



Inventory of Mammals (Excluding Bats) of Colonial National Historical Park

Natural Resource Technical Report NPS/NCBN/NRTR—2010/321



ON THE COVER

White-footed mouse (*Peromyscus leucopus*) in Colonial National Historical Park
Photograph by Heather Warchalowski

Inventory of Mammals (Excluding Bats) of Colonial National Historical Park

Natural Resource Technical Report NPS/NCBN/NRTR—2010/321

Ronald E. Barry

Bates College
Biology Department
409 Carnegie Science Hall
44 Campus Avenue
Lewiston, Maine 04240

Heather P. Warchalowski, and Dana T. Strang

Department of Biology
201 Compton Science Center
Frostburg State University
101 Braddock Road
Frostburg, Maryland 21532-2303

May 2010

U.S. Department of the Interior
National Park Service
Natural Resource Program Center
Fort Collins, Colorado

The National Park Service, Natural Resource Program Center publishes a range of reports that address natural resource topics of interest and applicability to a broad audience in the National Park Service and others in natural resource management, including scientists, conservation and environmental constituencies, and the public.

The Natural Resource Technical Report Series is used to disseminate results of scientific studies in the physical, biological, and social sciences for both the advancement of science and the achievement of the National Park Service mission. The series provides contributors with a forum for displaying comprehensive data that are often deleted from journals because of page limitations.

All manuscripts in the series receive the appropriate level of peer review to ensure that the information is scientifically credible, technically accurate, appropriately written for the intended audience, and designed and published in a professional manner.

This report received informal peer review by subject-matter experts who were not directly involved in the collection, analysis, or reporting of the data. Data in this report were collected and analyzed using methods based on established, peer-reviewed protocols and were analyzed and interpreted within the guidelines of the protocols.

Views, statements, findings, conclusions, recommendations, and data in this report are those of the author(s) and do not necessarily reflect views and policies of the National Park Service, U.S. Department of the Interior. Mention of trade names or commercial products does not constitute endorsement or recommendation for use by the National Park Service.

This report is available from (<http://www.nps.gov/nero/science/>) and the Natural Resource Publications Management website (<http://www.nature.nps.gov/publications/NRPM>).

Please cite this publication as:

Barry, R. E., H. P. Warchalowski, D. T. Strang. 2010. Inventory of mammals (excluding bats) of Colonial National Historical Park. Natural Resource Technical Report NPS/NCBN/NRTR—2010/321. National Park Service, Fort Collins, Colorado.

Contents

	Page
Figures.....	v
Tables.....	vii
Executive Summary	ix
Acknowledgments.....	xi
Introduction.....	1
Study Area and Habitats	5
Delineation of habitats	5
Methods.....	7
Sampling protocol.....	7
Yearly Sampling Protocol.....	13
Compilation and analysis of data.....	13
Results.....	15
Historical records and predicted species.....	15
Field survey	15
Species diversity	21
Voucher specimens.....	22
Discussion	27
Species records	27
<i>Habitat generalists</i>	27
<i>Habitat specialists</i>	29
<i>Exotic species</i>	30
<i>Habitat-specific species diversity</i>	30
<i>Species diversity by geographic unit</i>	31

Sampling efficiency	31
Conclusions and Management Recommendations	33
Additional inventories	33
Habitat Management.....	35
Species Management	35
Literature Cited	37
Appendix A. Trapping schedule, habitats, locations, and efforts for Sherman traps for 2003 in Colonial National Historical Park.....	45
Appendix B. Trapping schedule, habitats, locations, and efforts for Tomahawk and pitfall traps for 2003 at Colonial National Historical Park.....	49
Appendix C. Capture record for mammals caught in Colonial National Historical Park from March through December 2003.	51
Appendix D. Trapping schedule, habitats, locations, and efforts for Sherman traps for 2004 in Colonial National Historical Park.....	57
Appendix E. Trapping schedule, habitats, locations, and efforts for Tomahawk, pitfall, and wooden box traps for 2004 at Colonial National Historical Park.	63
Appendix F. Capture record for mammals caught in Colonial National Historical Park from January through August 2004.	67

Figures

	Page
Figure 1. Location of Colonial National Historical Park (COLO) in Virginia.	2
Figure 2. Map of Colonial National Historical Park showing locations sampled for mammals in 2003 and 2004.	3
Figure 3. Rarefaction curves showing the estimated number of species of small mammals for variable sample sizes (number of individuals) for seven habitat types in Colonial National Historical Park.	23

Tables

	Page
Table 1. Sherman trap configuration for sampling sites at Colonial National Historical Park for 2003 and 2004.	9
Table 2. Comparison of predicted species for Colonial National Historical Park, and species observed during this study (2003-2004).	16
Table 3. Summary of numbers and relative abundances ¹ of small mammals captured with Sherman and pitfall traps among nine principal habitat types ² at Colonial National Historical Park, 2003-2004.	19
Table 4. Total captures of mammals in Tomahawk and wooden box traps ¹ among seven habitat types ² at Colonial National Historical Park, 2003-2004	20
Table 5. Summary of numbers and relative abundances ¹ of small mammals captured with Sherman and pitfall traps among geographic units of Colonial National Historical Park, 2003-2004.	20
Table 6. Mammal sightings or sign in Colonial National Historical Park, 2002-2004.	21
Table 7. Brillouin diversity index (H , determined using $\log_2$) and Smith and Wilson's measure of evenness (Krebs 1999) for small mammals captured in nine habitats in Colonial National Historical Park, 2003-2004.	22
Table 8. Specimens collected in Colonial National Historical Park that were assigned catalog numbers and accessioned into the FSU mammal collection (museum) in 2006.	24

Executive Summary

A survey of mammals (excluding bats) at Colonial National Historical Park (COLO) was conducted from 2003 to 2004 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 (e.g. tracks, scats), and remote photography. We identified nine principal habitats – field (grasslands, including old fields), mixed coniferous-deciduous forest, pine forest, deciduous forest, forested wetland, field/mixed forest edge, marsh/mixed forest edge, wetland (marsh and swamp), and golden bamboo – and targeted locations for sampling.

Twenty-seven species of mammals were either captured or observed within COLO. Altogether, six orders and 14 families of mammals are represented by these species. We documented 68% (27 of 40) of the species (excluding bats) predicted to occur and 66% (27 of 41) of those for which historical records exist. Although our surveys produced no new species records, our sampling efforts confirmed the presence of the hispid cotton rat (*Sigmodon hispidus*) for which only one previous record existed. The white-footed deermouse (*Peromyscus leucopus*) was captured in all nine principal habitat types and was the most abundant and widely distributed mammal in the park. The eastern harvest mouse (*Reithrodontomys humulis*) was the most abundant small mammal captured in field habitat. The marsh oryzomys or rice rat (*Oryzomys palustris*) was the most abundant small mammal in wetland habitat and the second most abundant in forested wetland and marsh/mixed forest edge. Small mammal species diversity and richness were greatest in grassy fields. Deciduous forest supported the lowest species diversity of small mammals.

The park supports a predictable assemblage of mammals given the diversity of habitats present. Habitat generalists, such as the white-footed deermouse, northern short-tailed shrew (*Blarina brevicauda*), Virginia opossum (*Didelphis virginiana*), 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 (*Microtus pennsylvanicus*). In addition, the hispid cotton rat persists in the park, albeit at low densities in isolated pockets of grassland habitat, at or near the northeastern extreme of the species range. Ample wetland and riverine/riparian habitats exist to support healthy populations of the marsh oryzomys, muskrat (*Ondatra zibethicus*), American beaver (*Castor canadensis*), and American river otter (*Lontra canadensis*).

Additional inventory and monitoring work should be conducted to determine the status of a number of species either detected in low numbers – the American least shrew (*Cryptotis parva*), woodland vole (*Microtus pinetorum*), and hispid cotton rat – or not confirmed but for which previous records exist – southern short-tailed shrew (*Blarina carolinensis*), American pygmy shrew (*Sorex hoyi*), star-nosed mole (*Condylura cristata*), marsh rabbit (*Sylvilagus palustris*), golden mouse (*Ochrotomys nuttalli*), cotton deermouse (*Peromyscus gossypinus*), brown rat (*Rattus norvegicus*), eastern fox squirrel (*Sciurus niger*), eastern chipmunk (*Tamias striatus*), meadow jumping mouse (*Zapus hudsonius*), coyote (*Canis latrans*), bobcat (*Lynx rufus*), long-tailed weasel (*Mustela frenata*), and American black bear (*Ursus americanus*). This work would

necessarily include additional sampling of grasslands (including old fields), wetlands, pine stands, and wooded habitats with dense underbrush. 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 wetlands that support a number of mammal species in COLO; 2) regulating visitor use of specific areas where sensitive species (e.g. the river otter) are 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, 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 monitoring of picnic areas and trash removal); 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. Raccoon and white-tailed deer populations, particularly because of rabies and Lyme disease (and abundance of the black-legged [deer] tick larvae and nymph reservoir-competent host, the white-footed deermouse), also are of potential public health significance in a historical park with high human visitation like COLO. In addition, the white-tailed deer is the most important host for *Amblyomma americanum*, the lonestar tick that is the vector of the etiologic agent (the spirochete, *Borrelia lonestari*) for Southern Tick-Associated Rash Illness (STARI).

Acknowledgments

Heather Warchalowski and Dana Strang, 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 Charles (Chuck) Rafkind, Natural Resource Manager, and Tom Nash for providing information on the park, collection permits, maps, and other materials and for the time he spent introducing us to the park and discussing the project with us. John Karish, James Comiskey, Sara Stevens, and Charles Rafkind provided comments on and information for drafts of this report. We are especially grateful to Kristina Callahan for the generation of metadata for the inventory and John B. Churchill of the University of Maryland Appalachian Laboratory for the production of ArcView files for GPS sampling locations. We are indebted to John Karish, Beth Johnson, Sara Stevens, and the National Park Service for funding the project. Frostburg State University provided much-appreciated matching funds and logistical support.

Introduction

Surveys of mammals in coastal and mid-Atlantic national parks in the Northeast Region are 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 Colonial National Historical Park (COLO), Virginia, in 2003-2004. COLO encompasses approximately 3,513 ha (8,677 acres – NPS 2000). It is located in the southern Coastal Plain region of Tidewater Virginia (Figure 1) and is comprised of Jamestown Island, Yorktown Battlefield, Swann's Point, Green Spring, and the 38-km (24-mile) Colonial Parkway that connects the island and battlefield (Figure 2). The park is contained within the counties of York, James City, Gloucester, and Surry, and the city of Williamsburg. COLO was designated a national park in 1936. Management objectives stated in the park's General Management Plan (NPS 1993) include the protection, enhancement, and interpretation of natural resources. This document called for the development of an inventory and database of natural resources. The park's strategic plan (NPS 2000) included the "goal category" of protecting, restoring, maintaining and managing natural and cultural resources within an ecosystem and cultural context. Long-term goals included completing inventories of the flora and fauna of the park.

Previous accounts of mammals at COLO (Terman and Huggett 1980; Brustlin Inc. 1996; Bradshaw 1999; Van Alstine et al. 2001; Chazal and Van Alstine 2002) produced records of 50 species, including 9 species of bats (NPSpecies database: www.science1.nature.nps.gov/npspecies/). Preliminary field work began in October 2002, and systematic sampling was conducted from March 2003 through August 2004. Surveys included sampling of small to medium-size mammals using Sherman, Tomahawk, and wooden box (for rabbits) 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 mammals squirrel-size and larger, beginning in October 2002.

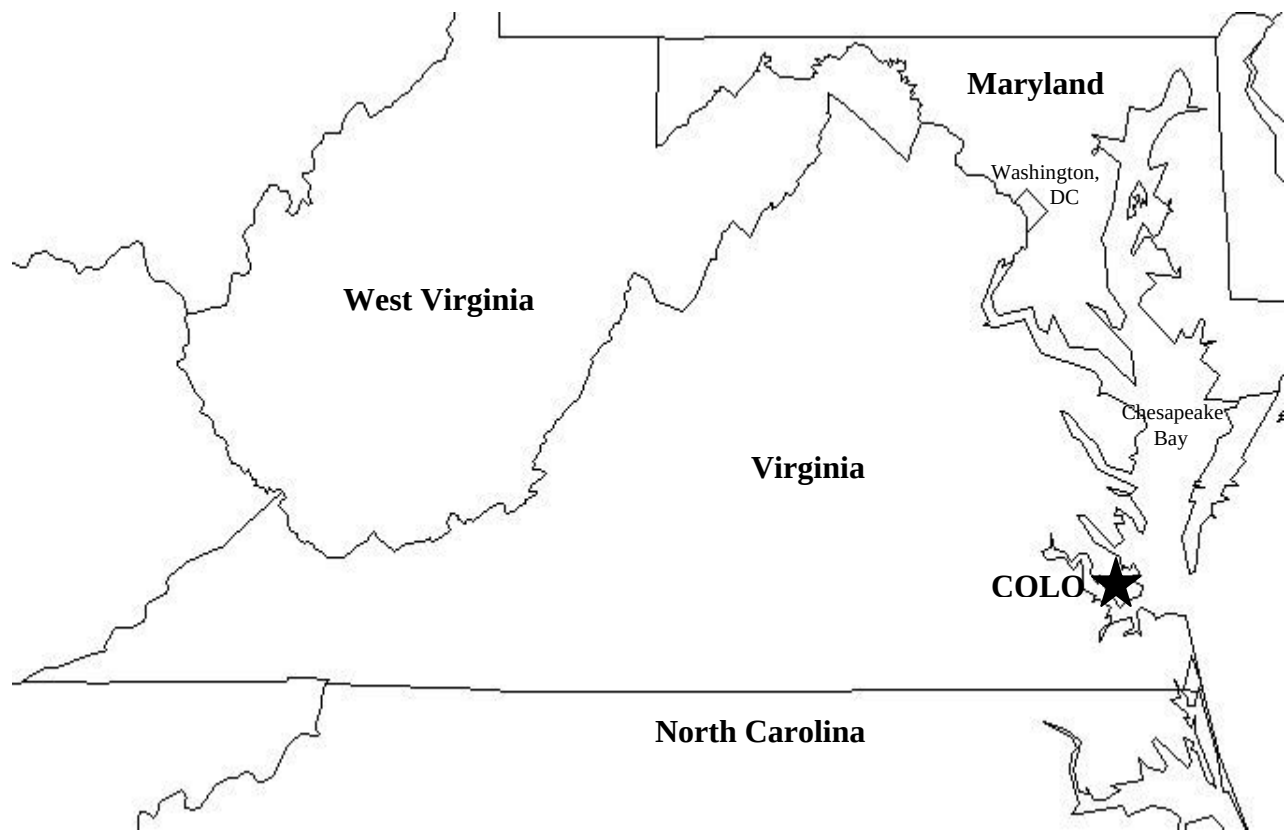


Figure 1. Location of Colonial National Historical Park (COLO) in Virginia.

Mammal Inventory Sampling Locations

Colonial National Historical Park
Jamestown - Yorktown, VA



Figure 2. Map of Colonial National Historical Park showing locations sampled for mammals in 2003 and 2004.

Study Area and Habitats

Colonial National Historical Park consists of approximately 3,213 ha (8,677 acres) of upland forests, wetlands (including forested wetland), grassland, and riverine systems and riparian habitat. Nearly 50% of the area (1,709 ha [4,221 acres]) is occupied by pine, mixed pine-hardwood, or hardwood forest (Rafkind 2004). Dominant woody vegetation includes loblolly (*Pinus taeda*) and Virginia pines (*Pinus virginiana*), tulip poplar (*Liriodendron tulipifera*), and white oak (*Quercus alba*), Southern and Northern red oak (*Quercus falcata* and *Quercus rubra*), and willow oak (*Quercus phellos*). Approximately 35% of COLO (1,239 ha [3,061 acres]) lies in floodplain. More than 25% (969 ha [2,394 acres]) is wetlands, including 277 ha (684 acres) of forested wetland. Managed fields constitute approximately 415 ha (1,025 acres). COLO contains approximately 55 km (33.6 miles) of shoreline along the James and York rivers, 40 km (24.4 miles) of perennial streams, and 51 km (30.9 miles) of intermittent streams and drainages (Rafkind 2004). Numerous springs, seeps, and sinkholes exist. Elevation ranges from sea level to over 37 m (120 feet).

Delineation of habitats

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

Nine principal habitat types – field (grasslands, including old fields), mixed coniferous-deciduous forest (with pure pine stands), pine forest, deciduous forest/pine forest edge, forested wetland, field/mixed forest edge, marsh/mixed forest edge, wetland (marsh, swamp, etc.), and golden bamboo - were identified for inventorying small mammals in COLO (Figure 2). The secure NPSpecies website lists vascular plants certified for the park.

Common vascular plants in fields include broomsedge (*Andropogon virginicus*), Bermuda grass (*Cynodon dactylon*), and other grasses (Poaceae), dandelion (*Taraxacum officinale*), asters (*Aster* spp.), goldenrods (*Solidago* spp.), and clover (*Trifolium* spp.). Important invasive grasses include Canada bluegrass (*Poa compressa*). Managed fields comprise most grassland habitat and are mowed regularly.

Mixed coniferous-deciduous forest comprises most forested habitat in COLO. Dominant canopy species are loblolly and Virginia pines, oaks (*Quercus* spp., including white, southern red, chinquapin [*Quercus muehlenbergii*], willow, northern red, and black [*Quercus velutina*]), sweet gum (*Liquidambar styraciflua*), and tulip poplar (Warchalowski 2006; Strang, in prep.). Common understory woody species include American holly (*Ilex opaca*), dogwood (*Cornus florida*), red maple (*Acer rubrum*), pawpaw (*Asimina triloba*), and American hornbeam (*Carpinus caroliniana*). Virginia creeper (*Parthenocissus quinquefolia*) and poison ivy (*Toxicodendron radicans*) are common vines. Greenbriar (*Smilax rotundifolia*) is locally abundant (dense). Significant invasive nonwoody species include Japanese stilt grass (*Microstegium viminum*) and Japanese honeysuckle (*Lonicera japonica*). Deciduous forest is less abundant at COLO and consists of mixed hardwoods of the species described above typically with isolated patches of pure pine stands. Small streams are scattered within the hardwood forests of COLO. Sycamore (*Platanus occidentalis*) is abundant in forested bottomland. Soil type in forests generally is fine sandy loam or silt loam, often with sandy and

loamy marine sediments in bottomlands. Field/mixed forest edge habitat is characterized by species dominant in field and forest habitat. Multiflora rose (*Rosa multiflora*) is an important invasive in this habitat and in various places along the Colonial Parkway. Pine forest consists of loblolly pine and Virginia pine, with sparsely scattered deciduous understory such as sweet gum. Understory herbaceous vegetation similarly is sparse. In September 2003 Hurricane Isabel, responsible for the largest power outage in Virginia history (National Weather Service 2003), passed over COLO. Its winds created numerous small (< 0.25 ha) and fewer large (> 0.5 ha) gaps throughout the forested portions of the park (Strang, in prep.).

Marshes are characterized by cattails (*Typha latifolia*), narrowleaf cattails (*Typha angustifolia*), bulrushes (*Scirpus* spp.), and cord grasses (*Spartina* spp.). Swamps contain panic grasses (*Panicum* spp.), rushes (*Juncus* spp.), and a diversity of woody species, including black willow (*Salix nigra*), loblolly pine, bald cypress, and red maple. The latter three species also are common in the shallow forested wetlands of the park. Woody species along marsh/mixed forest edge habitat include loblolly pine, bald cypress, sweet gum, tulip poplar, red maple, and black willow.

Golden bamboo habitat is in effect a monoculture of *Phyllostachys aurea* covering a small area of the Jamestown portion of the park. However, a number of patches are prominent in Yorktown, collectively comprising > 20 acres (Gounaris and Grubbs 2000).

Methods

Sampling protocol

Sampling sites were located within the nine identified habitat types to permit stratified sampling. Habitats initially were identified by aerial photo. 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 (composed of 30 x 30-m cells) 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 (e.g., Swann's Point), 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 x 8.9 x 22.9 cm) Sherman live traps. 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, dentition, and internal anatomy were required for identification of species (Caldwell and Bryan 1982), sex, and reproductive condition.

Sherman traps were configured at sampling points in randomly positioned linear transects and grids (Table 1; Appendixes A and D), with a trap interval of 10-20 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 to 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.

Muskrat- (small – 15.2 x 15.2 x 48.3 cm), raccoon-size (medium - 25.4 x 30.5 x 81.3 cm), and bobcat-size (large – 38.1 x 50.8 x 106.7 cm) Tomahawk live traps were used to capture mammals of squirrel size and larger, but particularly to target mesocarnivores such as raccoons (*Procyon lotor*) and red (*Vulpes vulpes*) and gray (*Urocyon cinereoargenteus*) foxes. One to several of these traps were placed in small mammal (Sherman) trapping grids and transects (Appendixes B and E) and opportunistically in habitats where mammal sign was detected or

where habitat features suggested the presence of larger species. Wooden box traps (18 x 22 x 60 cm) were used in transects specifically to target marsh rabbits (*Sylvilagus palustris*). Pitfall traps were arranged in arrays. An array consisted of either one 10 m length of silt fence with one pitfall trap (#10 vegetable can) at either end and two in the middle (4 traps total), or three 10-m lengths of silt fence with one pitfall trap at each end length of fence and two in the middle (10 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. Wooden box traps were baited with apples. 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, deposited, and maintained in the Frostburg State University (FSU) mammal museum.

Table 1. Sherman trap configuration for sampling sites at Colonial National Historical Park for 2003 and 2004.

Year	Habitat/Site ¹	Trap Configuration ²	Trap Nights			
			Sherman Trap	Tomahawk ³	Pitfall	Wooden Box
2003						
	Pk MF A	Trans (0.20)	40			
	Pk MF B	Trans (0.20)	40			
	Pk MF C	Trans (0.20)	40			
	Pk MF D	Trans (0.20)	40			
	Yt MF A2	Trans (0.20)	80			
	Yt MF B2	Trans (0.20)	80			
	Yt MF C2	Trans (0.20)	60			
	Yt MF D2	Trans (0.10)	30			
	Yt Fld E	Trans (0.15)	75			
	Yt Fld F	Trans (0.17)	85			
	Yt Fld G	Trans (0.15)	75			
	Yt FWL 2	Grid (1.00)	800			
	Yt Fld H	Trans (0.41)	164			
	Yt WL I	Trans (0.14)	112			
	Yt WL J	Trans (0.10)	80	16 ^s		
	Yt WL K	Trans (0.06)	48			
	Yt Bam L	Trans (0.10)	80			
	Yt Bam M	Trans (0.05)	40	8 ^m		
	Yt MF N	Trans (0.21)	147	6 ^s		
	Yt MF O	Trans (0.15)	105	6 ^s		
	Yt MF P	Trans (0.15)	105			
	Jm MF	Array			24	
	Jm MF Q	Trans (0.30)	210	14 ^s , 4 ^m		
	Jm MF R	Trans (0.30)	210	14 ^s		
	Jm M/MF S	Trans (0.30)	210	14 ^s		
	Jm MF T	Trans (0.30)	210	7 ^s		
	Yt MF 3	Grid (0.49)	245			
	Yt MF 4	Grid (0.49)	245	10 ^s		
	Yt MF U	Trans (0.20)	100	5 ^s		
	Yt Fld V	Trans (0.10)	50			
	Yt MF W	Trans (0.30)	150	30 ^s , 5 ^m , 5 ^l		

Table 1. Sherman trap configuration for sampling sites at Colonial National Historical Park for 2003 and 2004 (continued).

Year	Habitat/Site ¹	Trap Configuration ²	Trap Nights			
			Sherman Trap	Tomahawk ³	Pitfall	Wooden Box
2003 (continued)	Jm MF 5	Grid (0.49)	539	33 ^s		
	Jm F/MF X	Trans (0.30)	330	11 ^s		
	Jm DF/P Y	Trans (0.49)	510	11 ^s		
	Jm DF/P Z	Trans (0.30)	330	11 ^s		
	Jm MF 5	Pitfall array			32	
	Jm FWL AA	Trans (0.10)	90			
	Gs Fld 6	Grid (1.00)	800	6 ^s		
	Gs Fld BB	Trans (0.20)	160	6 ^s		
	Gs MF CC	Trans (0.10)	80	3 ^s		
	Gs MF DD	Trans (0.10)	80	3 ^s		
	Gs MF EE	Trans (0.10)	80			
	Gs MF FF	Trans (0.20)	120	6 ^s		
	Gs Fld GG	Trans (0.20)	120			
	Gs MF HH	Trans (0.20)	120	8 ^s		
	Gs MF II	Trans (0.20)	120	8 ^s		
	Yt Fld JJ	Trans (0.30)	90			
	Yt Fld KK	Trans (0.30)	90			
	Yt MF LL	Trans (0.30)	90			
	Yt MF MM	Trans (0.30)	90	6 ^s		
	Yt MF NN	Trans (0.30)	90			
	Yt MF OO	Trans (0.30)	90	6 ^s		
	Yt P PP	Trans (0.10)	30	3 ^s		
	Yt P QQ	Trans (0.15)	45			
	Yt Fld 7	Grid (0.40)	120	9 ^s		
	Yt Fld RR	Trans (0.45)	90	3 ^s		
	Yt Fld SS	Trans (0.45)	90	6 ^s		
	Yt Fld TT	Trans (0.45)	90	3 ^s		
	Pk M TT2	Trans (0.10)	30	6 ^s		
	Pk M UU	Trans (0.08)	24	3 ^s		
	Pk M VV	Trans (0.20)	60	3 ^s		
	Pk MF WW	Trans (0.10)	30	3 ^s		

Table 1. Sherman trap configuration for sampling sites at Colonial National Historical Park for 2003 and 2004 (continued).

Year	Habitat/Site ¹	Trap Configuration ²	Trap Nights			
			Sherman Trap	Tomahawk ³	Pitfall	Wooden Box
2003 (continued)	Yt MF MS 1	Grid (0.30)	240			
	Yt MF CS 1	Grid (0.30)	240			
	Yt MF MS 2	Grid (0.30)	240			
	Yt MF CS 2	Grid (0.30)	240			
	Yt MF MS 3	Grid (0.30)	150			
	Yt MF CS 3	Grid (0.30)	60			
	Pk MF MS 4	Grid (0.30)	60			
	Pk MF CS 4	Grid (0.30)	60			
2004						
	Yt MF MS1	Grid (0.30)	1110	10 ^s , 30 ^m	230	
	Yt MF CS1	Grid (0.30)	960	2 ^s , 13 ^m	240	
	Yt MF MS2	Grid (0.30)	960		270	
	Yt MF CS2	Grid (0.30)	960		270	
	Yt MF MS3	Grid (0.30)	990	2 ^s , 18 ^m	260	
	Yt MF CS3	Grid (0.30)	1050	3 ^s , 6 ^m	270	
	Pk MF MS4	Grid (0.30)	1080	4 ^m	270	
	Pk MF CS4	Grid (0.30)	1020	9 ^m	270	
	Yt MF SG1	Grid (0.40)	1000	1 ^s , 12 ^m	264	
	Yt MF SC1	Grid (0.40)	1040	5 ^s , 8 ^m	264	
	Yt MF SG2	Grid (0.49)	1225	7 ^s , 22 ^m	232	
	Yt MF SC2	Grid (0.49)	1323	8 ^s , 11 ^m	232	
	Yt MF SG3	Grid (0.42)	1134	2 ^m	232	
	Yt MF SC3	Grid (0.42)	1092		232	
	Yt MF LG1	Grid (0.63)	1092	2 ^s , 1 ^m	232	
	Yt MF LC1	Grid (0.63)	1050	8 ^s , 34 ^m	232	
	Yt MF LG2	Grid (0.68)	768	12 ^s , 18 ^m	264	
	Yt MF LC2	Grid (0.68)	576	8 ^s , 60 ^m , 12 ^l	264	
	Yt MF LG3	Grid (0.68)	783		264	
	Yt MF LC3	Grid (0.68)	783		264	
	Yt Fld XX	Trans (0.20)	80			
	Yt Fld YY	Trans (0.15)	60			
	Yt Fld ZZ	Trans (0.25)	100			
	Yt P AAA	Trans (0.20)	80			

Table 1. Sherman trap configuration for sampling sites at Colonial National Historical Park for 2003 and 2004 (continued).

Year	Habitat/Site ¹	Trap Configuration ²	Trap Nights			
			Sherman Trap	Tomahawk ³	Pitfall	Wooden Box
2004 (continued)	Yt P BBB	Trans (0.20)	80			
	Yt OF CCC	Trans (0.15)	101			
	Yt OF DDD	Trans (0.12)	84			
	Yt OF EEE	Trans (0.13)	91			
	Yt OF FFF	Trans (0.13)	91			
	Pk M/MF GGG	Trans				12
	Pk M/MF HHH	Trans				12
	Jm M/MF III	Trans				16
	Jm M/MF JJJ	Trans				16
	Gs Fld KKK	Trans (0.20)	80			
	Gs Fld LLL	Trans (0.20)	80			
	Gs Fld MMM2	Trans (0.20)	80			
	Yt Fld NNN	Trans (0.40)	240			
	Gs Fld NNN2	Trans (0.20)	80			
	Yt Fld OOO	Trans (0.20)	120			
	Yt Fld PPP	Trans (0.18)	108	20 ^s		
	Yt Fld QQQ	Trans (0.20)	20			
	Yt Fld RRR	Trans (0.05)	20			
	Yt FWL UUU	Trans (0.80)	120	9 ^s ,3 ^m		6
	Yt FWL VVV	Trans (0.20)	40	6 ^s ,4 ^m		4
	Pk M/MF WWW	Trans				20

¹ Units of COLO are identified as Pk = parkway, Yt = Yorktown, Jm = Jamestown, Gs = Green Spring. MF = mixed forest, P = pine forest, Fld = field, OF = old field, FWL = forested wetland, WL = wetland, M = marsh, Bam = bamboo stand, F/MF = field/mixed forest edge, DF/P = deciduous forest with pure pine stands, M/MF = marsh/mixed forest edge, MS = *Microstegium vimineum* experimental mixed forest area, CS = *Microstegium vimineum* control mixed forest area, SG = small canopy gap site, SC = small canopy gap control, LG = large canopy gap site, LC = large canopy gap control.

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 Tomahawk traps ^s = small, ^m = medium, ^l = large

Yearly Sampling Protocol

Preliminary sampling began in October 2002 and consisted of one night of trapping with Sherman live traps in October and two nights in November along a total of five transects for 160 trap nights total. Direct observations of mammals were recorded during trapping activities.

Sampling using Sherman live traps, small, medium, and large Tomahawk live traps, and pitfall trap arrays was conducted during 18 sampling periods (ranging from 2-11 nights each) from March through December 2003 at COLO (see Appendixes A and B). Nine principal habitats - field, field/mixed forest edge, marsh/mixed forest edge, mixed forest, deciduous forest, wetland (swamp, marsh, etc.), forested wetland, bamboo, and pine forest - were sampled for mammals. At 68 sampling locations Sherman traps comprised 14 grids covering 6.3 ha (15.5 acres) and/or 54 transects along 11.5 km (7.0 miles). These traps were spaced at 10-m intervals along all transects and in grids except for three transects in a Yorktown field where 15-m trap intervals were used. Eight pitfall arrays were used at two locations. Thirty-two locations were sampled with Tomahawk traps. Pitfall arrays and Tomahawk traps were spatially associated with Sherman traps. Trap nights totaled 9,874 with Sherman traps, 288 with Tomahawk traps, and 60 with pitfall arrays.

Sampling using Sherman, small, medium, and large Tomahawk live traps, pitfall trap arrays, and wooden box traps was conducted during 55 different sampling periods (ranging from 2-8 nights each) from January through August 2004 at COLO (Table 1; Appendixes D and E). Five principal habitat types – field (including old field), marsh/mixed forest edge, mixed forest, forested wetland, and pine forest - were sampled for mammals. Sherman traps comprised 20 grids covering 9.0 ha (22.2 acres) and 20 transects along 4.4 km (2.6 miles) at the 40 sampling locations. Sherman trap interval was 10 m for all but six grids (15-m intervals) in Yorktown mixed forest and one transect in forested wetland in Yorktown (20 m). Pitfall arrays were used at 20 locations. Eighteen locations were sampled with Tomahawk traps. Pitfall arrays and Tomahawk traps were spatially associated with Sherman traps. Wooden box traps were placed opportunistically at 15-m intervals in habitats suspected of harboring marsh rabbits - along two transects in Jamestown marsh/mixed forest edge, three transects in marsh/mixed forest edge along the Colonial Parkway, and two transects in Yorktown forested wetland. Trap nights totaled 21,751 with Sherman traps, 370 with Tomahawk traps, 5,056 with pitfall arrays, and 86 with wooden box traps.

Compilation and analysis of data

Species distributions among habitats were summarized. For the purpose of data summary and analysis, data from marsh and other wetland habitat were combined as the principal habitat type “wetland.” Marking and recognition of individuals captured in Sherman traps permitted estimates of relative abundance, 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 taken with digital and

remote cameras were stored and copies provided to the Database Manager for the Northeast Coastal and Barrier Network of NPS.

Results

Historical records and predicted species

The National Park Service's NPSpecies database contains historical records of plants and animals for each park. Publications and park records pertaining to the mammals of COLO were sought, and the summary of existing records was obtained from the NPSpecies database. Fifty species (56 "scientific names") representing 7 orders and 16 families are listed. Nine of the species are bats and thus not counted in our expected species list. In 2004 we confirmed the presence of the hispid cotton rat, *Sigmodon hispidus*, which is listed as unconfirmed on NPSpecies. The NPSpecies database reports no voucher specimens of mammals maintained within COLO. Similarly, no voucher specimens of mammals captured within COLO are maintained in collections or museums at Virginia Polytechnic and State University (Jack A. Cranford, pers. comm.), William and Mary College (Paul D. Heideman, pers. comm.; C. Richard Terman, pers. comm.), Virginia Commonwealth University (John F. Pagels, pers. comm.), and University of Richmond (Roni Kingsley, pers. comm.; Joseph C. Mitchell, pers. comm.). No voucher specimens are recognized specifically for COLO at the National Museum of Natural History, although records for 137 mammal specimens from the "area of COLO" (i.e., the counties and city of Williamsburg in which COLO resides) are maintained in the museum (Craig Ludwig, pers. comm.). Records were requested but not received from Old Dominion University and Virginia Museum of Natural History.

According to current taxonomy (Wilson and Reeder 2005), six orders and 16 families are represented among the 41 species recorded prior to this report (Table 2). The data source for most of the 41 nonchiropteran species listed in the NPSpecies database is Chazal and Van Alstine (2002), although Bradshaw (1999) noted 17 species in her faunal survey of the Green Spring unit of COLO, Brustlin Inc. (1996) reported on 6 species in York County, and Van Alstine et al. (2001) recorded 5 species in their study of sinkholes in the park. S. Roble (pers. comm., recorded by J. Karish in NPSpecies on 30 August 2001) stated that the marsh rabbit, although previously recorded in the park, likely was not an inhabitant.

We have listed species predicted to occur in COLO (Table 2). This list contains 40 species within six orders and 16 families of mammals (excluding bats and the marsh rabbit).

Field survey

Our survey of 2002-2004 resulted in 27 species of mammals either captured or observed within COLO (Table 2). These species belong to six orders and 14 families of mammals.

No mammals were captured during preliminary trapping exercises in October and November 2002. In 2003 at least 449 individuals representing 13 species of mammals were captured a total of 1,418 times at 62 sampling locations (Appendix C). Only the white-footed mouse was caught in pitfall traps, which were used in mixed forest habitat only. In 2004 at least 678 individuals representing 11 species of mammals were captured a total of 3,424 times at 34 sampling locations (Appendix F). 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 Appendices A-F.

Table 2. Comparison of predicted species for Colonial National Historical Park, and species observed during this study (2003-2004). Taxonomy and common names follow Wilson and Reeder (2005).

Order	Family	Species	Common Name	Predicted	Historical	Observed
Didelphimorphia						
	Didelphidae	<i>Didelphis virginiana</i>	Virginia opossum	X	X	X
Soricomorpha						
	Soricidae	<i>Blarina brevicauda</i>	Northern short-tailed shrew	X	X	X
		<i>Blarina carolinensis</i>	Southern short-tailed shrew	X	X	
			North American least shrew			
		<i>Cryptotis parva</i>	shrew	X	X	X
		<i>Sorex hoyi</i>	American pygmy shrew	X	X	
		<i>Sorex longirostris</i>	Southeastern shrew	X	X	X
	Talpidae	<i>Condylura cristata</i>	Star-nosed mole	X	X	
		<i>Scalopus aquaticus</i>	Eastern mole	X	X	X
Lagomorpha						
	Leporidae	<i>Sylvilagus floridanus</i>	Eastern cottontail	X	X	X
		<i>Sylvilagus palustris</i>	Marsh rabbit		X	
Rodentia						
	Castoridae	<i>Castor canadensis</i>	American beaver	X	X	X
	Cricetidae	<i>Microtus pennsylvanicus</i>	Meadow vole	X	X	X
		<i>Microtus pinetorum</i>	Woodland vole	X	X	X
		<i>Ondatra zibethicus</i>	Common muskrat	X	X	X
		<i>Oryzomys palustris</i>	Marsh oryzomys	X	X	X
		<i>Ochrotomys nuttalli</i>	Golden mouse	X	X	
		<i>Peromyscus gossypinus</i>	Cotton deermouse	X	X	
		<i>Peromyscus leucopus</i>	White-footed deermouse	X	X	X
		<i>Reithrodontomys humulis</i>	Eastern harvest mouse	X	X	X
		<i>Sigmodon hispidus</i>	Hispid cotton rat	X	X	X
		Muridae	<i>Mus musculus</i>	House mouse	X	X
	<i>Rattus norvegicus</i>		Brown rat	X	X	
	Sciuridae	<i>Glaucomys volans</i>	Southern flying squirrel	X	X	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	X	
		<i>Tamias striatus</i>	Eastern chipmunk	X	X	
	Dipodidae	<i>Zapus hudsonius</i>	Meadow jumping mouse	X	X	

Table 2. Comparison of predicted species for Colonial National Historical Park, and species observed during this study (2003-2004). Taxonomy and common names follow Wilson and Reeder (2005) (continued).

Order	Family	Species	Common Name	Predicted	Historical	Observed
Carnivora	Canidae	<i>Canis latrans</i>	Coyote	X	X	
		<i>Canis lupus</i>	Domestic dog	X	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	X	X
		<i>Lynx rufus</i>	Bobcat	X	X	
	Mephitidae	<i>Mephitis mephitis</i>	Striped skunk	X	X	X
	Mustelidae	<i>Lontra canadensis</i>	North American river otter	X	X	X
		<i>Mustela frenata</i>	Long-tailed weasel	X	X	
		<i>Neovison vison</i>	American mink	X	X	X
	Procyonidae	<i>Procyon lotor</i>	Raccoon	X	X	X
	Ursidae	<i>Ursus americanus</i>	American black bear	X	X	
Artiodactyla	Cervidae	<i>Odocoileus virginianus</i>	White-tailed deer	X	X	X

Comparison of predicted species for Colonial National Historical Park (based on Gap Analysis, <http://gapmap.nbii.gov/generatemap.php?species=GENUS%SPECIES&statelist=VA>, Webster et al. 1985, and Linzey 1998), historical records (Brustlin 1996; Bradshaw 1999; Van Alstine et al. 2001; Chazal and Van Alstine 2002)

The most abundant and widely distributed small mammal in COLO was the white-footed deermouse, *Peromyscus leucopus*. This species was captured in Sherman traps in all nine principal habitats sampled (Table 3) and was the most abundant species in all habitats except fields and wetlands (marshes and swamps). The eastern harvest mouse (*Reithrodontomys humulis*) was particularly abundant in an old field in Yorktown and was the most abundant small mammal captured in field habitat (Appendixes C and F) where the white-footed deermouse and northern short-tailed shrew (*Blarina brevicauda*) also were relatively abundant. The short-tailed shrew and southeastern shrew (*Sorex longirostris*) were the second and third most abundant species in mixed forest habitat. The marsh oryzomys (*Oryzomys palustris*) was the most abundant species in wetland habitat and the second most abundant in forested wetland and marsh/mixed forest edge.

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. The Virginia opossum (*Didelphis virginiana*) was common in mixed forest and also was found in field, forested wetland, field/mixed forest edge, and marsh/mixed forest edge habitats (Table 4). The raccoon (*Procyon lotor*) was common in mixed forest and also was found in forested wetland and bamboo habitats. Several captures of eastern gray squirrels were made in forested habitats.

The numbers of individuals and relative abundances of each species captured in Sherman traps were summarized by geographic unit of the park. The white-footed deermouse was the most abundant small mammal captured in each of the four units sampled (Table 5). The marsh oryzomys was the second most abundant small mammal in all but the Green Spring unit. The northern short-tailed shrew was present in all units. The eastern harvest mouse and southeastern shrew were captured only in Yorktown, and the house mouse (*Mus musculus*) was most abundant at Green Spring.

Sixteen species of mammals were documented based on observation, sign, or the recovery of remains (Table 6). Eleven of these species – eastern mole (*Scalopus aquaticus*), eastern gray squirrel (*Sciurus carolinensis*), woodchuck (*Marmota monax*), muskrat (*Ondatra zibethicus*), beaver (*Castor canadensis*), domestic dog (*Canis lupus*), red fox (*Vulpes vulpes*), striped skunk (*Mephitis mephitis*), mink (*Neovison vison*), raccoon (*Procyon lotor*), and white-tailed deer (*Odocoileus virginianus*) - were confirmed by identification of sign or recovery of remains. Raccoons also were documented by remote camera.

Opossums (*Didelphis virginiana*) frequently were found dead along the Colonial Parkway and were seen on a few occasions in fields and open areas of the park. Eastern mole sign (tunnel) was observed in a Yorktown old field. Eastern cottontail rabbits (*Sylvilagus floridanus*) were observed most often in or near mowed fields and cultivated lawns. We observed several cottontails in field/forest edge habitat, and two were spotted in wetland areas. Eastern gray squirrels were common along roads near deciduous and mixed coniferous-deciduous forests, in open areas, and along field/forest edge. Woodchucks were observed mostly in fields, lawns, and on roadsides. Muskrats were observed frequently, especially in the Jamestown unit and along the parkway, in or near marshes and wetland drainages (e.g., the Wormley drainage in Yorktown), along creeks, or in marsh/forest edge habitat. Beaver sign in the form of downed trees was found along marsh/forest edge in Jamestown and dams in a riparian corridor in Yorktown. Domestic cats (*Felis catus*) were seen at the park intern dormitory in Yorktown on several occasions. Domestic dogs were observed in open areas of the park and were likely from neighboring residential areas. An adult female red fox was found dead on the road at the end of the Colonial Parkway near Yorktown near the ramp for route 17 (UTM Region 18, Easting 0365359, Northing 412135) on 28 June 2003. A male was discovered dead on the parkway on the bridge to Brackens Pond (UTM Region 18, 0354435 4127571) on 27 July 2003. On 2 July 2004 a possibly mangy individual was observed foraging in Yorktown field/forest edge habitat (UTM Region 18, 0362307 4125433). On 15 August 2004 an individual was observed crossing the Goosley Road/Route 17 intersection near mixed forest habitat in Yorktown (UTM Region 18, 0365574 4120790). A gray fox (*Urocyon cinereoargenteus*) was spotted crossing Goosley Road in field/forest edge habitat in Yorktown at 1800 h on 18 July 2003.

Table 3. Summary of numbers and relative abundances¹ of small mammals captured with Sherman and pitfall traps among nine principal habitat types² at Colonial National Historical Park, 2003-2004.

Scientific Name	Common name	Habitat								
		FLD	MF	P	DF	FWL	F/MF	M/MF	WL	BB
(<i>Blarina brevicauda</i>)	Northern short-tailed shrew	9(0.25)	37(0.12)	0(0.00)	0(0.00)	1(0.10)	0(0.00)	0(0.00)	2(0.56)	0 (0.00)
(<i>Cryptotis parva</i>)	American least shrew	1(0.03)	0(0.00)	0(0.00)	0(0.00)	0(0.00)	0(0.00)	0(0.00)	0(0.00)	0 (0.00)
(<i>Sorex longirostris</i>)	Southeastern shrew	0(0.00)	20(0.07)	0(0.00)	0(0.00)	0(0.00)	0(0.00)	0(0.00)	0(0.00)	0 (0.00)
(<i>Microtus pennsylvanicus</i>)	Meadow vole	5(0.14)	0(0.00)	0(0.00)	0(0.00)	0(0.00)	0(0.00)	0(0.00)	0(0.00)	0 (0.00)
(<i>Microtus pinetorum</i>)	Woodland vole	0(0.00)	2(0.01)	0(0.00)	0(0.00)	0(0.00)	0(0.00)	0(0.00)	0(0.00)	0 (0.00)
(<i>Oryzomys palustris</i>)	Marsh oryzomys	2(0.06)	8(0.03)	0(0.00)	0(0.00)	8(0.76)	0(0.00)	8(3.81)	28(7.91)	0 (0.00)
(<i>Peromyscus leucopus</i>)	White-footed deer mouse	31(0.88)	789(2.62)	8(3.40)	47(5.60)	42(4.00)	15(4.55)	11(5.24)	8(2.26)	21(17.70)
(<i>Reithrodontomys humulis</i>)	Eastern harvest mouse	39(1.10)	3(0.01)	0(0.00)	0(0.00)	0(0.00)	0(0.00)	0(0.00)	0(0.00)	0 (0.00)
(<i>Sigmodon hispidus</i>)	Hispid cotton rat	4(0.11)	1(0.00)	0(0.00)	0(0.00)	0(0.00)	0(0.00)	0(0.00)	0(0.00)	0 (0.00)
(<i>Mus musculus</i>)	House mouse	8(0.23)	0(0.00)	0(0.00)	0(0.00)	0(0.00)	0(0.00)	0(0.00)	0(0.00)	0 (0.00)
(<i>Glaucomys volans</i>)	Southern flying squirrel	0(0.00)	5(0.02)	0(0.00)	1(0.12)	0(0.00)	0(0.00)	0(0.00)	0(0.00)	0 (0.00)
(<i>Sciurus carolinensis</i>)	Eastern gray squirrel	0(0.00)	2(0.01)	0(0.00)	0(0.00)	0(0.00)	0(0.00)	0(0.00)	0(0.00)	4 (3.33)
Total number of trap nights		3,534	30,064	235	840	1,050	330	210	354	120

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

² FLD = field (including old field), MF = mixed (coniferous-deciduous) forest, P = pine forest, DF = deciduous forest (with patches of pine), FWL = forested wetland, F/MF = field/mixed forest edge, M/MF = marsh/mixed forest edge, WL = wetland (swamps, marshes, etc.), BB = bamboo.

Table 4. Total captures of mammals in Tomahawk and wooden box traps¹ among seven habitat types² at Colonial National Historical Park, 2003-2004.

Scientific Name	Common name	Habitat						
		FLD	MF	DF	FWL	F/MF	M/MF	BB
<i>(Didelphis virginiana)</i>	Virginia opossum	2	32			1	2	1
<i>(Sciurus carolinensis)</i>	Eastern gray squirrel		2	1				
<i>(Procyon lotor)</i>	Raccoon		28		1			1

¹ See Appendices B and E for trap nights for each size Tomahawk trap and wooden box traps in each habitat.

² FLD = field (including old field), MF = mixed (coniferous-deciduous) forest, DF = deciduous forest (with patches of pine), FWL = forested wetland, F/MF = field/mixed forest edge, M/MF = marsh/mixed forest edge, BB = bamboo.

Table 5. Summary of numbers and relative abundances¹ of small mammals captured with Sherman and pitfall traps among geographic units of Colonial National Historical Park, 2003-2004.

Scientific Name	Common Name	Geographic Unit			
		Yorktown	Jamestown	Green Spring	Parkway
<i>(Blarina brevicauda)</i>	Northern short-tailed shrew	33(0.11)	6(0.21)	5(0.25)	5(0.17)
<i>(Cryptotis parva)</i>	American least shrew	0(0.00)	0(0.00)	1(0.05)	0(0.00)
<i>(Sorex longirostris)</i>	Southeastern shrew	20(0.07)	0(0.00)	0(0.00)	0(0.00)
<i>(Microtus pennsylvanicus)</i>	Meadow vole	4(0.01)	0(0.00)	1(0.05)	0(0.00)
<i>(Microtus pinetorum)</i>	Woodland vole	1(0.00)	1(0.03)	0(0.00)	0(0.00)
<i>(Oryzomys palustris)</i>	Marsh oryzomys	36(0.12)	8(0.27)	0(0.00)	10(0.34)
<i>(Peromyscus leucopus)</i>	White-footed deer mouse	658(2.28)	161(5.55)	75(3.65)	78(2.65)
<i>(Reithrodontomys humulis)</i>	Eastern harvest mouse	42(0.15)	0(0.00)	0(0.00)	0(0.00)
<i>(Sigmodon hispidus)</i>	Hispid cotton rat	2(0.01)	0(0.00)	3(0.15)	0(0.00)
<i>(Mus musculus)</i>	House mouse	1(0.00)	0(0.00)	7(0.35)	0(0.00)
<i>(Glaucmys volans)</i>	Southern flying squirrel	3(0.01)	2(0.07)	1(0.05)	0(0.00)
<i>(Sciurus carolinensis)</i>	Eastern gray squirrel	5(0.02)	0(0.00)	0(0.00)	1(0.03)
Total number of trap nights		28,873	2,920	2,000	2,944

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

Table 6. Mammal sightings or sign in Colonial National Historical Park, 2002-2004.

Scientific Name	Common name	Means of Observation		
		Direct	Signs or Remains	Remote Camera
<i>Didelphis virginiana</i>	Virginia opossum	X		
<i>Scalopus aquaticus</i>	Eastern mole		X	
<i>Ondatra zibethicus</i>	Muskrat	X	X	
<i>Castor canadensis</i>	American beaver		X	
<i>Sciurus carolinensis</i>	Eastern gray squirrel	X	X	
<i>Marmota monax</i>	Woodchuck	X	X	
<i>Sylvilagus floridanus</i>	Eastern cottontail	X		
<i>Canis lupus</i>	Domestic dog	X	X	
<i>Urocyon cinereoargenteus</i>	Gray fox	X		
<i>Vulpes vulpes</i>	Red fox	X	X	
<i>Felis catus</i>	Domestic cat	X		
<i>Mephitis mephitis</i>	Striped skunk		X	
<i>Neovison vison</i>	American mink		X	
<i>Lontra canadensis</i>	North American river otter	X		
<i>Procyon lotor</i>	Raccoon	X	X	X
<i>Odocoileus virginianus</i>	White-tailed deer	X	X	

A single striped skunk was detected by odor along the tour road in Yorktown. A mink skull was found on 28 June 2003 in mixed coniferous-deciduous forest in Jamestown (UTM Region 18, 0345433 4118928). Three river otters (*Lontra canadensis*) were recorded on 14 April 2004 swimming under a bridge on the Colonial Parkway near Williamsburg (UTM Region 18, 0349445 4122246). Besides being captured frequently in traps (Table 4), raccoons were observed often along the COLO parkway and tour road and in marsh/mixed forest edge habitat. White-tailed deer were observed frequently in fields, mixed coniferous-deciduous forest, and field/forest edge throughout the study period.

Species diversity

Species diversity of small mammals captured with Sherman traps was greatest in grassy fields and lowest in deciduous forest (Table 7). Evenness was greatest in marsh/mixed forest edge, but only because nearly equal numbers of individuals were captured of the only two species caught. For habitats where three or more species were captured, evenness was greatest in wetland habitats. Species richness was greatest in grassy fields where eight species were captured (Table 3) in a total of 3,534 trap nights; only one species was caught in both pine forest (235 trap nights) and field/mixed forest edge (330 trap nights) habitats. Nine species were captured in mixed forests, but trap nights totaled much more (24,802) than in other habitat types. At a sample size of 19 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 for fields was approximately twice that for wetlands, the habitat with the next highest estimated richness (Figure 3).

Voucher specimens

Ninety-six specimens of 11 species were collected from COLO, prepared, assigned FSU catalog numbers, and accessioned into the FSU mammal museum in 2006 (Table 8). Forty-six of the preparations consisted of both skin and skull. Multiple preparations were made of northern short-tailed shrews, southeastern shrews, and white-footed deermice. Fifteen specimens consisted of skull/carcass remains of larger species.

Table 7. Brillouin diversity index (H , determined using $\log_2$) and Smith and Wilson's measure of evenness (Krebs 1999) for small mammals captured in nine habitats in Colonial National Historical Park, 2003-2004.

Habitat	Brillouin Index (H)	Smith and Wilson's Evenness
Fields	2.074	0.4
Mixed forest	0.605	0.167
Pine forest	*	*
Deciduous forest	0.116	0.168
Forested wetlands	0.68	0.257
Field/mixed forest edge	*	*
Marsh/mixed forest edge	0.853	0.984
Wetlands	0.903	0.452
Bamboo	0.545	0.617

* Only 1 species was captured.

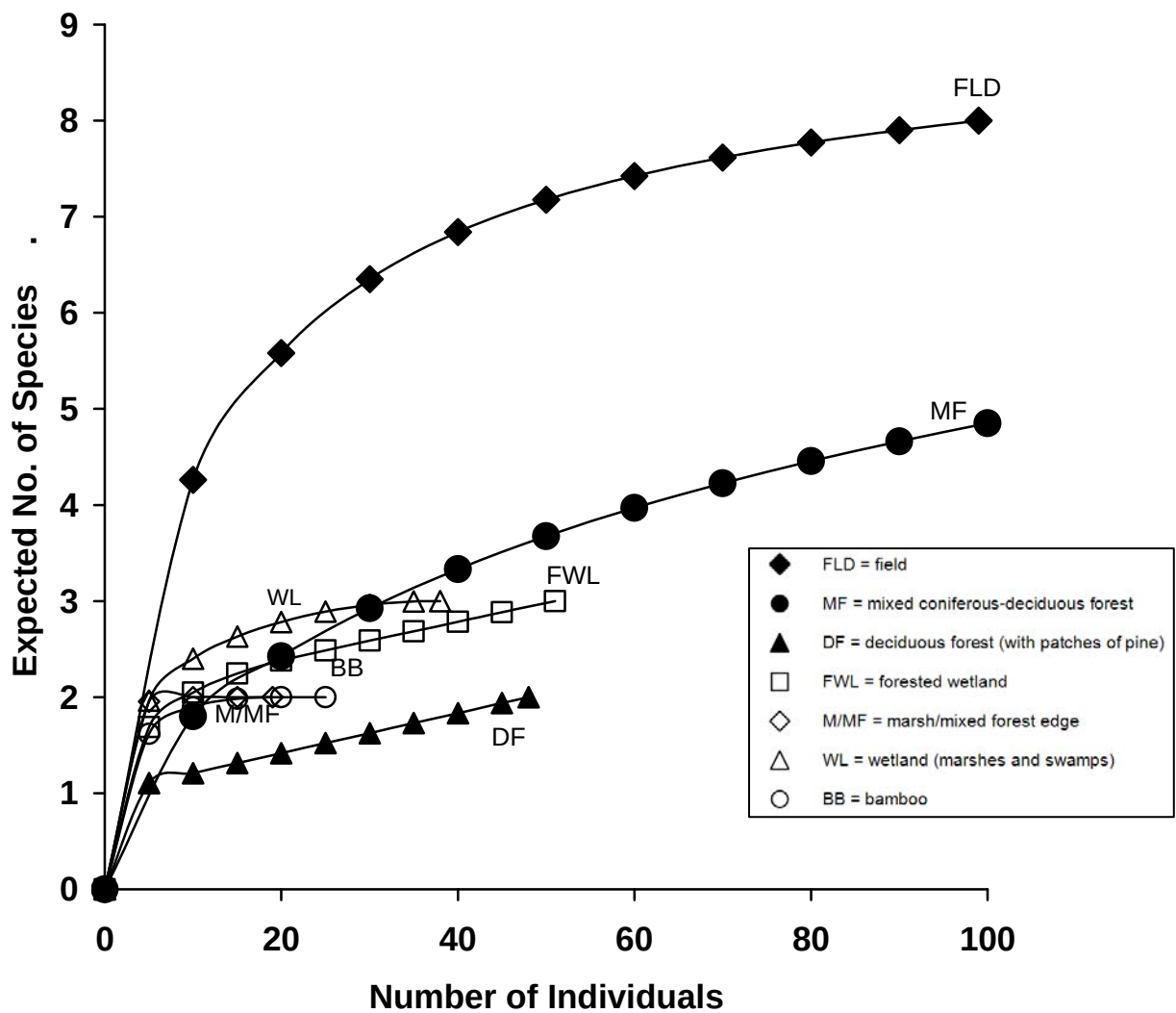


Figure 3. Rarefaction curves showing the estimated number of species of small mammals for variable sample sizes (number of individuals) for seven habitat types in Colonial National Historical Park.

Table 8. Specimens collected in Colonial National Historical Park that were assigned catalog numbers and accessioned into the FSU mammal collection (museum) in 2006.

Scientific Name	Common Name	Sex	Specimen Type ¹	FSU Catalog Number
<i>Blarina brevicauda</i>	Northern short-tailed shrew	M	SS	2751
		F	SS	2752
		M	SS	2753
			SS	2754
			SS	2755
			SI	2756
			SS	2757
			SI	2758
			SS	2759
		M	SS	2760
			SI	2761
			SS	2762
		M	SI	2763
		F	SS	2764
			SI	2765
		F	SS	2766
		M	SI	2767
		M	SS	2768
			SS	2769
		F	SI	2770
			SI	2771
		F	SI	2772
		M	SI	2773
			SS	2774
			SS	2775
		M	SS	2776
		M	SI	2777
		M	SS	2778
		M	SI	2779
		M	SS	2780
		M	SI	2781
		M	SS	2782
		F	SS	2783

Table 8. Specimens collected in Colonial National Historical Park that were assigned catalog numbers and accessioned into the FSU mammal collection (museum) in 2006 (continued).

Scientific Name	Common Name	Sex	Specimen Type ¹	FSU Catalog Number
<i>Sorex longirostris</i>	Southeastern shrew		SS	2784
			SS	2785
			SS	2786
			SI	2787
			SS	2788
			SI	2789
			SS	2790
			SI	2791
			SI	2792
		M	SI	2793
		M	SS	2794
		F	SI	2795
		M	SS	2796
		F	SS	2797
		F	SI	2798
		M	SI	2799
			SS	2800
		F	SS	2801
<i>Peromyscus leucopus</i>	White-footed deermouse	M	SS	2802
		M	SS	2803
		F	SS	2804
		M	SS	2805
		M	SS	2806
		M	SS	2807
		M	SI	2808
		M	SI	2809
		M	SS	2810
		M	SS	2811
		M	SS	2812
		M	SS	2813
		F	SS	2814
		M	SI	2815
		M	SS	2816
		M	SI	2817
		M	SS	2818

Table 8. Specimens collected in Colonial National Historical Park that were assigned catalog numbers and accessioned into the FSU mammal collection (museum) in 2006 (continued).

Scientific Name	Common Name	Sex	Specimen Type ¹	FSU Catalog Number
<i>Peromyscus leucopus</i> (continued)	White-footed deer mouse	M	SS	2819
		M	Sl	2820
		F	Sl	2821
		M	Sl	2822
		M	SS	2823
		F	Liquid	2824
		M	Sl	2825
		F	Sl	2826
		F	Sl	2827
		F	Sl	2828
		M	Sl	2829
		M	Sl	2830
<i>Ondatra zibethicus</i>	Common muskrat		Sl, carcass	2831
			Sl	2832
			Sl	2833
<i>Sciurus carolinensis</i>	Eastern gray squirrel		Sl	2834
<i>Canis lupus</i>	Domestic dog		Sl	2835
			Sl	2836
<i>Neovison vison</i>	American mink		Sl	2837
<i>Procyon lotor</i>	Raccoon		Sl	
			Sl	2838
				2839
<i>Odocoileus virginianus</i>	White-tailed deer	F	Sl	2840
		M	Sl	2841
		F	Sl	2842
		F	Sl	2843
		M	Sl	2844
		M	Sl	2845
<i>Reithrodontomys humulis</i>	Eastern harvest mouse	F	SS	2846

¹ Sk = skin, Sl = skull, SS = skin and skull.

Discussion

Species records

We have documented the presence in COLO of 68% (27 of 40) of the species predicted to occur and 66% (27 of 41) of the nonchiropteran species listed for COLO on NPSpecies. We were not able to confirm by capture or observation the presence of the following species for which there are historical records: southern short-tailed shrew (*Blarina carolinensis*), American pygmy shrew (*Sorex hoyi*), star-nosed mole (*Condylura cristata*), marsh rabbit (*Sylvilagus palustris*), golden mouse (*Ochrotomys nuttalli*), cotton deermouse (*Peromyscus gossypinus*), brown rat (*Rattus norvegicus*), eastern fox squirrel (*Sciurus niger*), eastern chipmunk (*Tamias striatus*), meadow jumping mouse (*Zapus hudsonius*), coyote (*Canis latrans*), bobcat (*Lynx rufus*), long-tailed weasel (*Mustela frenata*), and American black bear (*Ursus americanus*). It is possible, but unlikely, that one (or more) of the short-tailed shrews we captured was a southern short-tailed shrew. Of 33 specimens that were collected and prepared, none had the combination of foot length < 13 mm and body mass < 13.5 g that is used to distinguish the smaller *Blarina carolinensis* from *Blarina brevicauda* (McCay 2001). The southern short-tailed shrew is likely rare in the park and restricted to small, isolated patches of suitable pine stands, although it also inhabits, to a lesser degree, disturbed sites, fields, deciduous forests, and mixed coniferous-deciduous forests (McCay 2001). The marsh rabbit may not occur within the park (see Results). COLO represents the northern extreme of the range of the cotton deermouse, and although this species has been recorded in the park (Chazal and Van Alstine 2002), it probably is rare if it still is present.

Habitat generalists

The white-footed deermouse is a woodland species that occurs statewide (Linzey 1998). It was captured more frequently than any other species in Sherman traps in all the principal habitat types except fields and wetlands where it was the second most abundant 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 is known to occur also in fields. Its abundance in bamboo likely relates to this habitat's vertical structure (Barry and Francq 1980).

The northern short-tailed shrew occurs within a wide variety of habitats throughout its range (George et al. 1986) and was found in four of the nine habitats sampled in COLO. Numbers were not high at any of the sampling locations, but relative abundance was reasonably high in fields and wetlands. The predilection for wetlands presumably relates to this species' preference for moist habitats (i.e., avoidance of dry areas -- Merritt 1987).

The southeastern shrew is a diminutive species that 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, it was captured only in mixed forest in COLO. We likely would have captured individuals around wetlands if we had used pitfall traps in such habitats.

Only two woodland voles (*Microtus pinetorum*) were captured in COLO, both in mixed forest habitat. This is surprising in light of the wide variety of habitats occupied by this small mammal. It can be found in deciduous forests, grasslands, among shrubs, and especially 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 is an established, widely distributed resident of COLO and that more intensive sampling of deciduous and coniferous-deciduous woodland with abundant ground cover would have yielded more captures.

Eastern cottontails, gray squirrels, and woodchucks were observed frequently in open, grassy areas, field/forest edges, and also along roadsides in COLO, and gray squirrels were caught on several occasions in forested habitats. 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). Eastern gray squirrels are most common in mature, intact deciduous and mixed coniferous-deciduous woodlands but use a variety of habitats throughout their range (Koprowski 1994b; Linzey 1998; Edwards et al. 2003). Woodchucks typically occupy field-forest ecotone (Kwiecinski 1998). COLO provides extensive grassland habitat adjacent to forest tracts capable of supporting healthy populations of these three species.

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). The opossum was distributed widely within the park, having been captured in five of the principal habitat types sampled with Tomahawk traps, including forested wetland and marsh/mixed forest edge. The raccoon was persistent in mixed forest and also was captured in forested wetland and bamboo habitats. Mixed forest throughout COLO, and wetland (particularly marshes) and forested wetland habitats in Jamestown, Yorktown, and along the parkway, provide ideal habitat for the opossum and raccoon.

Red foxes were found dead on the road near forested habitat or in field/forest edge habitat. A single gray fox was observed crossing a road in field/forest edge habitat. 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). The resource requirements of both species are provided by the diversity of habitat and small mammal fauna found in COLO.

The detection of only one striped skunk was surprising, given the abundance of preferred woodland and field habitat in COLO. The infrequency of encounters could be related to the marked density fluctuations typical of this species in some areas (Wade-Smith and Verts 1982), with 2003-2004 representing a population trough. Nevertheless, we suspect that skunks are distributed widely in COLO as they move from place to place within their home ranges to forage primarily on insects, notably beetles (Rosatte and Lariviere 2003).

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 often in fields near forest (where they are most visible) and mixed forest. They appear to be abundant in COLO where a diversity of habitats provides 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 most abundant small mammal in COLO fields was the eastern harvest mouse. It was especially abundant in an old field in the Yorktown unit of the park. This species has been found primarily in old fields (Stalling 1997) containing plants such as broomsedge (*Andropogon* spp.) and goldenrod (*Solidago* spp.), two prominent taxa in COLO fields. Captures of the meadow vole were surprisingly sparse. This mammal is typically abundant in eastern open grasslands (Reich 1981; Linzey 1998) but was captured in only several locations in the Yorktown and Green Spring units of the park (Appendixes C and F). Only one American least shrew was captured, that in a field in the Green Spring unit (Appendix C). Typical habitat for the least shrew is grassy fields (Whitaker 1974; Linzey 1998). COLO represents the northeastern extreme of the range of the hispid cotton rat (Cameron and Spencer 1981), and this species is rare in the park, having been documented only once (Bradshaw 1999) before our study. Four of the five cotton rats captured in COLO were taken in fields, three of them in a single field in Green Spring (Appendixes C and F). The cotton rat is found most frequently in grassland habitats (Kaufman and Fleharty 1974; Cameron and Spencer 1981).

The only sign of eastern moles in COLO was in an old field in Yorktown. Soil type is a limiting factor for this animal, which prefers moist soils of loam or sand and avoids clay and gravel (Yates and Schmidly 1978). Within this restriction this species can be found in meadows, gardens, cultivated fields, forests, and river bottoms (Linzey 1998).

The southern flying squirrel was captured in deciduous and mixed coniferous-deciduous forest in COLO. This association with forested habitat is consistent with a preference for mature hardwood or mixed coniferous-deciduous forests in Virginia (Linzey 1998).

The marsh oryzomys (rice rat) is semiaquatic and found most often in wetland habitats (Wolfe 1982). This species is abundant at COLO, having been captured frequently in wetlands and marsh/mixed forest habitats and somewhat less frequently in forested wetlands.

Muskrats were common in COLO, which provides abundant habitat in the form of marshes, creeks and ponds. Muskrats occupy most aquatic habitats within their North American range, including creeks, lakes, marshes and ponds (Willner et al. 1980).

Beaver sign was found along a marsh in Jamestown and in riparian habitat in Yorktown. 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 adjacent wooded habitat in both COLO locations apparently provided adequate food resources at the time of occupancy. 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). The abundance of appropriate habitat in COLO, particularly in the Jamestown unit and along the parkway, would seem to provide important habitat for both otters and beavers.

The mink whose skull was retrieved from mixed forest in Jamestown was likely enroute to or from a nearby body of water or transported by a predator to the discovery location. American minks are usually found near water (Lariviere 1999) but may move from seasonal to permanent

wetlands as dry seasons approach (Humphrey and Zinn 1982), as might be expected in late June in COLO. Also, minks and North American river otters exhibit niche separation when syntopic (Ben-David et al. 1996), with minks occupying drier habitat (Humphrey and Zinn 1982). The infrequency of encounters/detections with minks during our survey likely relates to their mostly nocturnal habit (Lariviere 1999). Based on the extent of aquatic habitat and presumed abundance of muskrats, whose abandoned den sites minks occupy (Sargeant et al. 1973), we would expect minks to be widely distributed and reasonably abundant in COLO.

Exotic species

Domestic dogs and cats 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.

Eight house mice were captured in two fields in COLO, seven in a field in Green Spring and one in a field in Yorktown (Appendix C). This small mammal is introduced from Eurasia and commensal with humans, but often forms feral populations. It is commonly the most abundant mammal in cultivated fields (Linzey 1998).

Habitat-specific species diversity

Although the greatest number (nine) of small mammal species by habitat type was detected in mixed coniferous-deciduous forest, sampling effort in mixed forests far exceeded that in any other habitat type in COLO. When sampling effort was standardized at 19 individuals (the size of the smallest sample in the principal habitat types that yielded more than one species), grassy fields supported the greatest species diversity and estimated richness of small mammals. Grassland specialists, the eastern harvest mouse, hispid cotton rat, meadow vole, and least shrew, two habitat generalists, the northern short-tailed shrew and white-footed deermouse, the exotic house mouse, and wetland specialist, marsh oryzomys, were captured in grassland habitat. The comparatively high Brillouin index for this habitat was attributable largely to greater species richness than that found in other habitats.

Grassland habitats provide important resources, especially food, for a variety of small mammals. Harvest mice eat seeds of grasses and other herbaceous plants, green vegetation, and crickets and grasshoppers (Stalling 1997). Hispid cotton rats eat primarily grasses, with seasonal variation in the consumption of insects (Fleharty and Olson 1969; Cameron and Spencer 1981). Meadow voles subsist chiefly on available grasses, sedges, and herbaceous plants (Reich 1981). 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. 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). The exotic house mouse is often the most abundant small mammal in cultivated fields but also occupies other grassland habitats and wetlands (Linzey 1998). Whitaker (1966) found that 42% of its diet consisted of seeds, especially those of wild grasses. Although the marsh oryzomys is a wetland specialist, it is also found in freshwater meadows, commonly in association with the meadow vole, where part of its diet consists of plants, including seeds (Wolfe 1982).

When sample size was standardized at 19 individuals, wetlands exhibited the second highest estimate of richness among the seven COLO habitat types that supported more than one species. Three species were found in wetlands – the marsh oryzomys, white-footed deermouse, and northern short-tailed shrew. The former is a wetland specialist and the latter two habitat generalists (see earlier discussion). These same three species were captured in forested wetland, and the marsh oryzomys and white-footed deermouse were the two species caught along marsh/mixed forest edge.

Sampling effort in mixed forests was seven-fold greater than that in fields, the habitat type afforded the second greatest sampling effort. Special attention was afforded mixed forest habitat because forest, much of it mixed pine-hardwood, comprises approximately 50% of the park (Rafkind 2004) and was the context for M.S. research projects conducted by the junior authors of this report. Although more small mammal species were found in mixed forest habitat than in other habitat types, diversity and evenness were very low. Low small mammal diversity and evenness estimates for mixed forest habitat are attributable to the rareness of most species and comparably high abundance of the white-footed deermouse. This ubiquitous forest mammal comprised 91% of all individuals captured in COLO mixed forests. Species diversity and evenness were lowest in deciduous forest among the seven habitat types supporting more than one species. All individuals, except for one southern flying squirrel, were white-footed deermice. The white-footed deermouse was the only species captured in pine forest and field/mixed forest edge habitats in COLO. It is typically most abundant in forests dominated by hardwoods (Lackey et al. 1985).

Species diversity by geographic unit

Species diversity by geographic unit of COLO largely reflects overall sampling effort. More species (11) of small mammals were detected in Yorktown where the sampling effort was extraordinary, particularly within mixed coniferous-deciduous forest. What is apparent from the analysis of species distribution by geographic unit is that the white-footed deermouse and northern short-tailed shrew, and to a lesser extent, marsh oryzomys and southern flying squirrel, are widely distributed in the park.

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 considered more efficient (Szaro et al. 1988; Kirkland and Sheppard 1994). Nevertheless, only white-footed deermice were captured in pitfall traps despite their rather extensive use in mixed forest habitat. We limited the use of these traps to mixed forest 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 and sex without close examination of the dentition and internal reproductive anatomy. Tomahawk traps baited with canned cat food were efficient at sampling medium-size mammals (especially mesocarnivores) that are secretive or elusive. Remote cameras were 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

According to the 1993 General Management Plan for COLO (NPS 1993), management objectives for the park include protection, management and interpretation of natural resources “while supporting ... cultural resources.” The plan also calls for a program to inventory, research and monitor cultural and natural resources. In addition, the plan expresses concern for, and promotes actions to minimize (or, when necessary, mitigate), the effects of cultural and recreational activities on wildlife habitat and vegetation, especially in “open fields” and wetlands. The 1999 Resource Management Plan (NPS 1999) assessed the inventory of mammals within the park as “below standard” and indicated faunal surveys were a priority that awaited NPS I & M funding. Recommended activities included an inventory survey of small mammals and a LTEM (long-term environmental monitoring program) to generate basic information on natural resources so that proper management practices can be affected.

Our inventory of the mammals of COLO addresses the objectives, priorities and recommendations of the 1993 General Management Plan and 1999 Resource Management Plan and allows for the sustained attainment of the objectives. Most important, it 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 provides recommendations for their conservation and management.

The park supports a predictable assemblage of mammals, based on the types of habitat present. Both habitat generalist and specialist species are widely distributed geographically in the park, usually in reasonable abundance where they are found. Two of the most common mammals in eastern North America, the white-footed deermouse and northern short-tailed shrew, occur in most of the principal habitats (the former in all); the white-footed deermouse is especially abundant, as it is in most habitats where it occurs. Similarly, 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 small mammal species diversity in grassland habitat and the presence and relative abundance of two grassland species that either typically do not occur as dense populations or are rare in this region. The eastern harvest mouse was captured in a number of locations and was the most abundant grassland species in COLO fields. Current grassland management practices apparently are suitable for this species. Also, our survey corroborated the presence of the hispid cotton rat in COLO at the northeastern extreme of the species range.

Several species present in COLO are specialists dependent on wetland habitat, which is abundant in the park. The semiaquatic marsh oryzomys is abundant and was captured in several hydric habitats, including marshes, marsh/mixed forest edge, and forested wetlands. Similarly, muskrats and beavers appear to be common, minks are present, and watershed habitat in the Jamestown unit and along the Colonial Parkway and riparian habitat in Yorktown provide important habitat for beavers and American river otters.

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,

woodland vole, and hispid cotton rat) or could not confirm but that have been recorded previously (southern short-tailed shrew, American pygmy shrew, star-nosed mole, marsh rabbit, golden mouse, cotton deermouse, brown rat, eastern fox squirrel, eastern chipmunk, meadow jumping mouse, and long-tailed weasel). Additional locations in fields should be sampled to determine if least shrews are more abundant and widespread than we discovered. Pine stands should be sampled more intensively in search of the southern short-tailed shrew, for which there are park records (Chazal and Van Alstine 2002). The range of the American pygmy shrew includes all of Virginia (Linzey 1998), and it may be a resident of the park that was not revealed by our limited sampling effort with pitfall traps. We used pitfall trap arrays only in mixed coniferous-deciduous forest. 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.

Direct observation of individuals or sign along transects in selected habitats, in combination with trapping (Sherman, Tomahawk, and/or harpoon mole traps), could be used more intensively to obtain records of such species as the star-nosed mole, eastern fox squirrel, and eastern chipmunk. Adequate marshland and riparian habitat (Petersen and Yates 1980) exists in the park for the star-nosed mole to be present and reasonably abundant. Fox squirrels should be present in oak and pine stands (Koprowski 1994a) and chipmunks in deciduous forest, although the latter is likely rare in the park because it is uncommon in many coastal counties (Linzey 1998) and is not found along the coast south of Virginia (Snyder 1982).

Opportunistic trapping in wooded habitat with dense underbrush, especially where honeysuckle or greenbriar occur (Linzey and Packard 1977), could be conducted to establish the presence of the golden mouse. Intensive sampling in wetland habitats, and in hummocks and old fields (Wolfe and Linzey 1977), might yield an additional record of the cotton deermouse. Trapping in and around buildings would likely confirm the presence, if only seasonally or as a transient, of the exotic brown rat (Linzey 1998). Opportunistic sampling in thickly vegetated fields, or along ponds, streams, and marshes (Whitaker 1972), would likely confirm the presence of the meadow jumping mouse. 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 COLO.

We are not convinced that the marsh rabbit occurs in COLO (see Results). We targeted this species with box traps designed and proven to capture *Sylvilagus* spp. and placed them opportunistically along marshes where the rabbit might be expected to occur (Chapman and Willner 1981). COLO represents the extreme northern portion of the range of the marsh rabbit, and it may no longer be a permanent resident of the park.

We did not sample Swann's Point, the small portion of COLO along the James River on the opposite shoreline from Jamestown, because of limited accessibility to this portion of the park and the strategic difficulty in transporting sampling equipment to the location. Although it is unlikely that any new species records would be obtained from a mammal survey of Swann's

Point, future inventory work should include this strip of COLO to document the status of mammals present.

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. Wetlands provide critical habitat for a number of mammals (e.g., the marsh oryzomys and American river otter) found in COLO and 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 American least shrew, hispid cotton rat, and meadow jumping mouse might also benefit other grassland species. Old and open fields support healthy populations of many of these species. Properly scheduled mowing and prescribed burns can be used to interrupt succession and maintain a diversity of herbaceous vegetation suitable to the resource requirements of a variety of mammal species.

Species Management

Management for the control of particular mammal species in COLO might be warranted. Based on total captures in multiple habitats, it is apparent that the raccoon is 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 COLO may not be justified or practical, management practices (e.g., frequent monitoring of picnic areas and trash disposal) that would reduce the consequences of human activities that sustain raccoon populations can be intensified.

Based on frequent sightings (including a number of records obtained by remote photography) and abundant sign, the white-tailed deer would appear to be abundant in COLO. The 1999 Resource Management Plan calls for research on and monitoring of the deer population in the park in conjunction with adjacent jurisdictions. 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; C. L. Tanner, in prep.). 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 white-footed deer mouse, a highly competent host for black-legged tick larvae and nymphs (Ostfeld 1997).

Populations of COLO 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 affect proper stewardship of natural systems necessarily rely on periodic assessments of species diversity and abundances from inventory and monitoring activities.

Literature Cited

- ASM. 1998. Guidelines for the capture, handling, and care of mammals as approved by the American Society of Mammalogists. *Journal of Mammalogy* 79:1416-1431.
- Barry, R. E., K. A. Boyce, and A. C. Sucke. 1999. Local distribution, habitat, and home range of the Appalachian cottontail (*Sylvilagus obscurus*) at Dolly Sods. Final report submitted to the Nongame Wildlife and Natural Heritage Program, West Virginia Division of Natural Resources.
- Barry, R. E., Jr., and E. N. Francq. 1980. Orientation to landmarks within the preferred habitat by *Peromyscus leucopus*. *Journal of Mammalogy* 61:292-303.
- Beer, J. R. 1964. Bait preferences of some small mammals. *Journal of Mammalogy* 45:632-634.
- Ben-David, M., R. T. Bowyer, and J. B. Faro. 1996. Niche separation by mink and river otters: coexistence in a marine environment. *Oikos* 75:41-48.
- "Blank outline map of Virginia." Map. About.com. 6 April 2010
<http://geography.about.com/library/blank/blxusva.htm>.
- Boyce, K. A. 2001. Distribution, seasonal home range, movements and habitat of the Appalachian cottontail, *Sylvilagus obscurus*, at Dolly Sods, West Virginia. M. S. thesis, Frostburg State University, Frostburg, Maryland.
- Bradshaw, D. 1999. Faunal survey of the Green Spring Unit Colonial National Historical Park. Project Final Report, National Park Service Contract Number 553901-1247.
- Brustlin Inc. 1996. Threatened and endangered species: Colonial National Historical Park, York County, Virginia. Report to National Park Service by Vanasse Hangen Brustlin, Inc., 7188 Chapman Drive, Hayes, Virginia.
- Caldwell, R. S., and H. Bryan. 1982. Notes on distribution and habitats of *Sorex* and *Microsorex* (Insectivora: Soricidae) in Kentucky. *Brimleyana* 8:91-100.
- Cameron, G. N., and S. R. Spencer. 1981. *Sigmodon hispidus*. *Mammalian Species* 158:1-9.
- Carey, A. B., and C. A. Harrington. 2001. Small mammals in young forests: implication for management for sustainability. *Forest Ecology and Management* 154:289-309.
- Chapman, J. A., J. G. Hockman, and Ojeda C., M. M. 1980. *Sylvilagus floridanus*. *Mammalian Species* 136:1-8.
- Chapman, J. A., and J. A. Litvaitis. 2003. Eastern cottontail: *Sylvilagus floridanus* and allies. in *Wild mammals of North America: biology, management, and conservation*. 2nd ed. (G. A. Feldhamer, B. C. Thompson, and J. A. Chapman, eds.). John Hopkins University Press, Baltimore.

- Chapman, J. A., and G. R. Willner. 1981. *Sylvilagus palustris*. Mammalian Species 153:1-3.
- Chazal, A. C., and N. E. Van Alstine. 2002. Plants and animals recorded from the Jamestown Island 400 Project Area, Colonial National Historical Park. Natural Heritage Technical Report 02-01. Virginia Department of Conservation and Recreation, Division of Natural Heritage, Richmond Virginia. Unpublished report submitted to Colonial National Historical Park.
- Chew, R. M. 1978. The impact of small mammals on ecosystem structure and function. Pp 167-180 in Populations of small mammals under natural conditions (R. T. Hartman, ed.). Special Publication Series Vol. 5, Pymatuning Laboratory of Ecology, University of Pittsburgh.
- Cypher, B. L. 2003. Foxes: *Vulpes* species, *Urocyon* species, and *Alopex lagopus*. Pp. 511-546 in Wild mammals of North America: biology, management, and conservation. 2nd ed. (G. A. Feldhamer, B. C. Thompson, and J. A. Chapman, eds.). John Hopkins University Press, Baltimore.
- Edwards, J., M. Ford, and D. Guynn. 2003. Fox and gray squirrels: *Sciurus niger* and *S. carolinensis*. Pp. 248-267 in Wild mammals of North America: biology, management, and conservation. 2nd ed. (G. A. Feldhamer, B. C. Thompson, and J. A. Chapman, eds.). John Hopkins University Press, Baltimore.
- Fleharty, E. D., and L. E. Olson. 1969. Summer food habits of *Microtus ochrogaster* and *Sigmodon hispidus*. Journal of Mammalogy 50:475-486.
- Fogel, R., and J. M. Trappe. 1978. Fungus consumption (mycophagy) by small animals. Northwest Science 52:1:31.
- French, T. W. 1980. *Sorex longirostris*. Mammalian Species 143:1-3.
- Gage, K. L., R. S. Ostfeld, and J. G. Olson. 1995. Nonviral vector-borne zoonoses associated with mammals in the United States. Journal of Mammalogy 76:695-715.
- Gardner, A. L., and M. E. Sunquist. 2003. Opossum: *Didelphis virginiana*. Pp. 3-29 in Wild mammals of North America: biology, management, and conservation. 2nd ed. (G. A. Feldhamer, B. C. Thompson, and J. A. Chapman, eds.). John Hopkins University Press, Baltimore.
- Gehrt, S. D. 2003. Raccoon: *Procyon lotor* and allies. Pp. 611-634 in Wild mammals of North America: biology, management, and conservation. 2nd ed. (G. A. Feldhamer, B. C. Thompson, and J. A. Chapman, eds.). John Hopkins University Press, Baltimore.
- George, S. D., J. R. Choate, and H. H. Genoways. 1986. *Blarina brevicauda*. Mammalian Species 261:1-9.
- Gounaris, K., and H. Grubbs. 2000. Inventory of invasive exotic plants of Colonial National Historical Park. Final Report to the National Park Service.

- Humphrey, S. R., and T. L. Zinn. 1982. Seasonal use of habitats by river otters and Everglades mink in Florida. *Journal of Wildlife Management* 46:375-381.
- Jenkins, S. H., and P. E. Busher. 1979. *Castor canadensis*. *Mammalian Species* 120:1-8.
- Jones, C., W. J. McShea, M. J. Conroy, and T. H. Kunz. 1996. Capturing mammals. Pp. 115-122 in *Measuring and monitoring biological diversity: standard methods for mammals* (D. E. Wilson, F. R. Cole, J. D. Nichols, R. Rudran, and M. S. Foster, eds.). Smithsonian Institution Press, Washington, District of Columbia.
- Kaufman, D. W., and E. D. Fleharty. 1974. Habitat selection by nine species of rodents in north-central Kansas. *Southwestern Naturalist* 18:443-452.
- Kirkland, G. L., Jr., and P. K. Sheppard. 1994. Proposed standard protocol for sampling of small mammal communities. Pp. 277-283 in *Advances in the biology of shrews* (J. F. Merritt, G. L. Kirkland, Jr., and R. K. Rose, eds.). Special Publication of the Carnegie Museum of Natural History 18, Pittsburgh, Pennsylvania.
- Kollars, T. M., Jr., J. H. Oliver, Jr., L. A. Durden, and P. G. Kollars. 2000. Host associations and seasonal activity of *Amblyomma americanum* (Acari: Ixodidae) in Missouri. *Journal of Parasitology* 86:1156-1159.
- Koprowski, J. L. 1994a. *Sciurus niger*. *Mammalian Species* 479:1-9.
- Koprowski, J. L. 1994b. *Sciurus carolinensis*. *Mammalian Species* 480:1-9.
- Krebs, C. J. 1999. *Ecological methodology*. 2nd ed. Addison Wesley Longman, Inc., Menlo Park, California, 620 pp.
- Krebs, C. J. 2003. *Programs for ecological methodology*. 2nd ed. © Exeter Software, East Setauket, New York.
- Kunz, T. H., R. Rudran, and G. Gurri-Glass. 1996. Appendix 2: Human health concerns. Pp. 255-264 in *Measuring and monitoring biological diversity: standard methods for mammals* (D. E. Wilson, F. R. Cole, J. D. Nichols, R. Rudran, and M. S. Foster, eds.). Smithsonian Institution Press, Washington, District of Columbia.
- Kwiecinski, G. G. 1998. *Marmota monax*. *Mammalian Species* 591:1-8.
- Lackey, J. A., D. G. Huckaby, and B. G. Ormiston. 1985. *Peromyscus leucopus*. *Mammalian Species* 247:1-10.
- Lariviere, S. 1999. *Mustela vison*. *Mammalian Species* 608:1-9.
- Lariviere, S., and L. R. Walton. 1998. *Lontra canadensis*. *Mammalian Species* 587:1-8.
- Linzey, D. W. 1998. *The mammals of Virginia*. The McDonald & Woodward Publishing Co., Blacksburg, Virginia.

- Linzey, D. W., and R. L. Packard. 1977. *Ochrotomys nuttalli*. Mammalian Species 75:1-6.
- Lotze, J.-H., and S. Anderson. 1979. *Procyon lotor*. Mammalian Species 119:1-8.
- Maser, C., Z. Maser, and R. Molina. 1988. Small-mammal mycophagy in rangelands of central and southeastern Oregon. Journal of Range Management 41:309-312.
- McCay, T. S. 2001. *Blarina carolinensis*. Mammalian Species 673:1-7.
- McDiarmid, R. W., and D. E. Wilson. 1996. Data standards. Pp. 56-60 in Measuring and monitoring biological diversity: standard methods for mammals (D. E. Wilson, F. R. Cole, J. D. Nichols, R. Rudran, and M. S. Foster, eds.). Smithsonian Institution Press, Washington, District of Columbia.
- McManus, J. J. 1974. *Didelphis virginiana*. Mammalian Species 40:1-6.
- Merritt, J. F. 1987. Guide to the mammals of Pennsylvania. University of Pittsburgh Press for The Carnegie Museum of Natural History, Pittsburgh, Pennsylvania.
- Miller, D. H., and L. L. Getz. 1969. Life-history notes on *Microtus pinetorum* in central Connecticut. Journal of Mammalogy 50:777-784.
- Miller, K. V., L. I. Muller, and S. Demarais. 2003. White-tailed deer: *Odocoileus virginianus*. Pp. 906-930 in Wild mammals of North America: biology, management, and conservation. 2nd ed. (G. A. Feldhamer, B. C. Thompson, and J. A. Chapman, eds.). John Hopkins University Press, Baltimore.
- Mills, J. N., T. L. Yates, J. E. Childs, R. R. Parmenter, T. G. Ksiazek, P. E. Rollin, and C. J. Peters. 1995. Guidelines for working with rodents potentially infected with hantavirus. Journal of Mammalogy 76:716-722.
- Mitchell, J.C., S.Y. Erdle and J.F. Pagels. 1993. Evaluation of capture techniques for amphibian, reptile, and small mammal communities in saturated forested wetlands. Wetlands 13:130-136.
- National Weather Service. 2003. Hurricane Isabel preliminary post storm report. National Weather Service, Wakefield, Virginia. www.erh.noaa.gov/er/akq/wx-events/hurr/isabel_2003.htm.
- NPS 1993. General management plan for Colonial National Historical Park, Virginia. U.S. Department of the Interior, National Park Service, Denver Service Center. http://www.nature.nps.gov/im/units/ncbn/Data/planning/COLO/COLO_gmp1993.pdf
- NPS. 1998. Natural resource inventory & monitoring in national parks. NPS Inventory and Monitoring Informational Brochure. <http://www.nature.nps.gov/im/imb broch.htm>.

- NPS. 1999. Resource management plan for Colonial National Historical Park.
http://www.nature.nps.gov/im/units/ncbn/Data/planning/COLO/COLO_Plan_RMP_Rev%202_1.pdf
- NPS 2000. Strategic plan for Colonial National Historical Park, fiscal year 2001-2005.
<http://home.nps.gov/applications/parks/colo/ppdocuments/fy01-05.pdf>.
- NPSpecies database: www.science1.nature.nps.gov/npspecies/)
- Ostfeld, R. S. 1997. The ecology of Lyme-disease risk. *American Scientist* 85:338-346.
- Petersen, K. E., and T. L. Yates. 1980. *Condylura cristata*. *Mammalian Species* 129:1-4.
- Rafkind, C. D. 2004. Overview of natural resources and issues of Colonial National Historical Park, Virginia. Briefing Package NRM-COLO for Researchers.pdf. U.S. Department of the Interior, National Park Service.
- Reich, L. M. 1981. *Microtus pennsylvanicus*. *Mammalian Species* 159:1-8.
- Rosatte, R., and S. Lariviere. 2003. Skunks: genera *Mephitis*, *Spilogale*, and *Conepatus*. Pp. 692-707 in *Wild mammals of North America: biology, management, and conservation*. 2nd ed. (G. A. Feldhamer, B. C. Thompson, and J. A. Chapman, eds.). John Hopkins University Press, Baltimore.
- Rudran, R. 1996. General marking techniques. *Measuring and monitoring biological diversity: standard methods for mammals* (D. E. Wilson, F. R. Cole, J. D. Nichols, R. Rudran, and M. S. Foster, eds.). Smithsonian Institution Press, Washington, District of Columbia.
- Rudran, R., and M. S. Foster. 1996. Conducting a survey to assess mammalian diversity. *Measuring and monitoring biological diversity: standard methods for mammals* (D. E. Wilson, F. R. Cole, J. D. Nichols, R. Rudran, and M. S. Foster, eds.). Smithsonian Institution Press, Washington, District of Columbia.
- Rudran, R., and T. H. Kunz. 1996. Appendix 1: Ethics in research. *Measuring and monitoring biological diversity: standard methods for mammals* (D. E. Wilson, F. R. Cole, J. D. Nichols, R. Rudran, and M. S. Foster, eds.). Smithsonian Institution Press, Washington, District of Columbia.
- Sargeant, A. G., G. A. Swanson, and H. A. Doty. 1973. Selective predation by mink, *Mustela vison*, on waterfowl. *The American Midland Naturalist* 89:208-214.
- Sekgororoane, G. B., and T. G. Dilworth. 1995. Relative abundance, richness, and diversity of small mammals at induced forest edges. *Canadian Journal of Zoology* 73:1432-1437.
- Sheffield, S. R., and H. H. Thomas. 1997. *Mustela frenata*. *Mammalian Species* 570:1-9.
- Smolen, M. J. 1981. *Microtus pinetorum*. *Mammalian Species* 147:1-7.

- Snyder, D. P. 1982. *Tamias striatus*. Mammalian Species 168:1-8.
- Stalling, D. T. 1997. *Reithrodontomys humulis*. Mammalian Species 565:1-6.
- Strang, D. T. In preparation. Effects of hurricane-created canopy gaps on small mammals in a mid-Atlantic mixed forest. M.S. thesis, Frostburg State University, Frostburg, Maryland.
- Stromayer, K. A. K., and R. J. Warren. 1997. Are overabundant deer herds in the eastern United States creating alternate stable states in forest plant communities? Wildlife Society Bulletin 25:227-234.
- Szaro, R. D., L. H. Simons, and S. C. Belfit. 1988. Comparative effectiveness of pitfalls and live-traps in measuring small mammal community structure. Pp. 224-230 in Management of amphibians, reptiles, and small mammals in North America. U.S. Department of Agriculture. Flagstaff, Arizona.
- Tanner, C. L. In prep. Tick burdens of *Peromyscus leucopus* and *Borrelia* infection rates in ixodid ticks in a fragmented Virginia landscape. M.S. thesis, Frostburg State University, Frostburg, Maryland.
- Terman, C. R., and R. J. Huggett 1980. Occurrence of kepone in white-footed mice (*Peromyscus leucopus noveboracensis*) on Jamestown Island, Virginia. Virginia Journal of Science 31:102.
- USGS. Gap predicted species distribution. Map. 6 April 2010
<http://gapmap.nbii.gov/generatemap.php?species=GENUS%25SPECIES&statelist=VA>.
- Van Alstine, N. E., A. C. Chazal, and K. M. McCoy. 2001. A biological survey of the Coastal Plain depression ponds (seasonal ponds) of Colonial National Historical Park, Yorktown, Virginia. Natural Heritage Technical Report 01-9, Virginia Department of Conservation and Recreation, Division of Natural Heritage, Richmond, Virginia.
- Wade-Smith, J., and B. J. Verts. 1982. *Mephitis mephitis*. Mammalian Species 173:1-7.
- Warchalowski, H. P. 2006. Responses of small mammals to invasion by Japanese stilt grass (*Microstegium vimineum*) in mixed coniferous-deciduous forests of Colonial National Historical Park, Virginia. M.S. thesis, Frostburg State University, Frostburg, Maryland.
- Webster, W. D., J. F. Parnell, and W. C. Biggs, Jr. 1985. Mammals of the Carolinas, Virginia, and Maryland. University of North Carolina Press, Chapel Hill
- Whitaker, J. O., Jr. 1966. Food of *Mus musculus*, *Peromyscus maniculatus bairdii*, and *Peromyscus leucopus* in Vigo County, Indiana. Journal of Mammalogy 47:473-486.
- Whitaker, J. O., Jr. 1972. *Zapus hudsonius*. Mammalian Species 11:1-7.
- Whitaker, J. O., Jr. 1974. *Cryptotis parva*. Mammalian Species 43:1-8.

- Whitaker, J. O., Jr., and R. E. Mumford. 1972. Food and ectoparasites of Indiana shrews. *Journal of Mammalogy* 53:329-335.
- Willner, G. R., G. A. Feldhamer, E. E. Zucker, and J. A. Chapman. 1980. *Ondatra zibethicus*. *Mammalian Species* 141:1-8.
- Wilson, D. E., and D. M. Reeder (eds.). 2005. *Mammal species of the world: a taxonomic and geographic reference* (Vols. 1 and 2). 3rd ed. Johns Hopkins University Press, Baltimore.
- Wolfe, J. L. 1982. *Oryzomys palustris*. *Mammalian Species* 176:1-5.
- Wolfe, J. L., and A. V. Linzey. 1977. *Peromyscus gossypinus*. *Mammalian Species* 70:1-5.
- Yates, T. L., and D. J. Schmidly. 1978. *Scalopus aquaticus*. *Mammalian Species* 105:1-4.

Appendix A. Trapping schedule, habitats, locations, and efforts for Sherman traps for 2003 in Colonial National Historical Park.

Dates ¹	Habitat/Site ²	Location ³	Sherman Trap Configuration ⁴	Trap Nights ⁵
3/1 – 3/2	Pk MF A	0365272 4121477	Trans (0.20)	40
3/1 – 3/2	Pk MF B	0365245 4121650	Trans (0.20)	40
3/1 – 3/2	Pk MF C	0365142 4121443	Trans (0.20)	40
3/1 – 3/2	Pk MF D	0365145 4121413	Trans (0.20)	40
3/26 – 3/29	Yt MF A2	0366682 4120390	Trans (0.20)	80
3/26 – 3/29	Yt MF B2	0366672 4120565	Trans (0.20)	80
3/27 – 3/29	Yt MF C2	0366817 4120481	Trans (0.20)	60
3/27 – 3/29	Yt MF D2	0366836 4120444	Trans (0.10)	30
6/5 – 6/9	Yt Fld E	0364787 4119299	Trans (0.15)	75
6/5 – 6/9	Yt Fld F	0364806 4119344	Trans (0.17)	85
6/5 – 6/9	Yt Fld G	0364740 4119209	Trans (0.15)	75
6/5 – 6/12	Yt FWL 2	0365107 4118421	Grid (1.00)	800
6/10 – 6/13	Yt Fld H	0364784 4119497	Trans (0.41)	164
6/15 – 6/22	Yt WL I	0365651 4122502	Trans (0.14)	112
6/15 – 6/22	Yt WL J	0365667 4122496	Trans (0.10)	80
6/15 – 6/22	Yt WL K	0365655 4122499	Trans (0.06)	48
6/15 – 6/22	Yt Bam L	0366302 4120376	Trans (0.10)	80
6/15 – 6/22	Yt Bam M	0366244 4120955	Trans (0.05)	40
6/16 – 6/22	Yt MF N	0365952 4120079	Trans (0.21)	147
6/16 – 6/22	Yt MF O	0365848 4120087	Trans (0.15)	105
6/16 – 6/22	Yt MF P	0365913 4119914	Trans (0.15)	105
6/26 – 7/2	Jm MF Q	0344351 4120338	Trans (0.30)	210
6/26 – 7/2	Jm MF R	0344588 4118561	Trans (0.30)	210
6/26 – 7/2	Jm M/MF S	0345549 4118913	Trans (0.30)	210
6/26 – 7/2	Jm MF T	0342812 4119728	Trans (0.30)	210
7/7 – 7/11	Yt MF 3	0367542 4120376	Grid (0.49)	245
7/7 – 7/11	Yt MF 4	0365150 4120706	Grid (0.49)	245
7/7 – 7/11	Yt MF U	0367164 4120814	Trans (0.20)	100
7/7 – 7/11	Yt Fld V	0367211 4120777	Trans (0.10)	50
7/7 – 7/11	Yt MF W	0367659 4120423	Trans (0.30)	150
7/16 – 7/26	Jm MF 5	0343647 4118704	Grid (0.49)	539
7/16 – 7/26	Jm F/MF X	0345233 4118575	Trans (0.30)	330
7/16 – 7/26	Jm DF/P Y	0344189 4118957	Trans (0.49)	510
7/16 – 7/26	Jm DF/P Z	0343482 4119379	Trans (0.30)	330
7/21 – 7/29	Jm FWL AA	0343677 4118861	Trans (0.10)	90

Appendix A. Trapping schedule, habitats, locations, and efforts for Sherman traps for 2003 in Colonial National Historical Park (continued).

Dates ¹	Habitat/Site ²	Location ³	Sherman Trap Configuration ⁴	Trap Nights ⁵
8/14 – 8/21	Gs Fld 6	0340088 4124843	Grid (1.00)	800
8/14 – 8/21	Gs Fld BB	0340161 4125152	Trans (0.20)	160
8/14 – 8/21	Gs MF CC	0340024 4124824	Trans (0.10)	80
8/14 – 8/21	Gs MF DD	0340013 4124822	Trans (0.10)	80
8/14 – 8/21	Gs MF EE	0339997 4124815	Trans (0.10)	80
8/23 – 8/28	Gs MF FF	0340303 4124812	Trans (0.20)	120
8/23 – 8/28	Gs Fld GG	0340305 4124832	Trans (0.20)	120
8/23 – 8/28	Gs MF HH	0340490 4124880	Trans (0.20)	120
8/23 – 8/28	Gs MF II	0340475 4124841	Trans (0.20)	120
9/5 – 9/7	Yt Fld JJ	0363161 4121696	Trans (0.30)	90
9/5 – 9/7	Yt Fld KK	0363092 4121694	Trans (0.30)	90
9/5 – 9/7	Yt MF LL	0363076 4121576	Trans (0.30)	90
10/3 – 10/5	Yt MF MM	0365855 4121167	Trans (0.30)	90
10/3 – 10/5	Yt MF NN	0365776 4121200	Trans (0.30)	90
10/3 – 10/5	Yt MF OO	0365867 4120703	Trans (0.30)	90
10/3 – 10/5	Yt P PP	0365928 4120737	Trans (0.10)	30
10/3 – 10/5	Yt P QQ	0365948 4120657	Trans (0.15)	45
10/17 – 10/19	Yt Fld 7	0367002 4119086	Grid (0.40)	120
10/17 – 10/19	Yt Fld RR	0365832 4118506	Trans (0.45)	90
10/17 – 10/19	Yt Fld SS	0365899 4118549	Trans (0.45)	90
10/17 – 10/19	Yt Fld TT	0365902 4118626	Trans (0.45)	90
10/24 – 10/26	Pk M TT2	0364623 4122794	Trans (0.10)	30
10/24 – 10/26	Pk M UU	0364702 4122753	Trans (0.08)	24
10/24 – 10/26	Pk M VV	0364737 4122712	Trans (0.20)	60
10/24 – 10/26	Pk MF WW	0364736 4122616	Trans (0.10)	30
10/24 – 10/26	Yt MF MS 1	0364309 4118909	Grid (0.30)	240
11/7 - 11/9				
12/12 – 12/13				
10/24 – 10/26	Yt MF CS 1	0364311 4119203	Grid (0.30)	240
11/7 – 11/9				
12/12 – 12/13				
10/24 – 10/26	Yt MF MS 2	0364693 4119508	Grid (0.30)	240
11/7 – 11/9				

Appendix A. Trapping schedule, habitats, locations, and efforts for Sherman traps for 2003 in Colonial National Historical Park (continued).

Dates ¹	Habitat/Site ²	Location ³	Sherman Trap Configuration ⁴	Trap Nights ⁵
12/12 – 12/13				
10/14 – 10/26	Yt MF CS 2	0364433 4119523	Grid (0.30)	240
11/7 – 11/9				
12/12 – 12/13				
11/7 – 11/9	Yt MF MS 3	0367269 4120362	Grid (0.30)	150
12/12 – 12/13				
12/12 – 12/13	Yt MF CS 3	0367394 4120249	Grid (0.30)	60
12/12 – 12/13	Pk MF MS 4	0342498 4120836	Grid (0.30)	60
12/12 – 12/13	Pk MF CS 4	0342689 4120805	Grid (0.30)	60

¹ Dates are nights traps were open.

² Units of COLO are identified as Pk = parkway, Yt = Yorktown, Jm = Jamestown, Gs = Green Spring. MF = mixed forest, P = pine forest, Fld = field, FWL = forested wetland, WL = wetland, Bam = bamboo stand, F/MF = field/mixed forest edge, DF/P = deciduous forest with pure pine stands, M = marsh, M/MF = marsh/mixed forest edge, MS = *Microstegium vimineum* experimental mixed forest area, CS = *Microstegium vimineum* control mixed forest area.

³ UTM coordinates are for middle of grid or one end of transect; zone 18.

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 (Tran).

⁵ Total Sherman trap nights. Trap interval was 10 m, except for YT Fld RR, YT Fld SS, and YT FLD TT (15 m).

Appendix B. Trapping schedule, habitats, locations, and efforts for Tomahawk and pitfall traps for 2003 at Colonial National Historical Park (COLO).

Dates	Habitat/Site ¹	Location ²	Trap Nights	
			Tomahawk Traps ³	Pitfall Traps
6/15 – 6/22	Yt WL J	0365667 4122496	16 ^s	
6/15 – 6/22	Yt Bam M	0366302 4120955	8 ^m	
6/16 – 6/22	Yt MF N	0365952 4120079	6 ^s	
6/16 – 6/22	Yt MF O	0365848 4120087	6 ^s	
6/26 – 7/2	Jm MF Q	0344351 4120338	14 ^s , 4 ^m	
6/26 – 7/2	Jm MF R	0344588 4118561	14 ^s , 4 ^m	
6/26 – 7/2	Jm M/MF S	0345549 4118913	14 ^s	
6/26 – 7/2	Jm MF T	0342812 4119728	7 ^s	
6/27 – 7/2	Jm MF	Not recorded		24
7/7 – 7/11	Yt MF 4	0365150 4120706	10 ^s	
7/7 – 7/11	Yt MF U	0367164 4120814	5 ^s	
7/7 – 7/11	Yt MF W	0367659 4120423	30 ^s , 5 ^m , 5 ^l	
7/16 – 7/26	Jm MF 5	0343647 4118704	33 ^s	
7/16 – 7/26	Jm F/MF X	0345233 4118575	11 ^s	
7/16 – 7/26	Jm DF/P Y	0344189 4118957	11 ^s	
7/16 – 7/26	Jm DF/P Z	0343482 4119379	11 ^s	
7/20 – 7/27	Jm MF 5	0343606 4118771		32
8/14 – 8/21	Gs Fld 6	0340088 4124843	6 ^s	
8/14 – 8/21	Gs Fld BB	0340161 4125152	9 ^s	
8/14 – 8/21	Gs MF CC	0340024 4124824	3 ^s	
8/14 – 8/21	Gs MF DD	0340013 4124822	3 ^s	
8/23 – 8/28	Gs MF FF	0340303 4124812	6 ^s	
8/23 – 8/28	Gs MF HH	0340490 4124880	8 ^s	
8/23 – 8/28	Gs MF II	0340475 4124841	8 ^s	
10/3 – 10/5	Yt MF MM	0365855 4121167	6 ^s	
10/3 – 10/5	Yt MF OO	0365867 4120703	6 ^s	
10/3 – 10/5	Yt P PP	0365928 4120737	3 ^s	

Appendix B. Trapping schedule, habitats, locations, and efforts for Tomahawk and pitfall traps for 2003 at Colonial National Historical Park (COLO) (continued).

Dates	Habitat/Site ¹	Location ²	Trap Nights	
			Tomahawk Traps ³	Pitfall Traps
10/17 – 10/19	Yt Fld 7	0367002 4119086	9 ^s	
10/17 – 10/19	Yt Fld RR	0365832 4118506	3 ^s	
10/17 – 10/19	Yt Fld SS	0365899 4118549	6 ^s	
10/17 – 10/19	Yt Fld TT	0365902 4118626	3 ^s	
10/24 – 10/26	Pk M TT2	0364623 4122794	6 ^s	
10/24 – 10/26	Pk M UU	0364702 4122753	3 ^s	
10/24 – 10/26	Pk M VV	0364737 4122712	3 ^s	
10/24 – 10/26	Pk MF WW	0364736 4122616	3 ^s	

¹ Units of COLO are identified as Pk = parkway, Yt = Yorktown, Jm = Jamestown, Gs = Green Spring. MF = mixed forest, P = pine forest, Fld = field, WL = wetland, Bam = bamboo stand, F/MF = field/mixed forest edge, DF/P = deciduous forest with pure pine stands.

² UTM coordinates (zone 18) for Tomahawk traps are for middle of spatially associated Sherman trap grid or one end of Sherman trap transect. UTM coordinates (zone 18) for pitfall traps are for one end of pitfall array.

³ Tomahawk traps ^s = small, ^m = medium, and ^l = large.

Appendix C. Capture record for mammals caught in Colonial National Historical Park (COLO) from March through December 2003.

Habitat/site ¹	Trap Nights			Species Name	Common Name	No. individuals	Total captures	Relative Abundance ³
	Sherman Traps	Tomahawk Traps ²	Pitfall Traps					
Pk MF Trans A	40			<i>Peromyscus leucopus</i>	White-footed deermouse	3	3	7.5
Pk MF Trans B	40			<i>Peromyscus leucopus</i>	White-footed deermouse	2	2	5
				<i>Sciurus carolinensis</i>	Eastern gray squirrel	1	1	2.5
Pk MF Trans C	40			<i>Peromyscus leucopus</i>	White-footed deermouse	3	4	7.5
Pk MF Trans D	40			<i>Peromyscus leucopus</i>	White-footed deermouse	2	2	5
Yt MF Trans A2	80			<i>Peromyscus leucopus</i>	White-footed deermouse	3	3	3.8
Yt MF Trans B2	80			<i>Peromyscus leucopus</i>	White-footed deermouse	1	1	1.2
Yt MF Trans C2	60			<i>Peromyscus leucopus</i>	White-footed deermouse	1	2	1.7
Yt MF Trans D2	30			<i>Peromyscus leucopus</i>	White-footed deermouse	1	1	3.3
Yt FWL Grid 2	800			<i>Peromyscus leucopus</i>	White-footed deermouse	35	123	4.4
				<i>Oryzomys palustris</i>	Marsh oryzomys	8	0	1
Yt Fld Trans H	164			<i>Peromyscus leucopus</i>	White-footed deermouse	1	1	0.6
Yt WL Trans I	112			<i>Peromyscus leucopus</i>	White-footed deermouse	3	11	2.7
				<i>Oryzomys palustris</i>	Marsh oryzomys	1	1	0.9
Yt WL Trans J	80	16 ^s		<i>Oryzomys palustris</i>	Marsh oryzomys	9	9	11.2
Yt WL Trans K	48			<i>Peromyscus leucopus</i>	White-footed deermouse	3	4	6.2
				<i>Oryzomys palustris</i>	Marsh oryzomys	3	3	6.2
Yt Bam Trans L	80			<i>Peromyscus leucopus</i>	White-footed deermouse	17	37	21.2
				<i>Sciurus carolinensis</i>	Eastern gray squirrel	4	4	5
Yt Bam Trans M	40	8 ^m		<i>Peromyscus leucopus</i>	White-footed deermouse	4	14	10
				<i>Procyon lotor</i>	Raccoon	1	1	-
Yt MF Trans N	147	6 ^s		<i>Peromyscus leucopus</i>	White-footed deermouse	3	8	2
				<i>Sciurus carolinensis</i>	Eastern gray squirrel	1	1	16.7

Appendix C. Capture record for mammals caught in Colonial National Historical Park (COLO) from March through December 2003 (continued).

Habitat/site ¹	Trap Nights			Species Name	Common Name	No. individuals	Total captures	Relative Abundance ³
	Sherman Traps	Tomahawk Traps ²	Pitfall Traps					
Yt MF Trans O	105	6 ^s		<i>Didelphis virginiana</i>	Virginia opossum	1	1	-
				<i>Peromyscus leucopus</i>	White-footed deermouse	3	7	2.9
Jm MF Trans P	105			<i>Peromyscus leucopus</i>	White-footed deermouse	3	5	2.9
Jm MF Trans Q	210	14 ^s , 4 ^m		<i>Didelphis virginiana</i>	Virginia opossum	1	1	-
				<i>Peromyscus leucopus</i>	White-footed deermouse	13	25	6.2
				<i>Microtus pinetorum</i>	Woodland vole	1	1	0.5
				<i>Glaucomys volans</i>	Southern flying squirrel	1	1	0.5
Jm MF Trans R	210	14 ^s , 4 ^m		<i>Blarina brevicauda</i>	Northern short-tailed shrew	1	1	0.5
				<i>Peromyscus leucopus</i>	White-footed deermouse	38	132	18.1
Jm M/MF Trans S	210	14 ^s		<i>Didelphis virginiana</i>	Virginia opossum	1	1	-
				<i>Peromyscus leucopus</i>	White-footed deermouse	11	49	5.2
				<i>Oryzomys palustris</i>	Marsh oryzomys	8	15	3.8
Jm MF Trans T	210	7 ^s		<i>Blarina brevicauda</i>	Northern short-tailed shrew	2	2	1
				<i>Peromyscus leucopus</i>	White-footed deermouse	15	62	7.1
Yt MF Grid 3	245			<i>Peromyscus leucopus</i>	White-footed deermouse	7	22	2.9
Yt MF Grid 4	245	10 ^s		<i>Peromyscus leucopus</i>	White-footed deermouse	23	55	9.4
Yt MF Trans U	100	5 ^s		<i>Didelphis virginiana</i>	Virginia opossum	1	1	-
				<i>Peromyscus leucopus</i>	White-footed deermouse	5	11	5
Yt Fld Trans V	50			<i>Peromyscus leucopus</i>	White-footed deermouse	3	6	6
				<i>Oryzomys palustris</i>	Marsh oryzomys	2	4	4
Yt MF Trans W	150	30 ^s , 5 ^m , 5 ^l		<i>Peromyscus leucopus</i>	White-footed deermouse	3	9	2
				<i>Sciurus carolinensis</i>	Eastern gray squirrel	1	1	-

Appendix C. Capture record for mammals caught in Colonial National Historical Park (COLO) from March through December 2003 (continued).

Habitat/site ¹	Trap Nights			Species Name	Common Name	No. individuals	Total captures	Relative Abundance ³
	Sherman Traps	Tomahawk Traps ²	Pitfall Traps					
Jm MF Grid 5	539	33 ^s		<i>Blarina brevicauda</i>	Northern short-tailed shrew	3	3	0.6
				<i>Peromyscus leucopus</i>	White-footed deermouse	15	80	2.8
Jm F/MF Trans X	330	11 ^s		<i>Didelphis virginiana</i>	Virginia opossum	2	2	-
				<i>Peromyscus leucopus</i>	White-footed deermouse	15	61	4.5
Jm DF/P Trans Y	510	11 ^s		<i>Peromyscus leucopus</i>	White-footed deermouse	31	180	6.1
				<i>Sciurus carolinensis</i>	Eastern gray squirrel	1	1	-
Jm DF/P Trans Z	330	11 ^s		<i>Peromyscus leucopus</i>	White-footed deermouse	16	107	4.8
				<i>Glaucomys volans</i>	Southern flying squirrel	1	3	0.3
Jm MF 5			32	<i>Peromyscus leucopus</i>	White-footed deermouse	1	1	3.1
Jm FWL Trans AA	90			<i>Peromyscus leucopus</i>	White-footed deermouse	4	14	4.4
Gs Fld Grid 6	800	6 ^s		<i>Blarina brevicauda</i>	Northern short-tailed shrew	3	3	0.4
				<i>Peromyscus leucopus</i>	White-footed deermouse	15	80	1.9
Gs Fld Trans BB	160	9 ^s		<i>Didelphis virginiana</i>	Virginia opossum	1	1	-
				<i>Cryptotis parva</i>	North American least shrew	1	1	0.6
				<i>Mus musculus</i>	House Mouse	7	16	4.4
				<i>Peromyscus leucopus</i>	White-footed deermouse	3	5	1.9
				<i>Microtus pennsylvanicus</i>	Meadow vole	1	1	0.6
Gs MF Trans CC	80	3 ^s		<i>Didelphis virginiana</i>	Virginia opossum	1	1	-
				<i>Peromyscus leucopus</i>	White-footed deermouse	4	14	5
Gs MF Trans DD	80	3 ^s		<i>Peromyscus leucopus</i>	White-footed deermouse	6	12	7.5
				<i>Glaucomys volans</i>	Southern flying squirrel	1	1	1.2

Appendix C. Capture record for mammals caught in Colonial National Historical Park (COLO) from March through December 2003 (continued).

Habitat/site ¹	Trap Nights			Species Name	Common Name	No. individuals	Total captures	Relative Abundance ³
	Sherman Traps	Tomahawk Traps ²	Pitfall Traps					
Gs MF Trans EE	80			<i>Peromyscus leucopus</i>	White-footed deer mouse	4	20	5
Gs MF Trans FF	120	6 ^s		<i>Didelphis virginiana</i>	Virginia opossum	1	1	-
				<i>Peromyscus leucopus</i>	White-footed deer mouse	14	25	11.7
Gs Fld Trans GG	120			<i>Peromyscus leucopus</i>	White-footed deer mouse	3	3	2.5
Gs MF Trans HH	120	8 ^s		<i>Peromyscus leucopus</i>	White-footed deer mouse	15	25	12.5
Gs MF Trans II	120	8 ^s		<i>Peromyscus leucopus</i>	White-footed deer mouse	9	31	7.5
Yt Fld Trans JJ	90			<i>Sigmodon hispidus</i>	Hispid cotton rat	1	1	1.1
Yt Fld Trans KK	90			<i>Reithrodontomys humulis</i>	Eastern harvest mouse	1	1	1.1
Yt MF Trans LL	90			<i>Peromyscus leucopus</i>	White-footed deer mouse	16	25	17.8
Yt MF Trans MM	90	6 ^s		<i>Peromyscus leucopus</i>	White-footed deer mouse	7	11	7.8
Yt MF Trans OO	90	6 ^s		<i>Peromyscus leucopus</i>	White-footed deer mouse	6	13	6.7
Yt P Trans PP	30	3 ^s		<i>Peromyscus leucopus</i>	White-footed deer mouse	1	1	3.3
Yt P Trans QQ	45			<i>Peromyscus leucopus</i>	White-footed deer mouse	2	2	4.4
Yt Fld Grid 7	120	9 ^s		<i>Reithrodontomys humulis</i>	Eastern harvest mouse	3	4	2.5
Yt Fld Trans RR	90	3 ^s		<i>Mus musculus</i>	House Mouse	1	1	1.1
				<i>Microtus pennsylvanicus</i>	Meadow vole	1	1	1.1
Yt M Trans TT2	30	6 ^s		<i>Oryzomys palustris</i>	Marsh oryzomys	5	7	16.7
Pk M Trans UU	24	3 ^s		<i>Oryzomys palustris</i>	Marsh oryzomys	10	16	41.7
Pk M Trans VV	60	3 ^s		<i>Blarina brevicauda</i>	Northern short-tailed shrew	2	2	3.3
				<i>Peromyscus leucopus</i>	White-footed deer mouse	2	6	3.3

Appendix C. Capture record for mammals caught in Colonial National Historical Park (COLO) from March through December 2003 (continued).

Habitat/site ¹	Trap Nights			Species Name	Common Name	No. individuals	Total captures	Relative Abundance ³
	Sherman Traps	Tomahawk Traps ²	Pitfall Traps					
Pk MF Trans WW	30	3 ^s		<i>Peromyscus leucopus</i>	White-footed deer mouse	1	1	1.1
Yt MS 1	240			<i>Peromyscus leucopus</i>	White-footed deer mouse	8	24	3.3
				<i>Microtus pinetorum</i>	Woodland vole	1	2	0.4
Yt CS 1	240			<i>Peromyscus leucopus</i>	White-footed deer mouse	4	10	2.7
Yt MS 2	240			<i>Peromyscus leucopus</i>	White-footed deer mouse	7	30	4.7
				<i>Glaucomys volans</i>	Southern flying squirrel	1	2	0.4
Yt CS 2	240			<i>Peromyscus leucopus</i>	White-footed deer mouse	12	38	5
Yt MS 3	150			<i>Peromyscus leucopus</i>	White-footed deer mouse	1	1	0.7
				<i>Oryzomys palustris</i>	Marsh oryzomys	1	1	0.7
Yt CS 3	60			<i>Peromyscus leucopus</i>	White-footed deer mouse	1	1	1.7
				<i>Glaucomys volans</i>	Southern flying squirrel	1	1	1.7
Jm MS 4	60			<i>Peromyscus leucopus</i>	White-footed deer mouse	7	7	11.7

¹ Units of COLO are identified as Pk = parkway, Yt = Yorktown, Jm = Jamestown, Gs = Green Spring. MF = mixed forest, P = pine forest, Fld = field, FWL = forested wetland, WL = wetland, Bam = bamboo stand, F/MF = field/mixed forest edge, DF/P = deciduous forest with pure pine stands, M = marsh, M/MF = marsh/mixed forest edge, MS = *Microstegium vimineum* experimental mixed forest area, CS = *Microstegium vimineum* control mixed forest area. See

² Tomahawk traps ^s = small, ^m = medium, and ^l = large.

³ Relative abundance is individuals/100 Sherman and pitfall trap nights. Relative abundances are not determined for captures in Tomahawk traps.

Appendix D. Trapping schedule, habitats, locations, and efforts for Sherman traps for 2004 in Colonial National Historical Park.

Dates ¹	Habitat/Site ²	Location ³	Trap Configuration ⁴	Trap Nights
1/25-1/28	Yt MF MS1	0364326 4118874	Grid (0.30)	1110
2/19-2/22				
3/17-3/20				
4/2-4/4				
4/13-4/18				
5/15-5/19				
5/23-5/24				
6/4-6/8				
7/5-7/9				
8/2-8/6				
1/25-1/28	Yt MF CS1	0364336 4119161	Grid (0.30)	960
2/19-2/22				
3/17-3/20				
4/13-4/18				
5/15-5/19				
5/23-5/24				
6/4-6/8				
7/5-7/9				
8/2-8/6				
2/19-2/22	Yt MF MS2	0364659 4119503	Grid (0.30)	960
3/17-3/20				
4/13-4/18				
5/15-5/19				
6/4-6/8				
7/5-7/9				
8/3-8/6				
2/19-2/22	Yt MF CS2	0364434 4119480	Grid (0.30)	960
3/17-3/20				
4/13-4/18				
5/15-5/19				
6/4-6/8				
7/5-7/9				
8/3-8/6				

Appendix D. Trapping schedule, habitats, locations, and efforts for Sherman traps for 2004 in Colonial National Historical Park (continued).

Dates ¹	Habitat/Site ²	Location ³	Trap Configuration ⁴	Trap Nights
1/24-1/27	Yt MF MS3	0367265 4120367	Grid (0.30)	990
2/19-2/21				
3/18-3/21				
4/13-4/18				
5/15-5/19				
6/4-6/8				
7/5-7/9				
8/2-8/6				
1/24-1/27	Yt MF CS3	0367365 4120217	Grid (0.30)	1050
2/18-2/21				
3/18-3/21				
4/13-4/18				
5/15-5/19				
6/4-6/8				
7/5-7/9				
8/2-8/6				
1/24-1/27	Pk MF MS4	0342498 4120836	Grid (0.30)	1080
2/18-2/21				
3/18-3/21				
4/13-4/18				
5/15-5/19				
6/4-6/8				
7/5-7/9				
8/3-8/6				
1/24-1/27	Pk MF CS4	0342661 4120824	Grid (0.30)	1020
2/18-2/21				
3/18-3/21				
4/13-4/18				
5/15-5/19				
6/4-6/8				
7/5-7/9				
8/3-8/6				
2/12-2/15	Yt Fld XX	0367202 4119030	Trans (0.20)	80
2/12-2/15	Yt Fld YY	0367220 4119117	Trans (0.15)	60

Appendix D. Trapping schedule, habitats, locations, and efforts for Sherman traps for 2004 in Colonial National Historical Park (continued).

Dates ¹	Habitat/Site ²	Location ³	Trap Configuration ⁴	Trap Nights
2/12-2/15	Yt Fld ZZ	0367158 4119046	Trans (0.25)	100
2/12-2/15	Yt P AAA	0364444 4118928	Trans (0.20)	80
2/12-2/15	Yt P BBB	0364598 4118781	Trans (0.20)	80
3/23-3/25	Yt MF SG1	0367287 4119559	Grid (0.40)	1000
4/25-4/29				
5/21-5/25				
6/24-6/28				
7/11-7/14				
8/8-8/11				
3/23-3/25	Yt MF SC1	0367435 4119517	Grid (0.40)	1040
4/25-4/29				
5/21-5/25				
6/24-6/28				
7/11-7/14				
8/8-8/11				
3/10-3/13	Yt MF SG2	0364843 4118345	Grid (0.49)	1225
4/19-4/23				
6/18-6/22				
7/17-7/20				
8/20-8/23				
3/10-3/13	Yt MF SC2	0364697 4118273	Grid (0.49)	1323
4/19-4/23				
6/18-6/22				
7/17-7/20				
8/20-8/23				
3/10-3/13	Yt MF SG3	0364856 4120284	Grid (0.42)	1134
4/19-4/23				
5/9-5/13				
6/19-6/23				
7/11-7/14				
8/8-8/11				
3/10-3/13	Yt MF SC3	0364822 4120380	Grid (0.42)	1092
4/19-4/23				
5/9-5/13				
6/19-6/23				
7/11-7/14				
8/8-8/11				

Appendix D. Trapping schedule, habitats, locations, and efforts for Sherman traps for 2004 in Colonial National Historical Park (continued).

Dates ¹	Habitat/Site ²	Location ³	Trap Configuration ⁴	Trap Nights
3/10-3/13	Yt MF LG1	0367425 4120429	Grid (0.63)	1092
4/19-4/23				
5/9-5/13				
6/19-6/22				
7/11-7/14				
8/8-8/11				
3/10-3/13	Yt MF LC1	0367104 4120237	Grid (0.63)	1050
4/19-4/23				
5/9-5/13				
6/19-6/22				
7/11-7/14				
8/8-8/11				
3/23-3/26	Yt MF LG2	0364301 4119463	Grid (0.68)	768
4/25-5/2				
5/21-5/25				
6/24-6/28				
7/17-7/20				
8/20-8/23				
3/23-3/26	Yt MF LC2	0364237 4119306	Grid (0.68)	576
4/25-5/2				
5/21-5/25				
6/24-6/28				
7/17-7/20				
8/20-8/23				
3/23-3/26	Yt MF LG3	0365848 4120923	Grid (0.68)	783
4/25-4/29				
5/21-5/25				
6/24-6/28				
7/17-7/20				
8/20-8/23				
3/23-3/26	Yt MF LC3	0365784 4121027	Grid (0.68)	783
4/25-4/29				
5/21-5/25				
6/24-6/28				
7/17-7/20				
8/20-8/23				

Appendix D. Trapping schedule, habitats, locations, and efforts for Sherman traps for 2004 in Colonial National Historical Park (continued).

Dates ¹	Habitat/Site ²	Location ³	Trap Configuration ⁴	Trap Nights
5/2-5/7	Yt Fld NNN	0363099 4121643	Trans (0.40)	240
5/2-5/7	Yt Fld OOO	0363502 4121747	Trans (0.20)	120
5/2-5/7	Yt Fld PPP	0364677 4119604	Trans (0.18)	108
6/24-6/30	Yt OF CCC	0365641 4120570	Trans (0.15)	101
6/24-6/30	Yt OF DDD	0365636 4120547	Trans (0.12)	84
6/24-6/30	Yt OF EEE	0365613 4120560	Trans (0.13)	91
6/24-6/30	Yt OF FFF	0365601 4120548	Trans (0.13)	91
7/26-7/29	Gs Fld KKK	0340175 4124987	Trans (0.20)	80
7/26-7/29	Gs Fld LLL	0340083 4124866	Trans (0.20)	80
7/26-7/29	Gs Fld MMM2	0340074 4124860	Trans (0.20)	80
7/26-7/29	Gs Fld NNN2	0339999 4125038	Trans (0.20)	80
8/8-8/11	Yt Fld QQQ	0366275 4120855	Trans (0.20)	20
8/8-8/11	Yt Fld RRR	0366266 4120848	Trans (0.05)	20
8/17-8/19	Yt FWL UUU	0366565 4120350	Trans (0.80)	120
8/20-8/21	Yt FWL VVV	0366563 4120350	Trans (0.20)	40

¹ Dates are nights traps were open.

² Units of COLO are identified as Pk = parkway, Yt = Yorktown, Jm = Jamestown, Gs = Green Spring. MF = mixed forest, P = pine forest, Fld = field, OF = old field, FWL = forested wetland, MS = *Microstegium vimineum* experimental mixed forest area, CS = *Microstegium vimineum* control mixed forest area, SG = small canopy gap experimental site, SC = small canopy gap control site, LG = large canopy gap experimental site, LC = large canopy gap control site.

³ UTM coordinates are for middle of grid or one end of transect; zone 18.

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 (Tran).

Appendix E. Trapping schedule, habitats, locations, and efforts for Tomahawk, pitfall, and wooden box traps for 2004 at Colonial National Historical Park (COLO).

Dates	Habitat/Site ¹	Location ²	Trap Nights		
			Tomahawk ³	Pitfall	Woodenbox
3/19-3/20	Yt MF MS1	0364326 4118874	10 ^s ,30 ^m	230	
4/2-4/4					
4/13-4/18					
5/15-5/19					
6/4-6/8					
7/5-7/9					
8/2-8/6					
2/17-2/21	Yt MF CS1	0364336 4119161	2 ^s ,13 ^m	240	
3/19-3/22					
4/13-4/19					
5/15-5/19					
6/4-6/8					
7/5-7/9					
8/2-8/6					
4/13-4/19	Yt MF MS2	0364659 4119503		270	
5/15-5/19					
6/4-6/8					
7/5-7/9					
8/2-8/6					
4/13-4/19	Yt MF CS2	0364434 4119480		270	
5/15-5/19					
6/4-6/8					
7/5-7/9					
8/2-8/6					
2/17-2/21	Yt MF MS3	0367265 4120367	2 ^s ,18 ^m	260	
3/18-3/21					
4/13-4/19					
5/15-5/19					
6/4-6/8					
7/5-7/9					
8/2-8/6					

Appendix E. Trapping schedule, habitats, locations, and efforts for Tomahawk, pitfall, and wooden box traps for 2004 at Colonial National Historical Park (COLO) (continued).

Dates	Habitat/Site ¹	Location ²	Trap Nights		
			Tomahawk ³	Pitfall	Woodenbox
2/17-2/21	Yt MF CS3	0367365 4120217	3 ^s ,6 ^m	270	
3/18-3/21					
4/13-4/19					
5/15-5/19					
6/4-6/8					
7/5-7/9					
8/2-8/6					
2/17-2/21	Pk MF MS4	0342498 4120836	4 ^m	270	
3/18-3/21					
4/13-4/19					
5/15-5/19					
6/4-6/8					
7/5-7/9					
8/2-8/6					
2/17-2/21	Pk MF CS4	0342661 4120824	9 ^m	270	
3/18-3/19					
4/13-4/19					
5/15-5/19					
6/4-6/8					
7/5-7/9					
8/2-8/6					
4/25-5/1	Yt MF SG1	0367287 4119559	1 ^s ,12 ^m	264	
5/18-5/25					
6/24-6/30					
7/11-7/14					
7/17-7/22					
8/11					
8/20-8/25					
4/25-5/1	Yt MF SC1	0367435 4119517	5 ^s ,8 ^m	264	
5/18-5/25					
6/24-6/30					
7/11-7/14					
7/17-7/22					
8/11					
8/20-8/25					

Appendix E. Trapping schedule, habitats, locations, and efforts for Tomahawk, pitfall, and wooden box traps for 2004 at Colonial National Historical Park (COLO) (continued).

			Trap Nights		
Dates	Habitat/Site ¹	Location ²	Tomahawk ³	Pitfall	Woodenbox
3/12-3/13	Yt MF SG2	0364843 4118345	7 ^s , 22 ^m	232	
4/18-4/24					
5/9-5/15					
6/18-6/24					
7/11-7/14					
8/8-8/11					
8/21-8/23					
3/12-3/13	Yt MF SC2	0364697 4118273	8 ^s , 11 ^m	232	
4/18-4/24					
5/9-5/15					
6/18-6/24					
7/11-7/14					
8/8-8/11					
4/18-4/24	Yt MF SG3	0364856 4120284	2 ^m	232	
5/9-5/15					
6/18-6/24					
7/11-7/14					
8/8-8/11					
4/18-4/24	Yt MF SC3	0364822 4120380		232	
5/9-5/15					
6/18-6/24					
7/11-7/14					
8/8-8/11					
4/18-4/24	Yt MF LG1	0367425 4120429	2 ^s , 1 ^m	232	
5/9-5/15					
6/18-6/24					
7/11-7/14					
8/8-8/11					
4/18-4/24	Yt MF LC1	0367104 4120237	8 ^s , 34 ^m	232	
5/9-5/15					
6/18-6/24					
7/11-7/14					
8/8-8/11					

Appendix E. Trapping schedule, habitats, locations, and efforts for Tomahawk, pitfall, and wooden box traps for 2004 at Colonial National Historical Park (COLO) (continued).

Dates	Habitat/Site ¹	Location ²	Trap Nights		
			Tomahawk ³	Pitfall	Woodenbox
4/25-5/1	Yt MF LG2	0364301 4119463	12 ^s , 18 ^m	264	
5/18-5/25					
6/24-6/30					
7/17-7/22					
8/20-8/25					
4/25-5/1	Yt MF LC2	0364237 4119306	8 ^s , 60 ^m , 12 ^l	264	
5/18-5/25					
6/24-6/30					
7/17-7/22					
8/20-8/25					
4/25-5/21	Yt MF LG3	0365848 4120923		264	
5/18-5/24					
6/24-6/30					
7/17-7/22					
8/20-8/25					
4/25-5/1	Yt MF LC3	0365784 4121027		264	
5/18-5/24					
6/24-6/30					
7/17-7/22					
8/20-8/25					
5/2-5/7	Yt Fld PPP	0364677 4119604	20 ^s		
6/5-6/8	Pk M/MF WWW	Not recorded			20
6/30-7/2	Pk M/MF GGG	0357783 4126328			12
6/30-7/2	Pk M/MF HHH	0357709 4126288			12
7/26-7/29	Jm M/MF III	0344301 4118821			16
7/26-7/29	Jm M/MF JJJ	0344481 4119017			16
8/17-8/19	Yt FWL UUU	0366565 4120350	9 ^s , 3 ^m		6
8/19-8/21	Yt FWL VVV	0366563 4120350	6 ^s , 4 ^m		4

¹ Units of COLO are identified as Pk = parkway, Yt = Yorktown, Jm = Jamestown. MF = mixed forest, Fld = field, FWL = forested wetland, M/MF = marsh/mixed forest edge, MS = *Microstegium vimineum* experimental mixed forest area, CS = *Microstegium vimineum* control mixed forest area, SG = small canopy gap experimental site, SC = small canopy gap control site, LG = large canopy gap experimental site, LC = large canopy gap control site.

² UTM coordinates (zone 18) for Tomahawk and pitfall traps are for middle of spatially associated Sherman trap grid or one end of Sherman trap transect. UTM coordinates (zone 18) for wooden box traps are for one end of wooden box trap transect

³ Tomahawk traps ^s = small, ^m = medium, and ^l = large.

Appendix F. Capture record for mammals caught in Colonial National Historical Park (COLO) from January through August 2004.

Habitat/site ¹	Trap Nights				Species Name	Common Name	No. individuals	Total captures	Relative Abundance ³
	Sherman Traps	Tomahawk Traps ²	Pitfall Traps	Wooden Box Traps					
Yt MF MS1	1110	10s, 30m	230		<i>Didelphis virginiana</i>	Virginia opossum	1	1	-
					<i>Blarina brevicauda</i>	Northern short-tailed shrew	1	1	0.1
					<i>Sorex longirostris</i>	Southeastern shrew	1	1	0.1
					<i>Peromyscus leucopus</i>	White-footed deer mouse	20	78	1.5
					<i>Procyon lotor</i>	Raccoon	?	5	-
Yt MF CS1	960	2s, 13m	240		<i>Didelphis virginiana</i>	Virginia opossum	?	2	-
					<i>Blarina brevicauda</i>	Northern short-tailed shrew	1	1	0.1
					<i>Peromyscus leucopus</i>	White-footed deer mouse	21	51	1.8
					<i>Oryzomys palustris</i>	Marsh oryzomys	1	3	0.1
					<i>Procyon lotor</i>	Raccoon	?	2	-
Yt MF MS2	960		270		<i>Blarina brevicauda</i>	Northern short-tailed shrew	4	4	0.3
					<i>Sorex longirostris</i>	Southeastern shrew	1	1	0.1
					<i>Peromyscus leucopus</i>	White-footed deer mouse	25	203	2
					<i>Glaucomys volans</i>	Southern flying squirrel	2	3	0.2
Yt MF CS2	960		270		<i>Blarina brevicauda</i>	Northern short-tailed shrew	1	1	0.1
					<i>Sorex longirostris</i>	Southeastern shrew	2	2	0.2
					<i>Peromyscus leucopus</i>	White-footed deer mouse	35	313	2.8
Yt MF MS3	990	2s, 18m	260		<i>Didelphis virginiana</i>	Virginia opossum	1	1	-
					<i>Blarina brevicauda</i>	Northern short-tailed shrew	1	1	0.1
					<i>Sorex longirostris</i>	Southeastern shrew	3	3	0.2
					<i>Peromyscus leucopus</i>	White-footed deer mouse	15	33	1.2
					<i>Reithrodontomys humulis</i>	Eastern harvest mouse	3	5	0.2
					<i>Oryzomys palustris</i>	Marsh oryzomys	1	1	0.1
					<i>Procyon lotor</i>	Raccoon	?	3	-

Appendix F. Capture record for mammals caught in Colonial National Historical Park (COLO) from January through August 2004 (continued).

Habitat/site ¹	Trap Nights				Species Name	Common Name	No. individuals	Total captures	Relative Abundance ³
	Sherman Traps	Tomahawk Traps ²	Pitfall Traps	Wooden Box Traps					
Yt MF CS3	1050	3s, 6m	270		<i>Didelphis virginiana</i>	Virginia opossum	1	2	-
					<i>Blarina brevicauda</i>	Northern short-tailed shrew	2	2	0.2
					<i>Sorex longirostris</i>	Southeastern shrew	2	2	0.2
					<i>Peromyscus leucopus</i>	White-footed deer mouse	19	51	1.4
Pk MF MS4	1080	4m	270		<i>Blarina brevicauda</i>	Northern short-tailed shrew	2	2	0.1
					<i>Peromyscus leucopus</i>	White-footed deer mouse	38	254	2.8
Pk MF CS4	1020	9m	270		<i>Didelphis virginiana</i>	Virginia opossum	1	1	-
					<i>Blarina brevicauda</i>	Northern short-tailed shrew	1	1	0.1
					<i>Peromyscus leucopus</i>	White-footed deer mouse	20	199	1.6
					<i>Procyon lotor</i>	Raccoon	?	2	-
Yt P AAA	80				<i>Peromyscus leucopus</i>	White-footed deer mouse	2	5	2.5
Yt P BBB	80				<i>Peromyscus leucopus</i>	White-footed deer mouse	3	4	3.8
Yt MF SG1	1000	1s, 12m	264		<i>Didelphis virginiana</i>	Virginia opossum	2	2	-
					<i>Blarina brevicauda</i>	Northern short-tailed shrew	3	3	0.2
					<i>Peromyscus leucopus</i>	White-footed deer mouse	16	86	1.3
					<i>Procyon lotor</i>	Raccoon	1	1	-
Yt MF SC1	1040	5s, 8m	264		<i>Didelphis virginiana</i>	Virginia opossum	?	3	-
					<i>Peromyscus leucopus</i>	White-footed deer mouse	15	100	1.2
Yt MF SG2	1225	7s, 22m	232		<i>Didelphis virginiana</i>	Virginia opossum	?	4	-
					<i>Blarina brevicauda</i>	Northern short-tailed shrew	2	2	0.1
					<i>Peromyscus leucopus</i>	White-footed deer mouse	20	83	1.4
					<i>Oryzomys palustris</i>	Marsh oryzomys	1	1	0.1
					<i>Procyon lotor</i>	Raccoon	?	2	-

Appendix F. Capture record for mammals caught in Colonial National Historical Park (COLO) from January through August 2004 (continued).

69

Habitat/site ¹	Trap Nights				Species Name	Common Name	No. individuals	Total captures	Relative Abundance ³
	Sherman Traps	Tomahawk Traps ²	Pitfall Traps	Wooden Box Traps					
Yt MF SC2	1323	8s, 11m	232		<i>Blarina brevicauda</i>	Northern short-tailed shrew	2	2	0.1
					<i>Sorex longirostris</i>	Southeastern shrew	2	2	0.1
					<i>Peromyscus leucopus</i>	White-footed deer mouse	19	82	1.2
					<i>Procyon lotor</i>	Raccoon	?	3	-
Yt MF SG3	1134	2m	232		<i>Blarina brevicauda</i>	Northern short-tailed shrew	2	2	0.1
					<i>Sorex longirostris</i>	Southeastern shrew	1	1	0.1
					<i>Peromyscus leucopus</i>	White-footed deer mouse	17	106	1.2
					<i>Scirurus carolinensis</i>	Eastern gray squirrel	1	1	-
Yt MF SC3	1092		232		<i>Blarina brevicauda</i>	Northern short-tailed shrew	1	1	0.1
					<i>Peromyscus leucopus</i>	White-footed deer mouse	33	231	2.5
Yt MF LG1	1092	2s, 1m	232		<i>Didelphis virginiana</i>	Virginia opossum	2	2	-
					<i>Sorex longirostris</i>	Southeastern shrew	1	1	0.1
					<i>Peromyscus leucopus</i>	White-footed deer mouse	36	244	2.7
					<i>Oryzomys palustris</i>	Marsh oryzomys	1	1	0.1
Yt MF LC1	1050	8s, 34m	232		<i>Didelphis virginiana</i>	Virginia opossum	?	4	-
					<i>Blarina brevicauda</i>	Northern short-tailed shrew	1	1	0.1
					<i>Sorex longirostris</i>	Southeastern shrew	2	2	0.2
					<i>Sorex longirostris</i>	Southeastern shrew	33	98	2.6
					<i>Oryzomys palustris</i>	Marsh oryzomys	1	1	0.1
					<i>Procyon lotor</i>	Raccoon	?	3	-

Appendix F. Capture record for mammals caught in Colonial National Historical Park (COLO) from January through August 2004 (continued).

Habitat/site ¹	Trap Nights				Species Name	Common Name	No. individuals	Total captures	Relative Abundance ³
	Sherman Traps	Tomahawk Traps ²	Pitfall Traps	Wooden Box Traps					
Yt MF LG2	768	12s, 18m	264		<i>Didelphis virginiana</i>	Virginia opossum	?	3	-
					<i>Blarina brevicauda</i>	Northern short-tailed shrew	1	1	0.1
					<i>Sorex longirostris</i>	Southeastern shrew	3	3	0.3
					<i>Peromyscus leucopus</i>	White-footed deer mouse	34	175	3.3
					<i>Sigmodon hispidus</i>	Hispid cotton rat	1	1	0.1
					<i>Procyon lotor</i>	Raccoon	1	1	-
Yt MF LC2	576	8s, 60m, 12l	264		<i>Didelphis virginiana</i>	Virginia opossum	?	3	-
					<i>Sorex longirostris</i>	Southeastern shrew	1	1	0.1
					<i>Peromyscus leucopus</i>	White-footed deer mouse	19	57	2.3
					<i>Procyon lotor</i>	Raccoon	?	6	-
Yt MF LG3	783		264		<i>Blarina brevicauda</i>	Northern short-tailed shrew	4	4	0.4
					<i>Sorex longirostris</i>	Southeastern shrew	1	1	0.1
					<i>Peromyscus leucopus</i>	White-footed deer mouse	51	436	4.9
					<i>Oryzomys palustris</i>	Marsh oryzomys	2	2	0.2
Yt MF LC3	783		264		<i>Blarina brevicauda</i>	Northern short-tailed shrew	2	2	0.2
					<i>Peromyscus leucopus</i>	White-footed deer mouse	37	306	3.5
Yt Fld NNN	240				<i>Peromyscus leucopus</i>	White-footed deer mouse	1	2	0.4
					<i>Reithrodontomys humulis</i>	Eastern harvest mouse	1	1	0.4
Yt Fld OOO	120				<i>Reithrodontomys humulis</i>	Eastern harvest mouse	1	1	0.8
Yt Fld PPP	108	20s			<i>Didelphis virginiana</i>	Virginia opossum	1	1	-

Appendix F. Capture record for mammals caught in Colonial National Historical Park (COLO) from January through August 2004 (continued).

Habitat/site ¹	Trap Nights				Species Name	Common Name	No. individuals	Total captures	Relative Abundance ³
	Sherman Traps	Tomahawk Traps ²	Pitfall Traps	Wooden Box Traps					
Yt OF CCC/FFF	367*				<i>Blarina brevicauda</i>	Northern short-tailed shrew	4*	4*	1.1
					<i>Peromyscus leucopus</i>	White-footed deer mouse	2*	4*	0.5
					<i>Reithrodontomys humulis</i>	Eastern harvest mouse	33*	66*	9
					<i>Microtus pennsylvanicus</i>	Meadow vole	2*	2*	0.5
Gs Fld KKK	80				<i>Blarina brevicauda</i>	Northern short-tailed shrew	1	1	1.2
Gs Fld LLL	80				<i>Blarina brevicauda</i>	Northern short-tailed shrew	1	1	1.2
					<i>Sigmodon hispidus</i>	Hispid cotton rat	3	3	3.8
Gs Fld MMM2	80				<i>Peromyscus leucopus</i>	White-footed deer mouse	1	1	1.2
Gs Fld NNN2	80				<i>Peromyscus leucopus</i>	White-footed deer mouse	1	2	1.2
Yt Fld QQQ	20				<i>Microtus pennsylvanicus</i>	Meadow vole	1	1	5
Yt Fld RRR	20				<i>Peromyscus leucopus</i>	White-footed deer mouse	2	7	10
Yt FWL UUU	120	9s, 3m		6	<i>Blarina brevicauda</i>	Northern short-tailed shrew	1	1	0.8
					<i>Peromyscus leucopus</i>	White-footed deer mouse	3	3	2.5
Yt FWL VVV	40	6s, 4m		4	<i>Didelphis virginiana</i>	Virginia opossum	1	1	-
					<i>Procyon lotor</i>	Raccoon	1	1	-

¹ Units of COLO are identified as Pk = parkway, Yt = Yorktown, Jm = Jamestown, Gs = Green Spring, MF = mixed forest, P = pine forest, Fld = field, OF = old field, FWL = forested wetland, MS = *Microstegium vimineum* experimental mixed forest area, CS = *Microstegium vimineum* control mixed forest area, SG = small canopy gap experimental site, SC = small canopy gap control site, LG = large canopy gap experimental site, LC = large canopy gap control site.

² Tomahawk traps ^s = small, ^m = medium, and ^l = large..

* Trap nights, number of individuals, and total captures for Yt OF Trans CCC, DDD, EEE, and FFF were combined because of the proximity of the transects in the same old field.

³ Relative abundance is individuals/100 Sherman and pitfall trap nights. Relative abundances are not determined for captures in Tomahawk or wooden box traps.

The Department of the Interior protects and manages the nation's natural resources and cultural heritage; provides scientific and other information about those resources; and honors its special responsibilities to American Indians, Alaska Natives, and affiliated Island Communities.

NPS 333/102090, May 2010

National Park Service
U.S. Department of the Interior



Natural Resource Program Center
1201 Oakridge Drive, Suite 150
Fort Collins, CO 80525

www.nature.nps.gov