THE 2006 POTOMAC GORGE BIOBLITZ[1]
Overview and Results of a 30-hour Rapid Biological Survey

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ABSTRACT

The Potomac Gorge BioBlitz, held 23-25 June 2006, was a joint venture between the National Park Service and The Nature Conservancy. It was a 30-hour intensive survey designed to document undersurveyed organisms (algae, slime molds, fungi, bryophytes, selected flowering plants, mollusks, arachnids, and insects) at sites along the Potomac River administered by the George Washington Memorial Parkway in Virginia, and the Chesapeake & Ohio Canal National Historical Park in Maryland. Eighteen taxonomic survey teams consisting of 140 volunteer scientists, naturalists, and students donated a total of 2,322 hours before, during, and after the event to observe, collect, prepare, and identify 1,232 species of algae, fungi, plants, and animals. Detailed information on the preparation, execution, and wrap-up for all aspects of the event are presented, including volunteer recruitment, public and press relations, base camp preparations, survey techniques, and data and voucher disposition.

Key words: George Washington Memorial Parkway, Chesapeake & Ohio Canal National Historical Park, Virginia, Maryland, fungi, algae, vascular plants, bryophytes, reptiles, amphibians, snails, arthropods.

INTRODUCTION

The Nature Conservancy (TNC) and the National Park Service (NPS) launched a collaborative Potomac Gorge conservation partnership in 1996, when the two groups became co-owners of a 90-acre island in the heart of the Gorge. In 2000, the two entities jointly created a comprehensive conservation plan for the area (Allen & Flack, 2001). The Potomac Gorge conservation plan identifies the Gorge's important natural resources and analyzes their greatest threats, most notably invasive plants, overabundance of White-tailed Deer (*Odocoileus virginianus* [Boddaert]), park infrastructure and recreational use pressures, and surrounding land use and development. The plan also identified significant gaps in knowledge of the biota of the Potomac Gorge, particularly for invertebrates and non-vascular plants. The Potomac Gorge BioBlitz, held 23-25 June 2006, was a direct outgrowth of this plan and designed specifically to gather information on these taxa.

The Potomac Gorge BioBlitz was the third such event to be held in the National Capital Region and followed the 1996 BioBlitz in the Kenilworth Park and Aquatic Gardens National Park on the Anacostia River, District of Columbia (USGS, 1997), as well as the 1998 BioBlitz in the Chesapeake & Ohio Canal National Historical Park, which focused on the Chain Bridge Flats area along the north bank of the Potomac River in the District of Columbia and Maryland.

The Maryland and Virginia Natural Heritage Programs and the National Park Service had extensive survey data for vascular plants and vertebrates for the Potomac Gorge parklands, but data on fungi, algae, and most invertebrate groups were lacking, which is typical of most parklands across the United States. According to Kellert (1993), invertebrates make up over 90% of the world's estimated 10 million-plus animal species, but they are among the least well-studied and

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comprehensively inventoried taxonomic groups.

Whether invertebrates are measured in terms of diversity, biomass, or ecological dominance, these species comprise a key component of all terrestrial ecosystems and therefore must be considered in conservation planning and natural resource management (Fisher, 1998). Invertebrate inventories can provide a tremendous amount of information about natural systems. From a biogeographic and conservation perspective, studies of insect diversity can provide valuable insight into faunal patterns, community ecology, and ecosystem integrity (Collins & Thomas, 1991). Invertebrates can serve as indicators of the biodiversity in an area because of their high species diversity, their fine-grained response to environmental conditions, and their short-term response to environmental change (Longino, 1994).

Studies suggesting that species diversity enhances the productivity and stability of ecosystems (Johnson et al., 1996) underscore the importance of understanding and subsequently conserving the full range of diversity in natural areas. Essential ecosystem services provided by bacteria, fungi, and invertebrates help to generate soil and maintain its fertility, dispose of wastes and recycle nutrients, pollinate crops, and control pests that eat them (Ehrlich, 1987).

Sampling invertebrates poses problems due to high species diversity, with estimates ranging from six to 80 million species worldwide for insects alone (Hawksworth & Mound, 1991). The vast majority of natural areas remain undersurveyed for invertebrate groups. Coddington et al. (1991) suggested that species sampling methods should be fast, reliable, simple, and inexpensive. Their recommendations reflect the urgency felt in many areas where species are being lost faster than they can be catalogued, as well as the resource limitations often faced by both scientists and resource managers. Although collecting this important information can be overwhelming, Landau et al. (1999) demonstrated that a considerable proportion of the invertebrate diversity in an area can be inventoried during a short, intensive sampling survey, such as a BioBlitz. BioBlitzes bring together a diversity of experts devoted to conducting an intensive survey in a very short period of time for a relatively small investment in resources.

BioBlitzes provide only a snapshot of biodiversity and are not intended as substitutes for long-term inventory and monitoring efforts. Findings are influenced by season, lunar cycle, and weather conditions during the collection period, as well as the availability of taxonomic specialists and the experience of surveyors. Nevertheless, BioBlitzes can produce useful lists of species that may support effective natural resource management and suggest avenues for sustained research programs in the future.

Study Site

The 9,700-acre (3925.5 ha) Potomac Gorge project area (see map on inside front cover) is the 15-mile (21.4 km) river corridor from Great Falls to the Key Bridge, including parts of Maryland, Virginia, and the District of Columbia. It is in the midst of a major metropolitan region inhabited by over 4.5 million people (see Cohen, 2005). The Potomac Gorge is widely recognized as one of the most biologically rich areas in the eastern United States, with more than 400 known occurrences of 200 state or globally rare plant and animal species, and ten globally rare plant communities. The Gorge's unusual concentration of species diversity and rarity is the direct result of its unique hydrology, geology, and geomorphology. This wild and free-flowing section of the Potomac River is one of the most intact eastern Fall Zone river systems with an abundance of parkland not subject to the environmental pressures of residential or commercial development.

Approximately half of the Potomac Gorge project area is owned and managed by the George Washington Memorial Parkway and the Chesapeake & Ohio Canal National Historical Park. More than two million recreational users visit these two national parks each year. The remainder of the Gorge is a mixture of private, county, and federal land.

The Potomac Gorge BioBlitz survey teams were charged with conducting their inventory work on national park service lands administered by the George Washington Memorial Parkway (GWMP, DC, VA, and MD) and the Chesapeake & Ohio Canal National Historical Park (CHOH, MD). Specific survey sites in the GWMP included Chain Bridge Flats (DC), Great Falls Park (VA), Turkey Run Park (VA), and Glen Echo Park (MD), and those in the CHOH included Plummers Island (MD) and Great Falls Park (MD).

Planning and Logistics

The Nature Conservancy began initial planning for the Potomac Gorge BioBlitz in 2003 and sought funding through the National Park Service's Natural Resource Challenge-Natural Resource Protection Program. In the ensuing years, TNC also secured private funds and in-kind support for the BioBlitz from a variety of sources (see Acknowledgements). A few individuals also provided financial donations and in-kind support to the BioBlitz.

Dr. Arthur V. Evans was contracted by TNC to serve as the BioBlitz Coordinator. Evans had organized

two previous Virginia BioBlitzes (2002, 2003), and was thus already familiar with the logistics of recruiting, organizing, and directing taxonomic working groups consisting of team leaders, naturalists, and students. In addition to these duties, he was charged with securing the necessary collection permits (one state and two national parks), managing the species data, and preparing the final report for publication in a peer-reviewed journal. From his own resources, Evans provided the 50% funding match necessary to complete the task.

The Connecticut State Museum of Natural History's "BioBlitz Organization Guide" (Censky, 2001) provided useful information on methods and strategies that were implemented in organizing the Potomac Gorge BioBlitz. Detailed organizational planning for the BioBlitz with Evans and representatives of NPS (including staff from the CHOH, GWMP, and the National Capital Region Center for Urban Ecology) and TNC began in earnest a year before the event. This core team of BioBlitz organizers met several times and communicated regularly by phone and email to resolve various planning and data management issues leading up to the event. TNC staff coordinated the logistics for the survey weekend, including base camp organization, daily operations, participant safety, food, media relations, and public educational programming.

The initial goal of the BioBlitz Coordinator was to recruit as many skilled team leaders as possible to lead field teams to survey historically undersurveyed taxa on NPS lands in the Potomac Gorge. The recruitment of team leaders was a critical component of the Potomac Gorge BioBlitz because they were largely responsible for assembling their own teams of experts and skilled naturalists to conduct the surveys. The BioBlitz Coordinator began recruiting team leaders and survey volunteers in October of 2005. Invitations to participate in the Potomac Gorge BioBlitz were distributed through entomological web-based listserves, e-mail lists from previous Virginia BioBlitzes, and other electronic communications channels.

Specialists were sought to conduct field surveys for a broad array of undersurveyed organisms, including bacteria, algae, slime molds, fungi, and invertebrates. In total, 18 scientific team leaders were recruited to build and lead teams that would survey organisms spanning four kingdoms and as many as 25 classes/divisions of organisms. Besides teams to sample undersurveyed taxa, two additional teams participated in the Potomac Gorge BioBlitz. Members of the Virginia Herpetological Society volunteered to field a survey team for amphibians and reptiles to supplement data gathered during previous inventories. Also, a vascular plant survey team focused their efforts on selected rare plant species or species in need of verification as occurring in Great Falls Park (GWMP, VA). With guidance from NPS staff, each team leader set the survey strategy for the team, divided up responsibilities, and communicated with the team on all aspects of the survey. Team leaders then recruited members, which included research scientists, students, and amateur naturalists.

The weekend of 23-25 June was selected for the Potomac Gorge BioBlitz for a variety of reasons, including proximity to a new moon to enhance nighttime blacklight collection efforts for nocturnal insects, to follow the end of the academic year, to avoid conflicts with major holidays, and to take advantage of a peak in adult insect activity, a taxonomic group that would likely make up the majority of the species observed in the area.

One hundred forty survey volunteers (see photo on inside front cover) came from as far away as Washington state and California, but most were from the Mid-Atlantic region, representing more than 30 universities, government agencies, museums, non-profit organizations, nature centers, and schools. To support the work of the field research volunteers, TNC recruited 50 logistical support and public education volunteers who collectively donated hundreds of hours of effort before and during the survey.

The base camp for the Potomac Gorge BioBlitz was centrally located at Glen Echo Park in Maryland (part of the GWMP), which offered such amenities as restrooms, lab space (Fig. 1), and sleeping quarters. The nearby grounds provided the site for a series of public education programs and exhibits during the event.

Communications and Public Education

To facilitate communications with the BioBlitz participants, Virginia Natural History Society designed and supported a Potomac Gorge BioBlitz website, allowing the field researchers to download maps and directions, logistical information about food, travel, and lodging, and obtain instructions related to permitting, collecting, and data recording.

A key objective of the BioBlitz was to raise public awareness of the rich natural heritage of the Potomac Gorge. Glen Echo Park was selected as a base camp for the BioBlitz in part because it is a popular destination for area residents and provided an ideal setting for the event's public educational programming. The park allowed the placement of a large tent, under which twelve educational groups provided a range of engaging activities and exhibits, including leading children's bug walks, displaying and interpreting preserved insect collections, demonstrating the life cycle of butterflies,

Fig. 1. Researchers and volunteers worked long hours to sort, prepare, and identify specimens at the base camp located at Glen Echo Park, MD.

and explaining the purpose of the BioBlitz. Since access to the base camp laboratory was restricted to BioBlitz volunteers, several field researchers took time out from their survey and identification work to spend time with the public, answering questions as they sorted specimens.

To advertise the BioBlitz and its public educational programming prior to the event, TNC developed and disseminated a news release that was posted on the Website, sent to various community listserves, and distributed through other NPS communication channels.

To create a visual identity for the BioBlitz, snail team volunteer Kim Harrell designed an engaging logo for the event that was used on a promotional poster (see back cover). The luna moth logo also appeared on the official Potomac Gorge BioBlitz t-shirt that was given to all of the volunteers who participated on the teams that conducted surveys, provided educational programming, or assisted with logistical support. A BioBlitz brochure provided a schedule of public events and educational activities over the course of the weekend. The Kratt Brothers (Fig. 2), hosts of popular nature television programs, served as emcees for the BioBlitz closing ceremony and preliminary species count announcement on the final afternoon. Unfortunately, heavy rains in the region during the weekend resulted in lower than expected participation by the public in both the educational activities and the closing ceremony.

The BioBlitz generated extensive media coverage in the competitive Washington, D.C. media market, including a radio spot and more than 10 print and online articles. The most prominent features appeared in the Sunday edition of *The Washington Post* (Williamson, 2006) and in the magazine *Science Times* (Milius, 2006). The event was also featured in the Winter 2006 issue of *Nature Conservancy* magazine (Ferber, 2006), which is sent to 600,000 member households.

Fig. 2. Television's Kratt Brothers led the closing ceremony for the 2006 Potomac Gorge BioBlitz on a rainy afternoon at Glen Echo Park, MD.

TAXONOMIC SURVEY TEAMS

Each of the 18 taxonomic survey teams employed its own set of methods for conducting surveys, locating target taxa, and collecting and interpreting data, as described below.

Green algae survey (exclusive of diatoms and cyanobacteria)

The survey team split into two groups; the first group collected along the C & O Canal (CHOH) on the Maryland side of the Potomac, while the second gathered samples along the Potomac River on the Virginia side at Great Falls Park and in puddles located in Turkey Run Park (GWMP). Samples were gathered only on 24 June; the next day was spent preparing and identifying the collections.

Additional samples were collected and submitted by the Adkins family (Jasmine, Mike, and Sebastian), DorothyBelle Poli, and Ester Stein of the bryophyte team. One sample was collected from the shell of a Northern Red-bellied Cooter (*Pseudemys rubriventris*) by the amphibian and reptile survey team and was submitted by the team leader, Jason Gibson.

Generally, whole water samples of about 50 mL were collected using sterile whirl-pacs or tubes. Care was taken not to contaminate subsequent samples or habitats with algae from previous sample sites. In some cases, a 10 µm mesh plankton net was used to collect water from larger bodies of water. All samples were labeled and placed on ice until they could be examined in the laboratory. A portion of these samples was preserved in 5% Lugol's Solution with 10% glycerol and submitted to the National Park Service as voucher material.

Samples were taken to the University of Maryland in College Park where they could be examined with light microscopes and identified. Line drawings of cells were made (Fig. 11) and digital micrographs recorded. Cells were identified from the micrographs and living or preserved cells. Conjugating green algae and dinoflagellates were identified with the aid of various references, including field guides and regional floras (Smith, 1920, 1924; Conrad & Van Meel, 1952; Taft & Taft, 1971; Whitford & Schumacher, 1984; Croasedale & Flint, 1986, 1988; Hedgewald & Silva, 1988; Dillard, 2000; Prescott et al., 1975, 1983; Wehr & Sheath, 2003).

Slime mold and fungus survey

Slime molds and fungi were carefully collected in the field, brought back to the base camp, placed on paper plates, identified, labeled, and photographed (Fig. 3). The fungi were identified both in the field and at the base camp by knowledgeable experts, including Lance Biechele, John Ellifritz, Richard Gaines, Donna Mitchell, and William Roody. The nomenclature used follows that of Arora (1986) and Bessette et al. (1997).

Fig. 3. Labeled and identified fungi were photographed individually on paper plates at the BioBlitz. ©2006, Mark Godfrey.

Moss and liverwort survey

On 24 June, the bryophyte team split into two groups to collect grab-samples using two methods. Group A collected from 1000 to 1100 h and placed specimens directly into packets made of 8.5 x 11" folded 25 lb. cotton paper and recorded their collecting data on the outside of the field envelope, including date, collectors, section within the park, brief location description, GPS location, substrate, and other relevant observations. Samples were kept dry at room temperature in the packets prior to identification. Group B collected specimens from 1000 to 1900 h and placed them directly into 50 ml Falcon tubes and recorded sample numbers directly on the outside of each tube.

Sample numbers, along with their collecting data and other relevant observations were recorded in a notebook. Sample tubes were kept on ice packs in a cooler throughout the day while additional samples were collected. Prior to identification, all samples were kept in a refrigerator, within the original collection vials to maintain proper humidity and retard tissue decay while in storage.

Charles and Linda Davis prepared the voucher specimens collected by Group A for deposition with the NPS. Most of the species reported by Group B did not have high population numbers. As a result, species were observed and identified in the field only and no vouchers were prepared.

Identification of all samples was accomplished through extensive morphological and anatomical microscopy of the gametophytic and, if available, sporophytic generations. Species were keyed out using multiple sources (Dunham, 1916; Grout, 1928-1940; Conard, 1956; Crum, 1976, 1991; Crum & Anderson, 1981; Hicks, 1982; Ireland, 1982; Breil, 1996, 2003; Schofield, 2002; Porley & Hodgetts, 2005).

Select botanical survey

Since the vascular flora of the Potomac Gorge is relatively well known, the work of the botanical survey team was fundamentally different from that of other disciplines. Instead of conducting a comprehensive or inclusive inventory, work was targeted to specific taxa at Great Falls Park (GWMP, VA), for which an updated flora was under preparation by Brent Steury (Supervisory Biologist, GWMP, VA) and other cooperators (see Steury et al., 2008).

Before the Potomac Gorge BioBlitz, specific areas and habitats of Great Falls Park were prioritized for field inventory. Lists were assembled of vascular plant taxa that: 1) were known to occur in the region but had not been documented from the Park; 2) were reported from the Park without a voucher specimen; and 3) were documented only by historical specimens that may or may not have been collected within the present-day Park boundaries. Taxa that were likely to be identifiable, flowering, or fruiting in late June were targeted, and habitats likely to support these taxa were surveyed.

Fieldwork was conducted entirely on 24 June, from approximately 0900 to 1830 h. During this time several areas of Great Falls Park were visited for floristic inventory:

1. The Potomac River floodplain upstream from Great Falls proper and the Visitor Center.
2. Grasslands and rock outcrops adjacent to the Picnic Area, just downstream from Great Falls.
3. Low successional forests and the large swamp west of the Carriage Road and south of the south parking lot.
4. The bluffs and ridge above the Potomac River from Sandy Landing to near Difficult Run.
5. The floodplain and lower slopes of Difficult Run from Georgetown Pike to the Potomac River.

Specimens of taxa in need of documentation were collected, placed in plastic zip-loc bags, and ultimately into coolers during the course of the day. These were tentatively identified and placed into plant presses to dry on the evening of 24 June.

Identifications were later checked using several regional plant identification manuals, and vegetative specimens were compared with material in the Virginia Division of Natural Heritage herbarium. John F. Townsend (Staff Botanist, Division of Natural Heritage, Virginia Department of Conservation and Recreation, Richmond, VA) verified all species determinations. One problematic specimen was verified by Thomas F. Wieboldt, Assistant Curator of the Massey Herbarium at Virginia Tech in Blacksburg, VA. All vouchers were delivered to Brent Steury for deposition in the GWMP herbarium.

Triclad planarian survey

Since all triclad planarians are negatively phototactic, individuals were sought under cover objects such as rocks, logs, bark, fallen leaves, and in masses of aquatic vegetation. Collected individuals were placed in a small container and examined in subdued light under low magnification. Because their soft bodies require special fixation and preservation techniques for identification and storage, captured individuals were identified in the field and released at the point of capture; vouchers were not retained. Identifications were made according to external features illustrated by Norden et al. (1992).

Land snail survey

All places of concealment (logs, bark, leaf litter, rocks, etc.) were examined and then carefully returned to their original position. Soil samples were also collected for examination in the lab, where they were dried and sifted to remove plant material. The soil was then examined under low magnification for the presence of small snails.

Snails were identified in the field or returned to the lab to be examined under a microscope. In a few instances, specimens were dissected to reveal details of their internal anatomy. Identifications were based, in part, on Burch (1962) and Pilsbry (1939, 1948). Specimens were also identified by Tim Pearce with the assistance of the collections and library of the Carnegie Museum of Natural History, Pittsburgh, Pennsylvania.

Subterranean macroinvertebrate survey

The area extending for approximately one meter downstream from the point of seep or spring emergence was hand picked by sorting through submerged leaves, wood, and under rocks for the presence of subterranean macroinvertebrates. Free-roaming amphipods were captured by siphoning individuals directly into a turkey baster. A representative collection of no more than 12 crustaceans (epigean or subterranean) and aquatic spring snails was collected for identification from each site.

All specimens were immediately preserved with 70% ethanol. A field data sheet was completed for each seep or spring that included information on location (GPS), physical site description/map, water temperature, estimated flow rate, substrate composition, and other aquatic invertebrate taxa observed.

Species determinations were made using the following monographs, species descriptions, and keys: Shoemaker (1942) and Holsinger (1976, 1978) for subterranean amphipods; Holsinger (1976) for epigean amphipods; Bowman (1967) and Williams (1970) for aquatic isopods; and Hershler et al. (1990) for spring snails. Appendage removal for microscopic examination was required for many species determinations.

Crustacean survey (crayfish and copepods)

Diurnal searches for crayfishes were performed in both lentic and lotic habitats (see Table 10). Searches in headwater and second order streams involved turning over small rock slabs, boulders, and substrate debris. This technique was particularly efficient at collecting *Cambarus bartonii* from headwater streams, with the largest individuals procured from the largest available slabs. Detrital beds in thalwegs were sampled by dip nets and transferred to the stream bank to remove all captured crayfish.

Nocturnal searches were also employed to collect riverine tertiary burrowers. Casual searches were initiated at least two hours after sunset to ensure nocturnal species activity. Headlamps were used to illuminate crayfish foraging in the littoral zone of the Potomac River mainstem and associated eddies. These individuals were captured with dip nets and by hand, and transferred to collecting vessels.

Burrowing crayfish, such as *Cambarus diogenes*, were collected by excavating their burrows. Burrow activity was determined by the presence of chimneys or fresh mud pellets at burrow openings. Active burrows were excavated with trowels and shovels until an enlarged cul-de-sac or "resting chamber" was reached (Hobbs, 1981). Once the resting chamber was breached, the burrow was filled with water and then plunged with the investigator's hand and arm. This pumping action usually was sufficient to dislodge crayfish hiding deep within the confines of the burrow and draw them into the resting chamber where they were captured by hand.

If initial plunging efforts were unsuccessful in dislodging crayfish, the burrow was left undisturbed for several minutes. Crayfish curious about this disturbance would often rise to the water/air interface where their presence could be determined by waving antennae. In this situation, crayfish were quickly pinned to the sides of the burrow, carefully manipulated, and ultimately extracted. Burrow morphology data were collected on occupied burrows; data collected included central shaft depth, resting chamber width and height, and terminal burrow depth, as well as burrow contents. All burrows were measured in centimeters.

All vouchers were preserved in the field in 70% ethanol. Crayfish were identified in the laboratory using Hobbs (1972) and Jezerinac et al. (1995). Demographic data collected on all specimens included sex (Form I male, Form II male, or female) and life stage (neonate and adult). Morphometric data (see Table 11) were collected with vernier calipers and included carapace length (CPL) and palm length (PL) in millimeters.

Copepods inhabit open waters of lakes, ponds, stream eddies, and ephemeral water bodies, but by far the larger number are closely associated with different kinds of substrates, such as leaf packs in streams to muddy or sandy bottom sediments, and semiterrestrial situations such as damp soil or moss. In order to collect the widest range of species from a given area, it is best to sample in open waters and also in possible copepod-harboring substrates. During the BioBlitz, samples were

taken from the open water of Clay Pond at Great Falls Park (GWMP, VA) and the Chesapeake & Ohio Canal (CHOH, MD) with a small plankton net (mouth opening 10 cm and mesh size 100 μm). Samples of approximately 300-500 ml of wet soil, moss, and streambed sediments were placed in plastic bags. In all, 13 sites and substrates were sampled, 11 of which contained copepods.

All samples were transported on ice in a cooler to the laboratory, where the bags were stored in a refrigerator. Over the next several days, the still-living copepods were washed from the sediments into clear glass petri dishes and sorted with a micropipette, under a dissecting microscope. Sorting live samples is the most efficient way to locate the tiniest species, which are easily seen as they wiggle through the sediment. A few drops of alcohol added to the water in the dish serves to partly anesthetize the copepods, making it easy to catch them and also revealing more benthic species as they release their hold on the substrate.

Adult copepods were fixed and preserved in 70% isopropyl alcohol and identified using appropriate keys (e.g., Wilson & Yeatman, 1959). See Reid (2000) for detailed descriptions of procedures used in the taxonomic identification of copepods.

Arachnid survey

The arachnid team used both insect nets for sweeping vegetation and hand picking for capturing readily visible specimens. Other BioBlitz volunteers submitted samples from pitfall traps and/or sweeping (labeled "pooled" samples) and may have used additional collecting methods.

Vouchers were killed and stored in 70% isopropyl alcohol in patent lip vials with neoprene stoppers. Site labels were provided during the event; additional labels were printed. Each specimen was labeled with site, date, collector (if known), genus or species (spiders only), and determiner. Four orders of arachnids were collected, including Araneae (spiders), Acari (mites), Pseudoscorpiones (pseudoscorpions), and Opiliones (harvestmen). However, only spiders were identified to family, genus, and species levels.

Spiders were identified using several general resources and many monographs (e.g., Chamberlin & Ivie, 1941; Levi, 1956; Exline & Levi, 1962; Brady, 1964; Reiskind, 1969; Berman & Levi, 1971; Dondale & Redner, 1978, 1990; Kaston, 1978, 1981; Griswold, 1987; Dondale et al., 2003; Edwards, 2004; Richman & Vetter, 2004; Ubick et al., 2005). The current taxonomy for spider names was gleaned from Platnick (2007).

Fig. 4. Cast skins (exuviae) of dragonflies and damselflies were collected on rocks and vegetation along the shoreline of the Potomac River. ©2006, Richard Orr.

Dragonfly and damselfly survey

Adult dragonflies and damselflies were identified either through observations in the field or from collected specimens. Vouchers were prepared by placing living specimens in acetone for 24 hours. They were then dried and placed into clear envelopes with the associated data. Cast skins (exuviae) were collected on rocks and vegetation along the shores of rivers and streams (Fig. 4) and were dried, pinned, and labeled.

Mayfly, stonefly, caddisfly, and neuropteroid survey

Various methods were used to sample sites along the Potomac River, including dipnetting and visual searching of rocks, sticks, etc. in the bottom of small streams for the immature stages. All light trap collections were carefully examined for pertinent specimens. Immatures were preserved in alcohol and have not yet been identified. Adults from the light traps were either kept dry and pinned, or preserved in alcohol.

True bug survey

Most of the true bugs were collected either by a general sweep net or with a specialized shallow beating net and beating stick. The former is best for very general sampling, especially of old-field habitats and other disturbed areas. However, beating is the preferred method of collecting when attempting to determine host plants and is particularly useful for collecting species of plant bugs (Miridae). Additional specimens were taken

at UV light or in Malaise traps, both of which resulted in the collection of taxa not encountered by either beating or sweeping.

Collected specimens were pooled and returned to the National Museum of Natural History for mounting, labeling, and identification. All specimens were determined to species by Thomas Henry with the aid of the museum's reference collection and library.

Scorpionfly survey

Scorpionflies were collected with sweep nets. Specimens were initially placed into ethanol and later pinned and labeled. Field identifications were made using microscopes available at the BioBlitz. Confirmation of identifications was made later in the laboratory, using a Leica MZ6 dissecting microscope at magnifications of 6.3-400x and the key to the Nearctic species of *Bittacus* (Carpenter, 1931).

Beetle survey

The beetle team employed a variety of techniques to collect or attract as many species as possible within the limited time available for the survey. Of paramount importance was nighttime light trapping. Two 12-volt blacklight bucket traps (Fig. 5) were used, as well as a 175-watt mercury vapor light (Fig. 6) mounted on a camera tripod, to attract nocturnal species.

Pitfall traps baited with rotting meat (shrimp, chicken, fish), feces, or a mixture of fermenting molasses, banana peels, and yeast were also deployed. Funnel traps baited with a mixture of rotting bananas, beer, and yeast were hung at eye-level in tree branches.

Both diurnal and nocturnal inspections of various species of plants and their structures, including flowers, fruits, cones, branches, leaves, and needles were undertaken. Dead trees, logs, and stumps, especially those still covered with loose bark, and their associated

Fig. 5 (left). A 12-volt blacklight bucket trap for collecting nocturnal insects. ©2006, Roy Sewall.
Fig. 6 (right). A 175-watt mercury vapor light set up for collecting nocturnal insects. ©2006, Roy Sewall.

Fig. 7. Using a beating sheet at night with the aid of a headlamp to collect beetles. ©2006, Roy Sewall.

fungi, were carefully inspected. Free-living fungi, mosses, and lichens were also examined with a hand lens to locate adult beetles.

Vegetation was sampled, day and night, with the aid of a beating sheet (Fig. 7). Beetles beaten from vegetation were collected from the sheet either by hand or sucked into an aspirator.

Team members also searched beneath stones, logs, and other objects on the ground, especially in moist habitats along the edges of streams. Ponds, pools, streams, and other aquatic habitats were not surveyed for water beetles, although aquatic species were collected at lights at night.

All live specimens were transferred to killing jars charged with ethyl acetate or potassium cyanide, or placed in vials partially filled with 70% isopropyl. All specimens from each locality were then placed in separate white plates or plastic sorting trays and segregated by morphospecies. Typically, no more than six individuals of each morphospecies collected from each of the three parks (CHOH, GRFA, TRRU) were mounted (pinned or pointed) and labeled (Fig. 8).

Specimen labels included country, state, county, park, specific locality, latitude and longitude (if available), date, collector, and method of collection (if known). All specimens bear determination labels indicating genus, species (if known), authority, determiner, and year of determination. The determination labels on all specimens collected in Virginia bear labels with the line "Virginia Beetle Project." These specimens have been entered into a separate database maintained by A.V. Evans as part of a statewide beetle survey.

A.V. Evans, S. Lingafelter, D.L. Meade, J. Prena, W.E. Steiner, and N.E. Woodley identified vouchers to family, genus, or species. Resources for identifications included, in part, the two-volume *American Beetles* (Arnett & Thomas, 2001; Arnett et al., 2002) and many of the publications cited therein. Larger works of particular use were those of Ciegler (2000, 2003), Dillon & Dillon (1972), Downey & Arnett, (1996), Harpootlian (2001), Staines (2006), and Yanega (1996). Vouchers were also identified through comparison with specimens housed in the private collection of A.V. Evans in Richmond, Virginia, and the entomological collections of the National Museum of Natural History (NMNH), Washington, DC.

Fly survey

Nearly all flies were collected with aerial nets. The severe weather precluded use of additional collecting techniques. Smaller specimens were double mounted on minutens or glued to paper triangles, whereas larger specimens were directly pinned. All specimens were labeled with specific locality, date, and collector information. In most cases, geographic coordinates supplemented locality data. Prepared specimens were identified to family and sent to specialists for more specific determinations. Specimens of a few families were identified to morphospecies only.

Moth and butterfly survey

The fauna of the area was sampled using blacklight traps on the evenings of 23 June and 24 June. Traps were deployed at several sites, including Bear Island (J. Lewis), Carderock (D. & M. Davis), and Plummers Island (J. Brown & K. Vann) (CHOH, MD). Another black light trap was set in the GWMP, VA at Turkey Run (J. Brown & K. Vann). Additional specimens were procured from light traps operated at Great Falls Park (GWMP, VA) by the beetle survey team. Two diurnal surveys conducted on Plummers Island on 24 June provided observations of several butterfly species. The vast majority of the species and specimens were collected in the traps at night.

Ant and bee survey

Bees were collected using insect nets and a series of fluorescent yellow, fluorescent blue, and white 3.25 ounce "bee bowls." Bowls filled with water and a small amount of detergent were set on the ground. They were collected at the end of the day, and specimens were rinsed with water and transferred to alcohol. Bee vouchers were identified by Sam Droege, who consulted with Discoverlife online identification guides (www.discoverlife.org), Mitchell (1960, 1962), and an unpublished list of state bee records compiled by John Ascher. Wasps inadvertently collected during the

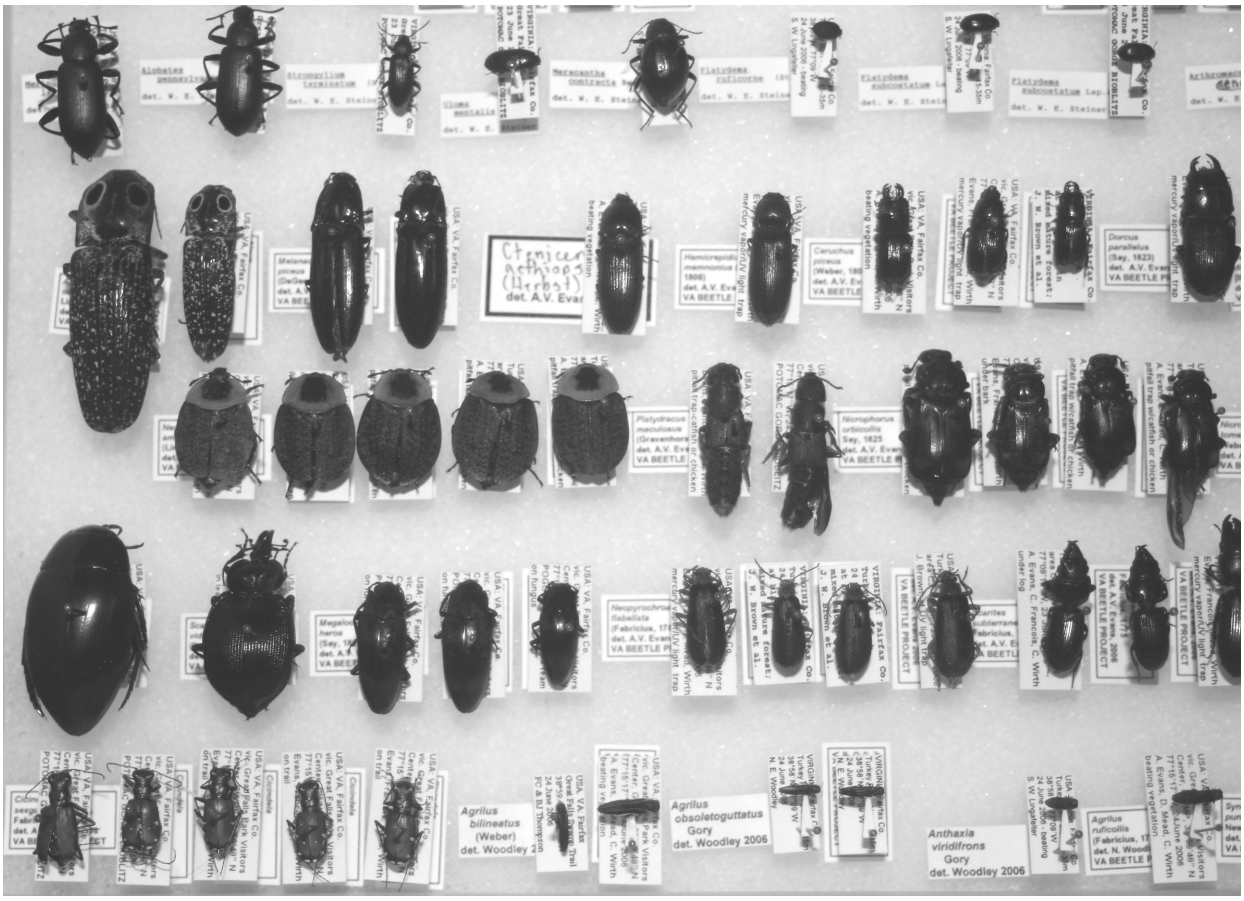

Fig. 8. A portion of the prepared, labeled, and identified beetle vouchers collected during the BioBlitz. The mandatory deposition of all vouchers in NPS facilities discouraged some scientists and their institutions from taking part in the Potomac Gorge BioBlitz. ©2006, Arthur V. Evans.

survey were not identified and are not included in the final species tally.

Ants were collected by various methods, pinned, and identified by Daniel Kjar who compared them with the collections of the National Museum of Natural History, Smithsonian Institution, and the entomological collections housed at Georgetown University.

Amphibian and reptile survey

Animals were collected by hand capture, dipnetting, visual encounter, overturning cover objects, digging through trash piles, and listening for calling anurans. Hoop turtle traps (Fig. 9) were deployed on 23 June in Great Falls Park (GWMP, VA), four in Clay Pond and three along the Potomac River. Each trap was baited with one can of water-packed sardines. In a concerted effort to prevent the possible spread of disease, traps and other collecting equipment were disinfected with bleach before moving from one wetland to another.

All captured animals were briefly examined for evidence of disease or parasites (Fig. 10). Digital photos were taken for vouchering purposes. At least two knowledgeable members of the group had to agree on the identification of each animal before it was released back into the wild. Paul Sattler or Jason Gibson recorded all observations.

Recording data

Initial observations and collection data for some voucher specimens were entered into computers supplied with a Microsoft Excel spreadsheet that included park code (CHOH, GLEC, GRFA, or TRRU), site, location, date, latitude, longitude, habitat, family, species, determiner, abundance, native?, #vouchers, #observed, collector(s)/observer(s), and comments. All data and voucher specimens from the GWMP were submitted to Brent Steury (Supervisory Biologist,

Fig. 9. Hoop turtle traps were deployed in Clay Pond and the Potomac River. ©2006, Roy Sewall.

Natural Resources Program Manager, George Washington Memorial Parkway, Park Headquarters, Turkey Run Park, McLean, VA 22101). Sam Tamburro (Park Historian, Chesapeake & Ohio Canal National Historical Park, 1850 Dual Highway, Suite 100 Hagerstown, MD 21740) received data and specimens collected in the CHOH. These data were also sent to Geoffrey Sanders (Data Manager, National Capital Region, Center for Urban Ecology, 4598 MacArthur Blvd., NW, Washington, DC 20007).

During the summer of 2007, Anna Santos (now with the MD/DC chapter of TNC) was hired as an intern by the NPS to accession and digitally catalog all Potomac Gorge BioBlitz specimens for both the GWMP (housed at Turkey Run Park) and CHOH (housed at the NPS Museum Resource Center). This project revealed many inconsistencies between the voucher specimens, species data sheets, and tallies that appeared in an early draft of the survey report. These discrepancies were resolved through close cooperation between Santos, Evans, and the team leaders (see Santos, 2007).

SURVEY RESULTS

Survey team leaders submitted summaries of their inventories, providing some or all of the following information, if pertinent to their survey:

1. A brief summary of previous surveys for the taxonomic group(s) in the region based on published scientific literature and unpublished reports filed with the NPS.

2. A description of methods and materials used to observe individuals, or to collect and prepare specimens (see previous section).

3. A list of the resources (museum and university collections, monographs, etc.) used for the identification of vouchers.

Fig. 10. Captured amphibians and reptiles were inspected for signs of disease or parasitic infection before their release. ©2006, Roy Sewall.

4. Comments on noteworthy species, especially, new state or park records, verification of historic records, species new to science, global or state rare (G1/S1) species, etc.

5. Comments on exotic or introduced species.

6. Offer personal impressions of the survey results, including effects of field conditions and seasonality on diversity, expected taxa vs. observed taxa, suggestions for maximizing the efforts of future surveys, suggested locales on NPS lands for future survey work, and conservation concerns, if any, and suggested remedies.

7. A complete list of team members and estimates of combined total hours spent by the team in the field (including travel time) and number of hours dedicated to specimen preparation and identification (including data entry, report writing, and specimen transfer to the NPS).