

National Park Service
U.S. Department of the Interior

Northeast Region
Philadelphia, Pennsylvania



Inventory of Amphibian and Reptile Species at Fort Necessity National Battlefield and Friendship Hill National Historic Site

Technical Report NPS/NER/NRTR--2005/031



ON THE COVER

Top left image: Jefferson salamander (*Ambystoma jeffersonianum*). Photograph by: Matt Kowalski.

Bottom left image: Drift-fence array 10 at Fort Necessity National Battlefield. Photograph by: Mindy Ross

Top right image: Drift-fence array 11 at Fort Necessity National Battlefield. Photograph by: Mindy Ross

Bottom right image: Northern slimy salamander (*Plethodon glutinosus*). Photograph by: Matt Kowalski

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December 2005

U.S. Department of the Interior
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This report was accomplished under Cooperative Agreement 4000-8-9024, Supplemental Agreement Number 001 with assistance from the NPS. The statements, findings, conclusions, recommendations, and data in this report are solely those of the author(s), and do not necessarily reflect the views of the U.S. Department of the Interior, National Park Service.

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Please cite this publication as:

Kowalski, Matthew J., Brian K. Paulson, and Melinda J. Ross. December 2005. Inventory of Amphibian and Reptile Species at Fort Necessity National Battlefield and Friendship Hill National Historic Site. Technical Report NPS/NER/NRTR—2005/031. National Park Service. Philadelphia, PA.

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Summary

Fort Necessity National Battlefield (FONE) and Friendship Hill National Historic Site (FRHI) are two national park units located in Pennsylvania's Appalachian Plateau Province, within Fayette County. Fort Necessity is in the Allegheny Mountain Section known as the Laurel Highlands and consists of three distinct units. The largest is the 344.8 ha (852 ac) main park unit, while the two smaller units, the 9.7 ha (24 ac) Braddock Grave (BRGR) and 10.52-ha (26-ac) Jumonville Glen (JUGL) sites, lie west of the main unit. FRHI is in the Pittsburgh Low Plateau Section, and is a 272.76-ha (674-ac) site about 40 km (25 mi) west of FONE. Our objective was to provide National Park Service personnel with the most complete inventory possible of amphibian and reptile species within these parks, to include presence, relative abundance, and distribution. We surveyed the amphibians and reptiles of these park units from 1999–2001 using specific survey methods that included auditory-call counts, drift-fence arrays, funnel-trap arrays, turtle traps, seine nets, dip nets, rappelling and rock searching, coverboards, and general survey methods.

A review of distribution records and literature on amphibians and reptiles revealed 49 species that could potentially be encountered in the areas surveyed. We encountered 34 (69%) of the predicted species, including three of four (75%) turtle species, 10 of 14 (71%) snake species, 12 of 18 (67%) salamander species, and nine of 11 (82%) frog and toad species. There were two lizard species predicted to occur, but no lizards were observed. We observed 16 species at BRGR, 12 species at JUGL, 29 species at FONE main unit, and 27 species at FRHI. No unpredicted species were discovered.

The greatest number of species ($n=28$) was observed using drift-fence arrays, followed by general survey methods ($n=23$), which include visual-encounter surveys, stream transects, and incidental encounters. Auditory-call counts produced records of eight species. Funnel-trap array, turtle trap, coverboard, dip net and seine net, rappelling and rock searching, and coverboard sampling produced low numbers of species encountered, and these methods revealed no species not observed by auditory-call counts, drift-fence arrays, or general survey methods.

Deciduous forest habitat produced the highest number of species (17 at FONE and 20 at FRHI). The greatest number of observations (3,321) came from perennial pond habitats, where large numbers of red-spotted newts and amphibian larvae were captured with seine nets and dip nets. Excluding the ponds, deciduous forest habitat had the highest number of encounters in FONE ($n=236$), BRGR ($n=96$) and JUGL ($n=40$). FRHI had the most encounters in streams ($n=111$) followed by deciduous forest ($n=100$).

Acknowledgments

This project was funded by the National Park Service. Special thanks go to National Park Service personnel C. Ranson, M. Marshall, and J. Karish for their cooperation and guidance. Field assistants are valuable resources in any project such as this and we would like to thank L. Klein, D. Vavro, J. Yakelis, A. Eck, J. Gregory, K. Smyth, and G. Hutchko for putting in long hours in what were often less than optimal conditions. We would also like to thank S. Droege, G. Rocco, K. Derge, J. Mravintz, and H. Tiebout for their advice and assistance.

Introduction

One of the many responsibilities of the National Park Service (NPS) is to manage the property of each park in ways that benefit the plants and animals of the ecoregion. For NPS personnel to make wise decisions about proposed projects and changes within park boundaries they must have knowledge of the various plant and animal taxa found within each park. The goal of the large Inventory and Monitoring Project recently undertaken by the entire National Park Service is to provide that knowledge. Park units have at least rudimentary baseline data for most plant and animal groups, but herpetological inventory data are lacking or anecdotal in many cases. The objective of this project was to inventory as completely as possible the presence of amphibians and reptiles at Fort Necessity National Battlefield main unit (FONE), the Braddock Grave (BRGR) and Jumonville Glen (JUGL) park units of FONE, and Friendship Hill National Historic Site (FRHI). Specific goals were to 1) review the literature and develop a database of potentially occurring amphibians and reptiles at these sites, 2) conduct an intensive inventory of the sites and determine presence/absence of the amphibian and reptile species, 3) obtain and present relative abundance and distribution data, and 4) propose monitoring recommendations for the amphibians and reptiles occurring in these park units.

Study Areas

Fort Necessity National Battlefield (FONE) and Friendship Hill National Historic Site (FRHI) are located in Fayette County, in southwestern Pennsylvania. Both parks lie within the Appalachian Plateau Province (Figure 1).

FRHI is located 4.8 km (3 mi) north of Point Marion on Route 166 in the Pittsburgh Low Plateau Section of the province and is 272.8 ha (674 ac) of primarily deciduous and coniferous forest. Approximately 19 ha (47 ac) of the unit is mowed hayfield, and another 51 ha (126 ac) are abandoned drift mine. Also present at FRHI are numerous rocky bluffs, four permanent streams, one perennial pond, approximately five ha (12 ac) of wetlands, and several intermittent streams. FRHI ranges in elevation from 242–320 m (794–1,050 ft).

Fort Necessity National Battlefield consists of the main park unit (FONE), Braddock Grave (BRGR), and Jumonville Glen (JUGL). All three units are located within the Allegheny Mountain Section of the Appalachian Plateau Province known as the Laurel Highlands.

The main unit of FONE is located 17.7 km (11 mi) east of Uniontown on Route 40 and is 344 ha (850 ac) in size. Approximately 206 ha (509 ac) are in maple/oak deciduous forest with roughly 105 ha (259 ac) of pasture/meadow, and about 35 ha (86 ac) of coniferous forest. There are four permanent streams, five ponds/impoundments, and various intermittent streams. The main unit of FONE ranges in elevation from 600–648 m (1,968–2,126 ft).

Braddock Grave (BRGR) is 9.71 ha (24 ac) of mostly maple/oak deciduous forest located about 2.4 km (1.5 mi) west of the main unit. It was landscaped in 2000–2001 to improve access and appearance and has about 0.8 ha (2 ac) of landscaped lawn. There is a single perennial stream present. BRGR has an elevation range of 578–594 m (1,896–1,949 ft).

Jumonville Glen (JUGL) is about 11 km (7 mi) northwest of the main unit and lies on the crest of Chestnut Ridge. Most of the 10.5 ha (26 ac) unit is mature oak/maple deciduous forest with less than one ha (about one acre) of rock outcroppings. This unit has a single stream which sometimes persists year round, but often dries completely during the summer months. JUGL lies at an elevation of 664–709 m (2,178–2,326 ft).

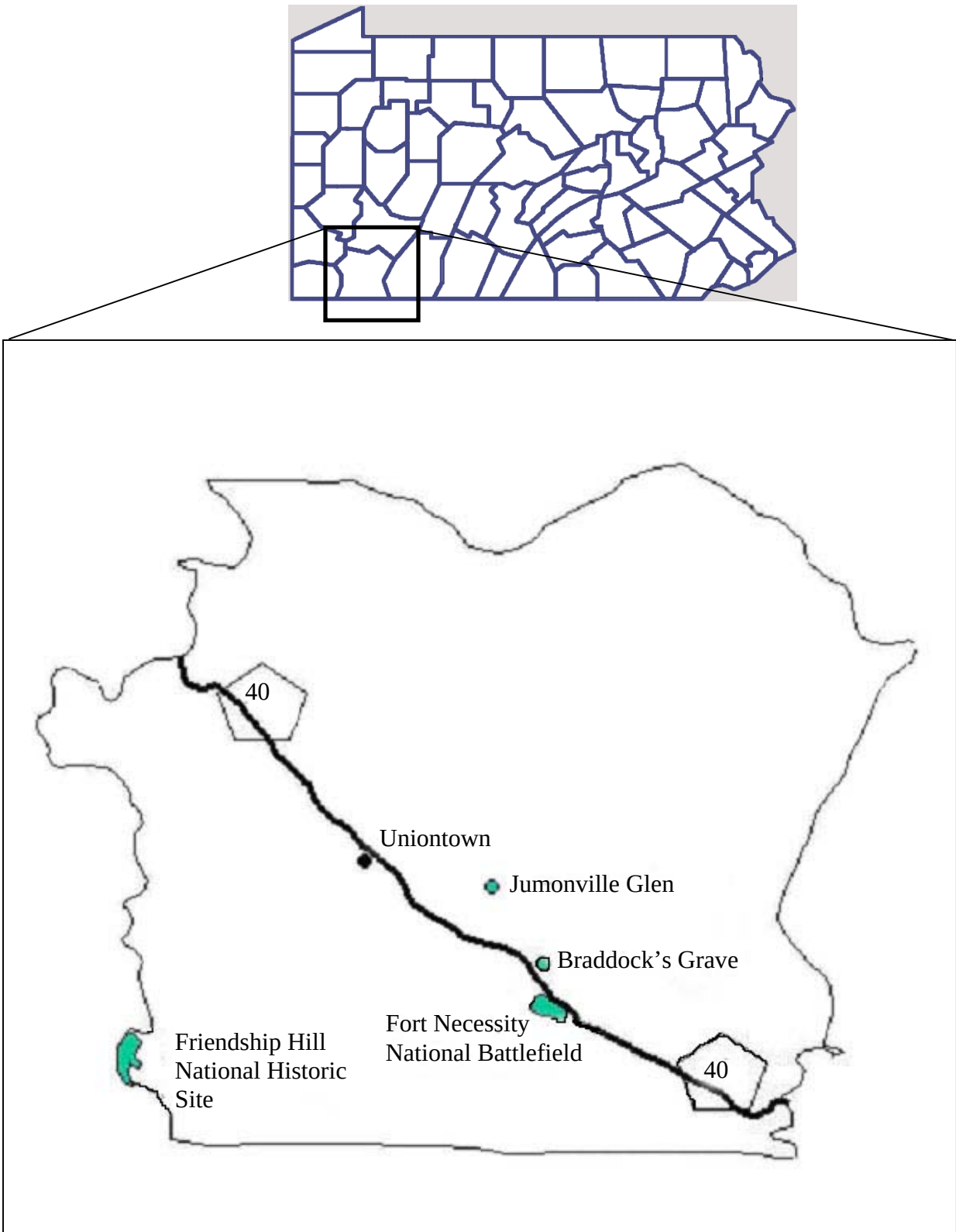


Figure 1. Locations of Friendship Hill National Historic Site, Fort Necessity National Battlefield, Jumonville Glen, and Braddock Grave within Fayette County, Pennsylvania.

Methods

Literature Review for Potentially Occurring Amphibians and Reptiles

Prior to this study no comprehensive species list was compiled for the amphibians and reptiles of these park units. To develop a list of potentially occurring species within the boundaries of Fort Necessity National Battlefield (including the Braddock Grave and Jumonville Glen units of FONE) and Friendship Hill National Historic Site, historic records of captures that were within the general geographic area of the parks were compiled from records of The Nature Conservancy and the Carnegie Museum of Natural History. The compiled data were used to produce a list of 54 predicted amphibian and reptile species at FONE and FRHI (Appendix 1).

Sampling Protocols

The generation of a herpetological species list (inventory) typically involves using familiar and well-published sampling protocols. One reason that comprehensive amphibian and reptile surveys are not often attempted is because there is no one sampling protocol that is effective for all herpetological groups. To conduct a complete inventory that will determine the presence/absence of all species, it is therefore necessary to use multiple techniques, with each protocol being relatively specific to the targeted species (Scott 1994; Olson and Leonard 1997; Yahner et al. 1999). Below are nine protocols used in our inventory of amphibian and reptile species at Fort Necessity National Battlefield and Friendship Hill National Historic Site.

Auditory-call Counts

Auditory surveys (call counts) are a useful, relatively easy way to identify frogs and toads present at a breeding site (Scott and Woodward 1994), although there is a chance of missing some species present because of low-volume vocalizations or lack of advertisement calls (Thoms et al. 1997). To conduct auditory-call counts (ACC), we approached suitable anuran breeding habitats to within 15 m (50 ft) and listened for the calls of male anurans attempting to attract a mate. Calls were estimated to be audible for at least 300 m (1,000 ft). Our surveys began approximately 30 minutes after sunset and lasted for three minutes each. ACC began one minute after arrival at the listening site to allow the animals to recover from any possible disturbance caused by the investigator's approach. Calls were identified to species, ranked according to the Wisconsin Index Values for Calling Amphibians (Table 1) (Scott and Woodward 1994; Mertz 1999), and recorded along with the location, time, and temperature of air and water.

We conducted auditory-call counts intensively in 1999 with parks sampled on a weekly basis beginning March 30 and ending June 23. Auditory-call counts were conducted on a monthly basis April–June of 2000 to compliment the 1999 data (Table 2).

Table 1. Wisconsin Index Values for Calling Amphibians: a system by which breeding frogs and toads are assigned a relative abundance according to their vocalizations.

Index Value	Description	Relative abundance
Index Value 0	No amphibians calling	No relative abundance
Index Value 1	Individuals can be counted; there is space between the calls.	Low relative abundance
Index Value 2	Calls of individuals can be distinguished, but there is some overlapping of calls.	Medium relative abundance
Index Value 3	Full chorus. Calls are constant, continuous, and overlapping.	High relative abundance

Table 2. Sampling schedules for selected protocols by park and date(s) for the inventory of reptiles and amphibians at Fort Necessity National Battlefield and Friendship Hill National Historic Site*.

Park	Protocol	Dates of sampling											
BRGR	ACC	4/8/99	4/13/99	4/20/99	4/30/99	5/13/99	5/19/99	5/28/99	6/13/99	6/23/99	4/30/00	5/13/00	
BRGR	TVES	6/22/99	7/12/99	9/27/99	5/24/00	7/27/00	8/31/00	5/30/01					
BRGR	SVES	7/12/99	8/12/99	10/14/99	6/27/00	8/31/00							
BRGR	DFA	8/10/99	4/1/00– 4/5/00	5/2/00– 5/5/00	5/23/00– 5/26/00	6/1/00– 6/5/00	7/5/00– 7/9/00	8/1/00– 8/5/00	9/7/00– 9/11/00	10/3/00– 10/6/00			
FONE	ACC	4/2/99	4/8/99	4/13/99	4/20/99	4/30/99	5/13/99	5/19/99	5/28/99	6/13/99	6/23/99	4/29/00	5/13/00
FONE	SN/DN	7/1/99	9/25/99	5/23/00	6/28/00	7/27/00	8/29/00						
FONE	DFA	7/7/99– 7/9/99	8/9/99– 8/12/99	9/9/99– 9/13/99	10/5/99– 10/11/99	4/1/00– 4/5/00	5/2/00– 5/5/00	5/22/00– 5/26/00	6/1/00– 6/5/00	7/5/00– 7/9/00	8/1/00– 8/5/00	9/7/00– 9/11/00	10/2/00– 10/6/00
FONE	TVES	7/11/99	9/21/99	4/27/00	5/23/00	5/24/00	6/26/00	7/24/00	8/28/00	9/28/00	6/1/01		
FONE	SVES	7/18/99	8/12/99	10/14/99	4/27/00	6/26/00							
FONE	TT	10/12/99	5/22/00– 5/25/00	6/27/00– 6/30/00	7/24/00– 7/27/00	8/28/00– 8/31/00	9/25/00– 9/29/00	6/4/01– 6/8/01	7/1/00– 7/4/00				
FRHI	ACC	3/30/99	4/7/99	4/12/99– 4/23/99	4/29/99	5/12/99	5/23/99	5/30/99	6/15/99	6/18/99	4/17/00	5/16/00	6/11/00
FRHI	TT	7/1/99	7/22/99– 7/24/99	5/22/00– 5/25/00	6/27/00– 7/7/00	7/24/00– 7/27/00	8/28/00– 8/31/00	9/26/00– 9/29/00	6/4/01– 6/7/01	7/2/01– 7/5/01			
FRHI	SN/DN	7/1/99	7/22/99	10/12/99	5/24/00	6/28/00	7/25/00	8/29/00					
FRHI	TVES	7/10/99	7/12/99	9/23/99	5/24/00	7/25/00	8/29/00	9/29/00	8/3/01	8/6/01			
FRHI	SVES	7/15/99	7/16/99	8/13/99	10/14/99	7/7/00	8/3/01						
FRHI	DFA	8/1/99– 8/4/99	9/14/99– 9/18/99	10/3/99– 10/4/99	4/2/00– 4/6/00	5/2/00– 5/6/00	5/23/00– 5/27/00	6/1/00– 6/5/00	7/5/00– 7/9/00	8/1/00– 8/5/00	9/6/00– 9/11/00	10/2/00– 10/6/00	
JUGL	ACC	4/8/99	4/13/99	4/20/99	4/30/99	5/13/99	5/19/99	5/28/99	6/3/99	6/13/99	6/23/99	5/13/00	
JUGL	RRS	6/3/99	6/30/99	7/31/99	5/25/00	6/29/00							
JUGL	TVES	7/12/99	5/25/00	6/26/00	7/27/00								
JUGL	SVES	7/12/99	6/26/00	5/30/01									
JUGL	DFA	8/11/99– 8/12/99	4/1/00– 4/5/00	5/2/00– 5/5/00	5/23/00– 5/26/00	6/1/00– 6/5/00	7/5/00– 7/9/00	8/1/00– 8/5/00	9/7/00– 9/11/00	10/3/00– 10/7/00			

*Park codes: BRGR=Braddock Grave Unit, FONE=Fort Necessity National Battlefield-Main Unit, FRHI=Friendship Hill National Historic Site, JUGL=Jumonville Glen Unit.

Protocol Codes: ACC=auditory-call counts, TVES=terrestrial visual-encounter survey, SVES=stream visual-encounter survey, DFA=drift-fence array, SN/DN=seine net and/or dip net, TT=turtle trap, RRS=rappelling and rock searching.

Sampling schedules for all inventory protocols including funnel-trap arrays and coverboards are provided in the text. The above table is intended to provide additional detail for the protocols employed.

Drift-fence Arrays

To sample for terrestrial amphibians and reptiles we used Y-shaped drift-fence arrays modeled after Corn (1994). To construct a drift-fence array (DFA), a 20-L (5-gal) bucket was buried with its upper lip flush with the surface of the ground as a central pitfall trap. Then three 10 m (32.8 ft) long x 91 cm (3 ft) high sections of black silt fence cloth were installed approximately 120 degrees from each other with the pitfall bucket in the middle. The silt fence cloth was the same type used to control siltation at construction projects (Forestry Suppliers, Inc., 205 West Ranken Street, P.O. Box 8397, Jackson, MS 39284) and was stapled to 122 cm (4 ft) wooden stakes driven into the ground to hold it erect as a drift fence. It was then buried in a trench 5–10 cm (2–4 in) deep to prevent animals from passing under the drift fence. At the outer end of each drift-fence arm, a 20-L pitfall trap (5-gal bucket) was buried as above. Midway along each of the three arms, one screen trap was placed flush with the ground on one side of the drift fence and one minnow trap was placed on the other (Figure 2).

Based on the measurements and dimensions given above, we determined that a DFA sampled a triangle with three sides equal to 17.3 m (56.76 ft.) each. This triangle had a surface area of 130 m² (1,399 ft²). Thus each DFA sampled 0.013 ha (0.3 ac).

Because the DFA is a non-discriminate sampling device there is no way to predict what amphibian and/or reptile species will encounter which trap. For this reason we decided to use two types of funnel trap: the screen trap (a funnel trap constructed of window screening) and a commercially purchased minnow trap constructed of 8 mm (1/4 in) hardware cloth (Frabill Industries, P.O. Box 79, Jackson, WI). In the event that one type of trap was more efficient than the other at capturing a given species, both types would be in use in each third of the DFA. Thus, if an animal escaped from or avoided one type of funnel trap, there was still the opportunity to capture it with the other type or with a pitfall trap.

Screen traps were constructed of aluminum window screening and staples. They were tubular traps, 80 cm (31.5 in) long and 20 cm (7.9 in) in diameter, with screen funnels at both ends. The funnels penetrated the tube approximately 13 cm (5 in) and had openings that measured 4–5 cm (1.5–2 in) in width, with the openings located along the midline of the trap (8 cm [3 in] from top and bottom of the trap). One funnel of each trap was attached with staples along the total circumference of the tube of the trap. The other funnel was attached with staples along half of the circumference of the trap with the remaining half fastened closed by six to eight large paperclips. The paperclips could be removed to create an opening between funnel and tube where animals could be removed from the trap. This type of opening is preferable in situations where investigators may capture venomous snakes, as the snakes can be released safely by first removing the paperclips then inverting the trap with the opening down and at a safe distance from the investigator. One disadvantage of the opening being located where the funnel and outer tube of the trap meet is that larger more powerful species like black rat snakes can push against the opening with enough force to dislodge the paperclips and thus escape. Knowledge of this disadvantage prompted the additional use of the minnow traps described above. The minnow traps are fastened along their midline with a large spring clasp that even a large snake cannot dislodge.

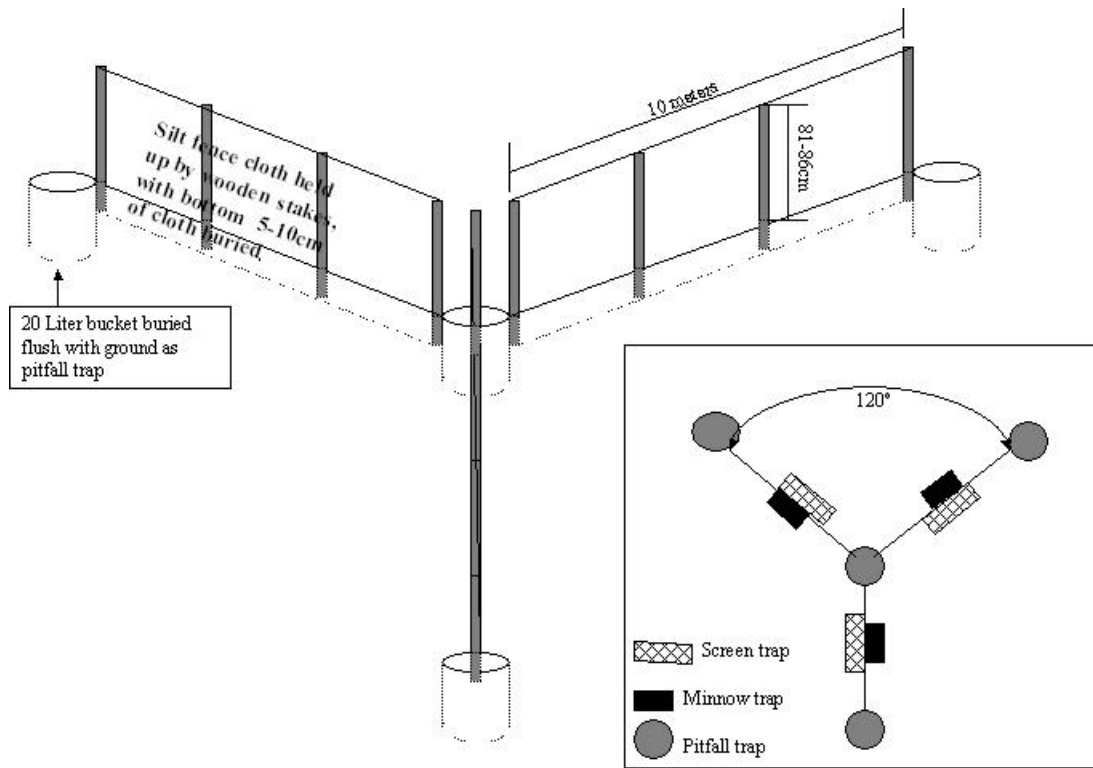


Figure 2. Schematic of the drift-fence array used to inventory amphibians and reptiles at Fort Necessity National Battlefield and Friendship Hill National Historic Site, 1999–2000 (funnel traps omitted for clarity). Inset diagram shows view of the drift-fence array from above with proper placement of funnel traps.

Each funnel trap was shaded by partially covering it with ground litter and/or vegetation to help prevent the overheating or desiccation of any trapped animals. The funnels of each trap were covered with soil/ground litter to create a natural substrate “ramp” within the opening of the trap, and prevented the animals from touching the screen of the funnel before becoming trapped. This soil/litter ramp also served the purpose of filling any gaps between the funnel traps and the drift-fence, thus preventing animals from crawling between the fence and trap (Figure 3). A large rock was placed inside each pitfall bucket to provide cover and an “island” on which animals could sit in the event that the bucket collected a large amount of water. A piece of string was attached to a small stick outside each bucket and lowered to the bottom surface of the pitfall traps to permit small mammals to escape by climbing the string. Three 15 cm pieces of 5 cm x 10 cm (6 in pieces of 2 x 4 in) lumber were attached to the top of each central bucket lid at 120 degree angles. Outer bucket lids had two 15 cm pieces of 5 cm x 10 cm (6 in pieces of 2 x 4 in) lumber attached at opposite sides of the lid. We opened the pitfall traps by inverting the lids and resting the lumber pieces on the rim of the bucket. The elevated lid allowed amphibians and reptiles access to the trap and provided shade for the pitfall trap (Figure 4). We believe that the lumber pieces may also improve the efficiency of the drift-fence/pitfall traps by helping to direct the animals into the pitfall once they reach the end of the drift-fence.

Each DFA was prepared for use by opening the pitfall traps, bailing out any water that may have accumulated, and inverting the lid for shade. The funnel traps were placed flush with the ground and covered with litter as stated above. Drift-fence arrays were set for four consecutive nights each month July–Oct 1999, and April–October 2000 (Table 2). Once opened, the drift-fence arrays were checked a minimum of once every 24 hours.

Funnel-Trap Arrays

In 2001 we decided to employ our funnel traps without the drift-fence array for two reasons:

- 1.) To survey habitat near the DFA that was previously not sampled; and
- 2.) To investigate the efficiency of the funnel traps as used alone, and evaluate this technique for herpetological sampling.

Funnel-traps arrays (FTA) were set in the general vicinity of the DFA used in 2000. This insured that the habitats originally selected for sampling were still being sampled while we tested an additional technique that we hoped would add to our list of species. The exceptions to FTA in an identical habitat placement with a DFA were FTA12 at FONE, FTA3/5 at FRHI, and FTA4 at FRHI. Funnel traps were placed along natural objects, such as logs and rocks, and were set in the same manner as those in the DFA (Figure 3). FTA were set for four nights each month in June and July of 2001.

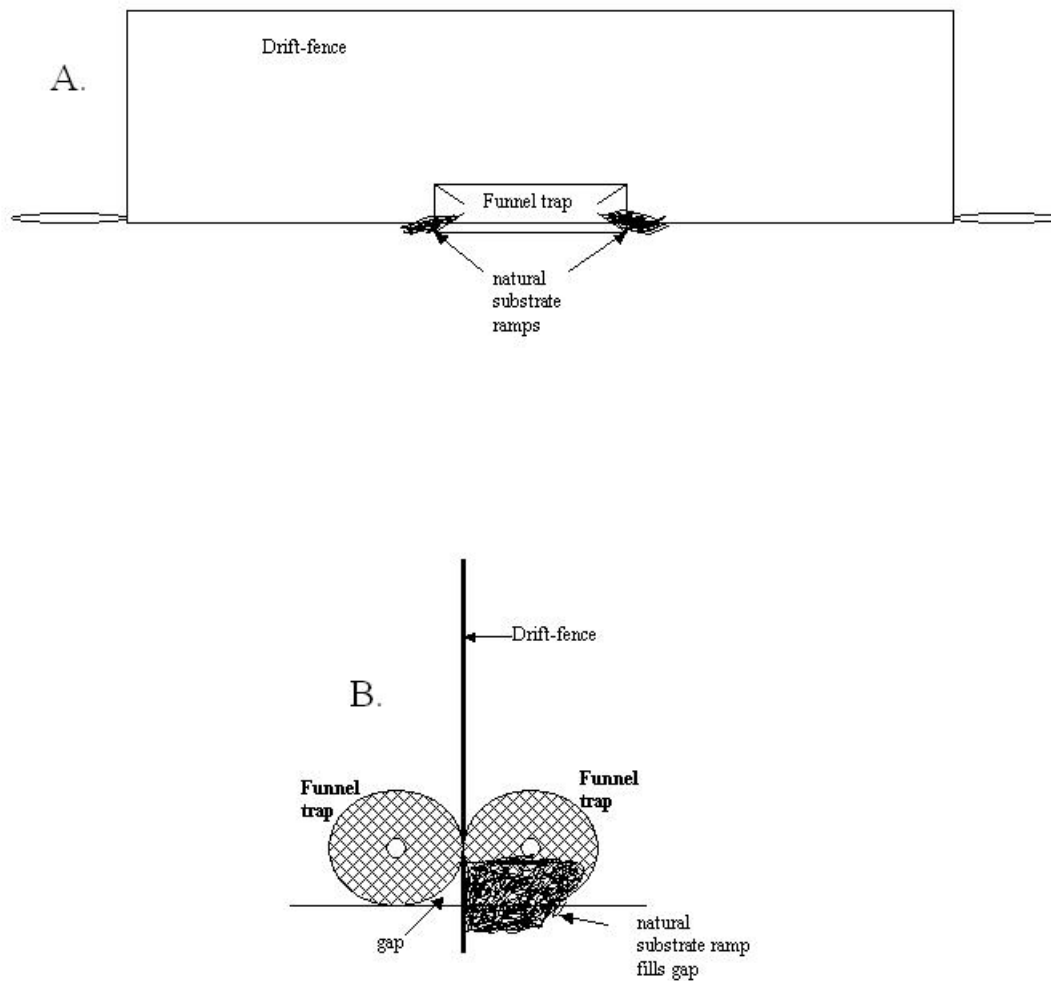


Figure 3. Schematic of natural substrate ramps in use with funnel traps as employed with drift-fence arrays and funnel-trap arrays at the Fort Necessity National Battlefield and Friendship Hill National Historic Site units. A. represents a side view of the ramps: animals entering traps touch natural substrate, not trap. B. represents the gap between the funnel trap and drift fence on the left, and shows the natural substrate ramp filling the gap on the right.

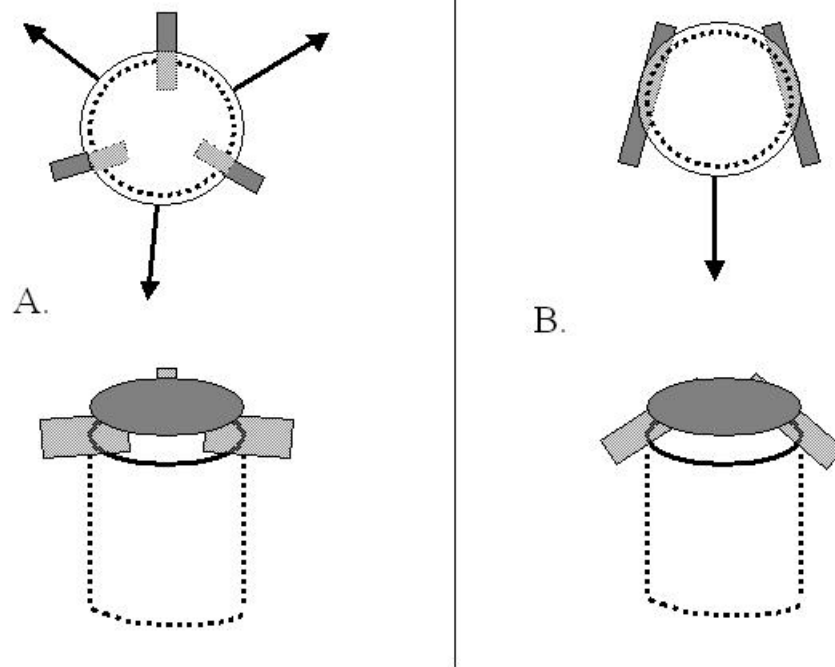


Figure 4. Schematic of the lids used for the pitfall traps of the drift-fence arrays at Fort Necessity National Battlefield and Friendship Hill National Historic Site. Pieces of 2in x 4in lumber were attached to the top of each lid with wood screws and used to hold the inverted lids above the pitfall traps. Upper diagrams show view from above, lower diagrams show a side view. Solid arrows indicate drift fences, which have been omitted from the side views for clarity. A. represents the central pitfall trap; B. represents the end pitfall trap.

Visual-encounter Surveys

Terrestrial visual-encounter surveys (TVES) performed in 1999 consisted of 100 m (109 yd) x 2 m (6.6 ft) straight-line walking transects. Straight-line transects were conducted by walking west-to-east along flagged transects and searching 1 m to each side of the center line. Cover objects such as logs, rocks, leaf piles, etcetera, were moved to search for amphibians and reptiles. Vegetation was thoroughly searched and logs were investigated using techniques such as debarking and dismantling (ripping apart rotten logs to search inside them). Any animals encountered were captured, identified to species, and measured in length. Terrestrial visual-encounter surveys were conducted monthly in 1999 beginning in June and ending in October (Table 2).

In an attempt to reduce the constraints imposed by the straight-line transects, general-habitat TVES (Crump and Scott 1994) were used during 2000 and 2001. A general habitat area (e.g., a hillside, a copse of trees, a field, etc.) was chosen for sampling, and suitable habitat within the area was searched extensively for amphibians and reptiles by turning over logs, rocks, leaf litter, et cetera, to expose any animals beneath. Investigators were careful to replace all overturned objects to their original position when done. Exact sampling protocol could be altered as necessary within each micro-habitat to insure the most thorough inventory specific to each micro-habitat. The use of a less strict sampling protocol allowed the investigators to sample more of each habitat and more thoroughly sample each particular habitat than in 1999, increasing the likelihood of encountering any amphibians and reptiles that may be present, thus potentially including more species in the inventory. Because the TVES in 2000 and 2001 were not restricted by area, there is no ability to calculate densities of the amphibians and reptiles we encountered. We are, however, still able to report species lists and species richness and make quantitative comparisons of species within habitat types. General habitat TVES were conducted monthly beginning in April 2000 and ending in September 2000. In 2001, General habitat terrestrial visual-encounter surveys were conducted in May at BRGR, in June at FONE, and in August at FRHI (Table 2).

A variation of TVES protocol, the stream visual-encounter survey (SVES) was used to sample the streams and streambeds found on the study areas. To sample streams and streambeds we selected a section of the stream (typically 25 m long) and searched it in an upstream direction. The SVES was limited to the stream and the immediate riparian surroundings within its banks. During ST we removed all cover objects and captured any amphibians and reptiles encountered. The search proceeded in an upstream direction until the section was completed. Captured animals were then processed and released. Stream visual-encounter surveys were conducted in July, August, and October of 1999. In 2000 and 2001 streams were sampled with SVES on an irregular basis because the TVES often included riparian habitat (Table 2).

Turtle Traps

Turtle traps were used to sample aquatic turtles in the perennial ponds. We used baited hoop nets of 76.2 cm (2.5 ft) and 91.4 cm (3 ft) diameter (Nylon Turtle Net, 3.8 cm (1.5 in) square mesh size, Nichols Net & Twine Co., Inc., Granite City, Illinois). We believed that using turtle traps, seine nets, and dip nets, we would thoroughly sample for all possible species and age classes.

Traps were baited by suspending opened cans of sardines from a string within the trap and were placed in shallow water such that a portion of the net remained above the surface of the water. This allowed any turtles trapped inside to surface and breathe. One trap was set in each pond and traps were checked a minimum of once every 24 hours while set. Turtle trapping was conducted from June through October in 1999, from May through September of 2000, and in June and July of 2001.

Seine Nets/Dip Nets

Seine Net: A 6-m (20-ft) seine net with a 4.0 mm (1/8 in) stretch mesh was used to sample ponds for amphibian larvae, aquatic turtles, aquatic snakes, and frogs (Shaffer et al. 1994). One person held an end of the seine net in the water near shore while another waded straight out from shore until the net was fully extended (6 m from shore). The individual out in the water then completed a quick sweep of the water, approaching shore by walking the arc created by the taut net. A third person was employed, if necessary, to keep the bottom of the seine net in contact with the bottom of the pond. When the individual performing the sweep reached the shore, the seine net was drawn parallel with the shore and dragged up the shore onto land. Captured individuals were either identified, recorded, and returned to the pond immediately, or were placed in a bucket of water to be identified and processed later. Ponds of FONE were seined in June and September, 1999. Sophia's Pond at FRHI was seined in June, July, and October 1999. All ponds at all sites were seined once each month from May to August of 2000 (Table 2).

Dip Net: In shallow water with thick vegetation the lead line of seine nets tends to lift above the pond's bottom and allow animals to escape beneath the net. For this reason dip nets with 6.4 mm (1/4 in) mesh were used to sample the outer perimeter of deep ponds, and entire ponds if shallow enough to cross with hip waders. Investigators swept the substrate and vegetation of the pond while moving toward the shore and lifted the dip net from the water at the shoreline. Any amphibians and reptiles captured were placed in a bucket for later identification and were released after all information was recorded. Dip netting was conducted along with seine netting in 1999, in May, June, July, and September of 2000, and in June of 2001.

Rappelling and Rock Searching

Rock bluffs/outcrops that required special equipment to survey safely were found only at FRHI and JUGL. Investigators searched the upper portions of these rock outcrops by rappelling rock searches (RRS). To allow the investigator to safely reach the bottom of the rocks 11 mm (7/16 in) static climbing rope of sufficient length was affixed to a tree above the outcrop to be surveyed. The investigator wore a nylon climbing harness that was attached to the rope via carabiner to a descending device. Because investigators needed both hands free to search for reptiles and amphibians, sometimes while holding flashlights to search cracks and crevices, a special "automatic-braking" descending device was employed. The Petzl "STOP" (PETZL America, Freeport Center M-7, PO Box 160447, Clearfield, UT 84016) allowed descent when a handle was squeezed, but locked in place on the rope when the handle was released. Investigators descended the rock outcroppings while searching for reptiles and amphibians. When all accessible areas had been searched the rope was moved to a new anchor and the search continued until the entire outcrop had been searched. Investigators searched the portions of the outcrops within 2 m (6 ft) of the ground on foot.

The rock outcropping at JUGL was searched via RRS in June and July of 1999. JUGL RRS were conducted in May and June of 2000. FRHI RRS were performed May through August of 1999 and June, July, and August of 2000 (Table 2).

Coverboards

Many amphibians and reptiles are known to take cover beneath surface objects. Using artificial wooden cover objects to encounter these animals is a common inventory technique (Fitch 1992; DeGraaf and Yamasaki 1992; Fellers and Drost 1994). We used large plywood coverboards (122 cm x 122 cm x 1.25 cm) in an attempt to attract amphibians and reptiles that could then be counted. A single board was placed in the vicinity of each drift-fence array on top of the substrate/debris. Checking coverboards involved lifting the board, identifying and recording individuals found beneath, and returning the board to its original position. Coverboards were set on July 1, 2001 and were checked monthly until September 2001.

Incidental Encounters

In addition to the protocols listed above, we recorded any species that were encountered within the parks while employing other survey methods. This would include encounters like observations of basking individuals, observations of breeding individuals, individuals seen on roads or trails, individuals near DFA but not in the traps, and individuals heard calling while performing protocols other than ACC.

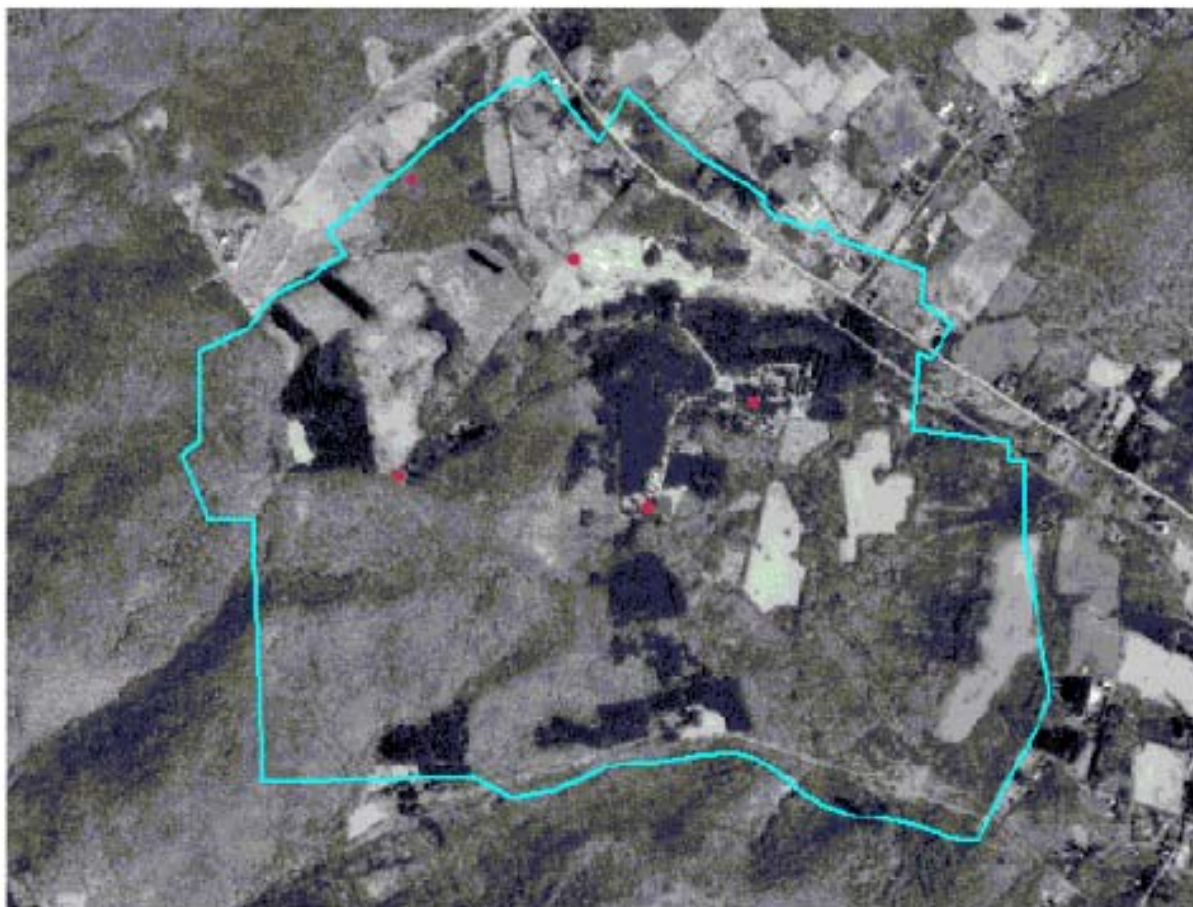
Sampling Locations

Auditory-call Counts

Listening sites for auditory-call counts were chosen based on the presence of perennial or vernal pools, perennial or intermittent streams, or wetlands at each site. In 1999, five ACC listening sites were selected at FONE, one each at BRGR and JUGL, and eight at FRHI (Figures 5–8). Listening site 2 (LS2) at FONE was dropped from the sampling regiment in 2000 because in 1999 only one toad was heard calling within 300 m of the location and no appropriate breeding habitat was found within audible sampling distance. The only records of northern spring peepers recorded from LS2 in 1999 were from frogs calling from listening station one. Table 3 contains the habitat type and location of each of the listening stations.

Drift-fence Arrays

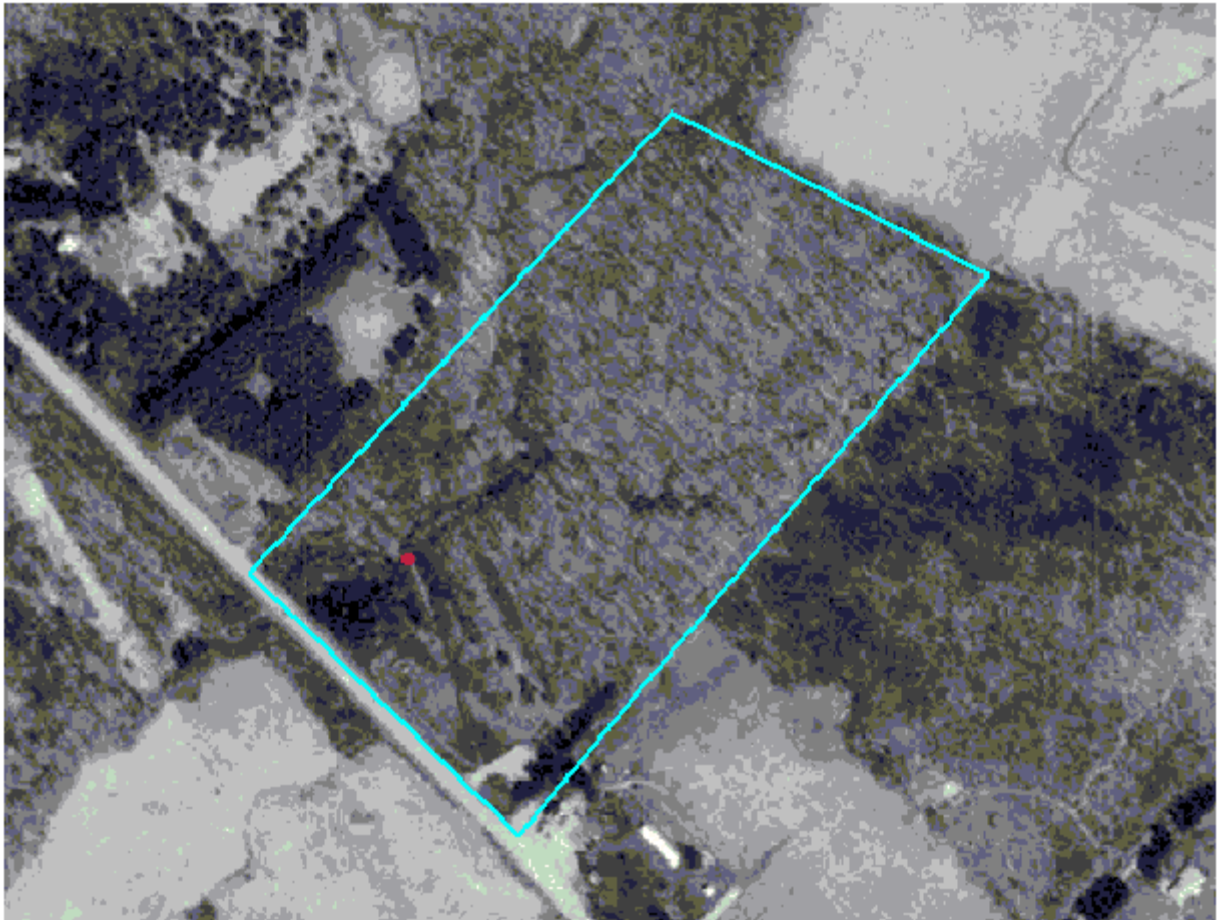
The selection of locations for placement of drift-fence arrays was based on a stratified random sampling design. East-west transects were established at landmarks that were approximately 300 m apart between the UTM coordinates 4406600 N and 4408500 N at FONE, and 4401600 N and 440400 N at FRHI. Points were determined for 20 m intervals along each of these transects. A randomly chosen point from each transect was used for placement of DFA. If a DFA location fell along a VES transect (see Visual-Encounter Surveys below) a new DFA location was determined. After all DFA locations were determined it was obvious that certain habitats of the park would be left unsampled; therefore, additional locations were chosen for DFA specifically for unsampled habitats.



● ACC Listening Stations
□ FONE Park Boundary



Figure 5. Listening stations (LS) for sampling breeding anurans via auditory-call counts (ACC), at Fort Necessity National Battlefield (FONE), main unit, 1999–2000.



● ACC Listening Station
□ BRGR Park Unit Boundary



Figure 6. Listening station (LS) for sampling breeding anurans via auditory-call counts (ACC) at Fort Necessity National Battlefield, Braddock Grave (BRGR) unit, 1999–2000.



• ACC Listening Station
JUGL Park Unit Boundary

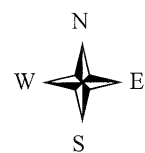


Figure 7. Listening station (LS) for sampling breeding anurans via auditory-call counts (ACC) at Fort Necessity National Battlefield, Jumonville Glen (JUGL) unit, 1999–2000.



• ACC Listening Stations
FRHI Park Boundary

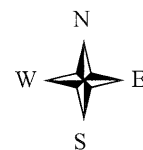


Figure 8. Listening stations (LS) for sampling breeding anurans via auditory-call counts (ACC) at Friendship Hill National Historic Site (FRHI), 1999–2000.

Table 3. Auditory call count listening stations by park, park unit, and habitat type*.

PARK	Park Subunit	ACC Listening Station	Habitat Type	E UTM	N UTM	UTM Zone	Map Datum
FONE ¹	BRGR ³	LS	deciduous forest	619706	4410162	17	NAD83 ⁵
FONE	JUGL ⁴	LS	deciduous forest	616309	4415300	17	NAD83
FONE	main unit	LS1	vernal pond	620245	4408478	17	WGS84 ⁶
FONE	main unit	LS2	deciduous forest	620212	4407656	17	NAD83
FONE	main unit	LS3	vernal pond	621244	4407851	17	WGS84
FONE	main unit	LS4	pond	620832	4407560	17	WGS84
FONE	main unit	LS5	wetland	620690	4408270	17	WGS84
FRHI ²		LS1	wetland	591475	4402569	17	WGS84
FRHI		LS2	pond	591661	4403062	17	NAD83
FRHI		LS3	wetland	592342	4402932	17	NAD83
FRHI		LS4	pond	592161	4403213	17	NAD83
FRHI		LS5	wetland	591877	4403714	17	NAD83
FRHI		LS6	vernal pond	591450	4404061	17	NAD83
FRHI		LS7	vernal pond	592206	4404354	17	NAD83
FRHI		LS8	deciduous forest	592373	4404302	17	NAD83

¹FONE=Fort Necessity National Battlefield.

²FRHI=Friendship Hill National Historic Site.

³BRGR=Braddock Grave Unit.

⁴JUGL=Jumonville Glen Unit.

⁵NAD83=North American Datum of 1983.

⁶WGS84=World Geodetic System 1984.

The final result was a total of 12 DFA locations selected at FONE, including adjoining property owned by the Rush family that was deeded for transfer to the NPS. Because the Rush Family had concerns about sampling on their property before it was legally transferred to NPS ownership, three DFA originally selected for placement there were omitted in 1999, leaving a total of nine DFA within FONE (Figure 9). In 2000, three more DFA (DFA3, DFA4, and DFA5) were installed in FONE habitat blocks that we determined had been undersampled in 1999, bringing the total number of DFA in FONE to 12 (Figure 10) (Table 4).

The relatively small sizes of Braddock Grave and Jumonville Glen precluded using a stratified random approach to determine DFA location, so a single DFA was placed randomly within each unit (Figures 11 and 12) (Table 4).

Seven DFA were established in 1999 at FRHI by the stratified random sampling protocol mentioned above (Figure13) (Table 4).

Funnel-trap Arrays

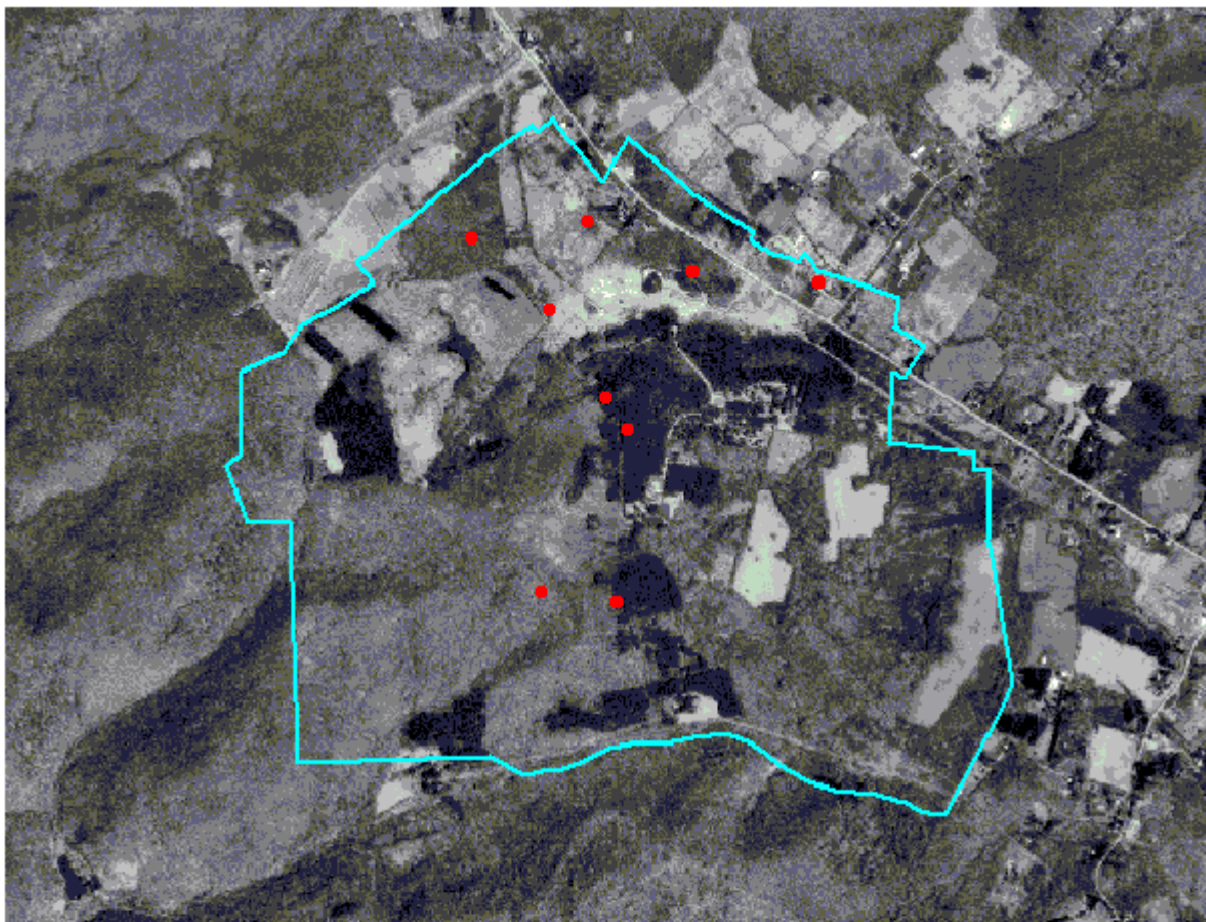
Funnel-trap arrays (FTA) were set in the general vicinity of the DFA used in 2000 (Table 5). Funnel-trap array 12 at FONE was located midway between the location of DFA12 and the Park Visitors' Center. The UTM coordinates for FTA12 are WGS84 17S, 62074N, 4408352W. The habitat of DFA12 was wetland, while FTA12 was located within a sparse copse of deciduous trees. The FTA was relocated because there were no natural objects to place the funnel traps against in the wetland habitat. The decision was then made to sample the forest area near the wetland.

Funnel-trap array 3/5 at FRHI was a combination of the funnel traps from DFA3 and DFA5. Because there were no cover objects within the mowed meadow habitat of DFA3 and 5, the traps were moved to the adjoining wooded area surrounding the perennial pond. The UTM coordinates for the pond around which the funnel traps were set are WGS84 17S, 591701N, 4403098W.

Funnel-trap array 4 at FRHI was not used. There were no natural objects in the area to place the funnel traps against; therefore, no FTA was used in the vicinity of DFA4.

Visual-encounter Surveys

The selection of locations for terrestrial visual-encounter surveys performed in 1999 was based on a stratified random sampling design. East-west transects were established at approximately 300 m intervals between UTM coordinates 4406600 N and 4408500 N at FONE, and 4401600 N and 440400 N at FRHI. Points were determined for 100 m intervals along each of these transects, and three points on each of the above transects were randomly selected to be beginning locations for the 100 m TVES. BRGR and JUGL were each sampled with three randomly located 100 m east-west TVES transects. Locations of the TVES conducted in 1999 are shown in Figures 14–17.



• DFA in 1999
□ FONE Park Boundary

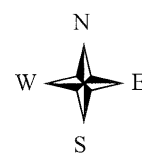
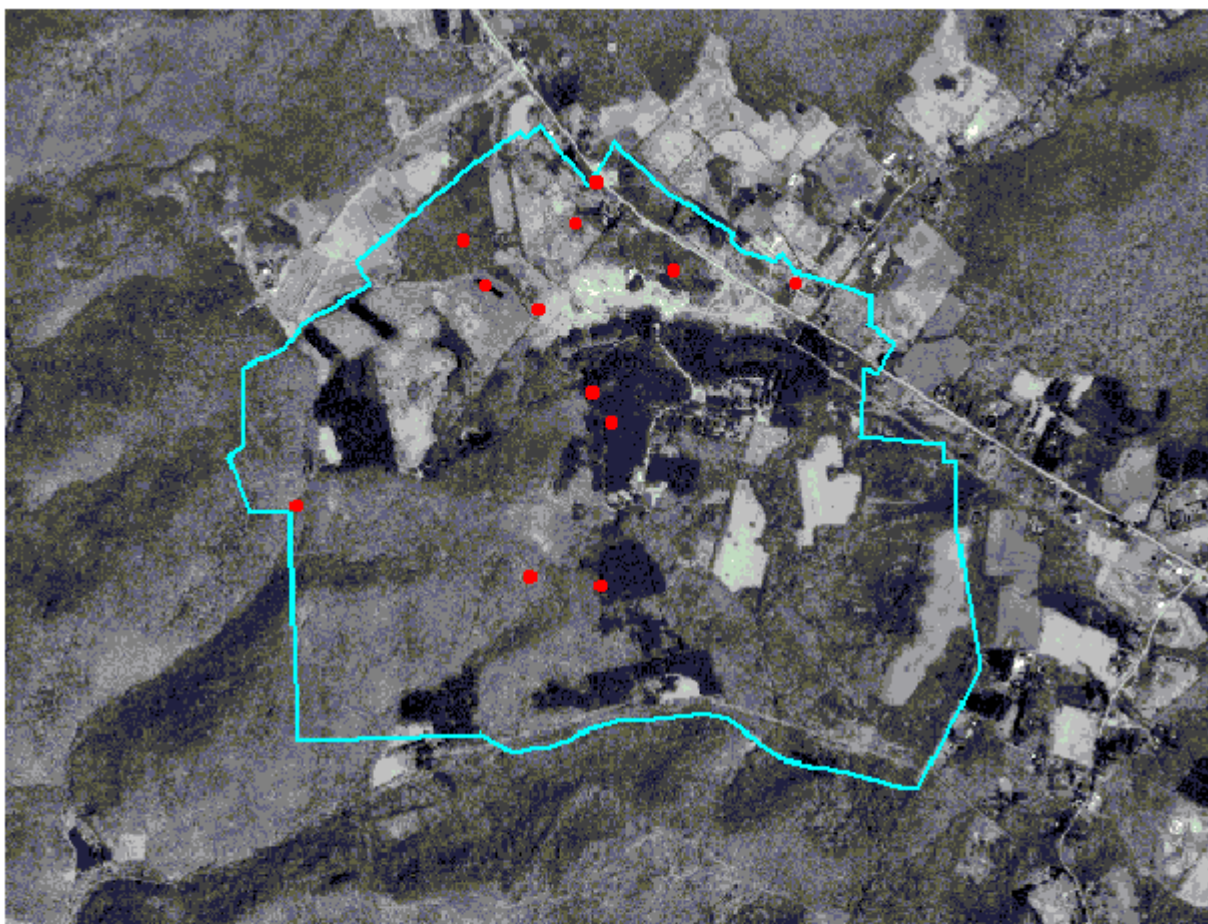


Figure 9. Locations of the nine drift-fence arrays (DFA) used in 1999 to inventory terrestrial amphibians and reptiles at Fort Necessity National Battlefield (FONE), main unit.



■ DFA in 2000
□ FONE Park Boundary

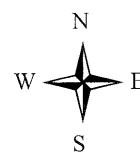


Figure 10. Locations of the 12 drift-fence arrays (DFA) used in 2000 to inventory terrestrial amphibians and reptiles at Fort Necessity National Battlefield (FONE) main unit.

Table 4. Drift-fence array locations by park, park unit, and habitat type.

Park	Park Subunit	Drift-fence Array	Habitat	E UTM	N UTM	UTM Zone	Datum
FONE ¹	BRGR ³	DFA	deciduous forest	619823	4410270	17	WGS84 ⁶
FONE	JUGL ⁴	DFA	deciduous forest	616301	4415256	17	WGS84
FONE	main unit	DFA1	pine	620850	4407293	17	WGS84
FONE	main unit	DFA2	deciduous forest	620565	4407330	17	WGS84
FONE	main unit	DFA3	deciduous forest	619827	4407551	17	NAD83 ⁵
FONE	main unit	DFA4	pine	620430	4408252	17	NAD83
FONE	main unit	DFA5	meadow	620832	4407560	17	NAD83
FONE	main unit	DFA6	deciduous/pine	620838	4407819	17	WGS84
FONE	main unit	DFA7	deciduous/pine	620776	4407918	17	WGS84
FONE	main unit	DFA8	meadow	620611	4408188	17	WGS84
FONE	main unit	DFA9	mowed lawn	621419	4408232	17	WGS84
FONE	main unit	DFA10	deciduous forest	621041	4408310	17	WGS84
FONE	main unit	DFA11	deciduous forest	620363	4408413	17	WGS84
FONE	main unit	DFA12	wetland	620719	4408465	17	WGS84
FRHI ²		DFA1	deciduous forest	591792	4402187	17	WGS84
FRHI		DFA2	deciduous forest	592853	4402605	17	WGS84
FRHI		DFA3	mowed hayfield	591753	4403066	17	WGS84
FRHI		DFA4	fallow field	592515	4403142	17	WGS84
FRHI		DFA5	mowed hayfield	591599	4403366	17	WGS84
FRHI		DFA6	deciduous forest	592142	4403892	17	WGS84
FRHI		DFA8	deciduous forest	591831	4404320	17	WGS84

¹FONE=Fort Necessity National Battlefield.

²FRHI=Friendship Hill National Historic Site.

³BRGR=Braddock Grave Unit.

⁴JUGL=Jumonville Glen Unit.

⁵NAD83=North American Datum of 1983.

⁶WGS84=World Geodetic System 1984.

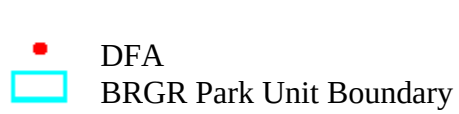


Figure 11. Location of the drift-fence array (DFA) used to inventory terrestrial amphibians and reptiles at Fort Necessity National Battlefield, Braddock Grave (BRGR) unit, 1999–2000.

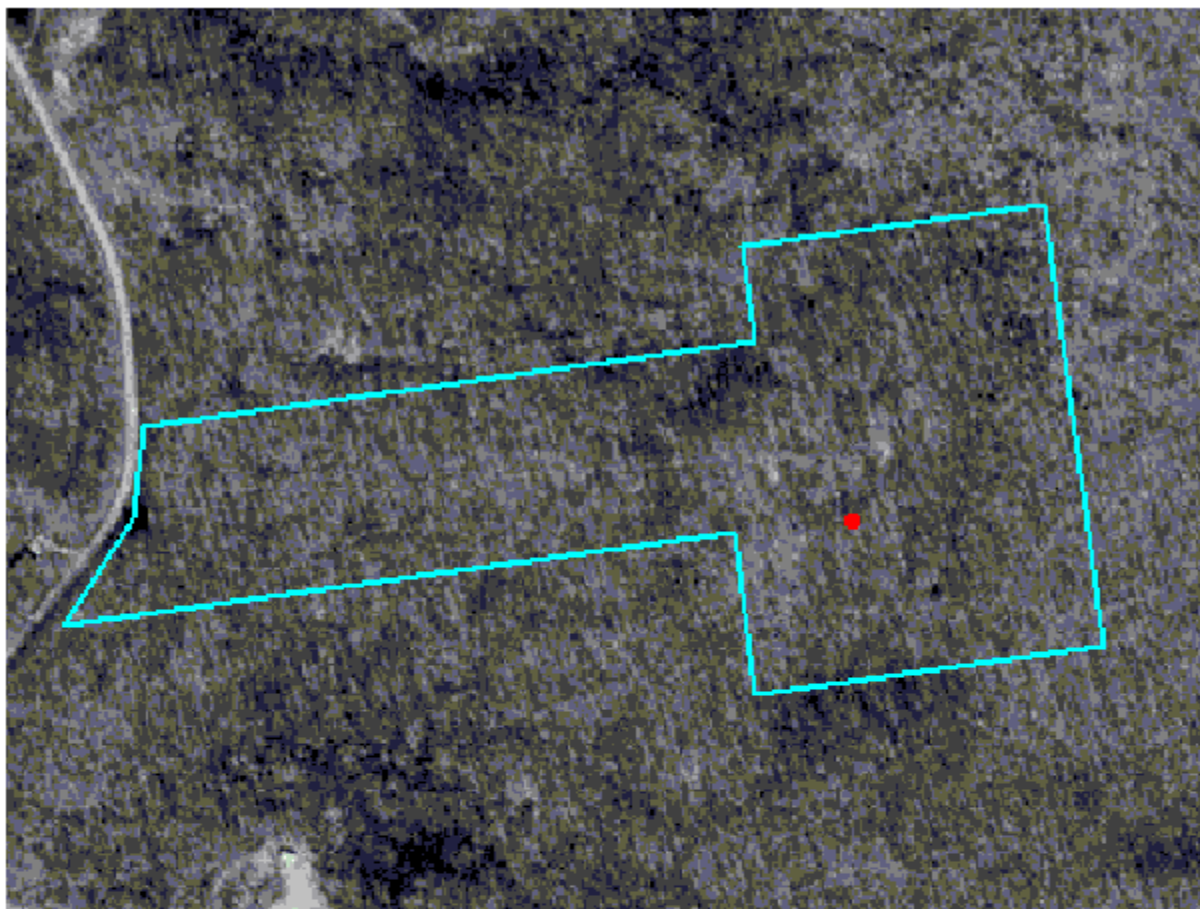


Figure 12. Location of the drift-fence array (DFA) used to inventory terrestrial amphibians and reptiles at Fort Necessity National Battlefield, Jumonville Glen (JUGL) unit, 1999–2000.



• DFA
□ FRHI Park Boundary

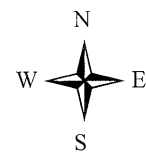


Figure 13. Locations of seven drift-fence arrays (DFA) used to inventory terrestrial amphibians and reptiles at Friendship Hill National Historic Site (FRHI), 1999–2000.

Table 5. Funnel-trap array locations by park, park unit, and habitat type.

Park	Park Subunit	Drift-fence		E UTM	N UTM	UTM Zone	Datum
		Array	Habitat				
FONE ¹	BRGR ³	FTA	deciduous forest	619778	4410285	17	WGS84 ⁶
FONE	JUGL ⁴	FTA	deciduous forest	616301	4415256	17	NAD83 ⁵
FONE	main unit	FTA1	pine	620876	4407365	17	WGS84
FONE	main unit	FTA2	deciduous forest	620589	4407447	17	WGS84
FONE	main unit	FTA3	deciduous forest	619992	4407549	17	WGS84
FONE	main unit	FTA4	pine	620469	4408239	17	WGS84
FONE	main unit	FTA5	pine	620654	4408639	17	WGS84
FONE	main unit	FTA6	clear cut	620848	4407798	17	WGS84
FONE	main unit	FTA7	deciduous/pine	620708	4407904	17	WGS84
FONE	main unit	FTA8	meadow	620583	4408133	17	WGS84
FONE	main unit	FTA9	mowed lawn	621506	4408261	17	WGS84
FONE	main unit	FTA10	deciduous forest	620983	4408351	17	WGS84
FONE	main unit	FTA11	deciduous forest	620341	4408423	17	WGS84
FONE	main unit	FTA12	deciduous forest	620826	4408403	17	WGS84
FRHI ²		FTA1	pin	591792	4402187	17	WGS84
FRHI		FTA2	pond	592853	4402605	17	WGS84
FRHI		FTA3/5	pond	591701	4403098	17	WGS84
FRHI		FTA6	deciduous forest	592211	4403531	17	WGS84
FRHI		FTA8	vernal pond	592171	4404294	17	WGS84

¹FONE=Fort Necessity National Battlefield.

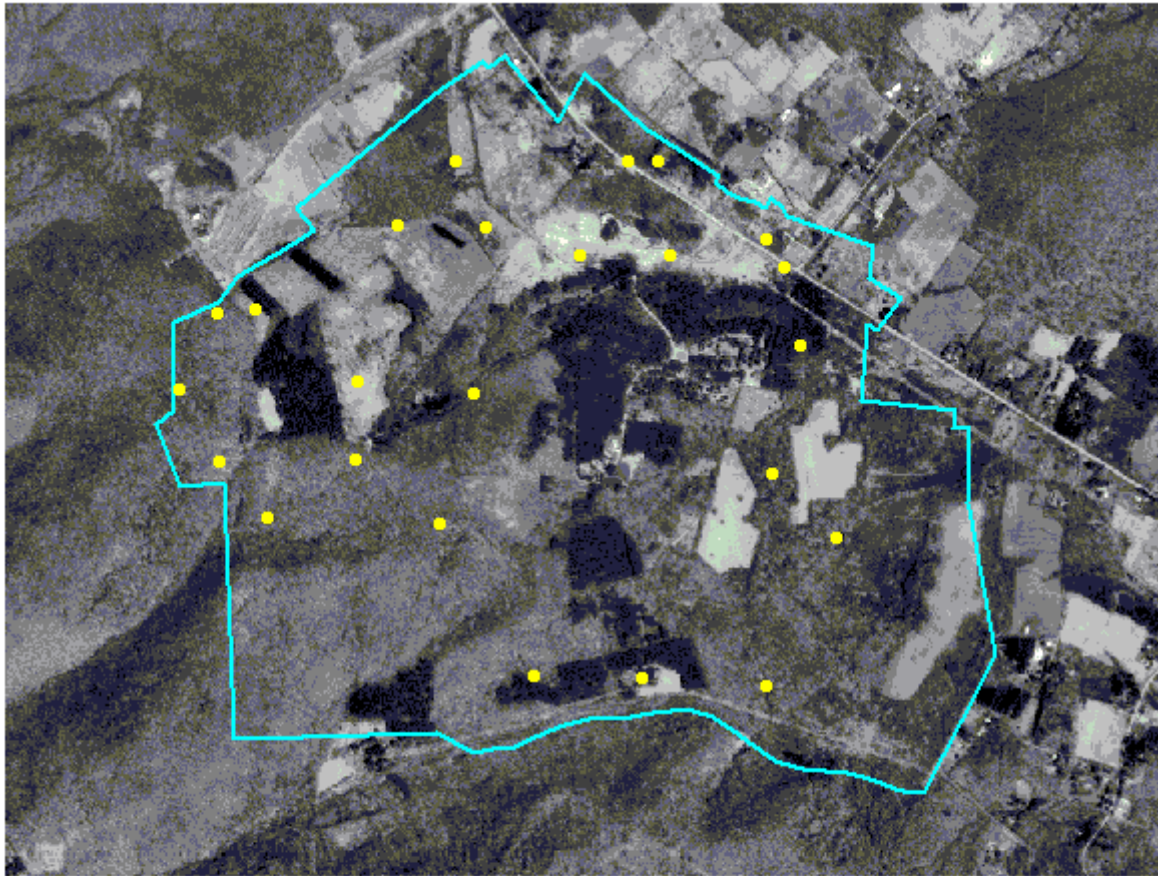
²FRHI=Friendship Hill National Historic Site.

³BRGR=Braddock Grave Unit.

⁴JUGL=Jumonville Glen Unit.

⁵NAD83=North American Datum of 1983.

⁶WGS84=World Geodetic System 1984.



● TVES Locations in 1999
□ FONE Park Boundary

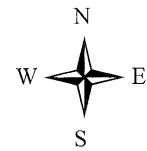
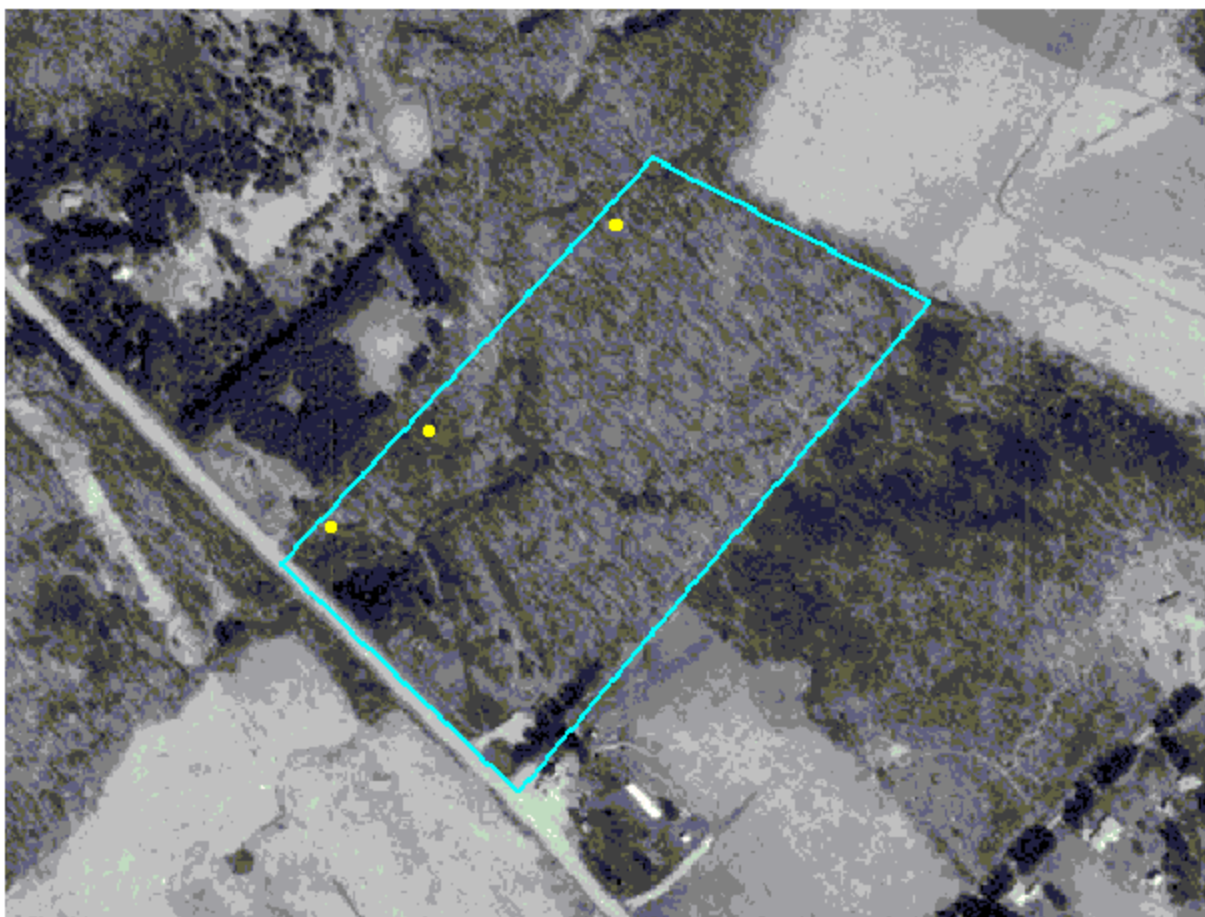


Figure 14. Locations of the 24 terrestrial visual-encounter survey (TVES) transects used to inventory amphibians and reptiles at Fort Necessity National Battlefield (FONE), main unit, in 1999.



● TVES Locations in 1999
□ BRGR Park Unit Boundary



Figure 15. Locations of the three terrestrial visual-encounter survey (TVES) transects used to inventory amphibians and reptiles at Fort Necessity National Battlefield, Braddock Grave (BRGR) unit, in 1999.



● TVES Locations in 1999
□ JUGL Park Unit Boundary

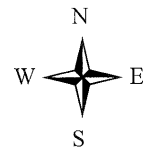


Figure 16. Locations of the three terrestrial visual-encounter survey (TVES) transects used to inventory amphibians and reptiles at Fort Necessity National Battlefield, Jumonville Glen (JUGL) unit, in 1999.

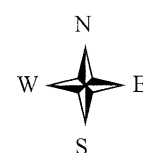


Figure 17. Locations of the 21 terrestrial visual-encounter survey (TVES) transects used to inventory amphibians and reptiles at Friendship Hill National Historic Site (FRHI) in 1999.

The TVES performed in 2000–2001 were conducted in various habitats as selected by the investigators (Table 6). Any area that was surveyed with a TVES was not surveyed again within the same field season.

Turtle Traps

Turtle traps were placed in the two largest ponds at FONE (Figure 18), in Sophia’s Pond at FRHI, and in the first (farthest upstream) pond of the wetland treatment ponds of Ice Pond Run at FRHI (Figure 19).

Seine Netting/Dip Netting

The perennial ponds in FONE and FRHI were sampled with seine and dip nets (Figures 18 and 19).

Rappelling and Rock Searches

RRS were conducted at FRHI on the rock bluffs that extend from just north of the gazebo to a few hundred meters south of the gazebo. JUGL was sampled with RRS on the Pottsville Sandstone outcrops that overlook the ephemeral stream.

Coverboards

A single coverboard was placed in close proximity to DFA to insure that all of the originally selected habitats were also sampled with coverboards.

Table 6. Terrestrial visual-encounter survey 100 m transects surveyed in 1999 and the number of transects in each habitat type, by park unit.

Park	Park Subunit	Habitat	Number of 100-m walking transects in habitat type
FONE ¹	JUGL ³	deciduous forest	3
FONE	BRGR ⁴	deciduous forest	3
FONE	main unit	deciduous forest	10
FONE	main unit	pine	3
FONE	main unit	wetland	1
FONE	main unit	meadow	10
FRHI ²		deciduous forest	12
FRHI		fallow field	3
FRHI		mowed hayfield	2
FRHI		bluffs	2
FRHI		deciduous floodplain	1
FRHI		mowed lawn	1

¹FONE=Fort Necessity National Battlefield.

²FRHI=Friendship Hill National Historic Site.

³BRGR=Braddock Grave Unit.

⁴JUGL=Jumonville Glen Unit.



 Aquatic Surveys
 FONE Park Boundary



Figure 18. Locations of the perennial ponds sampled via turtle traps, seine net, and dip nets for aquatic amphibians and reptiles at Fort Necessity National Battlefield (FONE), main unit, 1999–2001.



Figure 19. Locations of the perennial ponds sampled via turtle traps, seine net, and dip nets for aquatic amphibians and reptiles at Friendship Hill National Historic Site (FRHI), 1999–2001.

Results

Through the use of nine inventory protocols, we observed 34 of the 54 species (63%) originally predicted to occur at FONE and FRHI. When considering the updated distributions of the species on our original potential species list (Hulse et al. 2001), and excluding species that are now known to exist only outside of FONE and FRHI (see Appendix 1), our inventory recorded 34 (69%) of the predicted 49 reptile and amphibian species (Table 7). This included 3 of 4 turtle species (75%), 10 of 14 snake species (71%), 12 of 18 salamander species (67%), 9 of 11 frogs and toads (82%), and 0 of 2 lizard species.

The inventory of BRGR documented 16 (33%) of the 49 predicted species. Inventories at JUGL documented 12 (24%) species. The inventory of FONE listed 29 (59%) of the 49 predicted species. FRHI inventory protocols produced records of 27 (55%) of the predicted species.

Species Documented by the 1999–2001 Inventory

Chelydra serpentina (Common Snapping Turtle)

This species of turtle was encountered in the perennial ponds of FONE and FRHI. Juvenile, young, and adult individuals were collected. FRHI had a higher abundance of common snapping turtles in its perennial pond than FONE. The turtles were often seen basking on a partially submerged log in the FRHI pond. Based on the eggs found in a turtle nest at FONE, it was probably a snapping turtle nest.

Chrysemys p. picta (Eastern Painted Turtle)

This species of turtle was captured in turtle traps at FONE and was seen basking on the floating log in the perennial pond at FRHI.

Terrepenne c. carolina (Eastern Box Turtle)

The single record of this turtle was an incidental encounter. The carapace of a dead Eastern box turtle was found in mature deciduous forest at FONE. Given that the preferred habitats of this species are deciduous forest and ecotones between forests and old fields (Hulse et al. 2001), there is plenty of suitable habitat for the eastern box turtle in all park units of FONE and FRHI, so it is likely that they are present, but live animals were not encountered during the inventory.

Agkistrodon contortrix mokasen (Northern Copperhead)

One copperhead was captured in a DFA at FRHI. The snake was a juvenile and was captured in mature deciduous forest near old-field habitat. This preferred habitat of the snake (Hulse et al. 2001) is plentiful at FONE and FRHI, thus we expected to see more copperheads in both parks. The historic alteration of habitat at FONE and FRHI may account for some lack in abundance, but more likely, the heavy historic use of both parks by man was accompanied by human persecution of the species from which populations have never recovered.

Table 7. Complete list of the 34 species of amphibians and reptiles identified by inventories of Fort Necessity National Battlefield and Friendship Hill National Historic Site, 1999–2001.

Family	Genus	Scientific Name	Common Name
Reptiles			
	<u>Testudines (Turtles)</u>		
		<i>Chelydra serpentina</i>	common snapping turtle
		<i>Chrysemys p. picta</i>	eastern painted turtle
		<i>Terrepenne c. carolina</i>	eastern box turtle
	<u>Serpentes (Snakes)</u>		
		<i>Agkistrodon contortrix mokasen</i>	northern copperhead
		<i>Coluber c. constrictor</i>	northern black racer
		<i>Diadophis punctatus edwardsi</i>	northern ringneck snake
		<i>Elaphe o. obsoleta</i>	black rat snake
		<i>Heterodon platirhinos</i>	eastern hognose snake
		<i>Lampropeltis t. triangulatum</i>	eastern milk snake
		<i>Nerodia s. sipedon</i>	northern water snake
		<i>Opheodrys vernalis</i>	smooth green snake
		<i>Thamnopsis s. sirtalis</i>	eastern garter snake
		<i>Virginia valeriae pulchra</i>	mountain earth snake
Amphibians			
	<u>Caudata (salamanders)</u>		
		<i>Ambystoma jeffersonianum</i>	Jefferson salamander
		<i>Desmognathus f. fuscus</i>	northern dusky salamander
		<i>Desmognathus monticola</i>	seal salamander
		<i>Desmognathus ochrophaeus</i>	mountain dusky salamander
		<i>Eurycea bislineata</i>	northern two-lined salamander
		<i>Eurycea l. longicauda</i>	longtail salamander
		<i>Gyrinophilus p. porphyriticus</i>	northern spring salamander
		<i>Hemidactylium scutatum</i>	four-toed salamander
		<i>Notophthalmus v. viridescens</i>	red-spotted newt
		<i>Plethodon cinereus</i>	redback salamander
		<i>Plethodon g. glutinosus</i>	northern slimy salamander
		<i>Pseudotriton r. ruber</i>	northern red salamander
	<u>Anura (Frogs and Toads)</u>		
		<i>Bufo a. americanus</i>	eastern American toad
		<i>Bufo woodhousei fowleri</i>	Fowler's toad
		<i>Hyla versicolor/chrysoscelis</i>	gray treefrog
		<i>Pseudacris c. crucifer</i>	northern spring peeper
		<i>Rana catesbeiana</i>	bullfrog
		<i>Rana clamitans melanota</i>	green frog
		<i>Rana palustris</i>	pickerel frog
		<i>Rana pipiens</i>	northern leopard frog
		<i>Rana sylvatica</i>	wood frog

Coluber c. constrictor (Northern Black Racer)

Three northern black racers were caught in DFA during our study. The two at FRHI were caught in mowed fields, while the FONE capture was from meadow habitat. These locations correspond with the snake's preference for open habitats like meadows and old fields (Hulse et al. 2001).

Diadophis punctatus edwardsi (Northern Ringneck Snake)

The three northern ringneck snakes we encountered were all in deciduous forest habitat. Hulse et al. (2001) state that although the northern ringneck snake is a commonly encountered snake that occurs in a variety of habitats, it is usually found not far from woodlands. One was captured at FRHI in DFA8. The two from JUGL were found by RRS and DFA.

Elaphe o. obsoleta (Black Rat Snake)

Black rat snakes were captured at FONE from both of the DFA in meadow habitat. At FRHI, this species was captured in DFA in deciduous forest and mowed field. Deciduous forest and ecotones between forest and field are common habitats of this species (Hulse et al. 2001). They were also encountered at FRHI on the paved driveway and at the perennial pond.

Heterodon platirhinos (Eastern Hognose Snake)

The single eastern hognose snake we encountered was captured in a DFA at FRHI located in deciduous forest between the river bluffs and the state highway. The soil in this area is relatively dry and may be suitable to the species, as they prefer dry, sandy soils near or in deciduous forest. Hulse et al. (2001) do not include southern Fayette County in the range of the hognose snake but cite McCoy and Bianculli (1966) as postulating that one stock of the hognose snake has moved into Pennsylvania along the Ohio and Allegheny Rivers. It is possible that part of the population has also moved from the Ohio River southward along the Monongahela River into southwest Pennsylvania.

Lampropeltis t. triangulatum (Eastern Milk Snake)

The eastern milk snakes were caught in two DFA at FONE. One was in mixed deciduous/pine habitat and one was in meadow habitat. In Pennsylvania, the species is known to occupy open country, ecotones, areas disturbed by human habitation or alteration, and deciduous forest (Hulse et al. 2001). Both snakes were neonates captured in autumn of 1999.

Nerodia s. sipedon (Northern Water Snake)

Northern water snakes were seen and recorded as incidental encounters at the perennial ponds at FONE. At FRHI they were encountered in wetlands, ponds, vernal ponds, and deciduous forest by incidental encounters, FTA, and DFA. This species is a commonly encountered snake that occurs near aquatic and semi-aquatic habitats (Hulse et al. 2001).

Opheodrys vernalis (Smooth Green Snake)

Five smooth green snakes were captured in DFA at FONE. The captures were made in mowed lawn, wetland, and meadow habitats. This species is found in a variety of open habitats (Hulse et al. 2001).

Thamnopsis s sirtalis (Eastern Garter Snake)

A total of 31 eastern garter snakes were encountered from BRGR, FONE, and FRHI. This was the most commonly encountered snake species during our study. BRGR had one record of a juvenile via DFA. FONE had 10 encounters, nine of which were DFA captures. Drift-fence array captures occurred in deciduous forest, meadow, and mowed lawn. One incidental encounter was recorded at FONE when a snake was seen basking on the paved road near the foundation of the old maintenance building. FRHI had 20 records of eastern garter snakes; 18 were via DFA captures, most commonly in mowed field and fallow field habitats, but also in deciduous forest. Two incidental encounters at FRHI were in deciduous forest. Eastern garter snakes are the most commonly encountered snake in the northeastern U.S. and occupy almost any habitat (Hulse et al. 2001).

Virginia valeriae pulchra (Mountain Earth Snake)

The single mountain earth snake was captured in a DFA at FONE in deciduous forest habitat. The species is usually found in upland hardwood forests (Hulse et al. 2001).

Ambystoma jeffersonianum (Jefferson Salamander)

All Jefferson salamander records from the inventory were from FRHI. *Ambystoma* egg masses were seen each spring in the vernal pond located near Dublin Run and the railroad, but identification to species could never be made with enough confidence to include the data as a record for the inventory. Therefore, the development of the larvae was watched closely, and each year (1999–2001) all *Ambystoma* larvae were identified as Jefferson salamanders. Records include the capture of Jefferson salamander larvae in FTA traps set in Dublin Run Pond in 2001. Five adult salamanders were captured in DFA in mowed field and deciduous forest.

Hulse et al. (2001) state that the distribution of Jefferson salamanders in Pennsylvania is spotty but widespread. The species is found in deciduous or mixed hardwood/conifer forests with ponds (for reproduction). FRHI appeared to have a healthy population of the species within the park, with successful breeding attempts in 1999–2001. However, it appears that the entire population of the park may be dependent upon the single vernal pond (Dublin Run Pond) for its reproductive success. To ensure the success of Jefferson salamanders at FRHI, we recommend closely managing the watershed of Dublin Run in a mature deciduous forest. More importantly, we recommend protecting Dublin Run Pond and maintaining its presence as a vernal pond. Additional vernal ponds constructed in deciduous forest within FRHI could provide more breeding areas for the species and serve as a means to ensure the future success of Jefferson salamanders against any destruction or alteration of Dublin Run Pond.

Desmognathus f. fuscus (Northern Dusky Salamander)

This salamander was encountered 110 times during the inventory. It is a common species in Pennsylvania streams and is found in higher abundance in undisturbed stream habitats (Rocco et al. 1999). This species of dusky salamander was seen in all four park units. It was common in FRHI, BRGR, and FONE, and in streams was usually second in abundance only to mountain dusky salamanders during this inventory. This may be directly related to the acid deposition that southwestern Pennsylvania receives, especially in the Laurel Highlands. Kowalski (2002) showed that, with depression of the pH in a Laurel Highland stream, composition of the stream's salamander population moves from a diverse community, which includes spring, brook, and seal salamanders, to a community of primarily mountain dusky salamanders with only a few northern dusky salamanders.

Desmognathus monticola (Seal Salamander)

The seal salamander was seen in BRGR, FONE, and FRHI and was encountered most often in streams. One salamander with a nest of 16 embryos was found in a BRGR stream. Two were caught in a wetland DFA in FONE. With only 36 total encounters, the species was not common within any of the park units. The seal salamander was locally abundant in a few small streams and seeps, and these locations produced most of the records. These streams and seeps were probably alkaline and well buffered against the acid deposition of the region. Kowalski (2002) showed that seal salamanders were dependent on circumneutral water and were not encountered below a pH of 6.2. Seal salamanders are probably restricted to circumneutral waters of the parks.

Desmognathus ochrophaeus (Mountain Dusky Salamander)

Mountain dusky salamanders were relatively common with 256 encounters from BRGR, JUGL, FONE, and FRHI. This was the most common salamander encountered in streams and wet areas of the parks. It was encountered by DFA, FTA, incidental encounter, RRS, SVES, and TVES. This species of dusky salamander is the least dependent on stream habitat of all the dusky salamanders (Hulse et al. 2001) and was found in pine, mixed pine/deciduous, deciduous forest, stream, and wetland habitats. The reason for its dominance of the stream salamander populations may be related to the local acid deposition and the mountain dusky salamander's ability to tolerate streams of low pH. Rocco et al. (1999) and Kowalski (2002) both found that the mountain dusky salamander is the most abundant species in poorly buffered, acidified streams of the region.

Eurycea bislineata (Northern Two-lined Salamander)

The northern two-lined salamander was encountered in BRGR by VES and ST, and was encountered in FRHI by ST and DFA. Eighteen were encountered, three of which were larvae. This species is dependent on circumneutral streams to reproduce successfully (Kowalski 2002). Given the poorly buffered status of most of the streams in the parks and the acid deposition of southwestern Pennsylvania, it was not surprising to find a restricted population.

Eurycea l. longicauda (Longtail Salamander)

Four longtail salamanders were found during the study. One was encountered at BRGR by TVES. One larva was found in a SVES at JUGL. Two (one larva and one adult) were found by incidental encounter in Great Meadow Run at FONE. This species is dependent on circumneutral streams to reproduce successfully (Kowalski 2002). Given the poorly buffered status of most of the streams in the parks and the acid deposition of southwest Pennsylvania, it was not surprising to find a restricted population.

Gyrinophilus p. porphyriticus (Northern Spring Salamander)

This species was encountered eight times as adults in BRGR, JUGL, FONE, and FRHI via DFA, SVES, TVES, and incidental encounter. BRGR also had five encounters of larvae by SVES and TVES. A species with a relatively specific habitat preference of cool springs, spring seeps, or fast flowing streams with rocky substrate (Hulse et al. 2001), this species is further restricted in its distribution by its dependence on circumneutral streams to reproduce successfully (Kowalski 2002). Given the poorly buffered status of most of the streams in the parks and the acid deposition of southwestern Pennsylvania, it was not surprising to find a restricted population.

Hemidactylium scutatum (Four-toed Salamander)

Hulse et al. (2001) describe the habitat of this salamander as forested areas associated with mesic environments, with occasional encounters in meadows or dry hillsides. We captured nine four-toed salamanders at FONE in DFA. Habitats were deciduous forest, mowed lawn, and meadow. DFA where the species was captured were all near a wet environment. Of particular note were five salamanders caught in the pitfall traps of DFA8 at FONE when the traps were being opened in April 2000. These salamanders were probably moving as part of their early spring “migrations” to breeding sites (Bishop 1941) when they encountered the DFA and were captured.

Notopthalmus v. viridescens (Red-spotted Newt)

At FRHI, this species was caught as an eft (the juvenile, terrestrial stage of the salamander) on four occasions. Three were DFA captures in deciduous forest and one was caught in the seine net in the perennial pond. Red-spotted newt efts were recorded in BRGR by DFA and TVES and in JUGL three times by TVES.

The red-spotted newt was the most abundant species encountered at FONE. The perennial ponds yielded 1,287 adults by seine and dip nets, and 355 larvae were taken from temporary ponds, wetlands, and streams. The eft was the most commonly captured amphibian in FONE DFA in pine, mixed deciduous/pine, deciduous forest, wetland, and meadow habitats. The efts accounted for 67 total encounters at FONE.

The red-spotted newt was apparently uncommon at FONE until a previous employee of the park brought some adults back from the east and released these adults into the perennial ponds near the Great Meadows Center. In the years since the release, the species has become more and more common at FONE (C. Ranson, pers. comm.1999). Without the artificial ponds to breed in

and serve as adult habitat, the newt population would probably not be so large or successful at FONE.

Newts are common throughout the Northeastern U.S., but their large numbers at FONE may be placing undue stress on the populations of the other amphibians of the park. We observed red-spotted newts feeding extensively on the eggs of other amphibian species in ponds and vernal ponds of FONE. Given their abundance, their predation on the eggs of other pond-breeding amphibians could be devastating to populations of other amphibian species in the park. In the event that the abundance of other pond-breeding amphibians at FONE declines in the near future, one possible cause to investigate would be the relation between egg predation by newts to reproductive success of the declining species.

Plethodon cinereus (Redback Salamander)

A single redback salamander was captured by DFA in deciduous forest at FRHI. This salamander was encountered in relatively high abundance at BRGR, JUGL, and FONE. At JUGL four encounters were made by TVES and RRS. BRGR had 10 records of redback salamanders via TVES and DFA. Seventy-five salamanders were encountered at FONE via DFA, FTA, and TVES. The redback salamander was the second most abundant woodland salamander in our study behind the northern slimy salamander. Hulse et al. (2001) describe the habitat of this species as upland forest areas that are not too dry or exposed, nor too close to streams.

Plethodon g. glutinosus (Northern Slimy Salamander)

The northern slimy salamander was the most common woodland salamander in all four park units. BRGR recorded 32 individuals via TVES, SVES, and DFA. At JUGL, 10 were recorded via SVES, RRS, and TVES. FONE records of northern slimy salamanders totaled 70 and were produced via CB, DFA, FTA, incidental encounter, and TVES. FRHI had 13 records of this species via DFA and TVES. The habitats in which the northern slimy salamanders were encountered included mixed deciduous/pine forest, deciduous forest, fallow field, meadow, pine forest, stream, and wetland. The documented habitat of this species is heavily forested areas (especially mature woodlots) or shale-covered embankments, and hillsides near dense forest (Hulse et al. 2001).

Pseudotriton r. ruber (Northern Red Salamander)

This species was encountered at BRGR seven times via SVES, TVES, and incidental encounter. FONE produced only one record of a northern red salamander from a DFA in wetland habitat. This species requires clear, cool streams and springs that are fairly shallow with rock-strewn bottoms (Hulse et al. 2001). The stream at the Braddock Grave Unit fits this description perfectly, and the statement by Hulse et al. (2001) that occasional encounters occur in flatland swampy areas or open marshy regions describes the wetland habitat DFA in FONE.

Bufo a. americana (Eastern American Toad)

Two eastern American toads were captured in the DFA at BRGR. JUGL had two ACC records of the species and one capture in the DFA. FONE had 15 records via ACC, DFA, incidental

encounter, and TVES; habitats of encounter at FONE were mixed deciduous/pine, deciduous forest, meadow, mowed lawn, and vernal pond. FRHI had 50 encounters of eastern American toads via ACC, DFA, dip net, incidental encounter, seine net, and TVES; habitats of encounter at FRHI were deciduous forest, mowed field, pines, pond, vernal pond, and wetland.

Hulse et al. (2001) call the eastern American toad a habitat generalist found in open upland habitats, agricultural land, and suburban backyards, and less frequently in forests. In the breeding season they can be found near and in water.

Bufo woodhousei fowleri (Fowler's Toad)

Fowler's toads were encountered at JUGL, FONE, and FRHI. Two were seen at JUGL by DFA and incidental encounter. FONE produced two DFA records in deciduous forest and one in meadow via incidental encounter. There were two DFA encounters at FRHI in deciduous forest and one incidental encounter in deciduous forest. The Fowler's toad is primarily an inhabitant of lowland areas in open habitat with well-drained soils (Hulse et al. 2001).

Hyla versicolor/chrysoscelis (Gray Treefrog)

One record of this species was produced at FONE via ACC at the perennial ponds. FRHI had four ACC records of gray treefrogs from vernal pond and wetland habitats. Hulse et al. (2001) report that this species is usually found in deciduous woodlands but may be found near temporary waters, especially in the breeding season.

Pseudacris c. crucifer (Northern Spring Peeper)

The northern spring peeper was the most abundant species identified by ACC at BRGR, JUGL, FONE, and FRHI. With the single exception of FONE where 1,000 tadpoles were captured in a small pond via seine net, most of the records (90) of northern spring peepers were via ACC. This species congregated near any body of water in the spring and produced large choruses from habitats of pond, wetland, vernal pond, and deciduous forest. Records were also produced at FONE, BRGR, and FRHI via DFA from a variety of habitats. Incidental encounters at FRHI and FONE produced four encounters, usually by hearing calling males outside of the breeding season. A few northern spring peeper tadpoles were identified in dip net samples from FONE and FRHI. This species is very common near water bodies in the spring, and is a resident of woodlands outside of the breeding season (Hulse et al. 2001).

Rana catesbeiana (Bullfrog)

Bullfrogs were encountered at BRGR, FONE, and FRHI. BRGR records were via DFA and SVES. FONE records were via ACC, DFA, TVES, dip net, and incidental encounter, and ranged in habitat from pond to mixed deciduous/pine to pine. FRHI records were via ACC, FTA, and incidental encounters from pond and wetland habitats. The habitat requirements of bullfrogs are permanent bodies of water (Hulse et al. 2001).

Rana clamitans melanota (Green Frog)

The most commonly encountered large Ranid of this inventory, the green frog, was seen in BRGR, FONE, and FRHI. At BRGR five of six encounters were via SVES with the remaining encounter a DFA capture.

FONE had eight encounters of green frogs caught in DFA, five were heard with ACC, and one was an incidental encounter. Some juveniles were caught in dip net and seine net samples.

At FRHI the majority of mature green frogs were either heard with ACC (11) or recorded as incidental encounters (8). Three were taken in DFA, two in TVES, and six by seine net.

A number of “large Ranid” tadpoles were taken by seine net and dip net at both FONE and FRHI, but they were not included in the specific species counts because of the large numbers caught and the difficulty in differentiating the tadpoles of bullfrogs and green frogs. These numbers are included on species lists as “large Ranid” tadpoles.

Pooling encounters from all the park units, we could see that, of the metamorphosed individuals, 18 were juvenile and 23 were adult. Adults were encountered in ponds and wetlands; while juveniles were seen in deciduous forest, pine, stream, pond, wetland, mixed deciduous/pine, vernal pond, and meadow. This variety of habitats corresponds with the Hulse et al. (2001) description of the green frog as a habitat generalist that requires water.

Rana palustris (Pickerel Frog)

All records of the pickerel frog came from ACC. They were heard at FONE in pond habitat, and at FRHI in pond and wetland habitat. Hulse et al. (2001) describe their habitat as near bodies of water during the breeding season and in adjacent mesic habitats after breeding.

Rana pipiens (Northern Leopard Frog)

The northern leopard frog was encountered at FONE and FRHI. FONE encounters were via DFA in pine and wetland habitats, and via seine net and dip net at the permanent ponds. Most of these captures were tadpoles. Encounters at FRHI occurred via ACC, FTA, incidental encounter, and seine net. FRHI encounters occurred in pond and vernal pond habitats. Most FRHI encounters were tadpoles caught in seine nets. The habitat of the northern leopard frog is said by Hulse et al. (2001) to be primarily along the vegetated margins of large bodies of water, as well as in marshes and swampy situations.

Rana sylvatica (Wood Frog)

Wood frogs were encountered in all four park units. Three juveniles were captured in the DFA at BRGR. One incidental encounter occurred at JUGL. FONE wood frog records were produced via ACC, DFA, dip net, seine net, and incidental encounter; habitats at FONE were mixed deciduous/pine, deciduous forest, meadow, vernal pond, and wetland. FRHI had records of wood frogs via ACC, DFA, dip net, FTA, and incidental encounter; habitats at FRHI were deciduous forest, fallow field, pines, vernal pond, and wetland. The wood frog is known to

occur in moist or lowland deciduous forests, and during breeding season will be found in water in or near forests.

Species Predicted to Occur but Not Documented During the 1999–2001 Inventory

Clemmys guttata (Spotted Turtle)

The spotted turtle was included in our predicted species list because of its broad range (southern Maine, south in the east to central Florida) and because suitable habitats exist in both FRHI and FONE (marshy meadows, bogs, swamps, small ponds, ditches, or other shallow bodies of water [Conant and Collins 1998]). Hulse et al. (2001) reported a range within Pennsylvania for the spotted turtle that excludes all but the northernmost portion of Fayette County. It is possible, but unlikely, that *Clemmys guttata* exists within FONE and FRHI.

Clemmys insculpta (Wood Turtle)

Wood turtles are thought to occur throughout Pennsylvania (Hulse et al. 2001) in a wide array of habitats. Observations occur most often during the early spring, but are less common after herbaceous vegetation begins to grow and cover becomes more dense. Wood turtles are likely found at both FONE and FRHI, but none were documented by this inventory.

Sceloporus undulatus hyacinthinus (Northern Fence Lizard)

The northern fence lizard is found in open habitat within forests. They are active, diurnal lizards that should be easily observed when present (Hulse et al. 2001). According to Hulse et al. (2001) many of the records for this species in Pennsylvania are more than 60 years old and some populations may no longer be in existence. It is possible that the northern fence lizard is present in FONE and FRHI but was missed by our inventory.

Eumeces fasciatus (Five-lined Skink)

Skinks live under cover of leaf litter and are very secretive. Although the distribution of the five-lined skink includes all of southwestern Pennsylvania (Hulse et al. 2001), they are difficult to observe and may have been missed by our inventory. If present, they are probably not found in great numbers.

Crotalus horridus (Timber Rattlesnake)

The timber rattlesnake was predicted to occur in FONE, but not FRHI, as its potential distribution includes all but the westernmost portions of Fayette County (Hulse et al. 2001). Although apparent suitable habitat (rocky ledges and outcroppings) was located and intensively searched in FONE no rattlesnakes were observed. During the period of our inventory, one visitor to FONE reported seeing a rattlesnake while hiking on a trail through the Great Meadows. We could not confirm this sighting. If the timber rattlesnake does occur within the parks, it is probably a rare occurrence.

Regina septemvittata (Queen Snake)

Queen snake distribution encompasses all of Fayette County and the surrounding areas (Hulse et al. 2001). Adequate habitat (fast flowing streams and creeks, slow-moving streams, or ponds and small lakes) is found at FONE and FRHI, but queen snakes exist entirely on a diet of crayfish, which may not be in sufficient abundance to support a population. Although they were not observed during the inventory of FONE and FRHI, it is still possible that they may be found within these parks.

Storeria d. dekayi (Northern Brown Snake)

The distribution of the northern brown snake includes all of Fayette County and the surrounding counties in Pennsylvania. It is known to occur in a wide range of habitats, provided there are enough cover objects present. For this reason, it is found in greatest abundance in and around abandoned human habitation (Hulse et al. 2001). The lack of sufficient cover objects may account for the absence of this species in FONE and FRHI.

Storeria o. occipitamaculata (Northern Redbelly Snake)

The distribution of the northern redbelly snake includes eastern and southern Fayette County, including FONE. They are most often encountered hiding under natural cover objects (Hulse et al. 2001) along ecotonal areas at edges of woods. It is a very secretive species and is likely to inhabit FONE, but was not observed during this inventory.

Thamnopsis s. sauritis (Eastern Ribbon Snake)

While included in our predicted species list, Hulse et al. (2001) indicate that the eastern ribbon snake's distribution does not include the southwest portion of Pennsylvania.

Ambystoma maculatum (Spotted salamander)

The spotted salamander was included in our predicted species list because of its wide distribution throughout the Northeastern U.S. (Conant and Collins 1998). While adequate habitat exists for it within FONE and FRHI, this species was not recorded by our inventory. It is possible that it was missed due to the secretive/subterranean nature of the adult spotted salamander. If local populations are making reproductive efforts, aquatic sampling should produce records of egg masses and/or larvae. Although we found no egg masses or larvae, we conclude that it is possible that the spotted salamander occurs within FONE and FRHI.

Ambystoma opacum (Marbled Salamander)

The marbled salamander's possible distribution in Pennsylvania extends as far west as eastern Fayette County, and, as such, it was thought that it might be encountered at FONE. However, Hulse et al. (2001) refer to its spotty range, secretive habits, and short autumn activity making it unlikely to find even when it does occur. It is possible that the marbled salamander does occur within FONE and FRHI, but was simply not observed.

Aneides aenus (Green Salamander)

The green salamander was included on our potential species list because we believed that the Pottsville Sandstone bluffs of JUGL could provide adequate habitat for a small population of the salamanders. They have been found in nearby PA Gamelands Unit 51, and their population reaches from West Virginia northward to Ohiopyle State Park, PA (C. Bier, pers. comm., 2003). After thoroughly investigating the Pottsville formations within JUGL, we came to the conclusion that the green salamander is not a resident of the park. Other known populations within Fayette County live in much larger outcrop formations of their requisite Pottsville sandstone than exist at JUGL (C. Bier, pers. comm., 2003). It is therefore our belief that the limited size of the JUGL bluffs is inadequate to support a minimum viable population of green salamanders.

Cryptobranchus allegheniensis (Hellbender)

Although the hellbender is known to occur in areas surrounding the study areas (Hulse et al. 2001), the lack of appropriate preferred habitat (cold, shallow, moderate to fast-flowing areas with gravel or sandy bottom and an abundance of large flat rock slabs) explains its absence within the parks.

Necturus maculosus (Mudpuppy)

The distribution of the mudpuppy includes all of Fayette County, but they have never been recorded from sites within the county (Hulse et al. 2001). Habitats include all types of permanent bodies of water (Conant and Collins 1998). Based on our inventory, we conclude that the mudpuppy does not occur at FONE or FRHI.

Plethodon hoffmani (Valley and Ridge Salamander)

The study sites are actually beyond the known distribution of the valley and ridge salamander, but it was hoped that suitable habitat might be located within the park boundaries (deciduous or mixed conifer-hardwood habitat on hillsides and ridge tops with sandy or rocky, well-drained soil [Hulse et al. 2001]). The abundance of redback and slimy salamanders indicates that the soils are too moist for the valley and ridge salamander. Based on our inventory, it is our conclusion that the valley and ridge salamander does not occur at FONE or FRHI.

Plethodon richmondi (Ravine Salamander)

The distribution of the ravine salamander is known to extend as far east as western Fayette County (Hulse et al. 2001) and is suspected to include the area around FRHI. One possible explanation for its absence from our inventory was potential confusion with the redback salamander, which is morphologically very similar (Conant and Collins 1998), but distinguishable by fewer costal grooves (19 vs 20 or 21, [Hulse et al. 2001]). It is possible that the ravine salamander does exist at FRHI, but was not recorded by this inventory.

Plethodon wehrlei (Wehrle's Salamander)

Suspected distribution of Wehrle's salamander includes all of Fayette County except the most northwestern tip (Hulse et al. 2001). Like the valley and ridge salamander, Wehrle's salamander

tends to be more adapted to dryer soils and is replaced by the redback salamander in moister soils. Wehrle's salamander also can be confused with the northern slimy salamander, which was located in relative abundance. Wehrle's salamander may be found at FONE and FRHI, but was not observed during our inventory.

Pseudacris brachyphona (Mountain Chorus Frog)

The mountain chorus frog's historic distribution includes all of the counties in southwest Pennsylvania west of the Allegheny Front. All records of mountain chorus frogs in Pennsylvania are at least 20 years old (Hulse et al. 2001). Our inventory recorded no members of the species in FRHI and FONE. It is possible that the species has been extirpated from Pennsylvania.

Pseudacris t. triseriata (Western Chorus Frog)

The western chorus frog is found in the western counties of Pennsylvania as far east as western Fayette County (Hulse et al. 2001). It is possible that FRHI is beyond the eastern extent of their distribution. Based on our inventory, it is our conclusion that the western chorus frog does not occur within FONE or FRHI.

Relative Abundance, Species Richness, and Distribution

Braddock Grave (BRGR) Unit

Auditory-call Counts: Auditory-call counts at BRGR in 1999 and 2000 produced an account of one species, the northern spring peeper (Table 8). The highest Wisconsin Index Value assigned to the calls heard for this frog was 3. This indicates that the breeding population was too large to be counted, and that the relative abundance of northern spring peepers at BRGR was high during the breeding season. The calls came from the northwest portion of the park unit, indicating that the frogs were calling (and likely breeding) in the wetland area to the northwest of the parking area.

Drift-fence Arrays: The single drift-fence array at BRGR was located in deciduous forest habitat and caught one juvenile green frog in 1999, and 16 amphibians and one reptile in 2002. The pooled data are nine salamanders (50% of all captures) comprised of seven woodland salamanders and two newt efts, eight frogs and toads (44% of all captures), half of which were juvenile *Rana*, and one garter snake. Nine different species were captured, with the most common species being the northern slimy salamander, a woodland salamander, comprising 33% of all captures (Table 8).

Migrating *Rana* juveniles made up 22% of all captures, indicating that a significant portion of the herpetofauna population at BRGR may have been juvenile frogs moving through the park in search of suitable habitat. At 11% of the total encounters each, efts and eastern American toads are apparently present though not overly abundant at BRGR.

Table 8. Complete list of the 16 species of amphibians and reptiles identified by the inventory of Fort Necessity National Battlefield, Braddock Grave unit, and the corresponding numbers of encounters by species and inventory protocol, 1999–2001.

Species	Auditory Call Count	Drift- fence Array	Visual- Encounter Survey	Stream Transect	Incidental Encounter	Number of Encounters by Species
eastern American toad		2				2
northern dusky salamander				25		25
seal salamander			2	7		9
mountain dusky salamander			31	19		50
two-lined salamander			6	1		7
longtail salamander			1			1
northern spring salamander			3	3		6
red-spotted newt		2	8			10
redback salamander		1	9			10
northern slimy salamander		6	24	2		32
northern spring peeper	5	1				6
northern red salamander			1	5	1	7
bullfrog		1		1		2
greenfrog		1		5		6
wood frog		3				3
eastern garter snake		1				1
No. of species by protocol	1	9	9	9	1	grand total
No. of encounters by protocol	5	18	85	68	1	177

The species list produced by DFA at BRGR (from most common to least) is northern slimy salamander, wood frog, eastern American toad, red-spotted newt, redback salamander, northern spring peeper, bullfrog, green frog, and eastern garter snake for a species richness of R=9.

Funnel-trap Arrays: The funnel-trap array employed at BRGR in 2001 had no captures.

Visual-encounter Surveys: Terrestrial (TVES): The Braddock Grave unit of FONE was sampled in 1999 with three straight-line walking transects. These transects included various microhabitats within the overall deciduous forest habitat type. The data collected indicate which transect each individual was captured within, but do not allow differentiation between habitats along the individual transects. Because transects included various microhabitats (stream, spring, wetland, upland forest, etc.) there is no way to report abundance of different species within these microhabitats. Encounters by TVES in BRGR in 1999 are summarized in Table 9.

Data revealed 33 encounters, all of which were salamanders, for a species richness of R=9 and a mean density of 0.055 salamanders/m². The most common woodland salamander was the northern slimy salamander. The most abundant brook salamander was the two-lined salamander, while the mountain dusky salamander was the most abundant stream salamander and the most abundant species overall. The northern spring salamander was most abundant species in its Family.

In 2000, two general-habitat TVES were conducted in deciduous forest and one was done in wetland habitat at BRGR. The 2000 TVES data are summarized in Table 10. Deciduous forest habitat TVES revealed 20 salamanders and a species richness of R=4. The most common species was the northern slimy salamander, comprising 70% of all encounters. Only one individual, a mountain dusky salamander, was encountered in the wetland TVES. The species was also encountered in the deciduous forest habitat.

One general-habitat TVES was conducted in 2001 in deciduous forest habitat and one was done in a wetland. The results of the 2001 TVES are reported in Table 11. Both the deciduous habitat and the wetland habitat had a species richness of R=3. Pooling the 2001 TVES data produces a species richness of R=4. The most common species in deciduous habitat was the northern slimy salamander at 43% of the encounters. The most common species in wetland habitat was the mountain dusky salamander at 75% of the encounters.

The species that were documented by combining the TVES observations at BRGR from 1999–2001 (listed from most abundant to least) are the mountain dusky salamander, the northern slimy salamander, the redback salamander, the red-spotted newt, the two-lined salamander, the northern spring salamander, the seal salamander, the long-tailed salamander, and the northern red salamander for a species richness of R=9 (Table 8).

The most abundant species in upland deciduous forest habitat was the northern slimy salamander, comprising 56.5% (2000–2001) of the salamander population. In wetland habitats, the mountain dusky salamander was the most abundant species, comprising 87.5% (2000–2001) of the salamander population.

Table 9. Summary of amphibian and reptile terrestrial visual-encounter survey data collected in 1999 at the Braddock Grave Unit of Fort Necessity National Battlefield.

	Woodland Salamanders	Brook Salamanders	Stream Salamanders	Newts (efts)	Red/spring Salamanders
No. of salamander encounters	8	5	13	5	2
Percent of total encounters	24%	15%	39%	15%	6%

Table 10. Summary of amphibian and reptile terrestrial visual-encounter survey data collected in 2000 at the Braddock Grave unit of Fort Necessity National Battlefield.

Habitat	Total No. Salamanders	Woodland Salamanders	Stream Salamanders	Newt (eft)
Deciduous forest				
No. of salamander encounters	20	17	2	1
Percent of total encounters	100%	85 %	10%	5%
Wetland				
No. of salamander encounters	1	0	1	0
Percent of total encounters	100%	0 %	100%	0%

Table11. Summary of amphibian and reptile terrestrial visual-encounter survey data collected in 2001 at the Braddock Grave unit of Fort Necessity National Battlefield.

Habitat	Total No. Salamanders	Woodland Salamanders	Stream Salamanders	Newt (eft)
Deciduous forest				
No. of salamander encounters	7	5	0	2
Percent of total encounters	100%	71%	0 %	29 %
Wetland				
No. of salamander encounters	12	3	9	0
Percent of total encounters	100%	25%	75 %	0 %

The red-spotted newt (eft) tended to be encountered fairly commonly (15% of pooled population in 1999), but was almost always encountered in upland deciduous habitat within BRGR.

The highest densities of salamanders could be found in and immediately surrounding streams and springs (especially in dry years, like 1999), and consist mainly of dusky salamanders with a few woodland, brook, and red/spring salamander larvae. When woodland salamanders were encountered in upland deciduous habitat, they were usually under fallen logs or large debris.

Stream (SVES): The results of stream transects (SVES) at BRGR are reported separately because the specific nature of the stream habitat differentiates them from the TVES reported above. BRGR streams were sampled four times in 1999 and three times in 2000. Two of the transects were sampled in both 1999 and 2000, so results from these SVES were averaged before totaling the encounters for an adjusted (mean) total of five ST. Adjusted totals and densities for BRGR ST are reported in Table 12.

Of the nine species encountered during SVES, dusky salamanders were the most common group, comprising 72% of all encounters. The most abundant species was the northern dusky salamander. Fourteen percent of the SVES encounters were juvenile Ranids. The remaining portion of the population was composed of brook and red/spring salamanders, plus one woodland salamander (Table 8).

It is interesting to note that in the TVES, the mountain dusky salamander was the most abundant salamander in wet habitats, while the northern dusky salamander was the most abundant species in the SVES. The mountain dusky salamander was less dependent on stream habitat than the other dusky salamanders, and it appeared to exploit this habitat flexibility by occupying stream and wetland areas of BRGR.

Coverboards: The coverboard at BRGR produced no records.

Incidental Encounters: One northern red salamander was recorded at BRGR in deciduous forest habitat.

Jumonville Glen (JUGL) Unit

Auditory-call Counts: Auditory-call counts at JUGL in 1999 and 2000 produced accounts of two species, the northern spring peeper and the eastern American toad (Table 13). The highest Wisconsin Index Value assigned to the calls heard for the northern spring peeper was 2, indicating that the breeding population was of medium relative abundance. The highest Wisconsin Index Value assigned to the calls heard for the eastern American toad was 1, indicating that the relative abundance of breeding toads was low. Field records from ACCs indicate that there was only one individual toad calling. We were not able to determine the location within JUGL of the calling individuals.

Table 12. Summary of data collected via stream visual-encounter surveys at the Braddock Grave unit of Fort Necessity National Battlefield, 1999–2000.

Species	mean total number	mean density per survey	mean density per meter
Northern dusky salamander	15.5	3.1	0.124
Seal salamander	4.5	0.9	0.036
Mountain dusky salamander	11.5	2.3	0.092
Two-lined salamander	1.0	0.2	0.008
Northern spring salamander	2.0	0.4	0.016
Northern slimy salamander	1.0	0.2	0.008
Northern red salamander	2.5	0.5	0.020
Bullfrog	1.0	0.2	0.008
Green frog	5.0	1.0	0.040
Total	44.0	8.8	0.352

Table 13. Complete list of the 12 species of amphibians and reptiles identified by the inventory of Fort Necessity National Battlefield, Jumonville Glen unit, and the corresponding numbers of encounters by species and inventory protocol, 1999–2001.

Species	Auditory Call Count	Drift- fence Array	Rappelling Rock Search	Visual- Encounter Survey	Stream Transect	Incidental Encounter	Number of Encounters by Species
Eastern American toad	2	1					3
Fowler's toad		1				1	2
Northern dusky salamander					1		1
Mountain dusky salamander			7	3	25	1	36
Northern ringneck snake		1	1				2
Longtail salamander					1		1
Northern spring salamander		2					2
Red-spotted newt				3			
Redback salamander			1	3			4
Northern slimy salamander			5	4	1		10
Northern spring peeper	3						3
Wood frog						1	1
No. of species by protocol	2	4	4	4	4	3	grand total
No. of encounters by protocol	5	5	14	13	28	3	68

Drift-fence Arrays: The single DFA at JUGL was located in deciduous forest habitat and caught two individuals in 1999, one ring-neck snake and one eastern American toad. In 2000, there were three DFA captures, one Fowler's toad and a single northern spring salamander that was captured on consecutive nights. The most common species was thus the northern spring salamander, which was apparently moving in response to a rain event. Pooled species richness is $R=4$ (Table 13).

Toads and salamanders appeared to be the most common groups within the habitat sampled at JUGL at 40% each, but the very small sample size makes the 40% of the population comprised of toads seem more significant than it is.

Funnel-trap Arrays: The funnel-trap array employed in 2001 at JUGL produced no records of capture.

Visual-encounter Surveys: Terrestrial (TVES): Terrestrial visual-encounter surveys were conducted at JUGL in 1999 along three straight-line walking transects, all of which were in deciduous forest habitat. The three transects together uncovered only four salamanders (all within one transect that included a small hollow) for a mean density of 0.0067 salamanders/m². The pooled species richness was $R=3$ with the redback salamander as the most abundant species at only two individuals.

In 2000, four general-habitat TVES were performed within the deciduous forest of JUGL and a total of nine salamanders were encountered. The pooled species richness was $R=4$. The northern slimy salamander and mountain dusky salamander were the two most abundant species (33% of total encounters each), followed by the red-spotted newt (eft) at 22%, and the redback salamander at 11%.

No TVES were conducted at JUGL in 2001. Pooling data from 1999–2000 reveals that only 13 individuals were encountered with seven TVES at JUGL (Table 13). The species list produced includes the northern slimy salamander, the red-spotted newt, the redback salamander, and the mountain dusky salamander. The pooled species richness for 1999–2000 is $R=4$. TVES data from 1999–2000 are summarized in Table 14. The majority of encounters were in moist microhabitats like ephemeral stream channels or under large collections of leaves/debris.

Stream (SVES): The streams at JUGL were sampled with SVES in one location in 1999 and 2000, and a second location in 2001. Mean results from these encounters are reported in Table 15. Of the four species encountered, the most common group was the dusky salamanders at 90% of pooled encounters. The most abundant species was the mountain dusky salamander at 85% of all encounters (Table 13).

Rappelling and Rock Searching: The rock outcrops at JUGL were searched with rappelling/rock searches on three occasions in 1999 and two occasions in 2000. Pooled data indicate 14 total captures from four species (Table 13). Individuals encountered were not removed or marked, and may therefore have been reported multiple times within the five sampling sessions. Results were seven mountain dusky salamanders, five northern slimy salamanders, one redback salamander, and one ring-necked snake.

Coverboards: The coverboard at JUGL produced no records.

Table 14. Summary of amphibian and reptile terrestrial visual-encounter survey data collected from 1999–2000 at the Jumonville Glen unit of Fort Necessity National Battlefield.

Total # Salamanders	Woodland Salamanders	Stream Salamanders	Newts (eft)
n=13	7	3	3
	54%	23%	23%

Table 15. Summary of data collected via stream visual-encounter surveys at the Jumonville Glen unit of Fort Necessity National Battlefield, 1999–2001.

Species	Mean total number	Mean density per survey	Mean density per meter
Northern dusky salamander	0.5	0.25	0.01
Mountain dusky salamander	8.5	4.25	0.17
Longtail salamander	0.5	0.25	0.01
Northern slimy salamander	0.5	0.25	0.01
Total	10.0	5.00	0.20

Incidental Encounters: Three incidental encounters occurred at JUGL, all at or relatively near the rock outcrops in deciduous forest habitat. The species encountered were wood frog, Fowler's toad, and redback salamander (Table 13). The toad was a juvenile.

Fort Necessity National Battlefield (FONE) Main Unit

Auditory-call Counts: Auditory-call counts in 1999 and 2000 at FONE main unit produced accounts of seven anuran species (Table 16). The call of one species was initially identified wrongly as the western chorus frog. Every attempt to locate the individual producing a call that sounded like a western chorus frog led to a northern spring peeper. Defensive calls of the northern spring peeper are very similar to calls of the western chorus frog; therefore, great care should be taken to positively identify any individual that seems to have the call of the western chorus frog.

The species identified by ACC, along with their locations, Wisconsin Index Values (WIV), and relative abundances are shown in Table 17. Northern spring peepers were the most abundant species recorded during ACC at FONE, apparently breeding in any available ponds or wetlands. The Ranids (true frogs) apparently prefer to breed in the perennial ponds of FONE. Only one species of *Rana* was heard calling in a location other than the perennial ponds. The single record of a treefrog was also from the pond habitat. The eastern American toads that were heard calling were in a vernal pond and in deciduous forest habitat. It was the only anuran species that was actually calling within deciduous forest.

Drift-fence Arrays: The DFA at FONE were located as follows: two in mixed deciduous/pine habitat, four in deciduous forest habitat, two in meadow habitat, two in pine habitat, one in mowed lawn, and one in wetland habitat. In 1999, the eight DFA in use captured 45 reptiles and amphibians. In 2000, the total of 12 DFA captured 199 amphibians and reptiles. The pooled results of captures from 1999 and 2000 are summarized in Tables 16 and 18.

Pine Habitat: The amphibians caught by the two DFA in pine habitat were 86% salamanders and 14% frogs. The red-spotted newt (eft) made up 60% of the captures and was the most abundant species. Woodland salamanders comprised another 23% of the individuals, with only one stream salamander captured in pine habitat. Sixty seven percent of the *Rana* captures were juveniles. Northern spring peepers were present, though not common. No reptiles were captured.

The DFA-produced species list in pine habitat at FONE (from most abundant to least) was the red-spotted newt (eft), northern slimy salamander, redback salamander, northern spring peeper, green frog, northern leopard frog, wood frog, and mountain dusky salamander, for a species richness of $R=8$.

Table 16. Complete list of the 29 species of amphibians and reptiles identified by the inventory of Fort Necessity National Battlefield main unit and the corresponding numbers of encounters by species and inventory protocol, 1999–2001.

Species	Auditory Call Count	Drift- fence Array	Dip Net	Seine Net	Visual- encounter Survey	Stream Transect	Incidental Encounter	Funnel Trap Survey	Turtle Trap	Cover- board	No. of Encounters by Species
Eastern American toad	3	9			1		2				15
Fowler's toad		2					1				3
Eastern painted turtle									1		1
Common snapping turtle				2					2		4
Northern black racer		1									1
Northern dusky salamander		1			17	30	1				49
Seal salamander		2			1	3					6
Mountain dusky salamander		18			52	39	2	2			113
Black rat snake		2									2
Longtail salamander						2					2
Northern spring salamander		2					1				3
Four-toed salamander		9									9
Grey treefrog	1										1
Eastern milk snake		2									2
Northern water snake							2				2
Red-spotted newt		71	73	1,545	10	1	6	3			1,709
Smooth green snake		5									5
Redback salamander		44			30			1			75
Northern slimy salamander		29			25		6	7		3	70
Northern spring peeper	38	14	3	1,037			3				1,095
Northern red salamander		2									2
Bullfrog	4	1	1	1	1		1				9
Large ranid tadpoles*			366	163							529
Greenfrog	5	8	1	25			1				40
Pickerel frog	2										2
Northern leopard frog		2	1	8							11
Wood frog	2	10	1	11			2				26
Eastern box turtle							1				1
Eastern garter snake		9					1				10
Mountain earth snake		1									1
Unknown species							1	1			2
No. of species by protocol	7	22	5	6	8	5	13	4	2	1	grand total
No. of encounters by protocol	55	244	446	2,792	137	75	31	14	3	3	3,800

*large ranid tadpoles are either bullfrog or greenfrog tadpoles. ID to species was not made.

Table 17. Species of breeding frogs and toads identified by auditory-call counts at Fort Necessity National Battlefield main unit, 1999–2000. Species are shown along with the listening stations (LS) where they were heard, habitat type, the highest Wisconsin Index Values (WIV) recorded, and the corresponding relative abundances.

Species	Location	Habitat	Highest WIV	Relative Abundance
Northern spring peeper	LS1	Vernal pond	3	High
	LS3	Vernal pond	3	High
	LS4	Pond	3	High
	LS5	Wetland	3	High
Wood frog	LS4	Pond	3	High
	LS5	Wetland	3	High
Pickerel frog	LS4	Pond	1	Low
Bullfrog	LS4	Pond	1	Low
Green frog	LS4	Pond	1	Low
Eastern American toad	LS2	Deciduous forest	1	Low
	LS3	Vernal pond	1	Low
Grey treefrog	LS4	Pond	1	Low

Table 18. Pooled results from drift-fence array (DFA) captures at Fort Necessity National Battlefield, 1999–2001. DFA were used to sample for terrestrial amphibians and reptiles. Data are summarized by habitat type, number of captures, species richness (R), and type of animal..

# of DFA	Habitat	n	Species Richness (R)	Salamanders				Anura				Reptiles
				Woodland	Stream	Newt	Other	Toads	Rana	# Juvenile Toads and Rana	Peeper	Snakes
2	Deciduous/pine	32	10	5	9	7		2	6	7	2	1
1	Mowed lawn	33	6	21			1	3		3	3	5
1	Wetland	17	9	1	4	4	1		3	1	2	2
2	Meadow	32	12	9		5	7		3	2		8
2	Pine	43	8	10	1	26			3	2	3	
4	Deciduous forest	87	14	27	7	29	4	6	6	4	4	4
12	Totals	244	R=22	73	21	71	13	11	21	19	14	20

Mixed Deciduous/Pine Habitat: The population caught by DFA in mixed deciduous/pine habitat was composed of 65.6% salamanders, 31.2% frogs/toads, and 3.1% snakes. The most common species of capture was the mountain dusky salamander at 28% of the population. The red-spotted newt was 22% of the population. A mix of *Rana* species composed another 19% of the captures. Eighty-eight percent of the Ranids and toads captured were juveniles. The only snake species captured was the eastern milk snake.

The DFA-produced species list in mixed deciduous/pine habitat at FONE (from most abundant to least) was the mountain dusky salamander, the red-spotted newt (eft), the northern slimy salamander, the green frog, the wood frog, the eastern American toad, the northern spring peeper, the bullfrog, the redback salamander, and the eastern milk snake, for a species richness of $R=10$.

Deciduous Forest Habitat: The amphibian and reptile population caught by the four DFA in deciduous forest habitat was composed of 77% salamanders, 18% frogs and toads, and 5% snakes. The single most abundant species was the red-spotted newt (eft) at 33% of the captures. Woodland salamanders together composed another 31%, and stream salamanders accounted for 8% of captures. Thirty-three percent of *Rana* and toads were juvenile. Northern spring peepers were present, though not common. At 5%, snakes make up a small portion of the population in deciduous forest habitat.

The DFA-produced species list in mixed deciduous forest habitat at FONE (from most abundant to least) included the red-spotted newt (eft), northern slimy salamander, redback salamander, mountain dusky salamander, wood frog, northern spring peeper, eastern American toad, four-toed salamander, eastern garter snake, Fowler's toad, green frog, northern dusky salamander, northern red salamander, and mountain earth snake for a species richness of $R=14$.

Mowed Lawn Habitat: The amphibian and reptile population caught by DFA in mowed lawn habitat was composed of 67% salamanders, 18% northern spring peepers and toads, and 15% snakes. Sixty-three percent of captures were redback salamanders, making it the most abundant species. No stream salamanders were captured. All of the toads were juveniles. Snakes made up a relatively larger portion of captures, perhaps indicating a preference for the open habitat of the mowed lawn.

The DFA-produced species list in mowed lawn habitat at FONE (from most abundant to least) included the redback salamander, the eastern garter snake, the northern spring peeper, the eastern American toad, the four-toed salamander, and the smooth green snake for a species richness of $R=6$.

Wetland Habitat: The amphibian and reptile population caught by the single DFA in wetland habitat was composed of 59% salamanders, 29% frogs and toads, and 12% snakes. The red-spotted newt was the most abundant species, making up 24% of the entire population. Another 24% was stream salamanders. At 12% of the population, snakes compose a significant portion of the captures. Only one of the three Ranids (33%) was a juvenile. Northern spring peepers accounted for 12% of the population.

The DFA-produced species list in wetland habitat at FONE (from most abundant to least) included the red-spotted newt, seal salamander, mountain dusky salamander, smooth green snake, northern spring peeper, green frog, redback salamander, northern red salamander, and northern leopard frog for a species richness of $R=9$.

Meadow Habitat: The amphibian and reptile population caught by the two DFA in meadow habitat was composed of 66% salamanders, 9% Ranid frogs, and 25% snakes. Woodland salamanders were the most abundant group of amphibians at 28% of the population. No stream salamanders or northern spring peepers were captured in meadow habitat. Sixty-seven percent of the frogs were juveniles. Three species share the category of most abundant species in meadow habitat; the red-spotted newt, four-toed salamander, and northern slimy salamander each composed 15.6% of the captures. At 25% of the captures, snakes made up a significant portion of the meadow herpetofauna.

The DFA-produced species list in meadow habitat at FONE (from most abundant to least) included the red-spotted newt, four-toed salamander, northern slimy salamander, redback salamander, black rat snake, northern spring salamander, smooth green snake, eastern garter snake, wood frog, green frog, black racer, and eastern milk snake for a species richness of $R=12$.

Combined DFA data from FONE: The combined data from all 12 DFA at FONE main unit totaled 244 captures from 22 species ($R=22$) (Table 16) and lead to some general conclusions about the reptiles and amphibians within the park. Pooled DFA data showed 73% of captures were salamanders, and 40% of the salamanders were red-spotted newts. This suggests that red-spotted newts are very abundant within the park. In all habitats except mowed lawn and mixed deciduous/pine, newt efts were the most abundant capture.

Another 41% of salamanders were woodland species, indicating that woodland salamanders are also very common. In all habitats except mixed deciduous/pine and wetland, woodland salamanders comprised at least 23% of all captures. In mowed lawn, woodland salamanders accounted for 63% of captures, apparently filling the gap left open there by the absence of newts.

Of the 19% of the captures that were anurans (frogs and toads), 46% were Ranids, 30% were northern spring peepers, and 24% were toads. Sixty-three percent of the pooled *Rana* and toad captures were juvenile individuals, which may indicate that a significant portion of the herpetofauna population captured was recently metamorphosed, juvenile anurans moving through the park in search of suitable habitat.

Snakes comprised 8% of total captures. Drift-fence arrays in pine and mixed pine/deciduous habitats captured zero and 1 snake, respectively, indicating that the snakes in this area do not show a preference for pine habitat. Snakes were only 5% of the population in deciduous forest and were captured at the mean ratio of one snake/DFA over the two years of the study, indicating a density of 38.45 snakes/ha/yr. All habitats without canopy cover had large portions of the population consisting of serpents.

Meadows had a mean density of 153.8 snakes/ha/yr, mowed lawn had a mean of 192.3 snakes/ha/yr and wetlands had 76.9 snakes/ha/yr. Perhaps this open habitat allows the snakes

more opportunities for basking activity, or the presence of vegetation at ground level is more appealing to them as cover.

Funnel-trap Arrays: The funnel trap arrays (FTA) employed in 2001 were established as follows: six in deciduous forest, three in pine, and one each in meadow, mowed lawn, and clearcut habitats. Meadow, mowed lawn, and clearcut habitats produced no FTA captures.

Results in deciduous forest were 11 total FTA captures, with woodland salamanders as the most abundant group (63% of captures) and northern slimy salamanders as the most abundant species within that group with a species richness of $R=4$. The species caught in deciduous forest habitat were northern slimy salamander, red-spotted newt, mountain dusky salamander, and the redback salamander (Table 16).

Pine habitat FTA produced two records of salamanders, one woodland salamander, a northern slimy salamander, and the remains of a single salamander that had been consumed in the trap by a shrew. The single FTA in meadow habitat produced one record of a red-spotted newt.

Because DFA and FTA were not in use during the same period, no direct comparisons can be made between the two trapping methods. However, the FTA data do follow similar trends to those established by DFA in 2000. Salamanders were the most abundant group in deciduous forest habitats in both FTA and DFA, and woodland salamanders made up 30% of the DFA data while they made up 63% in FTA. Newts were 30% of deciduous forest DFA captures, and were 18% of deciduous forest FTA captures. Pine habitat DFA caught mainly salamanders (86%) and all FTA captures were salamanders. Woodland salamanders were commonly captured in pine habitats by both DFA and FTA. One red-spotted newt was caught in the meadow habitat with the FTA and efts were one of the three most common species in the meadow DFA.

Visual-encounter Surveys: Terrestrial (TVES): Twenty-four straight-line walking transects were conducted at FONE and on the adjoining Rush property in 1999. One TVES in deciduous wetland on Rush property revealed only one red-spotted newt per 200m². Ten TVES in meadow habitat and three in pine habitat produced no encounters of reptiles or amphibians. Of the remaining 10 TVES conducted in deciduous forest habitat, only three transects produced observations. Those three transects were located on the western edge of the park on a hillside with springs and seeps. The pooled data from all 10 TVES in deciduous forest produced 27 encounters, all salamanders. The mean density of salamanders in deciduous forest habitat was 0.0135/m². Pooled species richness (R) from 1999 equaled 4. Woodland salamanders made up 30% of the population, with the remaining 70% being stream salamanders. The most common woodland species was the redback salamander (26% of the population) and the most common stream salamander was the mountain dusky salamander at 63% of the population.

Eleven general-habitat TVES were conducted in deciduous forest habitat in 2000, producing 77 records of encounters with salamanders. Two TVES were done in pine habitat producing 18 records of amphibians. Results from TVES at FONE in 2000 are summarized in Table 19.

The deciduous and pine habitats had species richness values of $R=6$ and $R=5$, respectively. Pooling the 2000 TVES data from both habitats produces a species richness value of $R=7$. The most common species in the deciduous habitat were the mountain dusky salamander, a stream

Table 19. Summary of amphibians encountered via terrestrial visual-encounter survey at Fort Necessity National Battlefield main unit, 2000.

Habitat	Total No. Encounters	Woodland Salamanders	Stream Salamanders	Newts	Bullfrogs
Deciduous forest					
No. encountered	77	38	39	7	0
Percent of total encounters	100 %	49 %	50%	1%	0%
Pine					
No. encountered	18	4	13	0	1
Percent of total encounters	100 %	22 %	72%	0%	6%

salamander, and the redback salamander, a woodland species (at 28.5% and 27.3% of the deciduous population, respectively). The most common species in pine habitat were the mountain dusky salamander and the northern dusky salamander (at 39% and 33% of the encounters, respectively), both stream salamanders.

Two general-habitat TVES were performed in 2001 at FONE. One was in deciduous forest and produced 11 amphibians, including an eastern American toad, and a species richness of $R=4$. The remaining species were salamanders. The two most common species were the mountain dusky salamander and the northern slimy salamander at 36% of captures each. Newts were also encountered in the deciduous forest TVES. The TVES in pine habitat encountered two salamanders, one mountain dusky salamander and one redback salamander. Stream salamanders and woodland salamanders were equally common in each of the habitats sampled in 2001. The pooled data from 2001 TVES yields a species richness of $R=5$.

Combined observations of TVES at FONE main unit from 1999–2001 produced a species list, from most to least common, of mountain dusky salamander, redback salamander, northern slimy salamander, northern dusky salamander, red-spotted newt, seal salamander, bullfrog, and eastern American toad for a species richness $R=8$ (Table 16).

Deciduous Habitat: The most common species in deciduous habitat (2000–2001) was the mountain dusky salamander, a stream salamander (29% of deciduous forest TVES encounters). Stream salamanders accounted for 40% of all deciduous forest encounters. Woodland salamanders made up 47% of all encounters. Red-spotted newt efts were encountered infrequently (10%), but were more common than anurans, which tended to be encountered as migrating juveniles. Most encounters of stream salamanders occurred in or near stream channels, while woodland salamanders were commonly encountered under large cover-objects (like logs or rocks) in upland habitat.

Pine Habitat: The most common species in pine habitat (2000–2001) was the mountain dusky salamander, a stream salamander (40% of pine TVES encounters). Stream salamanders together accounted for 70% of all pine habitat encounters. Woodland salamanders made up 25% of all encounters. The dominance of stream salamanders in this habitat likely results from the fact that encounters in pine habitat are very rare unless there is an ephemeral stream channel. Salamander densities are highest in the microhabitat of stream channels and these channels contain more stream species than woodland species.

The presence of an ephemeral stream channel within pine habitat produces multiple records of stream salamanders despite the fact that the vast majority of pine habitat is vacant of these species. Disregarding the microhabitat of ephemeral stream channels, woodland salamander species would be the most common species. The same is also likely to be true for deciduous forest habitat.

Stream (SVES): FONE was sampled with eight SVES in 1999 and 2000 for a total of 75 encounters from five species for a species richness of $R=5$. Results and densities of species from SVES are shown in Tables 15 and 20. Most encounters were dusky salamanders (96%). The mountain dusky salamander was the most abundant salamander species encountered, comprising 52% of pooled captures.

Table 20. Summary of amphibian and reptile data collected via stream visual-encounter surveys at Fort Necessity National Battlefield main unit, 1999–2000.

Species	Total Number	Mean density per survey	Mean density per meter
Northern dusky salamander	30	3.750	0.150
Mountain dusky salamander	39	4.875	0.195
Seal salamander	3	0.375	0.015
Long-tailed salamander	2	0.250	0.010
Red-spotted newt	1	0.125	0.005
Total	75	9.375	0.375

Seine Nets/Dip Nets:

Seine Nets: The perennial ponds at FONE near the resource management office were sampled with a seine net on three occasions in 1999 for a total of 757 captures and a species richness of $R=5$. The red-spotted newt comprised 89% of the captures. Eighty-seven percent of the newts were adults and the remainder were larvae. Large *Rana* tadpoles (green frog and bullfrog) accounted for another 10% of captures. Other species taken were the common snapping turtle and northern spring peeper.

The ponds were sampled via seine net in 2000 on four separate occasions for a total of 2,035 captures and a species richness of $R=6$. Northern spring peeper tadpoles accounted for 51% of all individuals due to the abundance of their tadpoles in pond #4 (the pond between the resource management office and the Great Meadows house). One thousand northern spring peeper tadpoles were caught with a seine net in pond #4 on May 23, 2003. The second most abundant species in 2000 was the red-spotted newt. Newts made up 43% of the aquatic population as sampled with seine nets. The percentage of adult newts in 2000 was 69%, indicating that larval newts went from 13% of the newt population in 1999 to 31% of the population in 2000. Large *Rana* (bullfrog and green frog) tadpoles made up another 6% of the individuals. Northern leopard frog and wood frog tadpoles were also encountered.

Pooled seine net data from 1999 and 2000 yield a species richness of $R=7$.

Dip Nets: Ponds at FONE were sampled in 2000 by dip net on three occasions. A total of 442 individuals were captured. Large *Rana* (bullfrog and green frog) tadpoles produced the majority of the captures (83%) with adult newts composing almost 17% of the population. Northern spring peepers were also captured to produce a species richness of $R=4$ in 2000.

Dip netting was conducted once in 2001 in an attempt to add to the list of species in the inventory of FONE. Dip netting produced records of bullfrog, green frog, red-spotted newt, and northern leopard frog ($R=4$).

Pooled dip net data from 2000–2001 produced a species richness of $R=5$.

Turtle Traps: The perennial ponds at FONE were trapped in 1999, 2000, and 2001 according to the schedule in the Protocols section. One common snapping turtle was captured in 1999. One eastern painted turtle was caught in 2000. One common snapping turtle was captured in 2001. All turtle captures occurred during the month of July.

Coverboards: The coverboards at FONE produced three encounters. One coverboard in pine habitat was checked twice in July of 2001, and each time, a single northern slimy salamander was recorded (probably the same individual). The other record was also a northern slimy salamander, from a coverboard in deciduous forest habitat.

Incidental Encounters: Thirty incidental encounters that could be identified were recorded at FONE in six different habitats (Table 16). Deciduous forest had 19 incidental encounters of nine species, of which, the northern slimy salamander and red-spotted newt were the two most abundant species, and each accounted for 26% of the encounters.

The two meadow incidental encounters were both toads. One eastern garter snake was seen on paved road and one green frog was seen in stream habitat. Pine habitat incidental encounters were of one northern slimy salamander and one red-spotted newt.

The perennial ponds at FONE were the location of five incidental encounters. Two northern spring peepers, a green frog, and a northern water snake were seen. Additionally, a turtle nest was found on the outer edge of the largest pond. The nest suffered damage by a predator, but did indicate that a turtle of unknown species was attempting to use the ponds at FONE as a nesting area.

Pooled incidental encounters at FONE had a species richness of $R=15$.

Friendship Hill National Historic Site (FRHI)

Auditory-call Counts: Auditory-call counts in 1999 and 2000 at FRHI produced accounts of eight anuran species (Table 21). The call of one species was initially misidentified as the western chorus frog. Any attempt to locate the individual producing a call that sounded like a western chorus frog lead to a northern spring peeper. Defensive calls of the northern spring peeper are very similar to calls of the western chorus frog, and great care must be taken to positively identify any individual that seems to have the call of the western chorus frog.

The species identified by ACC, along with their locations, Wisconsin Index Values (WIV), and relative abundances, are shown in Table 22. Northern spring peepers were the most abundant species identified by ACC at FRHI, breeding in all habitat types at high relative abundance. Ranids were heard more often in ponds and wetlands than other habitats. The bullfrog was the most abundant Ranid. Eastern American toads were heard in every habitat type, but at low relative abundance in each. This may indicate lower densities than other species, along with a generalist/opportunistic strategy for breeding habitat selection. Grey treefrogs were heard at wetlands and vernal ponds.

Drift-fence Arrays: Four DFA at FRHI were located in deciduous forest habitat, two in mowed field, and one in fallow field habitat. In 1999, the seven DFA captured eight reptiles and amphibians. In 2000, the DFA captured 77 amphibians and reptiles. The pooled results of captures from 1999 and 2000 are summarized in Tables 21 and 23.

Deciduous Forest Habitat: The amphibian and reptile population caught by the four DFA in deciduous forest habitat was composed of 32% salamanders, 52% anurans, and 16% snakes. The single most abundant species was the wood frog at 25% of the captures, followed by the eastern American toad at 21%. Fifty-one percent of pooled *Rana* and toads were juvenile. The most abundant woodland salamander was the northern slimy salamander at 16% of captures. Snakes comprised a large portion of the population, with the eastern garter snake as the most common snake. An important species of capture is the Jefferson salamander. Though not rare, this species is an unusual find in southwestern Pennsylvania.

Table 21. Complete list of the 27 species of amphibians and reptiles identified by the inventory of Friendship Hill National Historic Site and the corresponding numbers of encounters by species and inventory protocol, 1999–2001.

Species	Auditory Call Count	Drift-fence Array	Funnel Trap Survey	Dip Net	Seine Net	Incidental Encounter	Stream Transect	Visual- encounter Survey	Turtle Trap	No. of Encounters by Species
Northern copperhead		1								1
Jefferson salamander		5	1							6
Eastern American toad	13	15		4	3	14		1		50
Fowler's toad		2				1				3
Eastern painted turtle						1				1
Common snapping turtle						4			12	16
Northern black racer		2								2
Northern dusky salamander							32	3		35
Seal salamander							15	6		21
Mountain dusky salamander							49	8		57
Northern ringneck snake		1								1
Black rat snake		3				3				6
Two-lined salamander		2					9			11
Northern spring salamander		1					1			2
Eastern hognose snake		1								1
Grey treefrog	4									4
Northern water snake		1	1			4				6
Red-spotted newt		3			1					4
Redback salamander		1								1
Northern slimy salamander		10						3		13
Northern spring peeper	44	2		4	2	1				53
Bullfrog	4		5		2	4				15
Large ranid tadpoles*				15	31					46
Greenfrog	11		3		6	8	2			30
Pickerel frog	5									5
Northern leopard frog	1		2		12	1				16
Wood frog	1	17	2	1		5				26
Eastern garter snake		18				2				20
Unknown species			2	1		3	1			7
No. of species by protocol	8	17	6	3	6	12	6	5	1	grand total
No. of encounters by protocol	83	85	16	25	57	51	109	21	12	459

*large ranid tadpoles are either bullfrog or greenfrog tadpoles. ID to species was not made.

Table 22. Species of breeding frogs and toads identified by auditory-call counts at Friendship Hill National Historic Site, 1999–2000. Species are shown along with the listening stations (LS) where they were heard, habitat type, the highest Wisconsin Index Values (WIV) recorded, and the corresponding relative abundances.

Species	Location	Habitat	Highest WIV	Relative Abundance
Northern spring peeper	LS1	wetland	3	high
	LS2	pond	3	high
	LS3	wetland	3	high
	LS4	pond	3	high
	LS5	wetland	3	high
	LS6	vernal pond	3	high
	LS8	deciduous forest	3	high
Northern leopard frog	LS2	pond	1	low
Wood frog	LS1	wetland	1	low
Pickerel frog	LS1	wetland	1	low
	LS2	pond	1	low
Bullfrog	LS2	pond	2	medium
	LS3	wetland	3	high
	LS4	pond	3	high
Green frog	LS2	pond	1	low
	LS3	wetland	2	medium
	LS4	pond	1	low
Eastern American toad	LS1	wetland	1	low
	LS2	pond	1	low
	LS3	wetland	1	low
	LS4	pond	1	low
	LS6	vernal pond	1	low
	LS8	deciduous forest	1	low
Grey treefrog	LS1	wetland	1	low
	LS3	wetland	1	low
	LS6	vernal pond	2	medium

Table 23. Pooled results from drift-fence array (DFA) captures at Friendship Hill National Historic Site, 1999–2001. DFA were used to sample for terrestrial amphibians and reptiles. Data are summarized by habitat type, number of captures, species richness (R), and type of animal.

No. of DFA	Habitat	No. of Captures (n)	Species Richness (R)	Salamanders					Anura			Reptiles	
				Woodland	Brook	Mole	Newt	Spring	Toads	Rana	No. Juvenile Toads and Rana	Spring Peeper	Snakes
4	Deciduous forest	63	16	11	2	3	3	1	15	16	20	2	10
2	Mowed field	14	5			2			2		2		10
1	Fallow field	8	2							1			7
7	Totals	85	R=17	11	2	5	3	1	17	17	22	2	27

Drift-fence arrays in deciduous forest habitat at FRHI produced captures of, listed from most to least abundant; wood frog, eastern American toad, northern slimy salamander, eastern garter snake, Jefferson salamander, red-spotted newt, Fowler's toad, black rat snake, two-lined salamander, northern spring peeper, northern copperhead, ring-necked snake, northern spring salamander, eastern hognose snake, northern water snake, and redback salamander. Species richness was $R=16$.

Mowed Field Habitat: The amphibians and reptiles caught by the two DFA in mowed field habitat were salamanders (14%), toads (14%), and snakes (71%). The most abundant species was the eastern garter snake at 50% of all captures and composing 70% of the snake population. The only salamander species was the Jefferson salamander. Both of the toads were juvenile eastern American toads.

The species list produced via DFA in mowed field (from most to least common) is eastern garter snake, black racer, eastern American toad, Jefferson salamander, and black rat snake for a species richness of $R=5$.

Fallow Field Habitat: The amphibian and reptile population caught by the single DFA in fallow field habitat was composed of one wood frog (12.5% of captures) and seven eastern garter snakes (87.5% of captures), making the garter snake the most abundant species by far, for a species richness of $R=2$.

Combined DFA Data from FRHI: The combined data from all seven DFA at FRHI total 85 captures from 17 species (Table 21) and lead to some general conclusions about the reptiles and amphibians within the park. Pooled DFA data show 26% of captures were salamanders, 42% were frogs and toads, and 32% were snakes. While the high percentages of salamanders and anurans suggest that these groups are somewhat common within FRHI, analyses by habitat indicate that salamanders, frogs, and toads are somewhat rare in habitats outside deciduous forest. While amphibians dominate the deciduous forest (84% of captures), snakes dominate the open habitat types of mowed field and fallow field, comprising 71% and 87% of the captures in those respective habitats. The open habitat of fields tends to create a dry climate that is inhospitable to many amphibian species, while reptiles are adapted to conserve water and are capable of exploiting the resources (such as basking sites and mammalian prey) that are associated with dry fields.

The species richness in deciduous forest is much higher than in the two field habitats. This is a direct result of the presence of nine species of amphibians in forest while the combined field habitats had only three species of amphibians captured.

One species of salamander, the Jefferson salamander, was captured in mowed field habitat. Two Jefferson salamanders were captured on rainy days in early autumn of 2000. It appears that these creatures were moving in response to rain events, as three more individuals of the same species were also captured within forest habitat on one of the same rainy days. Jefferson salamanders are typically encountered only during the spring breeding season, but have been reported by Bishop (1941) and Judd (1957) to be abundant in the fall. It is possible that the captured individuals were taking advantage of the wet conditions to migrate to their wintering locations.

Of the 34 Ranids and toads captured, 22 were juvenile, possibly indicating that a significant portion of the herpetofauna population at FRHI may be recently metamorphosed, juvenile anurans moving through the park in search of suitable habitat.

Funnel-trap Arrays: Funnel-trap arrays at FRHI were set at locations near the original DFA. If there was a body of water near the DFA, the FTA was located around and in the water. This approach led to the placement of one FTA in pine habitat, one FTA around the perennial pond, one FTA in deciduous forest, and two FTA at deciduous forest vernal ponds. No FTA was employed within fallow field habitat because there was no nearby water or objects against which to place the funnel traps.

The FTA in pine habitat captured a single, juvenile wood frog. The FTA around and in the shallow edges of the perennial pond captured nine Ranids and one tadpole of unknown species. Of the 10 captures, only one adult (a bullfrog) was captured. The rest were tadpoles or very recently metamorphosed frogs. The pond FTA had a species richness of $R=2$.

Of the three FTA in deciduous forest habitat, only the two in and around vernal ponds captured herpetofauna. The species captured in vernal pond FTA were wood frog, green frog, one unknown tadpole, Jefferson salamander, and northern water snake. Vernal pond species richness was $R=4$. The most abundant species was the wood frog. Hundreds of their tadpoles were in the ponds, and the number captured in the few funnel traps within the water was not counted, but numbered in the dozens. The Jefferson salamander larvae were also numerous, though not as abundant as the tadpoles. None of the herpetofauna captured with vernal pond FTA were adults.

Because the FTA were placed in different locations and employed at different times than the DFA, no direct comparisons can be made between the two trapping methods.

Visual-encounter Surveys (VES): Terrestrial (TVES): FRHI was sampled in 1999 with a total of 21 straight-line TVES. One TVES was in river bluffs, two were in deciduous floodplain, two were in mowed field, three were in fallow field, and 13 were in deciduous forest habitat. Encounters with reptiles and/or amphibians occurred within two TVES in deciduous forest, and in one TVES in fallow field. Results from the TVES are summarized in Table 24.

The only herpetofauna encountered were salamanders. Mean density of salamanders in deciduous forest habitat was $.007/m^2$ and the most common species was the mountain dusky salamander. In fallow field habitat, mean density of salamanders was $.003/m^2$, and both encounters were of northern slimy salamanders.

In 2000 and 2001, FRHI was sampled with a total of 10 general-habitat TVES, conducted as follows: one around the perennial pond, one in deciduous floodplain, one in deciduous forest, three in pine, and four at the Thomas Claire cemetery. One encounter of a juvenile eastern American toad was recorded in pine habitat. No other TVES produced encounters, although two shed skins of black rat snakes were found in the rock wall of the cemetery. At least one individual snake used the cemetery for a shedding location, but the actual snake was never encountered in the area.

Table 24. Summary of amphibian and reptile terrestrial visual-encounter survey data collected in 1999 at Friendship Hill National Historic Site.

Habitat	Total No. Encounters	Woodland Salamanders	Stream Salamanders
Deciduous forest			
No. encountered	18	1	17
Percent of total encounters	100 %	6 %	94 %
Fallow field			
No. encountered	2	2	0
Percent of total encounters	100 %	100 %	0 %

Stream (SVES): FRHI was sampled with nine SVES over the course of the inventory for a total of 110 encounters (Table 21). Two transects were sampled in 1999 and again in 2000. One SVES was performed in 2001. Results of the ST at FRHI are reported in Table 25.

The pooled SVES data have a mean total of 83.5 amphibians from six species ($R=6$). The majority (86%) of the encounters were dusky salamanders. The mountain dusky salamander, at 41% of all encounters, was the most abundant species in SVES at FRHI. Brook salamanders, including one encounter of an unknown species of *Eurycea*, account for another 11% of the pooled encounters. Ice Pond Run is heavily impacted by acid mine drainage, and neither of the two SVES conducted along this stream produced any records of reptiles or amphibians.

Turtle Traps: Turtle trapping was conducted in the perennial ponds at FRHI from 1999–2001 according to the schedule in the Protocols section. In 1999, seven common snapping turtles were captured in the perennial pond near the main house (Sophia's Pond). Four were captured on June 21, and three were captured on July 24. In 2000, TT caught two common snapping turtles from the same pond. One was caught on July 7, and the next on July 25. In 2001 three common snapping turtles were caught; one each on June 7 from the pond near the main house and from the first pond in the AMD treatment wetlands on Ice Pond Run, and one in the Sophia's Pond on July 4.

These data indicate that common snapping turtles were present in relatively high abundance in Sophia's pond near the main house, especially in 1999. In 2000 and 2001, both of which were years with more precipitation than 1999, fewer turtles were captured than in 1999. It is possible that the drought during the summer of 1999 may have encouraged the turtles to remain in the pond rather than traversing open terrain. Turtles were present and active at FRHI ponds mainly in June and July.

Seine Nets/Dip Nets:

Seine Nets: The perennial pond near the main house (Sophia's Pond) at FRHI was sampled with a seine net on three occasions in 1999 for a total of 30 captures. The majority of animals were large Ranid tadpoles (green frog and/or bullfrog) accounting for 93% of all captures. A northern leopard frog tadpole and red-spotted newt larva were also caught for a species richness of $R=3/4$ in 1999.

The same pond was also sampled on three occasions in 2000, for a total of 27 captures. Ranid tadpoles again made up most of the captures (81%) with large *Rana* (green frog and/or bullfrog) composing half of the Ranids and northern leopard frogs composing the other half. Captures also included eastern American toad tadpoles and northern spring peeper tadpoles for a species richness of $R=4/5$.

Pooling the seine net data from 1999–2000 yields the following species list of tadpoles and larvae (from most abundant to least): Large *Rana*- green frog and/or bullfrog, northern leopard frog, eastern American toad, northern spring peeper, and red-spotted newt for a pooled $R=5/6$.

The AMD treatment ponds near Ice Pond Run were sampled with seine nets in 1999 and again in 2000. No records of reptiles or amphibians were produced from the holding pond.

Table 25. Summary of data collected via stream visual-encounter surveys at Friendship Hill National Historic Site, 1999–2001.

Species	Mean total number	Mean density per survey	Mean density per meter
Northern dusky salamander	27.5	3.06	0.12
Mountain dusky salamander	34.5	3.83	0.15
Seal salamander	9.5	1.06	0.04
Two-lined salamander	9.0	1.00	0.04
<i>Eurycea</i> sp.	1.0	0.11	0.00
Northern spring salamander	1.0	0.11	0.00
Green frog	1.0	0.11	0.00
Total	83.5	9.28	0.37

Dip Nets: Ponds of FRHI were sampled with dip nets in 2000. The Sophia's Pond near the main house was sampled on four occasions for a total of 24 captures. All captures were tadpoles. Large *Rana* composed 63% of the population as sampled. Eastern American toad and northern spring peeper accounted for another 17% each. One unknown species of tadpole was also captured for an $R=3/4$ in Sophia's Pond.

The vernal pond near Dublin Run (ACC listening station 7) was also sampled with dip nets on one occasion in 2000. Hundreds of wood frog tadpoles were caught, producing a species richness of $R=1$.

Rappelling and Rock Searching: The river bluffs at FRHI were searched with rappelling/rock searches in 1999, 2000, and 2001. None of the searches produced any encounters with reptiles or amphibians in the bluffs.

Coverboards: The coverboards at FRHI produced no records.

Incidental Encounters: There were 51 incidental encounters at FRHI throughout the study (Table 21). Thirteen were in deciduous forest, 10 of which were toads and Ranids. Seventy percent of the toads and *Rana* were juveniles. Eastern garter snakes and northern spring peepers brought the species richness to 6 in deciduous forest.

Mowed fields yielded one eastern American toad. Paved road had two black rat snakes. One green frog was found in a stream, and one juvenile green frog and a northern water snake were seen in wetlands. Vernal ponds had wood frogs as larvae and juveniles, Jefferson salamander larvae, a water snake, a green frog, and a leopard frog as incidental encounters. The pooled incidental encounters at FRHI had a species richness of $R=13$.

Discussion

Facts provided in the results section are more specific than necessary to gain a basic understanding of the types and abundance of the various amphibians and reptiles within FONE and FRHI. The following summary will attempt to explain the species encountered in the different habitats of the Parks, irrespective of survey protocols.

Braddock Grave Unit of Fort Necessity National Battlefield (BRGR)

BRGR was occupied by an abundance (15 species) of amphibians, most of which (10 species and 87% of all encounters) were salamanders. The northern slimy salamander dominated the dry forest habitat, while the mountain dusky salamander dominated the streams and wetlands. There were five species of frogs and toads accounting for 12% of all encounters. Of the Ranids and toads, 79% of encounters were juveniles, indicating that juvenile anurans move actively throughout the park unit. This suggests that a significant portion (6%) of the reptile and amphibian population of BRGR is composed of young anurans dispersing from breeding habitats to suitable adult habitats. Another 10% of forest encounters were red-spotted newts, revealing a strong presence of this species at BRGR. One reptile, an eastern garter snake, was encountered. BRGR data are summarized in Table 26.

Jumonville Glen Unit of Fort Necessity National Battlefield (JUGL)

More amphibians than reptiles occupied JUGL. Eleven amphibian species composed 66 (97%) of 68 encounters. The mountain dusky salamander was by far the most abundant species, especially in stream habitat. Woodland salamanders (primarily the northern slimy salamander) made up 33% of forest habitat encounters. Frogs and toads made up another 20% of forest encounters. Two of the six (33%) Ranids and toads were juvenile, making JUGL's deciduous forest population 5% juvenile anurans that are dispersing from breeding habitats to suitable adult habitats. Red-spotted newts produced 7.5% of all encounters in forest habitat, representing a significant portion of the population of JUGL. Two reptiles, both ring-necked snakes, were encountered. JUGL data are summarized in Table 26.

Fort Necessity National Battlefield Main Unit (FONE)

The main unit of FONE was divided into 10 unique habitats for data analysis. The data for FONE are summarized in Table 26.

Pine

Pine habitat was dominated by the red-spotted newt (39%) and by woodland salamanders (27.5%). Most woodland salamanders were northern slimy salamanders. Stream salamanders comprised another 21.7% of pine encounters. Ten percent of encounters were frogs, and 50% of Ranids encountered were juvenile, indicating that juvenile anurans will move through pine habitat during their dispersal. No reptiles were encountered.

Table 26. Summary of amphibian and reptile encounters at Braddock Grave, Jumonville Glen, and Fort Necessity main unit, 1999–2001. Results are shown by species and habitat type. For ranids and toads, number of juveniles is noted in parentheses, the preceding number includes any juveniles. Data reported are raw and have not been corrected to avoid pseudo-replication. ACC data are included as one individual per ACC record for each species.

Species	FONE BRGR		FONE JUGL		FONE main unit									
	deciduous forest	stream	deciduous forest	stream	pine	deciduous forest/pine	deciduous forest	mowed lawn	paved road	meadow	stream	wetland	vernal pond	pond
AGCO														
AMJE														
BUAM	2		3 (1)			2 (2)	7 (3)	3 (3)		1			2	
BUWO			2 (1)				2 (1)			1				
CHPI														1
CHSE														4
COCO										1				
DEFU		25		1	6		13				30			
DEMO	2	7					1				3	2		
DEOC	21	17	11	25	9	9	54				39	2		
DIPU			2											
ELOB										2				
EUBI	6	1												
EULO	1			1							2			
GYPO	3	3	2				1			2				
HEPL														
HESC							3	1		5				
HYCH														1
LATR						1				1				
NESI														2
NOVI	10		3		27	7	45			6	1	5		1,618
OPVE								1		2		2		
PLCI	9		4		6	1	42	21		4		1		
PLGR	28	2	9	1	13	4	47			5				
PSCR	6		3		3	2	6	3				11	16	1,054
PSRU														
RACA	1 (1)	1 (1)			1	1 (1)								7 (2)
RACL	1 (1)	5 (6)			1 (1)	3 (3)	1 (1)			1 (1)	1 (1)	2 (1)		31 (3)
RAPA					1 (1)									2
RAPI					1							1		9
RASY	3 (3)		1			2 (1)	7 (2)			2 (1)		1		13
TECA							1							
THIS	1						3	4	1	2				
VIVA							1							
unknown					1									530 *
	R=15	R=9	R=10	R=4	R=10	R=10	R=17	R=6	R=1	R=14	R=6	R=10	R=2	R=11
	n=96	n=68	n=40	n=28	n=69	n=32	n=236	n=33	n=1	n=35	n=76	n=28	n=18	n=3,273

*of the 530 unknown species, 529 were RACA/CL tadpoles. One was a turtle nest.

Mixed Deciduous/Pine

Mixed deciduous/pine habitat had few encounters (n=33). Most records were of mountain dusky salamanders (27%), juvenile anurans (24%), or red-spotted newts (21%). Woodland salamanders made up 15% of the population. One snake was encountered.

Deciduous Forest

Deciduous forest had more species (R=17) than any other habitat at FONE and more encounters (n=236) than any habitat besides pond. Reptile encounters included four snakes of two species and the carapace of a dead eastern box turtle. Amphibians made up 97.9% of deciduous forest encounters and included 14 species. Salamanders were the largest group at R=9, n=207, and 87.7% of the encounters. The most abundant salamander species were mountain dusky salamander, northern slimy salamander, red-spotted newt, and redback salamander, in that order. There were 89 woodland salamanders (38% of the forest population) and 68 stream salamanders (29%).

Twenty-three encounters (10%) with five species of frogs and toads (R=5) occurred. Of the 17 Ranids and toads encountered, seven (41%) were juveniles, accounting for three percent of the entire herpetofauna population within deciduous forest. Thus, juvenile anurans do not compose the significant portion of the total population here that they do in other habitats.

Mowed Lawn

Mowed lawn had 33 encounters from only six species. The redback salamander made up 64% of all encounters. Six frogs and toads were encountered. All frogs were northern spring peepers. All three of the toads (nine percent of all encounters) were juvenile. This suggests that mowed lawn is another habitat through which young anurans are dispersing from breeding habitats to suitable adult habitats.

Five reptiles, all snakes, were encountered in mowed lawn. At 15% of all encounters, snakes make up an important portion of the population in mowed lawn. The eastern garter snake was the most abundant snake and comprised 12% of the total encounters.

Paved Road

Paved road is included here only because it is unique within the habitats and microhabitats of FONE. One eastern garter snake was seen basking on paved road, and likely chose the site as optimal for basking based on the unique thermal characteristics of the blacktop pavement.

Meadow

It should be mentioned that the data collected from meadow habitat are largely from a drift-fence array that was located in meadow, but within 85m of deciduous forest to the southeast and 35m from Japanese honeysuckle habitat to the southwest. Although the honeysuckle habitat was considered part of the meadow during this study, it was quite different from meadow habitat, and was largely avoided during sampling. Thus the data are more relevant to a grassland meadow

habitat. The important point is that the DFA, although located in meadow habitat, was arguably in an ecotone between three distinct habitats.

The encounters in meadow, although low in number (n=35), produced a list of 14 species (R=14). Seventy-seven percent of encounters were amphibians and 63% of encounters were salamanders. Woodland salamanders and red-spotted newts were the most abundant salamanders. Toads and Ranids comprised 17% of encounters, and 29% of them were juvenile. Juvenile anurans composed over 5% of the entire population of meadow encounters. This suggests that meadow is another habitat through which young anurans are dispersing from breeding habitats to suitable adult habitats.

Eight snakes (23% of encounters) were recorded in meadow habitat, suggesting that the meadow is preferable to snakes. Three species were equally abundant: eastern garter snake, black rat snake, and smooth green snake.

Stream

Stream habitats were dominated by dusky salamanders (95% of encounters). The mountain dusky salamander was the most abundant species.

Wetland

Wetlands produced 28 encounters from 10 species. The most abundant group was frogs, and northern spring peepers were the most abundant frog species. A few dusky salamanders were encountered, as well as a few red-spotted newts. One species of snake, the smooth green snake, was encountered twice.

Vernal Pond

Vernal pond encounters were all by auditory-call count and produced records of eastern American toads and northern spring peepers. Northern spring peepers made up 89% of the encounters.

Pond

Perennial ponds at FONE produced 3,273 records from 11 species. Seine net and dip net sampling of the ponds produced the vast majority of these records. Amphibian larvae and adult and larval newts accounted for roughly 98% of all encounters. Red-spotted newt was the most abundant species, followed by northern spring peeper tadpoles, and then the combination of bullfrog and green frog tadpoles. Large Ranids could be seen in the ponds throughout the summer and early fall.

The reptile population at the ponds was a collection of two turtle species, the common snapping turtle and the eastern painted turtle, and the northern water snake, which was encountered twice. An encounter of special note was the discovery of a turtle nest along the edge of the largest pond. The nest was, unfortunately, destroyed by a predator, but indicated reproductive efforts by turtles at the ponds.

Friendship Hill National Historic Site (FRHI)

The data from FRHI was divided into 12 distinct habitat categories. Three of the habitats (cemetery, deciduous floodplain, and river bluffs) produced no results. Cemetery and deciduous floodplain are not mentioned in the text, but were sampled as microhabitats. FRHI data are summarized in Table 27.

Pine

Pine habitat had only two encounters, one eastern American toad and one wood frog, and both were juvenile. We believe that the amphibians were probably dispersing through the habitat in search of more suitable adult habitat.

Deciduous Forest

Deciduous forest at FRHI produced the most species ($R=20$) of any habitat within any park unit. There were 100 encounters. The most abundant group was anurans; frogs and toads composed eight of the 20 species and 56% of all encounters. Of the Ranids and toads, 63% (27% of the entire sample from deciduous forest) were juvenile anurans making up a large percentage of the herpetofauna population. This habitat clearly has juvenile anurans dispersing through it and possibly settling within it.

Nine of the species and 38% of encounters were salamanders, with dusky salamanders dominating the category. The northern slimy salamander was the most abundant species of salamander. Three Jefferson salamanders were encountered in deciduous forests.

Snakes comprised the remaining six percent of encounters. Six species were seen, including the northern copperhead and eastern hognose snake. The most abundant snake was the eastern garter snake.

Paved Road

Paved road is included here only because it is unique within the habitats and microhabitats of FRHI. Two black rat snakes were seen basking on paved road, and likely chose the site as optimal for basking based on the unique thermal characteristics of the blacktop pavement.

Mowed Field

Mowed field habitat produced only 15 encounters from five species. Snakes dominated the data, accounting for three species and 67% of the encounters. The eastern garter snake was the most abundant species. The only amphibians encountered were the Jefferson salamander (thought to be migrating in response to an autumn rain) and the eastern American toad. Two of the three toads were juvenile. The meadow habitat is hot and dry through much of the year; therefore, it is not surprising to find it occupied mainly by snakes, rather than amphibians.

Table 27. Summary of amphibian and reptile encounters at Friendship Hill National Historic Site, 1999–2001. Results are shown by species and habitat type. For ranids and toads, the number of juveniles is noted in parentheses, the preceding number includes any juveniles. Data reported are raw and have not been corrected to avoid pseudo-replication. Auditory-call count (ACC) data are included as one individual per ACC record for each species.

Species	FRHI								
	deciduous forest	stream	pine	mowed field	paved road	fallow field	wetland	vernal pond	pond
AGCO	1								
AMJE	3			2				1	
BUAM	21(14)		1 (1)	3 (2)			5	3	17
BUWO	3 (3)								
CHPI									1
CHSE									16
COCO				2					
DEFU	3	32							
DEMO	6	15							
DEOC	8	49							
DIPU	1								
ELOB	2			1	2				1
EUBI	2	9							
EULO									
GYPO	1	1							
HEPL	1								
HESC									
HYCH							2	2	
LATR									
NESI	1						1	2	2
NOVI	3								1
OPVE									
PLCI	1								
PLGL	11					2			
PSCR	7						23	2	21
PSRU									
RACA							2 (1)		12 (4)
RACL	1 (1)	3 (3)					3	2 (1)	21 (1)
RAPA							1		4
RAPI								1	15 (3)
RASY	18 (9)		1 (1)			1	1	5 (1)	
TECA									
THSI	6			7		7			
VIVA									
unknown		1 [#]						4 [*]	48 ^{\$}
	R=20	R=6	R=2	R=5	R=1	R=3	R=8	R=8	
	n=100	n=111	n=2	n=15	n=2	n=10	n=38	n=22	

the unknown was a Erycea larva

* the unknowns included one tadpole and three Amystoma larvae

\$ the unknowns included 46 RACA/CL tadpoles and two other unknown tadpoles

Fallow Field

Fallow field is a designation given to habitat in FRHI that is neither deciduous forest nor mowed field, but rather something in between the two. Its vegetation is composed of a few grasses, with many herbs, shrubs, and young trees. Poison ivy is often quite dense.

With only 10 reptile and amphibian encounters from three species, this habitat is not densely populated or diverse. The most abundant species was the eastern garter snake at 70% of encounters. Two northern slimy salamanders and one wood frog were also encountered. The fallow field habitat, like meadow habitat, is hot and dry throughout much of the year; as such, it is not surprising to find it occupied mainly by snakes, rather than amphibians.

Stream

Streams of FRHI were dominated by dusky salamanders (86%) with the mountain dusky salamander the most abundant species. Two-lined salamanders were not uncommon, and comprised eight percent of the encounters. The only anurans encountered were three juvenile green frogs.

Wetland

Wetland areas of FRHI produced records of seven species of frogs and toads and one snake species (R=8). The most abundant species in wetlands was the northern spring peeper (60.5% of encounters). Eastern American toads accounted for 13% of encounters. Only one anuran was a juvenile. The single snake was a northern water snake.

Vernal Pond

Vernal ponds had species composition similar to wetlands in FRHI, but the dominance of northern spring peepers was absent. Ranids made up 41% of all encounters and two Ranids were juveniles. Toads accounted for another 13.6% of encounters. Jefferson salamander larvae were encountered in relatively high abundance in one of the vernal ponds. The single snake species in this habitat was the northern water snake.

Pond

Perennial pond habitat produced records of more species (R=11) than any habitat at FRHI other than deciduous forest. Anurans accounted for 87% of all encounters. The two species that were equally most abundant were northern spring peepers and green frog, each responsible for 13% of encounters. The single most abundant group was Ranid frogs at 63% of the encounters. Many of the frog encounters were tadpoles caught by seine net or dip net. At 10.6% of encounters, the common snapping turtle was a common sight at FRHI ponds. Other reptiles were eastern painted turtle, black rat snake, and northern water snake.

Evaluation of Inventory Protocols

To make appropriate recommendations for monitoring the amphibians and reptiles occurring in BRGR, JUGL, FONE, and FRHI, the inventory protocols must first be evaluated. A good monitoring policy will 1) include protocols that efficiently determine the presence of all or most of the species in the parks, and 2) collect enough data about the species to determine population status of important species and/or groups of amphibians and reptiles. Species captures by park unit and protocol are summarized in Tables 28–31.

Auditory-call Counts (ACC)

There were 148 individual records from eight species of breeding anurans from all four park units using ACC. The only inventory records of gray treefrog and pickerel frog were produced by ACC. This protocol was used to identify one species at JUGL, two species at FONE, and two species at FRHI that were not inventoried by any other protocol within each park unit. As such, auditory-call counts were very useful in completing the species list for each park unit.

Calls were categorized by the Wisconsin Index Values, a subjective classification system that assigns each species a general relative abundance value. While this system merely estimates relative abundance, it can be used to identify relative population sizes and trends if long-term data are collected.

Drift-fence Arrays (DFA)

Drift-fence array protocol produced 352 records from 28 species from all four park units. Species recorded only via DFA were northern copperhead, northern black racer, eastern hognose snake, eastern milk snake, smooth green snake, mountain earth snake, and four-toed salamander. This is a total of seven species, six of which are snakes. These results support the effectiveness of DFA for capturing secretive and elusive species (such as snakes and some salamanders). This method identified three species at BRGR, one species at JUGL, seven species at FONE, and five species at FRHI that were not inventoried by other protocols within each park unit. As such, DFA was very important in completing the species list for each park unit.

DFA can be constructed to a uniform size and set in a uniform manner. They allow the capture effort to be standardized by area covered (density) and by the amount of time that the DFA are open (trapnights, days/month, days/year, etc). Thus, DFA allow a number of possible data analyses, including determination of population densities and changes in populations over time.

Chi-square goodness-of-fit tests were used to test the DFA data in Table 32 against a 4:3:3 ratio for pitfall, minnow, and screen traps for each of the following groups: salamanders, anurans, and snakes. The 4:3:3 ratio is the expected capture ratio of individuals based on the number of pitfall, minnow, and screen traps at each DFA.

Table 28. Summary of the species inventoried at the Braddock Grave unit of Fort Necessity National Battlefield, 1999–2001, along with the protocols that produced the records. The number of species listed by each protocol and no other protocols is also shown.

Species	Protocol					
Eastern American toad	DFA					
Northern dusky salamander			ST			GSM
Seal salamander		VES	ST			GSM
Mountain dusky salamander		VES	ST			GSM
Two-lined salamander		VES	ST			GSM
Longtail salamander		VES				GSM
Northern spring salamander		VES	ST			GSM
Red-spotted newt	DFA	VES				GSM
Redback salamander	DFA	VES				GSM
Northern slimy salamander	DFA	VES	ST			GSM
Northern spring peeper	ACC	DFA				
Northern red salamander		VES	ST		1	GSM
Bullfrog	DFA		ST			GSM
Green frog	DFA		ST			GSM
Wood frog	DFA					
Eastern garter snake	DFA					
No. species by protocol	1	9	9	9	1	12
No. species not recorded by other protocol	0	3	1	1	0	7
ACC=Auditory Call Count	I=Incidental Encounter					
DFA=Drift-fence Array	GSM=General Search Methods; the protocols of					
VES=Visual Encounter Survey	VES, ST, and I combined					
ST=Stream Transect						

Table 29. Summary of the species inventoried at the Jumonville Glen unit of Fort Necessity National Battlefield, 1999–2001, along with the protocols that produced the records. The number of species listed by each protocol and no other protocols is also shown.

Species	Protocols						
Eastern American toad	ACC	DFA					
Fowler's toad		DFA				I	GSM
Northern dusky salamander					ST		GSM
Mountain dusky salamander			RRS	VES	ST	I	GSM
Northern ringneck snake		DFA	RRS				GSM
Longtail salamander					ST		GSM
Northern spring salamander		DFA					
Red-spotted newt				VES			GSM
Redback salamander			RRS	VES			GSM
Northern slimy salamander			RRS	VES	ST		GSM
Northern spring peeper	ACC						
Wood frog						I	GSM
No. of species by protocol	2	4	4	4	4	3	9
No of species not recorded by other protocol	1	1	0	1	2	1	7
ACC=Auditory Call Count	ST=Stream Transect						
DFA=Drift-fence Array	I=Incidental Encounter						
RRS=Rappelling Rock Search	GSM=General Search Methods; the protocols of						
VES=Visual Encounter Survey	VES, ST and I combined.						

Table 30. Summary of the species inventoried at the main unit of Fort Necessity National Battlefield, 1999–2001, along with the protocols that produced the records. The number of species listed by each protocol and no other protocols is also shown.

Species	Protocols										
Eastern American toad	ACC	DFA			VES		I	GSM			
Fowler's toad		DFA					I	GSM			
Eastern painted turtle										TT	
Common snapping turtle				SN						TT	
Northern black racer		DFA									
Northern dusky salamander		DFA			VES	ST	I	GSM			
Seal salamander		DFA			VES	ST		GSM			
Mountain dusky salamander		DFA			VES	ST	I	GSM	FTA		
Black rat snake		DFA									
Longtail salamander						ST		GSM			
Northern spring salamander		DFA			VES			GSM			
Four-toed salamander		DFA									
Grey treefrog	ACC										
Eastern milk snake		DFA									
Northern water snake							I	GSM			
Red-spotted newt		DFA	DN	SN	VES	ST	I	GSM	FTA		
Smooth green snake		DFA									
Redback salamander		DFA			VES			GSM	FTA		
Northern slimy salamander		DFA			VES		I	GSM	FTA		CB
Northern spring peeper	ACC	DFA	DN	SN			I	GSM			
Northern red salamander		DFA									
Bullfrog	ACC	DFA			VES		I	GSM			
Greenfrog	ACC	DFA	DN	SN							
Pickerel frog	ACC										
Northern leopard frog		DFA	DN	SN							
Wood frog	ACC	DFA	DN	SN			I	GSM			
Eastern box turtle							I	GSM			
Eastern garter snake		DFA					I	GSM			
Mountain earth snake		DFA									
No. of species by protocol	7	22	5	6	9	5	12	16	4	2	1
No. of species not recorded by other protocol	2	7	0	0	0	1	2	3	0	1	0

ACC=Auditory Call Count

DFA=Drift-fence Array

DN=Dip Net

SN=Seine Net

VES=Visual Encounter Survey

ST=Stream Transect

I=Incidental Encounter.

FTA=Funnel Trap Array

TT=Turtle Trap

CB=Coverboard

GSM=General Search Methods; the protocols of VES, ST and I combined

Table 31. Summary of the species inventoried at Friendship Hill National Historic site, 1999–2001, along with the protocols that produced the records. The number of species listed by each protocol and no other protocols is also shown.

Species	Protocols									
Northern copperhead		DFA								
Jefferson salamander		DFA	FTA							
Eastern American toad	ACC	DFA		DN	SN	I		VES	GSM	
Fowler's toad		DFA				I			GSM	
Eastern painted turtle						I			GSM	
Common snapping turtle						I			GSM	TT
Northern black racer		DFA								
Northern dusky salamander							ST	VES	GSM	
Seal salamander							ST	VES	GSM	
Mountain dusky salamander							ST	VES	GSM	
Northern ringneck snake		DFA								
Black rat snake		DFA				I			GSM	
Two-lined salamander		DFA					ST		GSM	
Northern spring salamander		DFA					ST		GSM	
Eastern hognose snake		DFA								
Grey treefrog	ACC									
Northern water snake		DFA	FTA			I			GSM	
Red-spotted newt		DFA			SN					
Redback salamander		DFA								
Northern slimy salamander		DFA						VES	GSM	
Northern spring peeper	ACC	DFA		DN	SN	I			GSM	
Bullfrog	ACC		FTA		SN	I			GSM	
Greenfrog	ACC		FTA		SN	I	ST		GSM	
Pickrel frog	ACC									
Northern leopard frog	ACC		FTA		SN	I			GSM	
Wood frog	ACC	DFA	FTA	DN		I			GSM	
Eastern garter snake		DFA				I			GSM	
No. of species by protocol	8	17	6	3	6	12	6	5	18	1
No. of species not recorded by other protocol	2	5	0	0	0	1	0	0	4	0
ACC=Auditory-call Count		I=Incidental Encounter								
DFA=Drift-fence Array		ST=Stream Transect								
FTA=Funnel-trap Array		VES=Visual-encounter Survey								
DN=Dip Net		TT=Turtle Trap								
SN=Seine Net		GSM=General Search Methods; the protocols of VES, ST and I combined								

Table 32. Summary of the terrestrial amphibians and reptiles captured by drift-fence arrays in Fort Necessity National Battlefield and Friendship Hill National Historic site, 1999–2000. Results are categorized by taxonomic group (salamander, anuran, snake) and trap type (minnow, screen, pitfall).

Taxonomic Group	Total DFA Captures	Total captures by each trap type		
		Minnow	Screen	Pitfall
Salamanders	176	36	64	76
Anurans	78	26	10	42
Snakes	39	32	5	2
Grand Total	293	94	79	120

Chi-square tests and subsequent subdivisions of the Chi-square revealed that significantly fewer salamanders were captured in minnow traps ($0.005 < P < 0.01$) than screen traps and pitfalls. Tests also showed that screen traps caught significantly fewer anurans ($0.001 < P < 0.005$) than minnow traps and pitfalls. Pitfalls caught significantly fewer snakes ($0.001 < P < 0.005$) than expected. Screen traps caught five snakes (6.2 fewer than the expected 11.2), and minnow traps caught significantly more snakes ($P < 0.001$) than expected.

Funnel-trap Arrays (FTA)

Funnel-trap arrays produced 30 records from nine species at FONE and FRHI. There were no FTA captures at BRGR and JUGL. The only FTA that caught a species not captured by a DFA were the FTA that were relocated from the original DFA site to aquatic habitats at FRHI. Funnel-trap arrays produced no records of species not inventoried by another protocol.

It is difficult to standardize the effort used when sampling with FTA. While trapnights can be counted, it is almost impossible to find identical cover objects and naturally occurring “drift fences” along which to set the traps. Depending upon the habitat, there may be no natural objects, thus reducing the effectiveness of FTA to zero. These inconsistencies make FTA a poor choice for monitoring herpetofauna populations.

Visual-Encounter Surveys (TVES and SVES)

Visual-encounter surveys were a valuable protocol for increasing the species list within the individual park units. Of the three VES protocols used, the straight-line transects were the least valuable. The general-habitat TVES and the SVES were the most rewarding. At BRGR, VES added six species that were not inventoried by any other protocol. At JUGL, VES located three species that were not inventoried by any other protocol. The visual-encounter surveys at FONE increased the species list by one, and at FRHI it added three species. Visual-encounter surveys listed one species (longtail salamander) not inventoried by any other protocol.

Terrestrial visual-encounter surveys from all four park units listed a total of 265 individuals from 12 species. The SVES produced a total of 281 captures from 10 species, but listed no species that was not also encountered by another protocol, at least in another park unit.

BRGR and FONE each had one species encountered via SVES only, while at JUGL, two species were SVES records only.

Visual-encounter surveys can easily be used to estimate populations and changes in populations over time if the search protocol includes a standardized search area or amount of time for each search (catch-per-unit-effort). It is important to include both TVES and SVES in the protocol.

Turtle Traps

Turtle traps were used only at FONE and FRHI and produced 15 records from two turtle species. Both turtle species were also inventoried by other techniques. At FONE, turtle traps caught one species not otherwise listed in the main unit. Turtle trapping can be easily standardized and included in population estimation techniques.

Seine Nets/Dip Nets

Seine netting and dip netting were used only at FONE and FRHI. The combined protocols listed eight species from both park units. Individually, seine netting captured 2,851 individuals from eight species and dip netting caught 471 individuals from six species. At FONE the common snapping turtle was captured only by seine netting and not by dip netting. At FRHI seine netting caught four species not caught by dip netting, while dip netting caught wood frog tadpoles not captured by seine netting. Neither netting protocol captured any species not inventoried by other protocols.

It is possible to standardize the effort used while sampling via seine net and dip net. Thus, population estimates can be produced, and with repeated sampling, population trends can be identified. Because the vast majority of encounters using these protocols are larval amphibians, standardized population estimates would be most helpful if it were important to monitor reproductive efforts and/or reproductive success of amphibians.

Rappelling and Rock Searching (RRS)

Rappelling and rock searching protocols were used only at FRHI and JUGL. No records of RRS encounters were made at FRHI. This protocol accounted for 15 encounters from four species at JUGL. No species were found by RRS that were not also listed by other inventory protocols.

Because of the unusual conditions involved in surveying for herps while rappelling rock bluffs, and inconsistencies in the bluffs themselves, it would be difficult to standardize the effort used to sample via RRS. While time spent searching could be quantified, it would not provide a measure of population density. Thus, if the RRS were conducted in a long-term study, it would be possible to compare data over time and determine population trends, but good estimates of densities would still be difficult to produce.

Coverboards

Only one species was recorded via coverboard, and only one park unit had coverboard encounters. The northern slimy salamander was found three times under coverboards at FONE.

It is easy to quantify the area sampled by coverboard and thus report densities of captured species. These densities estimate population size, and, if studied over time, can indicate population trends.

Incidental Encounters

There were 86 incidental encounters from 18 species in the four park units. Incidental encounters included only one species not listed by another protocol, the eastern box turtle. One species was listed only by incidental encounter in both JUGL and FRHI. FONE had two species that were recorded by incidental encounter and no other technique.

Because of the nature of incidental encounters, they are impossible to quantify by any standardized methods. They provide limited information about the species in the parks in terms of estimating populations.

Monitoring Recommendations

Based on the results reported above, recommendations for monitoring the amphibians and reptiles of Fort Necessity National Battlefield, including Braddock Grave and Jumonville Glen, and Friendship Hill National Historic site are as follows:

Auditory-call Counts (ACC)

Auditory-call counts should be used to monitor breeding anuran habitats in the park units beginning in mid-February to ensure encounters with early breeding species like wood frogs, and should continue through June in order to encounter late breeders like gray treefrogs. Surveys conducted every two weeks should be sufficient to encounter all the species breeding in the parks. By conducting ACC over a period of years, the NPS will be able to identify trends in frog and toad populations.

Drift-fence Arrays (DFA)

Drift-fence arrays should be constructed in all the major habitat types for any monitoring survey that is focusing on collecting a complete list of species present within the parks. While DFA are labor intensive to initially construct, they are crucial in collecting records of certain secretive and hard-to-find species (especially snakes). We recommend a DFA constructed of aluminum sheeting installed a minimum of 45cm (1.5 ft) high. Based on experience with other surveys, aluminum drift-fences are more durable than silt-cloth, and once installed, continue to serve their purpose for years (Renken and Kowalski, unpublished). They may also be more effective at capturing lizards, which would have been able to climb our silt-fence DFA with little difficulty.

Because pitfall traps catch mainly anurans and salamanders, we recommend replacing the pitfalls at the outer ends of the drift-fences with single-ended funnel traps constructed of aluminum window screening. Population information about salamanders and anurans can easily be collected using other techniques (see ACC and General Search Methods [GSM] below); therefore, the number of pitfall traps and screen traps can be reduced in DFA construction if other techniques are employed to inventory these groups. This will reduce most of the labor required in DFA construction, as the pitfall traps require more work to install than the drift-fence itself. A DFA constructed according to the design shown in Figure 20 should be simple to install and effective at capturing snakes and secretive amphibians.

General Search Methods

We recommend that a mixture of survey methods be employed to monitor amphibians and reptiles, focusing on salamander populations. General search methods should include terrestrial visual-encounter searches of a known area (for example, a square measuring 10m × 10m), replicated to increase sample size, and conducted in all habitat types over a number of years. Repeated surveys of the same areas will permit an analysis of terrestrial salamander species composition within and among habitats, as well as population trends.

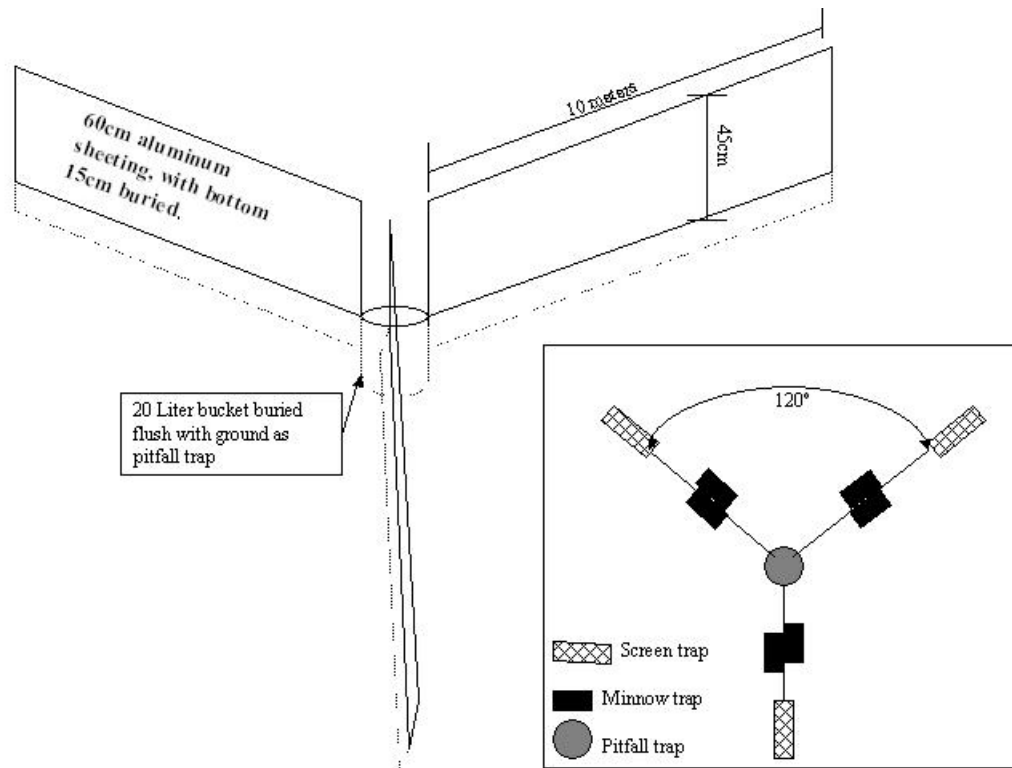


Figure 20. Diagram of the construction and trap placement for the drift-fence arrays recommended for monitoring terrestrial amphibians and reptiles at Fort Necessity National Battlefield and Friendship Hill National Historic Site.

The main diagram details construction dimensions; funnel traps have been removed for clarity. The inset shows proper location of the minnow traps and single-ended screen traps.

To monitor stream salamanders we recommend that stream visual-encounter surveys be conducted in all perennial streams and springs a minimum of once a year. Surveys in late spring and autumn (high flow and low flow) would be preferable to only one survey per year, but if an annual survey is done, we recommend it be conducted during the summer months. A 25m transect should be established along each stream and sampling should occur in the same location each year. This will allow the identification of species composition and population trends of the stream salamander species.

Areas surrounding ponds and wetlands should be visually searched in the summer months for reptiles and amphibians.

Any reliable incidental encounters of reptiles or amphibians should be recorded and added to the park database to complement the data collected by other protocols.

Aquatic Surveys

Aquatic habitats, like perennial ponds and vernal ponds, should be sampled as mentioned in ACC above. Ponds should also be visually inspected for evidence of pond-breeding amphibian species in the spring. Turtle trapping should be conducted during the months of June and July in any perennial ponds.

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Appendix 1. Predicted Amphibian and Reptile at Fort Necessity National Battlefield and Friendship Hill National Historic Site.

Reptiles		
	Testudines	Turtles
CHSE	<i>Chelydra serpentina</i>	common snapping turtle
CHPI	<i>Chrysemys p. picta</i>	eastern painted turtle
CLGU*	<i>Clemmys guttata</i>	spotted turtle
CLIN	<i>Clemmys insculpta</i>	wood turtle
TECA	<i>Terrepenne c. Carolina</i>	eastern box turtle
	Lacertilia	Lizards
EUFA	<i>Eumeces fasciatus</i>	five-lined skink
SCUN	<i>Sceloporus undulatus hyacinthinus</i>	northern fence lizard
	Serpentes	Snakes
AGCO	<i>Agkistrodon contortrix mokasen</i>	northern copperhead
COCO	<i>Coluber c. constrictor</i>	northern black racer
CRHO	<i>Crotalus horridus</i>	timber rattlesnake
DIPU	<i>Diadophis punctatus edwardsi</i>	northern ringneck snake
ELOB	<i>Elaphe o. obsoleta</i>	black rat snake
HEPL	<i>Heterodon platirhinos</i>	eastern hognose snake
LATR	<i>Lampropeltis t. triangulatum</i>	eastern milk snake
NESI	<i>Nerodia s. sipedon</i>	northern water snake
OPVE	<i>Opheodrys vernalis</i>	smooth green snake
RESE	<i>Regina septemvittata</i>	queen snake
STDE	<i>Storeria d.dekayi</i>	northern brown snake
STOC	<i>Storeria o. occipitomaculata</i>	northern redbellied snake
THSI	<i>Thamnopsis s sirtalis</i>	eastern garter snake
THSA*	<i>Thamnopsis s. sauritis</i>	eastern ribbon snake
VIVA	<i>Virginia valeriae pulchra</i>	mountain earth snake
Amphibians		
	Caudata	Salamanders
AMJE	<i>Ambystoma jeffersonianum</i>	Jefferson salamander
AMMA	<i>Ambystoma maculatum</i>	spotted salamander
AMOP	<i>Ambystoma opacum</i>	marbled salamander
ANAE	<i>Aneides aenus</i>	green salamander
CRAL*	<i>Cryptobranchus alleghehiensis</i>	eastern hellbender
DEFU	<i>Desmognathus f. fuscus</i>	northern dusky salamander
DEMO	<i>Desmognathus monticola</i>	seal salamander
DEOC	<i>Desmognathus ochrophaeus</i>	mountain dusky salamander
EUBI	<i>Eurycea bislineata</i>	northern two-lined salamander
EULO	<i>Eurycea l. longicauda</i>	longtail salamander
GYPO	<i>Gyrinophilus p. porphyriticus</i>	northern spring salamander
HESC	<i>Hemidactylium scutatum</i>	four-toed salamander
NEMA	<i>Necturus maculosus</i>	mudpuppy

Appendix 1. Predicted Amphibian and Reptile at Fort Necessity National Battlefield and Friendship Hill National Historic Site (continued).

Amphibians (continued)

	Caudata	Salamanders
NOVI	<i>Notophthalmus v. viridescens</i>	red-spotted newt
PLCI	<i>Plethodon cinereus</i>	redback salamander
PLGL	<i>Plethodon g. glutinosus</i>	northern slimy salamander
PLHO*	<i>Plethodon hoffmani</i>	valley and ridge salamander
PLRI	<i>Plethodon richmondi</i>	ravine salamander
PLWE	<i>Plethodon wehrlei</i>	Wehrle's salamander
PSRU	<i>Pseudotriton r. rubber</i>	northern red salamander
	Anura	Frogs and Toads
BUAM	<i>Bufo a. Americana</i>	eastern American toad
BUWO	<i>Bufo woodhousei fowleri</i>	Fowler's toad
HYCH	<i>Hyla versicolor/chrysoscelis</i>	gray treefrog
PSBR	<i>Pseudacris brachyphona</i>	mountain chorus frog
PSCR	<i>Pseudacris c. crucifer</i>	northern spring peeper
PSTR	<i>Pseudacris t. triseriata</i>	western chorus frog
RACA	<i>Rana catesbeiana</i>	bullfrog
RACL	<i>Rana clamitans melanota</i>	green frog
RAPA	<i>Rana palustris</i>	pickerel frog
RAPI	<i>Rana pipiens</i>	northern leopard frog
RASY	<i>Rana sylvatica</i>	wood frog

*species was included in original 1999 list, but documentation (Hulse et al., 2001) indicates species range does not include FONE and FRHI.

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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