National Park Service
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Northeast Region
Philadelphia, Pennsylvania

Survey of Mammals at Appomattox Court House National Historical Park

Technical Report NPS/NER/NRTR--2005/030

ON THE COVER
Golden mouse (*Ochrotomys nuttalli*) at Appomattox Court House National Historical Park, VA.
Photograph by: A. M. Roder and A. D. Chupp, Virginia Commonwealth University.

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U.S. Department of the Interior
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Abstract

Appomattox Court House National Historical Park (APCO), located in Appomattox County, Virginia, was surveyed to establish a baseline inventory of non-volant mammalian species during sampling in 2003 and 2004. Appomattox Court House NHP is a 718 ha (1,774 ac) park that includes a mosaic of successional habitat types that range from fescue fields to hardwood forests. We sampled in five major habitat types, field-forest edge, pine forest plantation, mixed pine hardwood, hardwood, and bottomland hardwood. Maintained fields and agricultural fields were not sampled. Mammals were sampled using several trap types, augmented by observations and night-camera photography. Twenty-one of 38 mammalian species that potentially could occur within APCO were documented. Capture success in traps was low, and the low number of recaptures prevented statistical analysis of differences in richness and relative abundance among habitat types. However, to serve as a baseline for more intensive future studies those numbers are presented within this report. During 6,797 trapnights 247 total individuals encompassing 14 species were captured. The white-footed mouse (*Peromyscus leucopus*) was the species captured most often, followed by the common raccoon (*Procyon lotor*), northern short-tailed shrew (*Blarina brevicauda*), and hispid cotton rat (*Sigmodon hispidus*). Field-forest edge and bottomland hardwood habitat types yielded the greatest relative abundance (numbers of individuals per unit effort) and richness of species. Species documented by observation included eastern cottontail (*Sylvilagus floridanus*), woodchuck (*Marmota monax*), and American beaver (*Castor canadensis*). The black bear (*Ursus americanus*) was documented by park personnel, and the common gray fox (*Urocyon cinereoargenteus*) and red fox (*Vulpes vulpes*) were documented only by night-camera photographs. Our findings strongly support the use of multiple sampling methods when attempting to document a diverse mammal fauna that ranges from the very small pygmy shrew (*Sorex hoyi*) to the black bear. Although several species may have been missed during our survey, there are factors that may have contributed to reducing the relative abundance and richness of species captured. The lack of true old-field habitat and maintenance of exotic fescue grass fields are detrimental to those species that depend on heterogeneous old-field habitat. One of our most successful sampling sites at APCO was a forest-field edge habitat type located adjacent to a field which had been chemically treated to discourage fescue grasses, and that had increased amounts of broomsedge (*Andropogon virginicus*) and bramble (*Rubus spp.*). Fields form an integral part of the cultural landscape of APCO, however, conversion of fescue fields to more characteristic secondary successional fields is encouraged to benefit mammals and other wildlife.

Executive Summary

Appomattox Courthouse National Historical Park (APCO), Appomattox County, Virginia, was surveyed to establish a baseline inventory of non-volant mammals in the years 2003 and 2004. No museum or published records of mammals from APCO were found, although distributional maps and personal knowledge of the area indicate that as many as 38 mammal species may potentially occur in the park. Habitat types at APCO largely reflect a continuum of successional habitats. Exclusive of maintained fescue fields that were not sampled, five major habitat types were identified and sampled, including field-forest edge, pine forest plantation, mixed pine hardwood, hardwood, and bottomland hardwood. Sampling was completed along a transect in the narrow field-forest edge habitat and in a circular plot in the other habitat types. A total of 21 mammal species were recorded that ranged in size from the pygmy shrew, one of the world's smallest mammals, to the black bear. Our findings support the importance of using multiple sampling methods in surveys. Of the 21 species recorded, 12 were captured only in traps, two were documented using night-camera photography, and four were documented through direct sighting or signs. Furthermore, most individuals of the two smallest species of shrews were captured in pitfall traps, most species the size of a mouse or rat were captured in small live traps, nearly all species the size of a Virginia opossum to a common raccoon were captured in large live traps, and most records of the largest species were obtained by night-camera photographs or observations. Overall trapping success was low during the survey. Because of a low number of recaptures, we could not statistically test whether differences in richness (number of species) and relative abundance (individuals captured per unit effort) were significantly different among habitats. Among the 14 species captured, seven species were represented by seven or fewer individuals. The white-footed mouse, a habitat generalist, represented nearly half of all individual mammals captured (115 of 247), and along with the common raccoon and Virginia opossum, was captured in all habitat types. Both relative abundance and richness of mammals were greatest in the field-forest edge habitat type, and lowest in the hardwood habitat type. Very little old-field habitat characteristic of secondary succession is present at APCO, and instead, the maintained and agricultural fields are dominated by fescue grasses. Mammal species, and wildlife in general, would likely benefit if fescue fields, or at least some of them, were converted to warm-season grasses. Our findings indicate a relatively rich mammal fauna at APCO, and as based on published distributional maps from the surrounding areas, with increased observations and sampling, the list of mammals that have been documented for APCO will increase considerably over time.

Introduction

The National Park Service has established the Inventory and Monitoring Program (I&M) to gather existing and new information about natural resources in the parks and to make that information readily available at different levels to park resource managers, the scientific community, and the public. For park managers to effectively maintain the biological diversity and ecological health of their parks they must have a basic knowledge of what natural resources exist in parks, as well as an understanding of those factors that may threaten them. One of the first goals of the I&M Program has been to establish baseline biological inventories for vascular plant and vertebrate species in order to provide reliable species lists—a fundamental tool for management.

This report presents the results of a baseline non-volant mammal inventory conducted at Appomattox Court House National Historical Park (APCO), located in Appomattox County, Virginia. The primary project objective was to document 90% of mammals, excluding bats, by confirming the existence of species known from the park and documenting the presence of new species. Excluding marine and domesticated species, 78 mammal species occur in Virginia (Linzey 1998). Based on distributional maps in Handley and Patton (1947), Linzey (1998), and Webster et al. (1985), 38 species are thought to occur at APCO. The NPSpecies (2005) database has no mammal species listed for APCO. Although we found no museum records of mammals designated as having been collected within APCO, some specimen records are available for Appomattox County.

Reconnaissance, identification of habitat types, and selection and layout of sampling sites were completed in spring 2003. Data collection was conducted over a 14-month period from June 2003 through August 2004. The study objectives were to 1) document 90% of mammal species, exclusive of bats, that occur within the boundaries of APCO, 2) document habitat-specific species abundance and richness to shed light on the importance of habitat types to mammals, 3) evaluate factors that impact sampling success and explore the use of multiple sampling techniques within the constraints of feasibility, and 4) provide park staff with conservation and management recommendations.

Study Area

Appomattox Court House National Historical Park (APCO) is located in Appomattox County, Virginia, roughly 110 km (68 mi) west of the fall line (the juncture of the Coastal Plain and Piedmont physiographic regions). The park is located in the Piedmont physiographic region of south-central Virginia, 148 km (92 mi) west of Richmond and 29 km (18 mi) east of Lynchburg. The average elevation at APCO is approximately 229 m (751 ft), and covers an area of 718 ha (1,774 ac) that includes a mosaic of successional habitat types ranging from fescue fields to hardwood forests. Approximately 469 ha (1,159 ac) are wooded, with 30% of the woodlands being deciduous and the remainder being coniferous. The site also contains approximately 13 km (8 mi) of bottomland hardwood (BLHWD) habitat along the Appomattox River and its tributaries. Approximately 243 ha (600 ac) of open fields can be found at APCO, most of which are maintained (mowed) once or twice a year. Although most of these fields consist of fescue grass (*Festuca spp.*), approximately 26 ha (64 ac) are being chemically treated and planted with the intention of bringing back warm-season (native) grasses. In addition to natural colonization by broomsedge, the mixed grass seed that is being planted includes Indian grass (*Sorgastrum nutans*), little blue stem (*Schizachyrium scoparium*), switch grass (*Panicum virgatum*), purple top (*Tridans flavus*), and gamma grass (*Tripsacum dactyloides*).

Methods

Development of Potential Species List

The potential species list was based on a literature search, a museum records search, and more than 35 years of personal experience working on Virginia mammals (John F. Pagels). Among the literature sources, we relied heavily on Linzey (1998, and personal communication) who searched hundreds of collections as part of his recent effort on "The Mammals of Virginia." Table 1 provides a list of the mammals that may occur at APCO and the literature that was searched. We found no museum records of mammals designated as having been collected within APCO, although some specimen records are available for Appomattox County. Primary collections contacted were the National Museum of Natural History, Carnegie Museum of Natural History, Virginia Museum of Natural History (which includes the Virginia Tech Mammal Collection), Virginia Commonwealth University Mammal Collection, North Carolina State Museum of Natural History (which includes the former George Mason University collection and University of Kentucky collection), Shippensburg State University Vertebrate Collection, and the University of Memphis Mammal Collection.

Site Selection

In fall 2002, with the initial help of natural resource manager Brian Eick and aerial photography, we determined the available habitat types and scouted possible sampling sites within each habitat type. Five major habitat types were identified: field-forest edge (FFE), pine forest plantation (PFP), mixed pine hardwood (MPH), hardwood (HWD), and bottomland hardwood (BLHWD). Although we had not planned to sample the field-forest edge (edge) habitat type, we did because of the abundance of edge situations and the likely impact of that habitat type on mammal presence.

Sample locations were selected randomly using a grid system, but in most cases required re-location in the field to ensure that the samples were located in an area representative of the selected habitat type. Three sampling sites (replicates) were established in each of the habitat types (15 sampling sites total). Boundaries of all sampling sites within the habitat types were at least 300 m apart, usually much more, and at least 30 m from the edge of the given habitat type. These minimum distances were typically dictated by the patchy distribution of habitat types. We did not trap for mammals in the actual fields because of potential conflict with maintenance practices (mowing) and agricultural contractors. Both in early reconnaissance trips and later during the survey, we were unable to find signs (i.e. runways, scats, or cuttings) that would indicate the presence of small mammals (except for moles) in the maintained or agricultural fields.

Sampling points in each of the habitat types are indicated on Figure 1. GPS coordinates for all sampling sites were taken using a Magellan GPS 315 (Magellan Corporation, San Dimas, California) with NAD27 datum and were converted to NAD83 for development of the site maps. All coordinates are Universal Transverse Mercator (UTM), Zone 18, and are provided in Appendix A.

Table 1. Potential mammal species that may occur in Appomattox Court House National Historical Park, Virginia.

Common Name	Scientific Name[a]	Literature[b]
Virginia opossum	*Didelphis virginiana*	1,2,4,5
Pygmy shrew	*Sorex hoyi*	2,3,4,5
Southeastern shrew	*Sorex longirostris*	1,2,3,4,5
Northern short-tailed shrew	*Blarina brevicauda*	1,2,3,4,5
Least shrew	*Cryptotis parva*	1,2,3,4,5
Eastern mole	*Scalopus aquaticus*	1,2,4,5
Star-nosed mole	*Condylura cristata*	1,2,3,4,5
Eastern cottontail	*Sylvilagus floridanus*	1,2,4,5
Eastern chipmunk	*Tamias striatus*	1,2,5
Woodchuck	*Marmota monax*	1,2,5
Eastern gray squirrel	*Sciurus carolinensis*	1,2,5
Fox squirrel	*Sciurus niger*	2
Red squirrel	*Tamiasciurus hudsonicus*	2
Southern flying squirrel	*Glaucomys volans*	1,2,4,5
American beaver	*Castor canadensis*	1,2,5
Marsh rice rat	*Oryzomys palustris*	4
Eastern harvest mouse	*Reithrodontomys humulis*	1,2,4,5
White-footed mouse	*Peromyscus leucopus*	1,2,4,5
Golden mouse	*Ochrotomys nuttalli*	1,2,4,5
Hispid cotton rat	*Sigmodon hispidus*	2,3,4
Norway rat	*Rattus norvegicus*	1,5
House mouse	*Mus musculus*	1,5
Meadow vole	*Microtus pennsylvanicus*	1,2,4,5
Woodland vole	*Microtus pinetorum*	1,2,4,5
Common muskrat	*Ondatra zibethicus*	1,2,5
Meadow jumping mouse	*Zapus hudsonius*	1,2,4,5
Coyote	*Canis latrans*	2,5
Red fox	*Vulpes vulpes*	1,2,5
Common gray fox	*Urocyon cinereoargenteus*	1,2,5
Black bear	*Ursus americanus*	1
Common raccoon	*Procyon lotor*	1,2,5
Long-tailed weasel	*Mustela frenata*	1,2,5
Least weasel	*Mustela nivalis*	3
American mink	*Mustela vison*	1,2,5
Striped skunk	*Mephitis mephitis*	1,2,5
Northern river otter	*Lontra canadensis*	1,2,5
Bobcat	*Felis rufus*	1,2,5
White-tailed deer	*Odocoileus virginianus*	1,2,5

[a]Nomenclature follows:
Jones et al. 1997.

[b]Literature:
1. Handley and Patton 1947.
2. Linzey 1998.
3. Pagels Unpublished information.
4. Pagels et al. 1992.
5. Webster et al. 1985.

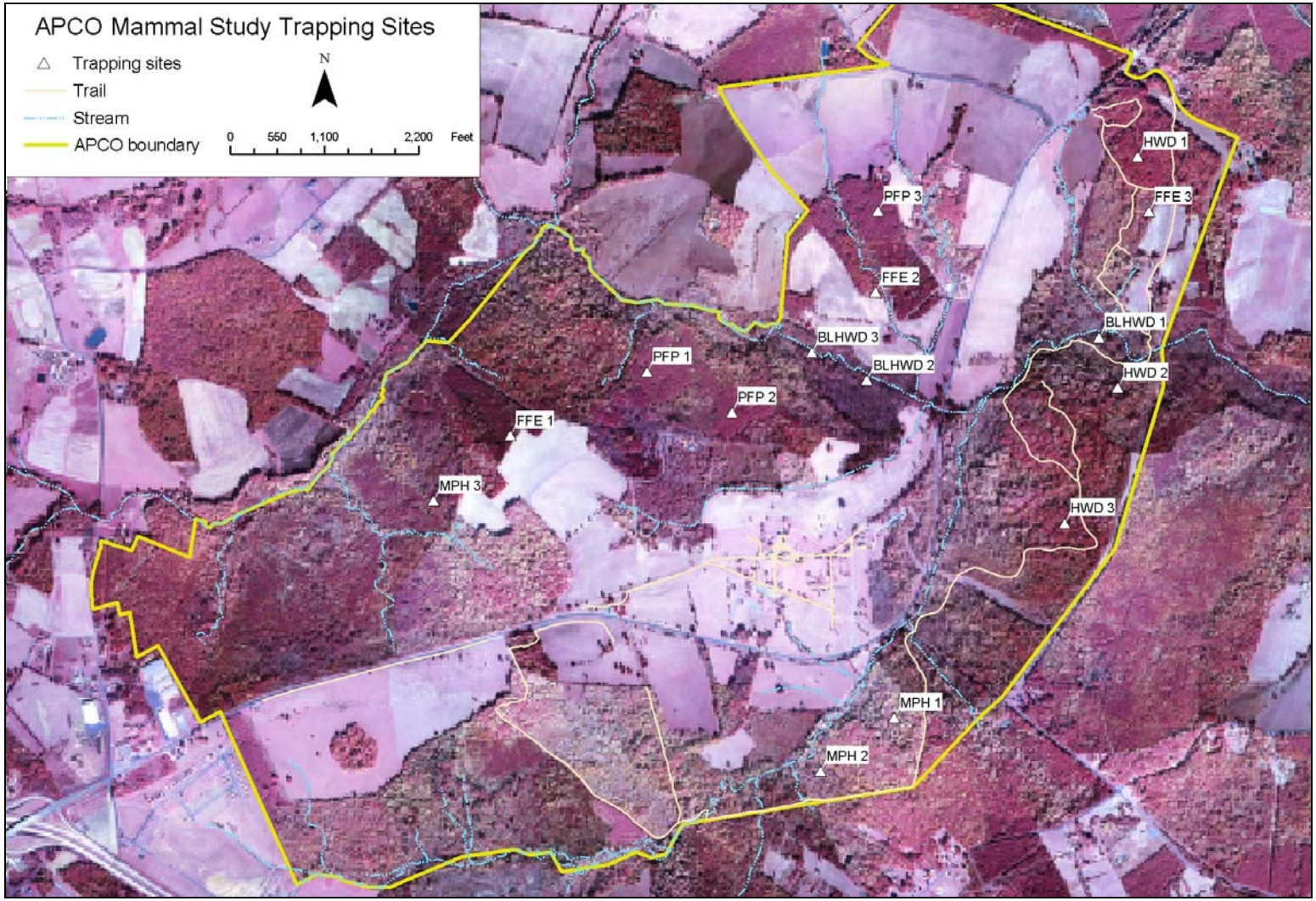

Figure 1. Locations of mammal sampling sites within Appomattox Court House National Historical Park, Virginia, inventoried during 2003–2004.

Habitat Types

Below is a brief description of vegetation in each of the habitat types. Relative basal area for tree species within each habitat type is given in Appendix B.

Field-forest Edge (FFE)

In nearly all situations field maintenance or mowing created very abrupt or narrow contact areas along the field and forest edges. In most areas the edge habitat type was only one to five meters wide. Vegetation along field-forest edges was typically a mix of field and forest vegetation and much more heterogeneous than in the field or forest. This habitat type contained both pine and deciduous species in the overstory. Evergreen species included loblolly pine (*Pinus taeda*), virginia pine (*Pinus virginiana*), and red cedar (*Juniperus virginiana*), but loblolly pine was much less common. Deciduous species were highly variable among sites and included black cherry (*Prunus serotina*), honey locust (*Gleditsia triacanthos*), red maple (*Acer rubrum*), white oak (*Quercus alba*), red oak (*Quercus rubra*), and hickories (*Carya spp*.). The understory was comprised of saplings of overstory species. However, the understory was often dominated by shade-intolerant pioneer species such as Virginia pine and red cedar. Shrubs were also common in the understory with sumac (*Rhus* sp.) and multiflora rose (*Rosa multiflora*) being the most abundant. Vines present in this habitat type often included Japanese honeysuckle (*Lonicera japonica*), poison ivy (*Rhus radicans*), Virginia creeper (*Parthenocissus quinquefolia*), and common greenbriar (*Smilax rotundifolia*). Herbs and grasses (nonnative fescue) were more common here than in other habitats. One site (FFE2) contained an abundance of native broomsedge and bramble.

Pine Forest Plantation (PFP)

At each of the PFP sites loblolly pine comprised the greatest number of overstory trees. Virginia pine was also relatively abundant in this habitat type. Following logging, pine stands were planted at these locations 20 to 25 years ago and have yielded very homogenous environments. Quantitative vegetation data reveals that the loblolly pines in these relatively young stands had a mean diameter at breast height (DBH) of 18.1 cm (PFP1), 18.3 cm (PFP2), and 24.5 cm (PFP3). When young, these stands can be very dense, but the stands we sampled had begun a natural thinning process and the understory was open in most situations. These stands were also characterized by a thick carpet of pine-needle litter. The understory of this habitat type was comprised of deciduous tree species such as black cherry, blackgum (*Nyssa sylvatica*), tulip poplar (*Liriodendron tulipifera*), red oak, and red cedar. Nearly all understory trees in this habitat type were small (DBH <10 cm). Vines were more frequent in this habitat than other habitats. The most common species were common greenbriar, Japanese honeysuckle, poison ivy, and Virginia creeper. Vines combined with shrubs and small deciduous saplings often formed thicket-like growth.

Mixed Pine Hardwood (MPH)

The MPH habitat type included both deciduous trees and pine trees in the overstory and understory. This habitat type is considered to be an intermediate successional stage between pine and hardwood forest. Both loblolly pine and Virginia pine were present in this habitat type,

however, Virginia pine was more common. Although deciduous trees were more abundant than pine species in the overstory, the DBH of pine species was considerably larger (i.e. there were fewer pine than deciduous trees, but the pines were larger). The most common deciduous trees in the overstory included tulip poplar, red maple, dogwood (*Cornus florida*), oak (white and red), and species of hickory. Understory trees were mostly saplings of overstory species. However, as expected in this successional stage, deciduous saplings were more common than pine saplings. Other common subcanopy species included blackgum, and ironwood (*Carpinus caroliniana*). Vine and shrub communities were similar to those described in the pine plantation habitat type.

Hardwood (HWD)

The hardwood forest habitat type was characterized by various deciduous species in the overstory and understory. Common overstory species included red maple, tulip poplar, blackgum, white oak, red oak, and hickories. Less common overstory species included American beech (*Fagus grandifolia*) and sassafras (*Sassafras albidum*). Common subcanopy species included dogwood and ironwood. There were no conifers recorded at our sites, although pine trees are scattered among hardwood stands at APCO. Vegetation data revealed that the DBH of trees ranged from approximately 9 cm in subcanopy trees to 35 cm among oak species. Ground cover consisted primarily of deciduous leaf litter. Herbaceous, grass, and shrub growth were relatively sparse and vines were infrequent in the HWD habitat types.

Bottomland Hardwood (BLHWD)

The BLHWD habitat type was largely restricted to floodplains along waterways. In fact, all three BLHWD sites were located within 50 m of the Appomattox River. Occasional washouts from flooding were not unusual at our BLHWD sampling sites. Overstory trees were primarily deciduous species, including American sycamore (*Platanus occidentalis*), red maple, tulip poplar, ash (*Fraxinus sp*), black cherry, and ironwood. American sycamore was the dominant species at two sites, contributing a large percentage of the total basal area. Our third BLHWD site contained no sycamore trees, but instead, was dominated by several large ash trees. The understory was comprised of saplings of overstory species, as well as dogwood, hackberry (*Celtis occidentalis*), box elder (*Acer negundo*), and pawpaw (*Asimina triloba*). The most abundant shrub in the understory was spicebush (*Lindera benzoin*). Vines present in this habitat type often included Japanese honeysuckle, poison ivy, Virginia creeper, and common greenbriar. A variety of grasses and herbs were observed in much greater abundance here than at any other site.

Survey and Collection Methodology

The circular-plot sampling scheme used at most sampling sites was modified from other studies. The scheme has been successfully used in studies on mammal population dynamics (Orrock et al. 2000), mammal communities (Bellows et al. 1999b; McShea et al 2003), documenting presence of endangered species (Orrock et al. 2000), and determining new records of occurrence (Bellows et al. 1999a). Each sampling site consisted of a 30 m diameter circle with markers in the center and 15 m from the center in each cardinal direction (Figure 2). In this way, the site was divided into four equal quadrants. Three 7.6 x 8.9 x 22.9 cm (3” x 3.5” x 9”) Sherman live

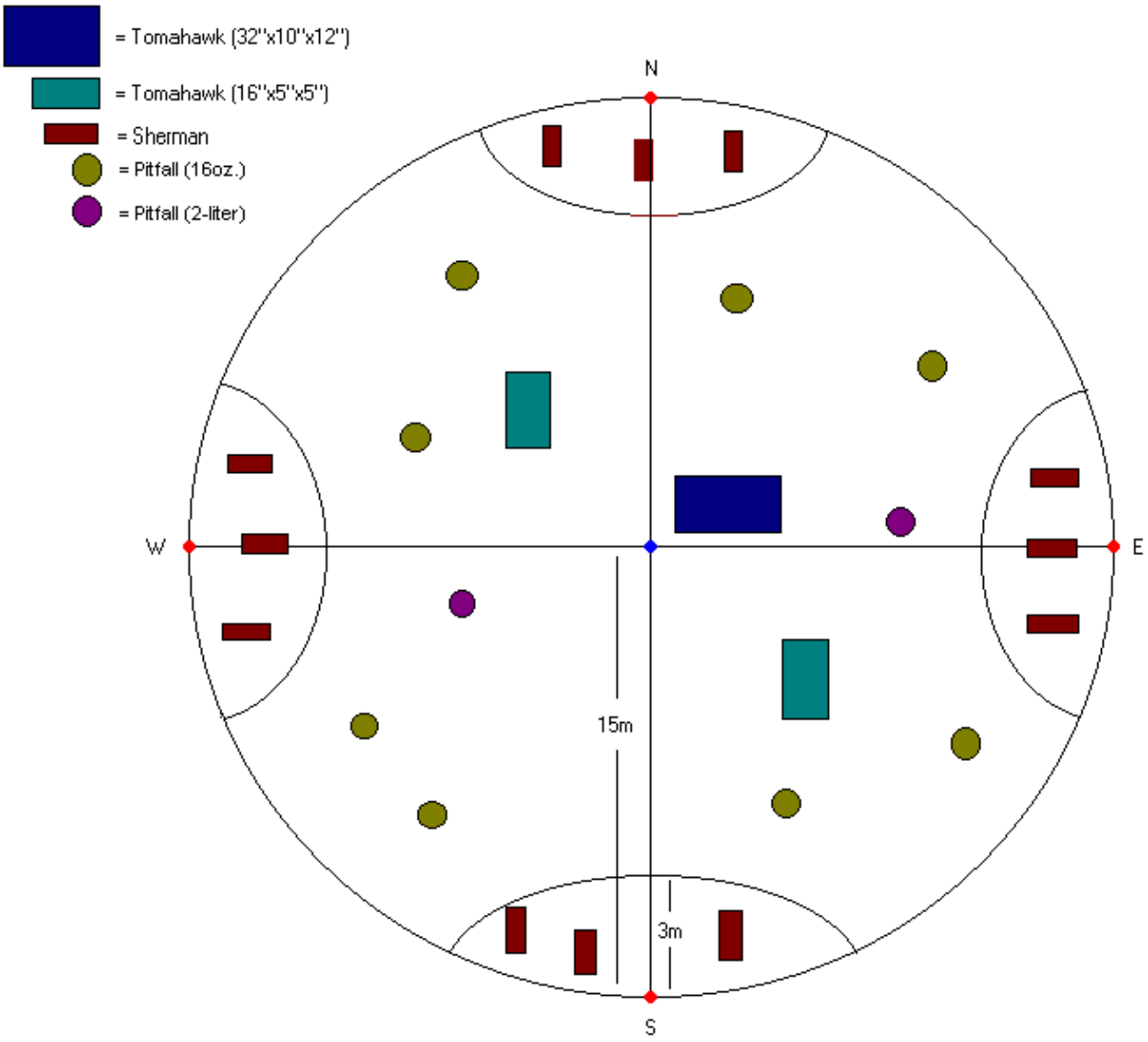

Figure 2. Mammal sampling configuration for circular plots used in the inventory of mammals at Appomattox Courthouse National Historical Park, Virginia, from 2003–2004. This circular style layout was used at all sites excluding the three field-forest edge trapping sites.

traps (H. B. Sherman Traps, Tallahassee, Florida) were placed at likely capture spots within a 2 m radius extending toward the center from each cardinal direction. Two 40.6 x 12.7 x 12.7 cm (16" x 5" x 5") Tomahawk live traps (Tomahawk Live Trap Co., Tomahawk, Wisconsin) were placed in opposite quadrants from each other, and one 81.3 x 25.4 x 30.5 cm (32" x 10" x 12") Tomahawk live trap was placed at or near the center of the site. Sherman live traps were baited with an oatmeal/ peanut butter mixture that was wrapped in wax paper and hung from the back door of the trap (small dabs of peanut butter were also placed on the open front door). Small Tomahawk traps were baited with apples covered in peanut butter. The large Tomahawk live traps were baited with apples and sardines. Live traps typically underestimate the abundance of shrews, whereas pitfall traps are very efficient in capturing shrews, especially the smallest species (Mitchell et al. 1993; Kirkland and Sheppard 1994). In order to more effectively sample smaller mammals such as shrews, two pitfall traps were placed in each of the sites' four quadrants. Natural drift fences (i.e., fallen logs and stumps) and 533 ml (16 oz) beverage cups filled with approximately five centimeters of water were used for all initial pitfall traps. Plastic mesh lids (15 cm x 15 cm) elevated by nails were used to shield the pitfall traps from falling leaves and other debris. Pitfall traps larger than those that we used are more effective for many small mammals (Mitchell et al. 1993); however, in initial discussions with NPS personnel we were encouraged to keep soil disturbance to a minimum at historical sites. Because of poor capture success of shrews, two larger pitfall traps were added to each site for sampling in spring 2004. For these pitfall traps we used two-liter bottles with the tops cut off (after Handley and Varn 1994). These larger traps required somewhat larger holes, however soil disturbance at sampling sites remained minimal. In addition, we installed two or three drift fences made of steel mesh 0.6 cm (1/4") hardware cloth (two drift fences if a natural barrier was present). Like all traps, the two-liter pitfall traps were placed at most likely capture spots (i.e., near coarse woody debris) whenever possible. The mesh was lowered over the pitfall traps to close them between sampling sessions (i.e., periods when sampling was not ongoing).

In order to more effectively sample the field-forest edge habitat type, transects were used instead of circular plots. The FFE habitats were narrow and use of the circular arrangement would have overlapped other habitat types. The sampling effort, as based on trap types and trap numbers, was equivalent to those of the circular plots, but traps were arranged in a linear fashion (Figure 3) at most likely capture spots, generally within two to four meters of the transect line.

Mammals the size of hispid cotton rats (*Sigmodon hispidus*) or smaller were tagged with Monel ear tags (National Band and Tag Co., Newport, Kentucky), weighed to the nearest gram, and examined for reproductive status and life history stage (e.g., adult, juvenile, etc.). Mammals the size of eastern gray squirrels (*Sciurus carolinensis*) or larger were marked with non-toxic spray paint and examined for distinguishable features and approximate age. The unique, but temporary paint marking allowed us to distinguish individuals captured in a single trapping session only. All animals were released at site of capture. Any deceased animals, for example all specimens captured in pitfall traps, were collected, stored in 70% propanol, placed on ice in the field, and are now frozen to serve as museum voucher specimens and as resources for additional studies. The frozen specimens are stored at Virginia Commonwealth University (VCU) in the VCU Mammal Collection. For all captures we recorded the site of capture (i.e. HWD 1), trap type, and trap location. In circular plots, for pitfalls and small Tomahawks we recorded the quadrant (i.e., NW) where the trap was located, and for Sherman traps we recorded the cardinal direction.

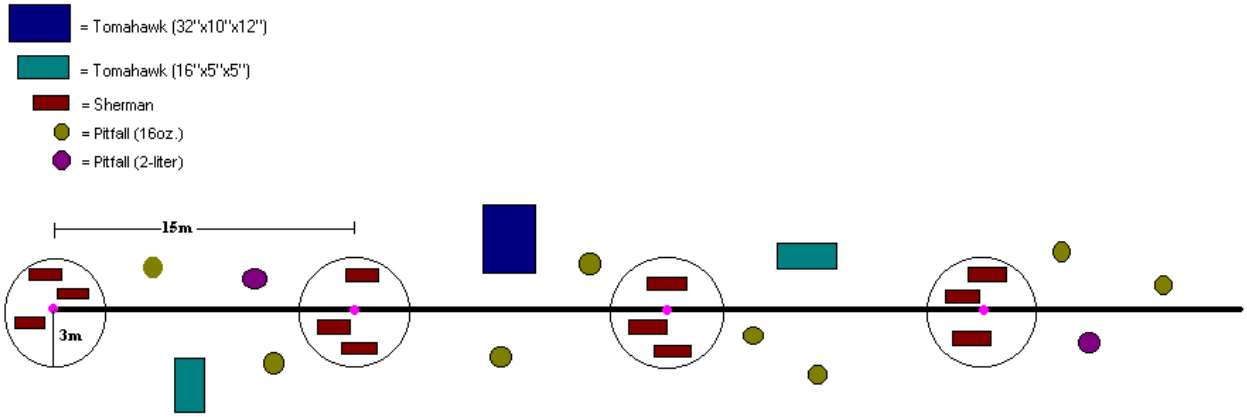

Figure 3. Mammal sampling configuration used for transects in field-forest edge habitat type at Appomattox Courthouse National Historical Park, Virginia, from 2003–2004.

In fall 2003 we began using night-camera photography as an additional method for documenting medium to large nocturnal species. We used TrailMaster's ActiveInfrared Trail Monitor (Model # TM1550) and Camera Kit (Model # TM35-1) (TrailMaster Infrared Trail Monitors, Lenexa, Kansas). Despite the initial costs of these instruments, it has been shown that this method is appropriate for use in mammal inventories where larger mammals need to be surveyed (Silveira et al. 2003). Three cameras were used simultaneously within different portions of APCO. During each trapping session (e.g., fall or winter sessions [Appendix C]) the cameras were active for the same number of nights as the trapping sites. Cameras were placed in areas most likely to be frequented by medium to large nocturnal mammals (i.e. game trails and small dirt roads or walking paths), and where vegetation and topography would not trigger the trail monitors. Cameras were not located near the sampling sites, and camera location, most often in wooded areas, was varied among sampling sessions. Cameras were active from approximately dusk to dawn and were baited with sardines, peanut butter, apples, and chicken.

Trapping sessions were partitioned into seasons and occurred between June 2003 and August 2004. All habitat types were sampled at the same time, and all were sampled during each of the four calendar seasons. Trapping effort was greatest during the summer due to time constraints in fall, winter, and spring. Trapping session dates and trapping effort with each trap type are given in Appendix C. Trapping effort within each habitat type is given in Appendix D. Sometimes traps were sprung and had been moved about, likely the result of raccoon activity, and on these occasions a trapnight was subtracted from the effort (modified from Nelson and Clark 1973).

Site Analysis

Within trapping sites, the diameter at breast height (DBH ~ 1 m) was recorded for all trees, defined as woody plants with a DBH ≥5 cm. For transect sites, any tree less than 5 m from the transect line was considered to be within the site. All trees with a DBH ≥5 cm were identified to species, except for those trees in the *Alnus, Carya, Fraxinus, Morus, Quercus,* and *Ulmus* groups. Ground cover, substrate composition, and seedling density were determined using the line-transect method of Canfield (1941). For circular sites, two 40-m transects were established that divided the sampling site into four equal quarters, bisecting in the center. For transect plots, the same 60-m transect line established for mammal sampling was extended by 10 m on each end. Eighty points were sampled for both types of plots at one-meter intervals. Using the line-transect method, we recorded observations in the following categories: herbaceous material, leaf litter, bare soil, rock, woody debris, moss, lichen, shrub, and seedling. Rocks were sized accordingly, as follows: size 1 <0.2 m, size 2 = 0.2–0.4 m, size 3 = 0.41–0.8 m, and size 4 >0.8 m. We considered woody debris to be any portion of a woody stem or trunk regardless of the size. The diameter was recorded for any woody debris that was greater than 10 cm. Tree seedlings were defined as woody plants with a DBH <5 cm and were categorized as either hardwood or pine.

Data Preparation and Analysis

We used the number of unique (original, not recaptures) individuals captured (M_{t+1}; Slade and Blair 2000) as our metric of relative abundance for each species. The number of individuals captured (M_{t+1}) was corrected for trapping effort by dividing the number captured by the number of trapnights at each site for traps where a species could be captured (i.e., trapnights for the

pygmy shrew was calculated using the number of pitfall traps only because this species is almost always only captured using this trapping method). The average relative abundance (± SE) was expressed per 100 trapnights.

Abundance estimated using M_{t+1} is an index of population size because the number of individuals captured is a function of population size as well as the likelihood that an individual will be captured (Slade and Blair 2000; Pollock et al. 2002). We use M_{t+1} because it performs as well as estimators that incorporate capture probability (i.e., the Lincoln-Petersen estimator) when captures are low and species vary between habitats (Slade and Blair 2000), as was the case for many of the species we detected. Our estimates of relative abundance assume that capture probability does not differ among habitat types, trapping sessions, or types of traps where animals were captured. Although capture probability for the same species may vary depending upon these factors (Pollock et al. 2002), we do not present estimates of habitat-, season-, and trap-specific capture probabilities because the limited data for most of the species in our study was prohibitive (Pollock et al. 2002). Therefore, differences in relative abundance due to habitat, season, and trap-type were not compared statistically. Instead, average relative abundance (± SE) of each species is used only as an index of the population and as a baseline for more intensive future studies.

For each habitat type, we also calculated species richness and species evenness. Although species richness is defined as the number of species within a community (Wilson et al. 1996), we herein use it to define the number of species within each habitat type. Evenness was calculated using Shannon's index, where evenness varies from 0 for communities composed of a single species, to 1 for communities where all species are equally abundant (Zar 1999). Again, due to the low number of recaptures for most species, capture probabilities were not calculated and valid statistical inferences could not be made. Thus, these data were used only as indices of the populations.

Within each sampling site, the basal area of each tree (with a DBH ≥5 cm) was determined from its DBH. These values were combined to get a total basal area value for each species of tree found in the sampling site. Relative basal area was calculated by dividing the basal area for each tree species by the total basal area for the site and therefore represents the percentage of basal area within the site given by each tree species (Appendix B).

Results

Thirty-eight species of mammals were expected to occur at APCO based on the available habitat and known species distributions (Table 1). The current inventory documented 21 species of mammals, representing 55% of the species expected to occur at the park (Table 2). None of the species documented are on State or Federal lists of species of concern. Night-camera photography and observations of mammals accounted for eight of the 21 species recorded. The presence of two species, the red fox (*Vulpes vulpes*) and common gray fox (*Urocyon cinereoargenteus*), was documented only by night-camera photography (Tables 2 and 3). The American beaver (*Castor canadensis*) was documented based on sightings or signs alone. The black bear (*Ursus americanus*) was observed and reported by park personnel. The species and numbers of individuals recorded by each sampling method largely reflect the relative body size of the mammal (Table 3).

During 6,797 trapnights 247 mammals were captured (Table 4). Although the numbers reflect initial captures (M_{t+1}) for most species, some of the large forms (i.e., the Virginia opossum [*Didelphis virginiana*] and the common raccoon [*Procyon lotor*]) were marked to distinguish them in a given trapping session only and some of the individuals were very likely recaptures from earlier sessions. For each habitat type, the relative abundance, i.e. the number of individuals captured (M_{t+1}) corrected for trapping effort, is given for each species in Table 5. The common raccoon had the highest relative abundance in three of the five habitat types (FFE = 15.6 ± 11.0, HWD = 10.3 ± 2.8, BLHWD = 7.4 ± 4.9). In these habitat types the white-footed mouse was second highest in relative abundance, and in PFP and MPH habitat types it ranked the highest in relative abundance (Table 5).

Overall trapping success and recapture rates were low during the survey, preventing a statistical comparison of differences in richness and relative abundance among habitat types. The overall richness (14) was relatively high for species captured, however, seven species were represented by seven or fewer individuals. The ubiquitous white-footed mouse, *Peromyscus leucopus,* represented nearly half of all mammals captured with 115 individuals trapped. Inclusive of the white-footed mouse, 10 species the size of hispid cotton rats or smaller were captured (Tables 3 and 4). Richness of species captured in the five habitats sampled ranged from six in the hardwood (HWD) habitat to 10 in the field-forest edge (FFE) habitat (Table 4). The number of mouse species captured generally differed between habitat types, with mouse species captured in the FFE and bottomland hardwood (BLHWD) habitats being greater than the number captured in MPH habitat. Species evenness was also slightly higher in FFE (0.79) and BLHWD (0.76) when compared to all other habitat types (Table 4). In most instances, a lack of species evenness resulted from the dominance of the white-footed mouse in the captures compared to other species.

Table 2. Potential mammal species that may occur at Appomattox Court House National Historical Park, Virginia, and those documented during inventories conducted in 2003–2004.

Common Name	Literature[a]	Field Study[b]
Virginia opossum	1,2,4,5	C,P
Pygmy shrew	2,3,4,5	C
Southeastern shrew	1,2,3,4,5	C
Northern short-tailed shrew	1,2,3,4,5	C
Least shrew	1,2,3,4,5	
Eastern mole	1,2,4,5	
Star-nosed mole	1,2,3,4,5	
Eastern cottontail	1,2,4,5	O
Eastern chipmunk	1,2,5	C
Woodchuck	1,2,5	O
Eastern gray squirrel	1,2,5	C,O
Fox squirrel	2	
Red squirrel	2	
Southern flying squirrel	1,2,4,5	C
American beaver	1,2,5	O
Marsh rice rat	4	
Eastern harvest mouse	1,2,4,5	C
White-footed mouse	1,2,4,5	C
Golden mouse	1,2,4,5	C
Hispid cotton rat	2,3,4	C
Norway rat	1,5	
House mouse	1,5	
Meadow vole	1,2,4,5	
Woodland vole	1,2,4,5	C
Common muskrat	1,2,5	
Meadow jumping mouse	1,2,4,5	
Coyote	2,5	
Red fox	1,2,5	P
Common gray fox	1,2,5	P
Black bear	1	O
Common raccoon	1,2,5	C,P
Long-tailed weasel	1,2,5	
Least weasel	3	
American mink	1,2,5	
Striped skunk	1,2,5	C
Northern river otter	1,2,5	
Bobcat	1,2,5	
White-tailed deer	1,2,5	P,O

[a]Literature:
1. Handley and Patton 1947.
2. Linzey 1998.
3. Pagels Unpublished information.
4. Pagels et al. 1992.
5. Webster et al. 1985.

[b]Field Study:
C. Captured
O. Observed
P. Night Photograph

Table 3. Number of captures (including recaptures) of each species* of mammals recorded within Appomattox Court House National Historical Park, Virginia, documented during inventories conducted in 2003–2004.

Common Name	Pitfall (16oz.)	Pitfall (2L)	Sherman	Small Tomahawk	Large Tomahawk	Night Photograph	Observation
Pygmy shrew	3						
Southeastern shrew	9	3	1				
Northern short-tailed shrew	4	4	14				
Woodland vole			7				
Eastern harvest mouse			3				
Golden mouse		1	26				
White-footed mouse	4		310				
Southern flying squirrel			3				
Eastern chipmunk			2	1			
Hispid cotton rat			37	4			
Eastern cottontail							X
Eastern gray squirrel				1	1		X
Striped skunk					2		
Woodchuck							X
Virginia opossum			1	4	12	16	
Common raccoon					23	34	
American beaver							X
Common gray fox						1	
Red fox						1	
White-tailed deer						1	X
Black bear							X
TOTAL	20	8	404	10	38	53	

*Species are arranged in increasing adult body length as approximated from Webster et al. (1985).

Table 4. Total number of species[a] captured in each habitat type[b] surveyed in Appomattox Court House National Historical Park, Virginia, documented during inventories conducted in 2003–2004.

Species[a]	FFE[b]	PFP[b]	MPH[b]	HWD[b]	BLHWD[b]	Total
Virginia opossum	5	3	4	2	3	17
Pygmy shrew		1	1	1		3
Southeastern shrew	8		2		3	13
Northern short-tailed shrew	4	1	7		10	22
Eastern chipmunk				1	1	2
Eastern gray squirrel		1			1	2
Southern flying squirrel		1	1			2
Eastern harvest mouse	1					1
White-footed mouse	30	13	27	21	24	115
Golden mouse	3	7			7	17
Hispid cotton rat	22					22
Woodland vole	2			4	1	7
Common raccoon	9	1	2	6	4	22
Striped skunk	2					2
Total	86	28	44	35	54	247
Trapnights						
Pitfall	540	540	540	540	464	2,624
Sherman	666	682	673	678	628	3,327
Small Tomahawk	110	114	115	114	105	558
Large Tomahawk	59	59	59	58	53	288
Total	1,375	1,395	1,387	1,390	1,250	6,797
Richness	10	8	7	6	9	14
Evenness	0.79	0.74	0.65	0.68	0.76	0.7

[a]Species are arranged phylogenetically (after Jones et al. 1997).
[b]Abbreviations:

FFE = Field-forest edge
PFP = Pine forest plantation
MPH = Mixed pine hardwood
HWD = Hardwood
BLHWD = Bottomland hardwood

Table 5. Average relative abundance (individuals per 100 trap[a] nights) of each species[b] captured within the different habitat types[c] ± standard error, in Appomattox Court House National Historical Park, Virginia, documented during inventories conducted in 2003–2004.*

Species[b]	FFE[c]	PFP[c]	MPH[c]	HWD[c]	BLHWD[c]
Virginia opossum	2.9 ± 0.5	1.8± 1.0	2.3 ± 0.6	1.2 ± 1.2	1.9± 0.0
Pygmy shrew		0.2± 0.2	0.2 ± 0.2	0.2 ± 0.2	
Southeastern shrew	1.5 ± 0.4		0.4 ± 0.2		0.7± 0.7
Northern short-tailed shrew	0.3 ± 0.2	0.1± 0.1	0.6 ± 0.3		0.9± 0.3
Eastern chipmunk				0.1 ± 0.1	0.2± 0.2
Eastern gray squirrel		0.8± 0.8			0.9± 0.9
Southern flying squirrel		0.1± 0.1	0.1 ± 0.1		
Eastern harvest mouse	0.2 ± 0.2				
White-footed mouse	4.6 ± 2.0	1.9± 1.5	4.0 ± 0.4	3.1 ± 0.2	3.8± 0.3
Golden mouse	0.4 ± 0.4	1.0± 0.5			1.1± 0.5
Hispid cotton rat	3.0 ± 2.8				
Woodland vole	0.3 ± 0.3			0.6 ± 0.6	0.2± 0.2
Common raccoon	15.6 ±11.0	1.8± 1.8	3.4 ± 1.7	10.3 ± 2.8	7.4± 4.9
Striped skunk	3.4 ± 1.7				

[a]Species are arranged phylogenetically (after Jones et al. 1997).
[b]Effort was determined from the trap types in which that species was captured.
[c]Abbreviations:

FFE = Field-forest edge
PFP = Pine forest plantation
MPH = Mixed pine hardwood
HWD = Hardwood
BLHWD = Bottomland hardwood

Discussion

The number of species recorded (21) represented 55% of the potential species expected to occur at APCO, but was relatively high considering that many species may be present, yet remain undetected. Our potential list included many species that are rarely captured in mammal surveys, and that are infrequently observed by sign or direct sightings (Table 1), including American mink (*Mustela vison*), long-tailed weasel (*Mustela frenata*), least weasel (*Mustela nivalis*), bobcat (*Felus rufus*), coyote (*Canis latrans*), and northern river otter (*Lontra canadensis*). Some of these species were registered outside of national park sites by fur trappers and hunters, or in parks as roadkills, but no such records were available for this inventory. Among small mammals, it is very likely that both the eastern mole (*Scalopus aquaticu*s) and the star-nosed mole (*Condylura cristata*) occur at APCO, but only signs for one or both species were observed. The star-nosed mole is now known to have a nearly statewide distribution (Pagels, unpublished information). The very small least weasel has been recorded from Appomattox County (VCU Mammal Collection), but is a species that can easily remain undetected. Just recently, its presence in the Coastal Plain of Virginia has been verified (Bellows et al. 1999a), and it is now known to have a nearly statewide distribution; though it is unlikely due to a range expansion, but rather had just not previously been detected.

Most small mammal species that we documented at APCO are habitat generalists, occurring in a variety of habitat types (Pagels et al. 1992). Some common small mammals that inhabit old fields and field edges in central Virginia, including those at APCO, include the southeastern shrew (*Sorex longirostris*), least shrew (*Cryptotis parva*), eastern harvest mouse (*Reithrodontomys humulis)*, hispid cotton rat, and eastern meadow vole (*Microtus pennsylvanicus*) (e.g., Jackson et al. 1976; Pagels 1977; Pagels et al. 1992; Bellows et al. 2001). Although it is likely that these species occur at APCO, neither the least shrew nor the eastern meadow vole was captured. The presence of the eastern meadow vole can be determined by the distinct runways it creates that typically contain grass clippings and scattered piles of scat material, none of which were found in the FFE situations or during examination of field sites. The hispid cotton rat was captured only in the field-forest edge. In contrast, the southeastern shrew was captured in field-forest edge and at two woodland habitats, suggestive of possible disturbance and patchiness in the woodland habitats. In Virginia the hispid cotton rat is often found associated with viny-shrub growth in cold months and may move outside of such areas in warm months when warm-season grasses, weedy plants, and legumes are nearby (Pagels 1977). Most of the old field mammal species noted above, as well as generalist species (i.e., northern short-tailed shrew and the white-footed mouse), also prefer such heterogeneous old field habitats; the maintained and agricultural fields of APCO are not old fields characteristic of secondary succession. Except for very spotty areas in some fields, such old field habitat is nearly lacking at APCO, and where it occurs is largely limited to the narrow field-forest edges. It is interesting that most of the hispid cotton rats captured, and the lone eastern harvest mouse, were taken at one of the field-forest edge sites that adjoined a field with considerable amounts of broomsedge, a warm-season plant, indicating that these field conditions provide a habitat for this species.

Unlike successional old fields, most fields at APCO are characterized by exotic cool-season grasses, such as tall fescue (*Festuca arundinacea*), that provide poor habitat for small mammals

(Indiana Division of Fish and Wildlife 2002). The Indiana Division of Fish and Wildlife (2002) publication also summarized the following: most fescues are aggressive, sod-forming grasses that create a thick, matted ground cover which severely limits the movement and foraging ability of ground-nesting and ground-feeding wildlife. In winter, the snow and ice may pack fescue grasses down even further. The thick matted growth form also prevents warm-season grass seed from germinating. In addition, the Indiana report also notes that tall fescue is allellopathic; it inhibits the germination and establishment of other more beneficial plant species. Delong and Brittingham (2001) observed that warm-season grasses are much more hospitable to small mammals. They noted that tall bunch grasses provide adequate food for granivores, good cover from predators, and excellent runways and nesting sites. In a recent study in Bath County, VA, Mengak (2004) captured significantly more mammals in fields that had been chemically treated, burned, and converted to warm-season grasses than in fescue fields. Maintained and agricultural fescue fields are an obvious feature of the landscape at APCO, largely to help interpret the Civil War cultural landscape of the park. Unfortunately, although fescues help to maintain the openness, they do little to encourage wildlife populations.

Several variables could have impacted our mammal survey results at APCO regardless of species that may have remained undetected or were absent from APCO during the study. For example, domestic cats (*Felis catus*) are known predators of numerous small mammals and birds (for example, Mitchell and Beck 1992), and it is likely that cats are common despite the rural setting of APCO. Further, several years of sampling are necessary to ensure that data reflect the status of the mammal populations. The year prior to our first sampling year, 2002, was the last in a three-year drought in Virginia. Based on Richmond records, which reflect the same weather patterns, the first sampling year (2003) was the second wettest on record. Precipitation in 2003 was 20 inches above a 109-year average and was the largest recorded departure from the average (NOAA 2004). Without long-term data from APCO, it is not possible to determine the impact these extreme conditions had on the mammal communities of the park, but such climatic extremes are likely to have impacted the population densities.

Conclusions and Management Recommendations

Inventory Limitations and Additional Work

The list of mammals that potentially occur at APCO included many species that were not detected in our survey, and that we did not expect to document. However, the 21 species that were documented for the park, as well as those reported in other portions of Appomattox County, indicate that a relatively rich mammal assemblage occurs in the area. Conversely, achieving only 55% of the expected species stresses the importance of considering several factors when developing potential species lists and interpreting survey results. Mammal distribution maps are typically based on observations or studies completed in different years, at different sites, and by different researchers. Should additional surveys be desired by the NPS to add to the list of documented species, we suggest surveys that are directed toward a particular group of species (e.g., small or large mammals) or a certain habitat type. Such surveys would allow for more intense sampling, not require as many sampling techniques, and likely be more productive when sampling in short survey periods.

Further, if not already in place, a protocol should be developed for park personnel to report and assist in the documentation of mammals (or other wildlife) observed or to maintain the remains of animals that may be found in the park. Such animal remains may include, for example, unidentified road-killed animals, skulls or other bones, scats with bones, owl pellets, and whole specimens that may be collected. Kits that minimally include simple water-proof data sheets, pencils, and plastic storage bags, could be regularly carried in the park vehicles of selected personnel. A simple repository for temporary storage of such items can be the freezer compartment of a refrigerator that is not used for storage of food. Subsequently, arrangements can be made with a state museum (i.e., Virginia Museum of Natural History) or university museum, for identification of the specimens.

In addition, weather conditions must be considered when interpreting sampling results. Even though our study involved two field seasons, we feel that drought, followed by extreme levels of precipitation, negatively impacted our capture success.

Grassland Management

Conversion from cool- to warm-season grasses in APCO fields will likely result in more natural heterogeneous old fields that would greatly benefit mammals while continuing to commemorate the park's cultural history. Managers at APCO have initiated this conversion that will increase old field successional habitats (i.e., the more heterogeneous habitats) through the use of warm-season grasses and the accompanying plants. Managers at APCO, perhaps in cooperation with local and state agricultural agencies, should develop a program for maintenance of converted old fields. Such a program will likely require mowing and, perhaps, prescribed burns, completed in a rotational fashion in selected portions of fields.

In hindsight, temporary "spot-trapping" of maintained and agricultural fields would have provided important baseline information as part of the field conversion, though we feel that it is unlikely that additional species would have been captured without intense sampling in many field areas. We suggest monitoring mammal populations in selected fescue fields being

converted to more heterogeneous old fields. The monitoring should include both fescue fields and converted fields. Notable targets should be old field species, such as the hispid cotton rat and eastern meadow vole, as well as selected generalist species, such as the northern short-tailed shrew and the white-footed mouse. Importantly, all of these species can be captured in Sherman live traps (i.e., they do not require the use of special sampling techniques).

Sampling Considerations

Our results support the importance of using multiple trap types and cameras in addition to actual observations (Table 3). Methods must target species of concern (i.e., pitfalls for small shrews, photographs for certain large species) to determine their presence and to measure management effectiveness. If geographic comparisons are a consideration for inventory and monitoring, the techniques used must be similar among different parks to allow for comparable results and to facilitate quantitative analyses (Mitchell et al. 1993).

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Appendix A. GPS coordinates* of all 15 trapping sites within Appomattox Court House National Historical Park, Virginia.

Site	Latitude (East)	Longitude (North)
FFE 1	694166	4139458
FFE 2	695467	4139970
FFE 3	696440	4140256
PFP 1	694653	4139685
PFP 2	694954	4139542
PFP 3	695475	4140259
MPH 1	695532	4138453
MPH 2	695270	4138263
MPH 3	693891	4139227
HWD 1	696400	4140452
HWD 2	696330	4139629
HWD 3	696140	4139146
BLHWD 1	696263	4139808
BLHWD 2	695436	4139656
BLHWD 3	695239	4139755

*All readings are Universal Transverse Mercator (UTM), Zone 17, NAD83 in meters.

Appendix B. Tree species and their contribution to the total basal area at each sampling site studied in Appomattox Court House National Historical Park, Virginia, documented during inventories conducted in 2003–2004.

Site	Common Name	Scientific Name	N	Basal Area (m^2)	Relative Basal Area
FFE1	Ash	*Fraxinus spp.*	7	0.263	27.2
	Virginia pine	*Pinus virginiana*	20	0.171	17.7
	Hickory	*Carya spp.*	5	0.165	17.0
	Loblolly pine	*Pinus taeda*	2	0.117	12.1
	Red cedar	*Juniperus virginiana*	2	0.092	9.5
	Black cherry	*Prunus serotina*	3	0.090	9.3
	Black walnut	*Juglans nigra*	1	0.031	3.2
	Unknown "A5"		1	0.031	3.2
	Red oak	*Quercus rubra*	1	0.006	0.7
	Willow oak	*Quercus phellos*	1	0.002	0.2
FFE2	Virginia pine	*Pinus virginiana*	41	0.442	55.1
	Black cherry	*Prunus serotina*	2	0.158	19.8
	Butternut	*Juglans cinerea*	3	0.069	8.6
	Red maple	*Acer rubrum*	3	0.052	6.5
	Honey locust	*Gleditsia triacanthos*	2	0.036	4.6
	Red oak	*Quercus rubra*	1	0.025	3.2
	Red cedar	*Juniperus virginiana*	5	0.019	2.3
FFE3	Virginia pine	*Pinus virginiana*	19	0.165	31.3
	Red cedar	*Juniperus virginiana*	5	0.162	30.8
	Honey locust	*Gleditsia triacanthos*	5	0.090	17.2
	Black cherry	*Prunus serotina*	6	0.076	14.4
	Redbud	*Cercis canadensis*	1	0.018	3.4
	Dogwood	*Cornus florida*	1	0.006	1.2
	Red oak	*Quercus rubra*	1	0.005	1.0
	Hickory	*Carya spp.*	1	0.002	0.4
	White oak	*Quercus alba*	1	0.002	0.4
PFP1	Loblolly pine	*Pinus taeda*	67	1.863	65.9
	Virginia pine	*Pinus virginiana*	85	0.612	21.6
	Black cherry	*Prunus serotina*	17	0.171	6.0
	Dogwood	*Cornus florida*	4	0.111	3.9
	Tulip poplar	*Liriodendron tulipfera*	11	0.051	1.8
	Various dead spp.		3	0.012	0.4
	Honey locust	*Gleditsia triacanthos*	1	0.008	0.3
	Red cedar	*Juniperus virginiana*	1	0.002	0.1
PFP2	Loblolly pine	*Pinus taeda*	89	2.413	90.0
	Virginia pine	*Pinus virginiana*	31	0.157	5.9
	Black cherry	*Prunus serotina*	7	0.031	1.2
	Various dead spp.		4	0.025	0.9
	Red maple	*Acer rubrum*	1	0.023	0.8
	Blackgum	*Nyssa sylvatica*	3	0.022	0.8
	Ash	*Fraxinus spp.*	1	0.010	0.4
PFP3	Loblolly pine	*Pinus taeda*	53	2.658	78.6
	Virginia pine	*Pinus virginiana*	7	0.291	8.6
	Black cherry	*Prunus serotina*	11	0.123	3.6
	Various dead spp.		7	0.091	2.7
	Red cedar	*Juniperus virginiana*	8	0.063	1.9
	Blackgum	*Nyssa sylvatica*	20	0.058	1.7

Appendix B. Tree species and their contribution to the total basal area at each sampling site studied in Appomattox Court House National Historical Park, Virginia, documented during inventories conducted in 2003–2004 (continued).

Site	Common Name	Scientific Name	N	Basal Area (m^2)	Relative Basal Area
	Red oak	*Quercus rubra*	13	0.040	1.2
	Tulip poplar	*Liriodendron tulipfera*	1	0.038	1.1
	White oak	*Quercus alba*	4	0.017	0.5
	Common catalpa	*Catalpa bignonioides*	1	0.004	0.1
MPH1	Loblolly pine	*Pinus taeda*	5	0.900	32.6
	Various dead spp.		10	0.569	20.7
	Virginia pine	*Pinus virginiana*	4	0.478	17.3
	Tulip poplar	*Liriodendron tulipfera*	9	0.392	14.2
	Red maple	*Acer rubrum*	12	0.170	6.2
	White oak	*Quercus alba*	4	0.139	5.0
	Ironwood	*Carpinus caroliniana*	6	0.038	1.4
	Hickory	*Carya spp.*	7	0.032	1.2
	Dogwood	*Cornus florida*	5	0.021	0.8
	Red oak	*Quercus rubra*	2	0.008	0.3
	Redbud	*Cercis canadensis*	1	0.005	0.2
	Blackgum	*Nyssa sylvatica*	1	0.004	0.1
	American beech	*Fagus grandifolia*	1	0.002	0.1
MPH2	Virginia pine	*Pinus virginiana*	12	0.995	33.5
	Various dead spp.		22	0.496	16.7
	Tulip poplar	*Liriodendron tulipfera*	6	0.455	15.3
	Loblolly pine	*Pinus taeda*	2	0.357	12.0
	Red maple	*Acer rubrum*	8	0.176	5.9
	American beech	*Fagus grandifolia*	14	0.115	3.9
	Ironwood	*Carpinus caroliniana*	5	0.100	3.4
	Hickory	*Carya spp.*	14	0.062	2.1
	Dogwood	*Cornus florida*	8	0.058	2.0
	Blackgum	*Nyssa sylvatica*	5	0.050	1.7
	Red cedar	*Juniperus virginiana*	6	0.047	1.6
	White oak	*Quercus alba*	5	0.032	1.1
	Red oak	*Quercus rubra*	5	0.027	0.9
MPH3	Virginia pine	*Pinus virginiana*	15	1.319	59.8
	Various dead spp.		10	0.225	10.2
	Red maple	*Acer rubrum*	7	0.153	6.9
	Hickory	*Carya spp.*	9	0.135	6.1
	Tulip poplar	*Liriodendron tulipfera*	3	0.123	5.6
	Blackgum	*Nyssa sylvatica*	7	0.114	5.2
	Dogwood	*Cornus florida*	10	0.039	1.8
	White oak	*Quercus alba*	2	0.037	1.7
	Red cedar	*Juniperus virginiana*	4	0.032	1.5
	Redbud	*Cercis canadensis*	3	0.023	1.1
	Black cherry	*Prunus serotina*	1	0.005	0.2
HWD1	White oak	*Quercus alba*	16	1.356	51.8
	Red oak	*Quercus rubra*	5	0.653	24.9
	Various dead spp.		4	0.516	19.7
	Blackgum	*Nyssa sylvatica*	9	0.051	1.9
	Hickory	*Carya spp.*	3	0.028	1.1
	Dogwood	*Cornus florida*	2	0.015	0.6

Appendix B. Tree species and their contribution to the total basal area at each sampling site studied in Appomattox Court House National Historical Park, Virginia, documented during inventories conducted in 2003–2004 (continued).

Site	Common Name	Scientific Name	N	Basal Area (m^2)	Relative Basal Area
HWD2	White oak	*Quercus alba*	8	1.585	45.5
	Tulip poplar	*Liriodendron tulipfera*	1	1.039	29.8
	American beech	*Fagus grandifolia*	4	0.341	9.8
	Hickory	*Carya spp.*	14	0.289	8.3
	Various dead spp.		5	0.196	5.6
	Red maple	*Acer rubrum*	4	0.014	0.4
	Redbud	*Cercis canadensis*	3	0.010	0.3
	Dogwood	*Cornus florida*	3	0.008	0.2
HWD3	White oak	*Quercus alba*	13	1.512	60.9
	Tulip poplar	*Liriodendron tulipfera*	1	0.238	9.6
	Unknown "A4"		6	0.235	9.5
	Various dead spp.		2	0.194	7.8
	Hickory	*Carya spp.*	2	0.091	3.7
	Blackgum	*Nyssa sylvatica*	9	0.075	3.0
	Ironwood	*Carpinus caroliniana*	2	0.073	2.9
	Red Maple	*Acer rubrum*	5	0.054	2.2
	Dogwood	*Cornus florida*	4	0.012	0.5
	Sassafras	*Sassafras albidum*	1	0.002	0.1
BLHWD1	American sycamore	*Platanus occidentalis*	2	0.887	46.8
	Tulip poplar	*Liriodendron tulipfera*	5	0.433	22.8
	Ash	*Fraxinus spp.*	5	0.177	9.4
	Black cherry	*Prunus serotina*	2	0.119	6.3
	Ironwood	*Carpinus caroliniana*	3	0.090	4.7
	Red maple	*Acer rubrum*	2	0.086	4.5
	Hickory	*Carya spp.*	2	0.067	3.5
	Dogwood	*Cornus florida*	3	0.017	0.9
	Hackberry	*Celtis occidentalis*	2	0.015	0.8
	Redbud	*Cercis canadensis*	1	0.005	0.3
BLHWD2	Ash	*Fraxinus spp.*	7	4.062	79.5
	Red maple	*Acer rubrum*	2	0.727	14.2
	Black cherry	*Prunus serotina*	7	0.250	4.9
	Tulip poplar	*Liriodendron tulipfera*	1	0.045	0.9
	American hophornbeam	*Ostrya virginiana*	2	0.015	0.3
	Butternut	*Juglans cinerea*	1	0.005	0.1
	Hackberry	*Celtis occidentalis*	1	0.004	0.1
BLHWD3	American sycamore	*Platanus occidentalis*	14	3.083	84.2
	Tulip poplar	*Liriodendron tulipfera*	7	0.344	9.4
	Box elder	*Acer negundo*	4	0.158	4.3
	Black cherry	*Prunus spp.*	9	0.067	1.8
	Pawpaw	*Asimina triloba*	3	0.006	0.2
	Ash	*Fraxinus spp.*	1	0.002	0.1

Appendix C. Number of trapnights for each trap type during each seasonal trapping period. Also given are the dates of the trapping session(s) within each seasonal trapping period at Appomattox Court House National Historical Park, Virginia.

Trap Type	Summer 17–20 June, 28–31 July 2003	Fall 7–9 Nov. 2003	Winter 6–8 Feb. 2004	Spring 7–9 May 2004	Summer 21–25 June, 2–6 Aug. 2004
Pitfall	720	208	224	296	1,176
Sherman	1,047	286	345	338	1,311
Sm. Tomahawk	177	39	57	55	230
Lg. Tomahawk	90	25	28	30	114
Camera	0	6	0	6	24

Appendix D. Number of trapnights per trap type at each trapping site within Appomattox Court House National Historical Park, Virginia between May 2003 and September 2004.

	Habitat Type and Site Number														
Trap Type	FFE1	FFE2	FFE3	PFP1	PFP2	PFP3	MPH1	MPH2	MPH3	HWD1	HWD2	HWD3	BLHWD1	BLHWD2[a]	BLHWD3[a]
Pitfall	180	180	180	180	180	180	180	180	180	180	180	180	182	134	148
Sherman	220	211	235	231	222	229	229	213	231	224	227	227	230	200	198
Sm. Tom.	37	34	39	40	36	38	40	38	37	38	39	37	36	34	35
Lg. Tom	20	19	20	20	19	20	19	20	19	19	19	20	18	17	18
Total	457	444	474	471	457	467	468	451	467	461	465	464	466	385	399
Total per Habitat Type		1,375			1,395			1,386			1,390			1,250	

[a] Due to weather constraints BLHWD2 and BLHWD3 were not trapped during the Fall 2003 trapping session

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