National Park Service
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Northeast Region
Philadelphia, Pennsylvania

Survey of Mammals at Booker T. Washington National Monument

Technical Report NPS/NER/NRTR—2005/032

ON THE COVER
Common gray fox (*Urocyon cinereoargenteus*) captured at Booker T. Washington National Monument, VA.
Photograph by: A. M. Roder and A. D. Chupp, Virginia Commonwealth University.

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Pagels, J. F., A. D. Chupp, and A. M. Roder

Department of Biology
Virginia Commonwealth University
1000 West Cary Street
Richmond, VA 23284

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Abstract

Twenty-six of 39 mammalian species that potentially could occur within Booker T. Washington National Monument (BOWA) located in Franklin County, Virginia, were documented in sampling that used several trap types, observations, and photography. We sampled in field-forest edge, mixed pine hardwood, hardwood, and bottomland hardwood habitat types; maintained fields and agricultural fields, including pastures, were not sampled. Low numbers of recaptures prevented statistical analysis of differences in richness and relative abundance among habitat types. During 5,608 trapnights 242 individuals encompassing 14 species were captured. The white-footed mouse (*Peromyscus leucopus*) and the northern short-tailed shrew (*Blarina brevicauda*) represented 53% and 17%, respectively, of all mammals captured. Among medium-sized mammals captured, both the Virginia opossum (*Didelphis virginiana*) and the common raccoon (*Procyon lotor*) were relatively abundant. The bottomland hardwood habitat type yielded the greatest richness (11) of species captured. The field-forest edge, mixed pine hardwood, and hardwood habitat types yielded eight, seven, and six species, respectively. Four species, Virginia opossum, common gray fox (*Urocyon cinereoargenteus*), common raccoon, and striped skunk (*Mephitis mephitis*), were recorded on the basis of both captures and night-camera photography, and the American mink (*Mustela vison*) and the coyote (*Canis latrans*) were photographed by park personnel. Other species observed by park personnel that added to the list of species documented included fox squirrel (*Sciurus niger*), American beaver (*Castor canadensis*), red fox (*Vulpes vulpes*), and black bear (*Ursus americanus*). The species and numbers of individuals recorded by various sampling methods largely reflected the body size of the mammal, findings that strongly support the use of multiple sampling methods when attempting to document a diverse mammal fauna. Fields characterized by cold-season tall fescue grass (*Festuca* spp) form an integral part of the cultural landscape of BOWA. Conversion of fescue fields to warm-season grasses and associated plants that are more characteristic of secondary succession is encouraged to benefit mammals and other wildlife.

Executive Summary

Booker T. Washington National Monument (BOWA), located in Franklin County, Virginia, was surveyed to establish a baseline inventory of non-volant mammals. No museum or published records of mammals were found, although distributional maps and personal knowledge of the area indicate as many as 39 mammal species potentially occur in the park. Habitat types largely reflect a continuum of successional habitats. Exclusive of maintained fescue fields and pastures that were not sampled, four major habitat types were identified and sampled: field-forest edge, 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. Twenty-six mammal species were recorded ranging 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 26 mammal species recorded, three were captured only in pitfall traps, six in pitfall or other trap types, and among the other 17 species, some were captured in traps and also recorded by observations or photography, including night-camera photography. Overall trapping success was low during the survey. Because of low numbers of captures and 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. However, to serve as a baseline for more intensive future studies, those numbers are presented within the report. Among the 14 species captured, eight were the size of eastern chipmunks or smaller, and nine were represented by seven or fewer individuals. The white-footed mouse, a habitat generalist, represented more than half of all individual mammals captured (129 of 242). The Virginia opossum, northern short-tailed shrew, white-footed mouse, and the common raccoon were captured in all habitat types. Richness of mammals captured was greatest in the bottomland hardwood habitat type. Four species, American beaver, meadow jumping mouse (*Napaeozapus hudsonius*), American mink, and long-tailed weasel (*Mustela frenata*), were captured (jumping mouse and weasel) or observed (beaver and mink) only in the BLHWD. Very little old-field habitat characteristic of secondary succession is present at BOWA, 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. Warm season grasses are much more hospitable to small mammals. Such grasses and associated native plants provide food, good cover from predators, and excellent runways and nesting sites. Our findings indicate a relatively rich mammal fauna at BOWA, and the number of mammals on the list will likely increase as a result of future observations and sampling.

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 easily 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 Booker T. Washington National Monument (BOWA), located in Franklin 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), 39 species may occur at BOWA. Our list is considerably longer than the NPSpecies (2005) database which lists only 19 species of mammals as present and one as probably present. The NPSpecies list is based on Litton and Rabenau's mammal survey in 1985; the only known mammal data collected in BOWA prior to our inventory. We found no museum records of mammals designated as having been collected within BOWA, although some specimen records are available for Franklin 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 to August 2004. The study objectives were to 1) document the 90% of mammal species, exclusive of bats, that occur within the boundaries of BOWA, 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

Booker T. Washington National Monument (BOWA) is located in the upper Piedmont Physiographic Region, 35 km (22 mi) southeast of Roanoke, in Franklin County, Virginia. The park lies within view of the Blue Ridge Mountains. The average elevation at BOWA is approximately 274 m (900 ft). The park covers an area of 91 ha (224 ac) that includes a mosaic of habitat types including fescue (*Festuca* spp.) fields and successional habitat types that range from pine forests to hardwood forests. The forests comprise most of the park except for approximately 26 ha (65 ac) of pasture and hay fields. Non-pasture fields are maintained (mowed) once or twice a year. Two small streams run through the park; Jack O' Lantern Branch runs along the eastern edge, and Gills Creek runs along the western edge of the park..

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*. A list of the mammals that may occur at BOWA and the literature that was searched is provided in Table 1. Although some specimen records are available for Franklin County, we found no museum records of mammals designated as having been collected within BOWA. 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 Timothy Sims and aerial photography, we determined the available habitat types and scouted possible sampling sites within each habitat type. Four major habitat types were identified: field-forest edge (FFE), 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 randomly selected 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, and some fields were pastures with grazing livestock. 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 sites 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) and are provided in Appendix A. All readings are Universal Transverse Mercator (UTM), Zone 17, NAD27 datum and were converted to NAD83 for development of the site maps. The location of each sampling site can be seen on the site map (Figure 1).

Table 1. Potential mammal species that may occur in Booker T. Washington National Monument, Virginia.

Common Name	Scientific Name[a]	Literature[b]
Virginia opossum	*Didelphis virginiana*	1,2,5
Pygmy shrew	*Sorex hoyi*	2,4,5
Southeastern shrew	*Sorex longirostris*	1,2,4,5
Northern short-tailed shrew	*Blarina brevicauda*	1,2,4,5
Least shrew	*Cryptotis parva*	1,2,4,5
Eastern mole	*Scalopus aquaticus*	1,2,5
Star-nosed mole	*Condylura cristata*	1,2,4,5
Eastern cottontail	*Sylvilagus floridanus*	1,2,5
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*	1,2,5
Red squirrel	*Tamiasciurus hudsonicus*	1,2,5
Southern flying squirrel	*Glaucomys volans*	1,2,5
American beaver	*Castor canadensis*	1,2,5
Eastern harvest mouse	*Reithrodontomys humulis*	1,2,5
White-footed mouse	*Peromyscus leucopus*	1,2,5
Golden mouse	*Ochrotomys nuttalli*	1,2,5
Hispid cotton rat	*Sigmodon hispidus*	2,4
Eastern woodrat	*Neotoma floridana*	1,2,5
Norway rat	*Rattus norvegicus*	1,5
House mouse	*Mus musculus*	1,5
Meadow vole	*Microtus pennsylvanicus*	1,2,5
Woodland vole	*Microtus pinetorum*	1,2,5
Common muskrat	*Ondatra zibethicus*	1,2,5
Southern bog lemming	*Synaptomys cooperi*	1,2,5
Meadow jumping mouse	*Zapus hudsonius*	1,2,5
Coyote	*Canis latrans*	2,5
Red fox	*Vulpes vulpes*	1,2,5
Common gray fox	*Urocyon cinereoargenteus*	1,2,5
Black bear	*Ursus americanus*	1,2,5
Common raccoon	*Procyon lotor*	1,2,5
Long-tailed weasel	*Mustela frenata*	1,2,5
Least weasel	*Mustela nivalis*	1,2,5
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*	1,2,3,5

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

[b]Literature:
1. Handley and Patton 1947.
2. Lindsey 1998.
3. NPFauna 2002.
4. Pagels Unpublished information.
5. Webster et al. 1985.

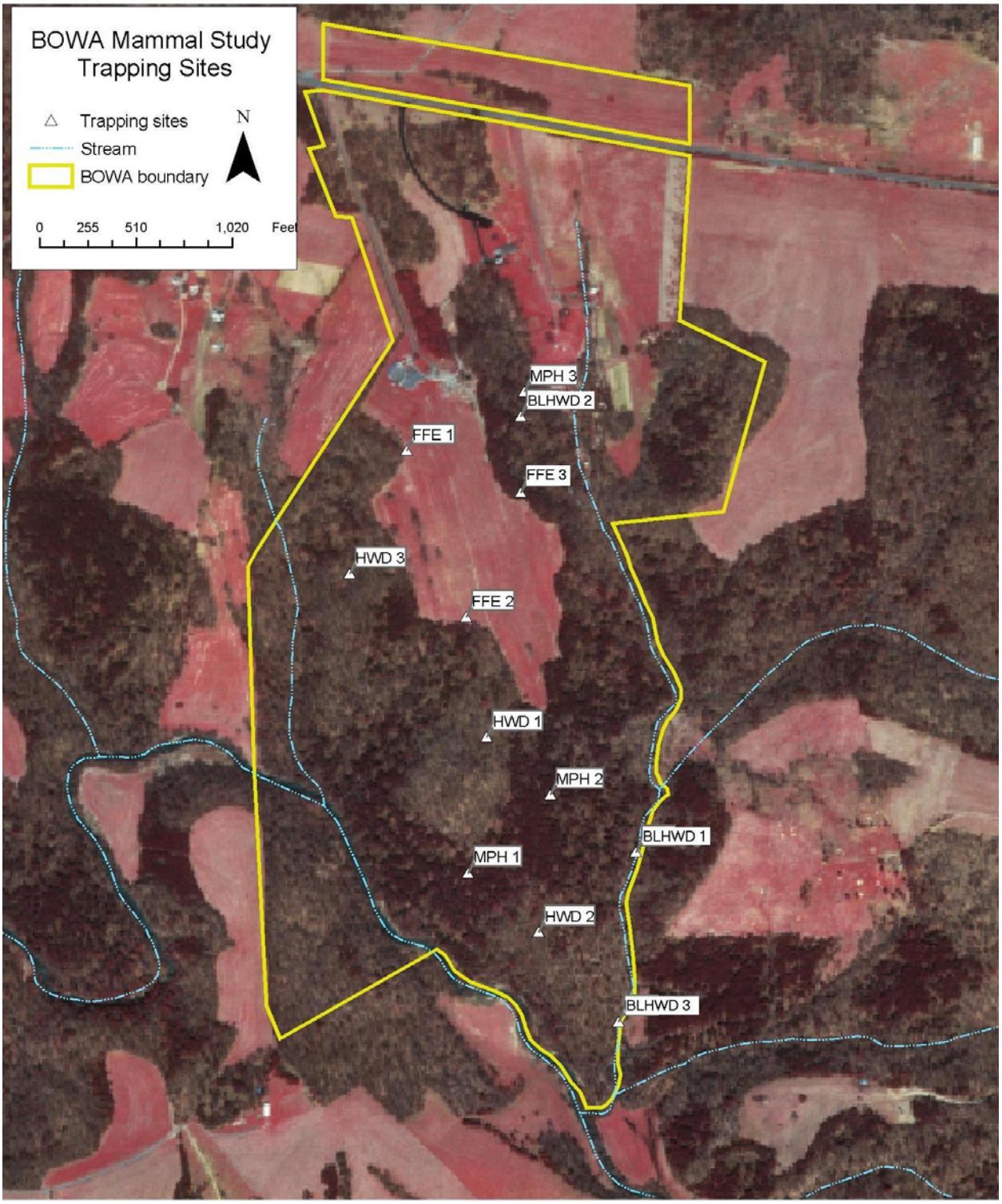

Figure 1. Locations of mammal sampling sites within Booker T. Washington National Monument, Virginia, inventoried during 2003 and 2004.

Habitat Types

Below is a brief description of 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 Virginia pine (*Pinus virginiana*) and red cedar (*Juniperus virginiana*). Deciduous species were variable among sites, but the more common species included blackgum (*Nyssa sylvatica*), dogwood (*Cornus florida*), tulip poplar (*Liriodendron tulipifera*), 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. 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 (non-native fescue) were more common here than in other habitats.

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. Virginia pine was the dominant pine species in this habitat, although one eastern white pine (*Pinus strobus*) was recorded which had a DBH of 75 cm. Virginia pine was an important component of this habitat with an average total basal area of 47% and an average relative density of 28%. Deciduous trees were small (DBH < 20 cm) and existed primarily in the understory. The most common deciduous trees in this habitat type included tulip poplar, red maple (*Acer rubrum*), dogwood, red oak, and sourwood (*Oxydendrum arboretum*). Understory trees were mostly saplings of overstory species. However, as expected in this successional stage, deciduous saplings were more common than pine saplings. Viney growth was minimal but poison ivy, Virginia creeper and common greenbriar were present in sparse amounts. Club moss of the genus *Lycopodium* was a common ground cover in this habitat type. Grasses and herbs were rarely observed in this 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, blackgum, tulip poplar, white oak, red oak, and hickories. Common subcanopy species included dogwood, ironwood (*Carpinus caroliniana*), and sourwood. There were no evergreen species recorded at our sites, although they are scattered among hardwood stands at BOWA. Vegetation data revealed that the DBH of trees ranged from approximately 9 cm in subcanopy trees to 60 cm among oak species. Ground cover consisted primarily of deciduous leaf litter. Herbaceous, grass, and shrub growth were relatively sparse in the HWD habitat types. Vines were of infrequent occurrence in the HWD habitat type.

Bottomland hardwood (BLHWD) – The BLHWD habitat type was restricted to floodplain areas along the Jack O' Lantern branch. Washouts from flooding were not common at these sites, however, we did notice debris build-up caused by flooding on a couple occasions. Overstory

trees were primarily deciduous species, including American sycamore (*Platanus occidentalis*), red maple, tulip poplar, ash (*Fraxinus* spp.), black cherry (*Prunus serotina*), and ironwood. Basswood (*Tilia americana*) was less commonly observed. Red cedar was the only evergreen species observed in this habitat type. Common subcanopy species included dogwood, redbud (*Cercis canadensis*), and pawpaw (*Asimina triloba*). The understory was comprised of saplings of overstory species as well as Alder (*Alnus* spp.), which grows as a larger shrub. Vines present in this habitat type often included 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. Substrate in this habitat was more moist than in other habitat types, and one site was infrequently disturbed by grazing cattle.

Survey and Collection Methodology

The circular-plot sampling scheme used at the mixed pine hardwood and hardwood 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 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).

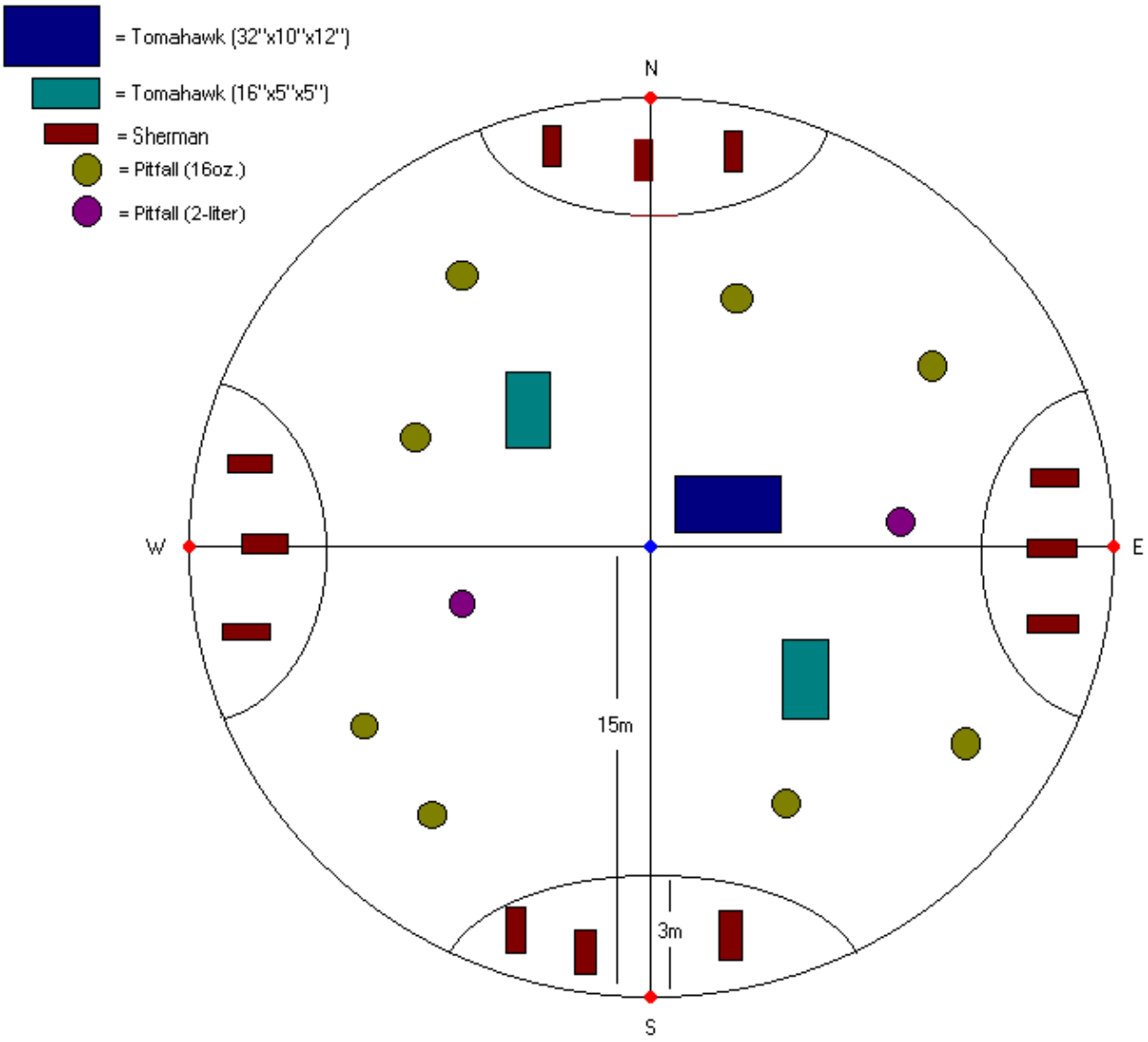

Figure 2. Mammal sampling configuration for circular plots used in mixed pine hardwood and hardwood habitat types at Booker T. Washington National Monument, Virginia.

In order to more effectively sample the field-forest edge and bottomland hardwood habitat types, transects were used instead of circular plots. The FFE and BLHWD 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.

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 BOWA. During each trapping session, e.g., a fall or winter session (Appendix B), 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, 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 B. Trapping effort within each habitat type is given in Appendix C. 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).

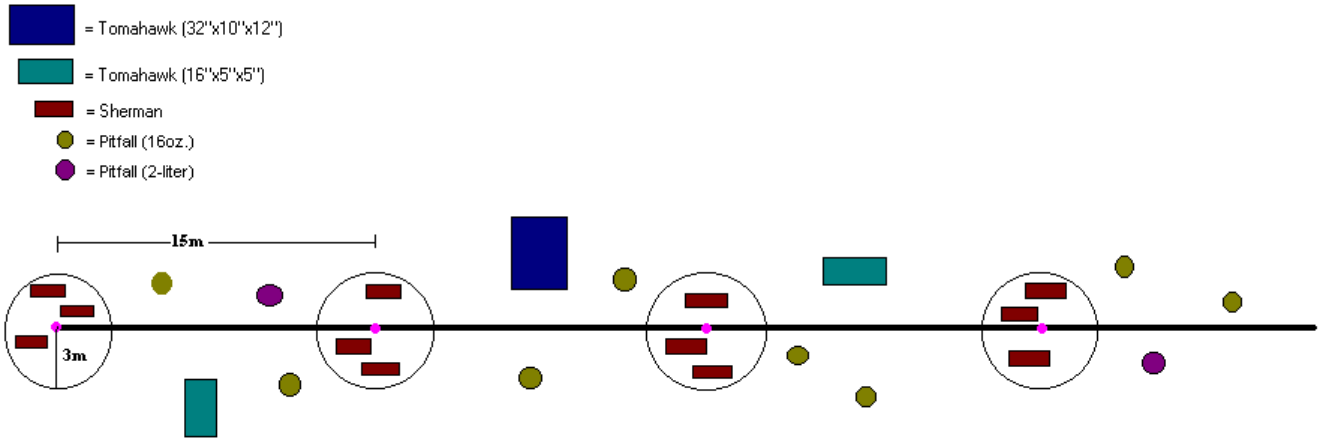

Figure 3. Mammal sampling configuration used for transects in field-forest edge and bottomland hardwood habitat types at Booker T. Washington National Monument, Virginia.

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,* and *Fraxinus* 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 were calculated using the number of pitfall traps because this species almost always is 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 animals are not encountered among all 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-nine species of mammals were expected to occur at BOWA based on known species distributions (Table 1). The current inventory, including reports by park personnel, documented 26 species of mammals, representing 67% of the 39 species (Table 2). None of the species documented are on State or Federal lists of species of concern. Observations accounted for 12 of the 26 species recorded. Four species were recorded on the basis of captures and night-camera photography (Tables 2 and 3), and the American mink (*Mustela vison*) and the coyote (*Canis latrans*) were photographed by park personnel. Other species observed by park personnel that added to the list of species documented included the fox squirrel (*Sciurus niger*), American beaver (*Castor canadensis*), red fox (*Vulpes vulpes*), and the black bear (*Ursus americanus*). The record for the red fox is based on observations made by park personnel several years ago. The species and numbers of individuals recorded by each sampling method largely reflected the relative body size of the mammal (Table 3).

A total of 242 mammals was captured during 5,608 trapnights (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 are likely recaptures from earlier sessions. Two species alone represented 70% of all mammals captured. The overall richness of species captures (14) was relatively high, however the ubiquitous white-footed mouse (*Peromyscus leucopus*), 129 individuals, and the northern short-tailed shrew (*Blarina brevicauda*), 42 individuals, represented 53% and 17% of the mammals captured. Among the 14 species captured, 8 species were chipmunk size or smaller. The relative abundance, i.e. the number of individuals captured (M_{t+1}) corrected for trapping effort for each habitat type, is given for each species in Table 5. Among larger species, the common raccoon was relatively abundant in all habitats with greatest abundance in the BLHWD, 33.3 ± 6.9 (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. Nine species were represented by seven or fewer individuals. Among the habitat types, richness of mammals captured ranged from six in the HWD to 11 in the BLHWD (Tables 4 and 5). The Virginia opossum, northern short-tailed shrew, white-footed mouse, and common raccoon were captured in all habitat types. Four species, (American beaver, [*Castor Canadensis*], meadow jumping mouse, [*Napaeozapus hudsonius*], American mink, [*Mustela vison*], and long-tailed weasel, [*Mustela frenata*]), were captured or observed (beaver and mink) only in the BLHWD. In most instances, a lack of species evenness resulted from the high numbers of white-footed mice captured compared to other species.

Table 2. Mammal species documented in the 2003–2004 inventories in Booker T. Washington National Monument, Virginia

Common Name	Field Study[a]
Virginia opossum	C,P
Pygmy shrew	C
Southeastern shrew	C
Northern short-tailed shrew	C
Least shrew	C
Eastern mole	O
Eastern cottontail	O
Eastern chipmunk	C
Woodchuck	O
Eastern gray squirrel	C,O
Fox squirrel	O
Southern flying squirrel	O
American beaver	O
White-footed mouse	C
House mouse	O
Woodland vole	C
Meadow jumping mouse	C
Coyote	O
Red fox	O
Common gray fox	C,P
Black bear	O
Common raccoon	C,P
Long-tailed weasel	C
American mink	O
Striped skunk	C,P
White-tailed deer	O

[a]Field Study:
C. Captured
O. Observed
P. Photographed

Table 3. Number of captures (including recaptures) of each species* of mammals recorded within Booker T. Washington National Monument, Virginia, documented during inventories conducted in 2003–2004.

Common Name	Pitfall (16 oz.)	Pitfall (2-Liter)	Sherman	Small Tomahawk	Large Tomahawk	Night Photograph	Observation
Pygmy shrew	2						
Least shrew	2	1					
Southeastern shrew	5						
Northern short-tailed shrew	9		32				
Woodland vole			12				
House mouse							X
White-footed mouse	1		320				
Meadow jumping mouse			1				
Eastern mole							X
Southern flying squirrel							X
Eastern chipmunk			4				
Long-tailed weasel			1				
Eastern cottontail							X
Eastern gray squirrel			1	9	2		X
Fox squirrel							X
American mink							X
Striped skunk				1		17	
Woodchuck							X
Virginia opossum				3	15	1	
Common raccoon					19	26	
Common gray fox					1	35	
Red fox							X
American beaver							X
Coyote							X
White-tailed deer							X
Black bear							X
TOTAL	19	1	371	13	37	79	

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

Table 4. Total number of individuals of each species* captured in each habitat type surveyed in Booker T. Washington National Monument, Virginia, during the mammal inventory conducted in 2003–2004.

	FFE	MPH	HWD	BLHWD	Total
Species					
Virginia opossum	6	2	5	4	17
Pygmy shrew			3		3
Southeastern shrew		2	1	1	4
Northern short-tailed shrew	10	9	7	16	42
Least shrew	3				3
Eastern chipmunk	1			2	3
Eastern gray squirrel	2	4		1	7
White-footed mouse	27	27	26	49	129
Woodland vole	3			8	11
Meadow jumping mouse				1	1
Common gray fox		1			1
Common raccoon	3	3	6	7	19
Long-tailed weasel				1	1
Striped skunk				1	1
Total	55	48	48	91	242
Trapnights					
Pitfall	564	563	564	564	2,255
Sherman	666	613	653	700	2,632
Small Tomahawk	122	114	117	119	472
Large Tomahawk	62	61	63	63	249
Total	1,414	1,351	1,397	1,446	5,608
Richness	8	7	6	11	14
Evenness	0.76	0.70	0.76	0.63	0.60

*Species are arranged phylogenetically (after Jones et al. 1997).

Abbreviations: FFE = Field-forest edge
MPH = Mixed pine hardwood
HWD = Hardwood
BLHWD = Bottomland hardwood

Table 5. Average relative abundance (individuals per 100 trapnights[a]) of each species captured within the different habitat types ± standard error, in Booker T. Washington National Monument, Virginia, documented during inventories conducted in 2003–2004.

Species[b]	FFE[c]	MPH[c]	HWD[c]	BLHWD[c]
Virginia opossum	9.7 ± 0.9	3.3 ± 0.6	8.5 ± 1.5	6.7 ± 1.1
Pygmy shrew			1.6 ± 0.5	
Southeastern shrew		1.1 ± 0.2	0.5 ± 0.2	0.5 ± 0.2
Northern short-tailed shrew	2.4 ± 0.4	2.3 ± 0.3	1.8 ± 0.3	3.7 ± 0.5
Least shrew	1.6 ± 0.3			
Eastern chipmunk	0.4 ± 0.1			0.9 ± 0.3
Eastern gray squirrel	3.3 ± 1.1	7.3 ± 2.4		1.6 ± 0.5
White-footed mouse	12.4 ± 0.9	13.9 ± 1.3	12.2 ± 0.7	21.3 ± 1.9
Woodland vole	1.4 ± 0.3			3.5 ± 0.7
Meadow jumping mouse				0.4 ± 0.1
Common gray fox		4.8 ± 1.6		
Common raccoon	15.0 ± 5.0	14.3 ± 4.8	28.6 ± 9.5	33.3 ± 6.9
Long-tailed weasel				0.4 ± 0.1
Striped skunk				2.5 ± 0.8

[a]Effort was determined from the trap types in which that species was captured.
[b]Species are arranged phylogenetically (after Jones et al. 1997).
[c]Abbreviations: FFE = Field-forest edge
MPH = Mixed pine hardwood
HWD = Hardwood
BLHWD = Bottomland hardwood.

Discussion

The 26 species recorded at BOWA, 67% of the species that may occur there, is high considering that other species may be present, yet remain undetected, and that some of the species may not occur there. The list of species that potentially occur at BOWA includes species that are rarely captured, or uncommonly observed by sign or sightings, but that otherwise should be present, even if as transient occurrences only (Table 1). Among these species would be the common muskrat (*Ondatra zibethicus*), bobcat (*Felis rufus*), and the river otter (*Lontra canadensis*). Some of these are encountered outside of national park sites by fur trappers and hunters or in parks as road kills, and records are not available from those sources. Among small mammals, it is very likely that both the eastern mole (*Scalopus aquaticus*) and the star-nosed mole (*Condylura cristata*) occur at BOWA. The star-nosed mole is now known to have a nearly statewide distribution (Pagels, VCU, personal information), and are present at BOWA, but only the eastern mole was recorded. The very small least weasel (*Mustela nivalis)* has been recorded from Appomattox County (VCU Mammal Collection), but is a species than 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 not previously been detected. Further, several of the mammals that we included on our potential species list that we did not document and that may not occur at BOWA may occur just to the west at somewhat higher elevations, that is, closer to the Blue Ridge. The red squirrel (*Tamiasciurus hudsonicus*), eastern woodrat (*Neotoma floridana*), and southern bog lemming (*Synaptomys cooperi*) are among the species in that group.

The small mammal that we captured in greatest numbers and in all habitats, the white-footed mouse, is a habitat generalist, occurring in a variety of habitat types (Pagels et al. 1992). Selected small mammals that inhabit old fields and field edges in Virginia, including the greater BOWA area, include the eastern harvest mouse (*Reithrodontomys humulis)*, hispid cotton rat (*Sigmodon hispidus*), 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 BOWA, none was captured. The presence of both the eastern meadow vole and hispid cotton rat can be determined by the distinct runways they create 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. Both species occur in somewhat more heterogeneous old-field habitats than those at BOWA. For example, the hispid cotton rat has been collected in much of central Virginia from near sea level to relatively high elevations, i.e., near 600 m in the Blue Ridge mountains (Pagels, personal observations). 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, such as the northern short-tailed shrew and the white-footed mouse, also prefer such heterogeneous old-field habitats; the maintained agricultural fields, and pastures do not exhibit the old-field characteristic of secondary succession. Except for very spotty areas in some fields, such old-field habitat is nearly lacking, and where it occurs is largely limited to the narrow field-forest edges.

Instead, most fields 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, tall fescue produces chemicals which are detrimental to the germination and establishment of other more beneficial grasses (allelopathic). 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. We concur with these observations. We did not trap in pastures because of presence of cattle, and, as noted above, did not trap for mammals in other fields because in early examination in many areas we were unable to find signs (i.e. runways, scats, and cuttings) that would indicate the presence of small mammals. Fields, including pastures, are an obvious feature of the landscape to maintain the cultural landscape of BOWA. Although the fescues nicely help maintain the cultural heritage, i.e. the openness of the park, they do little to encourage wildlife populations.

Several variables could have impacted our mammal survey results at BOWA regardless of species that may have remained undetected or were absent 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 BOWA. 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, Virginia 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 BOWA 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 BOWA included several species that were not detected in our survey and that we did not expect to document. However, the 26 species that were documented for the park, as well as those reported in areas nearby BOWA, indicate a relatively rich mammal assemblage. Conversely, considering that more than 30% of the species of potential occurrence were not recorded 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 and maintenance 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.

Finally, future conservation plans should prioritize the preservation of the apparently vital natural resource, Jack O' Lantern Branch and associated land features. The creek is adjacent to all three of our BLHWD trapping sites and abundance and diversity were high at these sites. Four species, the American beaver, meadow jumping mouse, American mink, and long-tailed weasel, were captured or observed only at these sites along Jack O' Lantern Branch.

Grassland Management

Conversion from cool- to warm-season grasses in BOWA fields would likely result in more natural heterogeneous old fields that would greatly benefit mammals while continuing to commemorate the parks' cultural history. Managers at BOWA, 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, and perhaps, prescribed burns, completed in a rotational fashion in selected portions of fields.

In hindsight, temporary "spot-trapping" of maintained and agricultural fields should have been completed, although we feel that it is unlikely that additional species would have been captured without intense sampling in many field areas. However, trapping in current fescue fields would have provided baseline information to help determine the importance to mammals of conversion of fescue fields to warm-season grasses. In conversions of fescue fields to more heterogeneous old fields we suggest mammal populations should be monitored in both fescue and converted fields. Notable mammal species to target 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 12 trapping sites within Booker T. Washington National Monument, VA during the 2003–2004 mammal inventory.

Site	Latitude (East)	Longitude (North)
FFE 1	612512	4108552
FFE 2	612608	4108283
FFE 3	612696	4108484
MPH 1	612611	4107870
MPH 2	612743	4107996
MPH 3	612701	4108647
HWD 1	612641	4108089
HWD 2	612725	4107774
HWD 3	612420	4108353
BLHWD 1	612882	4107903
BLHWD 2	612696	4108607
BLHWD 3	612854	4107629

*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 within Booker T. Washington National Monument, Virginia, documented during inventories conducted in 2003–2004.

Site	Common Name	Scientific Name	N	Basal Area (m^2)	Relative Basal Area
FFE1	Hickory	*Carya* spp.	12	0.204	5.7
	Dogwood	*Cornus florida*	8	0.041	1.1
	Tulip poplar	*Liriodendron tulipfera*	7	2.023	56.5
	White oak	*Quercus* spp.	7	0.544	15.2
	Cherry	*Prunus* spp.	6	0.285	8
	Black walnut	*Juglans nigra*	6	0.201	5.6
	Red maple	*Acer rubrum*	3	0.017	0.5
	Red cedar	*Juniperus virginiana*	2	0.017	0.5
	Red oak	*Quercus* spp.	1	0.238	6.6
	Sassafras	*Sassafras albidum*	1	0.010	0.3
FFE2	Virginia pine	*Pinus virginiana*	18	0.796	34
	Various dead spp.		11	0.255	10.9
	Red maple	*Acer rubrum*	9	0.078	3.3
	Dogwood	*Cornus florida*	9	0.048	2.1
	White oak	*Quercus* spp.	5	0.509	22
	Tulip poplar	*Liriodendron tulipfera*	4	0.112	4.8
	Red oak	*Quercus* spp.	3	0.409	17.6
	Cherry	*Prunus* spp.	2	0.031	1.4
	Red cedar	*Juniperus virginiana*	2	0.013	0.6
	Blackgum	*Nyssa sylvatica*	2	0.011	0.5
	American beech	*Fagus grandifolia*	1	0.042	1.8
	Ash	*Fraxinus* spp.	1	0.013	0.6
	Black locust	*Robinia pseudoacacia*	1	0.006	0.3
	Hickory	*Carya* spp.	1	0.002	0.1
FFE3	Virginia pine	*Pinus virginiana*	30	1.477	52
	Dogwood	*Cornus florida*	11	0.175	6.2
	Blackgum	*Nyssa sylvatica*	11	0.089	3.1
	Various dead spp.		7	0.126	4.4
	Sourwood	*Oxydendrum arboreum*	5	0.056	2
	Cherry	*Prunus* spp.	4	0.222	7.8
	Red cedar	*Juniperus virginiana*	3	0.057	2
	Red maple	*Acer rubrum*	2	0.112	3.9
	Sassafras	*Sassafras albidum*	2	0.011	0.4
	Red oak	*Quercus* spp.	1	0.442	15.6
	Tulip poplar	*Liriodendron tulipfera*	1	0.071	2.5
HWD1	Sourwood	*Oxydendrum arboreum*	28	0.531	19.7
	White oak	*Quercus* spp.	16	0.864	32.1
	Red maple	*Acer rubrum*	8	0.077	2.9
	Blackgum	*Nyssa sylvatica*	7	0.114	4.2
	Red oak	*Quercus* spp.	6	0.797	29.6
	Various dead spp.		3	0.046	1.7
	Hickory	*Carya* spp.	2	0.189	7
	Tulip poplar	*Liriodendron tulipfera*	2	0.074	2.7
	Dogwood	*Cornus florida*	1	0.002	0.1

Appendix B. Tree species and their contribution to the total basal area at each sampling site studied within Booker T. Washington National Monument, Virginia, documented during inventories conducted in 2003–2004 (continued).

Site	Common Name	Scientific Name	N	Basal Area (m^2)	Relative Basal Area
HWD2	Ironwood	*Carpinus caroliniana*	24	0.102	3.1
	Tulip poplar	*Liriodendron tulipfera*	8	1.202	36.3
	White oak	*Quercus* spp.	6	0.321	9.7
	Red maple	*Acer rubrum*	6	0.226	6.8
	Red oak	*Quercus* spp.	5	0.680	20.5
	Various dead spp.		5	0.280	8.5
	Sourwood	*Oxydendrum arboreum*	5	0.043	1.3
	Hickory	*Carya* spp.	4	0.146	4.4
	Ash	*Fraxinus* spp.	3	0.288	8.7
	Blackgum	*Nyssa sylvatica*	3	0.022	0.7
	Dogwood	*Cornus florida*	3	0.006	0.2
HWD3	Tulip poplar	*Liriodendron tulipfera*	18	0.256	11.4
	Blackgum	*Nyssa sylvatica*	12	0.101	4.5
	Ironwood	*Carpinus caroliniana*	12	0.065	2.9
	Dogwood	*Cornus florida*	8	0.022	1
	Hickory	*Carya* spp.	6	0.665	29.6
	Various dead spp.		4	0.432	19.2
	Red maple	*Acer rubrum*	3	0.121	5.4
	White oak	*Quercus* spp.	2	0.347	15.5
	Red oak	*Quercus* spp.	2	0.234	10.4
	Ash	*Fraxinus* spp.	1	0.002	0.1
MPH1	Virginia pine	*Pinus virginiana*	26	1.148	52.5
	Dogwood	*Cornus florida*	14	0.144	6.6
	Tulip poplar	*Liriodendron tulipfera*	11	0.261	11.9
	Red maple	*Acer rubrum*	8	0.036	1.6
	American beech	*Fagus grandifolia*	7	0.022	1
	Various dead spp.		3	0.035	1.6
	Red oak	*Quercus* spp.	3	0.013	0.6
	Hickory	*Carya* spp.	3	0.009	0.4
	White oak	*Quercus* spp.	2	0.027	1.3
	Blackgum	*Nyssa sylvatica*	2	0.018	0.8
	Ash	*Fraxinus* spp.	2	0.011	0.5
	Eastern white pine	*Pinus strobus*	1	0.442	20.2
	Sourwood	*Oxydendrum arboreum*	1	0.011	0.5
	Ironwood	*Carpinus caroliniana*	1	0.004	0.2
	Redbud	*Cercis canadensis*	1	0.004	0.2
	Red cedar	*Juniperus virginiana*	1	0.003	0.1
MPH2	Virginia pine	*Pinus virginiana*	45	1.784	69.2
	Sourwood	*Oxydendrum arboreum*	17	0.391	15.2
	Dogwood	*Cornus florida*	10	0.077	3
	Various dead spp.		9	0.135	5.2
	Red maple	*Acer rubrum*	9	0.043	1.7
	Tulip poplar	*Liriodendron tulipfera*	5	0.107	4.2
	Red oak	*Quercus* spp.	5	0.020	0.8
	American beech	*Fagus grandifolia*	3	0.022	0.8

Appendix B. Tree species and their contribution to the total basal area at each sampling site studied within Booker T. Washington National Monument, Virginia, documented during inventories conducted in 2003–2004 (continued).

Site	Common Name	Scientific Name	N	Basal Area (m^2)	Relative Basal Area
MPH3	Dogwood	*Cornus florida*	19	0.122	5.5
	Tulip poplar	*Liriodendron tulipfera*	9	0.699	31.4
	Various dead spp.		8	0.295	13.2
	Virginia pine	*Pinus virginiana*	5	0.402	18
	Red oak	*Quercus* spp.	4	0.473	21.2
	Blackgum	*Nyssa sylvatica*	3	0.027	1.2
	Cherry	*Prunus* spp.	2	0.147	6.6
	Sourwood	*Oxydendrum arboreum*	2	0.007	0.3
	Red cedar	*Juniperus virginiana*	1	0.020	0.9
	Butternut	*Juglans cinerea*	1	0.018	0.8
	Red maple	*Acer rubrum*	1	0.018	0.8
BLHWD1	Ironwood	*Carpinus caroliniana*	15	0.256	9
	Alder	*Alnus* spp.	10	0.027	1
	Redbud	*Cercis canadensis*	8	0.028	1
	Dogwood	*Cornus florida*	7	0.054	1.9
	American sycamore	*Platanus occidentalis*	4	0.799	28.1
	Red cedar	*Juniperus virginiana*	4	0.154	5.4
	American basswood	*Tilia americana*	3	1.013	35.6
	Various dead spp.		3	0.172	6
	Butternut	*Juglans cinerea*	1	0.113	4
	Red oak	*Quercus* spp.	1	0.113	4
	Tulip poplar	*Liriodendron tulipfera*	1	0.086	3
	Unknown		1	0.008	0.3
	Hickory	*Carya* spp.	1	0.008	0.3
	Unknown		1	0.008	0.3
	American beech	*Fagus grandifolia*	1	0.004	0.1
BLHWD2	American sycamore	*Platanus occidentalis*	6	1.329	54.5
	Red maple	*Acer rubrum*	5	0.160	6.6
	Various dead spp.		5	0.121	4.9
	Dogwood	*Cornus florida*	5	0.029	1.2
	Tulip poplar	*Liriodendron tulipfera*	4	0.321	13.2
	Cherry	*Prunus* spp.	3	0.219	9
	Sourwood	*Oxydendrum arboreum*	1	0.102	4.2
	Red cedar	*Juniperus virginiana*	1	0.080	3.3
	Blackgum	*Nyssa sylvatica*	1	0.035	1.4
	Ironwood	*Carpinus caroliniana*	1	0.023	0.9
	Unknown		1	0.020	0.8
BLHWD3	Tulip poplar	*Liriodendron tulipfera*	10	0.816	41.6
	Pawpaw	*Asimina triloba*	9	0.046	2.3
	Ironwood	*Carpinus caroliniana*	7	0.240	12.2
	Various dead spp.		5	0.212	10.8
	Ash	*Fraxinus* spp.	5	0.193	9.8
	Dogwood	*Cornus florida*	5	0.014	0.7
	Redbud	*Cercis canadensis*	3	0.017	0.9
	Hickory	*Carya* spp.	1	0.145	7.4
	American sycamore	*Platanus occidentalis*	1	0.108	5.5
	Red oak	*Quercus* spp.	1	0.071	3.6
	Cherry	*Prunus* spp.	1	0.049	2.5
	Red maple	*Acer rubrum*	1	0.031	1.6
	Unknown		1	0.020	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 Booker T. Washington National Monument, Franklin County, Virginia.

Trap Type	Summer 24–27 June, 4–8 Aug. 2003	Fall 21–23 Nov. 2003	Winter 13–15 Feb. 2004	Spring 14–16 May 2004	Summer 28 June–2 July, 9–13 Aug. 2004
Pitfall	672	192	192	239	960
Sherman	972	261	265	214	920
Sm. Tomahawk	163	46	42	42	179
Lg. Tomahawk	83	24	22	24	96
Camera	0	6	6	6	24

Appendix D. Number of trapnights per trap type during the 2003–2004 mammal inventory at each trapping site within Booker T. Washington National Monument, Franklin County, Virginia.

	Habitat Type and Site Number											
Trap Type	FFE1	FFE2	FFE3	MPH1	MPH2	MPH3	HWD1	HWD2	HWD3	BLHWD1	BLHWD2	BLHWD3
Pitfall	188	188	188	188	187	188	188	188	188	188	188	188
Sherman	242	223	201	215	240	158	235	228	190	237	214	249
Small Tomahawk	41	42	39	40	40	34	40	41	36	40	37	42
Large Tomahawk	20	21	21	20	20	21	21	21	21	21	21	21
Total	491	474	449	463	487	401	484	478	435	486	460	500
Total per Habitat Type		1,414			1,351			1,397			1,446	

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National Park Service
U.S. Department of the Interior

Northeast Region
Natural Resource Stewardship and Science
200 Chestnut Street
Philadelphia, Pennsylvania 19106-2878

http://www.nps.gov/nero/science/

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