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Northeast Region
Philadelphia, Pennsylvania



Survey for Endangered and Threatened Mammals at Gettysburg National Military Park and The Eisenhower National Historic Site

Technical Report NPS/NER/NRTR--2006/044



ON THE COVER

The field between the Slyder and Granite Farms, Gettysburg National Military Park, site of capture of a specimen of the least shrew (*Cryptotis parva*).

Photograph by: James A. Hart

Survey for Endangered and Threatened Mammals at Gettysburg National Military Park and The Eisenhower National Historic Site

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Northeast Region
Philadelphia, Pennsylvania

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Abstract and Keywords

Small mammal surveys were conducted in Gettysburg National Military Park and Eisenhower National Historic Site to determine what state or federally threatened or endangered small mammal species may occur within the two park units. Nine survey sites were selected in open lands which would likely support populations of the least shrew, *Cryptotis parva*, a species listed as endangered in Pennsylvania and the only state endangered species known to occur in south central Pennsylvania. Although this shrew ranged throughout much of Pennsylvania historically, it is currently thought to be restricted to the Piedmont Province of Pennsylvania.

Over the course of 2,650 trap-nights of effort (number of traps multiplied by the total number of nights traps were set), a single specimen of the least shrew was collected along with a single specimen of the pygmy shrew, *Sorex hoyi*, a species very rarely encountered in Pennsylvania although not currently listed as endangered or threatened. Other species captured included 29 northern short-tailed shrews (*Blarina brevicauda*), 72 white-footed mice (*Peromyscus leucopus*), 4 Norway rats (*Rattus norvegicus*), 370 meadow voles (*Microtus pennsylvanicus*), 1 woodland vole (*M. pinetorum*) and 37 meadow jumping mice (*Napaeozapus insignis*). A representative sample of all specimens captured is currently housed at the State Museum of Pennsylvania's Mammal Collection awaiting final deposition.

The information gathered will assist in defining boundaries for the Least Shrew Important Mammal Areas (IMA) site. Future research funded by the State Wildlife Grants program will be directed at defining habitat variables within the landscape of the IMA that are important in sustaining populations of the least shrew.

Keywords- NPS, Terrestrial small mammals, least shrew, *Cryptotis parva*, conservation, Important Mammal Area Project, Threatened and endangered species, pygmy shrew, *Sorex hoyi*, Gettysburg National Military Park, Eisenhower National Historic Site

Executive Summary

During May 2004 to October 2005, small mammal surveys were conducted in Gettysburg National Military Park and Eisenhower National Historic Site to determine what federal or state threatened or endangered small mammal species may occur within the two park units. Survey transects consisting of 20 to 25 stations, each containing a single pitfall container and either three or four Museum Special[®] snaptraps, were established at 10 sites within both park units. The survey sites selected were areas which would likely support populations of the least shrew, *Cryptotis parva*, a species listed as endangered in Pennsylvania and the only state endangered species known to occur in south central Pennsylvania. This species had formerly been captured in the Eisenhower National Historic Site in 1999 during surveys conducted by the Pennsylvania Natural Heritage Program under funding from the Pennsylvania Game Commission. It is currently believed that the least shrew, a medium-sized insectivore that ranged throughout much of Pennsylvania historically, is currently restricted to the Piedmont Province of Pennsylvania. Over the course of 2,650 trap-nights of effort (number of traps multiplied by the total number of nights traps were set), 515 specimens of eight species of small mammals were collected including a single specimen of the least shrew. A single specimen of the pygmy shrew (*Sorex hoyi*), a species very rarely encountered in Pennsylvania, was also collected although this species is not currently listed as either threatened or endangered in Pennsylvania. The information gathered during the latest research will be used to better define the boundaries of the Least Shrew Important Mammal Area as defined by the Important Mammal Areas (IMA) Project of the Mammal Technical Committee of the Pennsylvania Biological Survey. Future research funded by the State Wildlife Grants program will be directed at defining habitat variables within the landscape of the IMA that are important in sustaining populations of the least shrew.

Introduction

During 1999, small mammal surveys were conducted at Eisenhower National Historic Site in an attempt to determine whether the least shrew (*Cryptotis parva*) occurred within the park (Hart 2000B). Two specimens were captured at that time. One specimen was taken within a reverting agricultural field east of the Eisenhower Farm and another was taken along Willoughby Run on the Redding Farm (Hart 2000a) (Figure 1.). Since the least shrew is listed as “State Endangered” (Kirkland and Krim 1990), it was decided at the time to conduct further surveys within Eisenhower National Historic Site as well as the Gettysburg National Military Park in an attempt to further understand the distribution of this small insectivore.

During May 2004 to October 2005, small mammal surveys were conducted in Gettysburg National Military Park and Eisenhower National Historic Site to determine what federal or state threatened or endangered small mammal species may occur within the two park units although the only known listed species to occur in south central Pennsylvania is the least shrew.

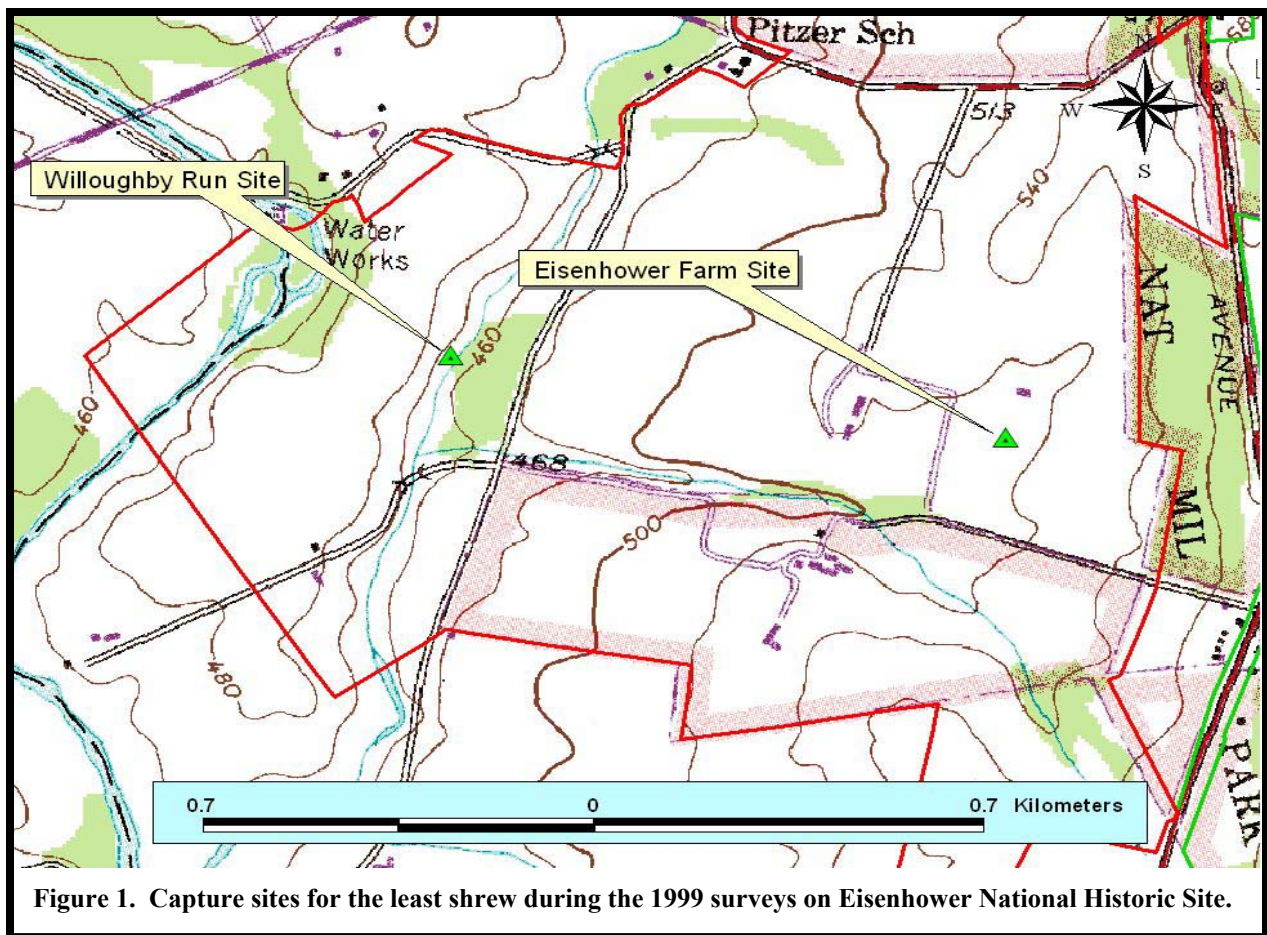
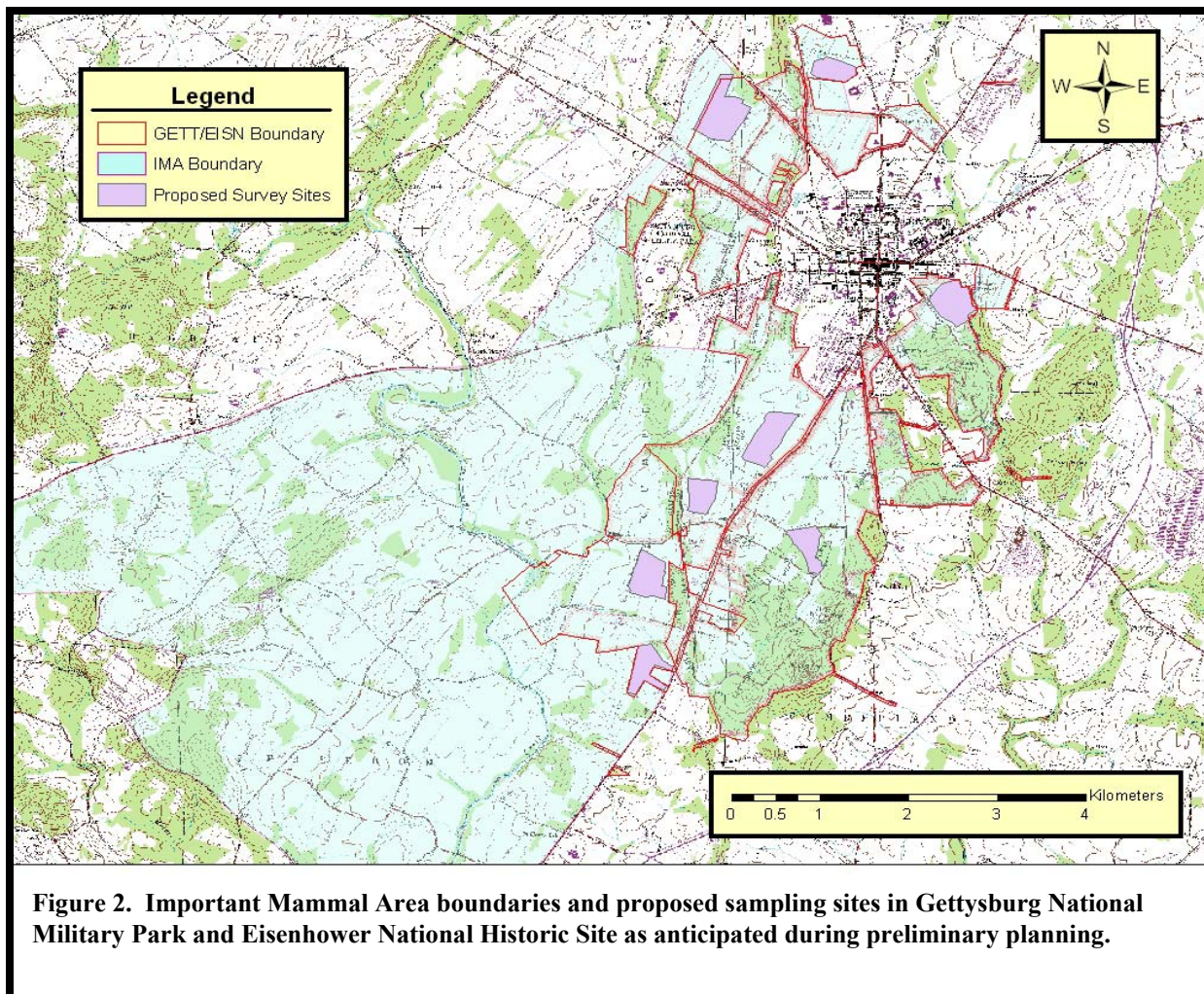


Figure 1. Capture sites for the least shrew during the 1999 surveys on Eisenhower National Historic Site.

Previous surveys conducted across Pennsylvania during the 1940's and 1950's revealed a much more extensive distribution for the least shrew (Gifford and Whitebread 1951, Grimm and Roberts 1950, Grimm and Whitebread 1952, Richmond and Roslund 1949, Roberts and Early

1952, Roslund 1951) than presently known. Since 1962, only 6 specimens have been taken at 5 sites over the course of over 15,000 trapnights of survey effort at both historical sites as well as new locations across the state that provide potential habitat for the least shrew. This research would suggest that the least shrew has declined over much of its range in Pennsylvania and may be presently restricted to the Piedmont Province in the south-central and southeastern portion of the state (Kirkland and Hart, 1999). If this is correct, Gettysburg National Military Park and Eisenhower National Historic Site become very important as a refuge for the least shrew within the state. The presence of the least shrew has compelled the Mammal Technical Committee of the Pennsylvania Biological Survey to designate the area as an Important Mammal Area (IMA) as shown in Figure 2. The current IMA includes the Eisenhower National Historic Site and Gettysburg National Military Park as well as several adjacent properties outside park boundaries where the least shrew, the only state listed mammal species known to occur within the boundaries of the two NPS units, was captured during surveys conducted in 2001.



The survey sites selected within Gettysburg National Military Park and Eisenhower National Historic Site were areas which would likely support populations of the least shrew. The majority

of the presently-defined IMA has not been surveyed for the least shrew, though the area appears to provide appreciable habitat to support the shrew at populations that would promote its stability in this portion of the state. Conservation of sites throughout the IMA would allow least shrew dispersal within and among populations, provided corridors are created and maintained. Further research is to be conducted during 2006-2007 by the Pennsylvania Natural Heritage Program in an attempt to discern the ecology of this small insectivore within the currently described IMA boundaries.

Project Area

Gettysburg National Military Park and Eisenhower National Historic Site comprise approximately 1,700 ha of land occurring along the Gettysburg-Newark Lowland Section of the Piedmont Physiographic Province in south-central Pennsylvania. Although the highest point in the study area is Big Round Top at 240m (785'), the mean elevation is just over 160m (525') (Yahner 1991). The drainages of Rock Creek, Marsh Creek, Plum Run, and Willoughby Run dominate the hydrology of the area, with many small intermittent tributary streams. The general topography consists primarily of rolling hills (Yahner 1991) with approximately 55% in agriculture or managed grasslands, 31% in forest and 14% in some form of development. Dry Oak - Mixed Hardwood Forest is the most common forest type (Perles et al., 2005) with oak (*Quercus* spp.), hickory (*Carya* spp.) and tulip poplar (*Liriodendron tulipifera*) as the canopy dominants. Grassland habitats are a mixture of types, including active agricultural fields and early successional shrublands and old fields.

Materials and Methods

Site Selection

Study sites for general surveys of terrestrial small mammals were selected on the basis of plant community structure and land usage (Perles et al. 2005) patterns based upon information concerning least shrew habitat requirements as described by Whitaker (1974). High intensity agricultural fields and heavily pastured sites were excluded due to the low likelihood of the presence of the least shrew. Figure 3 shows what typical least shrew habitat, composed primarily of grasses with little woody vegetation. This particular site, a wet meadow subject to periodic inundation, was surveyed during 1999 and resulted in the capture of a single specimen of the least shrew. During the 1999 surveys, a heavy period of rain resulted in this site being completely flooded. The survey transect was opened about 2 weeks after the flood event, with the specimen being captured the second night of the survey approximately 5m from Willoughby Run.



Figure 3. Typical least shrew (*Cryptotis parva*) habitat as occurring at a known capture site on the Redding Farm, Eisenhower National Historic Site.

Study sites selected had areas of 1 to 5 hectares so that the time invested in survey transect set-up was minimized. This also allowed the survey of several sites at the same time. A preliminary site assessment was conducted April 9th 2004 whereupon nine sites were found to contain habitat likely to support populations of the least shrew. These sites are depicted in Figure 4. In some cases, as with several fields within the vicinity of Culp's Hill and the base of Little Roundtop, sites with appreciable habitat were not accessible due to either high tourist visitation or the presence of livestock. The original sampling plan was to conduct surveys between late July and early October 2004, however, several occurred during June so that the amount of survey transects investigated could be maximized. Although the original Pennsylvania Game Commission (PGC) protocols stipulate surveys be conducted in late summer, the available habitat within Gettysburg National Military Park and Eisenhower National Historic Site appears such that large, stable populations of the least shrew could occur there. A single transect was also set up during October 2005 to resurvey several fields within the area of the Slyder and Granite Farms.

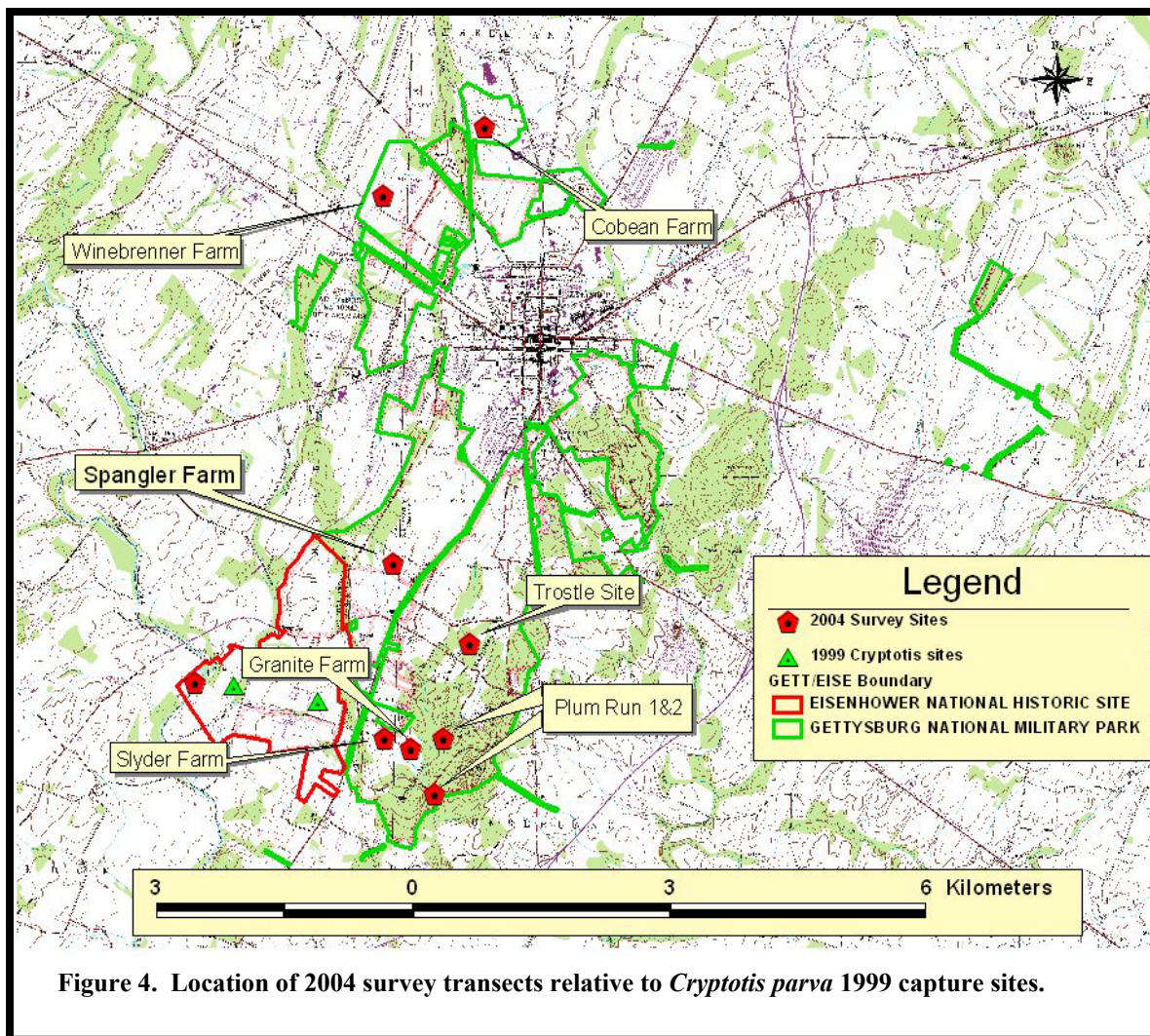


Figure 4. Location of 2004 survey transects relative to *Cryptotis parva* 1999 capture sites.

Survey Protocols

A combination of survey methods including pitfall trapping and snap-trapping was employed to survey for the presence of the least shrew and to document the presence of any other mammal species that may occur. Use of these methods, as outlined by the American Society of Mammalogists (1998) is regarded as the only feasible way for determining the occurrence, or lack thereof, of uncommon small mammal species including any that may be of special concern, rare or vulnerable.

A Collecting Permit (COL00106) was obtained from the PGC as required by law and all data acquired was reported to the Wildlife Diversity Section of the PGC Bureau of Wildlife Management. A research permit was also obtained from the NPS.

Within each selected site, a single rectangular shaped transect consisting of 20 to 25 stations 15 m apart was laid out. At each station a pitfall container (14.5 cm wide, 19.5 cm deep) was installed below ground level along with 3 or 4 Museum Special[®] snap-traps (7 cm wide, 14 cm long) set in a “best site” approximately 0.5 m from the pitfall container. A “best site” was defined as a runway or natural barrier that would tend to direct the travel of small mammals and increase capture success. Pitfall containers were baited with peanut butter applied to the rim of the container while snaptraps were baited with a mixture of rolled oats and peanut butter.

All pitfall containers and snap-traps were checked once daily in the early morning and a representative sample including at least 2 to 4 specimens of various ages and sexes of all species collected were prepared as voucher specimens (DeBlase and Martin 1981). Voucher specimens are stored at the Pennsylvania State Museum in Harrisburg. All soil removed in order to install the pitfall container was returned to the resulting hole upon completion of the survey. The survey methods outlined here are somewhat comparable to those as established by the PGC Wildlife Diversity Section under the advisement of the author of this report (PGC 2002) as noted in Appendix A. Figure 5 depicts just how a pitfall would appear along a survey transect.

A lack of any least shrew captures during the 2004 field season necessitated a change in the protocols to increase the number of pitfall containers used and eliminate the Museum Special[®] snaptraps. The social nature of the least shrew (Whitaker 1974) may cause “clumping” of the population so that the relatively restricted size of the original transect might limit the successful capture of any least shrews. Although the majority of specimens captured were by snaptraps, the species captured were primarily northern short-tailed shrews (*Blarina brevicauda*) and meadow voles (*Microtus pennsylvanicus*) which are not the targeted species. Also, the use of Museum Special[®] snaptraps might not be viable due to the lack of successful captures of least shrews with that type of trap. The protocols as outlined by the PGC were intended as guidelines for consultants and were previously used by PGC personnel to survey for all terrestrial small mammals. Although proven to work for other species, when the protocols were created for surveying for least shrews, there was not enough information available to determine whether they were appropriate. Studies like the present one illustrate possible shortcomings of the protocols such that in the future, a revised version of the protocols will be established.



During October 2005, 100 pitfall containers were set up in the fields between the Snyder and Granite Farms as depicted in Figure 6 (Figure A8 in Appendix B), the only site surveyed during 2005. This site was chosen because of the quality of habitat available. Surveys were conducted in October. The survey period was increased from 3 consecutive nights, as established in the original protocol, to 10 consecutive nights. This was done due to the lower capture rates predicted to occur using only pitfalls. A representative sample, as defined previously, of all species collected was processed in the field (i.e., identified, tagged and bagged) for shipment to the Pennsylvania State Museum where they will, at a later date, be prepared and temporarily housed until arrangements are made for transfer to another repository.

Table 1 contains locations, number of traps used, and short site descriptions for all sites investigated during 2004-2005. The position of every 5th station was taken with a Garmin GPS III+ and although not differentially corrected due to the nature of the GPS unit used, a positional accuracy of approximately 3-5m was obtained. All fieldforms containing all collected data were forwarded to the appropriate NPS authority.

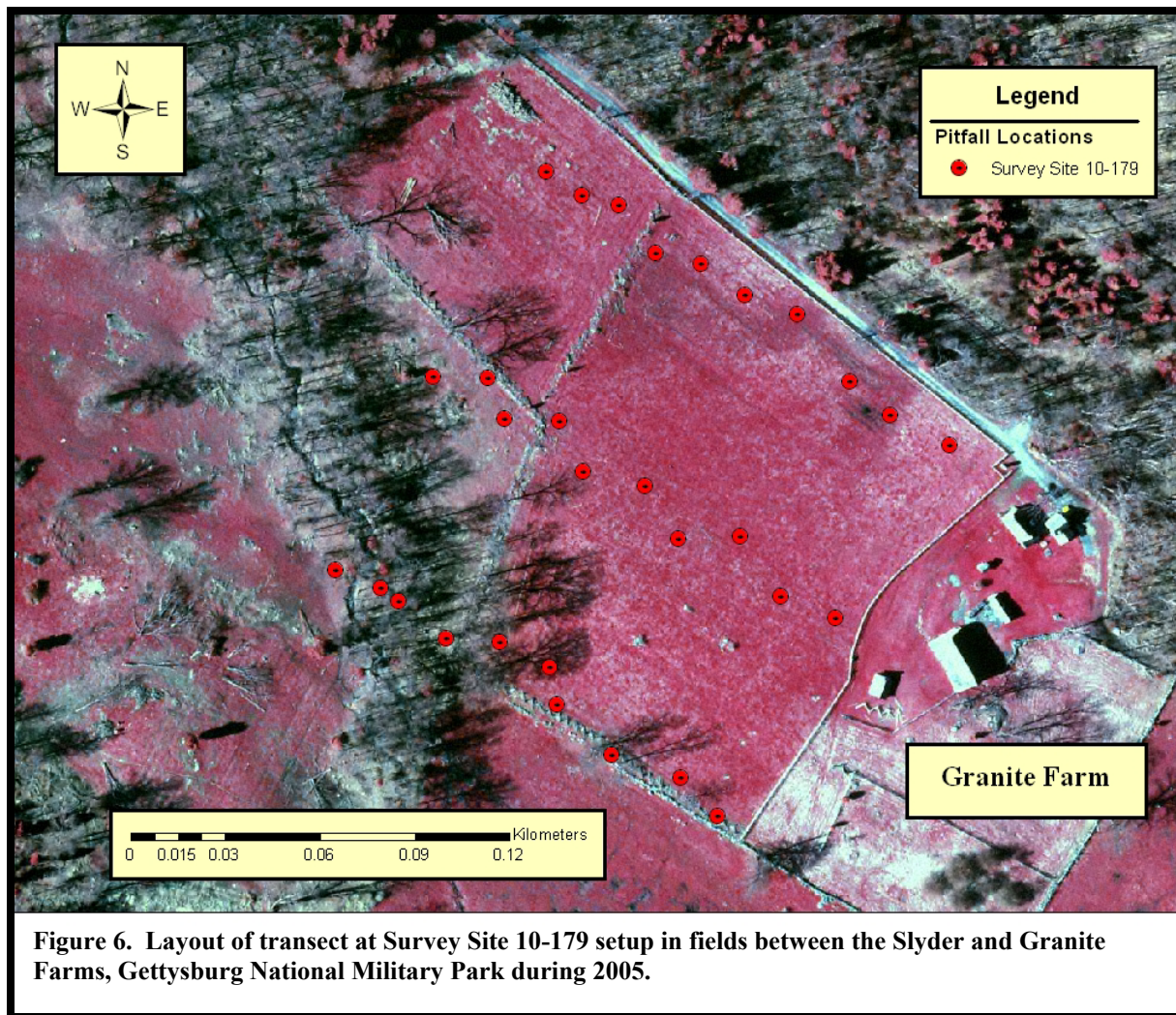


Table 1. Locations and descriptions of survey sites investigated during small mammal trapping at Gettysburg National Military Park and Eisenhower National Historic Site during 2004-2005.

Site Name and Number	Traps Used	Dates Surveyed	Latitude	Longitude	Site Description	Total Trapnights
Cobean Farm 10-154	Pitfalls- 20 Snaptraps-80	7/26 to 7/28, 2004	39-51-09	77-14-24	Vegetation consists of various forbs and oldfield vegetation. Part of field in CREP grasses.	300
Winebrenner Farm 10-155	Pitfalls- 20 Snaptraps-80	7/26 to 7/28, 2004	39-50-41	77-15-13	Vegetation was a mixture of forbs including ironweed, thistles and, in spots, impatiens. Vegetation was fairly diverse.	300
Trostle Farm 10-156	Pitfalls- 25 Snaptraps-25	7/27 to 7/29, 2004	39-47-57	77-14-24	A very diverse proliferation of forbs throughout the field. Forbs include Pileweed, heal all, milkweeds, black haw, umbrella sedge, red top, asters, blue vervain and eastern coneflower, a listed species. A bottled gentian was also found during a botany trip during August.	150
Marsh Creek 10-157	Pitfalls- 20 Snaptraps-80	8/9 to 8/11, 2004	39-47-42	77-16-38	Vegetation consists of various forbs and oldfield vegetation. Field is also cropped periodically.	300
Spangler Farm 10-158	Pitfalls- 20 Snaptraps-80	8/9 to 8/11, 2004	39-48-27	77-15-04	Grasses, grains and forbs make up most of the vegetation of this field with some cedars and shrubs also present.	300
Plum Run #1 10-159	Snaptraps-50	8/9 to 8/11, 2004	39-47-25	77-14-36	Hardwoods and shrubs along Plum Run. Many invasive species such as Japanese barberry and multi-flora rose present. Stream is deeply cut and very narrow in places. Cardinal flower and Great Lobelia occurred all along the stream.	150
Granite Farm 10-160	Pitfalls- 20 Snaptraps-80	8/23 to 8/25, 2004	39-47-18	77-14-52	Field consists of grains and forbs with very few shrubs scattered throughout the field.	300
Slyder Farm 10-161	Pitfalls- 20 Snaptraps-80	8/23 to 8/25, 2004	39-47-21	77-15-03	This field was primarily a mixture of woodlots and fields until cutting occurred during 2000. It is now a successional field made up primarily of many different herbaceous plants and shrubs.	300
Plum Run #2 10-162	Snaptraps-50	8/24 to 8/26, 2004	39-47-03	77-14-40	Primarily red maple, various hickories along with some sycamore. Invasive species such as barberry and multi-flora rose occur throughout the area.	150
Slyder/Granite Farms 10-179	Pitfalls- 100	10/03 to 10/07, 2005	39-47-21	77-14-58	Field consists of grains and forbs with very few shrubs scattered throughout the field. An old fencerow runs through the middle of the site. Scattered trees occur along the edges of site and along fencerow. A small stream runs through the last 3 rows of pitfalls.	400

Results

During the summer and fall of 2004 and the fall of 2005, 10 transects were set up at nine different sites to survey for the least shrew, a species listed as endangered in Pennsylvania and the only state endangered species known to occur in south central Pennsylvania. No federally listed small mammal species are known to occur within Gettysburg National Military Park and Eisenhower National Historic Site. Table 2 shows the results for small mammal trapping during the summer and fall of 2004 at Gettysburg National Military Park and Eisenhower National Historic Site as well as the surveys conducted during fall 2005 within the field between the Slyder and Granite Farms, Gettysburg National Military Park. Maps of all survey transect set-ups can be found in Appendix B. These maps depict the location of every 5th station along each transect as a more precise location for every trap was not necessary.

During the course of the project, 2,650 trap-nights (number of traps multiplied by the total number of nights traps were set) resulted in the capture of 515 specimens of 8 species (Table 1.) for an effort of 19.4 specimens per 100 trap-nights. Species, and number of specimens captured included 370 meadow voles (*Microtus pennsylvanicus*), 72 white-footed mice (*Peromyscus leucopus*), 37 meadow jumping mice (*Zapus hudsonius*), 29 northern short-tailed shrews (*Blarina brevicauda*), 4 Norway rats (*Rattus norvegicus*), and 1 each of the woodland vole (*Microtus pinetorum*), pygmy shrew (*Sorex hoyi*), and least shrew (*Cryptotis parva*). The most commonly encountered species among all sites included the northern short-tailed shrew (9 of 10 sites), meadow vole (8 of 10 sites) and white-footed mouse (8 of 10 sites). The meadow jumping mouse was found at three sites while the least shrew and pygmy shrew were only found at one site each. Although the majority of sites were located near farm buildings or in areas that the Norway rat would commonly be found, it was only taken at one site, the Spangler Farm, Gettysburg National Military Park.

In terms of the number of species taken at each site, five species were taken at one site, four at four sites, three at one site, and two at four sites. The most diverse site was the Spangler Farm and the least diverse sites were along Plum Run, two sites that were primarily non-grassland type habitats. Temporal comparisons revealed that there was very little difference between the numbers of specimens taken per 100 trapnights ranging from 20.9 specimens during July 2004 to 22.5 specimens during August 2004. The rate of capture for October, 2005 was approximately 5.0/100 trapnights, but this was most likely due to a change of protocols to include only pitfall traps in the transect and the fact that the line was closed upon the capture of the target species, the least shrew, as per the PGC protocol, resulting in fewer trapnights of effort (Appendix A). Closing the trapline upon capture of any listed species ensures that populations are not impacted by over sampling.

Trap success varied considerably with 89.9% of the specimens being taken in Museum Special[®] snap-traps and only 10.1% taken in pitfalls. Although other researchers have noted the success of pitfalls using drift fence to direct small mammals into the traps (Kirkland and Sheppard 1994), pitfall arrays lacking drift fence material are not as productive overall in open habitats. The use of drift fencing, however, restricts the overall size of the transect such that a much smaller area is sampled. As noted, this may reduce the efficiency of the sampling effort due to possible “clumping” of least shrew populations (Whitaker 1974). Pitfall traps, however, are more

Table 2. Results of small mammal trapping at Gettysburg National Military Park and Eisenhower National Historic Site during 2004-2005.

Site Name	Site Number	Set up date	Species Captured ^a								Total TN ^b	Totals Specimens
			<u>CRPA</u>	<u>SOHO</u>	<u>BLBR</u>	<u>PELE</u>	<u>RANO</u>	<u>MIPE</u>	<u>MIPI</u>	<u>ZAHU</u>		
Cobean Farm	10-154	7/26/04			1	10		44		4	300	59
Winebrenner Farm	10-155	7/26/04			1			68			300	69
Trostle Field	10-156	7/27/04				1		28			150	29
Marsh Creek	10-157	8/9/04			1	19		25		32	300	77
Spangler Farm	10-158	8/9/04		1	2	4	4	72			300	83
Plum Run #1	10-159	8/9/04			5	19			1		150	25
Granite Farm	10-160	8/23/04			5			71			300	76
Slyder Farm	10-161	8/23/04			7	7		51		1	300	66
Plum Run #2	10-162	8/24/04			3	8					150	11
Slyder/Granite	10-179	10/03/05	1		4	4		11			400	20
Totals			1	1	29	72	4	370	1	37	2650	515

^a CRPA- least shrew (*Cryptotis parva*), SOHO- pygmy shrew (*Sorex hoyi*), BLBR- northern short-tailed shrew (*Blarina brevicauda*), PELE- white-footed mouse (*Peromyscus leucopus*), RANO- Norway rat (*Rattus norvegicus*), MIPE- meadow vole (*Microtus pennsylvanicus*), MIPI-woodland vole (*Microtus pinetorum*), ZAHU- meadow jumping mouse (*Zapus hudsonius*)

^b TN- Trapnights

successful at the capture of shrew-sized mammals due to their weights of less than 5 gm which are too low to activate most types of live- and snaptraps. During the present study, no shrew species smaller than the northern short-tailed shrew were taken in Museum Special[®] snap-traps.

Discussion

Yahner et al. (1994) originally predicted the occurrence of 59 mammal species at both Gettysburg National Military Park and Eisenhower National Historic Site based on range maps found in Burt and Grossenheider (1980), a somewhat outdated and inaccurate source for this type of information. Yahner et al. (1994) also did not consider the specialized habitat requirements of many of these species nor their current known range in Pennsylvania. Foremost among the species not expected to occur within the study sites are the long-tailed shrew (*Sorex dispar*), northern water shrew (*S. palustris albibarbis*), Allegheny woodrat (*Neotoma magister*), northern flying squirrel (*Glaucomys sabrinus*), rock vole (*Microtus chrotorrhinus*), snowshoe hare (*Lepus americana*) as well as several furbearers including the fisher (*Martes pennanti*), martin (*M. americanus*) and river otter (*Lontra Canadensis*). Noteworthy for not being included in Yahner et al. (1994) are two insectivores, the least shrew (*Cryptotis parva*) and pygmy shrew (*Sorex hoyi*), both of which were considered by Genoways and Brenner (1985) to be listed as “Status Unknown”. Subsequent research (Keller et al. 1999) refined the predicted list to exclude all the above noted species except the woodrat and rock shrew. That research still failed to confirm the presence of the least shrew and pygmy shrew although the mammal faunal list was updated and more accurately reflects the species expected to occur. Although Yahner et al. (1994) and some subsequent studies reported very little information concerning the species of the mammalian order Chiroptera (bats), these species will be addressed under a separate study conducted by Hart (2006 in progress).

Further research (Van Fleet and Kirkland 1995) was conducted on Gettysburg National Military Park as part of an environmental study of the Codori-Trostle Woodlot prior to historical restoration to determine whether any federal or state-listed mammal, bird, reptile, or amphibian species occurred there. The mammal-trapping protocols used during that study were established by Kirkland and Sheppard (1994) and targeted primarily small, terrestrial mammal species such as rodents and insectivores. No new species were captured or reported during that study.

As mentioned previously, Hart (2000B) conducted surveys at several sites on Eisenhower National Historic Site and captured two specimens of the least shrew. This species is currently listed as state endangered and is likely declining throughout much of the interior portions of its northeastern US range. It may have been extirpated from Ohio and New York, although information concerning its present status in these states is lacking. Table 3 lists the least shrew’s current status in the northeast portion of the United States with comments on its status according to NatureServe (2004).

Although the least shrew is listed as secure in Virginia, most of the research conducted concerning this species has been carried out along the coastal areas. Kirkland (1990) found that during a study of the feral house mouse (*Mus musculus*) on Wallops Island, the least shrew was the second most abundant species captured after the house mouse in non-tidal marshes and grasslands areas.

Table 3. Status of the least shrew (*Cryptotis parva*) in the northeast and in states surrounding Pennsylvania.

Rank Classification ¹	States	Comments
SNR	DE, OH	Under review or status undetermined, it is believed extirpated from Ohio
SH	NY	Believed to be extirpated
S1	CT, PA	Critically imperiled
S2	WV	Imperiled
S3	MD	Vulnerable except along the coastal areas
S4	DC	Apparently secure but this is based on historical records
S5	VA	Secure but it is currently unknown what the status is for interior populations.

¹ NatureServe 2004 definitions for State Ranks: SNR- Not ranked in that state, SH- Historic occurrence but currently believed extirpated, S1- Critically Imperiled in that state and restricted to less than 5 sites, S2- Imperiled in that state and restricted to fewer than 20 sites, S3- Vulnerable and restricted to less than 80 sites, S4- Apparently secure but uncommon, S5- Secure.

The perceived rareness of the least shrew in recent times may be a reflection of the loss of prairie-type field habitats across Pennsylvania due to the re-growth and expansion of Pennsylvania forests (Kirkland and Hart 1999). In areas where forest re-growth is not a factor, a lack of crop rotation due to modern agricultural practices as well as the isolation of the least shrew's primary prairie-type habitat by development may contribute to the decline. This hypothesis is strengthened by a model proposed by Cade and Woods (1997) explaining the connection between landuse changes and the decline of the loggerhead shrike, a species of bird classified as critically imperiled in Pennsylvania. Specimens taken during this and previous research conducted by the author were from lands that were not heavily forested and had not been impacted by modern agricultural practices such as "no-till" cropping. Studies of the least shrew at the periphery of its distribution, however, are too few to form a consensus on the causes of its perceived rareness. More effort in determining the extent of the presently known populations in Pennsylvania should be carried out in order to understand both the ecology of this species as well as what factors may enhance its survival. If, in the long run, populations become "isolates" without appreciable habitat for dispersal, it is highly possible that the effects of stochastic extinction events will cause the extirpation of the least shrew in Pennsylvania.

Some researchers have suggested that the occurrence of the least shrew in Pennsylvania has become "unimportant" because of its present restricted occurrence in the state and the fact that Pennsylvania was primarily a forested state historically. Kirkland and Hart (1999) point out that the least shrew was present during the Pleistocene as evinced by the work of Guilday et al. (1966), although it was likely restricted to the Piedmont portion of Pennsylvania. Although presently restricted to a portion of the state that is suffering heavy impacts from development and habitat fragmentation, programs such as the Conservation Reserve Enhancement Program and the Important Mammal Areas Project, wetland and watershed restoration, and the growth of

conservation easements, may promote the conservation of habitats likely to sustain the least shrew. Further research will be conducted during 2006 to determine some of the ecological correlates of the least shrew in order to formulate management and conservation strategies that will enhance the persistence of the least shrew.

The pygmy shrew (*Sorex hoyi*) was listed by Genoways and Brenner (1985) as status undetermined in Pennsylvania due to the paucity of information concerning its occurrence and ecology in Pennsylvania. Since that time, its status has been changed to secure based on records gathered from over 10 counties and many different habitats within Pennsylvania (Kirkland and Hart, 1999). First documented in the state in 1987 (Kirkland et al. 1987), an increase in the use of pitfalls as a trapping regime has revealed its widespread occurrence, although it is apparently absent from the southeastern and northwestern portions of Pennsylvania. Although Kirkland and Hart (1999) reported it absent from the Piedmont, the record from the Spangler Farm during the 2004 survey period confirms its existence in that physiographic region. Despite the fact that most known specimens across the species range have been collected within forested habitats, Laerm et al. (1999) report that it has been documented from several non-forest type habitats including old fields and early-successional clear cuts.

Small mammal communities within both Gettysburg National Military Park and Eisenhower National Historic Site appear somewhat unremarkable. The occurrence of the least shrew in this case is only significant in that it has disappeared from much of the rest of Pennsylvania. It continues, however, to be a part of most small mammal grassland communities throughout much of its current range (NatureServe 2004). The meadow vole occurred at all sites except the two sites along Plum Run where habitat consisted primarily of forested riparian corridors. It is likely that the woodland vole (*Microtus pinetorum*) displaces the meadow vole along the periphery of these habitats as has been seen in other research (Kirkland and Cornbower 1983).

The preponderance of meadow voles captured during 2004 may have been the result of a typical microtine population cycle (Krebs et al. 1967). Possible corroboration for an upswing in the vole cycle lies with the occurrence during 2004 of an over-wintering population of short-eared owls (*Asio flammeus*) known to prey almost exclusively on meadow voles (Colvin and Spaulding 1983). This owl population was located on private property to the west of Eisenhower National Historic Site. Although it might be suggested that the high density of meadow voles throughout many of the sites investigated may have led to behavioral changes in least shrew activities such that least shrews were less prone to capture, this remains conjecture at best.

Kirkland (1991) and Fox and Kirkland (1992) suggested that shrew communities do not exist as a randomly occurring group among forested habitats but that there may be relationships between the size, commonality and niche specificity of a shrew species and the number of species occurring. Although the research documented in these two papers is primarily focused on forested communities, it is interesting to look at patterns of soricid occurrence in the present study. Kirkland (1991) classifies forest soricid communities based on size, relative abundance and habitat spectrum. He mentions that these classes appear to “fill” from large to small with relation to size of species, from common to uncommon with relation to abundance and from generalist to specialist with relation to habitat spectrum. Fox and Kirkland (1992) related that the functional groups or classes would fill in a non-random manner from large, abundant

generalists as the first group to small, rare specialists as the last group to fill. The four species expected to occur in the present study include the northern short-tailed shrew (large, abundant generalist), the least shrew (medium, rare specialist), the masked shrew (small, abundant generalist), and the pygmy shrew (small, uncommon generalist). If we apply Fox and Kirkland's assumption to the present study, we would expect that the northern short-tailed shrew would be common across all sites, which is, indeed the case. From this point on it becomes a bit more unclear. The least shrew occurred as well as the pygmy shrew but the masked shrew was never taken. Only the Spangler Farm and the fields between the Slyder and Granite Farms revealed the presence of two soricid species. Neither of these cases revealed a pattern comparable to that found in forested communities. It is likely that in a functional, relatively un-impacted grassland habitat the least shrew would be considered common and would occupy the second group as listed in Kirkland (1991) with the pygmy shrew in the third group. If this is the case, a point to be considered is that in grassland habitats at no time are all groups occupied and no large size soricid comparable to the water shrew in forested communities exists to occupy the large, rare specialist class.

One species of mouse that was expected to occur but was not encountered during the present study is the prairie deer mouse (*Peromyscus maniculatus bairdii*). This species has been found occurring at other sites where least shrews are captured (Hart 2000A) but appears to be in decline in Pennsylvania although it is unknown if this pattern occurs throughout its entire range. In all recent cases where least shrews have been detected in Pennsylvania, except at the Gettysburg National Military Park and Eisenhower National Historic Site sites, the prairie deer mouse has also been detected leading one to believe that the same factors affecting the survival of the least shrew may impact the prairie deer mouse as well.

Future Research

1. Continue studies within Eisenhower National Historic Site and Gettysburg National Military Park to determine the extent of known populations of the least shrew.
2. Collaborate with park neighbors and landowners to obtain permission to access private property for conducting least shrew surveys. This will increase knowledge of the distribution of populations of the least shrew in the landscape surrounding Eisenhower National Historic Site and Gettysburg National Military Park.
3. Locate occurrences of the barn owl (*Tyto alba*) in order to collect and analyze their pellets to possibly locate new occurrences for the least shrew.
4. Coordinate with the Pennsylvania Natural Heritage Program vegetation mapping projects to prepare a vegetation model that would help predict the occurrence of the least shrew as well as develop methods for retaining least shrew habitat.

Management Recommendations

1. Mowing of grasslands should coincide with plans that are currently in place to support populations of grassland nesting bird species. Mower height should not be set any lower than between 8 to 10 inches.
2. Woody plants and shrubs that normally lead to successional growth should be controlled either by chemical spraying or prescribed burning in order to maintain a grassland habitat type where they currently exist.
3. It is highly likely that the occurrence of the least shrew at a particular site is correlated to the occurrence of some form of water nearby such as a small swale or wetland-type area. Management of habitat along these water sources should be kept to a minimum except for the control of increased occurrences of such invasive species as multiflora rose and Japanese barberry.
4. Maintaining a matrix of habitat in areas surrounding known least shrew occurrences may ensure the persistence of the least shrew by creating refuge options during agricultural practices, mowing periods, and other activities that may impact habitats periodically.
5. Least shrews have been shown to be susceptible to predation by unnatural predators such as feral cats (Z. Bolitho, pers. comm.). If it is proven that feral cats at Gettysburg National Military Park and Eisenhower National Historic Site impact least shrew populations, a program designed to control feral cat populations should be initiated so that mortality of least shrews does not exceed that normally associated with predators such as raptors and foxes.
6. Areas known to be occupied by least shrews appear to have a diverse cover of both grasses and non-woody forbs. When managing for least shrew habitat, plant diversity should be stressed rather than single monocultures of grasses.
7. It will be unnecessary to control tourism in most areas where the least shrew is currently known to occur. In areas that may, in the future, receive high traffic from increased tourism, it may become necessary to limit traffic to paths that reduce the impact to the habitat.

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Appendix A. Pennsylvania Game Commission Least Shrew (*Cryptotis parva*) Survey Protocol

COMMONWEALTH OF PENNSYLVANIA
Pennsylvania Game Commission, Bureau of Law Enforcement, Technical Services Division
2001 Elmerton Avenue, Harrisburg, PA 17110-9797

Least Shrew (*Cryptotis parva*) Survey Protocol
PGC Listing- State Endangered

Site Evaluation

1. Size of site should be no less than 1 hectare
2. Site should consist of typical grassland habitat with no more than ¼ in shrub succession
3. Although a hayfield would be acceptable, some form of grassland should occur adjacent to the site.
4. Unused pastures may be regarded as possible habitat as long as it is not in the later stages of succession.
5. High intensity agricultural fields such as no-till fields and large cornfields should not be considered as possible habitat except where they adjoin a known least shrew occurrence or substantial amounts of probable habitat.

Equipment for surveying sites

1. Twenty to twenty-five pitfall containers with dimensions of approximately 15cm wide by 20cm deep. Interiors of these containers should be painted black as this increases the chances of catching very small shrew species (Crawford and Kurta, 2000).
2. Seventy-five to eighty Museum Special break-back snaptraps. The object is to get as many traps into the site as possible to increase the chance of capturing the target species. Low population densities of 1.7 to 5 per hectare (Whitaker and Hamilton, 1998) make this species appreciable hard to detect.
3. Skull tags. These will be used to label each individual specimen captured, regardless of species, so that the preparation of specimens at a later date for inclusion into a curated mammal collection is facilitated.
4. Some form of drying agent such as cornmeal or Cobdri[®]. This will absorb any moisture from body fluids or precipitation and lessen the degradation of the specimen.
5. Max/Min Thermometer and raingauge
6. GPS unit
7. Required PGC survey forms (P-4150-LstSrw and PT-4150 LstSrw)

Required Paperwork

1. A valid PGC Mammal Collecting permit
2. Accession number or the equivalent from either an accredited institution or a curated mammal collection. This will ensure that the specimens collected from the site are safely deposited into a collection that can be preserved for future reference by researchers.
3. Paperwork that accredits the surveyor with either the educational background or field experience necessary for conducting the survey.

4. Paperwork denoting the site of deposit for any specimens kept. This should include a valid Accession Number from the institution's Records Department.
5. Required PGC survey forms (P-4150-LstSrw and PT-4150 LstSrw)
6. Map (preferably on a USGS Quadrangle) with traplines illustrated and borders of suitable habitat outlined as polygons.

Reporting

The Site Description Form, Trapline Summary Form, required map and other generated reports will be sent, within 90 days to: PA GAME COMMISSION, Bureau of Wildlife Management, Wildlife Diversity Section, 2001 Elmerton Avenue, Harrisburg, PA 17110-9797

Bait

1. Bait should consist of a mixture of rolled oats, peanut butter and moist catfood rolled into a cloth ball. The ball should be suspended along the inside rim of the pitfall by a thin wire.
2. A small amount of the same type of bait should be applied to the Museum Special snaptraps.
3. Bait should be replaced upon checking individual traps each morning.

Survey Season

1. Due to the low population density estimates of this species occurrence (Howell, 1954) it is imperative that any surveying for least shrews occur during the period from late August to early October. It is likely that at that time the populations that may occur at a selected site will have become stable prior to the onset of fall and winter. Any surveys conducted prior to this period without positive results should be considered questionable at best.
2. Do not survey during periods when the temperature approaches freezing as water in the pitfalls will freeze and any captured specimens may escape.
3. If periods of high rain cause the pitfall containers to fill with water, they must be drained to half-full.
4. A site should be surveyed for no less than 3 nights. If a least shrew is captured, the survey transect should be closed immediately.

Trapline design

1. A minimum of one trapline consisting of between 20 to 25 stations will be set up for each hectare of suitable habitat. Each station should be numbered with overall trapline name/number and station number.
2. Each station should consist of 1 pitfall container set into the ground with the rim of the pitfall flush or just below the ground surface. Each pitfall container should be at most, half-full of water. If 20 pitfall containers (20 stations) are used, 4 Museum Special snaptraps set at the four cardinal corners of the station 1-1.5m from the pitfall should

surround each. If 25 pitfall –containers (25 stations) are used, this should be reduced to 3 Museum Special snaptraps. The total number of traps for each trapline should equal 100 for easier analysis and database entry.

3. Each station should be no less than 10m apart nor more than 15m. The least shrew is a fairly social species and the greater the separation of stations, the less chance of setting the station within the home range of a single individual. See #4 for discussion of narrow sites.
4. Depending on the size of the site, the trapline can run in a single line throughout the length of a site for those sites that are extremely narrow. This may necessitate setting stations closer together. If the site is larger in terms of length and width, the transect should be located no less than 15m from any edge and run in parallel lines along the site. Separation of stations should follow #3.
5. Survey transect should be checked each morning as early as possible to limit degradation of specimens.

Specimen Handling

1. Specimens should be removed from the trap/pitfall and a tag affixed to the right leg. This tag should include the 4-letter species identification code (1st two letters of Genus and 1st two letters of species, See below for example), date of capture and specimen number as noted on Trapline summary Form. Upon placement of this tag, the specimen should be put into a drying agent (cornmeal, Cobdri[®]) to absorb moisture from precipitation, pitfall or bodily fluids.
2. All undamaged specimens, regardless of species, should be retained as voucher specimens. Damaged specimens should be identified as closely as possible prior to discarding. Under no circumstances should any PA listed species (Genoways and Brenner, 1985) be discarded, regardless of condition.
3. Specimens should be dried completely to limit degradation. It should then have any residual drying agent (cornmeal, Cobdri[®]) cleaned off of its pelage.
4. Upon drying, several (commonly 3) specimens of the same species should be wrapped in a single papertowel and secured with a strip of masking tape. On this strip of masking tape should be written the date of capture, 4 letter identification of species (See below) included and the trapline name (Site Name) and number.
5. Several of these “packets” should be put into a small ziplock-type plastic bag. Several of these smaller ziplock bags can then be put into a larger ziplock-type plastic bag. This will guard against freezer burn until the specimens can be positively identified and prepared for inclusion into a curated mammal collection.
6. Upon completion of a single day of survey, the accumulated specimens should be frozen as quickly as possible to limit degradation.

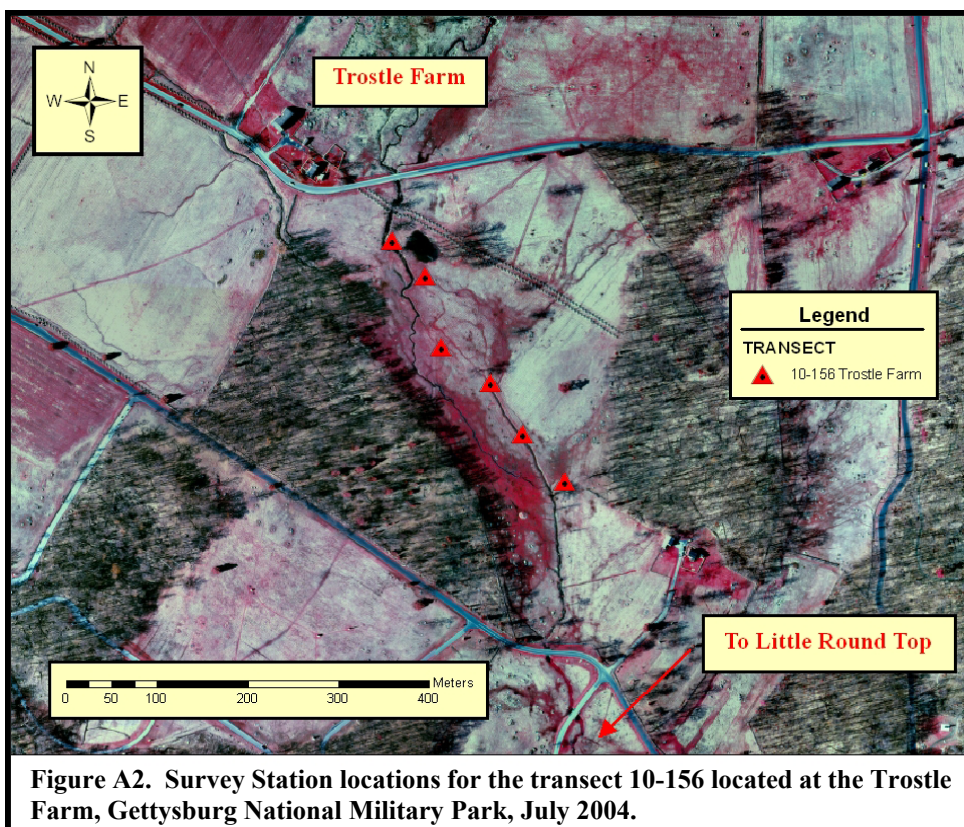
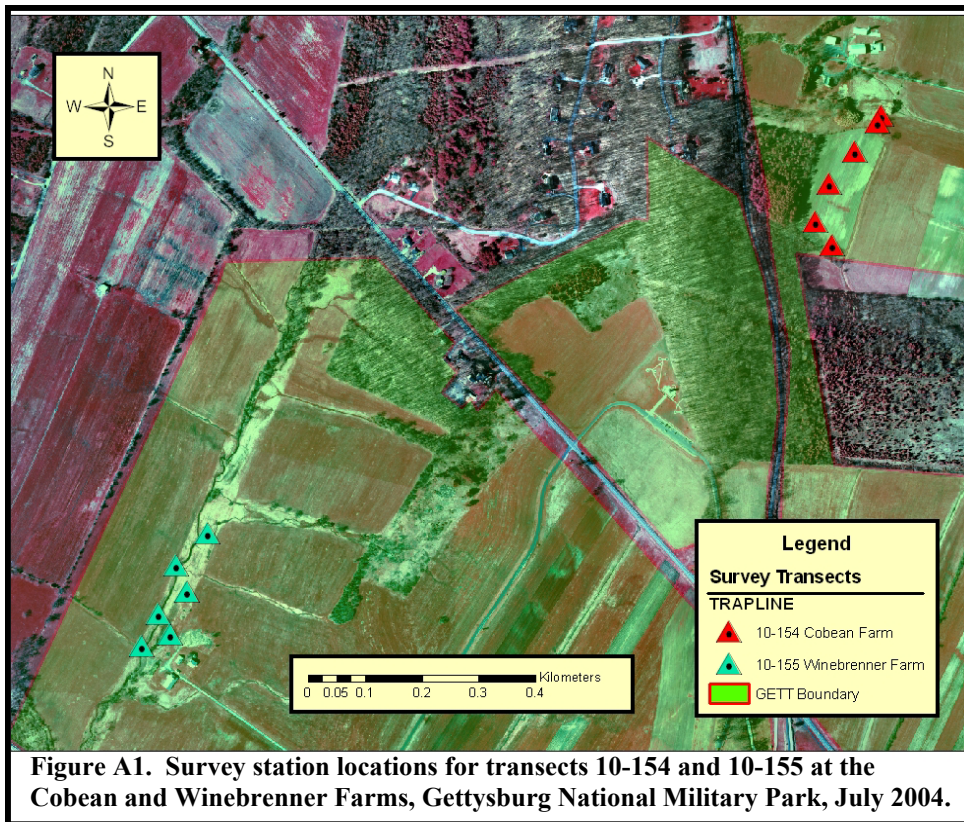
Literature Cited and Reference Material for PGC Least Shrew Protocols

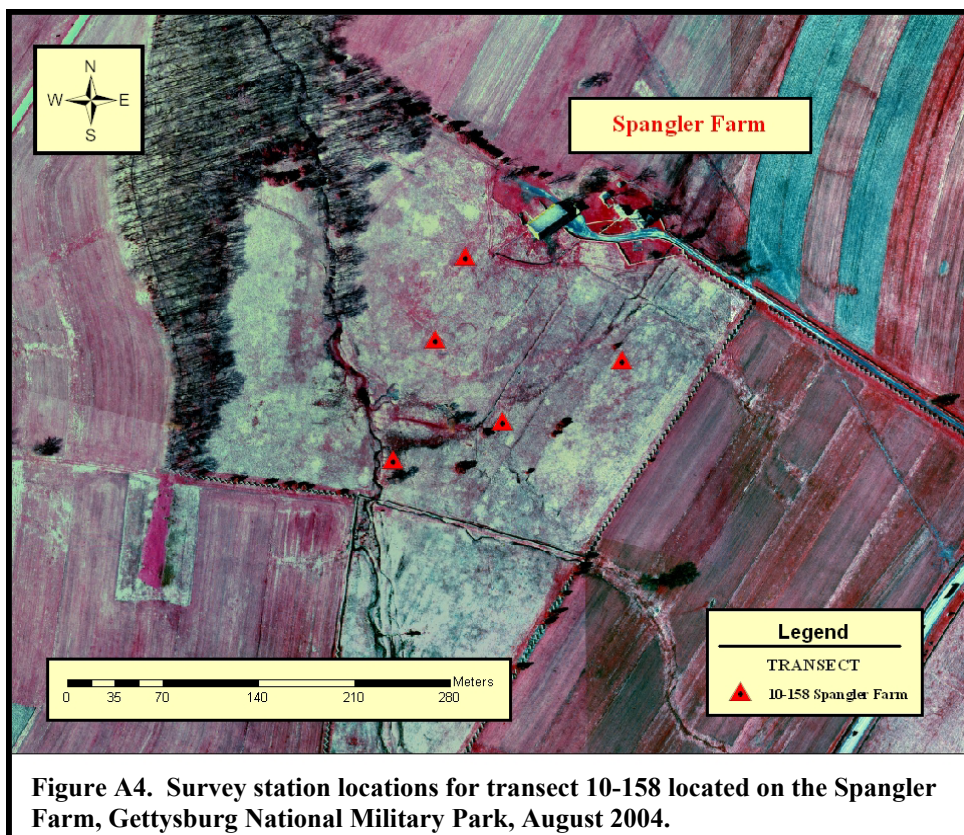
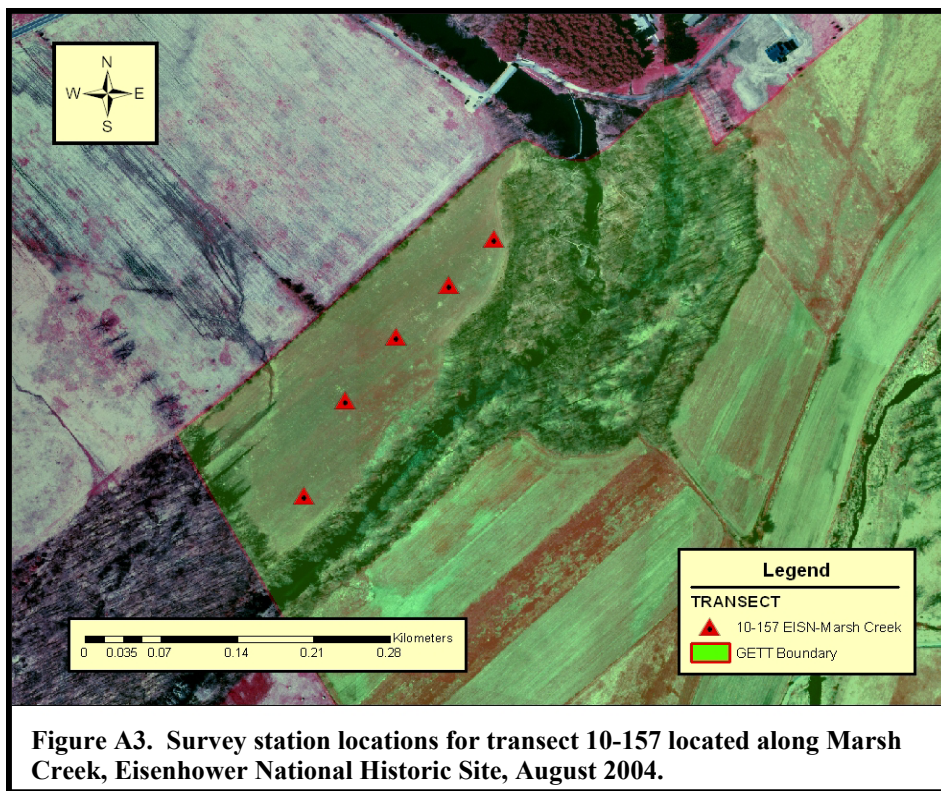
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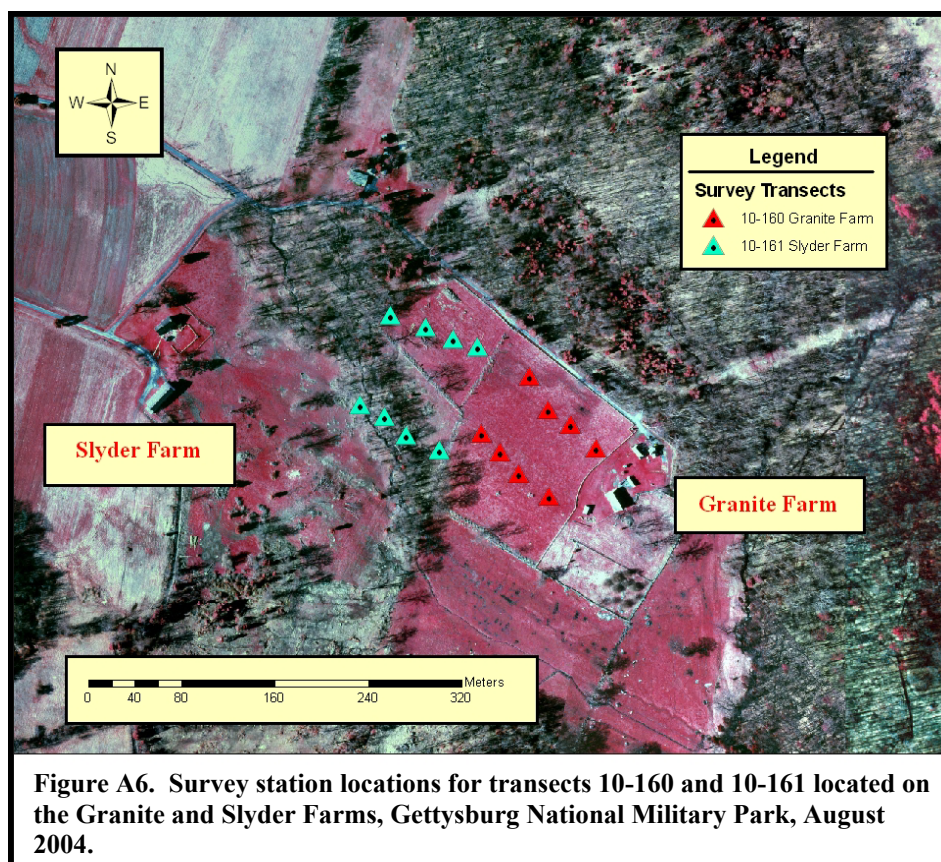
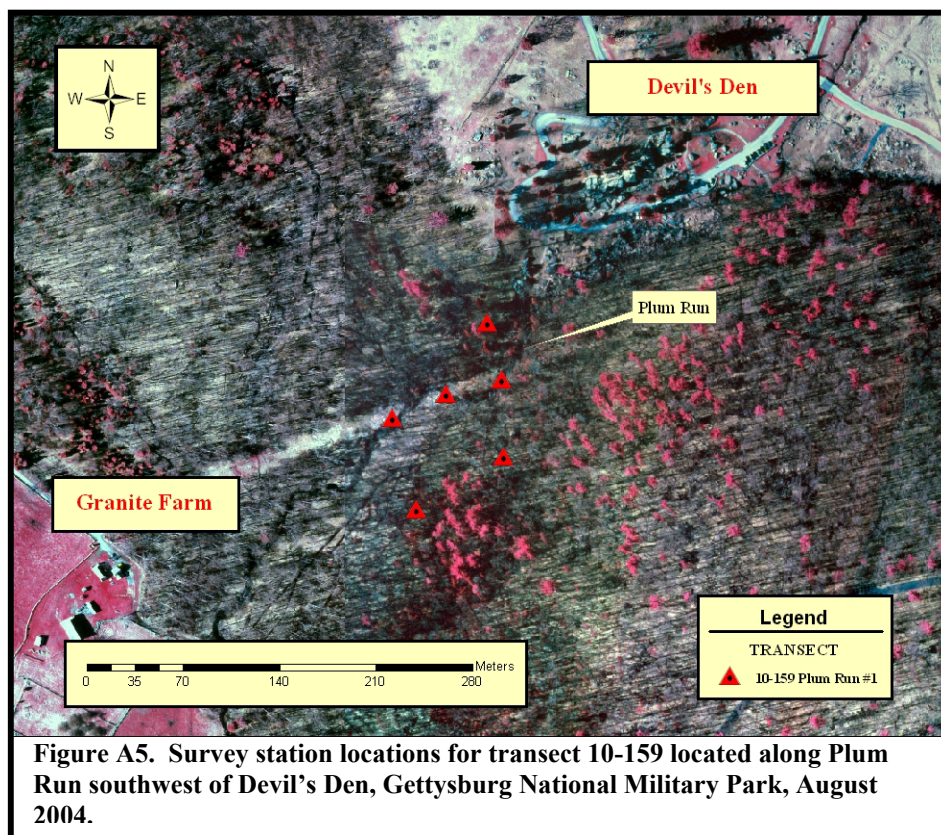
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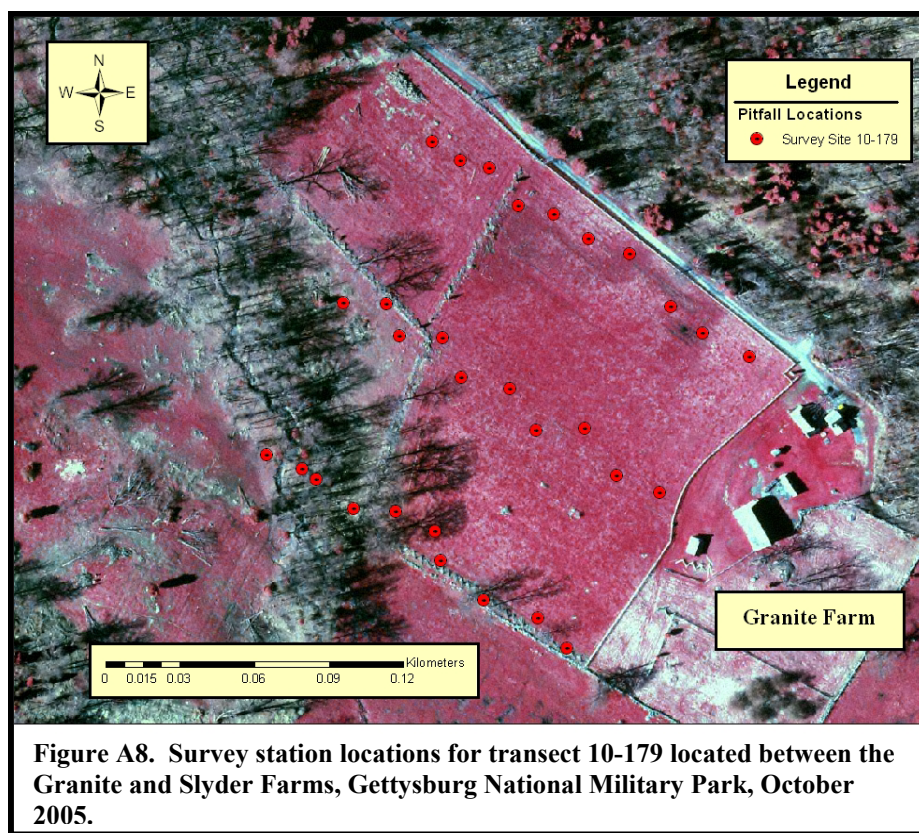
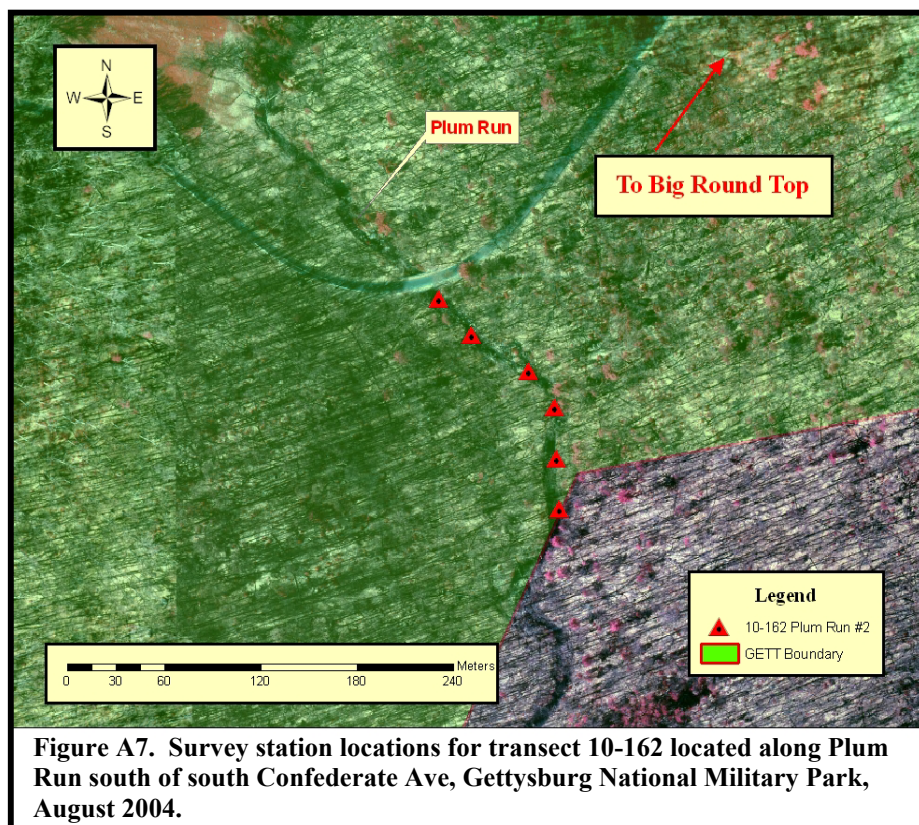
Appendix B. Transect and station locations for surveying small mammals in Gettysburg National Military Park and Eisenhower National Historic Site during 2004-2005.

Survey Transect and Station Locations









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

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