Inventory of Distribution, Composition, and Relative Abundance of Mammals at Hopewell Culture National Historical Park

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Summary

An inventory of the presence/absence of mammals (excluding bats) was conducted at Hopewell Culture National Historical Park from June 2003 to May 2004. Twenty eight of 37 (76%) expected species were documented via live trap, pitfalls, photo capture, random sightings, and coverboards. Species collected are typical of eastern deciduous forests, old farm fields, and riparian areas. No state or Federally listed species were observed.

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Introduction

The U.S. Congress passed the 1998 National Parks Omnibus Management Act in response to concerns about the condition of natural resources within the national parks. The act requires each park to gather baseline inventory data on pertinent natural resources, data that will provide a pivotal step toward establishing an effective monitoring program, and further our ability to effectively manage and protect park resources. The National Park Service (NPS) responded with the Natural Resource Challenge program, including the establishment of biome-based inventory and monitoring networks. The Heartland Network, as part of the NPS Inventory and Monitoring (I&M) program, has undertaken inventories of vascular plants and vertebrates within fifteen parks in eight Midwestern states.

Hopewell Culture National Historical Park was established to preserve, protect, and interpret the remnants of the Hopewell, thereby increasing understanding of their culture. Since the establishment of the park in 1923, focus has been on the archeological remnants of the Hopewell culture. Work and study of the natural resources in the park however, has been limited and incomplete.

A comprehensive survey of the mammals, not including bats, that may utilize Hopewell Culture National Historical Park was initiated to determine species diversity and create a baseline inventory of mammal species present in the park. The collection of this information will then be incorporated into park monitoring and management plans in order to successfully manage for healthy and diverse populations of mammals. Bats were not included in the survey as they were inventoried in a separate study in 2004.

Throughout the state of Ohio 54 species of mammals are known to occur. Excluding 11 bat species, 37 of these may occur in Ross County, Ohio (Gottschang 1981) and are listed in Table 1. The results of a flora inventory of the park indicated that "even though the park is small in area, the total number of taxa represents 40% of the species, 57% of the genera, and 76% of the families of Ross County, which is fairly good representation" (Bennett and Course 1996). As such, the high diversity of plants may in turn create a variety of habitats for animals.

The badger (*Taxidea taxus*) is the only species considered a species of concern (SOC) by the state of Ohio and is expected to occur in Ross County (ODOW 2002).

The goal of the inventory is to document 90% of the species that are reasonably expected to occur at the park. This inventory is a census of the five park units and will provide data on mammal species composition, distribution, and relative abundance.

Study Area

Hopewell Culture National Historical Park is composed of five non-contiguous park units totaling more than 445.3 ha (1,100 ac) in size. The park units are Mound City Group, Hopeton Earthworks, Hopewell Mound Group, High Bank Works, and Seip Earthworks (Figure 1 and Figures 4-8) and are located around the town of Chillicothe, Ross County, Ohio. Two phytogeographic regions of Ohio meet along a NE/SW line. The northwest portion of the park and Ross County is composed of calcareous, glaciated till plain, while the southeast is made up of non-glaciated area (Braun 1989). The meeting of two regions may result in higher diversity of flora and fauna.

Each site utilizing pit-fall traps was inventoried for vegetation in a 50 m radius prior to any mammal sampling (see methods below).

Mound City Group (Mound City) is located at 16062 State Route 104, Chillicothe. This park unit contains five buildings, 1.6 km. (1 mi) of trails, and 1.2 km (0.74 mi) of road. The entire unit contains 48.6 ha (120 ac), with 12.1 ha (30 ac) actively mowed, 18.2 ha (45 ac) mowed periodically for hay, and 18.2 ha (45 ac) of early successional mixed mesophytic forest. The Scioto River borders the eastern edge of the unit.

Mound City site 1-Woods/Upland: Due to the small size of Mound City, the vegetation plot in the wooded lot was near a regularly mowed area, thereby tall fescue was predominant and composed approximately 20% of the area. The woods at this site are mostly early successional mixed mesophytic forest (Bennett and Course 1996). The canopy and sub-canopy is dominated by hackberry (*Celtis occidentalis*) and black walnut (*Juglans nigra*) trees. Wild black cherry trees (*Prunus serotina*) also make up the canopy, while box elder (*Acer negundo*) can be found in the sub-canopy. The shrub layer is primarily composed of tatarian honeysuckle (*Lonicera tatarica*), with some trumpet creeper (*Campsis radicans*) and black raspberry (*Rubus occidentalis*). The aggressive non-native Japanese honeysuckle (*Lonicera japonica*) is present at every layer and dominates the herbaceous vegetation. Other plants found on the ground level is poison ivy (*Toxicodendron radicans*) and the invasive garlic mustard (*Alliaria petiolata*).

Mound City site 1- Riparian: The Scioto River flows along the eastern edge of Mound City and is known to contain a wide diversity of aquatic and riparian habitats. Severe erosion occurs in many areas of this river, in part due to the six dams in its upper reaches. Based on the extensive surveys conducted by the Ohio Environmental Protection Agency (OEPA) for more than 20 years, the designated aquatic use of the river improved from “Modified” to “Exceptional” warmwater (ODSW 2002). The attainment of “Exceptional” warmwater is based on the increase in species diversity, composition, and functional organization of fish and invertebrates. The river flows approximately nine-tenths of a kilometer (0.6 mi) along the park boundary, with a portion causing extensive erosion. Some areas along the river are flooded periodically, while others are located at upper terraces. The randomly selected study site was located on the upper terrace and extends almost 200 m from the river. The study site is mostly wooded, with the canopy and sub-canopy dominated by hackberry and black walnut trees. Tatarian honeysuckle dominates the shrub layer, with some black raspberry. In a battle for the understory, Japanese honeysuckle grows throughout, with the periwinkle (*Vinca minor*) gaining ground. Unfortunately both are

non-native. Other plants peeking through the herbaceous layer are smooth sweet cicely (*Osmorhiza longistylis*), small-flowered leaf cup (*Polymnia canadensis*), poison ivy and garlic mustard.

Hopeton Earthworks (Hopeton) is located at the 1100 block of Hopeton Road, Chillicothe. This is one of the largest parcels encompassing approximately 151.9 ha (375.4 ac). The majority of the area, 96.0 ha (237.3 ac), is mainly composed of orchard grass (*Dactylis glomerata*) and alfalfa (*Medicago sativa*) and has been harvested for hay in the recent past. A relatively young fence row bisects the property and is composed mainly of hackberry, with some wild black cherry. Currently there is an active gravel mining operation located on the western half of the property. The Scioto River flows along a portion of the western side of the gravel mining operation. In addition, a no-till corn/soybean field owned by the park is located on the western side of the mining operation. Another 1.6 ha (4 ac) contains mowed grass and black walnut trees, while the remaining area is composed of early successional mixed deciduous open forest, with an intermittent stream, Dry Run, flowing through the 5.5 ha (13.6 ac) parcel.

Hopeton site 1-Agriculture/Old Field: Fields within this site comprise the largest acreage –96.0 ha (237.3 ac), however the site is not entirely contiguous as an active gravel mining operation is located on the western portion of this park unit. Most of this site has and continues to be actively mowed for hay. The randomly selected study site is located in the northeast section of the park unit. This site had not been mowed for hay since 2001. Due to its history, the canopy, sub-canopy and shrub layers are mainly located along tree lines that fall within the plot. Within the tree line are hackberry and wild black cherry, which are present in both the canopy and sub-canopy. White mulberry (*Morus alba*) can also be found in the sub-canopy layer. The shrubs within the tree line are mainly tartarian honeysuckle and multiflora rose (*Rosa multiflora*). The main ground cover is the herbaceous layer which is dominated by common and giant goldenrod (*Solidago gigantea*), Philadelphia fleabane (*Erigeron philadelphicus*), and poison hemlock (*Conium maculatum*).

Hopewell Mound Group (Hopewell) is located at 4731 Sulphur Lick Road, Chillicothe. An intermittent stream, Sulphur Lick, runs near the northern and eastern boundary of this 125.6 ha (310 ac) site, with the North Fork of Paint Creek bordering the southern edge. Currently the property is mainly composed of 73.0 ha (180.4 ac) of orchard grass pasture. The northern portion of the property includes 33.6 ha (83.0 ac) of semi-mature mixed mesophytic forest with a 1/3-acre impoundment located on the eastern edge within these woods.

Hopewell site 1-Agriculture/Old Field: The 73-hectare (180.4 ac) field has a history of active agriculture, and was last cut for hay in 2002. The randomly selected study site was located in the middle of one of the hayfields. No canopy, sub-canopy, or shrub layer was evident within the plot. Outside of the circle, tree lines were located on the eastern and western borders of this site, Sulphur Lick Road along the southern edge and the upland woods bordering the north. The dominant plant in the field is orchard grass, with some barnyard grass (*Echinochloa crus-galli*) and horseweed (*Conyza canadensis*).

Hopewell site 1-Woods/Upland: This 33.6 ha (83.0 ac) site is located in semi-mature mesophytic forest (Bennett and Course 1996). Ohio buckeye (*Aesculus glabra*) dominate the shrub/sub-

canopy through this slightly hilly area. Multiflora rose is also present within the shrub layer, however not dominant. There is evidence of ephemeral streams as established headwater stream beds are present, however no water has been observed flowing at the times of sampling. The canopy is mainly composed of sugar maple (*Acer saccharum*), wild black cherry, and hackberry. Other trees are present, but not as dominant. The herbaceous layer is composed of wingstem (*Verbesina alternifolia*), common blue violet (*Viola sororia*), and multiflora rose. During the October 2003 sampling, the leaves of puttyroot (*Aplectrum hyemale*) were observed within the sampling area.

Hopewell site 2-Woods/Upland: The second site is predominantly a shrubby/grassy upland area, with a mix of tall fescue (*Festuca elatior*) and common goldenrod (*Solidago canadensis*). A few trees were present, mainly white ash (*Fraxinus americana*) and honey locust (*Gleditsia triacanthos*). Multiflora rose was present at varying stages, dominating the sub-canopy and shrub layers. Other plants in the sub-canopy were dotted hawthorn (*Crataegus punctata*) and Russian olive (*Elaeagnus angustifolia*). Younger forms of Russian olive and white ash also contributed to the shrub layer. The herbaceous layer, which composed more than 60% of the cover, was composed of tall fescue, common goldenrod and common blackberry (*Rubus allegheniensis*).

Seip Earthworks (Seip) is located on US 50 bordering Seip State Memorial, near Paint Valley High School, Bainbridge. The property is divided into two parcels, with Ohio Historical Society land located between the units. The southern border of this 67.0 ha (165.6 ac) site lies alongside Paint Creek. The creek is bordered by a 5.9 ha (14.6 ac) wooded riparian corridor.

Seip site 1-Agriculture/Old Field: This park unit contains 58.2 ha (143.8 ac) of fields separated into two parcels that measure 52.1 ha (128.8 ac) and 6.1 ha (15.0 ac) each. The randomly selected site is located in the larger parcel, along the western portion. Most of the 50 m radius circle includes the old field, however a small part of the outer edge falls along the treeline. Walnut dominates the canopy, while younger walnut, box elder, and elm dominate the sub-canopy within the treeline. No shrub layer is evident, and the rest of the field is mainly covered by fleabane and common and giant goldenrod. Other plants contributing to the herbaceous layer are poison hemlock, yellow sweet clover, and wingstem.

Seip site 1- Riparian: Paint Creek is a tributary to the Scioto River and the lower portion flows along the southern edge of Seip. According to the Ohio EPA's 2002 Integrated Report for Large River Assessment Units, the lower portion of Paint Creek is among the highest quality large rivers in the state. The incredible fish diversity in this portion of the stream, 91 species, reveals the excellent habitat and water quality evident in the stream (Cavender and Kibbey 1999). The designated aquatic life use is considered Exceptional Warm Water habitat and the eastern hellbender (*Cryptobranchus alleghaniensis*), a state endangered species and Federal Species of Concern, has been found in this watershed (Pfingsten and Downs 1989). The riparian area at Seip is approximately 5.7 ha (14 ac), and is L-shaped as it borders the creek at a bend for a half mile. The randomly selected site to be surveyed was located in a narrow part of the riparian area, with a width of 50 m. The canopy was composed of a few sycamore, box elder, silver maple, and hackberry. The sub-canopy consisted of smaller box elder and hackberry, and paw-paw (*Asimina triloba*). The only plant contributing to the shrub layer was paw-paw, whereas the

herbaceous layer was mainly composed of Canadian woodnettle. Other plants contributing to the riparian floor was garlic mustard, common blue violet, smooth sweet cicely, and tall fescue.

High Bank Works (High Bank) is a 67.5 ha (166.8 ac) parcel located at the end of County Road 900, off US 35 south of Chillicothe. Approximately 20.2 ha (50 ac) of this site is composed of alfalfa/orchard grass, with a slightly larger parcel left fallow. These fields have been mowed at least once a year. Another 5.3 ha (13.0 ac) is composed of winter wheat (*Triticum aestivum*), and yet another 2.8 ha (7.0 ac) was chemically treated early in 2003. The Scioto River borders the western edge of this property, where a 11.8 ha (29.0 ac) riparian woodland exists. The remaining acreage is still under negotiation.

High Bank site 1- Riparian: The Scioto River also flows by this park unit, but further downstream and along a 450 m (#1,476 ft) stretch of the western border of the property. This is the largest riparian parcel, extending 8.9 ha (22 ac), and also contains an ox-bow that is periodically flooded. The width of the riparian area ranges from 130-290 m (426-951 ft), and is located on the lower terrace. The canopy in this area is extensive and composed of sycamore (*Platanus occidentalis*), cottonwood (*Populus deltoides*) and silver maple (*Acer saccharinum*). Hackberry and box elder dominate the sub-canopy, with some Ohio buckeye and younger silver maple interspersed. Young Ohio buckeye also make up the only component in the shrub layer. The herbaceous layer is mostly tall fescue, Canadian woodnettle (*Laportea canadensis*), jewelweed (*Impatiens capensis*), and garlic mustard.

Materials and Methods

Mammal surveys were conducted June 2003 to May 2004 using pitfall traps, Sherman live capture traps, Tomahawk standard live traps, photo capture, random sightings, and coverboards. Each survey was conducted five days each month checking traps twice a day, once in the morning and again in the afternoon, during the new to quarter moon phases (Table 4). An expected species list (Boetsch et al 2000) was provided before survey work began to be used as a search list (see table 1).

Habitat throughout the park was stratified into three categories: 1) Woods/upland, 2) Riparian, and 3) Agriculture/old field and plot origins were randomly selecting using ArcView GIS 3.3 (Figures 3-7). Acreage not included for live trapping was composed of developed areas such as roads and buildings, and actively mowed areas such as the earthworks at Mound City.

Prior to conducting the actual survey for mammals, the habitat was evaluated. A circle with a 50 m radius was studied to determine the immediate terrestrial habitat at each study site. Location data was determined using the Trimble Pro XR GPS. Photos were taken at each site and elevation recorded from topographic maps. The slope, aspect, topographic position, hydrologic regime, and ground cover were recorded. The vegetation was described based on plant type and growth, along with physiognomic class. Species were identified and stratified based on various cover classes and height classes. In addition, the percent of each cover class was estimated. An example of the "terrestrial habitat data form" used to record habitat description is shown in Appendix 1.

Three pitfall trap locations per strata were sampled. The three largest parcels of strata (based on area) were selected from the five units, with the pitfall locations selected randomly within these sites (Table 2). Because there were only two park units, Mound City and Hopewell, that contained "woods or upland strata," one pitfall site was randomly selected from Mound City, and two pitfall sites were randomly selected from Hopewell. The two sites selected at Hopewell were based on the larger "woods or upland strata" located within this unit.

Each pitfall trap site was oriented to the cross-type design (Figure 2). The design consists of a central pitfall with four drift fences extending in each cardinal direction 10 m from the center pit with additional pitfalls placed at the end of each fence. The central pit was labeled Pit A, and the four others B (north), C (east), D (south), and E (west), were labeled based on a clockwise pattern from North. Pitfalls were dug to a depth of 30 cm and diameter of 27 cm. Five-gallon plastic containers were placed in the holes, and when not in use, the pitfalls were covered or filled with vegetation in order to allow animals a chance to go in and out.

The randomly selected pit-fall trap sites were navigated to using a Trimble Pro XR GPS receiver (NAD83 CONUS). Plot origins were flagged and pitfall locations marked for archeological excavation (final results for the archeology to be added to final report).

One 150-meter (492 ft) transect for live trapping was located 50 meters (164 ft) from the pitfall trap location. The bearing of the transect was based on the size and shape of the strata it was

located in. For instance, if the strata shape was longer than wide, the transect was placed perpendicular to the pitfall trap location, while if the strata shape was wider than long, then the transect was placed parallel (Figure 3). This configuration allows the transect to be centrally located thereby maximizing the strata type surrounding the traps. Each transect consisted of 22 Sherman traps—two traps placed at 15-meter (49 ft) intervals. A mixture of peanut butter and rolled oats was used as bait. Each trap was placed within a 2-meter (7 ft) radius from the trap site along the transect, preferably under some type of cover to avoid overheating. One end of the transect was marked as transect point A, with the following trap sites marked alphabetically up to transect point K. Because two Sherman traps were placed at each transect site, each was labeled either "1" or "2." In order to prepare the Sherman traps for outdoor use by wildlife, they were left outdoors for a week prior to the first survey.

In order to survey for flying squirrels (*Glaucomys volans*), i.e. whenever the "riparian" or "woods/upland" strata were being sampled with live traps and pitfalls, two Tomahawk standard live traps (40.6 cm x 12.7 cm x 12.7 cm) were placed approximately 1.5 m off the ground tied to a tree and baited with peanut butter sandwiches. They were laid on a branch whenever possible with the entrance facing outward. When no branches were available, the trap was tied to the trunk facing up.

Picture vouchers were collected of all mammals trapped. Voucher specimens were retained of all dead mammals encountered and processed according to Wobeser et al (1980). Scientific collection permits were obtained from the National Park Service and Ohio Department of Natural Resources Division of Wildlife (Appendices 2 and 3 respectively).

Two Stealth Cams (MC1-D, 35 mm camera) were used to monitor larger and nocturnal mammals. Cameras were tied around trees approximately 1.5 m off the ground at areas that have mammal tracks and checked once-a-day. This was done in conjunction with live-trapping events, and whenever tracks were observed in various areas.

Random sightings of mammals by park staff were documented on park lists and if possible, the Park Biologist was notified in order to obtain a picture voucher. Oftentimes, dead animals were found and park staff immediately notified the Park Biologist to determine whether the carcass was acceptable as a specimen voucher.

Coverboards left by a previous herpetological survey were also randomly checked to see whether mammals were utilizing the area.

Specimens were identified following Barbour and Davis (1974), Burt and Grossenheider (1984), and Gottschang (1981).

Results

Of the 37 mammals that may be found in Ross County, Ohio, 28 (76%) have been documented at the park (Tables 1, 5 and 6). Of the nine species yet to be documented in the park, they may not be found due to the restriction of sampling time and area or lack of appropriate habitat. Status of three species is unknown.

The Mound City unit is represented by the highest number of species, 13, the Seip unit had eight species, the Hopeton and Hopewell units were tied with seven species each, and High Bank with four species (Table 6). The high number of species observed at Mound City resulted from park staff keeping an eye out for salvage specimens that are easier to document. Most of the results for the other park units rely solely on results from Sherman live traps and pitfall traps.

The use of a mammal cam was helpful in capturing the activity of white-tailed deer (*Odocoileus virginianus*) but both cameras were stolen, therefore the use of this method was limited.

Sampling along transects using live-traps have shown high numbers of *Peromyscus* species in all types of strata (Table 7, Figure 9). Total species numbers were similar, with the highest in Agriculture/old field strata, for a total of eight species encountered, the Woods/upland strata represented by seven species, and the Riparian strata inventoried with six species. Approximately 792 trap nights were conducted per strata type utilizing Sherman live traps.

Pitfall trapping resulted with three species inventoried in Agriculture/old field and Riparian strata, while no mammals have been found in Woods/upland strata (Table 8, Figure 10). Meadow voles (*Microtus ochrogaster*) were the most common species found, making up 75% of the total specimens surveyed to date. Trapping effort for pitfall trapping in both Agriculture/old field strata and Woods/upland strata was 180 nights each, while there was only 168 nights of trapping done at the Riparian strata. The High Bank unit pitfall location was flooded with 3 of the 5 pitfall holes destroyed.

Through random sightings and salvage, four species were found in both Agriculture/old field and Mowed areas, three species in Woods/upland strata, and one Riparian strata (Table 9, Figure 11)

Discussion

After one year, the number of specimens documented are a good reflection of the methods being utilized. Small mammals such as mice (*Peromyscus* spp.) and voles (*Microtus* spp.) have been documented in habitat with which they are normally associated.

Expected Species

Of the 37 mammals that may be found in Ross County, Ohio, nine have yet to be documented in the park due to the restriction of sampling time and area or lack of appropriate habitat. Three are not expected to occur due to non-conducive habitat; three are listed as probably present, and three have unknown status.

The smoky shrew (*Sorex fumeus*) is commonly found in the Allegheny Plateau, in birch-hemlock forests. Habitat within park grounds do not seem conducive to this species, however, two specimens were caught near Chillicothe during another study (Gottschang 1981), which may be indicative of a range expansion into glaciated regions.

Similar to the smoky shrew, the hairy-tailed mole (*Parascalops breweri*) mainly occurs in areas of Ohio that are unglaciated. Although the Eastern portion of Ross County is unglaciated, all of the park units lie west of those areas. This mole prefers sandy loam, and may eventually move west onto park land.

The only squirrel not observed during this survey was the red squirrel (*Tamiasciurus hudsonicus*). Once again, habitat may have restricted their presence here. These squirrels prefer evergreen forests, however may occur in hardwood forests (Gottschang 1981). During sampling at all five park units, red squirrels have never been observed, however, specimens have been collected in counties southeast of Ross County. Clearing throughout Ohio is theorized to have extirpated these species, but the population has reestablished itself (Gottschang 1981). Their chatty scoldings will be listened for in the event they are heard or seen on park land.

Woodland voles (*Microtus pinetorum*) have copious amounts of habitat within park land, however their populations are considered cyclic and tend to be locally abundant in limited areas (Burt 1984; Gottschang 1981). Due to these fluctuations, woodland voles may occur within park land, but the past year may not been conducive to high numbers, thereby reducing the chances of sampling these voles.

The common Norway rat (*Rattus norvegicus*) is probably at the park, but were not present in the areas surveyed. The areas sampled ranged from fallow fields, woods, uplands, and riparian corridors. None of these were located near buildings that may have offered food and shelter, and thereby attracting higher numbers of these rodents. One site at Mound City Group is located near a “dump” area (fallen trees removed from trails and excess organic material is placed here). Neither pitfall or Sherman traps contained any rats, but perhaps their wary nature encouraged them to avoid the traps. Based on surveys of existing buildings, evidence of gnawing and burrows was not observed.

Neither habitat nor food for the long-tailed weasel (*Mustela frenata*) is lacking within park boundaries. These carnivores favor riparian areas, fencerows, forest edge and shrubby areas (Barbour and Davis 1974). Some of their main food items are mice and shrews, which were documented at all five park units. Due to their carnivorous and nocturnal nature, this weasel is difficult to document through the use of smaller Sherman traps and pitfalls. Based on their life history and abundance, this weasel is probably present at the park, however larger traps with meaty bait may be required to document their presence.

Southern bog lemmings (*Synaptomys cooperi*) are generally found in their namesake, however in Ohio they may occur in grassy fields (Gottschang 1981). In addition, southern bog lemmings have sporadic populations and are not consistently distributed (Barbour and Davis 1974). The park definitely has potential habitat for these rodents, however, only through continuous monitoring will their presence or absence be determined. Based on findings by Barbour and Davis (1974), these animals seem to refuse bait and are difficult to trap. Selective trapping location along active runways may provide a more successful determination of their presence.

Similar to other forest-dependent species, the gray fox (*Urocyon cinereoargenteus*) was once very common throughout Ohio, however, with the advent of settling and clearing, their numbers have fallen (ODOW 2004d). Some gray fox habitat, mainly woodlands, is present within park boundaries, however, evidence of them has been lacking. Their preference for areas with little human disturbance and heavily wooded areas with partial open brush land, has become less common in this state. In addition, the nocturnal habit of gray foxes increase the difficulty in observing these canines.

Badgers have not been recorded in Ross County, however, they are active in Deer Creek Wildlife Area, which spans three Ohio counties, Fayette, Madison and Pickaway. Pickaway and Fayette County border Ross County to the north and northwest, respectively, and the wildlife area is 34 miles from park grounds. Habitat, primarily grassland, is abundant at this park, as is their favorite food items- ground squirrels. It may simply be a matter of time for badgers to move into this area, as they have been observed to increase their range south and east (Gottschang 1981).

Mammals that were observed but no physical or photographic voucher were obtained are listed on Table 10. The seven species detected in this manner are included in the total number of mammals observed during this survey and include: eastern mole (*Scalopus aquaticus*), gray squirrel (*Sciurus carolinensis*), woodchuck (*Marmota monax*), beaver (*Castor canadensis*), coyote (*Canis latrans*), red fox (*Vulpes vulpes*), and mink (*Mustela vison*).

Mole activity can be seen on the grounds of Mound City unit and have been documented, however an actual specimen has not been observed. Because the range of hairy-tailed mole occurs only in the unglaciated portion of Ohio, which lies to the east of park land, the activity is probably due to the eastern mole.

Gray squirrels appear infrequently at Hopewell and Mound City. Although not native to Ohio, fox squirrels (*Sciurus niger*) are by far the dominant squirrel species in the woodlots of the park (ODOW 2004c). Gray squirrels have been observed by park staff only in heavily wooded areas and never in high numbers. These squirrels were once the most populous species in Ohio,

however, due to early settlement and clearing of trees, their numbers have declined (ODOW 2004e). As the parks woodlots mature, perhaps their numbers will increase.

Woodchuck burrows are found at various park units, especially Mound City Group and Hopewell Mound Group, with their inhabitants observed nearby. Their quick response to any disturbance has made it difficult to document these animals with a photograph. The obvious size of their burrows along with freshly disturbed soil are definite indicators of woodchucks utilizing park land.

Beavers had been extensively hunted in the past, leading to their extirpation in Ohio by 1830, however wildlife management practices have enabled their numbers to thrive once more (ODOW 2004a). Within the park, beavers have left their distinctive mark of chewed trees along the riparian area at Mound City. Tracks were also found and photographed in the same area. Mammal cameras were set-up in the area for a few nights to document their movement, however, no positive results developed. The activity was observed by the Scioto River, which is too large and swift for dam construction, therefore, the beavers may have been transient visitors, searching for better habitat (ODOW 2004a).

Another beneficiary of settlements in Ohio is the coyote, which is not native to Ohio, but can now be found throughout the state once forests were cleared (ODOW 2004b). Many sightings by park staff have been made of coyote, especially at Mound City and Hopeton units. Evidence of these canines was collected by photographing their scat and recording when observations were made. In addition, a road-kill deer was placed at Mound City in a remote location. Within the following week, coyote sightings increased, and the carcass was quickly consumed.

During an early morning bird survey in January, 2004, at Seip, a red fox was heard calling along the riparian area. The time of year overlaps their traditional courtship and mating period, therefore we may have disturbed their newly established den (ODOW 2004f). Movement was observed, and visual confirmation obtained when the fox began running along Paint Creek. Park staff have also observed red fox at Mound City in the more remote riparian corridor and hay field. This species is estimated to have moved into Ohio in the mid-1700s, coinciding with opening up of the forests for farmland.

Sightings of mink have been reported from Hopeton by archeologists working out in the field. A carcass was observed, however, by the time the biologist went out to confirm, the carcass had been removed by some opportunistic critter.

Conclusion

Management of land to ensure quality habitat for native mammals is an on-going process with many challenges. Several issues to consider are invasive plants, development and human population pressures, and cultural resources.

By far the biggest problem for this park is invasive plants. These invaders can out-compete native vegetation, and thereby decrease the quality of habitat and biodiversity in many areas. For field habitats, all potential management tools such as mowing, herbicide application, and prescribed burning should be considered in order to maintain open grassy areas. Riparian and forested areas should also be heavily managed for invasive species, with the use of manual removal and chemical application (when appropriate).

Another challenge to native wildlife is development. As more areas are converted to highways, houses, and other construction plans, less habitat is available for wildlife (Yoakum et al. 1980). Initial impacts that have irrevocably altered the mammals in Ohio was observed when the state was first settled and acres of woods were cleared. Forest-dependent species such as the gray fox and gray squirrel have dropped in numbers, and are now not as populous as species not native to Ohio such as the coyote, red fox, and fox squirrel. Based on this change, the goal of managing for mammals species native to Ohio may not be feasible, however, striving for high diversity and managing for species native to North America may be an appropriate goal.

Within the last ten years, the US Census Bureau recorded an increase in the human population of Ross County at 5.8% (U.S. Census Bureau 2003). This increase is a percentage point higher than the state average, indicating development may also increase. Areas targeted for housing are generally agriculture fields, which results in less areas for wildlife to utilize, especially as we found abundant wildlife in agriculture/old field strata. Due to the noncontiguous nature of this park, the potential for park land to become sinks for wildlife is a possibility, as lands surrounding park land is converted to buildings. Based on the results of this survey, all types of habitat was used by wildlife, therefore larger ecosystem-wide vision should be used when considering management on and off park land. Partnerships and networking with local, state and Federal agencies and organizations may help broaden the ecosystem view of the health of our landscape, and in turn create an awareness of maintaining and identifying important habitat and wildlife areas.

This park was established to preserve, protect, and interpret the remnants of the Hopewell, thereby increasing understanding of their culture. All management options should take into consideration the potential impact to cultural resources at this park. With this in mind, certain habitats cannot be managed for as they may have adverse impact to the cultural resources. An example is restoring agricultural fields to forested areas, as tree roots may damage cultural resources below ground and increase the difficulty of access for researchers to certain sites.

Unfortunately not all mammals work well with cultural resources, especially those that are considered destructive in their digging activities. Currently, thirteen-lined ground squirrels (*Spermophilus tridecemlineatus*) have established themselves in the mowed mounds at Mound

City Groups unit. Their population seems to be growing based on increased activity each year. Their small holes may cause problems when dug on established walkways. Potential control techniques range from habitat modification to lethal methods (poison, shooting, snaptraps) (Hawthorne 1980). Occasionally, woodchucks dig into reconstructed mounds, and are removed promptly when observed as their larger holes are detrimental to the mounds. The method currently in place to remove woodchucks is fumigants placed in their burrows.

Management options

Based on the results for the survey, this park offers a good mix of habitat for many mammal species. Conversion of agricultural fields to native warm season grassland and limiting mowing so as to provide cover year-round for wildlife will increase habitat quality. In addition to mammals, these practices will also help other wildlife species such as birds and insects.

Based on the high numbers of voles (*Microtus* spp.) found in Agriculture/old fields, the importance of these critters as a food source is valuable for raptors. Traditionally, the Ross-Pickaway County Line Road has been an important area for wintering raptors ranging from Northern harriers (*Circus cyaneus*), rough-legged hawks (*Buteo lagopus*), American kestrels (*Falco sparverius*), common barn-owls (*Tyto alba*), eastern screech owls (*Otus asio*), great horned owls (*Bubo virginianus*), and short-eared owls (*Asio flammeus*) (Thomson 1994). As development occurs along that road, the once fertile, open fields that attracted these birds of prey are disappearing. Of the five park units, the Hopeton Earthworks unit lies closest to this road, and may provide these birds an alternative site for hunting and roosting. Managing park units as a fallow field or restored to native warm season grasses may help to maintain the high levels of voles within park boundary, thereby increasing the number of predators that rely on them.

Currently the impact of white-tailed deer is not noticeable within park boundaries, however there is potential their numbers could increase, thereby increasing their feeding regimen. Monitoring of deer populations can be accomplished through deer-check stations of areas neighboring park boundaries. Throughout the state, this species is the most managed animal, as it offers important recreation opportunities for hunters, however, adverse impact to agricultural crops and natural areas are also monitored by the state (ODOW 2004g). Should problems such as visible deer browse lines or declines in forest regeneration occur, increased monitoring within park boundaries may be justified. In addition, the presence of Chronic Wasting Disease has not been documented in Ohio, however, should positive results arise, increased monitoring of deer populations should be established.

Long-term monitoring of mammals should also be considered. Sites that have been productive during this survey can be used continually to detect trends in population and diversity. Additional intensive studies that include marking the animals can also be conducted. Nearby schools in the area can also participate and potentially adopt certain areas to help with the monitoring effort.

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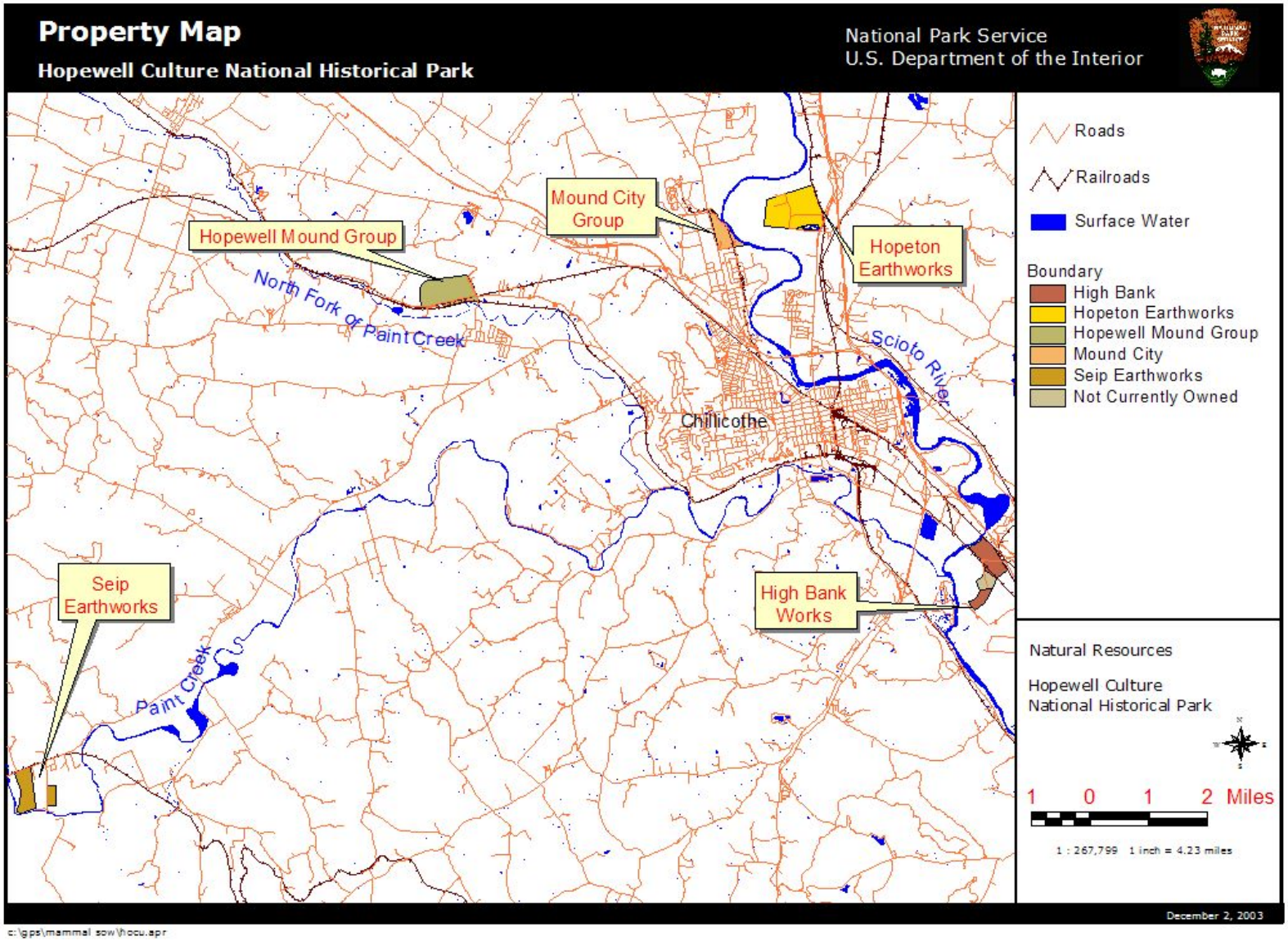


Figure 1. Map of Hopewell Culture National Historical Park, Chillicothe, Ross County, Ohio.

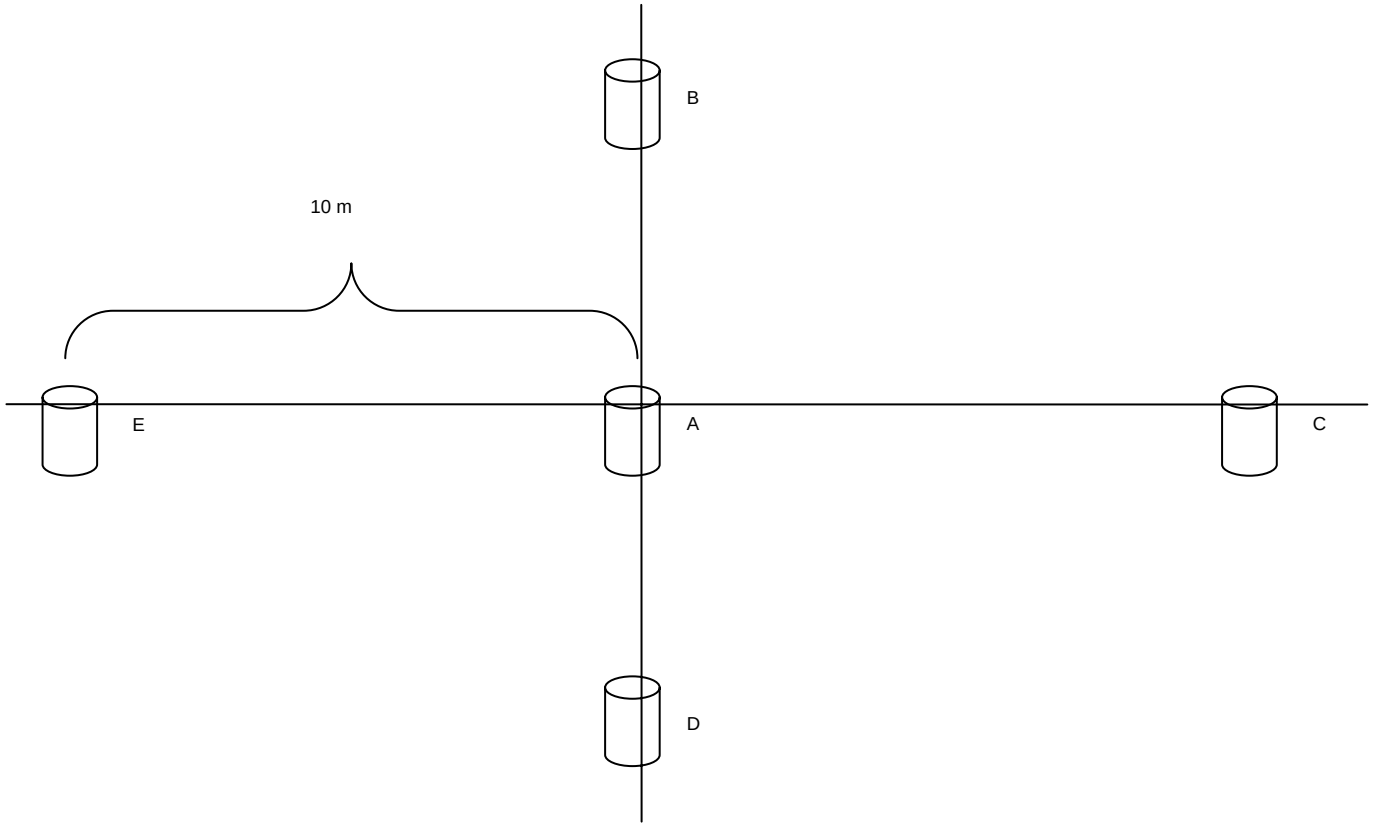
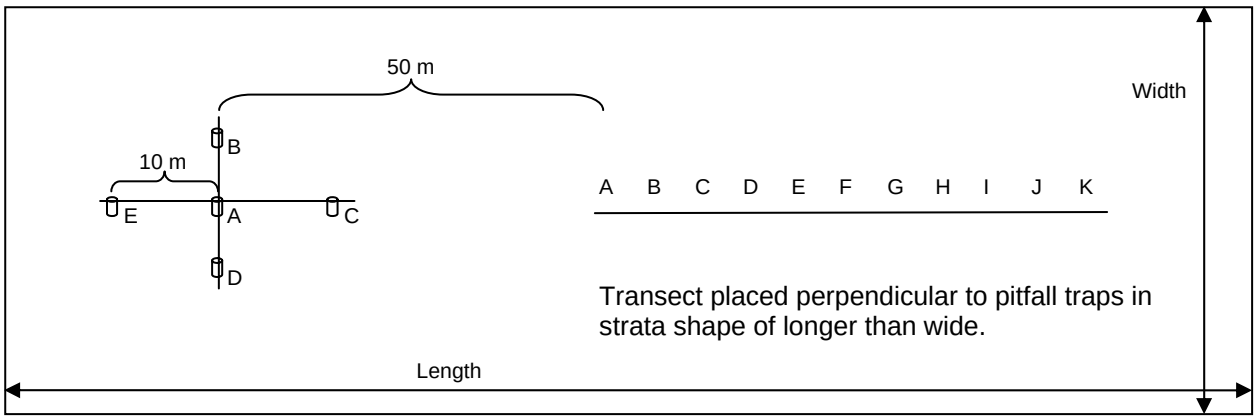


Figure 2. Cross-type design for pitfalls.



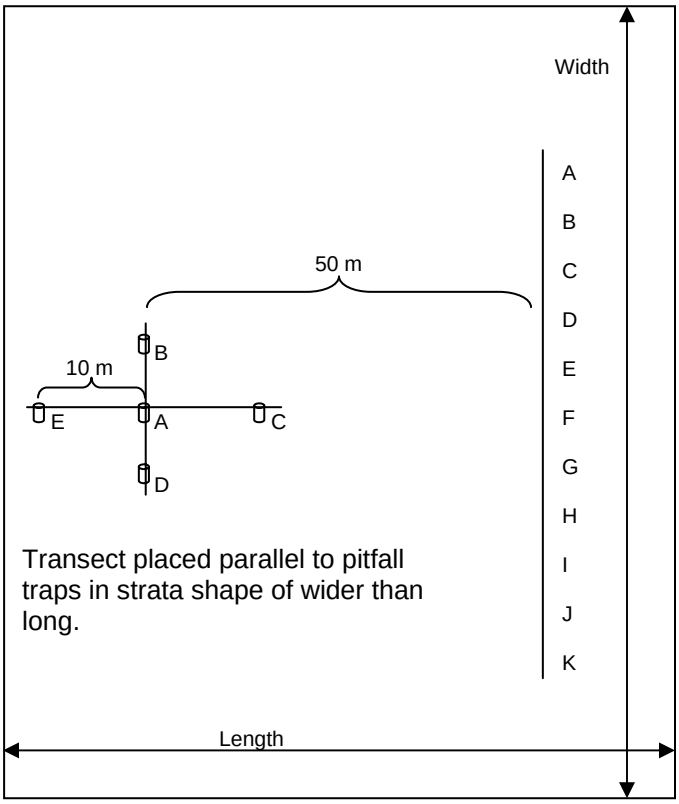


Figure 3. Location of transect relative to pitfall traps in different strata shapes (not to scale).

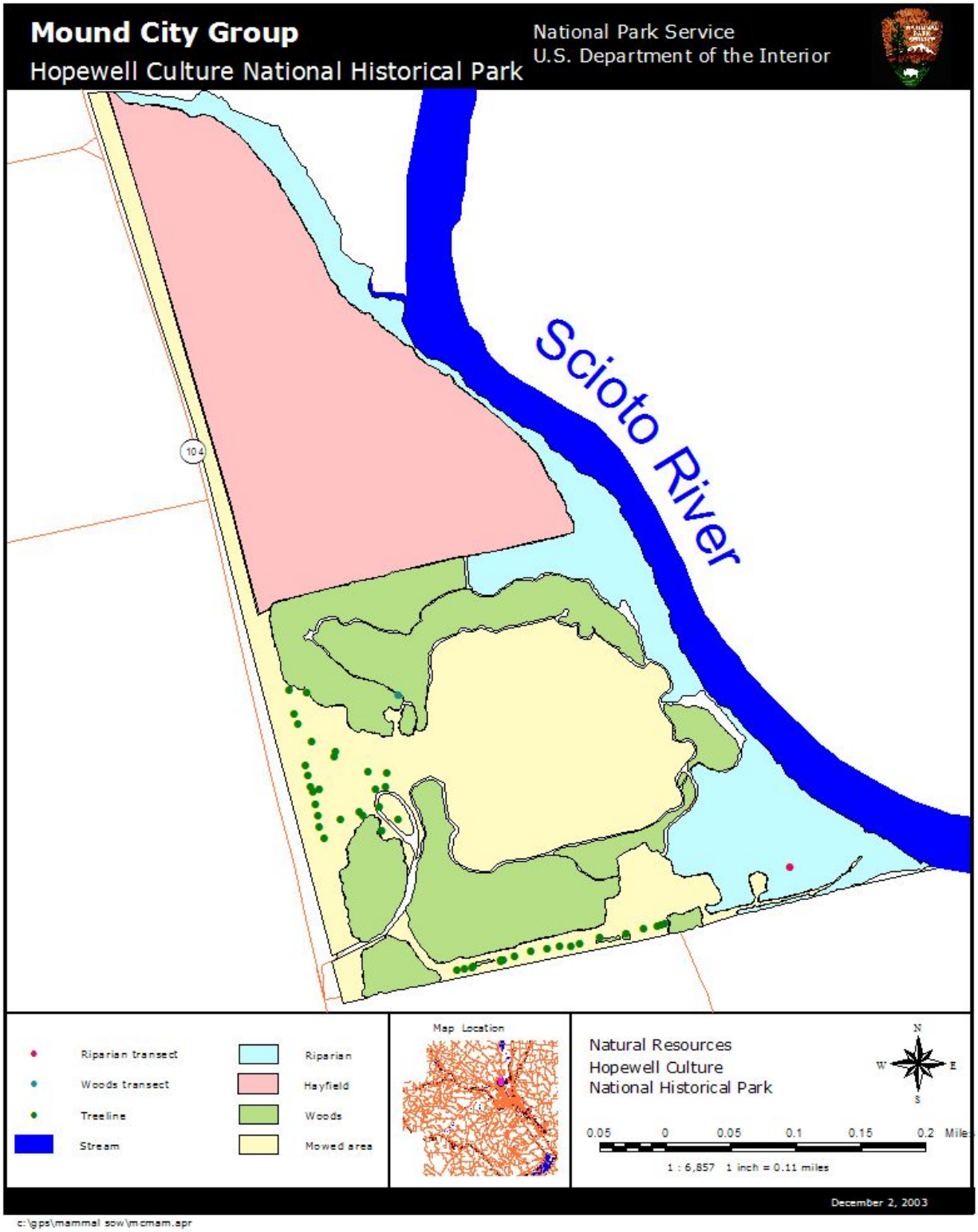


Figure 4. Map of Mound City Group with randomly selected mammal sites.

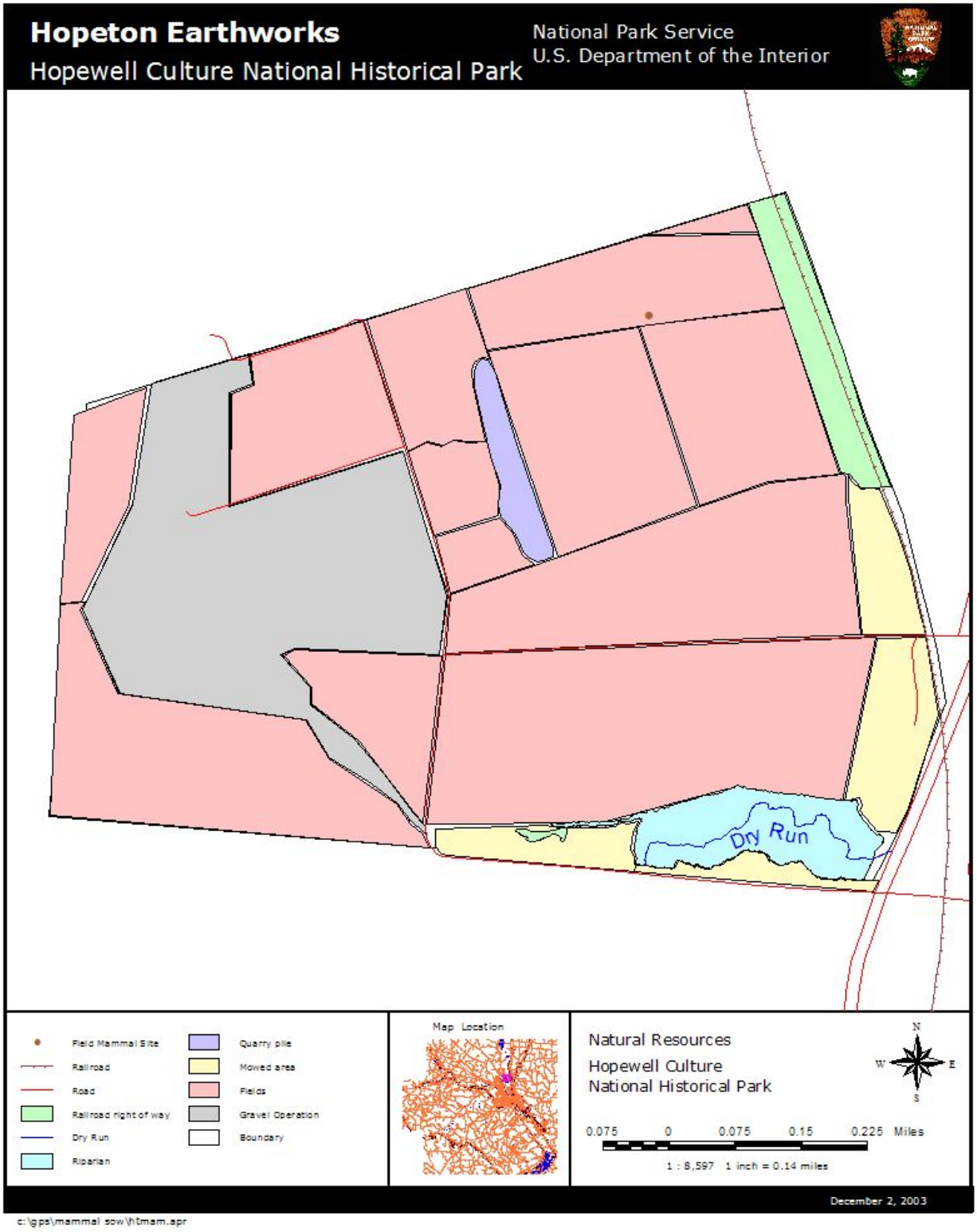


Figure 5. Map of Hopeton Earthworks with randomly selected mammal sites.

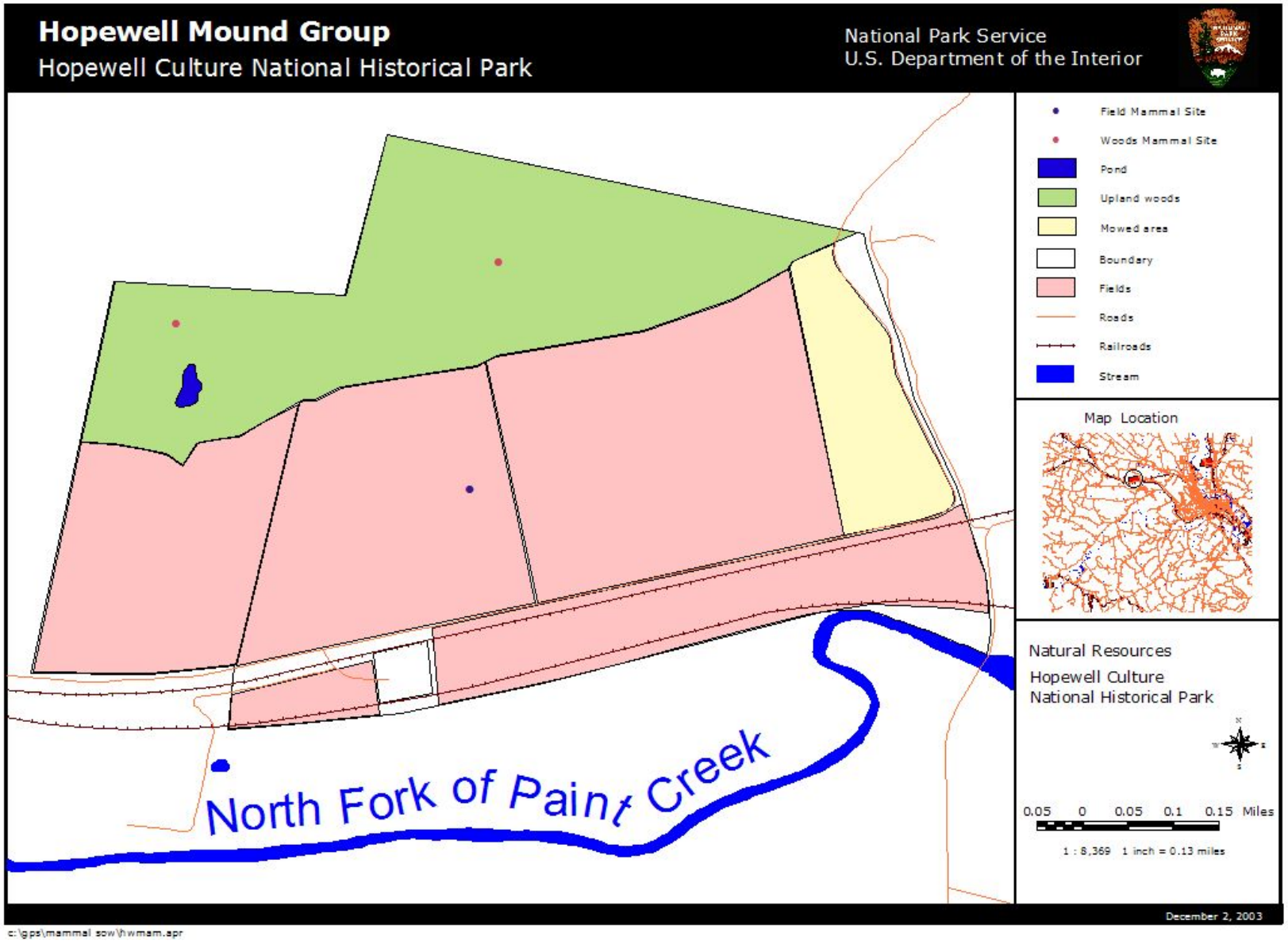


Figure 6. Map of Hopewell Mound Group with randomly selected mammal sites.

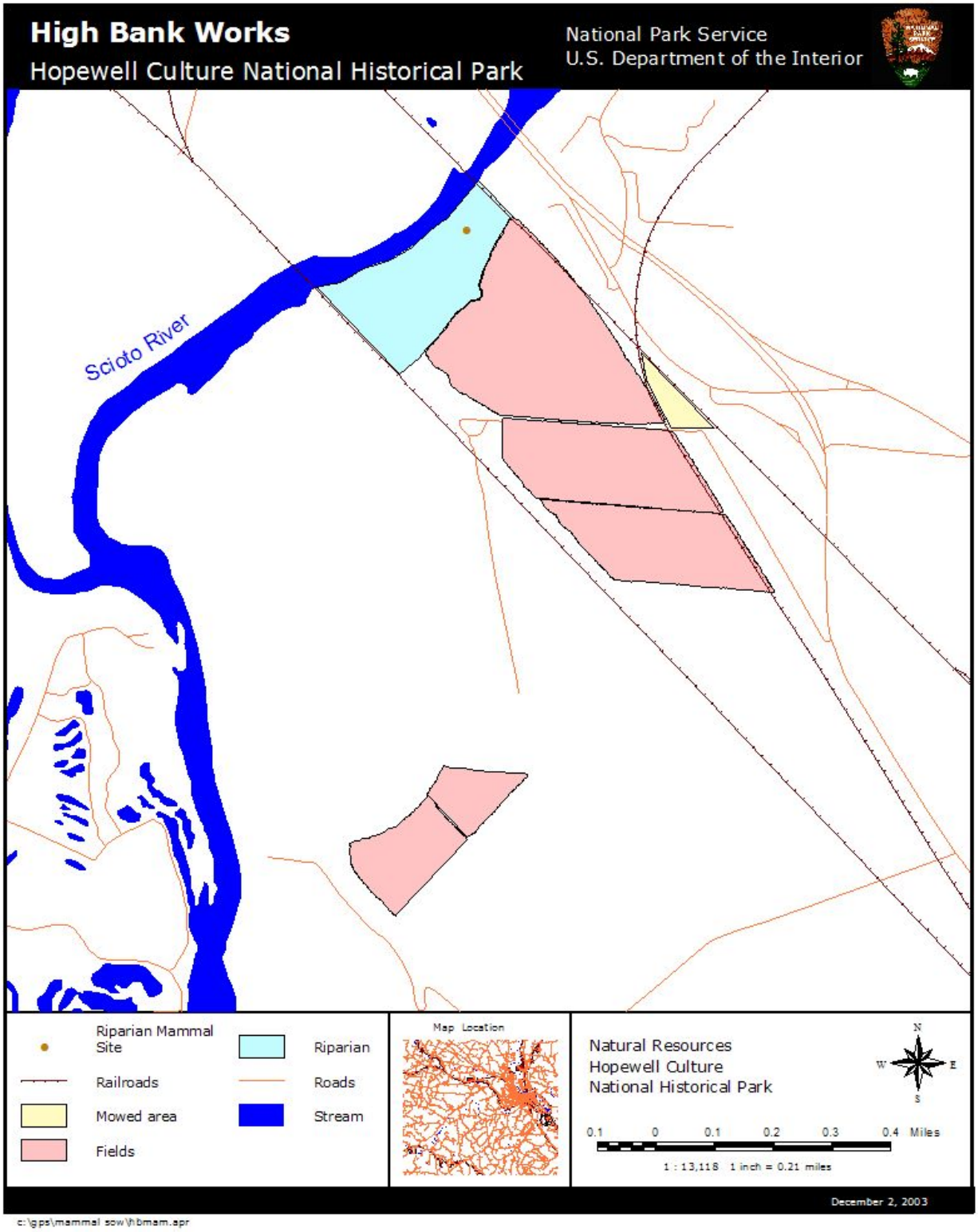


Figure 7. Map of High Bank Earthworks with randomly selected mammal sites.

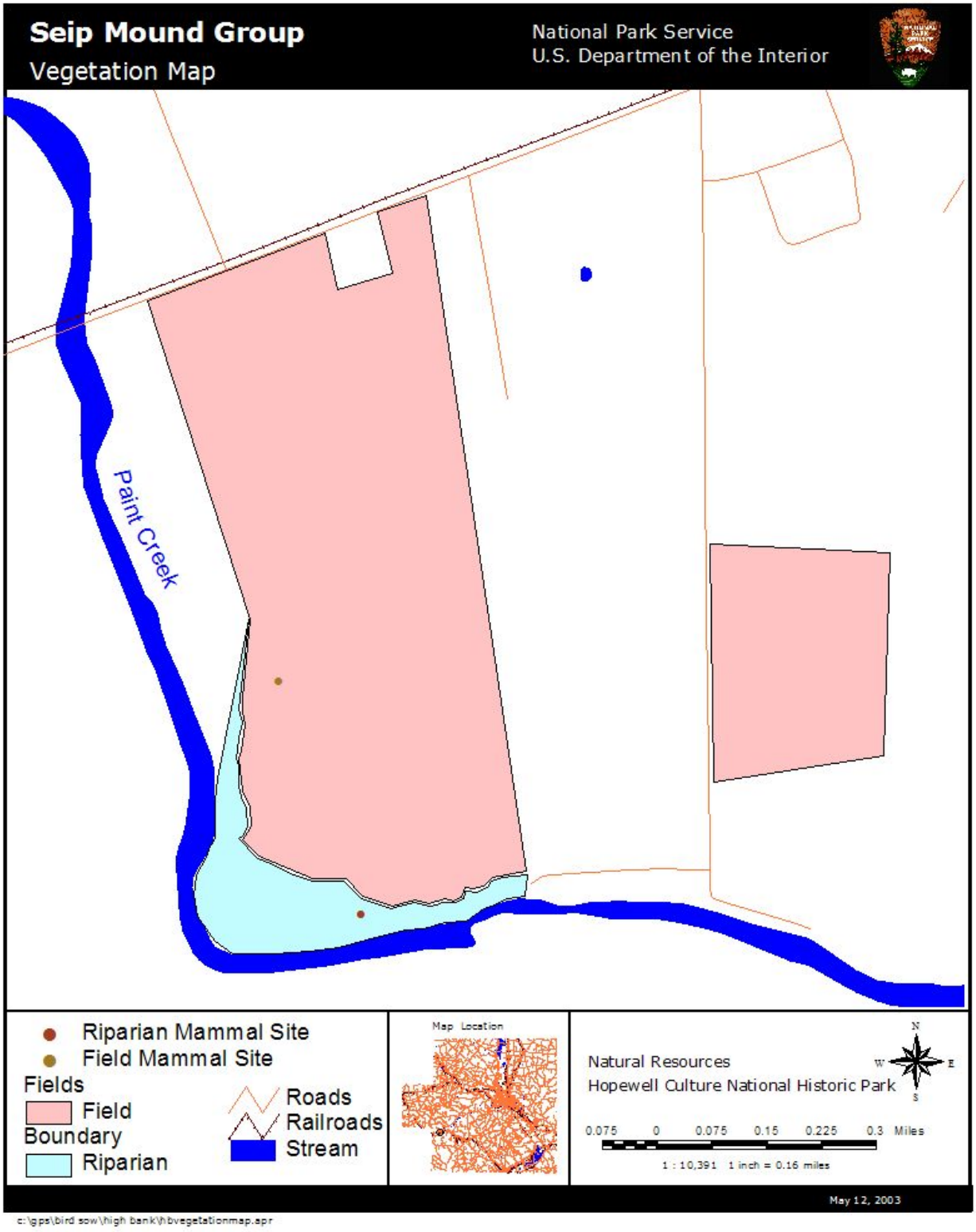


Figure 8. Map of Seip Earthworks with randomly selected mammal sites.

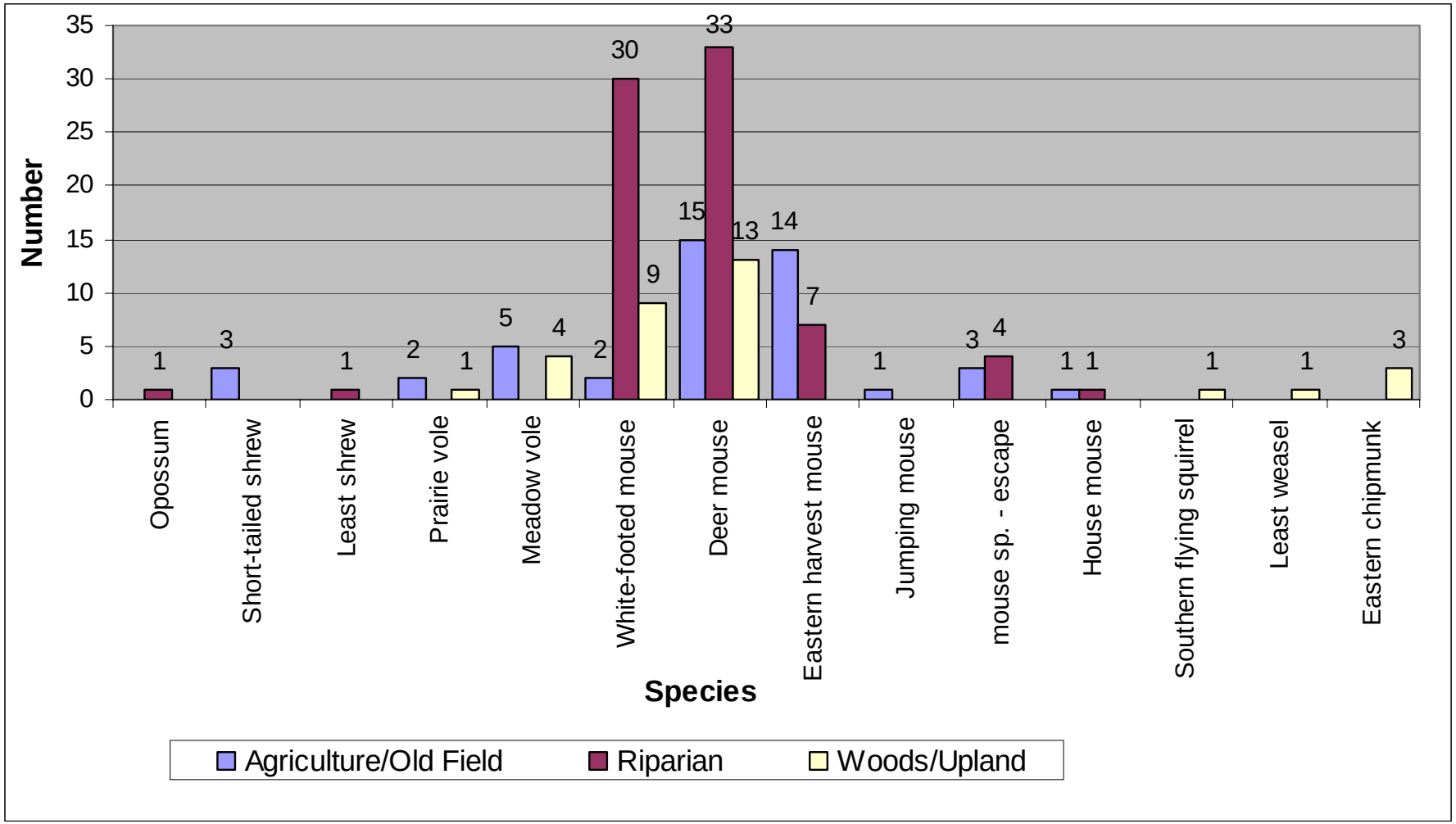


Figure 9. Mammal occurrence (transects) by strata at Hopewell Culture NHP.

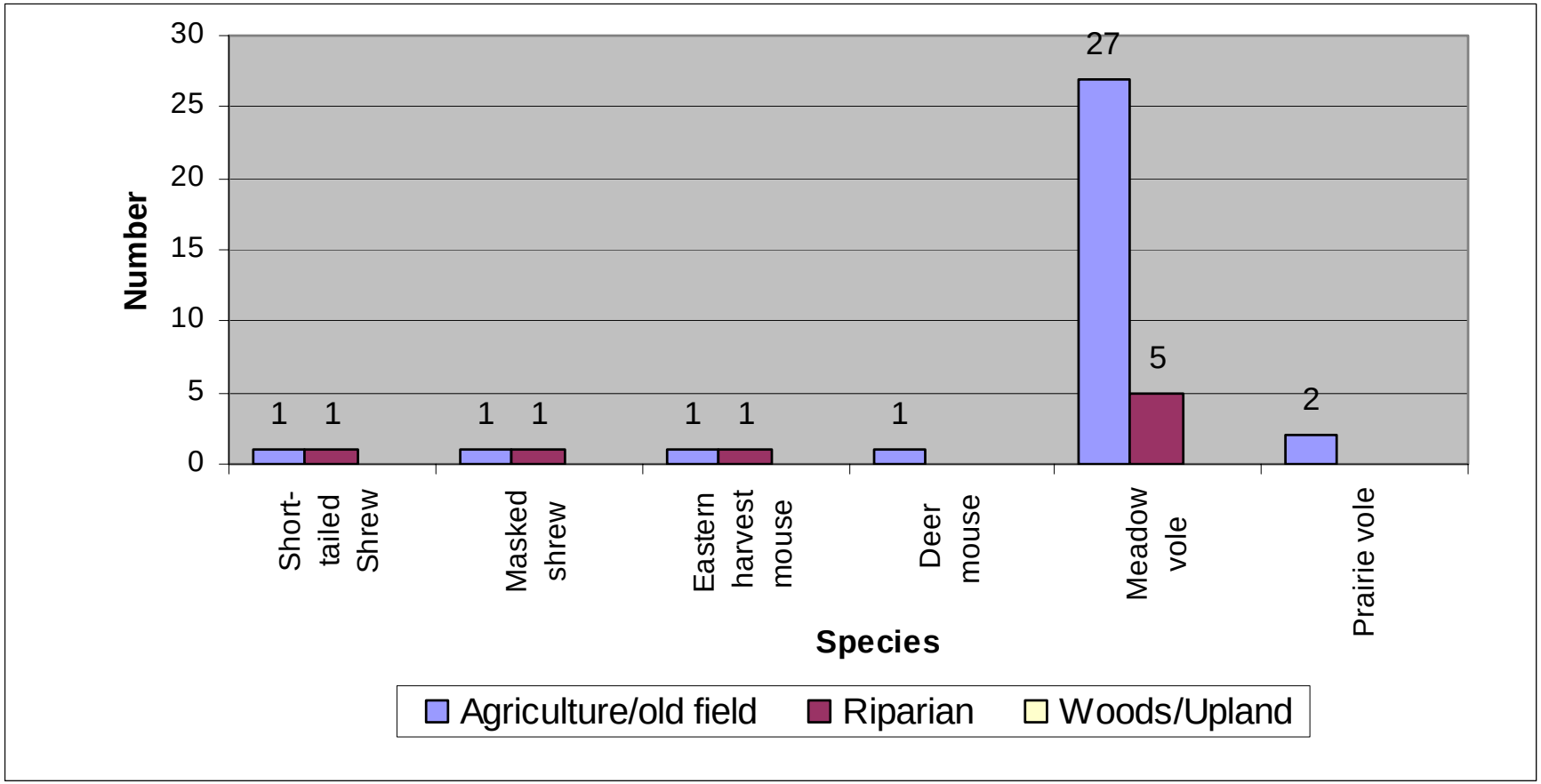


Figure 10. Mammal occurrence (pitfalls) by strata at Hopewell Culture NHP.

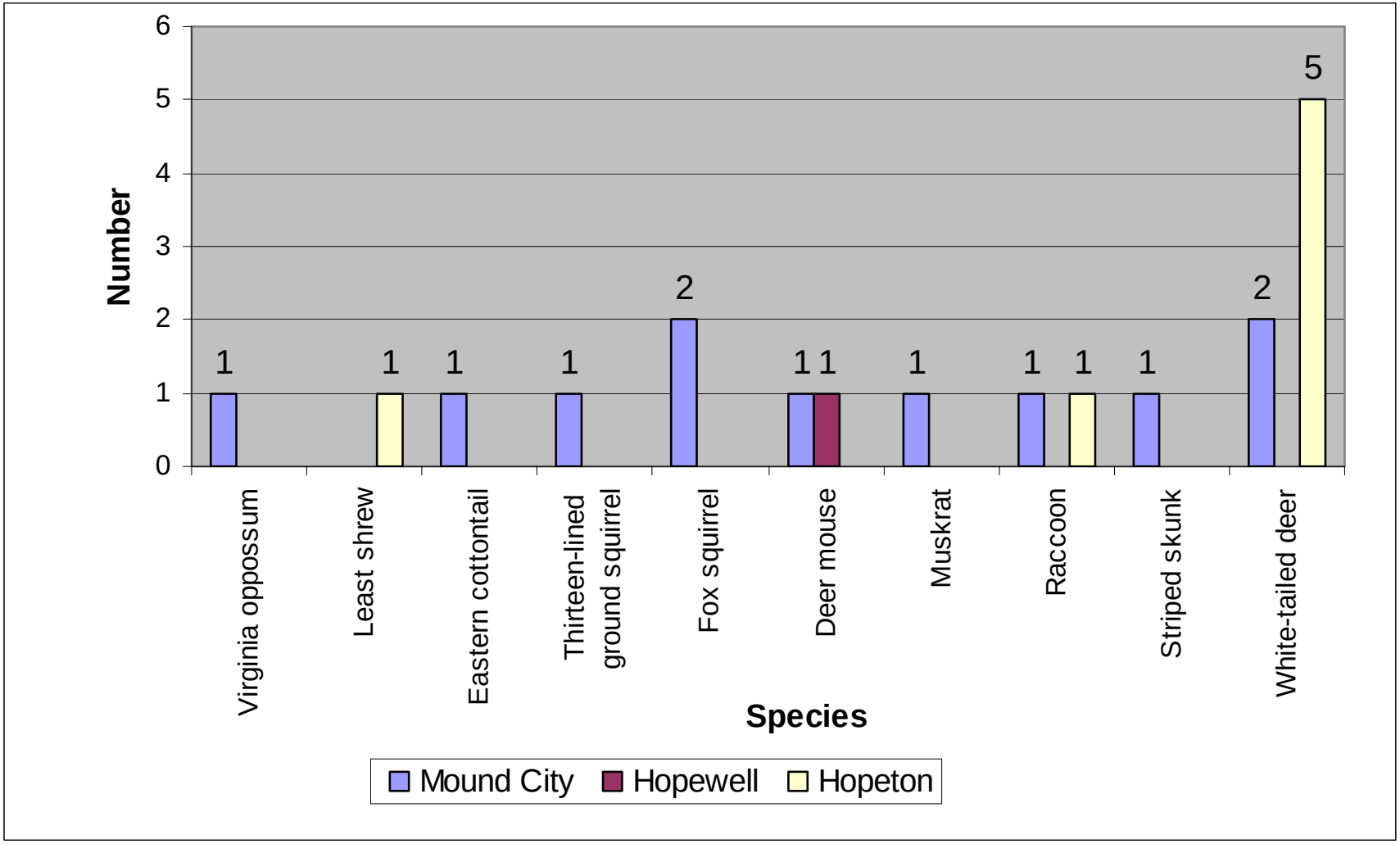


Figure 11. Random mammal observations at Hopewell Culture NHP..

Table 1. List of mammals expected and current status at Hopewell Culture NHP.

	Scientific Name	**Common Name**	**Park**	**Old**	**New**
1.	*Didelphis virginiana*	Virginia opossum	C	1	2
2.	*Blarina brevicauda*	Short-tailed shrew	C	1	2
3.	*Cryptotis parva*	Least shrew	U	1	2
4.	*Sorex cinereus*	Masked shrew	U	1	2
5.	*Sorex fumeus*	Smoky shrew	R-O	1	0
6.	*Parascalops breweri*	Hairy-tailed mole	R-O	1	0
7.	*Scalopus aquaticus*	Eastern mole	U	1	2
8.	*Sylvilagus floridanus*	Eastern cottontail	A	1	2
9.	*Sciurus carolinensis*	Gray squirrel	U	1	2
10.	*Sciurus niger*	Fox squirrel	A	1	2
11.	*Spermophilus tridecemlineatus*	Thirteen-lined ground squirrel	A	1	2
12.	*Glaucomys volans*	Southern flying squirrel	C	1	2
13.	*Tamias striatus*	Eastern chipmunk	C	1	2
14.	*Tamiasciurus hudsonicus*	Red squirrel	R-O	1	0
15.	*Marmota monax*	Woodchuck	A	1	1
16.	*Castor canadensis*	Beaver	U	1	2
17.	*Reithrodontomys humulis*	Eastern harvest mouse	U	1	2
18.	*Peromyscus leucopus*	White-footed mouse	A	1	2
19.	*Peromyscus maniculatus*	Deer mouse	A	1	2
20.	*Microtus ochrogaster*	Prairie vole	C	1	2
21.	*Microtus pennsylvanicus*	Meadow vole	A	1	2
22.	*Microtus pinetorum*	Woodland vole	U	1	1
23.	*Mus musculus*	House mouse	A	1	2
24.	*Rattus norvegicus*	Norway rat	C	1	1
25.	*Ondatra zibethicus*	Muskrat	U	1	2
26.	*Synaptomys cooperi*	Southern bog lemming	R	1	?
27.	*Zapus hudsonius*	Meadow jumping mouse	C	1	2
28.	*Canis latrans*	Coyote	C	1	2
29.	*Urocyon cinereoargenteus*	Gray fox	U	1	?
30.	*Vulpes vulpes*	Red fox	C	1	2
31.	*Procyon lotor*	Racoon	C	1	2
32.	*Mephitis mephitis*	Striped skunk	C	1	2
33.	*Mustela frenata*	Long-tailed weasel	U	1	1
34.	*Mustela nivalis*	Least weasel	U/C	1	2
35.	*Mustela vison*	Mink	U	1	2
36.	*Taxidea taxus* (SOC)	Badger	R	1	?
37.	*Odocoileus virginianus*	White-tailed deer	A	1	2

A= Abundant, C= Common, U= Uncommon, R= Rare, O= Does not occur due to lack of habitat. “Old” indicates the status prior the inventory, “New” the status after the inventory. Values for Old and New follow Boetsch et al (2000): a “1” is used to indicate that a given species is expected, “2” indicates that the species was observed (documented within the park); “?” indicates a questionable status.

Table 2. Habitat and acreage for each unit at Hopewell Culture NHP.
(areas inventoried are in bold font)

Unit/Strata	**WOODS/ UPLAND**	**Pitfall/ Transect**	**RIPARIAN**	**Pitfall/ Transect**	**AG/OLD FIELD**	**Pitfall/ Transect**	**TOTAL**
Mound City	**9.5 ha**	1/1	**7.4 ha**	1/1	15.8 ha		32.8 ha
High Bank			**11.7 ha**	1/1	48.2 ha		59.9 ha
Hopeton			5.5 ha		**96.1 ha**	1/1	101.6 ha
Hopewell	**33.6 ha**	2/2			**73.0 ha**	1/1	106.6 ha
Seip			**5.9 ha**	1/1	**58.2 ha**	1/1	64.1 ha
TOTAL	43.1 ha	3/3	30.6 ha	3/3	291.3 ha	3/3	365.0 ha

Table 3. Coordinates for the central pit in the pitfall cross design at each sampling site.

Site	Site ID	NAD 1983 CONUS	
		Easting	Northing
Hopewell	HWMAF1P_	319585	4358943
Hopewell	HWMAW1P_	319067	4359236
Hopewell	HWMAW2P_	319635	4359346
Mound City	MCMAR1P_	327647	4360310
Mound City	MCMAW1P_	327165	4360524
Seip	SPMAF1P_	307974	4345160
Seip	SPMARIP_	308113	4344767
High Bank	HBMAR1P_	334310	4352170
Hopeton	HTMAF1P_	329437	4361713

Table 4. Sampling schedule for mammal survey.

Site	Code Name	Round 1	Round 2	Round 3	Transect nights	Pit-fall nights
Hopewell	HWMAF1P_	June 2003	October 2003	February 2004	264	60
Hopewell	HWMAW1P_	June 2003	October 2003	February 2004	264	60
Hopewell	HWMAW2P_	July 2003	October 2003	February 2004	264	60
Mound City	MCMAR1P_	July 2003	November 2003	March 2004	264	60
Mound City	MCMAW1P_	July 2003	November 2003	March 2004	264	60
Seip	SPMAF1P_	August 2003	December 2003	April 2004	264	60
Seip	SPMARIP_	August 2003	December 2003	April 2004	264	48*
High Bank	HBMAR1P_	September 2003	January 2004	May 2004	264	60
Hopeton	HTMAF1P_	September 2003	January 2004	May 2004	264	60
				Total number of nights sampled	2376	528
				Agriculture/Old Field	792	180
				Woods/Upland	792	180
				Riparian	792	168

* Pit-fall traps were destroyed by flooding during the April, 2004 sampling.

Table 5. Abundance and voucher collection of mammals surveyed.

	Scientific Name	Common	Voucher	State	Ross County	Park
1.	*Didelphis virginiana*	Virginia opossum	Y	C	C	C
2.	*Blarina brevicauda*	Short-tailed shrew	P	C	C*	C
3.	*Cryptotis parva*	Least shrew	Y	U	U*	U
4.	*Sorex cinereus*	Masked shrew	Y	U	U	U
5.	*Sorex fumeus*	Smoky shrew	-	C	N*	R-O
6.	*Parascalops breweri*	Hairy-tailed mole	-	U/C	U/C	R-O
7.	*Scalopus aquaticus*	Eastern mole	O	C	U*	U
8.	*Sylvilagus floridanus*	Eastern cottontail	P	C	C*	A
9.	*Sciurus carolinensis*	Gray squirrel	O	C	C*	U
10.	*Sciurus niger*	Fox squirrel	P	C	C*	A
11.	*Spermophilus tridecemlineatus*	Thirteen-lined ground squirrel	P	C	C*	A
12.	*Glaucomys volans*	Southern flying squirrel	Y	C	C*	C
13.	*Tamias striatus*	Eastern chipmunk	P	C	C*	C
14.	*Tamiasciurus hudsonicus*	Red squirrel	-	U/C	U	R-O
15.	*Marmota monax*	Woodchuck	O	C	C*	A
16.	*Castor canadensis*	Beaver	O	C	C	U
17.	*Reithrodontomys humulis*	Eastern harvest mouse	Y	U	N	U
18.	*Peromyscus leucopus*	White-footed mouse	Y	C	C*	A
19.	*Peromyscus maniculatus*	Deer mouse	Y	C	C*	A
20.	*Microtus ochrogaster*	Prairie vole	Y	U/C	U/C*	C
21.	*Microtus pennsylvanicus*	Meadow vole	Y	C	C*	A
22.	*Microtus pinetorum*	Woodland vole	-	C	C*	U
23.	*Mus musculus*	House mouse	P	C	C*	A
24.	*Rattus norvegicus*	Norway rat	-	C	C*	C
25.	*Ondatra zibethicus*	Muskrat	Y	C	C	U
26.	*Synaptomys cooperi*	Southern bog lemming	-	U	U	R
27.	*Zapus hudsonius*	Meadow jumping mouse	P	C	C*	C
28.	*Canis latrans*	Coyote	O	C	C	C
29.	*Urocyon cinereoargenteus*	Gray fox	-	U	U	U
30.	*Vulpes vulpes*	Red fox	O	C	C	C
31.	*Procyon lotor*	Racoon	P	C	C*	C
32.	*Mephitis mephitis*	Striped skunk	P	C	C	C
33.	*Mustela frenata*	Long-tailed weasel	-	C	C	U
34.	*Mustela nivalis*	Least weasel	Y	U	U*	U/C
35.	*Mustela vison*	Mink	O	C	C*	U
36.	*Taxidea taxus* (SOC)	Badger	-	U	N	R
37.	*Odocoileus virginianus*	White-tailed deer	P	C	C*	A

P=picture voucher, Y=picture and body voucher, O=Other (see table 10); C= Common, U= Uncommon, N= Not Likely, A= Abundant, C= Common, U= Uncommon, R= Rare, O= Does not occur due to lack of habitat, SOC= Ohio Species of concern; * Record exists in Ross County (Gottschang 1981)

Table 6. Mammal species documented at each park unit.

	Scientific Name	Common	Mound City	Hopewell	Hopeton	High Bank	Seip
1.	*Didelphis virginiana*	Virginia opossum	1				1
2.	*Blarina brevicauda*	Short-tailed shrew		3			1
3.	*Cryptotis parva*	Least shrew			1		1
4.	*Sorex cinereus*	Masked shrew	1				
5.	*Sylvilagus floridanus*	Eastern cottontail	1				
6.	*Tamias striatus*	Eastern chipmunk	3				
7.	*Spermophilus tridecemlineatus*	Thirteen-lined ground squirrel	1				
8.	*Sciurus niger*	Fox squirrel	2				
9.	*Glaucomys volans*	Southern flying squirrel		1			
10.	*Reithrodontomys humulis*	Eastern harvest mouse				2	20
11.	*Peromyscus maniculatus*	Deer mouse	22	2	7	9	24
12.	*Peromyscus leucopus*	White-footed mouse	13		2	13	13
13.	*Peromyscus sp.*	Mouse sp. (escaped)			1		6
14.	*Microtus pennsylvanicus*	Meadow vole		28	2	4	2
15.	*Microtus ochrogaster*	Prairie vole		4			1
16.	*Ondatra zibethicus*	Muskrat	1				
17.	*Mus musculus*	House mouse	1		1		
18.	*Zapus hudsonius*	Meadow jumping mouse		1			
19.	*Procyon lotor*	Raccoon	1		1		
20.	*Mustela nivalis*	Least weasel		1			
21.	*Mephitis mephitis*	Striped skunk	1				
22.	*Odocoileus virginianus*	White-tailed deer	2		3		
		Total number of species	14	7	8	4	9
		Total number of individuals	50	40	18	28	69

Table 7. Mammal species collected in transects.

	Scientific Name	Common Name	Agriculture/ Old Field	Riparian	Woods/ Upland	Totals
1.	*Blarina brevicauda*	Short-tailed shrew	2			**2**
2.	*Cryptotis parva*	Least shrew	1			**1**
3.	*Glaucomys volans*	Eastern flying squirrel			1	**1**
4.	*Tamias striatus*	Eastern chipmunk			3	**3**
5.	*Reithrodontomys humulis*	Eastern harvest mouse	18			**18**
6.	*Peromyscus maniculatus*	Deer mouse	25	8	11	**44**
7.	*Peromyscus leucopus*	White-footed mouse	5	14	7	**26**
8.	*Peromyscus sp.*	Mouse	5			**5**
9.	*Microtus pennsylvanicus*	Meadow vole	5		3	**8**
10.	*Microtus ochrogaster*	Prairie vole	2		1	**3**
11.	*Mus musculus*	House mouse		1		**1**
12.	*Zapus hudsonius*	Jumping mouse	1			**1**
13.	*Mustela nivalis*	Least weasel			1	**1**
		Total number of species/individuals	**9/64**	**3/23**	**7/27**	**13/114**

Table 8. Mammal species collected in pitfalls.

	Species	Common Name	Agriculture/ Old field	Riparian	Woods/ Upland	Total
1.	*Sorex cinereus*	Masked shrew	-	1	-	**1**
2.	*Reithrodontomys humulis*	Eastern harvest mouse	-	1	-	**1**
3.	*Peromyscus maniculatus*	Deer mouse	1	-	-	**1**
4.	*Microtus pennsylvanicus*	Meadow vole	9	3	-	**12**
5.	*Microtus ochrogaster*	Prairie vole	1	-	-	**1**
		Total number of species/individuals	**3/11**	**3/5**	**0/0**	**5/16**

Table 9. Mammal species documented through other techniques

	Scientific Name	Common	Mound City	Hopewell	Hopeton	High Bank	Seip	Technique used
1.	*Didelphis virginiana*	Virginia opossum	1					Salvage-roadkill
2.	*Cryptotis parva*	Least shrew			1			Randomly caught in the field
3.	*Sylvilagus floridanus*	Eastern cottontail	1					Salvage-lawn mower
4.	*Spermophilus tridecemlineatus*	Thirteen-lined ground squirrel	1					Photographed outdoors
5.	*Sciurus niger*	Fox squirrel	2					Photographed outdoors
6.	*Peromyscus maniculatus*	Deer mouse	1	1				Caught in buildings
7.	*Ondatra zibethicus*	Muskrat	1					Salvage-cause of death unknown
8.	*Procyon lotor*	Raccoon	1		1			Salvage-cause of death unknown
9.	*Mephitis mephitis*	Striped skunk	1					Salvage-cause of death unknown
10.	*Odocoileus virginianus*	White-tailed deer	2		3			Salvage-roadkill
		Total number of species	9	1	3	0	0	
		Total number of individuals	11	1	5	0	0	

Table 10. Mammal species observed, but no photographic or physical vouchers were obtained.

	Scientific Name	**Common**	**Method of Observation**	**Park unit observed**
1.	*Scalopus aquaticus/ Parascalops breweri*	Eastern mole/ Hairy-tailed mole	Activity	MC
2.	*Marmota monax*	Woodchuck	Visual, Activity	MC, HW
3.	*Sciurus carolinensis*	Gray squirrel	Visual	MC, HW
4.	*Castor canadensis*	Beaver	Activity	MC
5.	*Canis latrans*	Coyote	Visual, Scat	MC
6.	*Vulpes vulpes*	Red fox	Visual, Audio	SP
7.	*Mustela vison*	Mink	Visual	HT

Appendix 1. Terrestrial habitat data form for Vertebrate and Vascular Plant Inventories.

Date: _____ Park: HB HT HW MC SP Plot ID #: _____

Surveyors: _____
UTM Zone:17N Datum: NADCON 1983 Easting: _____ Northing: _____ Project File: _____ WP#:_____

Location Description: _____

Quad: ___ T: ___ R: ___ S: ___ Plot size, length (m):__ width (m):__ radius (m):__ Photo Roll ID:__ Photo #:__

Site Characteristics:

Elevation (ft): _____ Slope: _____ Var: high med low Aspect: _____ Var: high med low

Topographic position: level toe slope lower-slope mid-slope upper-slope escarpment/face ledge crest depression draw

Slope-shape, Horizontal (30m): concave straight convex Vertical (30m): concave straight convex Surface water: in plot <50m >50m

Hydrologic regime: permanently flooded semi-permanently flooded seasonally/temporarily flooded intermittently flooded seep upland

Ground Cover: bryophyte/lichen 1 2 3 4 5 woody debris 1 2 3 4 5 grass litter 1 2 3 4 5 tree leaf litter 1 2 3 4 5
bedrock/boulder 1 2 3 4 5 gravel/cobble 1 2 3 4 5 sand/soil 1 2 3 4 5
(cover classes 1: <1%, 2: 1-5% 3: 5-25% 4: 25-50% 5: 50-100%)

Vegetation Description:
Leaf phenology (of uppermost stratum having > 10% cover):

Trees and shrubs
___Evergreen
___Deciduous
___Mixed (evergreen, deciduous)
Herbs
___Annual
___Perennial

Physiognomic class (see definitions):

___Forest
___Woodland
___Sparse Woodland
___Shrubland
___Sparse Shrubland
___Herbaceous
___Sparse Vegetation

Strata	Stratum Height[1]	Stratum Cover Class[2]	Dominant Species (list top 3-5 species in order; use = sign to indicate equal importance)
Canopy	1 2 3 4 5 6	A B C D	_____ _____ _____ _____ _____
Sub-canopy	1 2 3 4 5 6	A B C D	_____ _____ _____ _____ _____
Shrub	1 2 3 4 5 6	A B C D	_____ _____ _____ _____ _____
Herbaceous	1 2 3 4 5 6	A B C D	_____ _____ _____ _____ _____

[1]Stratum Height Classes: 1: <0.5m 2: 0.5-5m 3: 5-10m 4: 10-20m 5: 20-30m 6: >30m
[2]Stratum Cover Classes: A: <10% B: 10-25% C: 25-60% D: >60

Appendix 2. Scanned copy of National Park Service collection permit.

Search: Applications | Permits | IARs | Bibliographic References | Research Needs

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The National Park Service
U.S. National Park Service Research
Permit and Reporting System

SCIENTIFIC RESEARCH AND COLLECTING PERMIT

Grants permission in accordance with the attached general and special conditions

United States Department of the Interior
National Park Service

Hopewell Culture NHP

Study#: HOCU-00005
Permit#: HOCU-2003-SCI-0002
Start Date: Jun-01-2003
Expiration Date: Dec-01-2003
Coop Agreement#: n/a
Optional Park Code: n/a

Name of principal investigator:
Name: Mrs Myra Vick **Phone:** 740-774-1126 [illegible].a_Vick@nps.gov

Name of institution represented:
Hopewell Culture National Historical Park

Additional investigator(s):
Name: Constance Jones **Phone:**740-774-1126 **Email:**Constance_Jones@nps.gov

Project title:
Inventory of Distribution, Composition, and Relative Abundance of Mammals at Hopewell Culture National Historical Park within the Heartland Network Inventory and Monitoring Program

Purpose of study:
No general, comprehensive inventory of mammals at Hopewell Culture National Historical Park (HOCU) exists. A survey of the site will provide baseline data on species composition and relative abundance. This inventory will provide a foundation for future monitoring, allow for the determination and implementation of monitoring regimes, and help better manage resources and predict the possible impacts of management decisions on mammals. In order for scientifically sound management decisions to be made, basic information on species occurrence, distribution, and environmental data are needed to gain a cursory understanding of the role mammals have in ecosystems.

Locations authorized:
Surveying will be conducted on all five park units.

Transportation method to research site(s):
Access will be conducted through use of vehicles and by foot.

Collection of the following specimens or materials, quantities, and any limitations on collecting:
Any mid to small-sized mammals that are found already deceased and in relatively good shape to be used as voucher specimens.

Name of repository for specimens or sample materials if applicable:

Specific conditions or restrictions (also see attached conditions):
n/a

Appendix 3. Scanned copy of Ohio DNR Division of Wildlife collection permit.

DIVISION OF WILDLIFE

Ohio Department of Natural Resources

Division of Wildlife Headquarters
1840 Belcher Drive
Columbus, Ohio 43224-1300
1-800-WILDLIFE

SOCIAL SECURITY NUMBER: 575-90-3642

WILD ANIMAL PERMIT: 326

SCIENTIFIC COLLECTION

Others authorized on permit

NO

H.

MYRA H. VICK
16062 ST. RT. 104
CHILLICOTHE, OH 45601

STEVEN A GRAY
Chief, Division of Wildlife

6/2/2003
DATE ISSUED

is hereby granted permission to take, possess, and transport at any time and in any manner specimens of wild animals, subject to the conditions and restrictions listed below or any documents accompanying this permit.

This permit, unless revoked earlier by the Chief, Division of Wildlife, is effective from: 3/16/2003 to: 3/15/2004

This permit must be carried while collecting wild animals and be exhibited to any person on demand.

THIS PERMIT IS RESTRICTED TO THE FOLLOWING

1. Permittee must notify the Wildlife District office at least 24 hours prior to collecting. When collecting in Lake Erie, permittee must notify the Lake Erie Enforcement office at (419) 625-8062

2. Permittee must consult with Wildlife's Environmental Section prior to conducting any wild animal work associated with compliance requirements of the Clean Water Act (CWA), Section 401 and/or 404. The Fish Management Section an be reached at (614) 265-6308 (Bob Fletcher) or (614) 265-6631 (Becky Jenkins).

3. All gill nets must be marked with an 18" square yellow flag identifying the agency/institution/organization, name and permit number.

4. Collection is prohibited in Big Darby, Little Darby and Fish Creeks without explicit permission from the Division of Wildlife.

5. Previously unreported state fish and aquatic invertebrate species must be reported to the Division of Wildlife within 24 hours of collection.

Locations of Collecting:
MOUND CITY, HOPEWELL MOUND GROUP, HOPETON EARTHWORKS, HIGH BANK, SEIP EARTHWORKS

Equipment and method used in collection:
BIRS, FISH, MAMMALS

Name and number of each species to be collected:
FISH MAY BE TAKEN BY SEINES AND ELECTROSHOCKER, BIRD & MAMMALS ARE SALVAGE

RESTRICTIVE DOCUMENTS ACCOMPANYING THIS PERMIT? NO

This permit is not valid for collecting migratory birds, their nests, or eggs unless a current permit from the U.S. Fish and Wildlife Service has been obtained.

NO ENDANGERED SPECIES MAY BE TAKEN