

National Park Service
U.S. Department of the Interior

Northeast Region
Philadelphia, Pennsylvania



Inventory of Mammals (Excluding Bats) of Fredericksburg and Spotsylvania National Military Park

Technical Report NPS/NER/NRTR—2008/121



ON THE COVER

Eastern harvest mouse (*Reithrodontomys humulis*) in Fredericksburg and Spotsylvania National Military Park.
Photograph by Janet Mulligan.

Inventory of Mammals (Excluding Bats) of Fredericksburg and Spotsylvania National Military Park

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May 2008

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This report was accomplished under Cooperative Agreement 1443DCA309701200, Task Order Number T-3097-01-300 with assistance from the NPS. The statements, findings, conclusions, recommendations, and data in this report are solely those of the author(s), and do not necessarily reflect the views of the U.S. Department of the Interior, National Park Service.

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Please cite this publication as:

Barry, R. E., C. L. Tanner, and J. M. Mulligan. 2008. Inventory of Mammals (Excluding Bats) of Fredericksburg and Spotsylvania National Military Park. Technical Report NPS/NER/NRTR—2008/121. National Park Service. Philadelphia, PA.

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Abstract

Frostburg State University (FSU) conducted a survey of the mammals of Fredericksburg and Spotsylvania National Military Park (FRSP) within eight units in and west of Fredericksburg, Virginia, in Spotsylvania, Stafford, Orange, and Caroline counties. The primary purpose of the study, in keeping with the stated objectives of the NPS Inventory and Monitoring Program, was to inventory the mammals and their habitat associations and document the presence of $\geq 90\%$ of the species occurring within the park's boundaries. The specific objective of the inventory was to confirm the existence of currently listed species and generate new records for species not detected in the park previously. The data are intended to provide important baseline information useful in monitoring changes and trends in mammal populations at FRSP.

Mammals (except bats) were surveyed in 2004–2005. Stratified (by habitat type) sampling of small to medium-sized mammals relied on the use of Sherman and Tomahawk live traps. Small shrews (*Sorex* spp. and *Cryptotis parva*) were targeted with pitfall traps. Direct observation was used to detect individuals (particularly squirrel-size and larger) and mammal sign, and remote photography helped confirm the identification of individuals of elusive species. Eight principal habitat types—fields (grasslands), deciduous forest, coniferous forest, mixed deciduous-coniferous forest, floodplain forest, streamside (riparian), wetland, and acid seep habitats—were identified for sampling. Grids and transects of Sherman traps encompassed 2.3 ha (5.7 ac) and 8.2 km (5.0 mi) at 64 locations in 2004 and 6.5 ha (16.1 ac) and 0.8 km (0.5 mi) at 22 locations in 2005. Data were analyzed for species distributions and relative abundances and species diversity by habitat type. Habitat, mammal captures, and observation data were stored in an electronic (MS Access) database. Voucher specimens were prepared and accessioned into the mammal museum at Frostburg State University.

Our survey resulted in 24 species of mammals either captured or observed within FRSP. These species represent six orders and 13 families of mammals. We documented the presence of 65% (24 of 37) of the species (excluding bats) predicted to occur and 87% (13 of 15) of those for which historical records exist. Our survey resulted in nine new species records for FRSP. The white-footed deermouse (*Peromyscus leucopus*) was the most abundant and widely distributed mammal in the park. It was captured in Sherman traps in all eight principal habitat types sampled and was the most abundant species in seven of these habitats. The meadow vole (*Microtus pennsylvanicus*), eastern harvest mouse (*Reithrodontomys humulis*), and northern short-tailed shrew (*Blarina brevicauda*) were the most abundant small mammals captured in field habitat where the American least shrew (*Cryptotis parva*) also was established. A single pygmy shrew (*Sorex hoyi*) was captured in coniferous forest. Similarly, one marsh oryzomys or rice rat (*Oryzomys palustris*) was captured in wetland habitat, especially significant because FRSP is close to the northern extreme of the geographic distribution of this species. Small mammal species diversity was greatest in grassy fields and lowest in mixed forest for those habitat types where at least two species were captured. Small mammal species richness was comparably high in fields, deciduous forest, and coniferous forest. Eastern cottontails (*Sylvilagus floridanus*) were observed frequently in fields and forest-field edge habitat. American beaver (*Castor canadensis*) sign was observed in riparian habitat within deciduous and mixed forest. Raccoons (*Procyon lotor*) and white-tailed deer (*Odocoileus virginianus*) were observed and photographed on a number of occasions in a variety of habitats and are presumed

to be abundant in the park. Sixty-eight specimens of 10 species of mammals were collected, prepared, and accessioned into the FSU mammal museum.

FRSP supports a predictable assemblage of mammals in reasonable abundances, based on the types of habitat present. Additional inventorying and monitoring of mammals should be conducted. Pine stands should be sampled (trapped) more intensively in search of the pygmy shrew, red squirrel (*Tamiasciurus hudsonicus*), and eastern fox squirrel (*Sciurus niger*). Deciduous forest should be sampled with tree-mounted Sherman traps to confirm the status of the southern flying squirrel (*Glaucomys volans*) in the park. Tomahawk traps should be used in fields and adjacent woodlands in search of the long-tailed weasel (*Mustela frenata*). Opportunistic trapping should be conducted in thickly vegetated fields and near water to confirm the status of the meadow jumping mouse (*Zapus hudsonius*). Direct observation to detect individuals and/or sign could be intensified in search of the eastern mole (*Scalopus aquaticus*), red squirrel, and eastern fox squirrel. Pitfall traps should be used in search of small shrew species in fields and wetlands. Conservation of wetlands and careful management of fields, both habitats important to the maintenance of mammalian species diversity, should remain priorities in the management of the park's natural resources. Management for the control of the raccoon and white-tailed deer at FRSP are recommended for consideration.

Executive Summary

A survey of mammals (bats excluded) at Fredericksburg and Spotsylvania National Military Park (FRSP) was conducted from 2004 to 2005 to document the presence of $\geq 90\%$ of the mammals in the park, describe their distributions and relative abundances, quantify habitat-specific species diversity, and provide recommendations for management and conservation. Surveys relied on live trapping with Sherman, Tomahawk, and pitfall traps for small to medium-size mammals, direct observation of individuals and their sign (tracks, scats), and remote photography. We identified eight principal habitats—fields (grasslands), deciduous forest, coniferous forest, mixed deciduous-coniferous forest, floodplain forest, streamside (riparian), wetland, and acid seep habitats—and certain targeted locations for sampling.

Twenty-four species of mammals were either captured or observed within FRSP. Altogether, six orders and 13 families of mammals are represented by these species. We documented 65% (24 of 37) of the species (excluding bats) predicted to occur and 87% (13 of 15) of those for which historical records exist. Our survey resulted in nine new species records for FRSP. The white-footed deermouse (*Peromyscus leucopus*) was the most abundant and widely distributed mammal in the park, occurring in all principal habitats sampled. The most abundant small mammals captured in field habitat were the meadow vole (*Microtus pennsylvanicus*), eastern harvest mouse (*Reithrodontomys humulis*), and northern short-tailed shrew (*Blarina brevicauda*). Small mammal species diversity was greatest in grassy fields and lowest in mixed forest for those habitat types where at least two species were captured. Small mammal species richness was comparably high in fields, deciduous forest, and coniferous forest.

FRSP supports a predictable assemblage of mammals in reasonable abundances, based on the types of habitat present. Habitat generalists, such as the Virginia opossum (*Didelphis virginiana*), northern short-tailed shrew, eastern cottontail (*Sylvilagus floridanus*), white-footed deermouse, eastern gray squirrel (*Sciurus carolinensis*), red (*Vulpes vulpes*) and gray (*Urocyon cinereoargenteus*) foxes, raccoon (*Procyon lotor*), and white-tailed deer (*Odocoileus virginianus*), are widely distributed. Adequate quality and quantity of habitat exist to sustain populations of grassland specialists such as the eastern harvest mouse and meadow vole.

Additional inventory and monitoring work should be conducted to determine the status of a number of species either detected in low numbers (American least shrew [*Cryptotis parva*], pygmy shrew [*Sorex hoyi*], southeastern shrew [*Sorex longirostris*], marsh oryzomys [*Oryzomys palustris*], and meadow jumping mouse [*Zapus hudsonius*] or are suspected of being present but were not detected (star-nosed mole [*Condylura cristata*], woodland vole [*Microtus pinetorum*], common muskrat [*Ondatra zibethicus*], southern flying squirrel [*Glaucomys volans*], eastern fox squirrel [*Sciurus niger*], red squirrel [*Tamiasciurus hudsonicus*], bobcat [*Lynx rufus*], North American river otter [*Lontra canadensis*], long-tailed weasel [*Mustela frenata*], and American mink [*Neovison vison*]). This work would necessarily include additional sampling of grasslands, marsh habitats and riparian zones, pine stands, and deciduous forests. A concerted effort should be directed toward documenting the populations of small shrews (*Sorex* spp.) in the park with greater use of pitfall traps (only after proper archeological compliance or oversight has been completed). In addition, the following resource management strategies might be considered, continued, or enhanced: 1) affording special consideration for the protection and conservation of

the restricted acreage of wetland where species with habitat constraints, such as the marsh oryzomys, exist in low abundance; 2) regulating visitor use of specific areas where sensitive species (e.g, the river otter) are [or may be] found; 3) maintaining diverse herbaceous communities and interrupting succession in managed fields by careful attention to mowing and burning schedules; 4) periodically monitoring for exotic murid rodents, the house mouse (*Mus musculus*), brown rat (*Rattus norvegicus*), and black rat (*Rattus rattus*); 5) using management practices that either reduce the raccoon population or the consequences of human activities that sustain it (e.g., more frequent trash removal in high-traffic areas); and 6) monitoring and, if necessary, using management practices to regulate the white-tailed deer population to ensure the preservation of vegetation communities and understory cover important to mammals and birds. Raccoons, because of rabies, and white-tailed deer, as important hosts of the lonestar tick (*Amblyomma americanum*) that is the vector of the etiologic agent (*Borrelia lonestari*) for Southern Tick-Associated Rash Illness (STARI), also are of potential public health significance in a historical park like FRSP with high human visitation.

Acknowledgments

Cheryl Tanner and Janet Mulligan, M.S. students at Frostburg State University (FSU) and co-authors of this report, under the supervision of the senior author, conducted the bulk of the field work and prepared voucher specimens for the FSU mammal museum. We thank Gregg Kneipp, Natural Resources Manager, for providing information on the park, collection permits, maps, specimens, and other materials, and for the time he spent introducing us to the park and discussing the project with us. We are especially grateful to Kristina Callahan for the generation of metadata for the inventory and the production of the map of sampling locations for the report. We are indebted to John Karish, James Comiskey, Beth Johnson, the National Park Service, and Frostburg State University for funding and logistic support.

Introduction

Surveys of mammals in coastal and mid-Atlantic national parks in the Northeast Region is in compliance with the Natural Resource Inventory and Monitoring Program of the National Park Service (NPS 1998). One of the five long-term goals established by this program is to complete baseline inventories of basic biological and geophysical natural resources for the national parks. During Phase 1 of the natural resource inventory the National Park Service (NPS) has set an objective of documenting the presence of $\geq 80\%$ of all plant and animal species (excluding invertebrates) occurring within a park's boundaries; the stated objective for the mammal survey of the parks is 90%. Surveys will attempt to confirm the existence of currently listed species and document the presence of additional expected species. Of particular importance is the detection of any threatened and endangered species that merit special attention. Data collected can be used by park natural resource specialists in the proper stewardship of the park.

We conducted a survey of mammals (except bats, order Chiroptera) in Fredericksburg and Spotsylvania National Military Park (FRSP), Virginia, in 2004–2005 (Figure 1). FRSP is comprised of approximately 2,933 ha (7,248 ac) within eight units in and around Fredericksburg, Virginia, in Spotsylvania, Stafford, and Orange counties (Figure 2; Davis et al. 2006). The park was established in 1927 and lies within both the Piedmont physiographic province and Coastal Plain.

One species currently exists on the NPSpecies database for FRSP. The Virginia State Museum has a record of the woodchuck (*Marmota monax*) in the park (Virginia Museum of Natural History, Nancy Moncrief, Curator of Mammals, pers. comm., 2004).

The Web site, www.data2.itc.nps.gov/nature/documents/mammals.htm, generated on 19 July 2001, is a list of 15 mammals found at the park. We have uncovered no other historical records of mammals in the literature or in museum, college/university, or official park records.

Field work began in February 2004 and continued through October 2005. Surveys included sampling of small to medium-size mammals using Sherman and Tomahawk live traps. Small shrews (*Sorex* spp.) were targeted with arrays of pitfall kill traps so that individuals could be collected for accurate identification to species by use of skull morphology and dentition. Observations and sign, including scats and roadkills, were used to account for squirrel-size and larger mammals, beginning in February 2004.

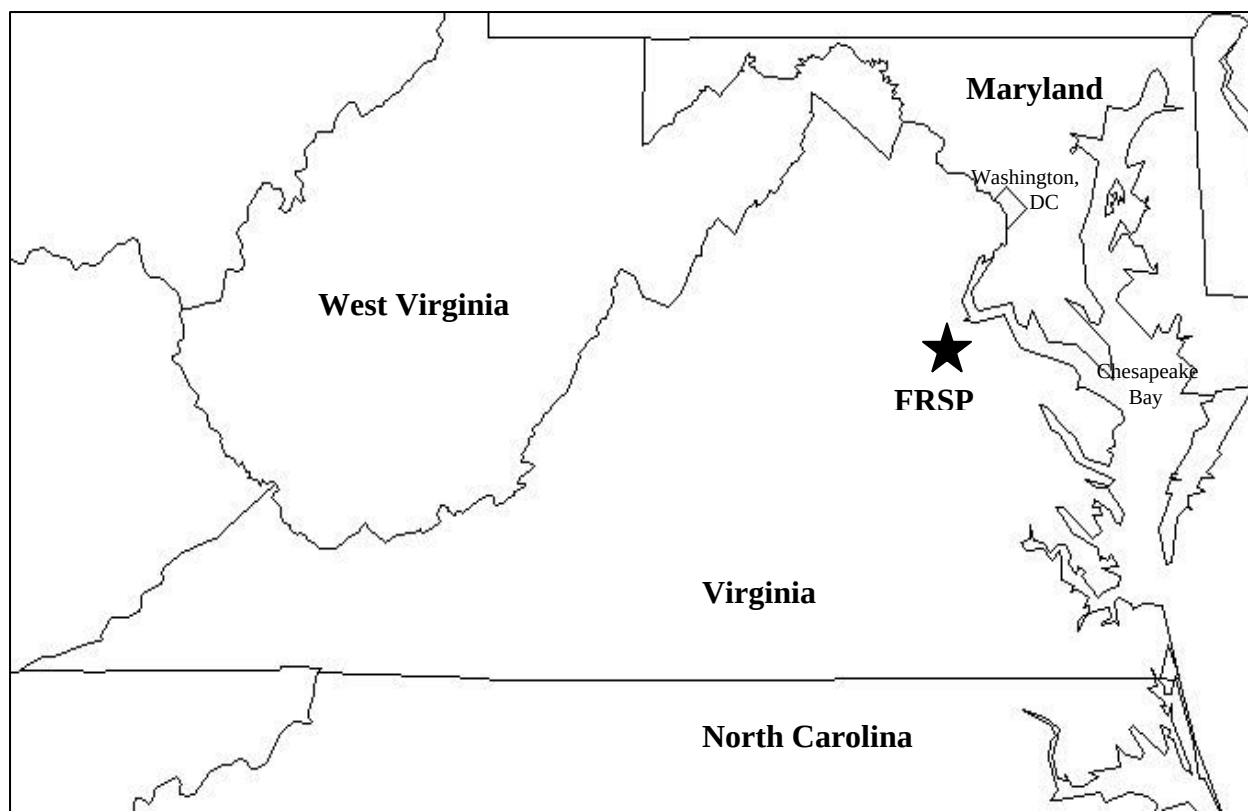


Figure 1. Location of Fredericksburg and Spotsylvania National Military Park in Virginia.
Source of map outline is <http://geography.about.com/library/blank/blxusva.htm>.

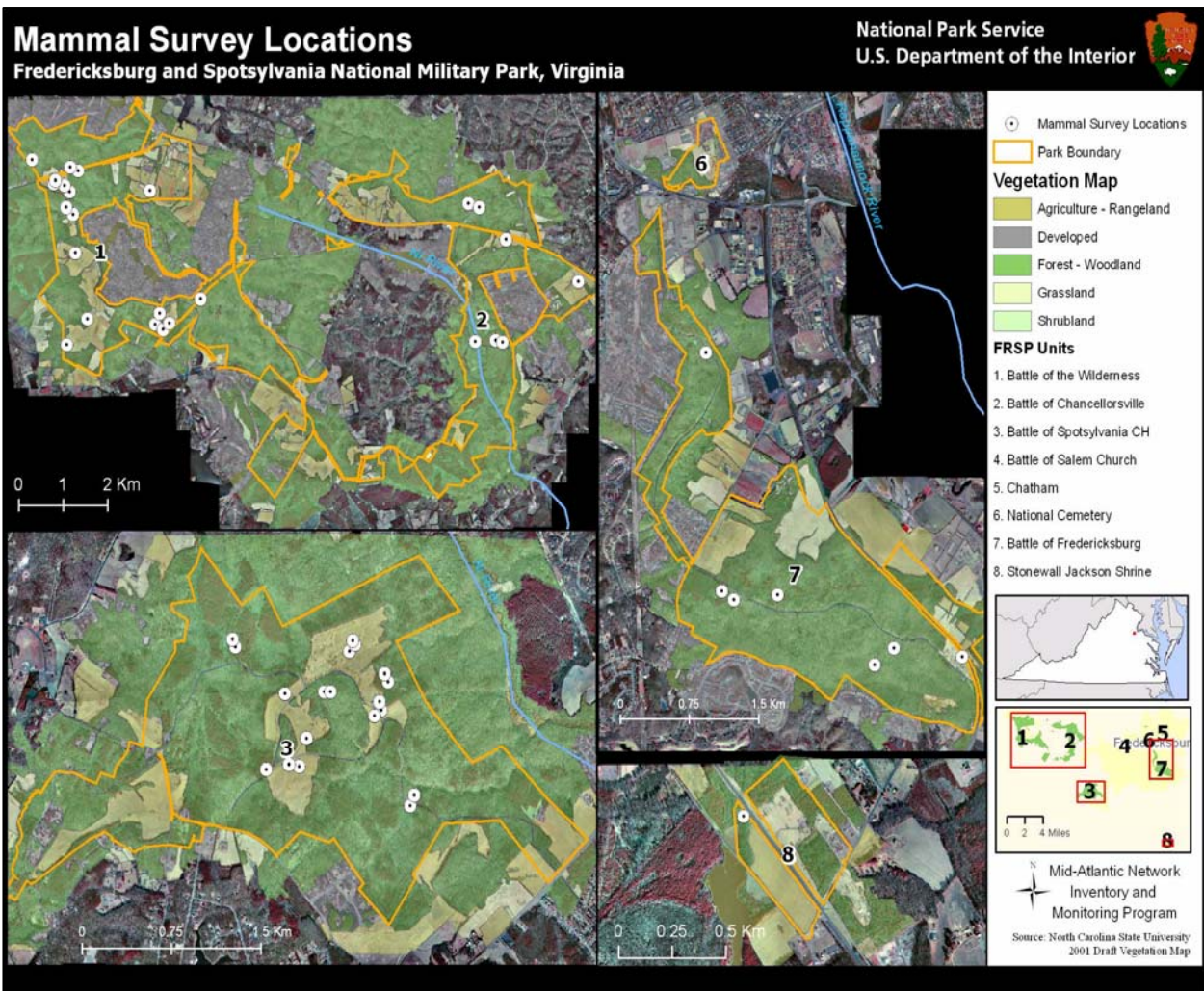


Fig. 2. Outline (yellow) of Fredericksburg and Spotsylvania National Military Park showing locations (white dots) sampled for mammals in 2004 and 2005.

Study Area and Habitats

Fredericksburg and Spotsylvania National Military Park consists of approximately 525 ha (1,300 ac) of managed fields and 2,080 ha (5,137 ac) of forest (primarily oak-hickory), including much riparian habitat (Davis et al. 2006). Forests are dominated by oaks (*Quercus* spp.), hickories (*Carya* spp.), red maple (*Acer rubrum*), sweet gum (*Liquidambar styraciflua*), tulip poplar (*Liriodendron tulipifera*), dogwood (*Cornus* spp.), and Virginia (*Pinus virginiana*) and shortleaf pines (*P. echinata*). Wetlands occupy approximately 223 ha (550 ac). The Rappahannock, Ni, and Po rivers are found within the park, with about 32 km (20 mi) of permanent streams present. Elevation ranges from just above sea level to greater than 106 m (350 ft).

Delineation of Habitats

The recognition of major habitat types allowed stratification of the sampling effort in FRSP. This permitted a representative and comprehensive survey of the small mammal fauna by increasing the efficiency with which individual species were detected.

Eight principal habitat types (fields [grassland], deciduous forest, coniferous forest, mixed deciduous-coniferous forest, floodplain forest, streamside [riparian], wetland, and acid seep habitats) were identified for inventorying small mammals in FRSP. The secure NPSpecies website, <https://science1.nature.nps.gov/npspecies>, lists vascular plants certified for the park.

Fields (Grasslands)

In fields we observed broomsedge (*Andropogon virginicus*), fescue (*Festuca* spp.), timothy (*Phleum pratense*), redtop (*Agrostis gigantea*), deer tongue (*Panicum clandestinum*), and other grasses (Poaceae). Only five species of grasses are documented for FRSP (see <https://science1.nature.nps.gov/npspecies>). Other common vascular plants in fields include clovers (*Trifolium* spp.), asters (*Aster* spp.), goldenrods (*Solidago* spp.), milkweeds (*Asclepias* spp.), poison ivy (*Toxicodendron radicans*), and the invasive Japanese honeysuckle (*Lonicera japonica*).

Deciduous Forest

Deciduous forest comprises most forested habitat in FRSP. Dominant woody species in deciduous forest include oaks (including white [*Quercus alba*], scarlet [*Q. coccinea*], southern red [*Q. falcata*], willow [*Q. phellos*], northern red [*Q. rubra*], and black [*Q. velutina*]), hickories, tulip poplar, sweet gum, red maple, and American beech (*Fagus grandifolia*). American holly (*Ilex opaca*), dogwoods, sassafras (*Sassafras albidum*), lowbush blueberry (*Vaccinium angustifolium*), and Allegheny blackberry (*Rubus allegheniensis*) are common understory and ground species. Greenbriar (*Smilax* sp.) and Japanese honeysuckle are locally abundant (dense). Common vines include Virginia creeper (*Parthenocissus quinquefolia*) and poison ivy.

Coniferous Forest

Dominant conifers in coniferous forest are Virginia, shortleaf, and loblolly (*Pinus taeda*) pines.

Mixed Deciduous-Coniferous Forest

Virginia, shortleaf, and loblolly pines, tulip poplar, and sweet gum are abundant in mixed deciduous-coniferous forest.

Floodplain Forest

Sycamore (*Platanus occidentalis*), ferns (Pterophyta), sedges (Cyperaceae), and grasses (Poaceae) characterize forested floodplain habitat.

Streamside (Riparian)

Riparian habitat is abundant within mostly hardwood forest, having species listed earlier (deciduous forest).

Wetland Habitat (Marsh)

Wetland habitat (marsh) is restricted in the park and is best represented at Stonewall Jackson Shrine, where cutgrass (*Leersia oryzoides*), broadleaf arrowhead (*Sagittaria latifolia*), wild iris (*Iris* sp.), and sedges are abundant. Swampland includes black willow (*Salix nigra*), loblolly pine, bald cypress (*Taxodium distichum*), and red maple.

Acid Seeps

Acid seeps are located within deciduous forest where crowfoot (*Dentaria laciniata*) is abundant.

Methods

Sampling Protocol

Sampling sites were located within the eight identified habitat types to permit stratified sampling. Habitats initially were identified from aerial photos. Strata were ground-truthed before final selection of sampling sites. The number of sampling locations (sample units) was dependent on 1) number, size, and distribution of habitat types, and 2) constraints imposed by accessibility, equipment, and personnel.

To identify sampling points a systematic grid of UTM coordinates was overlaid on an aerial photograph that depicted habitat types (NPS 2000). Points on the grid, within a habitat type, were selected without replacement by the generation of random numbers representing grid cells (Rudran and Foster 1996). Once selected on a map, a sampling point was identified in real space using a Trimble GeoExplorer 3 or comparable GPS unit. Portions of the park frequented by the public and areas either inaccessible to ground personnel or logistically impractical to sample with live traps generally were removed from consideration as sampling locations after the initial visit.

Sampling of small mammals relied primarily on capture with rat-sized (7.6×8.9×22.9 cm) Sherman live traps (www.shermantraps.com); Sherman live traps are generally highly effective for capture of rodents and large shrews such as *Blarina* spp. (Mitchell et al. 1993). Pitfall traps were used to capture shrews and small mammals <10 g (Kirkland and Sheppard 1994). Pitfalls for shrews were used as kill-type traps containing 3–5 cm of water, because careful measurements and examination of skull morphology and dentition were required for identification of species (Caldwell and Bryan 1982).

Sherman traps were configured at sampling points in randomly positioned linear transects and grids (Table 1; Appendixes A and B) with a trap interval of 10 m. Trap configuration and number of traps (i.e., grid size or transect length) were dependent on habitat type, patch size, availability of traps, and need for detailed demographic information. Transects were used where practical because they traverse more home ranges per effort than grids and are especially appropriate for inventory work where accurate estimates of abundance or density are not necessary (Jones et al. 1996). Effective sampling area of a grid was computed by adding a boundary strip equal to one-half the trap interval to all four sides of the grid (Krebs 1999). Effective sampling length of a transect was computed by adding one-half trap interval to each end of the transect. Sampling periods of consecutive days of trapping ranged from 2–11 days. This sampling regime permitted estimates of species richness and relative abundance (unique individuals per 100 trap nights) for the principal habitat types. While sampling for small mammals at designated locations we also observed and noted sign of larger mammals (species, location, and date for each such observation were recorded).

Skunk- (small - 15.2×15.2×48.3 cm) and raccoon-size (medium - 25.4×30.5×81.3 cm) Tomahawk live traps (www.livetrapp.com) were used to capture mammals of squirrel size and larger. One to several of these traps were placed in small mammal (Sherman) trapping grids and

Table 1. Sherman trap configuration for sampling sites at Fredericksburg and Spotsylvania National Military Park for 2004 and 2005.

Year	Habitat/site ¹	Sherman Trap Configuration ²	Trap Nights ³
2004	Fld Burn C-1	Trans (0.11)	55
	Fld HH burn 1	Trans (0.16)	80
	Fld Burn J-1	Trans (0.11)	55
	Fld J control	Trans (0.26)	67
	Fld Biggie control	Trans (0.15)	45
	Fld Cannon control	Trans (0.15)	45
	Fld HH burn 2	Grid (0.20)	200
	Fld Cannon burn	Trans (0.20)	200
	Fld Biggie burn 1	Grid (0.80)	800
	Fld Burn C-2	Trans (0.09)	90
	Fld Burn J	Trans (0.10)	200
	Fld Burn J2	Trans (0.10)	200
	MF Grant Dr. Mix	Grid (0.32)	320
	DF Grant's Headquarters	Trans (0.62)	620
	DF Grant's Headquarters	Grid (0.30)	300
	MF Spotsy conif strip	Grid (0.20)	200
	Fld Biggie burn 2	Trans (0.54)	540
	Fld Burn C-3	Trans (0.10)	100
	Fld Cannon burn 2	Trans (0.20)	200
	Fld HH burn 3	Grid (0.20)	200
	CF Loblolly	Trans (0.40)	400
	MF Inn	Trans (0.35)	350
	Strm/DF Copperhead	Trans (0.20)	200
	Fld Ashley field	Trans (0.20)	220
	DF Country club	Trans (0.40)	400 [42]
	MF Gordon's Flank	Trans (0.30)	300 [28]
	CF WILD conif strip	Trans (0.15)	150 [42]
	DF Burnside decid	Trans (0.30)	300 (200 ^s) [60]
	Strm/DF Burnside	Trans (0.13)	130 [40]
	CF Grant Dr. conif	Trans (0.30)	300 (200 ^s) [60]
	DF Biggie decid	Trans (0.20)	200 (360 ^s) [60]
	DF Boardwalk	Trans (0.20)	200 [40]
	DF Cabin trail	Trans (0.30)	300
	Fld Prospect Hill	Trans (0.20)	200
	DF AS	Trans (0.20)	180 (90 ^s , 18 ^m) [36]
	CF Loblolly 2	Trans (0.30)	270 (90 ^s , 18 ^m) [36]
	MF Bullock mix	Trans (0.25)	225 (90 ^s , 18 ^m) [54]
	DF Saunders decid	Trans (0.30)	360 (260 ^s) [39]
	Strm/DF Saunders	Trans (0.20)	260 [39]
	MF Tapp mix	Grid (0.28)	364 (208 ^s) [52]
	Fld Saunders field	Trans (0.20)	260
	Fld Inn field	Trans (0.20)	220
	Fld Tapp field	Trans (0.20)	200
2005	CF/Prospect conifer	Trans (0.15)	150
	CF/Prospect conifer	Trans (0.15)	150
	AS/Special Fred	Trans (0.10)	100
	FF/Special Higginson	Trans (0.10)	100
	AS/Special Tapp	Trans (0.10)	100
	WL/Jackson Shrine	Trans (0.15)	135

Table 1. Sherman trap configuration for sampling sites at Fredericksburg and Spotsylvania National Military Park for 2004 and 2005 (continued).

Year	Habitat/site ¹	Sherman Trap Configuration ²	Trap Nights ³
2005 (cont'd)	Fld/Saunders Field	Grid (1.00)	2,229 (8 ^s)
	Fld/Tapp Field	Grid (1.00)	2,129
	DF/Middlebrook	Grid (1.00)	343 (48 ^m)
	DF/Ellwood	Grid (0.49)	632 (6 ^m)
	DF/Higgerson	Grid (1.00)	1,339
	DF/Carver	Grid (0.49)	439 (4 ^m)
	DF/Chewning Large	Grid (1.00)	355 (12 ^m)
	DF/Chewning Small	Grid (0.49)	306

¹ Fld = field; MF = mixed forest; DF = deciduous forest; CF = coniferous forest; WL = wetland; AS = acid seep; FF = floodplain forest; AS = acid seep within DF; Strm/DF = streamside (riparian) within DF

² Numbers in parentheses for Sherman trap configuration represent effective sampling areas in ha for grids and effective sampling lengths in km for transects.

³ Trap nights are totals for the habitat/site for Sherman live traps, with trap nights for Tomahawk live traps (^s = small Tomahawk traps, ^m = medium Tomahawk traps – see Methods) in parentheses and pitfall arrays in brackets.

transects (Appendixes A and B) and opportunistically in habitats where mammal sign was detected or where habitat features suggested the presence of larger species. Pitfall traps were arranged in arrays. An array typically consisted of a 10-m length of silt fence with one pitfall trap (#10 vegetable can) at either end and two in the middle (four traps total). Each array was placed within a Sherman trap grid and at least 30 m from another array. Remote cameras were used sporadically to document the presence of larger nocturnal species (e.g., raccoon) where sign was evident.

Dominant vegetation, percent canopy cover, percent ground cover, degree of disturbance (e.g., primary or secondary forest or plantation), presence of rock piles, topography, and elevation were noted for each sampling site at 5–15 (proportional to the number of Sherman traps) random locations within Sherman live-trap transects and grids (McDiarmid and Wilson 1996; Barry et al. 1999; Boyce 2001). These detailed observations were recorded as baseline habitat information.

Sherman traps were baited with a combination of peanut butter and rolled oats (Beer 1964), and bird seed was added as a source of quickly metabolizable energy. Tomahawk traps usually were baited with canned cat food. Pitfall and remote camera locations were not baited. Captured individuals of small species (those in Sherman and pitfall traps) were removed from traps, identified to species, weighed using a Pesola scale, and examined for age, sex, and reproductive condition (Jones et al. 1996). Individuals captured in Tomahawk traps were identified to species and examined for age, sex, and reproductive condition. Because recognition of individuals was used for determining relative abundances and measures of species diversity, captured individuals of small mammal species were marked by toe-clipping (Rudran 1996; ASM 1998). To obtain meaningful scientific data on shrews, they were collected by kill trapping (see above). Release

of captured individuals (other than shrews or accidental deaths) was immediate at the capture location after measurements were obtained. Live-trapping, handling procedures, pitfall trapping, and specimen collection were conducted humanely (Rudran and Kunz 1996), consistent with the animal handling guidelines of the American Society of Mammalogists (ASM 1998), and were approved by the Institutional Review Board/Animal Care and Use Committee (IACUC # A2002-01) at Frostburg State University. Proper precautions were taken by investigators to prevent human injury and exposure to disease, especially rabies, Lyme disease, hantaviral pulmonary syndrome (HPS), and human ehrlichiosis (Gage et al. 1995; Mills et al. 1995; Kunz et al. 1996). Animals found dead in traps (most frequently in pitfalls), if salvageable, were collected, prepared, and deposited in the Frostburg State University (FSU) mammal museum.

Sampling Periods

We used Sherman, small and medium Tomahawk live traps, and pitfall arrays during 21 sampling periods (1–11 nights each) from February to October 2004 at FRSP (Table 1; Appendix A). Fields, deciduous forest, coniferous forest, mixed deciduous-coniferous forest, streamside (riparian), and acid seep habitats were sampled for mammals. Sherman traps were placed in seven grids covering 2.3 ha (5.5 ac) and 57 transects along 8.2 km (5 mi) at the 42 sampling locations. Sherman trap nights totaled 10,506, Tomahawk trap nights 1,552, and pitfall trap nights 628 at FRSP in 2004 (Table 1). Direct observations of mammals were recorded during trapping activities.

We used Sherman and small and medium Tomahawk live traps during 55 sampling periods (1–7 nights each) from April to October 2005 at FRSP (Table 1; Appendix B). Fields, coniferous forest, deciduous forest, floodplain forest, wetland, and acid seep habitats were sampled for mammals. Sherman traps were placed in eight grids covering 6.5 ha (16 ac) and six transects along 0.8 km (0.5 mi) at the 14 sampling locations. Sherman trap nights totaled 8,557 and Tomahawk trap nights totaled 78 at FRSP in 2005 (Table 1). Direct observations of mammals were recorded during trapping activities.

Compilation and Analysis of Data

Species distributions among habitats were summarized. Marking and recognition of individuals captured in Sherman and pitfall traps permitted estimates of relative abundance (individuals per 100 trap nights), species diversity (Brillouin's H), rarefaction estimates of richness (number of species), and Smith and Wilson's measure of evenness (distribution of individuals among the species) for small species for principal habitat types. Analyses followed Krebs (1999) and were conducted at Frostburg State University using EcoMeth software (Krebs 2003).

Data on habitat characteristics and all mammals captured or observed were stored in an electronic database (Microsoft Access). Voucher specimens were prepared and accessioned into the mammal museum at Frostburg State University. Color photographs were provided to the Database Manager for the Mid-Atlantic Network of the NPS.

Results

Historical Records and Predicted Species

One mammal species (*Marmota monax*) currently exists on the NPSpecies database (<https://science1.nature.nps.gov/npspecies>) for FRSP. The Virginia State Museum has a record of the woodchuck, *Marmota monax*, in the park (Nancy Moncrief, in litt.). The Web site, www.nps.gov/applications/nature/documents/mammals.htm, generated on 19 July 2001, is a list of 15 mammals (representing 12 families) that occupy the park. We have uncovered no other historical records of mammals in the literature or in museum, college/university, or official park records.

According to current taxonomy (Wilson and Reeder 2005), five orders and 10 families are represented among the 15 species recorded prior to this report (Table 2). We have listed species predicted to occur (based on geographic distributions and habitat preferences) in FRSP (Table 2). This list contains 37 species within six orders and 16 families of mammals (excluding bats).

Field Survey

Our survey of 2004–2005 resulted in 24 species of mammals either captured or observed within FRSP (Table 2). These species belong to six orders and 13 families of mammals. In 2004 at least 213 individuals representing 10 species of mammals were captured a total of 415 times at 35 sampling locations (Appendix C). Four species of small mammals were captured in pitfall traps in 2004: three southeastern shrews (*Sorex longirostris*) and one each, northern short-tailed shrew (*Blarina brevicauda*), pygmy shrew (*Sorex hoyi*), and meadow vole (*Microtus pennsylvanicus*). In 2005 at least 485 individuals representing 11 species of mammals were captured a total of 1,163 times at 13 sampling locations (Appendix D). Types of habitats, sampling dates, numbers of trap nights, individuals captured, capture frequencies, and relative abundances for mammal species are summarized for each sampling location, by year, in Appendixes A–D.

The most abundant and widely distributed small mammal in FRSP was the white-footed deermouse (*Peromyscus leucopus*). This species was captured in Sherman traps in all eight principal habitats sampled (Table 3) and was the most abundant species in all forested habitats and wetlands; the marsh oryzomys (*Oryzomys palustris*) was the only other small mammal captured in wetland habitat. The northern short-tailed shrew was abundant in fields and widely distributed in forest habitats. The meadow vole and eastern harvest mouse (*Reithrodontomys humulis*) were both very abundant in field habitat. Particularly noteworthy was the capture of the rare, diminutive pygmy shrew in a pitfall trap in coniferous habitat along Grant Drive.

Capture frequencies of larger mammals captured in Tomahawk traps were recorded, but relative abundances were not obtained because individuals of these larger species were not marked for individual recognition. Only two species were captured in Tomahawk traps (see Appendixes C and D). Twenty-six eastern gray squirrels (*Sciurus carolinensis*) were caught, most in deciduous and mixed deciduous-coniferous forest habitats. Two opossums (*Didelphis virginiana*) were captured in deciduous forest at Chewning Farm (Figure 2).

Table 2. Comparison of predicted species for Fredericksburg and Spotsylvania National Military Park (based on historical records from the Virginia State Museum [Nancy Moncrief, in litt.]; the NPSpecies database¹; NPS web site²; Gap Analysis³; Webster et al. 1985; and Linzey 1998) and species observed during this study (2004–2005). Taxonomy and common names follow Wilson and Reeder (2005).

Order	Family	Species	Common Name	Predicted	FRSP Historical	FRSP Observed
Didelphimorphia	Didelphidae	<i>Didelphis virginiana</i>	Virginia opossum	X	X	X
Soricomorpha	Soricidae	<i>Blarina brevicauda</i>	northern short-tailed shrew	X		X
		<i>Cryptotis parva</i>	North American least shrew	X		X
		<i>Sorex hoyi</i>	American pygmy shrew	X		X
		<i>Sorex longirostris</i>	southeastern shrew	X		X
	Talpidae	<i>Condylura cristata</i>	star-nosed mole	X		
		<i>Scalopus aquaticus</i>	eastern mole	X		X*
Lagomorpha	Leporidae	<i>Sylvilagus floridanus</i>	eastern cottontail	X	X	X
Rodentia	Castoridae	<i>Castor canadensis</i>	American beaver	X	X	X
	Cricetidae	<i>Microtus pennsylvanicus</i>	meadow vole	X		X
		<i>Microtus pinetorum</i>	woodland vole	X		
		<i>Ondatra zibethicus</i>	common muskrat	X		
		<i>Oryzomys palustris</i>	marsh oryzomys	X		X
		<i>Peromyscus leucopus</i>	white-footed deer mouse	X	X	X
		<i>Peromyscus maniculatus</i>	deer mouse		X	
		<i>Reithrodontomys humulis</i>	eastern harvest mouse	X		X
	Muridae	<i>Mus musculus</i>	house mouse	X	X	X
		<i>Rattus norvegicus</i>	brown rat	X		X
	Sciuridae	<i>Glaucomys volans</i>	southern flying squirrel	X		
		<i>Marmota monax</i>	woodchuck	X	X	X
		<i>Sciurus carolinensis</i>	eastern gray squirrel	X	X	X
		<i>Sciurus niger</i>	eastern fox squirrel	X		
		<i>Tamias striatus</i>	eastern chipmunk	X	X	X
		<i>Tamiasciurus hudsonicus</i>	red squirrel	X		
	Dipodidae	<i>Zapus hudsonius</i>	meadow jumping mouse	X		X
Carnivora	Canidae	<i>Canis latrans</i>	coyote	X		
		<i>Canis lupus</i>	domestic dog	X		X
		<i>Urocyon cinereoargenteus</i>	gray fox	X	X	X
		<i>Vulpes vulpes</i>	red fox	X	X	X
	Felidae	<i>Felis catus</i>	domestic cat	X		
		<i>Lynx rufus</i>	bobcat	X		
	Mephitidae	<i>Mephitis mephitis</i>	striped skunk	X	X	X
	Mustelidae	<i>Lontra canadensis</i>	North American river otter	X		
		<i>Mustela frenata</i>	long-tailed weasel	X		
		<i>Neovison vison</i>	American mink	X		
	Procyonidae	<i>Procyon lotor</i>	raccoon	X	X	X
	Ursidae	<i>Ursus americanus</i>	black bear	X	X	
Artiodactyla	Cervidae	<i>Odocoileus virginianus</i>	white-tailed deer	X	X	X

* Specimen captured in October 2003

¹ <https://science1.nature.nps.gov/npspecies>

² <http://data2.itc.nps.gov/nature/documents/mammals.htm>

³ <http://gapmap.nbii.gov/generatemap.php?species=GENUS%SPECIES&statelist=VA>

Table 3. Summary of numbers and relative abundances¹ of small mammals captured with Sherman and pitfall traps among eight principal habitat types² at Fredericksburg and Spotsylvania National Military Park, 2004–2005.

Common name	Scientific name	Habitat							
		FLD	DF	CF	MF	FF	Streamside	WL	AS
northern short-tailed shrew	<i>Blarina brevicauda</i>	107(1.22)	22(0.33)	1(0.07)	2(0.11)	0(0.00)	2(0.54)	0(0.00)	0(0.00)
American least shrew	<i>Cryptotis parva</i>	6(0.07)	0(0.00)	0(0.00)	0(0.00)	0(0.00)	1(0.27)	0(0.00)	0(0.00)
pygmy shrew	<i>Sorex hoyi</i>	0(0.00)	0(0.00)	1(0.07)	0(0.00)	0(0.00)	0(0.00)	0(0.00)	0(0.00)
southeastern shrew	<i>Sorex longirostris</i>	0(0.00)	1(0.02)	1(0.07)	1(0.05)	0(0.00)	0(0.00)	0(0.00)	0(0.00)
meadow vole	<i>Microtus pennsylvanicus</i>	149(1.71)	1(0.02)	0(0.00)	0(0.00)	0(0.00)	0(0.00)	0(0.00)	0(0.00)
marsh oryzomys	<i>Oryzomys palustris</i>	0(0.00)	0(0.00)	0(0.00)	0(0.00)	0(0.00)	0(0.00)	1(0.74)	0(0.00)
white-footed deermouse	<i>Peromyscus leucopus</i>	15(0.17)	148(2.23)	23(1.63)	33(1.74)	3(3.00)	2(0.54)	6(4.44)	2(0.48)
eastern harvest mouse	<i>Reithrodontomys humulis</i>	137(1.57)	0(0.00)	0(0.00)	0(0.00)	0(0.00)	0(0.00)	0(0.00)	0(0.00)
meadow jumping mouse	<i>Zapus hudsonius</i>	1(0.01)	0(0.00)	0(0.00)	0(0.00)	0(0.00)	0(0.00)	0(0.00)	0(0.00)
house mouse	<i>Mus musculus</i>	3(0.03)	2(0.03)	0(0.00)	0(0.00)	0(0.00)	0(0.00)	0(0.00)	0(0.00)
brown rat	<i>Rattus norvegicus</i>	0(0.00)	1(0.02)	0(0.00)	0(0.00)	0(0.00)	0(0.00)	0(0.00)	0(0.00)
eastern gray squirrel	<i>Sciurus carolinensis</i>	0(0.00)	2(0.03)	0(0.00)	0(0.00)	0(0.00)	0(0.00)	0(0.00)	0(0.00)
eastern chipmunk	<i>Tamias striatus</i>	0(0.00)	8(0.12)	0(0.00)	0(0.00)	0(0.00)	0(0.00)	3(2.22)	0(0.00)
Total number of trap nights		8,735	6,634	1,408	1,893	100	370	135	416

¹ Relative abundance calculated as the number of individuals per 100 trap nights and shown in parentheses.

² FLD = field (including old field), DF = deciduous forest, CF = coniferous forest, MF = mixed [coniferous-deciduous] forest, FF = floodplain forest, Streamside = riparian habitat within DF, WL = wetland (marsh), AS = acid seep within DF.

Twelve species of mammals were documented based on observation, sign, the recovery of remains, and/or by remote camera (Table 4). Ten species were observed directly. Sign or remains of five species were found. Five species were photographed by remote camera. Opossums were seen in deciduous forest (including acid seep), coniferous forest, mixed forest, forest-field edge, and urban habitats. Eastern cottontails (*Sylvilagus floridanus*) and their sign were observed in managed fields, deciduous and coniferous forest, and forest-field edge habitat. Beaver (*Castor canadensis*) sign was found on several occasions in riparian habitat within deciduous and mixed forest. The eastern chipmunk (*Tamias striatus*) and eastern gray squirrel were spotted only in deciduous forest. Woodchucks were observed in several habitat types, including managed fields, deciduous forest, fragmented mixed forest, and field-forest edge. Domestic dogs (*Canis lupus*) were observed in open areas of the park and were likely from neighboring residential areas. Remains of two gray foxes (*Urocyon cinereoargenteus*) were found within approximately 12 m (40 ft) of each other on Route 621 adjacent to mixed forest on 27 July 2004. Another was recorded with remote camera on 21 May 2005 in grassy habitat adjacent to a barn where it may have had a den site. Red foxes (*Vulpes vulpes*) were observed in Ashley Field (E270551, N4242199) and on North Lee Drive (E284047, N4238632). A striped skunk (*Mephitis mephitis*) and raccoon (*Procyon lotor*) were captured by remote photography at a woodchuck burrow (where the woodchuck had also been photographed) in deciduous woodland/field edge habitat (E261104, N4245038) in the Battle of the Wilderness unit of the park. Raccoons, or their sign, were observed (including by remote camera) on a number of occasions in forested habitats. White-tailed deer (*Odocoileus virginianus*) were spotted and photographed in a variety of habitats – deciduous (including acid seep), coniferous, and mixed forest, field (including recently burned), and on roads adjacent to forested habitats. A carcass being scavenged by a turkey vulture was discovered on 13 July 2005 in mixed forest habitat.

Species Diversity

Species diversity of small mammals captured with Sherman traps was greatest in grassy fields (Table 5). Only one species, *Peromyscus leucopus*, was captured in floodplain forests and streamside and acid seep habitats in deciduous forest. Within habitats where two or more species were captured, species diversity was lowest in mixed forest. Evenness was greatest in wetland habitat, but only two species (*P. leucopus* and *Oryzomys palustris*) were captured in this relatively restricted habitat type within FRSP. Species richness was greatest in deciduous forests (eight species) and fields (seven species), although this was attributable to the greater sampling effort in these habitats. At a sample size of 26 individuals as a basis for comparison of richness among habitats (to account for differences in sample sizes), the rarefaction estimate of expected number of species was greatest and similar for fields, deciduous forest, and coniferous forest (Figure 3).

Voucher Specimens

Sixty-eight specimens of 10 species were collected from FRSP, prepared, assigned FSU catalog numbers, and accessioned into the FSU mammal museum in 2007 (Table 6). Thirty-one of the preparations consisted of both skin and skull. Twenty-seven specimens were whole-body liquid preservations. Multiple preparations were made of the northern short-tailed shrew, American

Table 4. Mammal sightings or sign in Fredericksburg and Spotsylvania National Military Park, 2004–2005.

Common name (<i>Scientific name</i>)	Means of Observation ¹
Virginia opossum (<i>Didelphis virginiana</i>)	✓
Eastern cottontail (<i>Sylvilagus floridanus</i>)	✓☑
Beaver (<i>Castor canadensis</i>)	☑
Eastern chipmunk (<i>Tamias striatus</i>)	✓
Eastern gray squirrel (<i>Sciurus carolinensis</i>)	✓
Woodchuck (<i>Marmota monax</i>)	✓*
Domestic dog (<i>Canis lupus</i>)	✓
Gray fox (<i>Urocyon cinereoargenteus</i>)	✓*
Red fox (<i>Vulpes vulpes</i>)	✓
Striped skunk (<i>Mephitis mephitis</i>)	☑*
Raccoon (<i>Procyon lotor</i>)	✓☑*
White-tailed deer (<i>Odocoileus virginianus</i>)	✓☑*

✓ Direct observation; ☑ Identified from sign or recovery of remains; * Photographed with remote camera

Table 5. Brillouin diversity index (determined using $\log_2$) and Smith and Wilson's measure of evenness (Krebs 1999) for small mammals captured in eight habitats in Fredericksburg and Spotsylvania National Military Park, 2004–2005.

Habitat	Brillouin Index (H)	Smith and Wilson's Evenness (E_{var})
Fields	1.849	0.177
Deciduous forest	1.005	0.212
Coniferous forest	0.536	0.316
Mixed forest	0.400	0.263
Floodplain forest ¹	*	*
Streamside ¹	0.981	0.932
Wetlands ¹	0.971	0.683
Acid seeps ¹	*	*

* Only 1 species was captured

¹ Sample size ≤ 10 individuals

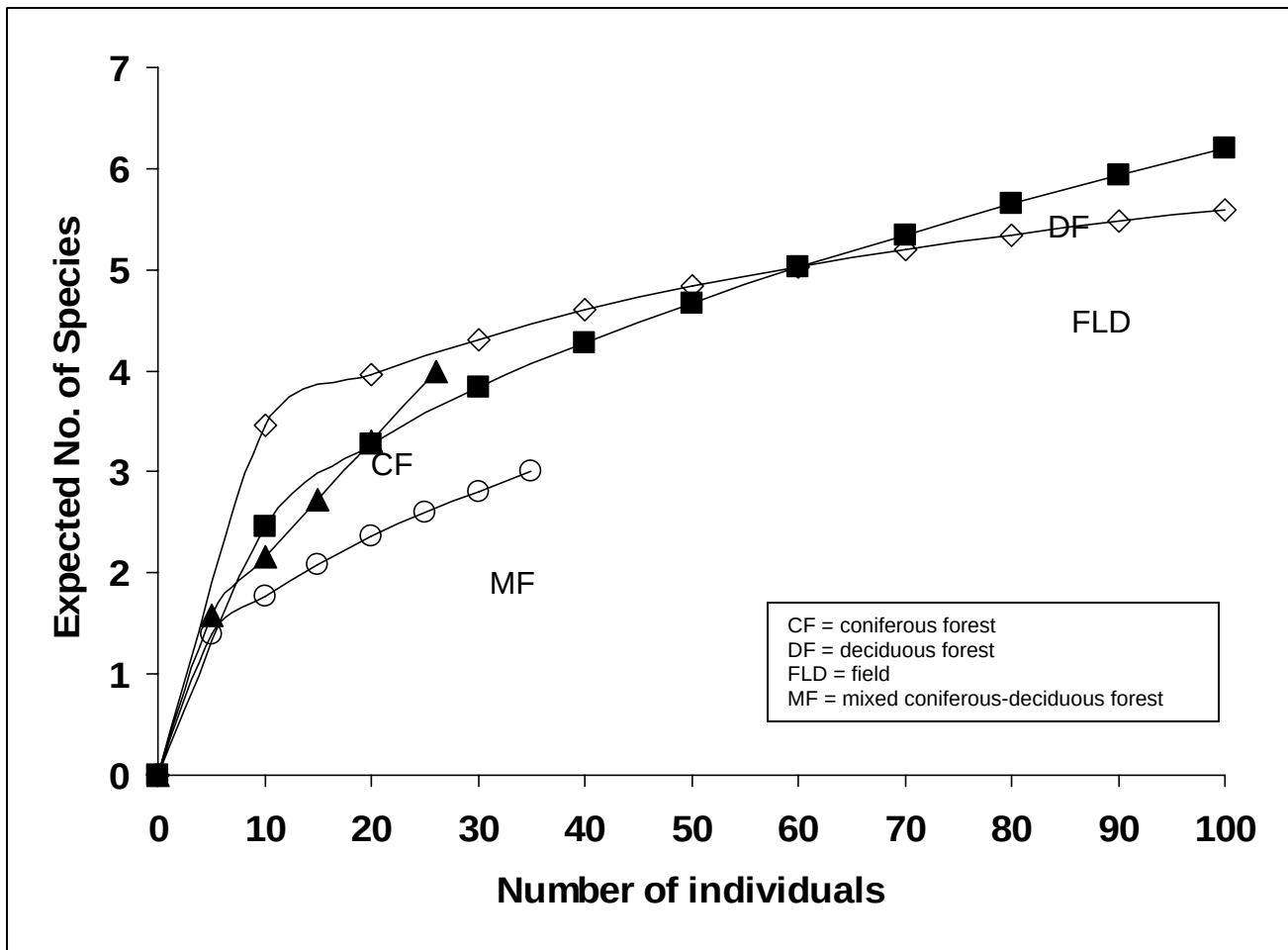


Figure 3. Rarefaction curves showing the estimated number of species of small mammals for variable sample sizes (number of individuals) for four habitat types in Fredericksburg and Spotsylvania National Military Park.

Table 6. Specimens collected in Fredericksburg and Spotsylvania National Military Park that were assigned catalog numbers and accessioned into the FSU mammal collection (museum) in 2007.

Species	Common Name	Sex ¹	Specimen Type ²	FSU Catalog Number
<i>Blarina brevicauda</i>	northern short-tailed shrew		SS	2861
			SS	2862
			SS	2863
			SS	2864
			SS	2869
			SS	2870
			Sk	2871
			Li	2872
		F	SS	2873
			Li	2875
		M	SS	2878
		F	SS	2881
		M	SS	2883
			Li	2884
		F	SS	2885
		F	Li	2886
		F	SS	2889
			Li	2893
			Li	2907
			Li	2909
			Li	2910
			Li	2912
			Li	2917
<i>Cryptotis parva</i>	American least shrew		SS	2860
			Sl	2896
			Li	2897
			Li	2898
			Li	2899
			Li	2911
			Li	2918
			Li	2919
			Li	2920
<i>Sorex hoyi</i>	pygmy shrew	F	Sk	2857
<i>Sorex longirostris</i>	southeastern shrew		Li	2894
			Li	2895
<i>Microtus pennsylvanicus</i>	meadow vole	M	Li	2913
			SS	2853
		F	Sk	2854
		M	Sk	2855
		M	SS	2856
			SS	2867
		F	SS	2874
		F	Li	2876
		F	SS	2877
		F	SS	2879
		F	Li	2880
		F	SS	2882

Table 6. Specimens collected in Fredericksburg and Spotsylvania National Military Park that were assigned catalog numbers and accessioned into the FSU mammal collection (museum) in 2007 (continued).

Species	Common Name	Sex ¹	Specimen Type ²	FSU Catalog Number
<i>Microtus pennsylvanicus</i> (cont'd.)	meadow vole	F	SS	2887
		M	SS	2888
		M	SS	2890
		M	SS	2891
		M	Li	2892
		M	SS	2901
		F	Sl	2904
		F	Li	2908
		M	Li	2914
<i>Peromyscus leucopus</i>	white-footed deermouse	F	SS	2858
		M	Sl	2859
		M	SS	2865
		M	SS	2866
		F	Sl	2868
		M	Sl	2902
		F	SS	2903
<i>Reithrodontomys humulis</i>	eastern harvest mouse	M	SS	2900
<i>Mus musculus</i>	house mouse	M	Li	2915
		F	Li	2916
<i>Sciurus carolinensis</i>	eastern gray squirrel	M	SS	2905
		M	Sl	2906

¹ M = male, F = female. Blank space means sex is unknown.

² Sk = skin, Sl = skull, SS = skin and skull, Li = whole-body liquid preservation.

least shrew, southeastern shrew, meadow vole, white-footed deermouse, house mouse, and eastern gray squirrel.

Three of the specimens were obtained before formal sampling began for the mammal inventory. On 2 September 2003 an American least shrew (FSU #2896) was retrieved from Carver pool (Fredericksburg and Spotsylvania National Military Park, G. Kneipp, Natural Resources Manager, 2004). An eastern mole (*Scalopus aquaticus*, FSU #2913) was captured (Fredericksburg and Spotsylvania National Military Park, G. Kneipp, Natural Resources Manager, 2004) in October 2003. On 25 January 2004 an eastern gray squirrel (FSU #2905) from Chancellorsville was salvaged.

Discussion

Species Records and Predicted Occurrences

We have documented the presence in FRSP of 65% (24 of 37) of the nonchiropteran species predicted to occur and 87% (13 of 15) of the species for which a historical record exists and/or that are listed in the NPSpecies database and NPS Web site, <http://data2.itc.nps.gov/nature/documents/mammals.htm>. We were not able to confirm by capture or observation the presence of the deer mouse (*Peromyscus maniculatus*) or black bear (*Ursus americanus*), both of which are listed on the NPS Web site above. However, a roadkill was confirmed as a black bear in July 2007 (Fredericksburg and Spotsylvania National Military Park, G. Kneipp, Natural Resources Manager, pers. comm., 2007) after completion of our inventory and a disjunct portion of the Virginia range of this species includes FRSP (Linzey 1998), so this mammal may exist as a transient species in the park. We do not know the source of the park record for the deer mouse and did not predict the presence of this species in the park. The cloudland deer mouse (*P. m. nubiterrae*) is restricted to the higher elevations of the Appalachian Mountains to the west. The other subspecies that occurs in the state, the prairie deer mouse (*P. m. bairdii*), is not listed for Spotsylvania, Stafford, Orange, or Caroline counties by Linzey (1998), but has been found in Fairfax, Fauquier, and Warren counties just to the north and Rockingham and Rockbridge counties to the west. Distinction between *P. m. nubiterrae* and *P. leucopus* in the field can be difficult, but *P. m. bairdii* and *P. leucopus* are easily distinguished and segregated by habitat. It is unlikely that either subspecies of *P. maniculatus* is a resident of FRSP.

We were not able to confirm by capture or observation the presence of the following species that we predicted reside within FRSP: star-nosed mole (*Condylura cristata*), woodland vole (*Microtus pinetorum*), common muskrat (*Ondatra zibethicus*), southern flying squirrel (*Glaucomys volans*), eastern fox squirrel (*Sciurus niger*), red squirrel (*Tamiasciurus hudsonicus*), coyote (*Canis latrans*), domestic cat (*Felis catus*), bobcat (*Lynx rufus*), North American river otter (*Lontra canadensis*), long-tailed weasel (*Mustela frenata*), and American mink (*Neovison vison*). Our failure to confirm the presence of the star-nosed mole, muskrat, river otter, and mink is likely attributable to the comparatively small acreage of wetland and riparian habitats within the park, which restricts the distribution and abundance of these species. The star-nosed mole is associated with marshland and riparian habitat (Petersen and Yates 1980). Muskrats occupy most aquatic habitats within their North American range, including creeks, lakes, marshes, and ponds (Willner et al. 1980). The North American river otter is restricted to permanent watersheds within its range and is often associated with beavers or beaver lodges in bodies of water with banked shores (Lariviere and Walton 1998). American minks are usually found near water (Lariviere 1999) and may seek permanent wetlands as dry seasons approach (Humphrey and Zinn 1982). One or more of these four species may reside in FRSP but in low numbers.

The woodland vole, southern flying squirrel, and eastern fox squirrel should reside in the forests of FRSP. The woodland vole can be found in deciduous forests, grasslands, among shrubs, and in orchards—anywhere where ground cover in the form of litter or vegetation is abundant (Miller and Getz 1969; Smolen 1981). It is likely that the woodland vole resides in FRSP and that more intensive sampling of deciduous and deciduous-coniferous woodland with abundant ground

cover would confirm the presence of this species. The southern flying squirrel has a preference for mature hardwood or mixed deciduous-coniferous forests in Virginia (Linzey 1998). Additional sampling in mature forested habitat with tulip poplar and/or use of live traps mounted above ground on tree trunks likely would confirm the presence of this species in FRSP. Fox squirrels inhabit oak and pine stands (Koprowski 1994a) and should be present in FRSP. However, appropriate habitat for the red squirrel may be limited in the park. This species is abundant only in western and northern portions of Virginia (Linzey 1998) and prefers boreal coniferous forest, although it is also found in mixed deciduous-coniferous stands (Steele 1998).

Despite not being seen during inventory work at FRSP, feral cats likely occupy the park. No coyote was observed during sampling in 2004–2005, but remote photography (C. L. Tanner, Fredericksburg and Spotsylvania National Military Park) documented the presence of this species in the park in 2006 after formal sampling activities for our study had terminated. Although no bobcats or their sign were observed in FRSP, suitable habitats and prey (lagomorphs, voles, sciurids, and larger rodents) are present (Lariviere and Walton 1997) to support this species.

Habitat Generalists

The white-footed deermouse is a woodland species that occurs statewide (Linzey 1998). It occurred in all principal habitat types sampled and in all habitats except fields and was more abundant than, or as abundant as, any other species. It commonly occupies brushy habitat or wooded areas dominated by deciduous species and ample, downed woody debris (Barry and Francq 1980; Lackey et al. 1985), but it also is known to occur in fields.

The northern short-tailed shrew occurs within a wide variety of habitats throughout its range (George et al. 1986) and was found in five of the eight habitats sampled in FRSP. This species was abundant in fields where it often coexists with and preys on the meadow vole.

The diminutive pygmy shrew is often found in boreal habitats and in or near wetlands (Long 1974). The only individual we captured was in coniferous forest, suggesting that this species is scarce in FRSP.

The southeastern shrew has been found in a variety of habitats within its range, although it seems to be more abundant in wet areas bordering marshes, swamps, or rivers (French 1980). However, only three individuals were captured in FRSP, and those in forested habitats. We likely would have captured individuals around wetlands had we used pitfall traps in such habitats.

Eastern cottontails and woodchucks were observed frequently in open, grassy areas, forested habitats, and forest-field edges in FRSP. Eastern cottontails are widely distributed among habitats within their range (Chapman et al. 1980), although they prefer old fields, brushy areas, field-woodland edge (Linzey 1998), and early successional habitat (Chapman and Litvaitis 2003). Woodchucks typically occupy field-forest ecotone (Kwiecinski 1998). FRSP provides extensive grassland habitat adjacent to forest tracts capable of supporting healthy populations of these two species.

Eastern gray squirrels use a variety of habitats throughout their range (Koprowski 1994b; Linzey 1998; Edwards et al. 2003) but are most common in mature, intact deciduous and mixed deciduous-coniferous woodlands. We captured and observed them mostly in deciduous and mixed forested habitats in FRSP.

The raccoon and Virginia opossum exhibit a wide breadth of habitat use, with predilection for wooded areas near water (McManus 1974; Lotze and Anderson 1979; Gardner and Sunquist 2003; Gehrt 2003). Raccoons were observed and trapped numerous times in wooded habitats. Opossums were captured in deciduous woodland and seen in a variety of forested habitats, forest-field edge, and urban areas. Ample forest and field acreage in FRSP provide abundant habitat for these two generalists.

Both gray and red foxes traverse a variety of habitats within their considerable home ranges. Gray foxes are more often associated with woodlands and red foxes with fragmented landscapes, but gray foxes in eastern North America prefer a mix of fields and forest (Cypher 2003). Gray fox remains from roadkills were found adjacent to mixed forest in FRSP, and one was photographed in grassy habitat. Red foxes were associated with fields and deciduous forest. FRSP provides ample suitable habitat for these canids.

The infrequent detection of the striped skunk was surprising, given the abundance of preferred woodland and field habitat in FRSP. The paucity of encounters could be related to either the marked density fluctuations typical of this species in some areas (Wade-Smith and Verts 1982), with 2004–2005 representing a population trough, or their frequent movements to forage primarily on insects, notably, beetles (Rosatte and Lariviere 2003). We suspect that skunks are distributed as widely in FRSP as elsewhere within their range.

White-tailed deer are cosmopolitan in their habitat affinities, occupying both open and forested habitats (Miller et al. 2003). Nevertheless, they are most often associated with woodlands (Linzey 1998). We observed them in and near a variety of forest types and fields. They appear to be abundant in FRSP where a diversity of habitats provide concealment and thermal cover and satisfies the foraging needs of this species.

Habitat Specialists

Several of the small mammal species represented in our survey can be considered grassland or field specialists. The eastern mole can be found in meadows, gardens, cultivated fields, forests, and river bottoms (Linzey 1998). Soil type is a limiting factor for this species, which prefers moist soils of loam or sand and avoids clay and gravel (Yates and Schmidly 1978). The meadow vole and eastern harvest mouse were abundant in Saunders and Tapp fields (see Appendixes C and D). The meadow vole is typically abundant in eastern open grasslands (Reich 1981; Linzey 1998). The eastern harvest mouse has been found primarily in old fields (Stalling 1997) containing plants such as broomsedge (*Andropogon* spp.) and goldenrod (*Solidago* spp.), two prominent taxa in FRSP fields. Six of the seven American least shrews captured were taken in fields, typical habitat for the least shrew (Whitaker 1974; Linzey 1998). We caught one meadow jumping mouse in a field. This species occupies a variety of habitats besides fields, including thickly vegetated edges of ponds, streams, and swamps (Whitaker 1972), and may be more widespread within FRSP than our sampling results indicate.

The eastern chipmunk was observed in deciduous forest and wetland habitat. The preferred habitat of this species is deciduous forest, especially where crevices are abundant that serve as refuges (Snyder 1982).

Beaver sign was found in riparian sites within wooded habitats. Beavers typically are associated with flowing water or other habitats that permit dam construction (Linzey 1998). Availability of food is an important factor in the suitability of a habitat for occupation (Jenkins and Busher 1979), and wooded habitat in FRSP apparently provided adequate food resources at the time of occupancy.

A single marsh oryzomys ("rice rat") was captured in wetland habitat at the Jackson Shrine in FRSP. This mammal is semiaquatic and found mostly in wetlands (Wolfe 1982). FRSP is close to the northern extreme of the geographic distribution of the marsh oryzomys.

Exotic Species

Domestic dogs were observed on a few occasions in the park. We do not know if these animals are feral or merely individuals from adjacent residential neighborhoods, but we suspect the latter based on the locations of the sightings. Although we did not observe domestic cats, we believe that the prey base (e.g., meadow voles) is sufficient to attract and sustain feral cats, at least as transients.

House mice were captured in fields and deciduous forest and a single brown rat in deciduous forest in FRSP. The house mouse is introduced from Eurasia and commensal with humans, but often forms feral populations. It occupies fields, swamps, and salt marshes in Virginia and is commonly the most abundant mammal in cultivated fields (Linzey 1998). Individuals captured in deciduous forest likely were in transit to or between fields. The brown rat is usually found in association with human habitations (Linzey 1998). The individual in this study was captured in deciduous forest in Ellwood and perhaps was resident in or around the house or outbuildings there.

Habitat-specific Species Diversity

Species diversity of small mammals at FRSP was greatest for fields. Although the greatest number (eight) of small mammal species by habitat type was detected in deciduous forest and the next highest species richness (seven) occurred in fields, sampling efforts in these habitats far exceeded those in other habitat types. The emphasis on sampling in fields and deciduous forest related not only to the large proportion of total area in FRSP comprised by these habitat types but also to the M.S. research projects conducted in these habitats by the junior authors of this report. When sampling effort was standardized at 26 individuals (the size of the smallest sample in the four principal habitat types that yielded more than one species and 20 individuals) in rarefaction analysis, grassy fields, coniferous forest, and deciduous forest supported similarly high estimated species richness. Grassland specialists (least shrew, meadow vole, eastern harvest mouse, and meadow jumping mouse), two habitat generalists (northern short-tailed shrew and white-footed deer mouse), and the exotic house mouse were captured in grassland habitat. The comparatively high Brillouin index for this habitat was attributable largely to high species richness.

Grassland habitats provide important resources, especially food, for a variety of small mammals. Lepidopteran larvae (caterpillars), earthworms, spiders, crickets and grasshoppers, and beetles that inhabit grassy habitats are important foods of least shrews (Whitaker and Mumford 1972). Northern short-tailed shrews are often associated with meadow voles, and earthworms and millipedes make up most of their diet (George et al. 1986). Meadow voles subsist chiefly on available grasses, sedges, and herbaceous plants (Reich 1981). Harvest mice eat seeds of grasses and other herbaceous plants, green vegetation, and crickets and grasshoppers (Stalling 1997). Seeds, especially those of grasses, constitute the principal food of the meadow jumping mouse (Whitaker 1972). White-footed deermice, although chiefly woodland creatures, visit fields to forage for insects and seeds and also use grasses to line their nests (Lackey et al. 1985). Whitaker (1966) found that 42% of the diet of the exotic house mouse consisted of seeds, especially those of wild grasses.

Deciduous forest supported a high relative abundance of the white-footed deermouse and successively lower abundances of the northern short-tailed shrew, eastern chipmunk, eastern gray squirrel, house mouse, brown rat, southeastern shrew, and meadow vole. The white-footed mouse prefers woodlands (see earlier discussion), and the short-tailed shrew is a common species in deciduous woodlands in the East (George et al. 1986). The eastern chipmunk (Snyder 1982) and gray squirrel (Edwards et al. 2003) are common in eastern deciduous forests. The house mouse and brown rat are commensal with humans (Linzey 1998) and rarely found in woodland habitats. The few individuals of these species trapped in FRSP woodland likely were in transit to more preferred sites. Only one southeastern shrew was captured in deciduous forest; this species, although an occupant of a variety of habitats, prefers wetland and riparian zones (French 1980). Similarly, only one meadow vole, a grassland specialist, was caught in woodland habitat.

At a standardized sample size of 26 individuals, coniferous forest exhibited a comparatively high estimate of richness of small mammals. Four species were found in coniferous forest—the northern short-tailed shrew, pygmy shrew, southeastern shrew, and white-footed deermouse. Although a number of individual white-footed deermice were captured in coniferous forest, relative abundance of this species in this habitat was comparable to that observed in mixed forest and lower than in deciduous forest, floodplain forest, and wetland habitats. Coniferous forest clearly is not a preferred habitat for *P. leucopus* in FRSP. This species is typically most abundant in forests dominated by hardwoods (Lackey et al. 1985).

Species evenness was greatest among principal habitat types in streamside habitat within deciduous forest, although only five individuals of three species (short-tailed shrew, least shrew, and white-footed deermouse) were captured. Evenness in wetlands was reasonably high, but only seven individuals of two species (marsh oryzomys and white-footed mouse) were captured in this habitat type. Sampling effort was limited in wetland habitat because of the small proportion of the total area in FRSP comprised by this habitat type. Relative abundance of the deermouse was higher in this habitat than in any other habitat type; although, it is not considered to be a wetland species. The white-footed deermouse also was the only species captured in floodplain forest and acid seeps within deciduous forest.

Sampling Efficiency

Sherman traps are the industry standard for live capture of rodents and shrews of body mass ≥ 10 g (Mitchell et al. 1993) and were used with success to capture a number of species in a variety of habitats. However, for smaller species pitfall traps are more efficient (Szaro et al. 1988; Kirkland and Sheppard 1994; Umetsu et al. 2006; Sedivec and Whidden 2007). Four species, three of which were shrews, were captured in pitfall traps. We limited the use of these traps to forested habitat (including streamside) specifically to target small shrews that cannot be captured by any other means. The placement of pitfall traps is labor-intensive, and these traps must be used as kill traps because small shrews are difficult to identify to species without close examination of the dentition. Although Tomahawk traps were used extensively (primarily in forested habitats), only two species (eastern gray squirrel and opossum) were captured with these traps. We obtained images of five species with remote cameras, but these devices are labor-intensive, not very productive, and thus were used sparingly. Direct observation, especially while conducting trap sampling, is efficient for detecting sign and medium-to-large, nonsecretive species.

Conclusions and Management Recommendations

It is our understanding that no recent General Management Plan (GMP) or Resource Management Plan (RMP) exists for FRSP. Nevertheless, our survey of mammals of the park addresses one of the five long-term goals established by the Natural Resource Inventory and Monitoring Program of the National Park Service (NPS 1998) for the mid-Atlantic parks of the Northeast region: to complete baseline inventories of basic biological and geophysical natural resources. Our inventory of the mammals of FRSP documents the presence of particular species of mammals, notes their habitat associations, describes sampling protocol, and provides information that can be used to monitor mammal populations, and herein provides recommendations for their conservation and management.

The park supports a predictable assemblage of mammals, based on the types of habitat present. Habitat generalists are widely distributed geographically in the park, usually in reasonable abundance where they are found. One of the most common mammals in eastern North America, the white-footed deermouse, occurs in all of the principal habitats sampled and is abundant in forested areas and wetlands. The generally widespread northern short-tailed shrew was found in five of the eight principal habitats, although it was abundant only in fields. Other common species, such as eastern cottontail rabbits, eastern gray squirrels, woodchucks, Virginia opossums, raccoons, and white-tailed deer, were trapped or observed frequently in their preferred habitats.

Especially noteworthy was the species diversity of small mammals in grassland habitat and the presence and relative abundance of the eastern harvest mouse that typically does not occur as dense populations in this region. The eastern harvest mouse was captured in a number of locations and was nearly as abundant in FRSP as the ubiquitous grassland specialist, the meadow vole. In addition, the American least shrew and meadow jumping mouse were captured in field habitat, although in small numbers. Current grassland management practices apparently are suitable for a reasonable diversity of small mammal species, although special attention should be paid to the protection and maintenance of moist grassland preferred by meadow jumping mice.

Several species present in FRSP are specialists dependent on wetland habitat, which comprises a comparatively small proportion of the area of the park. The semiaquatic marsh oryzomys was found (but not abundant) at Jackson Shrine, where the largest acreage of wetland habitat exists in FRSP. Beavers occupy (or occupied) riparian areas within forested habitats of FRSP. Of concern was our failure to observe muskrats, river otters, or mink, all of which depend on wetland and riparian habitats. Because wetlands are restricted in FRSP, it is extremely important that careful attention be paid to the protection and maintenance of such areas to sustain existing populations and, potentially, increase the diversity of wetland species in the park.

Four species of small mammals were captured in coniferous forest, although only the white-footed deermouse was abundant in this habitat. Nevertheless, the rare pygmy shrew was captured among conifers, and such habitat should support red squirrels, which were not captured or observed in our survey. Additional sampling with pitfall traps should be conducted in stands of conifers to confirm the persistence of the pygmy shrew, and tree-mounted Sherman and/or Tomahawk traps should be used in an attempt to find red squirrels.

Additional Inventories

Additional inventory and monitoring work should be conducted to determine the status of a number of the species we either detected in low numbers (e.g., the American least shrew, pygmy shrew, southeastern shrew, and meadow jumping mouse) or could not confirm but that may be present because FRSP is within their ranges and contains what appears to be suitable habitat (star-nosed mole, woodland vole, common muskrat, southern flying squirrel, eastern fox squirrel, red squirrel, coyote, bobcat, North American river otter, long-tailed weasel, and American mink). Additional locations in fields should be sampled to determine if least shrews and meadow jumping mice are more abundant and widespread than we discovered. Similarly, marsh habitat and riparian zones should be monitored for sign of the star-nosed mole (Petersen and Yates 1980), muskrat, river otter, and mink; harpoon traps could be used in an attempt to capture the star-nosed mole in such habitats.

Pine stands should be sampled more intensively in search of the pygmy shrew, red squirrel, and fox squirrel. Deciduous forest should be sampled with tree-mounted Sherman traps to confirm the status of the southern flying squirrel in the park. In addition, transects should be walked and Tomahawk traps used more extensively in this habitat to establish the presence/absence of the eastern fox squirrel, which typically occurs in oak and pine stands (Koprowski 1994a). Increased sampling effort with small Tomahawk traps in forested and field habitats should reveal the presence of the long-tailed weasel. This species is a generalist in terms of habitat and diet (Sheffield and Thomas 1997) and should be widespread in FRSP.

We used pitfall trap arrays only in forested habitats (including riparian areas and acid seeps). The use of pitfall traps should be extended to additional habitats to establish the presence and status of small shrew species. However, pitfall traps must be used responsibly and with adequate supervision—only after archeological compliance or oversight has been completed so that archeological remains are not disturbed and large numbers of individuals of any single species are not sacrificed. Further, pitfall traps in frequently visited and/or heavily used areas of the park may pose a public safety issue.

Habitat Management

Inventorying and monitoring activities will continue to provide important information on how habitats should be managed for the conservation of the park's natural resources. FRSP wetlands and wooded riparian zones provide critical habitat for such mammals as the marsh oryzomys and beaver and perhaps other species not detected but present in low abundance (e.g., the muskrat and mink); such habitat should receive special consideration for conservation efforts.

Fields exhibited considerably more diversity than other habitat types and should be maintained and managed carefully to retain healthy populations of small mammals, which, in turn, sustain larger species. Management specifically for such grassland specialists as the meadow vole, eastern harvest mouse, American least shrew, and meadow jumping mouse might also benefit other grassland species. Old and open fields support healthy populations of the vole, harvest mouse, and northern short-tailed shrew. Properly scheduled mowing and prescribed burns can be used to interrupt succession and maintain herbaceous vegetation suitable to the resource requirements of such species as the eastern harvest mouse (Tanner and Kneipp 2007).

Conifer stands should be protected as suitable habitat for shrews, most notably, the pygmy shrew. We estimated species richness as high in coniferous forest, with three species of shrews present and the potential that it also supports limited populations of red and eastern fox squirrels (although these were not detected).

Species Management

Management for the control of particular mammal species in FRSP might be warranted. Based on frequency of sightings (including remote photography), abundance of sign, and frequent disturbance of Sherman traps, the raccoon appears to be abundant in the park and may be of special concern for several reasons. In numbers it can be a significant predator on bird and reptile eggs and nestlings. It is also the primary terrestrial reservoir of rabies in the Southeast, and raccoon rabies is easily spread to feral cats. Most cases of human exposure to rabies result from contact with cats (Gehrt 2003). Although measures to reduce the number of raccoons in FRSP may not be justified or practical, management practices (e.g., frequent trash disposal in high-traffic areas) that would reduce the consequences of human activities that sustain raccoon populations can be intensified.

Management for the control of the white-tailed deer in FRSP might be warranted. Frequent sightings (including by remote photography), abundant sign, and recovery of remains are evidence that this species is abundant in the park. When overabundant deer potentially pose several problems. These can include an alteration of the stable state of a northern temperate forest (Stromayer and Warren 1997), which can affect understory cover important to mammals and birds. Also, deer serve as hosts to an extraordinary diversity of ectoparasites, including adult, breeding *Ixodes scapularis*, the black-legged tick that is the vector of the etiologic agent (the spirochete, *Borrelia burgdorferi*) for Lyme disease (Miller et al. 2003), and *Amblyomma americanum*, the lonestar tick that is the vector of the etiologic agent (the spirochete, *Borrelia lonestari*) for Southern Tick-Associated Rash Illness (STARI – Kollars et al. 2000). Tanner (2007) failed to find ixodid ticks infected with *Borrelia burgdorferi* in the park but did find lonestar ticks infected with *B. lonestari*. Monitoring the deer population (e.g., with pellet-group counts) and understory browse in the park is recommended. If such monitoring suggests that deer may be altering the habitat to the detriment of other fauna, management practices to control the deer population may be worthy of consideration, especially considering the abundance of the lonestar tick in the park (Tanner 2007).

Populations of FRSP mammals we documented should be monitored, and efforts to confirm the presence or absence of those species expected to be residents should be continued. In addition to the impacts of larger species on systems, such as those described earlier, the roles of small mammals as critical components of biological communities has been recognized for some time (e.g., Chew 1978). Small mammals consume, transport, and deposit spores and mycelia of mycorrhizal fungi (Fogel and Trappe 1978; Maser et al. 1988) and seeds of many plant species, mix soil and decompose organic matter and litter, regulate invertebrate (e.g., insect) populations, and serve as prey for numerous terrestrial and avian predators (Sekgororoane and Dilworth 1995; Carey and Harrington 2001). Management decisions that can effect proper stewardship of natural systems necessarily rely on periodic assessments of species diversity and abundances from inventory and monitoring activities.

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Appendix A. Trapping schedule, habitats, locations, and efforts for Sherman traps for 2004 in Fredericksburg and Spotsylvania National Military Park.

Dates ¹	Habitat/Site ²	Location ³	Sherman Trap Configuration ⁴	Trap Nights ⁵
2/20–2/21 2/25–2/27	Fld Burn C-1	0272895 4233402	Trans (0.11)	55
2/20–2/21 2/25–2/27	Fld HH burn 1	0272293 4233127	Trans (0.16)	80
2/20–2/21 2/25–2/27	Fld Burn J-1	0272975 4233553	Trans (0.11)	55
2/20–2/21 2/25–2/27	Fld J control	0272950 4233618	Trans (0.26)	67
2/25–2/27	Fld Biggie control	0272652 4233787	Trans (0.15)	45
2/25–2/27	Fld Cannon control	0272113 4233463	Trans (0.15)	45
3/19–3/28	Fld HH burn 2	0272233 4232907	Grid (0.20)	200
3/19–3/28	Fld Cannon burn	0272113 4233463	Trans (0.20)	200
3/19–3/28	Fld Biggie burn 1	0272699 4233840	Grid (0.80)	800
3/19–3/28	Fld Burn C-2	0272864 4233296	Trans (0.09)	90
3/19–3/28 6/19–6/28	Fld Burn J	0272907 4233404	Trans (0.10)	200
3/19–6/28 6/19–6/28	Fld Burn J2	0272919 4233342	Trans (0.10)	200
5/20–5/30	MF Grant Dr. mix	0271700 4233822	Grid (0.32)	320
5/21–5/30	DF GH	0286065 4236223	Trans (0.62)	620
		0285856 4236060	Grid (0.30)	300
5/21–5/30	MF Spotsy conif strip	0271957 4232885	Grid (0.20)	200
6/19–6/28	Fld Biggie burn 2	0272680 4233872	Trans (0.54)	540
6/19–6/28	Fld Burn C-3	0272864 4233296	Trans (0.10)	100
6/19–6/28	Fld Cannon burn 2	0272113 4233463	Trans (0.20)	200
6/19–6/28	Fld HH burn 3	0272148 4232923	Grid (0.20)	200
7/8–7/17	CF Loblolly	0268982 4241033	Trans (0.40)	400
7/8–7/17	MF Inn	0262978 4243461	Trans (0.35)	350
7/8–7/17	DF Copperhead stream	0268531 4241005	Trans (0.20)	200
7/24–8/1	Fld Ashley field	0270840 4242236	Trans (0.20)	220
7/24–8/1	DF Country club	0262349 4241872	Trans (0.40)	400 [42]
7/24–8/1	MF Gordon's Flank	0258549 4244731	Trans (0.30)	300 [28]
7/24–8/2	CF WILD conif strip	0259586 4244499	Trans (0.15)	150 [42]
8/3–8/12	DF Burnside decid	0273164 4232609	Trans (0.30)	300 (200 ^s) [60]
8/3–8/12	DF Burnside stream	0273198 4232687	Trans (0.13)	130 [40]
8/3–8/12	CF Grant Dr. conif	0271726 4233806	Trans (0.30)	300 (200 ^s) [60]
8/3–8/12	DF Biggie decid	0272444 4233477	Trans (0.20)	200 (360 ^s) [60]
9/2–9/4 9/8–9/11 9/15–9/17	DF Boardwalk	0284205 4236787	Trans (0.20)	200 [40]
9/2–9/4 9/8–9/11 9/15–9/17	DF Cabin trail	0284811 4236751	Trans (0.30)	300
9/2–9/4 9/8–9/11 9/15–9/17	Fld Prospect Hill	0286806 4236142	Trans (0.20)	200
9/23–9/25 9/30–10/2 10/7–10/9	DF/AS	0268374 4243830	Trans (0.20)	180 (90 ^s , 18 ^m) [36]

Appendix A. Trapping schedule, habitats, locations, and efforts for Sherman traps for 2004 in Fredericksburg and Spotsylvania National Military Park (continued).

Dates ¹	Habitat/Site ²	Location ³	Sherman Trap Configuration ⁴	Trap Nights ⁵
9/23–9/25 9/30–10/2 10/7–10/9	CF Loblolly 2	0269143 4240988	Trans (0.30)	270 (90 ^s ,18 ^m) [36]
9/23–9/25 9/30–10/2 10/7–10/9	MF Bullock mix	0268615 4243755	Trans (0.25)	225 (90 ^s ,18 ^m) [54]
10/14–10/16 10/20–10/22 10/27–10/28 11/2–11/5	DF Saunders decid	0259403 4244073	Trans (0.30)	360 (260 ^s) [39]
10/14–10/16 10/20–10/23 10/27–10/28 11/3–11/6	DF Saunders stream	0259287 4244203	Trans (0.20)	260 [39]
10/14–10/16 10/20–10/23 10/27–10/28 11/3–11/6	MF Tapp mix	0261319 4241344	Grid (0.28)	364 (208 ^s) [52]
10/15–10/16 10/20–10/23 10/27–10/29 11/3–11/6	Fld Saunders field	0259034 4244248	Trans (0.22)	260
10/16 10/20–10/23 10/27–10/28 11/3–11/6	Fld Inn field	0269222 4243101	Trans (0.20)	220
10/16 10/20–10/22 10/27–10/28 11/3–11/6	Fld Tapp field	0261498 4241250	Trans (0.20)	200

¹ Dates are nights Sherman traps were open.

² Fld = field; MF = mixed forest; DF = deciduous forest; CF = coniferous forest; WL = wetland;

AS = acid seep within DF; stream = streamside (riparian)

³ UTM coordinates are for middle of grid or one end of transect; zone 18. See Figure 2 for map of locations.

⁴ Numbers in parentheses for Sherman trap configuration are effective sampling area in ha for grids (Grid) and effective sampling length in km for transects (Trans).

⁵ Total Sherman trap nights (trap interval =10 m), with Tomahawk (^s = small, ^m = medium – see Methods) trap nights in parentheses and pitfall trap nights in brackets

Appendix B. Trapping schedule, habitats, locations, and efforts for Sherman traps for 2005 in Fredericksburg and Spotsylvania National Military Park.

Dates ¹	Habitat/Site ²	Location ³	Sherman Trap Configuration ⁴	Trap Nights ⁵
4/5–4/11	CF Prospect conifer	Equipment failure	Trans (0.15)	150
4/17–19				
4/5–11	Fld Prospect II	Equipment failure	Trans (0.15)	200
4/17–19				
8/28–9/3	AS Special FRED	0284029 4239144	Trans (0.10)	100
9/15–17				
8/28–9/3	FF Special Higgerson	0259473 4243622	Trans (0.10)	100
9/15–17				
8/28–9/3	AS Special Tapp	0261427 4241575	Trans (0.10)	100
9/15–9/17				
9/23–9/29	WL Jackson Shrine	0285870 4224844	Trans (0.15)	135
10/1–2				
6/16	Fld Saunders Field	0259077 4244303	Grid (1.00)	2229*(8 ⁵)
6/21				
6/26–30				
7/10–14				
7/29				
8/22				
8/27–28				
9/2–4				
9/22				
9/25				
10/1–2				
10/7–8				
10/14				
6/16	Fld Tapp Field	0261637 4241374	Grid (1.00)	2129*
6/29–30				
7/10–14				
7/29				
8/22				
8/27–29				
9/2–4				
9/15–17				
9/22				
10/1–2				
10/7–8				
10/14				

Appendix B. Trapping schedule, habitats, locations, and efforts for Sherman traps for 2005 in Fredericksburg and Spotsylvania National Military Park (continued).

Dates ¹	Habitat/Site ²	Location ³	Sherman Trap Configuration ⁴	Trap Nights ⁵
4/28–30	DF Middlebrook	0259407 4244580	Grid (1.00)	343* (48 ^m)
5/29–31				
6/12–13				
6/26–28				
7/10–11				
7/24–25				
8/21–22				
9/9–10				
10/6–7				
10/21–22				
4/28–30	DF Ellwood	0261212 4244102	Grid (0.49)	632* (6 ^m)
5/29–31				
6/12–14				
6/26–28				
7/10–11				
7/24–25				
8/21–22				
9/9–10				
10/6–7				
10/21–22				
5/5–7	DF Higginson	0259317 4243760	Grid (1.00)	1339*
6/1–3				
6/15–17				
6/29–7/1				
7/12–13				
7/26–27				
8/24–25				
9/11–12				
10/8–9				
10/23–24				
5/5–7	DF Carver	0259524 4242828	Grid (0.49)	439* (4 ^m)
6/1–3				
6/15–17				
6/29–7/1				
7/12–13				
7/26–27				
8/24–25				
9/11–12				
10/8–9				
10/23–24				

Appendix B. Trapping schedule, habitats, locations, and efforts for Sherman traps for 2005 in Fredericksburg and Spotsylvania National Military Park (continued).

Dates ¹	Habitat/Site ²	Location ³	Sherman Trap Configuration ⁴	Trap Nights ⁵
5/11–13	DF Chewning Large	0259339 4240939	Grid (1.00)	355* (12 ^m)
6/4–6				
6/18–20				
7/2–3				
7/14–15				
7/28–29				
8/26–27				
9/13–14				
10/10–11				
5/11–13	DF Chewning Small	0259790 4241466	Grid (0.49)	306*
6/4–6				
6/18–20				
7/2–3				
7/14–15				
7/28–29				
8/26–27				
9/13–14				
10/10–11				

¹ Dates are nights traps were open.

² Fld = field; DF = deciduous forest; CF = coniferous forest; AS = acid seep within DF; FF = floodplain forest; WL = wetland (marsh).

³ UTM coordinates are for middle of grid or one end of transect; zone 18. See Figure 2 for map of locations.

⁴ Numbers in parentheses for Sherman trap configuration are effective sampling area in ha for grids (Grid) and effective sampling length in km for transects (Trans).

⁵ Total Sherman trap nights (trap interval =10 m; * adjusted for trap disturbances), with Tomahawk (^s = small, ^m = medium – see Methods) trap nights in parentheses

Appendix C. Capture record for mammals caught in Fredericksburg and Spotsylvania National Military Park from February through November 2004.

Habitat/site ¹	TNs ²	Species ³	No. individuals	Total captures	Relative Abundance ⁴
Fld HH burn 1	80	<i>Microtus pennsylvanicus</i>	1	1	2.5
Fld Cannon control	45	<i>Microtus pennsylvanicus</i>	1	2	2.2
Fld HH burn 2	200	<i>Peromyscus leucopus</i>	1	1	0.5
		<i>Reithrodontomys humulis</i>	1	4	0.5
Fld Cannon burn	200	<i>Reithrodontomys humulis</i>	5	9	2.5
Fld Biggie burn 1	800	<i>Peromyscus leucopus</i>	2	6	0.2
Fld Burn C-2	90	<i>Peromyscus leucopus</i>	3	4	3.3
Fld Burn J2	200	<i>Peromyscus leucopus</i>	3	5	1.5
MF Grant Dr. Mix	320	<i>Peromyscus leucopus</i>	6	19	1.7
DF GH	920	<i>Peromyscus leucopus</i>	3	8	0.3
MF Spotsy conif strip	200	<i>Peromyscus leucopus</i>	5	9	2.5
Fld Biggie burn 2	540	<i>Peromyscus leucopus</i>	4	6	0.7
Fld Burn C-3	100	<i>Peromyscus leucopus</i>	2	7	2.0
Fld Cannon burn 2	200	<i>Reithrodontomys humulis</i>	3	9	1.5
CF Loblolly	400	<i>Peromyscus leucopus</i>	7	23	1.8
MF Inn	350	<i>Peromyscus leucopus</i>	7	30	2.0
DF Copperhead strm	200	<i>Peromyscus leucopus</i>	1	2	0.5
Fld Ashley field	220	<i>Zapus hudsonius</i>	1	1	0.5
DF Country club	400 [42]	<i>Sorex longirostris</i>	1	1	0.2
		<i>Peromyscus leucopus</i>	17	62	3.8
MF Gordon's Flank	300 [28]	<i>Sorex longirostris</i>	1	1	0.3
		<i>Peromyscus leucopus</i>	7	9	2.1
CF WILD con strip	150 [42]	<i>Sorex longirostris</i>	1	1	0.5
		<i>Peromyscus leucopus</i>	4	10	2.1
DF Burnside decid	300 (200 ^s) [60]	<i>Peromyscus leucopus</i>	11	23	3.1
		<i>Sciurus carolinensis</i>	2	2	0.6
DF Burnside stream	170 [40]	<i>Peromyscus leucopus</i>	2	5	1.2
CF Grant Dr. conif	360 (200 ^s) [60]	<i>Blarina brevicauda</i>	1	1	0.3
		<i>Sorex hoyi</i>	1	1	0.3
		<i>Peromyscus leucopus</i>	11	26	3.1
		<i>Sciurus carolinensis</i>	2	2	-
DF Boardwalk	240 [40]	<i>Peromyscus leucopus</i>	1	2	0.4
DF Cabin trail	300	<i>Peromyscus leucopus</i>	1	1	0.3
Fld Prospect Hill	200	<i>Mus musculus</i>	2	2	1.0
DF/AS	180 (90 ^s ,18 ^m) [36]	<i>Sciurus carolinensis</i>	7	7	-
CF Loblolly 2	270 (90 ^s ,18 ^m) [36]	<i>Peromyscus leucopus</i>	2	2	0.8
		<i>Sciurus carolinensis</i>	1	1	-
MF Bullock mix	225 (90 ^s ,18 ^m) [54]	<i>Peromyscus leucopus</i>	5	11	1.8
		<i>Sciurus carolinensis</i>	4	7	-
DF Saunders decid	360 (260 ^s) [39]	<i>Blarina brevicauda</i>	4	4	1.0
		<i>Peromyscus leucopus</i>	7	13	1.8
		<i>Microtus pennsylvanicus</i>	1	1	0.3
		<i>Sciurus carolinensis</i>	1	1	-
DF Saunders stream	260 [39]	<i>Blarina brevicauda</i>	2	2	0.7
		<i>Cryptotis parva</i>	1	1	0.3
MF Tapp mix	364 (208 ^s) [52]	<i>Blarina brevicauda</i>	2	2	0.5
		<i>Peromyscus leucopus</i>	3	5	0.7
		<i>Sciurus carolinensis</i>	8	11	-

Appendix C. Capture record for mammals caught in Fredericksburg and Spotsylvania National Military Park from February through November 2004 (continued).

Habitat/site ¹	TNs ²	Species ³	No. individuals	Total captures	Relative Abundance ⁴
Fld Saunders field	260	<i>Blarina brevicauda</i>	7	7	2.7
		<i>Cryptotis parva</i>	1	1	0.4
		<i>Reithrodontomys humulis</i>	6	8	2.3
		<i>Microtus pennsylvanicus</i>	11	13	4.2
Fld Inn field	220	<i>Mus musculus</i>	1	1	0.5
Fld Tapp field	200	<i>Blarina brevicauda</i>	5	5	2.5
		<i>Cryptotis parva</i>	1	1	0.5
		<i>Reithrodontomys humulis</i>	6	10	3.0
		<i>Microtus pennsylvanicus</i>	6	6	2.1

¹ Fld = field; MF = mixed forest; DF = deciduous forest; CF = coniferous forest; WL = wetland;

AS = acid seep within DF; stream = streamside (riparian)

See Figure 2 and Appendix A for locations of habitat/site.

Sites from Appendix A not listed here yielded no captures.

² TNs = total Sherman trap nights in **bold**, small (°) and medium (°) Tomahawk trap nights in parentheses, and pitfall trap nights in brackets [].

³ See Table 2 for common names.

⁴ Relative abundance is individuals/100 Sherman and pitfall trap nights.

Relative abundances are not determined for captures in Tomahawk traps.

Appendix D. Capture record for mammals caught in Fredericksburg and Spotsylvania National Military Park from April through October 2005.

Habitat/site ¹	TNs ²	Species ³	No. individuals	Total captures	Relative Abundance ⁴
CF Prospect conifer	150	<i>Peromyscus leucopus</i>	1	1	0.7
Fld Prospect II	200	<i>Reithrodontomys humulis</i>	2	2	1.0
FF Special Higginson	100	<i>Peromyscus leucopus</i>	3	10	3.0
AS Special Tapp	100	<i>Peromyscus leucopus</i>	2	3	2.0
WL Jackson Shrine	135	<i>Peromyscus leucopus</i>	6	8	4.4
		<i>Oryzomys palustris</i>	1	6	0.7
		<i>Tamias striatus</i>	3	4	2.2
Fld Saunders field	2229(8^s)	<i>Microtus pennsylvanicus</i>	113	348	5.1
		<i>Reithrodontomys humulis</i>	39	74	1.7
		<i>Blarina brevicauda</i>	43	52	1.9
Fld Tapp field	2129	<i>Microtus pennsylvanicus</i>	17	33	0.8
		<i>Reithrodontomys humulis</i>	75	166	3.5
		<i>Blarina brevicauda</i>	2	100	2.4
		<i>Cryptotis parva</i>	4	4	0.2
DF Middlebrook	343(48^m)	<i>Peromyscus leucopus</i>	13	36	3.8
		<i>Blarina brevicauda</i>	1	1	0.3
		<i>Tamias striatus</i>	1	1	0.3
DF Ellwood	632(6^m)	<i>Peromyscus leucopus</i>	15	53	2.4
		<i>Mus musculus</i>	2	3	0.3
		<i>Blarina brevicauda</i>	4	5	0.6
		<i>Rattus norvegicus</i>	1	1	0.2
DF Higginson	1,339	<i>Peromyscus leucopus</i>	26	100	1.9
		<i>Blarina brevicauda</i>	12	12	0.9
		<i>Tamias striatus</i>	4	4	0.3
		<i>Sciurus carolinensis</i>	1	1	0.1
DF/Carver	439(4^m)	<i>Peromyscus leucopus</i>	29	72	6.6
		<i>Tamias striatus</i>	1	2	0.2
		<i>Blarina brevicauda</i>	1	1	0.2
DF Chewning Large	355(12^m)	<i>Peromyscus leucopus</i>	13	16	3.7
		<i>Tamias striatus</i>	2	2	0.6
		<i>Didelphis virginiana</i>	2	2	-
DF Chewning Small	306	<i>Peromyscus leucopus</i>	16	30	5.2

¹ CF = coniferous forest; Fld = field; AS = acid seep; FF = floodplain forest;

WL = wetland; DF = deciduous forest

See Figure 2 and Appendix B for locations of habitat/site.

Sites from Appendix B not listed here yielded no captures.

² TNs = total Sherman trap nights in **bold**, small (^s) and medium (^m) Tomahawk trap nights in parentheses.

³ See Table 2 for common names.

⁴ Relative abundance is individuals/100 Sherman and pitfall trap nights.

Relative abundances are not determined for captures in Tomahawk traps.

As the nation's primary conservation agency, the Department of the Interior has responsibility for most of our nationally owned public land and natural resources. This includes fostering sound use of our land and water resources; protecting our fish, wildlife, and biological diversity; preserving the environmental and cultural values of our national parks and historical places; and providing for the enjoyment of life through outdoor recreation. The department assesses our energy and mineral resources and works to ensure that their development is in the best interests of all our people by encouraging stewardship and citizen participation in their care. The department also has a major responsibility for American Indian reservation communities and for people who live in island territories under U.S. administration.

NPS D-075 May 2008

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