with a mix of pine and hardwood, and (4) hardwood stands. The objective was to elucidate differences in community composition, species richness, and relative abundances of these animals, and to determine if the shelterwood treatment was adversely or positively affecting populations of these forest floor vertebrates. During March-September 2000 we

captured a total of 427 small mammals representing 14 species. Three species, Virginia opossum, eastern cottontail, woodchuck, were represented by one juvenile each. The remaining species were insectivores (4 species), rodents (6), and a single southern flying squirrel. More individuals (172) were captured in shelterwood sites, all other forest types had similar but lower numbers. The number of species in the four forest types varied from 7 to 9 (hardwood, 7 species; mixed, 8; pine, 9; shelterwood, 8). The shelterwood site had more downed woody debris due to recent logging operations and more herbaceous ground cover than the other forest types. This microhabitat provides more resources for seed and grass-eating rodents, especially the white-footed mouse, a habitat generalist species, and the meadow jumping mouse and eastern harvest mouse, two species well adapted to grassland habitats. The other forest types do not provide as much of the forest floor microhabitat favored by these mammals. Reducing forest canopy cover favors these rodents much more other insectivores, except the least shrew that commonly frequents open habitats.

The primary objective of our furbearer survey was to provide a first-level assessment of furbearer mammals on APH through analysis of trapping success and measurements of captured individuals. We worked with local licensed trappers and the Environmental and Natural Resources Division of APH. We collected data from animals trapped on APH between 5 December 1998 and 9 February 1999. Trappers provided daily capture success reports during this period. We recorded data from 345 individuals representing 10 furbearer mammal species. The external measurements and age for these individuals are provided in the associated species accounts. All of the 10 species of mid-sized mammals represented in this survey are known to occur in this area (Webster et al., 1985). Four other mid-size mammals that occur on APH, eastern cottontail, woodchuck, gray squirrel, and long-tail weasel, were not captured and were not addressed in this survey. The trappers reported no captures of wild domestic dogs or feral cats, although we have commonly observed them on APH.

The large geographic area encompassed by APH (30,329 ha) provides an excellent opportunity for examining population trends and habitat use of furbearer mammals. Population densities of many of these species fluctuate greatly from year-to-year, especially those species dependent on small mammal populations for food.

Our bat inventory on APH was designed to assess composition and variation in bat communities in different habitats. Eight of the 9 species of bats captured thus far in this survey (April 2000-June 2001) are known to occur in the region—no additional species are expected. All species are insectivorous and are members of the family Vespertilionidae, the most widely distributed family of bats (van Zyll de Jong, 1985). Two of the 8 species, silver-haired bat and hoary bat, should be present on the post in spring and fall only as they pass through the region on migratory routes. Another migratory species, the red bat, spends the summer here but generally migrates south where it overwinters (Shump and Shump, 1982b). Male red bats have been reported to overwinter and forage in the Great Dismal Swamp (Padgett and Rose, 1991). Little is known about migratory patterns of evening bats, but published records suggest that southern winter movements are frequently quite distant (Humphrey and Cope, 1968). Four species, little brown myotis, northern myotis, eastern pipistrelle, and big brown bat, are likely year-round residents in Virginia, although short seasonal migrations to and from hibernacula within the region are commonplace (Fenton and Barclay, 1980).

The southeastern myotis, a bat we recently discovered on APH (May 2001), reaches the northernmost limits of its range in Virginia (D. Webster, personal communication).

Bats were captured using mist nets set in likely corridors of bat movement at sites ranging from ground or water level to a height of 10 m. Our most successful sets were positioned over logging roads and road rut puddles, in openings in riparian/upland interfaces, and over woodland creeks with little or no emergent vegetation. Other productive sets included those under streetlights, over and under bridges, and across small power line openings. The red bat was the species most frequently captured. The big brown bat and eastern pipistrelle were also commonly captured. The remaining 7 species were captured in low numbers; two of these, silver-haired bat and hoary bat, are seasonal migrants.

Taken together, our research on APH allows for a robust evaluation and description of the mammalian fauna representative of the upper Coastal Plain of Virginia and the mid-Atlantic region. The value of such research in a military installation is obvious when one realizes that relatively intact landscapes and habitats are fast disappearing from eastern Virginia. Such public lands should be evaluated for all taxa, although we should not ignore other lands being deforested for agriculture and urban and suburban growth. Comparisons of mammalian faunas and those of other taxa between habitat islands, like APH, and altered landscapes would help explain the differences created by such anthropogenic changes.

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