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Northeast Region
Natural Resource Stewardship and Science

Biodiversity Associated with Eastern Hemlock Forests: Assessment and Classification of Invertebrate Biodiversity within Shenandoah National Park

Technical Report NPS/NER/NRTR--2004/001

ON THE COVER

Top: This twig of eastern hemlock (*Tsuga canadensis*) was removed from a tree at Limberlost in August 1997. The white material at the base of the needles is produced by the female hemlock woolly adelgid (*Adelges tsugae*) and provides protection for nymphs and eggs of this species. Eastern hemlocks are injured by the adelgids inserting their piercing-sucking mouthparts into the base of the needles and removing plant fluids. This nonnative insect has caused decline and mortality of nearly all eastern hemlocks in Shenandoah National Park.

Bottom: These insects, primarily in the Order Lepidoptera, were captured using a light trap in Limberlost during August 1997. This collection represents some of the biodiversity associated with hemlock stands in Shenandoah National Park.

Photographs by Carolyn G. Mahan.

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Project Summary

To assess invertebrate biodiversity associated with eastern hemlock (*Tsuga canadensis*) forests at Shenandoah National Park (SHEN), 12,978 invertebrate specimens were collected at a hemlock forest (Limberlost) and, for comparison, a hardwood forest (Matthews Arm) during August 1997. The specimens we collected comprised 19 insect orders representing 161 families. In addition, 14 other related invertebrate orders representing 33 families were collected. As of June 2004, of the 12,978 total specimens collected, 286 species (both genus and species known) were identified. However, another 3,286 specimens (25%) were identified to the morphospecies level. For the purpose of this report, morphospecies are specimens that have been sorted and classified as distinct, although unidentified, taxa according to their shape and morphological characteristics. All Coleoptera (beetles), Lepidoptera (moths and butterflies), Opiliones (daddy longlegs or harvestmen), Araneae (spiders), Hemiptera (true bugs), Homoptera (aphids, planthoppers, scale insects), Hymenoptera (bees, wasps and ants), Plecoptera (stoneflies), Psocopotera (psocids), Trichoptera (caddisflies), Thysanoptera (thrips), Chilopoda (centipedes), Diplopoda (millipedes), and Blattaria (cockroaches) were identified either to the named species level or sorted to morphospecies. Most of the Diptera (flies), except for the families Cecidomyiidae, Sciaridae, and Sphaeroceridae have been identified to species or morphospecies. Of the remaining invertebrate orders, most were identified to the family level except Acari (mites, ticks), Pseudoscorpiones (pseudoscorpians), Ephemeroptera (mayflies), Protura (proturans), Isopoda (sowbugs), Siphonaptera (fleas), and Stylomatophora (snails and slugs). Our collection potentially contains many more species because 1,209 specimens of Acari (mites), 2,478 specimens of Collembola (springtails), and 3,138 specimens of Cecidomyiidae (gall midges) were not sorted to morphospecies.

All specimens were prepared and curated at the Frost Entomological Museum, The Pennsylvania State University. Furthermore, all specimens identified were entered into the SHEN Biodiversity Database and will be provided to park personnel for inclusion in the NPSpecies online database.

The invertebrate biodiversity of the hemlock (Limberlost) and hardwood (Matthews Arm) forest stands at SHEN were compared by examining species richness and abundance as well as conducting guild analyses. The species were assigned to guilds based on immature feeding behavior as reported in the literature. These guilds were used to describe differences between the two forest types. The hemlock stand contained higher numbers of individuals in 14 out of 33 orders collected at SHEN. In particular, Ephemeroptera (mayflies), Plecoptera (stoneflies), and Psocoptera (booklice) were only found, or were more abundant, at Limberlost. In addition, members of the moss grazer guild were only found at Limberlost. These taxa may be dependent on the dense canopy and moist microclimate that occur within hemlock stands.

Our study documented one new state record (*Arctogeophilus fulvus*) and a new Madison County record (*Stimamia bidens*) for centipedes collected at Limberlost. In addition, a new species in the order Homoptera (*Cyrtolobus* n. sp. nr. *invermis*) and ten new species in the order Diptera in the families Mycetophilidae (9) and Psychodidae (1) were documented.

Acknowledgments

Funding for this project was provided by the National Park Service. We would like to express our appreciation for the time and energy given by all that have made this project possible. Our first round of appreciation goes to the National Park Service personnel for their generous cooperation, especially John Karish, James Akerson, Gary Hunt, and Robert Krumenaker. We especially appreciate the work provided by field and lab assistants including Bryan Black, John Greham, Ann Schrot, and R. P. Withington. We thank Gordon Olson and Richard Yahner for taking the time to read and comment on this report. Finally, we especially thank Emily Hill for formatting this final report.

Introduction

The eastern hemlock (*Tsuga canadensis*) is a shade-tolerant, late-successional conifer that provides significant riparian and upland habitat in the deciduous forest landscape (DeGraaf et al. 1992). Hemlocks influence microclimate, soil chemistry, and forest floor environment, and contribute to regional biological diversity (Benzinger 1994). The eastern hemlock may be particularly important in the mid-Atlantic region, where it is one of few native conifers found within the eastern deciduous forest and is a major component of many remaining old-growth forest stands.

Because the eastern hemlock is a long-lived "climax" species, some plants and animals may have evolved in association with hemlock stands (Benzinger 1994). For example, several bird species, such as solitary vireo (*Vireo solitarius*), black-throated green warbler (*Dendroica virens*), and blackburnian warbler (*Dendroica fusca*), depend on, or strongly prefer, hemlock habitats (Benzinger 1994). Water shrews (*Sorex palustris*), a species of special concern in the northeast, also have been found to be closely associated with hemlock stands (Sciascia and Pehek 1995). At Shenandoah National Park (SHEN), the federally endangered Shenandoah salamander (*Plethodon shenandoah*) occurs in dense hemlock stands (Mitchell 1991; Watson et al. 1994). In addition, plant species, such as painted trillium (*Trillium undulatum*), grow primarily under the canopy of hemlock trees (Radford et al. 1968). Because riparian hemlocks shade adjacent waters and help to maintain cool stream temperatures, many streams that support naturally reproducing populations of brook trout (*Salvelinus fontinalis*) are associated with hemlock forests (Ross and Bennett 1995). Aside from their ecological qualities, eastern hemlock stands are highly valued for aesthetic and recreational appeal.

At SHEN (Figure 1), aesthetic, recreational, and ecological values of hemlock stands are threatened by the hemlock woolly adelgid (*Adelges tsuga*). Hemlock woolly adelgid (HWA) was first detected in SHEN in the fall of 1988 and now infests all eastern hemlock stands at SHEN, causing significant mortality of hemlock trees (Watson et al. 1994, Bair 2002). Since 1997 (when our study was conducted), hemlock mortality at SHEN has been dramatic with approximately 50% of all hemlocks classified as dead in 2000 (Bair 2002). Biodiversity associated with hemlock stands could be at risk if the current trend of HWA infestation and resulting mortality continues. The National Park Service (NPS) endeavors to protect and maintain the natural heritage of its lands, particularly under the threat of an invasive exotic species such as the HWA.

Baseline information on the biotic components of hemlock ecosystems is fundamental to the protection and restoration of biodiversity and to the maintenance of ecosystem dynamics in hemlock stands at SHEN. Investigating entire natural communities is a formidable task because of high diversity of species associated with ecosystems. To focus on a more manageable unit, ecologists often restrict their analyses of ecosystem components and function to a representation of the larger system such as guilds (Root 2001). The guild concept defined by Root (1967) provides a manageable, functional unit for studying organization of natural communities. The objectives of our study were to collect information on the biotic components of hemlock ecosystems at SHEN and to test the use of the ecosystem profile method in estimating

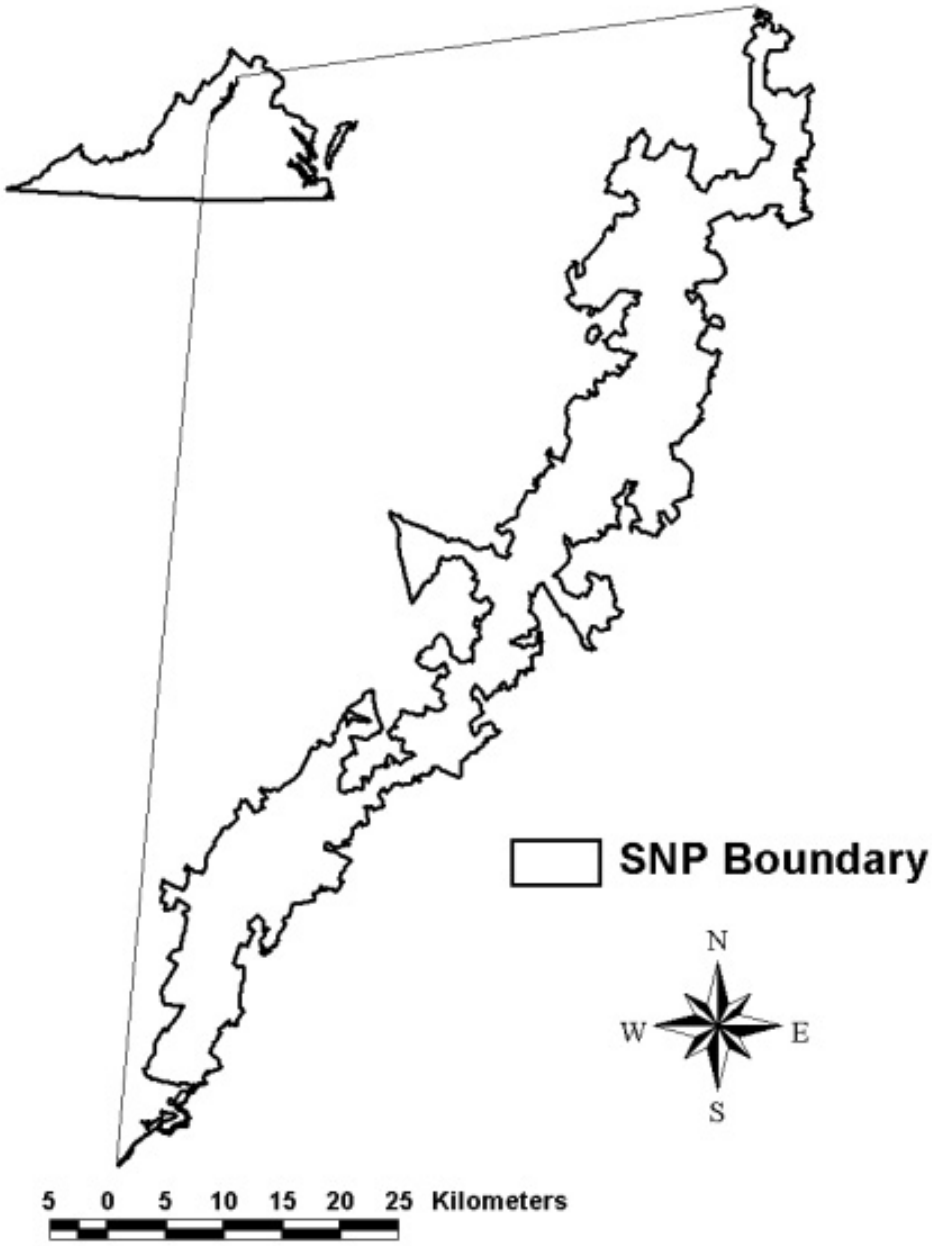


Figure 1. Map and location of Shenandoah National Park in association with the state of Virginia.

biodiversity (Mahan et al. 1998a). The plant and vertebrate species inventory component of the study were described in earlier reports (Mahan et al. 1998b). This report documents the results of the assessment, classification, and guild associations of the invertebrate biodiversity component of the SHEN study.

Methods and Procedures

Biodiversity Database

As the first step in the completion of a biodiversity inventory, we developed a database for historical and potential invertebrate species occurrence data in SHEN (called the SHEN Biodiversity Database). Existing documentation of invertebrate species was searched and entered into a Microsoft Access database. This consisted primarily of searching the published literature and internal reports for evidence of invertebrate species documented in SHEN, the surrounding counties, or the state. This database was later updated to include all species collected as part of this project. A copy of the database was provided to the Division of Natural Resources at SHEN.

The SHEN Biodiversity Database contains the full taxonomy of each included species along with links from each species to the source of the information and the locations where the species was known to occur. Lists of species can be output from the database comprehensively or limited by any of the database's fields, such as locality.

Site Design

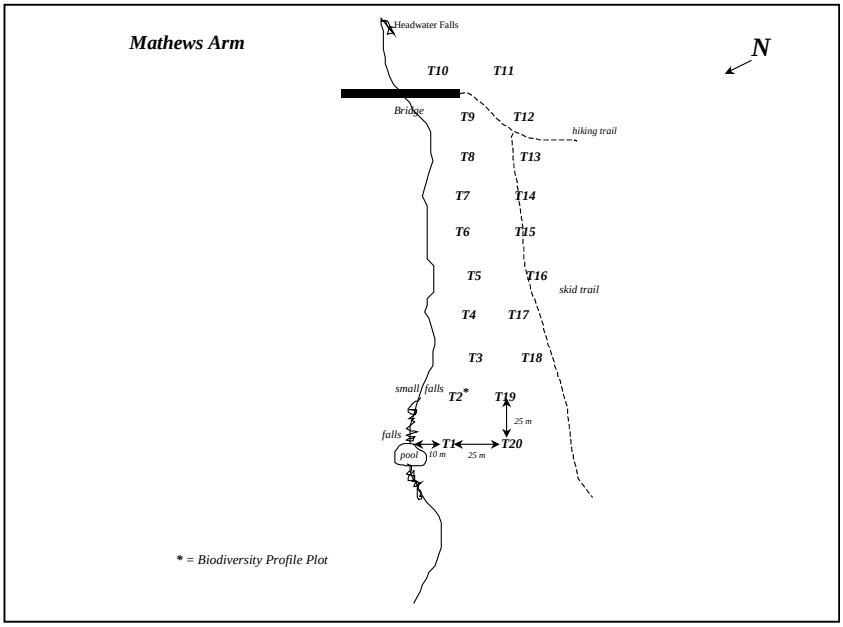
Potential hemlock and hardwood forest stands were selected within SHEN based on a sampling design method developed by researchers at the United States Geological Survey (USGS) Biological Resources Division (BRD) (Smith et al. 1996). Hemlock stands were clustered into three topographic types (clusters 1, 2, or 3) based on landscape attributes. Cluster 1 stands were termed bench stands and were relatively low gradient sites. Cluster 2 stands were termed ravine stands and were steep sites with a highly variable, often stepping, gradient. Cluster 3 stands were termed mid-slope stands and had a steep, but less variable, slope with a convex or only slightly concave shape in cross section.

Selected hemlock stands then were paired with hardwood stands based upon similarities in elevation, slope, aspect, solar radiance, terrain shape, stand size and perimeter, and occurrence of first, second, and third order streams. Seven pairs of stands were identified as having similar physiographic characteristics but different forest composition. Only one pair of stands was selected for sampling in 1997 because of funding constraints; therefore, we selected Limberlost (hemlock) and Matthews Arm (hardwood) as our pair of study stands (Mahan 1997) (Figures 2a and 2b). These stands were bench stands (cluster 1) that contained first order streams.

A plot-based ecosystem profile inventory was conducted at both Limberlost and Matthews Arm and was supplemented with more extensive stand-based sampling across a larger area (Kim 1993, Mahan et al. 1998a). The ecosystem profile inventory included intensive sampling for multiple taxonomic groups (plants, flying insects, soil- and litter-dwelling invertebrates, trunk-dwelling invertebrates, mammals, and amphibians) from the forest floor to the forest canopy within a 20 x 20 m sampling plot. More extensive sampling for mammals, amphibians, soil- and litter-dwelling invertebrates, and vascular plants also was conducted at trapping stations throughout the forest stands (Mahan et al. 1998a).

a)

38º 45 ' N 78 º 17 ' W



b)

38º 34 ' 78 º 22 ' W

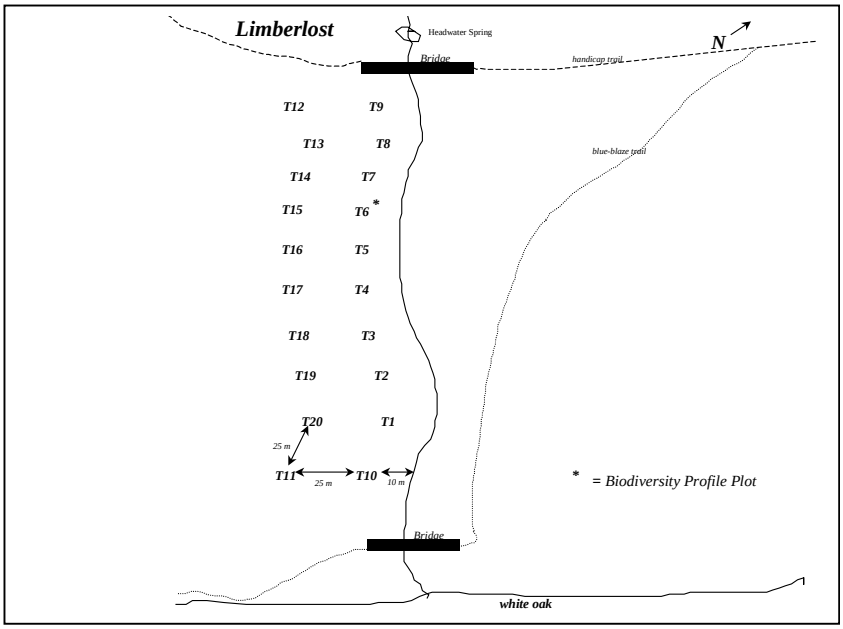


Figure 2. Maps of sites in Shenandoah National Park, Virginia, sampled for invertebrates in 1997: a) Plot at Matthews Arm and b) Plot at Limberlost. Only trapping stations (T) marked with an asterisk were sampled using the ecosystem profile plot technique.

Sampling Strategy

We used a variety of collecting techniques to sample invertebrates from nearly all habitat levels from within the plots (Table 1). Selection of each method and field protocols for the traps were based on Mahan et al. (1998a). Because of limited funding, we only were able to sample in August 1997. We focused our sampling on invertebrates because they comprise at least 75% of all known species of animals, and yet they often are ignored in ecological studies. Because insects are a major driving force behind many ecosystem processes, without them, our present ecosystems would not function. Invertebrates perform many ecological functions, such as pollination and nutrient cycling, and serve as food for many other organisms; therefore, they are valuable as indicators of many different kinds of environmental disturbances. Failure to include insects and other invertebrates in ecosystem inventories, monitoring, conservation, and management, leads to a misrepresentation of ecosystem integrity and dynamics. Because of their diversity, insects provide the opportunity to detect smaller, more inconspicuous changes in ecosystems that might otherwise go undetected by focusing only on larger, more conspicuous vertebrate species (Danks 1996).

Beating Sheet

To sample invertebrates associated with understory vegetation we used a beating sheet and 10 beats on above-ground vegetation at selected points within a plot. Five randomly chosen points within the ecosystem profile plot were selected for use of the beating sheet at Matthews Arm and Limberlost.

Branch Clipping

In order to inventory invertebrates that inhabit the forest canopy, we collected branch clippings from two overstory trees within the ecosystem profile plot at both Matthews Arm and Limberlost (Schowalter 1989). Branches were sampled by quickly enclosing a 0.5-m length of foliage-bearing branch in a 60-liter plastic bag, clipping the branch, and sealing the bag (Mahan et al. 1998a). Three branches constituted one sample, and each tree was sampled at upper-crown level (top of canopy) and lower-crown level (bottom of canopy).

Canopy Malaise Traps

To sample flying insects in the forest canopy we arranged for a tree climber to place two canopy malaise traps in each ecosystem profile plot (Nyrop and Simmons 1986; Mahan et al. 1998a). One trap was placed in the mid- to upper-canopy of each of two trees (one trap per tree) within each ecosystem profile plot. Traps were placed a minimum of 5 m apart. Canopy malaise traps were set for a four-day period and were checked and emptied daily.

Ground Malaise Traps

To sample flying insects we set two ground malaise traps within each ecosystem profile plot in randomly selected locations (Mahan et al. 1998a). Ground malaise traps were set for a four-day period and were checked and emptied daily.

Table 1. Sampling methods used to inventory the invertebrate biodiversity at Shenandoah National Park in August 1997.

Sampling Method	Sampling Locations (E or B)*	Frequency or duration of sampling period
Soil cores	B	One time
Leaf litter samples	B	One time
Pitfall traps	B	One time
Trunk traps	E	Four days
Beating	E	One time
Sweeping	E	One time
Substrate search	B	One time
Ground malaise traps	E	Four days
Canopy malaise traps	E	Four days
Branch clipping	E	One time
Light traps	E	One night

*E=sampling conducted only in the ecosystem profile plot.
*B=sampling conducted in both ecosystem profile plot and at trapping stations throughout the stand.

Leaf Litter

We hand-collected leaf litter samples from the forest floor using a 0.25 x 0.25-m quadrant (Edwards 1991). Once collected, leaf litter samples were placed in sealed bags and stored at 5^{o}C until the samples could be sorted manually and invertebrates could be removed. We collected five leaf litter samples within the ecosystem profile plot at both Matthews Arm and Limberlost. In addition, we collected one leaf litter sample at each of 10 randomly selected trapping stations at each site.

Light Traps

We used light trapping to inventory nocturnal flying insects. We placed one light trap equipped with a 10-watt blacklight tube within the ecosystem profile plot at both Matthews Arm and Limberlost. Traps were run for one night, from dusk to dawn.

Pitfall Traps

We placed six pitfall traps within each ecosystem profile plot allowing at least 10 m between traps and forming a grid system. In addition, we placed pitfall traps at five randomly selected trapping stations at each site. Invertebrate pitfall traps were constructed from 9-cm diameter plastic drinking cups placed beneath the ground so that the top of the traps were level with the soil surface. We used table salt, placed to a depth of 1-2 cm in the bottom of the trap and covered with water, as a preservative. Pitfall traps were opened for a four-day period and were checked and emptied daily.

Soil Cores

We took five soil core samples (5 cm diameter and 2-5 cm deep) each within the ecosystem profile plot at both Matthews Arm and Limberlost. In addition, we took one soil core sample at each of 10 randomly selected trapping stations at each site. Soil cores were taken to a depth of 2-5 cm and were kept intact for extraction (Edwards and Fletcher 1971; Mahan et al. 1998a). Soil cores were maintained at 4-10^{o} C until the invertebrates could be extracted. A modified Tullgren Funnel method was employed to extract invertebrates from the soil cores (Tullgren 1918).

Substrate Searches

To further sample invertebrates on the ground we conducted a plot-based substrate search and collected all invertebrates encountered. Within a 5-m radius circle centered on the trapping station, two observers turned rocks and logs and searched the soil surface for 10 minutes each. One substrate search was collected at each ecosystem profile plot and all trapping stations at each site.

Sweeping

We collected five sweep samples to inventory invertebrates on herbaceous vegetation within the ecosystem profile plot at Matthews Arm and Limberlost. We randomly chose the starting point

of each sweep sample within the plot. Ten sweeps, one taken at each step, constituted one sample (Winchester and Scudder 1993; Mahan et al. 1998a).

Trunk Traps

To sample invertebrates from tree trunks, we attached trunk traps to five trees each within the ecosystem profile plot at both Matthews Arm and Limberlost (Moeed and Meads 1983). Trunk traps were opened for four days and were checked and emptied daily.

Preservation and Identification

Field collected samples were kept in dry condition or preserved in glass vials containing 70% ethyl alcohol. In the laboratory, samples were processed, separated, and sorted into orders and subsequently into families. Specimens were sent to taxonomic specialists for identification to the genus and species level. Specimens that were not sent out to taxonomic specialists were separated into identifiable taxa known as morphospecies (Morpho sp.). All specimens were labeled with identification information, locality, and an accession code number. For the purpose of this report, morphospecies are specimens that have been sorted and classified as distinct, although unidentified, taxa according to their shape and morphological characteristics. All specimens are currently maintained in the Frost Entomological Museum, The Pennsylvania State University.

Taxonomic Specialists

Our laboratory assistants did the initial sorting and identification of the invertebrate specimens at the Frost Entomological Museum. However, in most cases, for specimen identification to the species level, we sent specimens to taxonomic experts. A list of those specialists and the taxa they worked on is presented in Appendix A.

Statistical Treatments

Invertebrate specimens were sorted to order, family, genus, and species (or morphospecies) level. The numbers of species and individuals were used to describe species richness and abundance for each site. These data were used to develop a species list of invertebrates found at SHEN and enabled us to group these species into guilds for an in-depth ecological comparison between sites.

Root (1967) defined a guild as groups of species that exploit the same class of resources in a similar way. Guilds are based on activities of animals such as feeding habits, breeding, animal size, structural features of the vegetation, and surrounding physical features of the habitat, or a mixture of feeding and habitat features (Severinghaus 1981; Moran and Southwood 1982; Short and Burnham 1982; Roberts 1987).

We assigned species to guilds based on immature feeding behavior in this study, as very little is known about adult feeding behavior for invertebrates. Some adults are non-feeders, or their feeding behavior is the same as in the immature stage. We then compared the invertebrate

species assemblages between hemlock and hardwood forests at SHEN based on primary and secondary guilds as outlined in Table 2. We also divided the two sites into primary guilds based on occurrence of invertebrates from the ground, subcanopy and canopy zones. The trapping methods used to define each of the zones is presented in Table 3.

Table 2. Terms and definitions used to describe the invertebrate immature feeding guilds found at Shenandoah National Park in August 1997.

Primary Guilds	Secondary Guilds
Phytophagy – feeding on flowering plants, trees, ferns, lichens, mosses (bryophytes), liverworts (hepatics,) and algae (diatoms).	Leaf chewer, leaf miner, cone feeder, gall-maker, grazer, flower feeder, pollen feeder, nectar feeder, honeydew feeder, sap feeder, seed feeder, root feeder, woodborer, nut borer, fruit borer, diatom feeder – feeding on algae, general plant feeder – feeding on multiple plant parts (generalist).
Zoophagy – feeding on other animals.	Predator – feeding on smaller or weaker animals, usually using one or more for a single meal. Living apart from their prey and seeking animals in different places for different meals. Parasite and parasitoid – living in or on the bodies of their hosts and live continually with their hosts during at least a part of their life cycle. Obtaining successive meals from these hosts, and their feeding is at the expense of the hosts. Entomophagous –feeding on insects. Haemophagous – feeds on blood or takes a blood meal from live animals.
Saprophagy – feeding on dead or decaying plant or animal materials, such as carrion, leaf litter, dead logs, and the like.	Detritivore – feeding on dead plant material and fragments of organic matter. Carrion feeder – feeding on dead animals. Coprophagous – feeding on feces. Filter feeder
Mycetophagy – feeding on fungi, mold, and yeast.	Fungivore, mold feeder, yeast feeder.
Omnivory – combination of two or more of the above guilds. Feeding on living or dead plant and animal material.	Microphagous – feeding on plant and animal microorganisms (phytoplankton and zooplankton). Regurgitated food feeder.

Table 3. Trapping methods used to inventory invertebrates from the ground, subcanopy, and canopy zones at Shenandoah National Park in August 1997.

Ground Zone	Subcanopy Zone	Canopy Zone
Invertebrate pitfall traps	Light traps	Beat sheets
Mammal pitfall traps	Ground malaise traps	Branch clips
Leaf litter		Canopy malaise traps
Natural substrate searches		Trunk traps
Soil cores		
Sweeping		

Results

Our comprehensive inventory provides a baseline of invertebrate biodiversity information for future management programs. Our results emphasize the presence of a diverse range of invertebrates, particularly insects, within the forested ecosystems of SHEN. With additional support from the NPS, we have made an aggressive effort for species identification. To assist in this effort we have engaged many taxonomists to help us in this project and have developed a database of taxonomists available for taxonomic identification services (Appendix A). Despite these efforts, many species are still unidentified or only identified to morphospecies.

Invertebrates

Using 11 sampling techniques, we collected 12,978 invertebrates from 33 orders at SHEN in August, 1997 (Table 4). The specimens we collected comprised three phyla, seven classes, 33 orders, and 194 families of invertebrates (Table 5). The collected specimens represented 297 known genera and 286 named species of invertebrates (Table 5). We captured 6,317 specimens at Limberlost and 6,661 specimens at Matthews Arm. Diptera was the most abundant order at both Matthews Arm and Limberlost, followed by Collembola, Lepidoptera, and Hymenoptera. The most abundant arthropods other than insects were the Acari and Araneae at both Limberlost and Matthews Arm. There were fewer invertebrate orders collected at Limberlost than at Matthews Arm (Table 4).

Of the 11 sampling techniques used, we collected the highest number of individuals using ground malaise traps, leaf litter samples, and light traps, respectively (Table 6). We captured the greatest number of Diptera and Hymenoptera using ground malaise traps. We captured the greatest number of Lepidoptera and numerous Diptera at light traps. However, we caught the greatest number of Acari, Araneae, Chordeumatida, Geomorphila, Lithiobiomorpha, Coleoptera, Collembola, Julida, and Psocoptera specimens in leaf litter samples.

In this report, the taxa are presented by taxonomic order unless otherwise noted. All table numbers beginning with a “B” (e.g., Table B1) are found in Appendix B. Due to the amount of material collected, combined with budget and time constraints for the project, we were not able to establish a professional staff team sufficient in numbers and duration of employment to handle the species identification of every specimen. However, some specimens were sent to specialists while Frost Entomological Museum employees sorted the remainder to species, genus, family, order, class, or morphospecies when possible.

Order Stylomatophora (Phylum Mollusca, Class Gastropoda; snails and slugs): We collected five specimens, one from Limberlost and four from Matthews Arm (Table B1).

Class Oligochaeta (Phylum Annelida; worms): Seven specimens from undetermined orders were collected, three from Limberlost and four from Matthews Arm (Table B2).

Order Araneae (Phylum Arthropoda, Class Arachnida; spiders): We collected 383 individuals from 13 Araneae families at Limberlost and 17 families at Matthews Arm (Table B3). The

Table 4. Number of invertebrate specimens by class, order, and stand collected at Shenandoah National Park in August 1997.

		Study Stand		
Class	Order	Limberlost	Matthews Arm	Total number of specimens
Gastropoda	Stylomatophora	1	4	5
Annelida	Oligochaeta	3	4	7
Arachnida	Araneae	205	178	383
Arachnida	Opiliones	58	60	118
Arachnida	Acari	747	462	1209
Arachnida	Pseudoscorpiones	17	43	60
Malacostraca	Isopoda	1	0	1
Diplopoda	Chordeumatida	48	72	120
Diplopoda	Julida	173	58	231
Diplopoda	Polydesmida	20	11	31
Diplopoda	Spirobolida	0	6	6
Diplopoda	Undetermined	2	1	3
Chilopoda	Geophilomorpha	4	22	26
Chilopoda	Lithobiomorpha	107	84	191
Chilopoda	Scolopendromorpha	12	22	34
Chilopoda	Undetermined	9	2	11
Insecta	Protura	19	7	26
Insecta	Collembola	928	1550	2478
Insecta	Diplura	3	2	5
Insecta	Ephemeroptera	7	0	7
Insecta	Orthoptera	4	8	12
Insecta	Blattaria	1	0	1
Insecta	Plecoptera	133	24	157
Insecta	Psocoptera	132	65	197
Insecta	Hemiptera	5	31	36
Insecta	Homoptera	40	155	195
Insecta	Thysanoptera	2	7	9
Insecta	Neuroptera	4	2	6
Insecta	Coleoptera	70	225	295
Insecta	Mecoptera	0	4	4
Insecta	Siphonaptera	3	7	10
Insecta	Diptera	2859	2662	5521
Insecta	Trichoptera	128	119	247
Insecta	Lepidoptera	380	294	674
Insecta	Hymenoptera	192	470	662
	Grand Total	6317	6661	12978

Table 5. Number of known invertebrate phyla, classes, orders, families, genera, species, and new species discoveries collected from a hemlock (Limberlost) and hardwood (Matthews Arm) forest stand at Shenandoah National Park, August 1997.

	Stand		
Taxonomic level	Limberlost	Matthews Arm	Total
Phyla	3	3	3
Classes	7	6	7
Orders	31	30	33
Families	133	166	194
Genera	194	199	297
Species	185	188	286
New species discoveries	5	7	11

Table 6. Number of invertebrate specimens by taxonomic order and trap type collected in Limberlost (LL) and Mathews Arm (MA) at Shenandoah National Park in August 1997.

			Trap type													
Stand	Order	Total number specimens	Beating sheet	Canopy malaise	Ground malaise	Invertebrate pitfall	Leaf litter	Light trap	Lower branch clip	Mammal pitfall	Soil core	Substrate search	Sweep net	Trunk trap	Upper branch clip	Unknown
LL	Stylomatophora	1	0	0	0	1	0	0	0	0	0	0	0	0	0	0
MA	Stylomatophora	4	0	0	0	2	1	0	0	1	0	0	0	0	0	2
LL	Oligochaeta	3	0	0	0	0	0	0	0	0	3	0	0	0	0	0
MA	Oligochaeta	4	0	0	0	0	0	0	0	0	4	0	0	0	0	0
LL	Araneae	205	41	0	1	6	123	1	4	3	0	2	5	8	2	9
MA	Araneae	178	23	1	3	9	68		2	2	2	8	22	10	6	22
LL	Opiliones	58	2	0	10	2	3	5	1	2	0	9	1	23	0	0
MA	Opiliones	60	4	0	15	18	3	0	0	0	0	3	0	17	0	0
LL	Acari	747	1	1	0	11	229	87	0	5	392	19	1	0	1	0
MA	Acari	462	9	0	11	15	154	9	0	0	263	1	0	0	0	0
LL	Pseudoscorpiones	17	0	0	0	0	13	1	0	0	3	0	0	0	0	0
MA	Pseudoscorpiones	43	0	0	0	0	35	0	0	0	8	0	0	0	0	0
LL	Isopoda	1	0	0	0	1	0	0	0	0	0	0	0	0	0	0
MA	Isopoda	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
LL	Chordeumatida	48	0	0	0	1	46	0	0	0	1	0	0	0	0	0
MA	Chordeumatida	72	0	0	0	1	67	0	0	0	1	3	0	0	0	0
LL	Julida	173	0	0	0	4	161	0	0	0	3	5	0	0	0	0
MA	Julida	58	0	0	0	1	43	0	0	1	0	13	0	0	0	0
LL	Polydesmida	20	0	0	0	2	12	0	0	0	2	3	0	0	0	1
MA	Polydesmida	11	0	0	0	2	5	0	0	0	3	1	0	0	0	0
LL	Spirobolida	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
MA	Spirobolida	6	0	0	0	5	1	0	0	0	0	0	0	0	0	0
LL	Undetermined[a]	2	0	0	0	0	2	0	0	0	0	0	0	0	0	0
MA	Undetermined[b]	1	0	0	0	0	1	0	0	0	0	0	0	0	0	0
LL	Geophilomorpha	4	0	0	0	0	4	0	0	0	0	0	0	0	0	0
MA	Geophilomorpha	22	0	0	0	0	16	0	0	0	3	3	0	0	0	0
LL	Lithobiomorpha	107	0	0	0	0	72	0	0	1	31	3	0	0	0	0
MA	Lithobiomorpha	84	0	0	0	0	52	0	0	0	31	1	0	0	0	0
LL	Scolopendromorpha	12	0	0	0	0	4	0	0	1	0	7	0	0	0	0
MA	Scolopendromorpha	22	0	0	0	0	13	0	0	0	1	8	0	0	0	0
LL	Undetermined[b]	9	0	0	0	0	5	0	0	0	4	0	0	0	0	0
MA	Undetermined[b]	2	0	0	0	0	2	0	0	0	0	0	0	0	0	0
LL	Protura	19	0	0	0	0	0	0	0	0	19	0	0	0	0	0
MA	Protura	7	0	0	0	0	0	0	0	0	7	0	0	0	0	0

Table 6. Number of invertebrate specimens by taxonomic order and trap type collected in Limberlost (LL) and Mathews Arm (MA) at Shenandoah National Park in August 1997 (continued).

			Trap type													
Stand	Order	Total number specimens	Beating sheet	Canopy malaise	Ground malaise	Invertebrate pitfall	Leaf litter	Light trap	Lower branch clip	Mammal pitfall	Soil core	Substrate search	Sweep net	Trunk trap	Upper branch clip	Unknown
LL	Collembola	928	2	0	0	35	526	0	0	62	255	1	2	45	0	0
MA	Collembola	1550	4	0	9	169	872	0	1	2	270	1	1	221	0	0
LL	Diplura	3	0	0	0	0	0	0	0	0	3	0	0	0	0	0
MA	Diplura	2	0	0	0	0	0	0	0	0	2	0	0	0	0	0
LL	Ephemeroptera	7	0	0	0	0	0	7	0	0	0	0	0	0	0	0
MA	Ephemeroptera	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
LL	Orthoptera	4	0	0	0	0	0	1	0	0	0	0	0	3	0	0
MA	Orthoptera	8	0	0	0	5	3	0	0	0	0	0	0	0	0	0
LL	Blattaria	1	0	0	0	0	0	0	0	0	0	1	0	0	0	0
MA	Blattaria	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
LL	Plecoptera	133	10	4	27	0	0	59	1	0	0	0	0	25	7	0
MA	Plecoptera	24	1	0	12	0	0	6	0	0	0	0	0	5	0	0
LL	Psocoptera	132	17	0	2	3	43	36	10	0	1	0	0	1	19	0
MA	Psocoptera	65	49	0	4	1	9	0	0	0	0	0	1	0	1	0
LL	Hemiptera	5	1	0	0	0	0	1	0	0	0	0	1	1	1	0
MA	Hemiptera	31	2	1	1	1	7	1	8	0	0	0	4	2	4	0
LL	Homoptera	40	0	2	17	1	1	13	0	0	1	0	3	2	0	0
MA	Homoptera	155	6	7	97	2	3	20	3	1	2	0	10	3	1	0
LL	Thysanoptera	2	0	0	0	0	0	0	0	0	0	0	0	0	2	0
MA	Thysanoptera	7	2	1	0	0	1	0	0	0	2	0	0	0	1	0
LL	Neuroptera	4	3	1	0	0	0	0	0	0	0	0	0	0	0	0
MA	Neuroptera	2	0	0	2	0	0	0	0	0	0	0	0	0	0	0
LL	Coleoptera	70	1	0	3	15	29	5	1	1	6	7	2	0	0	0
MA	Coleoptera	225	8	1	27	27	86	15	3	10	10	11	3	19	5	0
LL	Mecoptera	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
MA	Mecoptera	4	0	0	3	1	0	0	0	0	0	0	0	0	0	0
LL	Siphonaptera	3	0	0	0	0	0	0	0	3	0	0	0	0	0	0
MA	Siphonaptera	7	0	0	0	6	0	0	0	0	1	0	0	0	0	0
LL	Diptera	2859	5	22	1668	21	32	1046	0	7	16	0	18	24	0	0
MA	Diptera	2662	9	26	2036	185	28	257	0	0	38	0	61	22	0	0
LL	Trichoptera	128	0	1	6	0	0	121	0	0	0	0	0	0	0	0
MA	Trichoptera	119	0	0	19	0	0	99	0	0	0	0	0	1	0	0
LL	Lepidoptera	380	11	2	23	1	10	315	6	1	0	0	0	8	3	0
MA	Lepidoptera	294	9	3	40	5	26	168	14	0	0	0	5	14	10	0

Table 6. Number of invertebrate specimens by taxonomic order and trap type collected in Limberlost (LL) and Mathews Arm (MA) at Shenandoah National Park in August 1997 (continued).

			Trap type													
Stand	Order	Total number specimens	Beating sheet	Canopy malaise	Ground malaise	Invertebrate pitfall	Leaf litter	Light trap	Lower branch clip	Mammal pitfall	Soil core	Substrate search	Sweep net	Trunk trap	Upper branch clip	Unknown
LL	Hymenoptera	192	3	1	63	4	60	38	0	0	0	10	6	6	1	0
MA	Hymenoptera	470	2	3	252	7	60	28	2	0	11	86	11	7	1	0
	Grand Total	12946	225	77	4351	570	2931	2339	56	103	1399	206	157	467	65	32

[a] Undetermined order in the Class Diplopoda
[b] Undetermined order in the Class Chilopoda

species were divided between the two sites with 16 named species at Limberlost and 13 named species at Matthews Arm. About half of the specimens collected were immatures. Four families, including the Gnaphosidae (hunting spiders), Lycosidae (wolf spiders), Pisaurida (nursery-web and fishing spiders), and Thomisidae (crab spiders) were found only at Matthews Arm. Individuals of Agelenidae (grass and funnel-web spiders), Antrodiaetidae (folding-door tarantulas), Araneidae (orb weavers), Clubionidae (two-clawed hunting spiders), Dictynidae (hackled-band weavers), Hahniidae (hahniid sheet-web spiders), Linyphiidae (sheet-web spiders), Philodromidae (philodromids), Salticidae (jumping spiders), and Theridiidae (comb-footed spiders) were captured in both stands.

Order Opiliones (Phylum Arthropoda, Class Arachnida; harvestmen): We collected 118 individuals from two Opiliones families (Table B4). Both families were found in each stand. Two species *Leiobunum politum* and *L. nigropalpe* were collected only at Matthews Arm, whereas two other species, *L. aldrichi* and *L. calcar*, were collected in both stands.

Order Acari (Phylum Arthropoda, Class Arachnida; mites): We collected 1,209 specimens of Acari (mites) (Table B5). More Acari were collected at Limberlost than at Matthews Arm.

Order Pseudoscorpiones (Phylum Arthropoda, Class Arachnida; pseudoscorpions): Sixty individuals were collected but remain unidentified (Table B6). Pseudoscorpions were more than twice as abundant at Matthews Arm than at Limberlost.

Order Isopoda (Phylum Arthropoda, Class Malacostraca; sowbugs) Only one sowbug was collected at Limberlost and none were collected at Matthews Arm (Table B7).

Class Diplopoda (Phylum Arthropoda; millipedes): We collected 388 individuals from four named orders and eight families representing ten species (Tables B8-B11). In addition, three specimens were collected from an undetermined order in the Class Diplopoda (Table B12). Individuals from the orders Chordeumatida, Julida, and Polydesmida were collected at both stands. Spirobolida specimens only were collected at Matthews Arm (Table B11). Within the order Chordeumatida, specimens of the families Branneridae and Cleidogonidae were found in both stands. Polydesmidae specimens only were collected at Limberlost, and Striariidae specimens only were collected at Matthews Arm. One Julidae specimen was collected at Matthews Arm, and Parajulidae and Polydesmidae specimens were collected in both stands. Xystodesmidae and Polydesmidae specimens only were collected from Limberlost, and Spirobolidae specimens only were collected from Matthews Arm.

Class Chilopoda (Phylum Arthropoda; centipedes): We collected 251 individuals from three named orders and five families (Tables B13-B15). In addition, 11 specimens were collected from an undetermined order in the Class Chilopoda (Table B16). Individuals from all orders were found in both stands (Table B13). Within the order Geophilomorpha, members of each family were found in both stands. However, *Strigamia bidens* and *Strigamia bothriopa* were found only at Matthews Arm. We collected five specimens of *Arctogeophilus fulvus*, one at Limberlost and four at Matthews Arm. Both Lithobiomorpha families were found at each stand (Table B14). Within the order Scolopendromorpha, individuals of the family Cryptopidae were found in both stands (Table B15).

Order Protura (Phylum Arthropoda, Class Insecta; proturans): Only 26 individual proturans were collected; 19 (73%) from Limberlost (Table B17).

Order Collembola (Phylum Arthropoda, Class Insecta; springtails): We collected 2,478 Collembola specimens from six families (Table B18). Neelidae, with one undetermined species, was the only family only in Matthews Arm. Although Collembola were collected using a variety of methods, they were most abundant in leaf litter and soil samples. However, there was a difference in the number of Collembola captured in leaf litter samples between stands. More Collembola were collected in the leaf litter at Matthews Arm than in the leaf litter at Limberlost.

Order Diplura (Phylum Arthropoda, Class Insecta; diplurans): Five Diplura specimens were collected representing two families (Table B19). Campodeidae was only collected at Matthews Arm and Japygidae was only collected at Limberlost.

Order Ephemeroptera (Phylum Arthropoda, Class Insecta; mayflies): Seven specimens of Ephemeroptera were collected in light traps at Limberlost only (Table B20). None were captured at Matthews Arm.

Order Orthoptera (Phylum Arthropoda, Class Insecta; crickets): Only 12 specimens of two families were collected (Table B21). Acrididae specimens were collected at Limberlost and Gryllacrididae specimens at Matthews Arm.

Order Blattaria (Phylum Arthropoda, Class Insecta; roaches): One specimen of *Cryptocerus punctulatus* was collected at Limberlost and no roaches were collected at Matthews Arm (Table B22).

Order Plecoptera (Phylum Arthropoda, Class Insecta; stoneflies): There were five families of Plecoptera collected represented by six named species (Table B23). *Alloperia* sp. was found only at Limberlost and *Perlesta frisoni* was found only at Matthews Arm. Five other species were found at both sites. However, there were four times as many stoneflies at Limberlost than at Matthews Arm. *Leuctra ferruginea* of the family Leuctridae were very abundant at Limberlost compared to Matthews Arm.

Order Psocoptera (Phylum Arthropoda, Class Insecta; psocids): We collected 197 individuals from ten Psocoptera families (Table B24). Individual species from three families, Amphipsocidae, Lachesillidae, and Philotarsidae, were only collected at Matthews Arm, two families, Elipsocidae and Peripsocidae, were only collected at Limberlost, and five families were collected at both stands.

Order Hemiptera (Phylum Arthropoda, Class Insecta; true bugs): We collected 36 individuals from seven Hemiptera families (Table B25). Individuals from each of the seven Hemiptera families were collected at Matthews Arm, whereas only two families were represented at Limberlost.

Order Homoptera (Phylum Arthropoda, Class Insecta; cicadas, hoppers, psyllids, whiteflies, aphids, and scale insects): We collected 195 specimens representing six families (Table B26).

Aphidae and Cicadellidae were collected at both stands, while Cercopidae was only found at Matthews Arm, and Delphacidae, Membracidae, and Triozidae were only found at Limberlost. The most abundant families were Aphididae and Cicadellidae. Infestation of HWA was noted in Limberlost but no specimens were collected through the sampling techniques used in our study.

Order Thysanoptera (Phylum Arthropoda, Class Insecta; thrips): We collected nine specimens of Thysanoptera; seven of these from Matthews Arm (Table B27). The only Thysanoptera species at Limberlost was *Echinothrips subflavus.*

Order Neuroptera (Phylum Arthropoda, Class Insecta; lacewings): Six individuals of the Neuropteran family Hemerobiidae were collected at both stands combined (Table B28). Hemerobiidae are brown lacewings generally found in wooded areas.

Order Coleoptera (Phylum Arthropoda, Class Insecta; beetles): We collected 295 individuals from 28 families (Table B29). Matthews Arm had higher Coleoptera species richness and more individuals than Limberlost. Fifteen (50%) of the 31 named Coleoptera species collected were found only in Matthews Arm. Ten (33%) of the named species collected were found only in Limberlost.

Order Mecoptera (Phylum Arthropoda, Class Insecta; scorpionflies): We collected three and one specimens from the Meropeidae and Panorpidae families, respectively, at Matthews Arm and none at Limberlost (Table B30).

Order Siphonaptera (Phylum Arthropoda, Class Insecta; fleas): We collected only 10 individuals of Siphonaptera (Table B31). Three specimens were captured at Limberlost and seven were collected at Matthews Arm.

Order Diptera (Phylum Arthropoda, Class Insecta; flies): We collected 5,521 specimens, representing 38 families and 112 named species (Table B32). We identified 10 species potentially new to science in this order. Of the 38 families, five were found only at Limberlost and 12 were found only at Matthews Arm.

Order Trichoptera (Phylum Arthropoda, Class Insecta; caddisflies): We collected 247 specimens from six families (Table B33). All six families occurred at both sites. One species of Limnephilidae and two species of Rhyacophilidae were found exclusively in Matthews Arm. One species of Polycentropidae and an undetermined species were found exclusively in Limberlost.

Order Lepidoptera (Phylum Arthropoda, Class Insecta; moths and butterflies): We collected 674 individuals from 18 families (Table B34). Agonoxenidae, Drepanidae, Gelechiidae, Gracilariidae, and Yponomeutidae were found only at Limberlost. Epiplemidae, Limacodidae, and Saturniidae were found only at Matthews Arm. Ten families were collected in both stands. One hundred eight specimens (16%) of the Lepidoptera captured from both sites were immatures.

Order Hymenoptera (Phylum Arthropoda, Class Insecta; sawflies, parastic wasps, ants, wasps,

and bees): We collected 662 individuals from 22 families (Table B35). Ormyridae and Pompilidae were found only at Limberlost and Apidae, Mymaridae, Proctotrupidae, Scelionidae, Sphecidae, Tenthredinidae, and Vespidae were found only at Matthews Arm. Twelve families were collected in both stands. Matthews Arm had more than twice as many individual Hymenoptera as Limberlost.

Guild Analyses

Phytophagous and saprophagous guilds were the most common two primary guilds at both Limberlost and Matthews Arm, but the saprophagous guild was more common at Matthews Arm than Limberlost (Figure 3). The occurrence of zoophagous guilds were similar at both sites, but the omnivorous guild was more common at Limberlost compared to Matthews Arm. The mycetophagous guilds were uncommon at both sites. There were about a 1,000 individuals at both sites that could not be assigned a primary guild, due to either the lack of identification of the specimens, or lack of information from the literature.

The largest secondary phytophagous guilds were the gall makers at both Limberlost and Matthews Arm (Figure 4). More leaf chewers occurred at Limberlost than at Matthews Arm and more sap feeders were found at Matthews Arm than at Limberlost. Leaf miners, leaf rollers, and lichen feeders were more abundant at Limberlost than at Matthews Arm (Figure 5). Very low numbers of crown borers, flower feeders, honey dew feeders, liverwort feeders, seed feeders, and wood borers were found only at Matthews Arm. Very low numbers of moss grazers and nut borers were found only at Limberlost. Root feeders were found at both Limberlost and Matthews Arm.

The saprophagous secondary guilds were mostly undetermined (Figure 6). The remaining guilds occurred at similar frequency between sites.

Entomophagous predators were the largest zoophagous secondary guilds at both Limberlost and Matthews Arm (Figure 7). Entomophagous parasites were twice as abundant at Matthews Arm compared to Limberlost.

Many of the individuals in the mycetophagous secondary guilds were undetermined (Figure 8). Of the assigned guilds, fungivores were twice as abundant at Matthews Arm compared to Limberlost. Mold feeders were fewer in number and occurred in similar numbers between sites.

The omnivorous secondary guilds were predominately microphagous with over twice as many at Limberlost compared to Matthews Arm (Figure 9). Regurgitated food feeders were more common at Matthews Arm.

The saprophagous guilds were the largest primary guilds in the ground zone with slightly more found at Matthews Arm than at Limberlost (Figure 10). A large number of invertebrates were not assigned a guild. Of the remaining primary guilds in the ground zone, only the zoophagous guild was abundant with slightly more detected at Matthews Arm than at Limberlost.

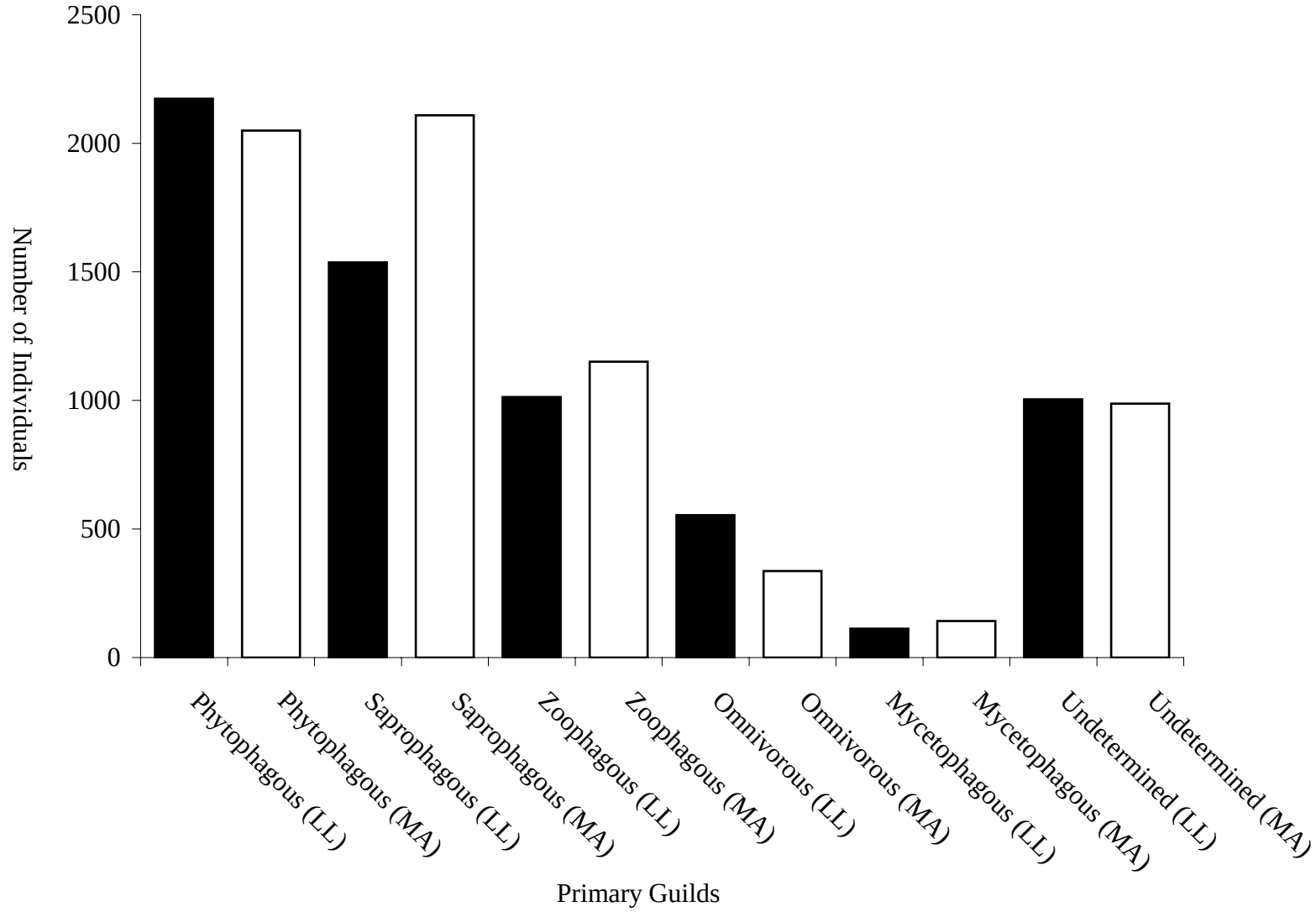


Figure 3. Number of individuals for each primary invertebrate guild collected in Limberlost (LL) and Matthews Arm (MA) at Shenandoah National Park in August 1997.

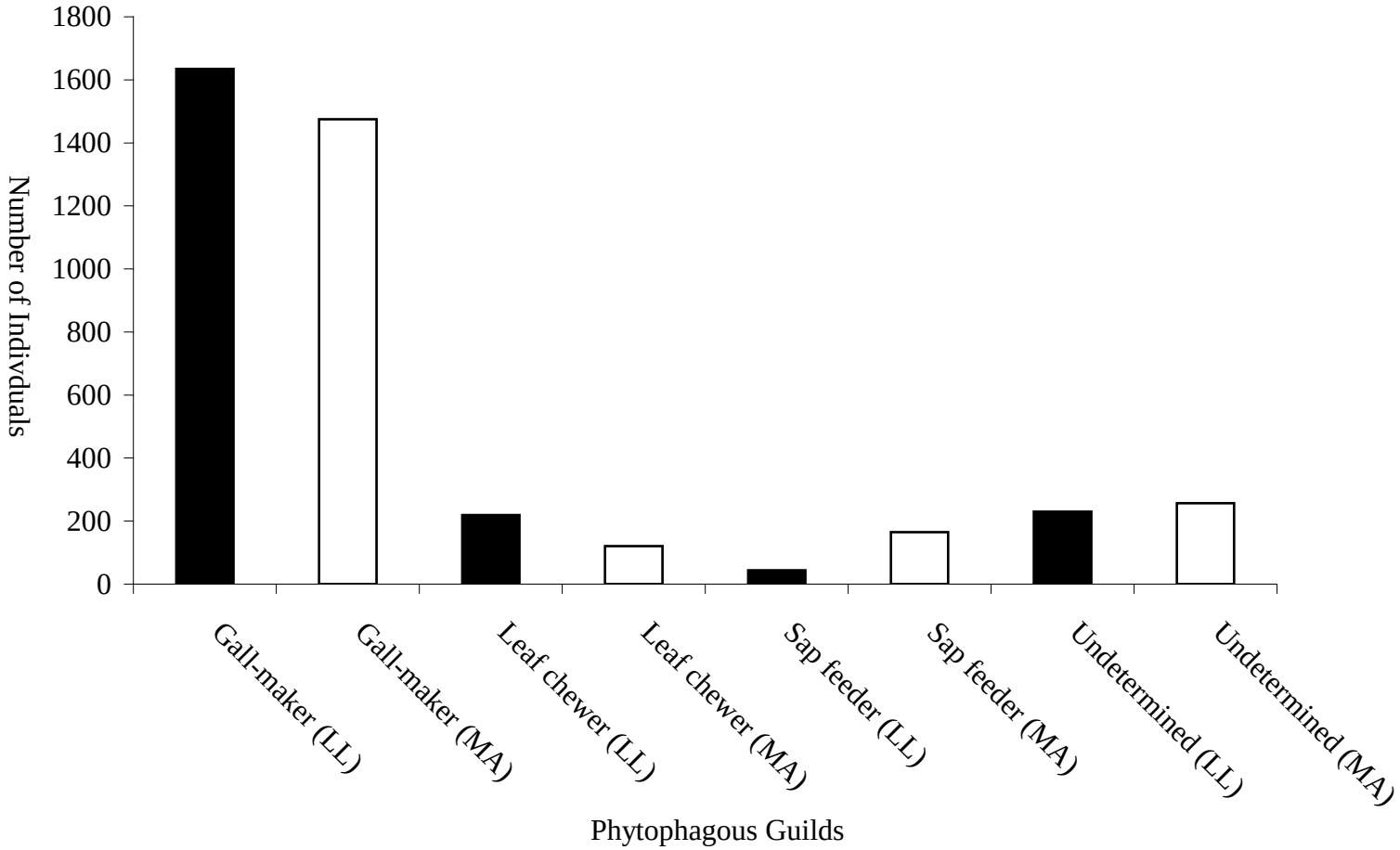


Figure 4. Number of individuals for each phytophagous secondary invertebrate guild collected in Limberlost (LL) and Matthews Arm (MA) at Shenandoah National Park in August 1997.

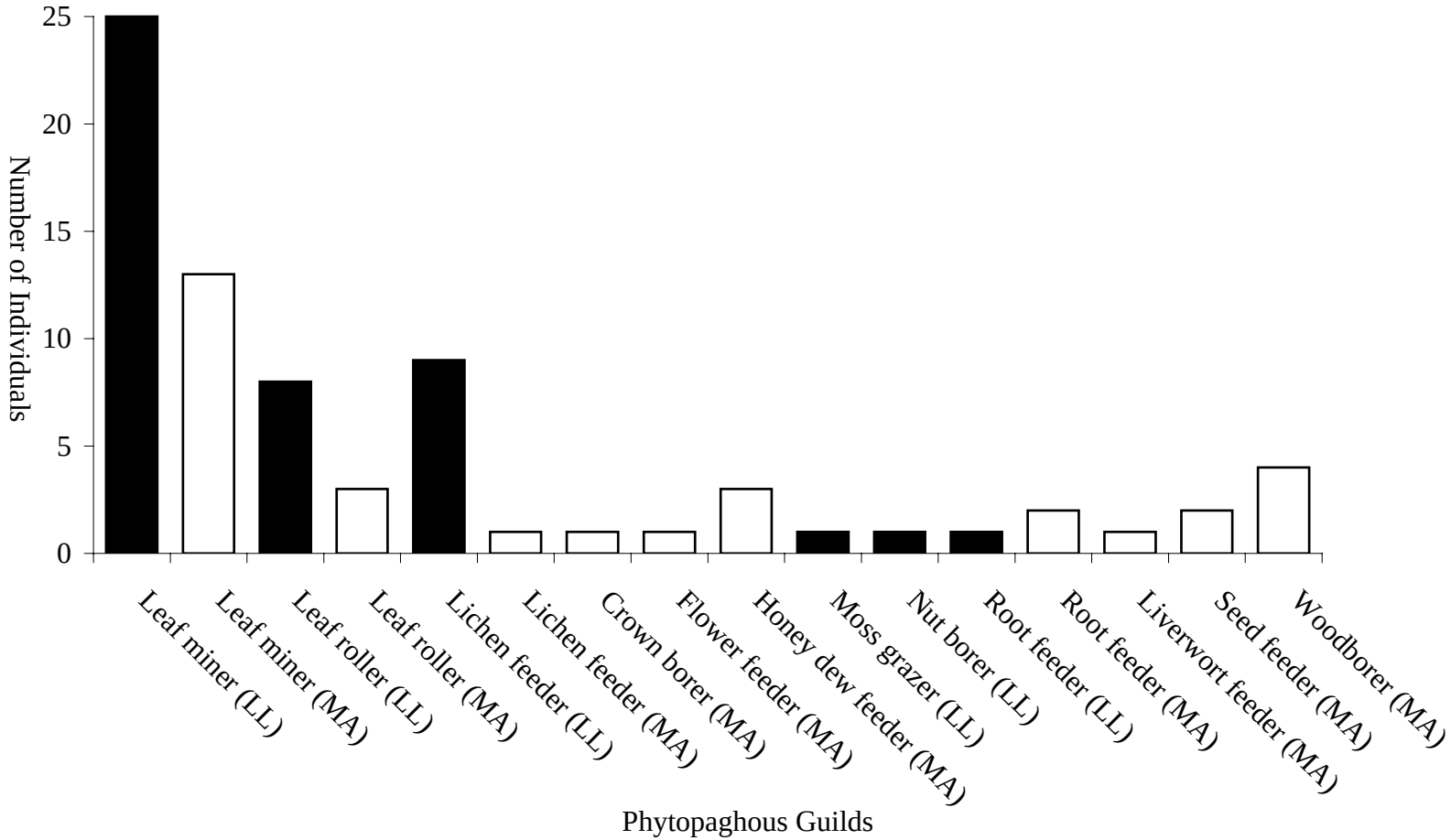


Figure 5. Number of individuals for each additional phytophagous secondary invertebrate guild collected in Limberlost (LL) and Matthews Arm (MA) at Shenandoah National Park in August 1997.

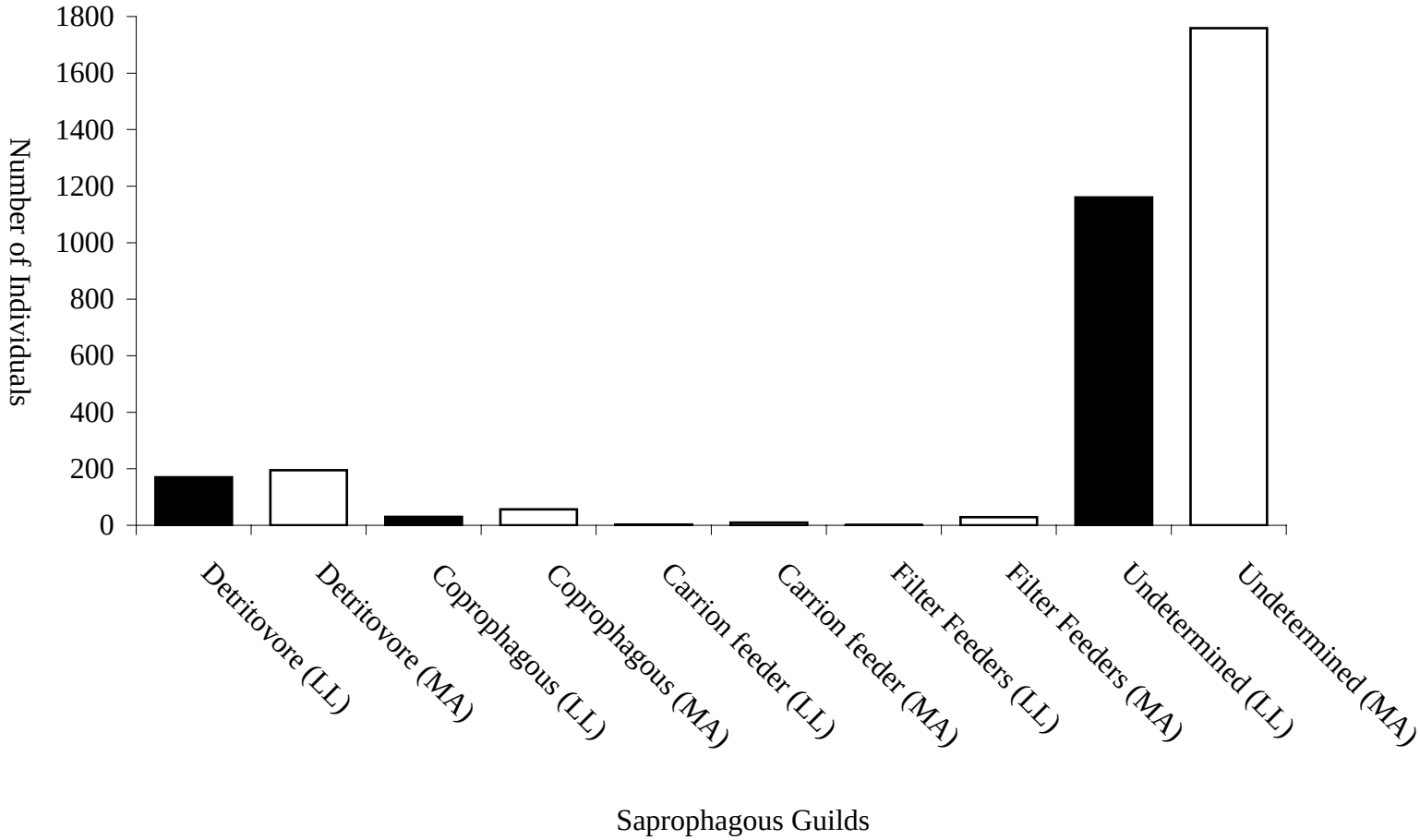


Figure 6. Number of individuals for each saprophagous secondary invertebrate guild collected in Limberlost (LL) and Matthews Arm (MA) at Shenandoah National Park in August 1997.

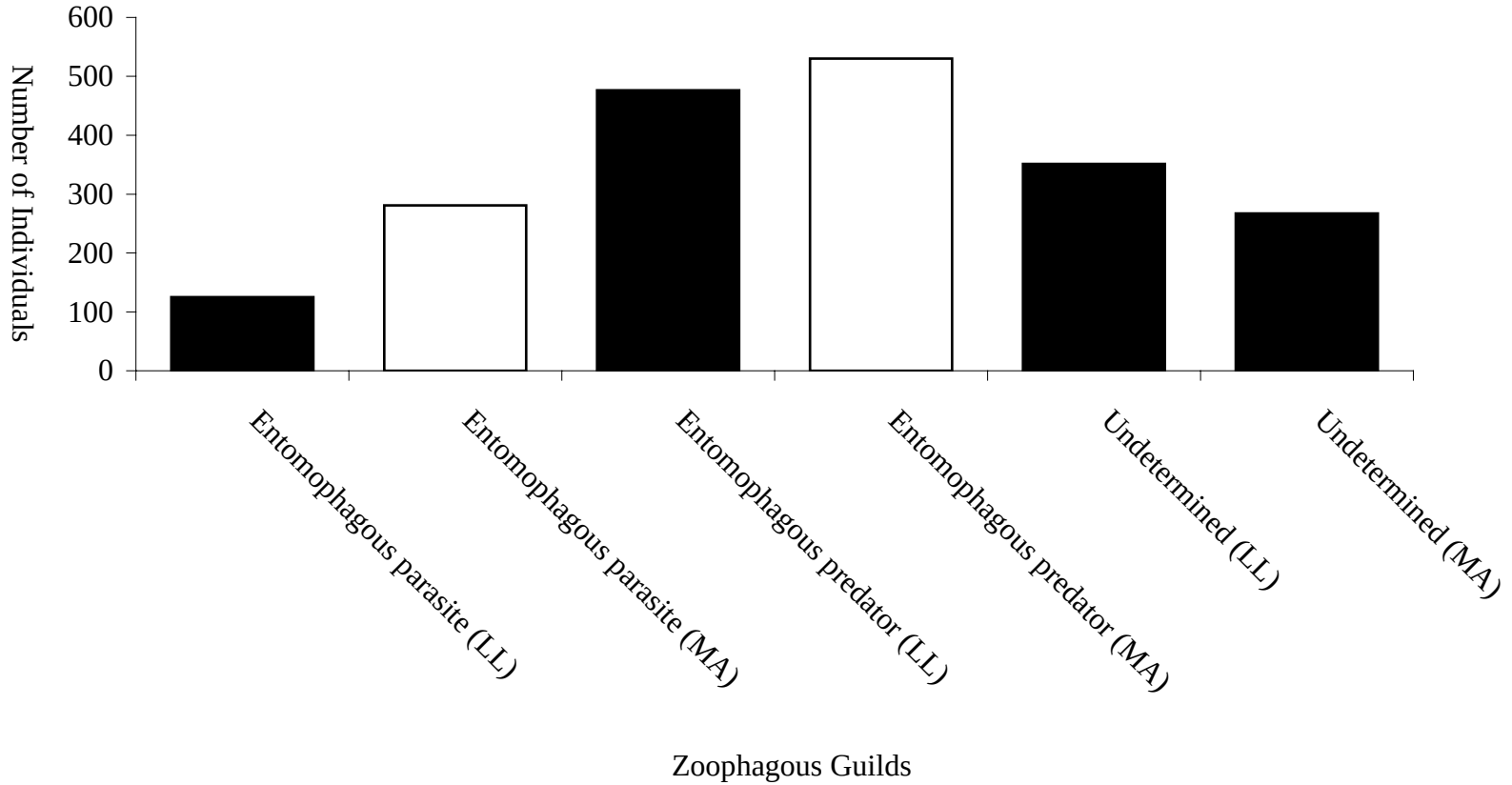


Figure 7. Number of individuals for each zoophagous secondary invertebrate guild for collected in Limberlost (LL) and Matthews Arm (MA) at Shenandoah National Park in August 1997.

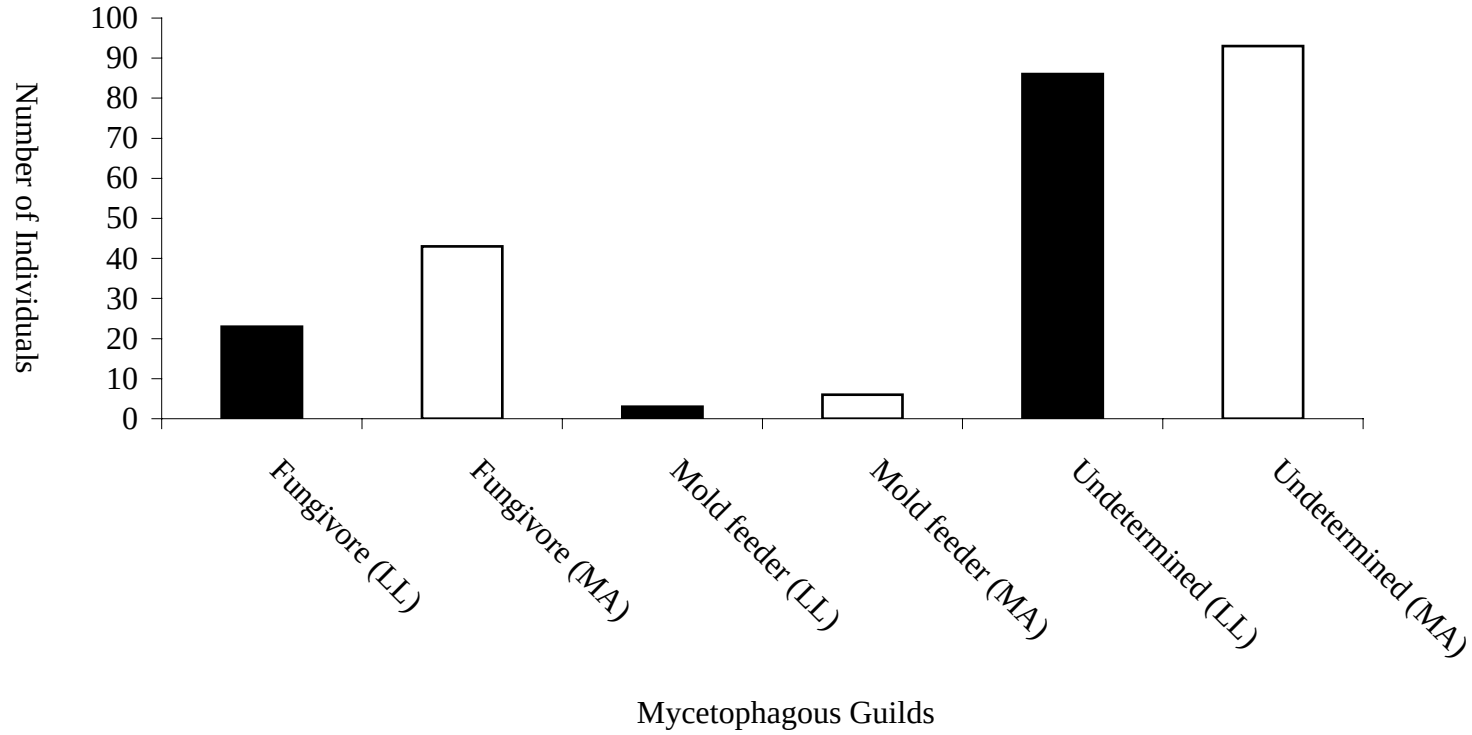


Figure 8. Number of individuals for each mycetophagous secondary invertebrate guild collected in Limberlost (LL) and Matthews Arm (MA) at Shenandoah National Park in August 1997.

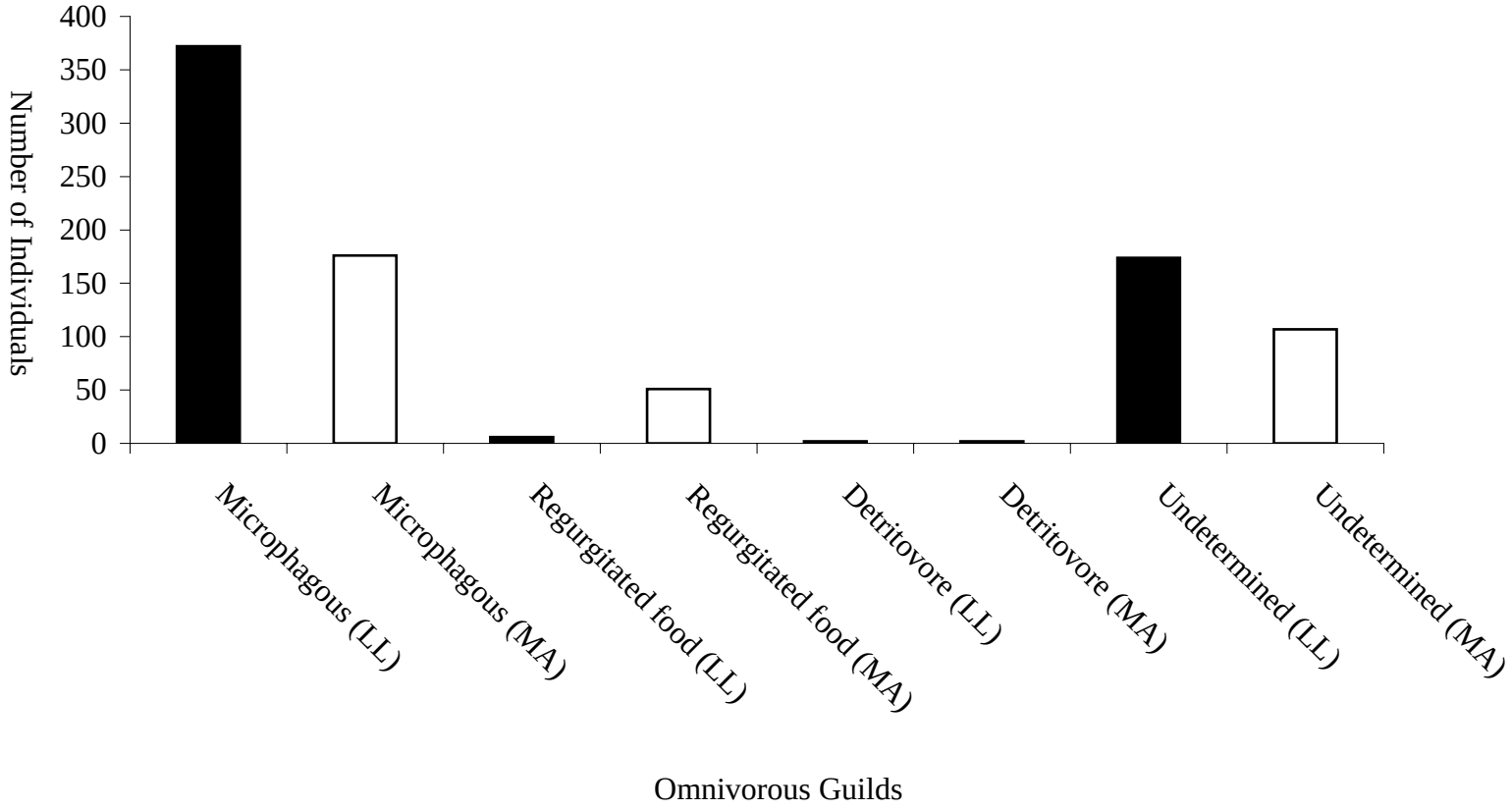


Figure 9. Number of individuals for each omnivorous secondary invertebrate guild collected in Limberlost (LL) and Matthews Arm (MA) at Shenandoah National Park in August 1997.

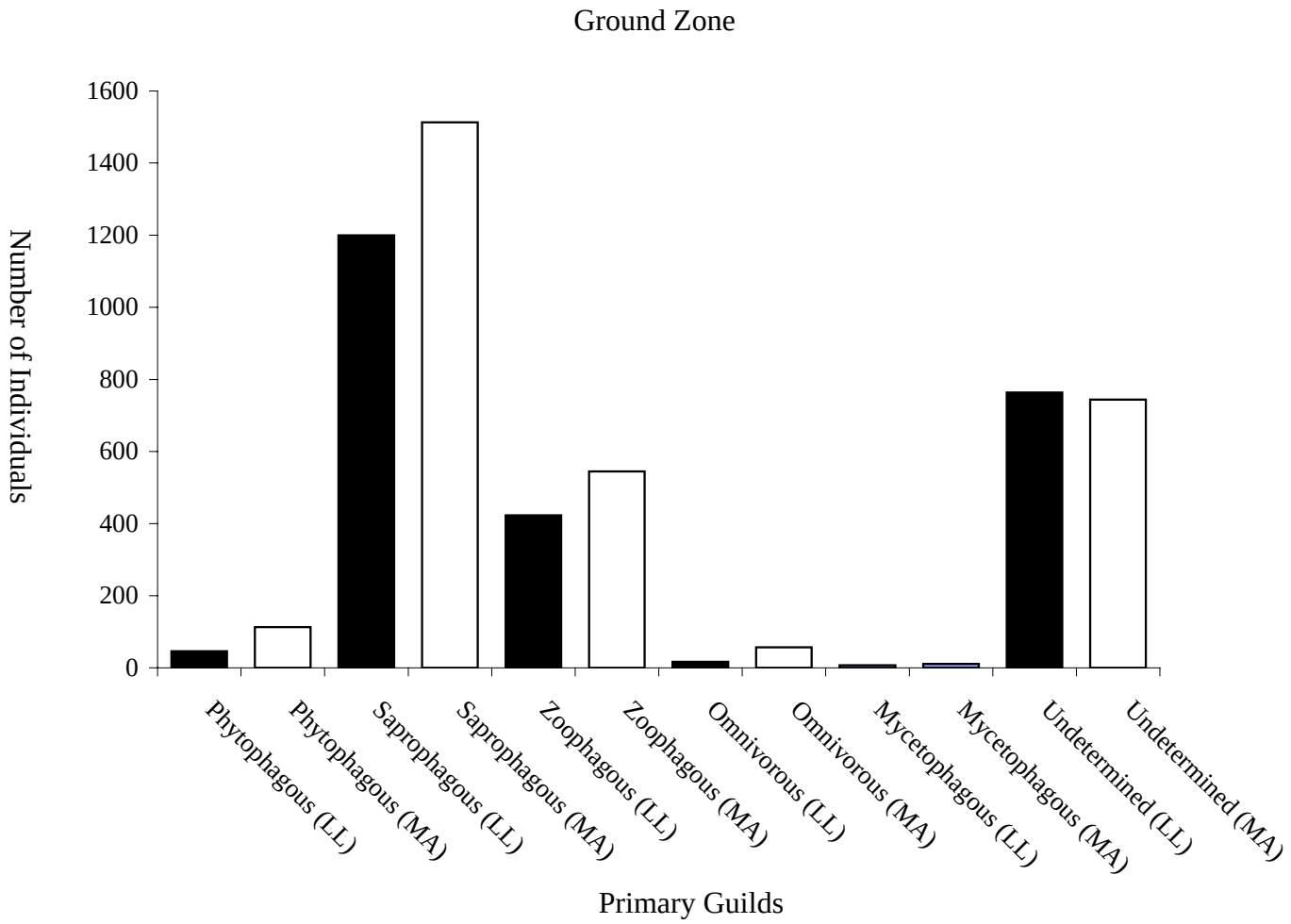


Figure 10. Number of individuals for each primary invertebrate guild from the ground zone in Limberlost (LL) and Matthews Arm (MA) at Shenandoah National Park in August 1997.

The subcanopy zone at Matthews Arm had more individuals in the saprophagous and phytophagous primary guilds compared to Limberlost (Figure 11). The zoophagous guilds were similar in occurrence at both sites but the omnivorous guild was more common at Limberlost.

The phytophagous guild was the most abundant primary guild in the canopy zone (Figure 12). Slightly more phytophagous forms were found at Limberlost. We found more omnivorous species at Limberlost than at Matthews Arm.

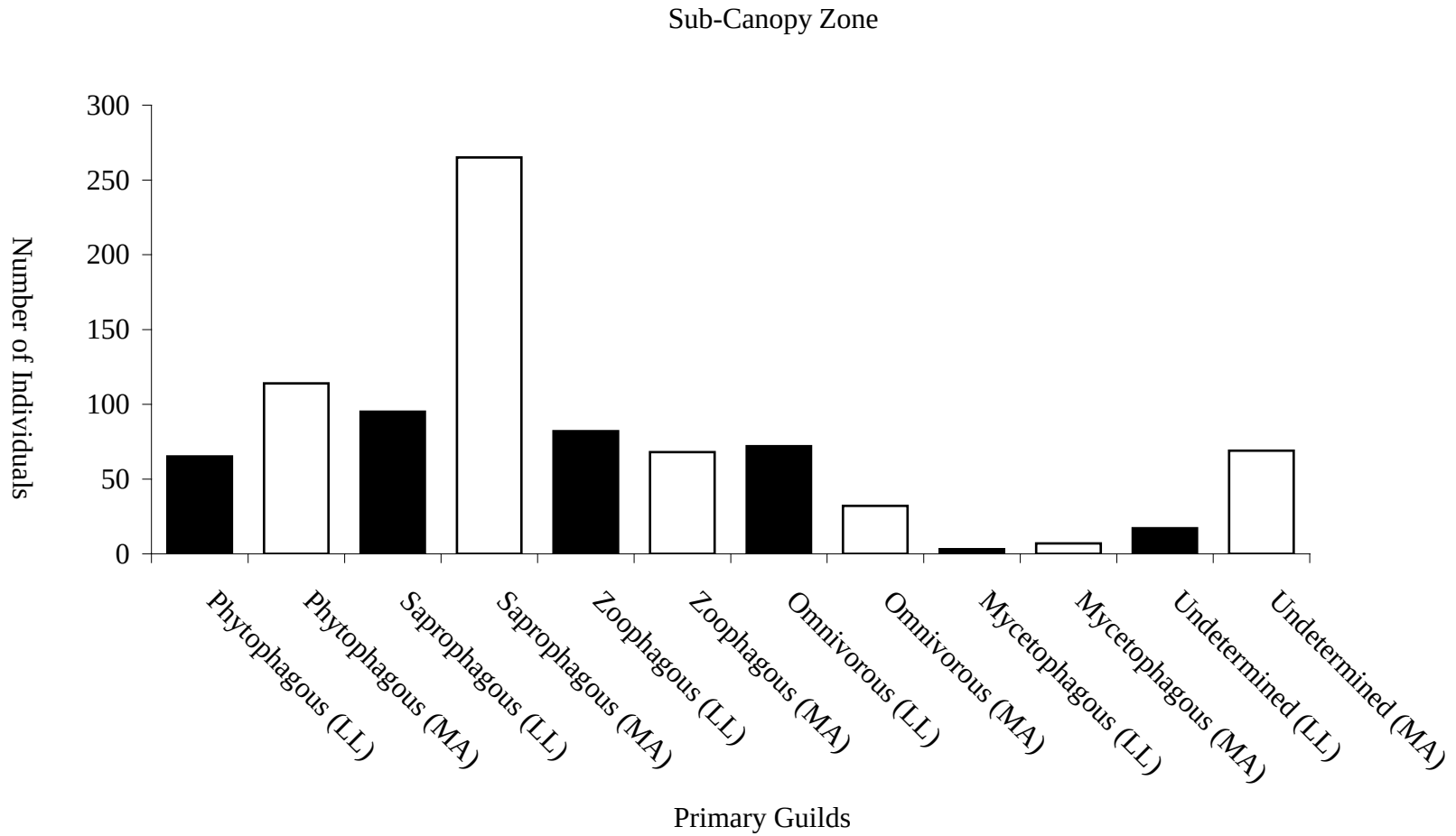


Figure 11. Number of individuals for each primary invertebrate guild collected from the subcanopy zone in Limberlost (LL) and Matthews Arm (MA) at Shenandoah National Park in August 1997.

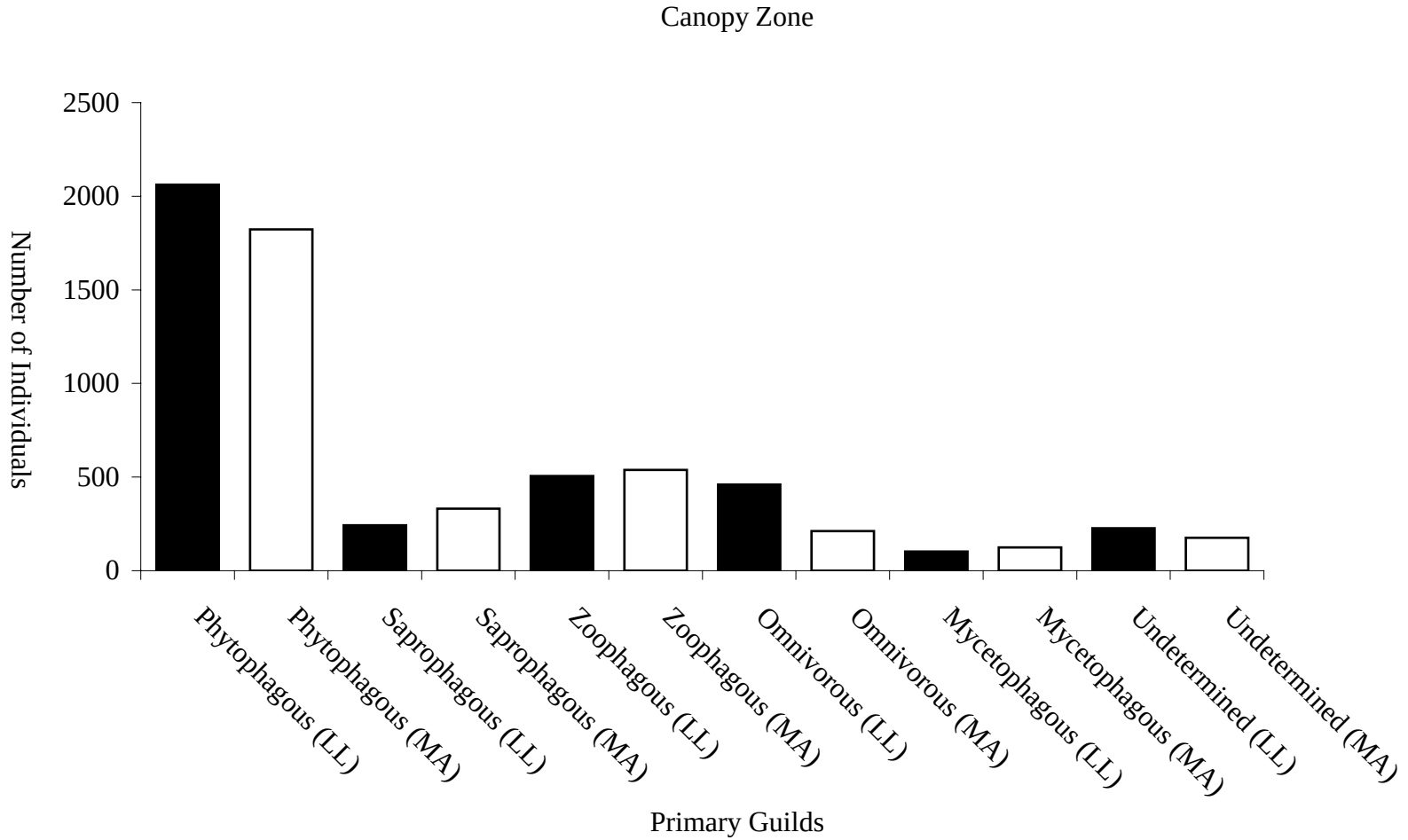


Figure 12. Number of individuals for each primary invertebrate guild collected from the canopy zone in Limberlost (LL) and Matthews Arm (MA) at Shenandoah National Park in August 1997.

Discussion

New Species Records and New Undescribed Species

Less than 50 percent of the extant species diversity of North American insects and arachnids is known (Kosztarab and Schaeffer 1990). Comprehensive site-specific inventories as well as taxon-based collection efforts will, therefore, yield numerous new species and new records for distribution of known species. Expectedly, this study produced new records and discovered many new species in SHEN.

New State and County Species Records

Class Chilopoda (Phylum Arthropoda; centipedes): *Arctogeophilus fulvus*, a rare northern species, was found for the first time in Virginia. *Stimamia bidens* is a new county record.

New Undescribed Species

We documented 10 new undescribed species in the Order Diptera: *Allodiopsis* new species near *domestica*, *Exechia* new species, *Macrocera* new species, *Mycetophila* new species near *stricklandi*, *Orfelia* new species (n. sp.) 1, *Orfelia* n. sp. 2, *Orfelia* n. sp. 3, *Symmerus* new species, *Tetragoneura* new species, and *Psychoda* new species.

We also documented one new undescribed species in the Order Homoptera: *Cyrtolobus* species near *invermis* is a new undescribed species in the Family Membracidae.

Definitive species identification of morphospecies and undetermined specimens will likely add new species records and new species descriptions, particularly in Hymenoptera and Diptera. Our research also may be used to generate new taxonomic records pertaining to host plants and range distribution.

Invertebrate Guilds Associated with Hemlock and Hardwood Forests

Guilds may be used to measure disturbances in habitats. For example, if resource availability (e.g. hemlock trees) changes with time, guild structure might shift as resources change (Hawkins and MacMahon 1989). Therefore, if hemlocks die from HWA infestation, those guilds associated with hemlock should change over time in comparison to similar guilds in hardwood forests not affected by HWA infestation. For example, phytopaghous secondary guilds, such as leaf miners, leaf rollers, lichen feeders, moss grazers, nut bores, and root feeders, that were only found in or more abundant in Limberlost, may decline as hemlock mortality increases.

Hemlock forests in Limberlost provide coniferous habitats and environmental conditions for many species of invertebrates. These environmental conditions may support distinctive assemblages of invertebrates. Our study found that several orders of invertebrates contained species and families that seem to be endemic to hemlock forests and may be potential indicators of hemlock ecosystem health and integrity.

Araneae (Phylum Arthropoda, Class Arachnida; spiders)

Although we did not find a recognizable difference in the spider community between the two sites, spiders may serve as excellent indicators of habitat integrity under certain circumstances. Hatley and MacMahon (1980) stated that spiders are ideal for ecological studies because they are locally abundant in terms of individuals and taxa. MacFadyen (1957) estimated that spider densities range from 175 to 650 individuals per square meter of soils. Spiders are ecologically important as predators of other invertebrates and as prey for small vertebrate predators, including shrews and birds (Fitch 1963). Different hunting strategies make some species more adept at capturing certain types of prey (e.g., flying insects versus non-flying insects) than others. In addition, although many species occupy a wide range of biotopes, species associations may be notably different among biotopes (Turnbull 1973).

Opiliones (Phylum Arthropoda, Class Arachnida; harvestmen)

Harvestmen are both predators and scavengers, feeding on live and dead insects. Harvestmen generally prefer shaded habitats with closed canopies (Jennings et al. 1984). *Odiellus pictus* prefers habitat of moderate to dense canopies, and was more abundant at Limberlost. *O. pictus* may prefer the dense canopy and microclimate conditions in hemlock stands, and may be useful as an indicator of hemlock ecosystem integrity. Conversely, *Leiobunum calcar*, which was more abundant at Matthews Arm, is a hardy species able to tolerate a wider range of habitat conditions (Edgar 1971). *L. politum*, which was only found in Matthews Arm, occurs in both fields and woods (Weed 1893).

Class Diplopoda (Phylum Arthropoda; millipedes)

The biology of millipedes is poorly known, in part because their taxonomy is incomplete. Shear (1972) speculated that less than a quarter of the millipedes in the United States have been described. Shear (1972) also stated that hardwood forests are the most productive habitats for millipedes, while coniferous forests are considered to support relatively few millipedes. Hartman (1977), however, found a greater abundance of millipedes and centipedes in hemlock stands than in hardwood stands in Connecticut. In addition, Dirks-Edmunds (1947) found five times as many millipedes and centipedes in Douglas fir-hemlock communities than in oak communities in Oregon.

Like Hartman (1977), we captured more millipedes in the hemlock stand than in the hardwood stand. The greater abundance of millipedes at Limberlost was due to the abundance of the family Parajulidae. Leaf litter in hemlock stands may be more moist, and therefore, better feeding habitat for saprophagous invertebrates such as millipedes (Hartman 1977). However, according to R. Hoffman of the Virginia Museum of Natural History (pers. comm. 2002), Parajulidae generally inhabit open fields. Identification of millipede specimens to species may reveal further differences in the millipede communities between hemlock and hardwood stands.

Class Chilopoda (Phylum Arthropoda; centipedes)

Arctogeophilus fulvus is a very rare northern species (Virginia Museum of Natural History, Hoffman, pers. comm. 2002). This species only has been collected at elevations above 909 meters, indicating that *A. fulvus* has a sub-boreal range in the Appalachians (Hoffman 1995) (the southernmost known record is for Roan Mountain, TN, at 1,515 meters). Our specimens constitute the first known records of this rare species from SHEN and may be a good indicator of high elevation hemlock ecosystem integrity. Our specimens of *Strigamia bidens* also constitute a new county record. Previously, *S. bidens* only was recorded from eight western counties of Virginia (Hoffman 1995). However, it is considered to be more widespread, its limited known range is due to a lack of collection in other areas.

Order Collembola (Phylum Arthropoda, Class Insecta; springtails)

Springtails live in soil, leaf litter, under bark, in decaying logs, and in fungi (Borror et al. 1989). They avoid dry habitats and, in moist habitats, may move above the surface of the ground into trees (Christiansen and Bellinger 1980). Most springtails feed on decaying plant material, fungi, and bacteria. Differences in the percentage of springtails that occupy leaf litter between Limberlost and Matthews Arm may be due to a difference in the location of available food. Hemlock needles decompose more slowly than hardwood leaves due to the presence of waxes and lignins and cooler microclimatic conditions associated with hemlock stands (Benzinger 1994). In addition to slow litter decomposition, hemlock litter typically is more acidic and has lower nutrient content than hardwood litter. Therefore, much of the available nutrients in hemlock stands may be located in the organic layer of the soil below the litter layer. Along with more nutrients, more fungi and bacteria may be located in the organic layer of the soil than in leaf litter in hemlock stands. Conversely, in hardwood stands, decaying organic material may be most abundant in the leaf litter and, therefore, Collembola were more common in the leaf litter at Matthews Arm than at Limberlost.

Another possible cause for a difference in the percentage of springtails occupying the leaf litter in hardwood versus hemlock stands may be the availabe food source in each stand. Fungi are twice as abundant in hemlock litter than in hardwood litter (Benzinger 1984). Conversely, bacteria are more abundant in hardwood litter. Species identification may reveal that Collembola species that feed predominantly on fungi are more abundant in hemlock stands, whereas species that prefer bacteria and decaying plant material are more abundant in hardwood stands.

Order Ephemeroptera (Phylum Arthropoda, Class Insecta; mayflies)

Mayflies are dependent on cool, clear streams and, in our study, were only collected at Limberlost. The closed canopy of the hemlock forest provides shade and, hence, cooler stream temperatures. Mayflies, therefore, may be a good indicator of hemlock ecosystem integrity in stands that contain streams.

Order Plecoptera (Phylum Arthropoda, Class Insecta; stoneflies)

Leuctra ferruginea, of the family Leuctridae, were very abundant at Limberlost compared to Matthews Arm. Snyder et at. (1998) found that *Leuctra* sp. were strongly associated with streams in hemlock stands. Stoneflies in the family Leuctridae may be useful indicators of hemlock ecosystem integrity.

Order Psocoptera (Phylum Arthropoda, Class Insecta; psocids or booklice)

Psocoptera are primarily herbivores and detritivores and may feed on algae, lichens, molds, fungi, and detritus (Mockford 1993). A few psocids are partially predators, feeding on insect eggs and scale insects. They may inhabit bark, foliage, and litter or rock surfaces. Psocids may serve as good indicators of hemlock ecosystem integrity as individuals of the family Peripsocidae only were found at Limberlost. Three species of peripsocids, most of which were *Peripsocus subfasciatus*, were identified. Mockford (Illinois State University, pers. comm. 2002) stated that *P. subfasciatus* is more common in hemlock stands than hardwood stands in Illinois. In addition, *P. subfasciatus* has both a parthenogenetic (thelytoky) and a sexual form. Within the interior of the eastern United States only the sexual form (males) have been found in hemlock stands, although the reason for this is unknown. It is possible that the parthenogenetic form out competes the sexual form in other habitats, but that the increase in genetic diversity resulting from sexual reproduction is an advantage within hemlock ecosystems.

We captured two male *P. subfasciatus* at Limberlost and none at Matthews Arm; further supporting Mockford's findings. These specimens constitute the first record of male *P. subfasciatus* known from Virginia. Therefore, hemlock stands may support specific psocid species as well as a greater amount of genetic diversity within species. More individuals of the family Caeciliidae and Epipsocidae also were captured at Limberlost. Many species of the family Caecilidae are known to inhabit coniferous trees (Mockford 1993). Species of Epipsocidae inhabit woodland litter, shaded rock outcrops, and coniferous trees.

Order Coleoptera (Phylum Arthropoda, Class Insecta; beetles)

We speculate that higher diversity and abundance of vegetation may support a greater abundance of invertebrate prey within hardwood stands than within hemlock stands. Subsequently, there may be more food available to support predatory invertebrates such as predaceous Coleoptera at Matthews Arm.

Order Diptera (Phylum Arthropoda, Class Insecta; true flies)

Some or all members of the Dipteran families that were collected in both stands share a dependence upon decaying organic matter, fungus, mold, and dung. Immature Bibionids (march flies) feed on most kinds of vegetable matter, including live plants and leaf mold (Oldroyd 1964). As adults, bibionids are flower-feeders. Most immature Cecidomyiids (gall-midges) burrow into the tissues of living plants and cause formation of galls. However, others feed in rotting vegetable matter, dung, fungus, and mold. Most members of the family Chironomidae (midges) are aquatic whereas others are terrestrial. Many immatures live in moss, humus, dung,

and rotting vegetation that is wet and rich in organic matter (Borror et al. 1989). Like the Chironomids, the Empididae (dance flies) have both aquatic and terrestrial species. Adults feed on nectar and are predaceous. Terrestrial immatures are predominantly predaceous and inhabit rich soil, humus, rotten wood, and decaying vegetation. Immature Lauxaniids also inhabit decaying organic material and leaf mold, and feed primarily on microorganisms and fungi found on decaying plants. Members of this family are common in moist, shady places (Miller 1977).

Several families including Anthomyiidae, Fanniidae, Muscidae, Phoridae, and Sciaridae were more abundant at Matthews Arm than at Limberlost. Many of the Anthomyiidae are plant feeders feeding in roots, some are leafminers, and some live in dung. Immature Fanniids breed in excrement and decaying materials. Immature Muscids breed in filth of all kinds, decaying straw and dung. Phorids have varied habitats, some breed in decaying organic matter, some occur on fungi, and some are parasites of ants. Sciaridae (mushroom flies) feed on fungi.

At the family level, reasons for differences in abundance of particular flies in hemlock or hardwood stands was not apparent. Individuals of different families may play similar ecological roles within different ecosystems. Most of the families that were more abundant in Limberlost contain species that are aquatic or prefer moist, shady places. Perhaps individuals of these families are attracted to hemlock stands because of the cooler, moister microclimate that exists there. By further identifying the flies to species level, more differences may become apparent. For example, the Lauxaniids were identified to species level, and had higher species diversity at Limberlost than at Matthews Arm. *Homoneura philadelphica*, the most abundant species, is the only *Homoneura* species recorded from eastern hemlock forest (Miller 1977). We found 14 specimens of *Homoneura incerta,* at Limberlost and 3 specimens of *H. fraterna* at Matthews Arm.

Order Lepidoptera (Phylum Arthropoda, Class Insecta; moths and butterflies)

The Lepidoptera specimens we captured are species typical of mixed hardwood habitats in the northeast. Although there are several moth species that are hemlock obligates in the northeast (e.g., *Semiothisa fissinotata*), we did not capture any of these species during our limited sampling effort. Sampling at different times throughout the summer might yield species that are indicative of hemlock ecosystems, however, we were unable to identify any potential indicator species in 1997. Further research should focus on determining if *Semiothisa fissinotata* is found in hemlock forests at SHEN.

Order Hymenoptera (Phylum Arthropoda, Class Insecta; sawflies, parastic wasps, ants, wasps, and bees)

Members of the Hymenoptera serve very important roles in ecosystem function. Many of its members are important pollinators. Many others are parasitic on other insects and invertebrates, and are valued for their role in regulating insect populations (Borror et al. 1989). We found a higher diversity and abundance of Hymenoptera specimens at Matthews Arm than at Limberlost. Because Matthews Arm had a higher diversity of plant species, as well as a greater abundance and diversity of invertebrates, we expected Hymenoptera to play a more important role in the hardwood stand. Although we recognize their importance, Hymenoptera may not serve as good

indicators of hemlock ecosystem integrity. Species identification of Hymenoptera may elucidate differences in species composition in hemlock versus hardwood forests.

Management Recommendations and Future Research

The information resulting from the SHEN invertebrate inventory conducted at Limberlost and Matthews Arm can be useful in the management of invertebrate biodiversity. The discovery of unnamed and undescribed species suggests that SHEN is a regionally significant area that supports unknown or poorly documented invertebrate species. This role should be recognized in park policy. An external stressor such as HWA may change the biodiversity structure of an ecosystem or habitat. It is, therefore, important to develop biodiversity inventories for specific habitats and ecosystem types prior to external-stressor events.

Our forest inventory provides the first ecosystem profile of SHEN specific to Limberlost (hemlock) and Matthews Arm (hardwood forest). Additional biodiversity and habitat assessments should be conducted for other sites based on the priority of natural resource management needs. Few studies have explored successional shifts in guild composition of invertebrate faunas after disturbance (Hawkins and MacMahon 1989). The post-HWA infestation biodiversity inventory should be conducted to understand the process of biodiversity turnover and measure the impact of HWA infestation on the community structure. This post-HWA inventory could focus on those groups that we identified as being potential indicators of hemlock ecosystem integrity. For example, we recommend post-HWA inventories for Diptera, Ephemeroptera, Plecoptera, Psocoptera, Lepidoptera, Araneae, and Diplopoda.

Several biocontrol agents for HWA are in the research and development phase, however, only one, the predatory Pt beetle (*Pseudoscymnus tsugae*) is available for use (Evans 2003). This beetle has been released at several hemlock stands in the mid-Atlantic and northeastern states with varying degrees of success. If and when an effective biological control method of suppressing HWA has been developed, it may be possible to restore eastern hemlocks in the mid-Atlantic. For successful restoration of eastern hemlock ecosystems knowledge of the biological components of the system is critical. Our study provides a comprehensive snapshot of the biological community that is associated with this threatened ecosystem.

We recommend several changes in sampling techniques for future inventories. In particular, canopy malaise trap should be replaced with alternative, or additional means of sampling invertebrates found in the canopy, for instance, the use of aerial sticky traps. In addition, inventory sampling should be done in such a way as to be temporally and/or spatially relevant. This means either time or space should be constant in the trapping scheme. For instance, if park management wants to know what invertebrates are found at a given site, traps would be set up at that site over the course of the year, yielding a more complete inventory of the species found in that area. If management wanted to know what invertebrates are found in the park at a given time of year, traps would be set up throughout the park at that time. In both cases, optimal sampling would replicate the trapping in following years to reduce the effect any naturally occurring cycles might have on the results.

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Appendix A. Taxonomists who identified specimens for the inventory of invertebrates collected at Shenandoah National Park.

Taxa/Name	Affiliation	Department	Address
Araneae			
Young, Skip	PPL Corp.	Environmental Management Division	2 North Ninth St., Allentown, PA 18101
Coleoptera			
Davidson, Robert	Carnegie Museum of Natural History	Invertebrate Zoology	4400 Forbes Ave., Pittsburgh, PA 15213
Diptera			
Adler, Peter	Clemson University	Entomology	Box 340365, Clemson, SC 29634-0365
Borkent, Art	Royal British Columbia Museum	Entomology	1171 Mallory Rd. R1-S20-C, Enderby, BC, V0E 1V0 Canada
Burger, John	University of New Hampshire	Zoology	Spaulding Hall, Durham, NH 03824
Coher, Edward	Long Island University	Division of Natural Sciences	239 Montauk Hgwy., Southampton, NY 11968
Cuny, Robert	Lakeland College	Environmental Science	Bag 6600, 2602-59 Av., Lloydminster, Alberta, T9V 1Z3, Canada
Dahlem, Gregory	Northern Kentucky University	Biological Sciences	Highland Heights, KY 41099
Fee, Frank	None	None	910 Cricklewood Dr., State College, PA 16801
Fitzgerald, Scott	Oregon State Univ.	Entomology	2046 Cordley Hall, Corvallis, OR 97330
Griffiths, Graham	None	None	117 Collingwood Cove, 51551 Range Rd. 212A, Sherwood Park, AB, T8G 1B2, Canada
Hurley, Richard	Montana State University	Entomology	Bozeman, MT 59717
Kulasekera, Varuni	American Museum of Natural History	Invertebrate Zoology	79th St. @ CPW, New York, NY 10024
Metz, Mark	Penn State University	Entomology	501 ASI Bldg. State college, PA 16802
Norbom, Allen	Systematic Entomology Lab	Entomology	c/o Smithsonian Institution, Washington, D.C. 20560
O'Grady, Peter	American Museum of Natural History	Invertebrates	Central Park West @ 79th St., NY, NY 10024
Quate, Laurance	None	None	16271 Oak Creek Trail, Poway, CA 92064
Scheffer, Sonja	Systematic Entomology Lab	Entomology	Bld 005, BARC-W, Beltsville, MD 20705
Skipper, David	None	None	State College, PA 16801
Webb, Donald	Illinois Natural History Inventory	Center for Biodiversity	607 E. Peabody Dr., Champaign, IL 61820
Withington, R. P.	Penn State University	Entomology	501 ASI Bldg. State College, PA 16802
Woodley, Norman	Systematic Entomology Lab	Entomology	c/o Smithsonian Institution, Washington, D.C. 20560
Young, Chen	Carnegie Museum of Natural History	Invertebrate Zoology	4400 Forbes Ave., Pittsburgh, PA 15213
Plecoptera			
Earle, Jane	PA Dept. of Environmental Protection, Bureau of Watershed Management	Entomology	P. O. Box 8555, Harrisburg, PA 17105-8555

Appendix A. Taxonomists who identified specimens for the inventory of invertebrates collected at Shenandoah National Park (continued).

Taxa/Name	Affiliation	Department	Address
Lepidoptera			
Adamski, Dave	Systematic Entomology Lab	Entomology	Bld 005, BARC-W, Beltsville, MD 20705
Brown, John	Systematic Entomology Lab	Entomology	Bld 005, BARC-W, Beltsville, MD 20705
Grehan, John	Buffalo Museum of Science	Zoology	1020 Humboldt Prkwy, Buffalo, NY 14211-1293
Solis, Alma	Systematic Entomology Lab	Entomology	Bld 005, BARC-W, Beltsville, MD 20705
Thysanoptera			
Nakahara, Steve	Systematic Entomology Lab	Entomology	Bld 005, BARC-W, Beltsville, MD 20705
Hymenoptera			
Grissel, Eric	Systematic Entomology Lab	Entomology	Bld 005, BARC-W, Beltsville, MD 20705
Smith, Dave	Systematic Entomology Lab	Entomology	Bld 005, BARC-W, Beltsville, MD 20705
Homoptera			
Bartlett, Charles	University of Delaware	Entomology	250 Townsend Hall, Newark, DE 19717-1303
Miller, Douglass	Systematic Entomology Lab	Entomology	Bld 005, BARC-W, Beltsville, MD 20705
Rothschild, Mark	None	None	27722 Nanticoke Rd., Salisbury MD 21801-1647

Appendix B. List of invertebrate species and the number of specimens collected at Shenandoah National Park in August 1997.

In the totals section of each table, the number of species identified includes named species (both genus and species known) only.

For the purposes of this report, morphospecies (Morpho sp.) are specimens that have been sorted and classified as distinct, although unidentified, taxa according to their shape and morphological characteristics.

Page

Appendix B. List of invertebrate species and the number of specimens collected at Shenandoah National Park in August 1997 (continued).

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For the purposes of this report, morphospecies (Morpho sp.) are specimens that have been sorted and classified as distinct, although unidentified, taxa according to their shape and morphological characteristics.

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Table B1. Order Stylomatophora (Phylum Mollusca, Class Gastropoda; snails and slugs) collected at Shenandoah National Park in August 1997 (LL=Limberlost; MA=Matthews Arm).

Family	Genus	Species	LL specimens	MA specimens	Total
Undetermined	Morpho	sp. 1	0	1	1
	Morpho	sp. 2	0	1	1
	Morpho	sp. 3	1	2	3
Totals					
Number of families identified			0	0	0
Number of genera identified			0	0	0
Number of species identified			0	0	0
Number of specimens			1	4	5

Table B2. An undetermined Order in the Class Oligochaeta (Phylum Annelida; worms) collected at Shenandoah National Park in August 1997 (LL=Limberlost; MA=Matthews Arm).

Family	Genus	Species	LL specimens	MA specimens	Total
Undetermined	Morpho	sp. 1	3	4	7
Totals					
	Number of families identified		0	0	0
	Number of genera identified		0	0	0
	Number of species identified		0	0	0
	Number of specimens		3	4	7

Table B3. Order Araneae (Phylum Arthropoda, Class Arachnida; spiders) collected at Shenandoah National Park in August 1997 (LL=Limberlost; MA=Matthews Arm).

Family	Genus	Species	LL specimens	MA specimens	Total
Agelenidae	*Agelanopsis*	*emertoni*	1	2	3
	A.	*pennsylvanica*	1	2	3
	Morpho	sp. 1 (immature)	1	2	3
Amaurobiidae	*Callobius*	*bennetti*	1	0	1
	C.	sp.	1	0	1
	Coras	sp.	0	2	2
	Wadotes	*calcaratus*	2	0	2
	W.	sp.	5	1	6
Amaurobiidae	Morpho	sp. 1 (immature)	1	2	3
Antrodiaetidae	*Antrodiaetus*	*unicolor*	3	3	6
Araneidae	*Araniella*	sp.	5	2	7
	Mangora	sp.	1	0	1
	Neoscona	sp.	1	0	1
	Morpho	sp. 1 (immature)	3	13	16
Clubionidae	*Clubiona*	sp.	3	1	4
	Elaver	*excepta*	1	0	1
	Morpho	sp. 1	0	6	6
	Morpho	sp. 2 (immature)	5	8	13
Dictynidae	*Cicurina*	*brevis*	1	0	1
	C.	sp.	2	6	8
	Morpho	sp. 1 (immature)	0	1	1
Gnaphosidae	*Nerpyllus*	*ecclesiatica*	0	1	1
Hahniidae	*Calymmaria*	*persica*	1	3	4
	Cryphoeca	*montana*	2	1	3
	Neoantistea	*magna*	7	0	7
	N.	sp.	25	9	34
	Morpho	sp. 1 (immature)	2	5	7
Linyphiidae	*Ceraticehus*	sp.	2	0	2
	Ceratinella	*brunnea*	9	0	9
	C.	sp.	1	0	1
	Ceratinopsis	*nigripalpis*	3	2	5
	Drapetisca	*alteranda*	0	2	2
	Lepthyphantes	sp.	32	0	32
	Maso	*sundevallii*	0	2	2
	M.	sp.	0	1	1
	Pityohyphantes	*costatus*	10	17	27
	Tenuiphantes	*zebra*	15	0	15
	Morpho	sp. 1	0	8	8
	Morpho	sp. 1 (immature)	20	15	35
Liocranidae	*Phrurotimpus*	*alarius*	0	1	1
	P.	sp.	1	0	1
Lycosidae	*Pirata*	*insularis*	0	2	2
	Morpho	sp. 1 (immature)	0	24	24
Philodromidae	*Philodromus*	*imbecillus*	0	2	2
	P.	*rufus*	1	0	1
	Morpho	sp. 1 (immature)	7	7	14
Pisauridae	Morpho	sp. 1 (immature)	0	1	1
Salticidae	*Neon*	*nellii*	2	0	2
	N.	sp.	0	4	4
	Morpho	sp. 1 (immature)	14	3	17

Table B3. Order Araneae (Phylum Arthropoda, Class Arachnida; spiders) collected at Shenandoah National Park in August 1997 (LL=Limberlost; MA=Matthews Arm) (continued).

Family	Genus	Species	LL specimens	MA specimens	Total
Tetrangnathidae	*Leucauge*	sp.	2	1	3
	Tetragnatha	sp.	0	1	1
	Morpho	sp. 1 (immature)	9	3	12
Theridiidae	*Theridion*	sp.	2	6	8
	Morpho	sp. 1 (immature)	0	1	1
Thomisidae	*Xysticus*	sp.	0	5	5
Totals					
	Number of families identified		13	17	17
	Number of genera identified		24	23	31
	Number of species identified		16	13	22
	Number of specimens		205	178	383

Table B4. Order Opiliones (Phylum Arthropoda, Class Arachnida; harvestmen) collected at Shenandoah National Park in August 1997 (LL=Limberlost; MA=Matthews Arm).

Family	Genus	Species	LL specimens	MA specimens	Total
Leibunidae	*Leiobunum*	*politum*	0	5	5
	L.	*aldrichi*	20	17	37
	L.	*calcar*	7	19	26
	L.	*nigropalpe*	0	1	1
Phalangiidae	*Odiellus*	*pictus*	29	18	47
Undetermined	Morpho	sp. 1	2	0	2
Totals					
	Number of families identified		2	2	2
	Number of genera identified		2	2	3
	Number of species identified		3	5	5
	Number of specimens		58	60	118

Table B5. Order Acari (Phylum Arthropoda, Class Arachnida; mites) collected at Shenandoah National Park in August 1997 (LL=Limberlost; MA=Matthews Arm.

Family	Genus	Species	LL specimens	MA specimens	Total
Undetermined	Gen.	sp.	747	462	1209
Totals					
	Number of families identified		0	0	0
	Number of genera identified		0	0	0
	Number of species identified		0	0	0
	Number of specimens		747	462	1209

Table B6. Order Pseudoscorpiones (Phylum Arthropoda, Class Arachnida; pseudoscorpions) collected at Shenandoah National Park in August 1997 (LL=Limberlost; MA=Matthews Arm).

Family	Genus	Species	LL specimens	MA specimens	Total
Undetermined	Gen.	sp.	17	43	60
Totals					
	Number of families identified		0	0	0
	Number of genera identified		0	0	0
	Number of species identified		0	0	0
	Number of specimens		17	43	60

Table B7. Order Isopoda (Phylum Arthropoda, Class Malacostraca; sowbugs) collected at Shenandoah National Park (LL=Limberlost; MA=Matthews Arm).

Family	Genus	Species	LL specimens	MA specimens	Total
Undetermined	Morpho	sp. 1	1	0	1
Totals					
	Number of families identified		0	0	0
	Number of genera identified		0	0	0
	Number of species identified		0	0	0
	Number of specimens		1	0	1

Table B8. Order Chordeumatida (Phylum Arthropoda, Class Diplopoda; millipedes) collected at Shenandoah National Park in August 1997 (LL=Limberlost; MA=Matthews Arm).

Family	Genus	Species	LL specimens	MA specimens	Total
Branneridae	Gen.	sp.	17	20	37
Cleidogonidae	Gen.	sp.	31	50	81
Striariidae	*Striaria*	sp.	0	2	2
Totals					
	Number of families identified		2	3	3
	Number of genera identified		0	1	1
	Number of species identified		0	0	0
	Number of specimens		48	72	120

Table B9. Order Julida (Phylum Arthropoda, Class Diplopoda; millipedes) collected at Shenandoah National Park in August 1997 (LL=Limberlost; MA=Matthews Arm).

Family	Genus	Species	LL specimens	MA specimens	Total
Julidae	Morpho	sp. 1	0	1	1
Parajulidae	Gen.	sp.	173	57	230
Totals					
	Number of families identified		1	2	2
	Number of genera identified		0	0	0
	Number of species identified		0	0	0
	Number of specimens		173	58	231

Table B10. Order Polydesmida (Phylum Arthropoda; Class Diplopoda; millipedes) collected at Shenandoah National Park in August 1997 (LL=Limberlost; MA=Matthews Arm).

Family	Genus	Species	LL specimens	MA specimens	Total
Polydesmidae	Gen.	sp.	19	11	30
Xystodesmidae	*Semionellus*	*placidus*	1	0	1
Totals					
	Number of families identified		2	1	2
	Number of genera identified		1	0	1
	Number of species identified		1	0	1
	Number of specimens		20	11	31

Table B11. Order Spirobolida (Phylum Arthropoda, Class Diplopoda; millipedes) collected at Shenandoah National Park in August 1997 (LL=Limberlost; MA=Matthews Arm).

Family	Genus	Species	LL specimens	MA specimens	Total
Spirobolidae	Gen.	sp.	0	6	6
Totals					
	Number of families identified		0	1	1
	Number of genera identified		0	0	0
	Number of species identified		0	0	0
	Number of specimens		0	6	6

Table B12. An undetermined Order in the Class Diplopoda (Phylum Arthropoda; millipedes) collected at Shenandoah National Park in August 1997 (LL=Limberlost; MA=Matthews Arm).

Family	Genus	Species	LL specimens	MA specimens	Total
Undetermined	Gen.	sp.	2	1	6
Totals					
	Number of families identified		0	0	0
	Number of genera identified		0	0	0
	Number of species identified		0	0	0
	Number of specimens		2	1	3

Table B13. Order Geophilomorpha (Phylum Arthropoda, Class Chilopoda; centipedes) collected at Shenandoah National Park in August 1997 (LL=Limberlost; MA=Matthews Arm).

Family	Genus	Species	LL specimens	MA specimens	Total
Chilenophilidae	*Arctogeophilus*	*fulvus*	1	4	5
Dignathodontidae	*Strigamia*	*bidens*	0	2	2
	S.	*bothriopa*	0	1	1
	S.	*cf. branneri*	3	15	18
Totals					
	Number of families identified		2	2	2
	Number of genera identified		2	2	2
	Number of species identified		2	4	4
	Number of specimens		4	22	26

Table B14. Order Lithobiomorpha (Phylum Arthropoda, Class Chilopoda; centipedes) collected at Shenandoah National Park in August 1997 (LL=Limberlost; MA=Matthews Arm).

Family	Genus	Species	LL specimens	MA specimens	Total
Henicopidae	Gen.	sp.	18	13	31
Lithobiidae	Gen.	sp.	89	69	158
Undetermined	Gen.	sp.	0	2	2
Totals					
	Number of families identified		2	2	2
	Number of genera identified		0	0	0
	Number of species identified		0	0	0
	Number of specimens		107	84	191

Table B15. Order Scolopendromorpha (Phylum Arthropoda, Class Chilopoda; centipedes) collected at Shenandoah National Park in August 1997 (LL=Limberlost; MA=Matthews Arm).

Family	Genus	Species	LL specimens	MA specimens	Total
Cryptopidae	*Cryptops*	sp.	0	1	1
	Gen.	sp.	8	21	29
Undetermined	Gen.	sp.	4	0	4
Totals					
	Number of families identified		1	1	1
	Number of genera identified		0	1	1
	Number of species identified		0	0	1
	Number of specimens		12	22	34

Table B16. An undetermined Order in the Class Chilopoda (Phylum Arthropoda;centipedes) collected at Shenandoah National Park in August 1997 (LL=Limberlost; MA=Matthews Arm).

Family	Genus	Species	LL specimens	MA specimens	Total
Undetermined	Gen.	sp.	9	2	11
Totals					
	Number of families identified		0	0	0
	Number of genera identified		0	0	0
	Number of species identified		0	0	0
	Number of specimens		9	2	11

Table B17. Order Protura (Phylum Arthropoda, Class Insecta; proturans) collected at Shenandoah National Park in August 1997 (LL=Limberlost; MA=Matthews Arm).

Family	Genus	Species	LL specimens	MA specimens	Total
Undetermined	Gen.	sp.	19	7	26
Totals					
	Number of families identified		0	0	0
	Number of genera identified		0	0	0
	Number of species identified		0	0	0
	Number of specimens		19	7	26

Table B18. Order Collembola (Phylum Arthropoda, Class Insecta; springtails) collected at Shenandoah National Park in August 1997 (LL=Limberlost; MA=Matthews Arm).

Family	Genus	Species	LL specimens	MA specimens	Total
Entomobryidae	Gen.	sp.	607	1083	1690
Hypogastridae	Gen.	sp.	80	165	245
Isotomidae	Gen.	sp.	105	101	206
Neelidae	Gen.	sp.	0	1	1
Onychiuridae	Gen.	sp.	112	175	287
Sminthuridae	Gen.	sp.	24	23	47
Undetermined	Gen.	sp.	0	2	2
Totals					
	Number of families identified		5	6	6
	Number of genera identified		0	0	0
	Number of species identified		0	0	0
	Number of specimens		928	1550	2478

Table B19. Order Diplura (Phylum Arthropoda, Class Insecta; diplurans) collected at Shenandoah National Park in August 1997 (LL=Limberlost; MA=Matthews Arm).

Family	Genus	Species	LL specimens	MA specimens	Total
Campodeidae	Gen.	sp.	0	2	2
Japygidae	Gen.	sp.	3	0	3
Totals					
	Number of families identified		1	1	2
	Number of genera identified		0	0	0
	Number of species identified		0	0	0
	Number of specimens		3	2	5

Table B20. Order Ephemeroptera (Phylum Arthropoda, Class Insecta; mayflies) collected at Shenandoah National Park in August 1997 (LL=Limberlost; MA=Matthews Arm).

Family	Genus	Species	LL specimens	MA specimens	Total
Ephemerellidae	Gen.	sp.	1	0	1
Heptageniidae	*Epeorus*	sp.	1	0	1
	Nixie	sp.	2	0	2
	Gen.	sp.	2	0	2
Leptophlebiidae	*Paraleptophlebia*	*ontario*	1	0	1
Totals					
Number of families identified			3	0	3
Number of genera identified			3	0	3
Number of species identified			3	0	3
Number of specimens			7	0	7

Table B21. Order Orthoptera (Phylum Arthropoda, Class Insecta; grasshoppers, crickets) collected at Shenandoah National Park in August 1997 (LL=Limberlost; MA=Matthews Arm).

Family	Genus	Species	LL specimens	MA specimens	Total
Acrididae	Gen.	sp.	4	0	4
Gryllacrididae	Gen.	sp.	0	8	8
Totals					
	Number of families identified		1	1	2
	Number of genera identified		0	0	0
	Number of species identified		0	0	0
	Number of specimens		4	8	12

Table B22. Order Blattaria (Phylum Arthropoda, Class Insecta; roaches) collected at Shenandoah National Park in August 1997 (LL=Limberlost; MA=Matthews Arm).

Family	Genus	Species	LL specimens	MA specimens	Total
Cryptoceridae	*Cryptocercus*	*punctulatus*	1	0	1
Totals					
Number of families identified			1	0	1
Number of genera identified			1	0	1
Number of species identified			1	0	1
Number of specimens			1	0	1

Table B23. Order Plecoptera (Phylum Arthropoda, Class Insecta; stoneflies) collected at Shenandoah National Park in August 1997 (LL=Limberlost; MA=Matthews Arm).

Family	Genus	Species	LL specimens	MA specimens	Total
Chloroperlidae	*Alloperia*	sp.	1	0	1
Leuctridae	*Leuctra*	*ferruginea*	98	17	115
Nemouridae	*Amphinemura*	*wui*	17	2	19
	Acroneuria	*abnormis*	2	0	2
Perlidae	*Eccoptura*	*xanthenes*	1	3	4
	Perlesta	*frisoni*	14	0	14
Perlodidae	*Isoperla*	*holochlora*	0	2	2
Totals					
Number of families identified			4	4	5
Number of genera identified			6	4	7
Number of species identified			5	4	7
Number of specimens			133	24	157

Table B24. Order Psocoptera (Phylum Arthropoda, Class Insecta; psocids) collected at Shenandoah National Park in August 1997 (LL=Limberlost; MA=Matthews Arm).

Family	Genus	Species	LL specimens	MA specimens	Total
Amphipsocidae	Morpho	sp. 1	0	1	1
Caeciliidae	Morpho	sp. 1	11	0	11
	Morpho	sp. 2	2	0	2
	Morpho	sp. 3	0	1	1
Ectopsocidae	Morpho	sp. 1	9	30	39
Elipsocidae	Morpho	sp. 1	3	0	3
Epipsocidae	Morpho	sp. 1	20	2	22
Lachesillidae	Morpho	sp. 1	0	1	1
Peripsocidae	*Peripsocus*	*madidus*	2	0	2
	P.	*subfasciatus*	43	0	43
	Morpho	sp. 1	1	0	1
Philotarsidae	Morpho	sp. 1	0	2	2
	Morpho	sp. 2	0	1	1
Psocidae	Morpho	sp. 1	21	1	22
Psoquillidae	Morpho	sp. 1	4	2	6
Undetermined	Gen.	sp. (immature)	16	24	40
Totals					
	Number of families identified		7	8	10
	Number of genera identified		1	0	1
	Number of species identified		2	0	2
	Number of specimens		132	65	197

Table B25. Order Hemiptera (Phylum Arthropoda, Class Insecta; true bugs) collected at Shenandoah National Park in August 1997 (LL=Limberlost; MA=Matthews Arm).

Family	Genus	Species	LL specimens	MA specimens	Total
Acanthosomatidae	Morpho	sp. 1	0	1	1
Anthocoridae	Morpho	sp. 1	0	1	1
Cynidae	Morpho	sp. 1	0	1	1
Lygaeidae	Morpho	sp. 1	0	2	2
Miridae	Morpho	sp. 1	0	2	2
	Morpho	sp. 2	1	0	1
	Morpho	sp. 3	0	3	3
	Morpho	sp. 4	1	0	1
	Morpho	sp. 5	0	1	1
	Morpho	sp. 6	0	1	1
	Morpho	sp. 7	2	0	2
	Morpho	sp. 8	0	1	1
Pentatomidae	Morpho	sp. 1	0	1	1
	Morpho	sp. 2	0	1	1
	Morpho	sp. 3	1	0	1
	Morpho	sp. 4	0	1	1
Reduviidae	Morpho	sp. 1	0	1	1
	Morpho	sp. 2	0	3	3
Undetermined - immatures			0	11	11
Totals					
Number of families identified			2	7	7
Number of genera identified			0	0	0
Number of species identified			0	0	0
Number of specimens			5	31	36

Table B26. Order Homoptera (Phylum Arthropoda, Class Insecta; hoppers, aphids) collected at Shenandoah National Park in August 1997 (LL=Limberlost; MA=Matthews Arm).

Family	Genus	Species	LL specimens	MA specimens	Total
Aetalionidae	Morpho	sp. 1 (immature)	0	1	1
Aphididae	Morpho	sp. 1	1	14	15
	Morpho	sp. 2	1	0	1
	Morpho	sp. 3	2	0	2
	Morpho	sp. 4	0	1	1
	Morpho	sp. 5	0	1	1
	Morpho	sp. 6	0	1	1
	Morpho	sp. 7	1	1	2
	Morpho	sp. 8	1	3	4
	Morpho	sp. 9	0	3	3
Cercopidae	*Aphrophora*	*parallel*	0	1	1
	Clastoptera	*obtuse*	0	1	1
	Morpho	sp. 1	0	1	1
Cicadellidae	*Draeculocephala*	*constricta*	0	3	3
	Empoasca	sp.	3	41	44
	Macrosteles	*fascifrons*	1	0	1
	Morpho	sp. 1	8	45	53
	Morpho	sp. 2	0	4	4
	Morpho	sp. 3	2	1	3
	Morpho	sp. 4	0	3	3
	Morpho	sp. 5	2	2	4
	Morpho	sp. 6	0	1	1
	Morpho	sp. 7	0	3	3
	Morpho	sp. 8	2	0	2
	Morpho	sp. 9	0	2	2
	Morpho	sp. 10	0	2	2
	Morpho	sp. 11	3	2	5
	Morpho	sp. 12	7	7	14
	Morpho	sp. 13	0	1	1
	Morpho	sp. 14	0	1	1
	Morpho	sp. 15	0	1	1
	Morpho	sp. 16	0	1	1
	Morpho	sp. 17	1	1	2
	Morpho	sp. 18 (immature)	1	2	3
Delphacidae	*Liburniella*	*ornata*	1	0	1
Membracidae	*Cyrtolobus*	*New species discovered nr. inermis*	1	0	1
	Ophiderma	*flava*	1	0	1
Triozidae	*Bactericera*	sp.	1	0	1
Undetermined	Morpho	sp. 1	0	1	1
Undetermined	Gen.	sp. (immature)	0	3	3

Table B26. Order Homoptera (Phylum Arthropoda, Class Insecta; hoppers, aphids) collected at Shenandoah National Park in August 1997 (LL=Limberlost; MA=Matthews Arm) (continued).

Family	Genus	Species	LL specimens	MA specimens	Total
Totals					
	Number of families identified		5	4	7
	Number of genera identified		6	4	9
	Number of species identified		3	3	6
	New species discovered		1	0	1
	Number of specimens		40	155	195

Table B27. Order Thysanoptera (Phylum Arthropoda, Class Insecta; thrips) collected at Shenandoah National Park in August 1997 (LL=Limberlost; MA=Matthews Arm).

Family	Genus	Species	LL specimens	MA specimens	Total
Phlaeothripidae	*Haplothrips*	*kurdjumovi*	0	1	1
	Liothrips	sp.	0	1	1
	Taeniothrips	*inconsequens*	0	2	2
Thripidae	*Echinothrips*	*subflavus*	2	0	2
	Frankliniella	*stylosa*	0	1	1
	Neohydatothrips	*floridanus*	0	1	1
Undetermined	Morpho	sp. 1 (immature)	0	1	1
Totals					
	Number of families identified		1	2	2
	Number of genera identified		1	5	6
	Number of species identified		1	4	6
	Number of specimens		2	7	9

Table B28. Order Neuroptera (Phylum Arthropoda, Class Insecta; lacewings) collected at Shenandoah National Park in August 1997 (LL=Limberlost, MA=Matthews Arm).

Family	Genus	Species	LL specimens	MA specimens	Total
Hemerobiidae	Gen.	sp.	4	2	6
Totals					
Number of families identified			1	1	1
Number of genera identified			0	0	0
Number of species identified			0	0	0
Number of specimens			4	2	6

Table B29. Order Coleoptera (Phylum Arthropoda, Class Insecta; beetles) collected at Shenandoah National Park in August 1997 (LL=Limberlost, MA= Matthews Arm).

Family	Genus	Species	LL specimens	MA specimens	Total
Alleculidae	*Mycetochara*	sp.	0	1	1
Anobiidae	*Caenocara*	sp.	0	2	2
Buprestidae	Morpho	sp. 1	0	1	1
Cantharidae	Morpho	sp. 1	1	1	2
Carabidae	*Anillinus*	*virginiae*	1	0	1
	Carabus	*goryi*	0	1	1
	Myas	*cyanescens*	1	0	1
	Platynus	*angustanus*	1	0	1
	Pterostichus	*coracinus*	5	19	24
	P.	*lachrymosus*	0	1	1
	P.	*tristis*	0	1	1
	Rhadine	*caudata*	0	1	1
	Scaphinotus	*ridingsi*	2	1	3
	S.	*viduus*	0	1	1
	Sphaeroderus	*schaumi "acciavatti"*	2	1	3
	S.	*stenostomus*	1	2	3
	Stenolophus	*ochropezeus*	1	0	1
	Trechus	*quadristriatus*	1	0	1
	Trichotichnus	*vulpeculus*	0	1	1
	Morpho	sp. (immature)	3	0	3
Cerambycidae	*Pidona*	*ruficollis*	0	1	1
	Urgleptes	*facetus*	0	1	1
Chrysomelidae	*Diabrotica*	*undecimpunctata howardi*	1	0	1
	Lema	*trivitatta*	0	1	1
	Monocesta	*coryli*	1	2	3
	Odontota	*dorsalis*	1	7	8
	Morpho	sp. 1	0	1	1
	Morpho	sp. 2	1	0	1

Table B29. Order Coleoptera (Phylum Arthropoda, Class Insecta; beetles) collected at Shenandoah National Park in August 1997 (LL=Limberlost, MA= Matthews Arm) (continued).

Family	Genus	Species	LL specimens	MA specimens	Total
Coccinellidae	*Psyllobora*	*vigintimaculata*	0	3	3
	Morpho	sp. 1	0	1	1
	Morpho	sp. 2	0	1	1
	Morpho	sp. 3	0	2	2
	Morpho	sp. 4	0	1	1
Cryptophagidae	Morpho	sp. 1	0	1	1
Curculionidae	*Curculio*	sp. 1	0	2	2
	C.	sp. 2	0	1	1
	C.	sp. 3	0	1	1
	C.	sp. 4	12	1	13
	Curculio	sp. 5	3	0	3
	C.	sp. 6	0	2	2
	Morpho	sp. 1	0	4	4
	Morpho	sp. 2	1	1	2
	Morpho	sp. 3	0	1	1
Dascillidae	Morpho	sp. 1	0	1	1
Elateridae	*Ctenicera*	*hieroglyphicus*	0	1	1
	Melanotus	sp.	0	2	2
	Morpho	sp. 1	1	3	4
	Morpho	sp. 2	0	1	1
	Morpho	sp. 3 (immature)	0	3	3
Erotylidae	Morpho	sp. 1	0	3	3
Geotrupidae	*Geotrupes*	*balyi*	3	0	3
	G.	*blackburnii blackburnii*	0	5	5
Leiodidae	*Catopocerus*	*ulkei*	4	0	4
	Morpho	sp. 1	0	1	1
Leptodiridae	Morpho	sp. 1	1	7	8
	Morpho	sp. 2	0	1	1
Lycidae	*Calopteron*	*reticulatum*	0	1	1
	Plateros	sp. 1	0	3	3

Table B29. Order Coleoptera (Phylum Arthropoda, Class Insecta; beetles) collected at Shenandoah National Park in August 1997 (LL=Limberlost, MA= Matthews Arm) (continued).

Family	Genus	Species	LL specimens	MA specimens	Total
Melandryidae	Morpho	sp. 1	1	3	4
	Morpho	sp. 2	1	0	1
Mordellidae	Morpho	sp. 1	0	3	3
	Morpho	sp. 2	0	2	2
Nitidulidae	Morpho	sp. 1	0	5	5
	Morpho	sp. 2	0	1	1
Phalacridae	Morpho	sp. 1	0	1	1
Ptiliidae	Morpho	sp. 1	0	5	5
Scarabaeidae	*Aphodius*	sp. 1	0	1	1
	A.	sp. 2	1	0	1
	Dialytes	*striatulus*	0	1	1
	D.	*truncatus*	1	0	1
	Onthophagus	sp.	0	1	1
Scydmaenidae	Morpho	sp. 1	2	9	11
	Morpho	sp. 2	1	1	2
Silphidae	*Nicrophorus*	*orbicollis*	1	3	4
	N.	*tomentosus*	1	0	1
Staphylinidae	Morpho	sp. 1	0	24	24
	Morpho	sp. 2	0	2	2
	Morpho	sp. 3	0	1	1
	Morpho	sp. 4	0	1	1
	Morpho	sp. 5	0	2	2
	Morpho	sp. 6	0	1	1
	Morpho	sp. 7	0	1	1
	Morpho	sp. 8	0	1	1
	Morpho	sp. 9	0	1	1
	Morpho	sp. 10	1	22	23
	Morpho	sp. 11	2	3	5
	Morpho	sp. 12	1	0	1

Table B29. Order Coleoptera (Phylum Arthropoda, Class Insecta; beetles) collected at Shenandoah National Park in August 1997 (LL=Limberlost, MA= Matthews Arm) (continued).

Family	Genus	Species	LL specimens	MA specimens	Total
Tenebrionidae	Morpho	sp. 1	0	1	1
Trogidae	*Trox*	sp.	1	0	1
Undetermined immatures			8	26	34
Totals					
Number of families identified			14	27	28
Number of genera identified			18	24	32
Number of species identified			17	21	31
Number of specimens			70	225	295

Table B30. Order Mecoptera (Phylum Arthropoda, Class Insecta; scorpionflies) collected at Shenandoah National Park in August 1997 (LL=Limberlost, MA=Matthews Arm).

Family	Genus	Species	LL specimens	MA specimens	Total
Meropeidae	*Merope*	*tuber*	0	3	3
Panorpidae	Morpho	sp. 1	0	1	1
Totals					
Number of families identified			0	2	2
Number of genera identified			0	1	1
Number of species identified			0	1	1
Number of specimens			0	4	4

Table B31. Order Siphonaptera (Phylum Arthropoda, Class Insecta; fleas) collected at Shenandoah National Park in August 1997 (LL=Limberlost, MA=Matthews Arm).

Family	Genus	Species	LL specimens	MA specimens	Total
Undetermined	Gen.	sp.	3	7	10
Totals					
Number of families identified			0	0	0
Number of genera identified			0	0	0
Number of species identified			0	0	0
Number of specimens			3	7	10

Table B32. Order Diptera (Phylum Arthropoda, Class Insecta; flies) collected at Shenandoah National Park in August 1997 (LL=Limberlost, MA=Matthews Arm).

Family	Genus (subgenus)	species	LL specimens	MA specimens	Totals
Agromyzidae	*Agromyza*	sp.	0	1	1
	Japanagromyza	*viridula*	5	0	5
Anisopodidae	*Mycetobia*	*divergens*	1	0	1
Anthomyiidae	*Anthomyia*	*oculifera*	1	2	3
	Delia	sp.	3	0	3
	Eutrichota	*lipsia*	0	1	1
	Hylemya	*alcathoe*	2	9	11
	Paregle	sp.	0	1	1
	Pegomya	sp.	1	3	4
	Strobilomyia	sp.	1	0	1
Asilidae	*Leptogaster*	*flavipes*	2	0	2
Bibionidae	*Bibio*	*townesi*	14	0	14
Calliphoridae	*Pollenia*	*rudis*	0	5	5
Cecidomyiidae	Gen.	sp.	1634	1504	3138
Ceratopogonidae	*Atrichopogon*	*fusculus*	1	0	1
	A.	sp.	2	29	31
	Brachypogon	sp.	2	0	2
	Culicoides	*chiopterus*	1	3	4
	C.	*guttipennis*	3	0	3
	C.	*nanus*	0	1	1
	C.	*sanguisuga*	2	0	2
	Dasyhelea	*grisea*	1	0	1
	D.	*oppressa*	1	1	2
	F.	*fairfaxensis*	1	0	1
	F.	*glauca*	5	8	13
	F.	*gravesi*	8	0	8
	F.	*pinicola*	17	0	17
	Forcipomyia	*pluvialis*	0	3	3
	F.	sp.	37	8	45
	Palpomyia	*basalis*	0	1	1
	P.	*walteri*	0	1	1
	Stilobezzia	*lutea*	6	7	13
Chironomidae	Morpho	sp. 1	13	15	28
	Morpho	sp. 2	3	1	4
	Morpho	sp. 3	8	0	8
	Morpho	sp. 4	14	5	19
	Morpho	sp. 5	70	21	91
	Morpho	sp. 6	5	13	18
	Morpho	sp. 7	1	1	2
	Morpho	sp. 8	31	4	35
	Morpho	sp. 9	14	12	26

Table B32. Order Diptera (Phylum Arthropoda, Class Insecta; flies) collected at Shenandoah National Park in August 1997 (LL=Limberlost, MA=Matthews Arm) (continued).

Family	Genus (subgenus)	species	LL specimens	MA specimens	Totals
Chironomdae	Morpho	sp. 10	4	0	4
	Morpho	sp. 11	3	4	7
	Morpho	sp. 12	0	2	2
	Morpho	sp. 13	0	3	3
	Morpho	sp. 14	5	0	5
	Morpho	sp. 15	2	0	2
	Morpho	sp. 16	0	1	1
	Morpho	sp. 17	0	3	3
Chloropidae	Morpho	sp. 1	1	0	1
Clusiidae	*Sobarocephala*	sp.	0	1	1
Culicidae	Gen.	sp.	0	2	2
Diastatidae	*Diastata*	sp.	0	1	1
Dixidae	Gen.	sp.	20	18	38
Dolichopodidae	*Calyxochaetus*	*fortunatus*	2	0	2
	C.	*frontalis*	0	1	1
	Chrysotimus	*delicatus*	3	0	3
	C.	sp.	0	3	3
	Chrysotus	*exilis*	0	1	1
	Dolichopus	*pantomimus*	0	2	2
	D.	*slossonae*	3	0	3
	D.	*variabilis*	0	10	10
	Hercostomus	*constrictus*	1	0	1
	H.	*flavus*	0	8	8
	H.	*frequens*	1	0	1
	H.	*nigricomus*	25	2	27
	H.	*opacus*	0	3	3
	H.	*subdilatatus*	0	3	3
	H.	*vockerothi*	0	1	1
	H.	sp.	1	1	2
	Sciapus	*scintillans*	0	1	1
	Xanthochlorus	*helvinus*	0	4	4
Drosophilidae	*Drosophila*	*putrida*	0	2	2
	D.	*tripunctata*	2	1	3
	D.	sp.	16	1	17
	Microdrosophila	*quadrata*	0	1	1
	Scaptomyza	sp.	19	3	22
Empididae	*Clinocera*	sp. 1	0	2	2
	C.	sp. 2	0	1	1
	Morpho	sp. 1	155	29	184
	Morpho	sp. 2	0	1	1
	Morpho	sp. 3	1	0	1
	Morpho	sp. 4	1	0	1

Table B32. Order Diptera (Phylum Arthropoda, Class Insecta; flies) collected at Shenandoah National Park in August 1997 (LL=Limberlost, MA=Matthews Arm) (continued).

Family	Genus (subgenus)	species	LL specimens	MA specimens	Totals
Empididae	Morpho	sp. 5	1	0	1
	Morpho	sp. 6	35	2	37
	Morpho	sp. 7	5	0	5
	Morpho	sp. 8	18	7	25
	Morpho	sp. 9	0	2	2
	Morpho	sp. 10	1	3	4
	Morpho	sp. 11	0	1	1
	Morpho	sp. 12	0	1	1
Fanniidae	*Fannia*	*sociella*	2	0	2
Lauxaniidae	*Homoneura*	*fraterna*	0	3	3
	H.	*incerta*	14	0	14
	H.	*philadelphica*	48	6	54
Micropezidae	*Calobatina*	*geometra*	1	0	1
Muscidae	*Helina*	*pectinata*	3	2	5
	H.	*troene*	1	3	4
	Coenosia	*frisoni*	8	24	32
	C.	*lata*	19	3	22
	C.	*mollicula*	0	1	1
	C.	*toshua*	8	2	10
	Mesembrina	*latreillii*	3	18	21
	Muscina	*levida*	0	6	6
	Mydaea	*neglecta*	2	7	9
	Phaonia	*apicalis*	2	0	2
	P.	*bysia*	65	32	97
	P.	*errans*	0	20	20
	Spilogona	*longipes*	0	1	1
	Thricops	*diaphanus*	0	4	4
	Morpho	sp. 1	1	8	9
Mycetophilidae	*Allodia*	sp.	0	1	1
	Allodiopsis	*New species discovered nr domestica*	0	3	3
	Asindulum	sp	1	0	1
	Boletina	*sciarina*	0	1	1
	Brevicornu	*bella*	1	1	2
	Cordyla	sp. 1	0	2	2
	C.	sp. 2	0	1	1
	Drepanocercus	*ensifer*	0	1	1
	Dziedzickia	*vittata var fasciate*	0	1	1
	Ectrepesthoneura	*bicolor*	3	0	3
	Epicypta	*scatophora*	0	1	1
	E.	*attrita*	2	0	2
	Exechia	sp.	1	0	1

Table B32. Order Diptera (Phylum Arthropoda, Class Insecta; flies) collected at Shenandoah National Park in August 1997 (LL=Limberlost, MA=Matthews Arm) (continued).

Family	Genus (subgenus)	species	LL specimens	MA specimens	Totals
Mycetophilidae	*Exechia*	*New species discovered*	0	1	1
	Exechiopsis	sp.	1	0	1
	Leia	*melaena*	0	1	1
	L.	*sublunata*	1	0	1
	L.	sp.	10	11	21
	Lygistorrhina (Probolaeus)	sp.	1	0	1
	Macrocera	*formosa*	1	0	1
	M.	*New species discovered*	0	1	1
	Monoclona	*rufilatera*	0	1	1
	Mycetophila	*New species discovered nr stricklandi*	0	2	2
	M.	*sepulta*	1	1	2
	M.	*unipunctata*	1	0	1
	M.	sp.	0	4	4
	Mycomya (Calomycomya)	*pulchella imitans*	21	9	30
	M. (Cymomya)	*obliqua*	2	7	9
	M. (Mycomya)	*onusta*	0	2	2
	M. (Mycomya)	*pura*	1	2	3
	M. (Mycomya)	sp.	11	0	11
	M. (Mycomyopsis)	*byseri*	1	0	1
	M. (Mycomyopsis)	*dentata*	5	1	6
	M. (Mycomyopsis)	*sublittoralis*	9	0	9
	M. (Mycomyopsis)	sp.	21	0	21
	Orfelia	*pellita*	0	3	3
	O.	sp. 1	0	1	1
	O.	sp. 2	0	1	1
	O. (? n. subg.)	*New species discovered*	2	2	4
	O. (Neoplatyura)	*New species discovered*	0	4	4
	O. (Urytalpa)	*New species discovered*	1	0	1
	Phronia	*nebulosa*	1	0	1
	Phthinia	*tanypus*	0	1	1
	P.	sp.	0	8	8
	Rymosia	*filipes*	1	1	2
	Saigusaia	*cincta*	1	5	6
	Symmerus	*lautus*	1	0	1
	S. (Psilosymmerus)	*vockerothi*	0	2	2
	S. (Psilosymmerus)	*New species discovered*	1	0	1
	Synapha	*tibialis*	3	1	4

Table B32. Order Diptera (Phylum Arthropoda, Class Insecta; flies) collected at Shenandoah National Park in August 1997 (LL=Limberlost, MA=Matthews Arm) (continued).

Family	Genus (subgenus)	species	LL specimens	MA specimens	Totals
Phoridae	Morpho	sp. 1	10	156	166
	Tetragoneura	*New species discovered*	1	24	25
	Zygomyia	*ignobilis*	0	1	1
	Z.	*ornata*	3	1	4
	Z.	*varia*	0	1	1
	Morpho	sp. 1	0	9	9
	Morpho	sp. 2	33	67	100
	Morpho	sp. 3	25	23	48
	Morpho	sp. 4	0	1	1
	Morpho	sp. 5	0	2	2
	Morpho	sp. 6	23	27	50
	Morpho	sp. 7	7	5	12
	Morpho	sp. 8	0	2	2
	Morpho	sp. 9	0	1	1
	Morpho	sp. 10	0	1	1
Pipunculidae	*Pipunculus (Pipunculus)*	sp.	0	2	2
Psychodidae	*Psychoda*	*cinerea*	0	1	1
	P.	*phalaenoides*	0	3	3
	P.	*umbracola*	17	1	18
	P.	*New species discovered*	0	2	2
Rhagionidae	*Chrysopilus*	*quadratus*	0	1	1
Sarcophagidae	*Boettcheria*	*latisterna*	0	1	1
Scathophagidae	*Norellisoma*	*spinimanum*	0	1	1
Sciaridae	Gen.	sp.	93	138	231
Simuliidae	*Simulium*	*jenningsi*	1	29	30
Sphaeroceridae	Gen.	sp.	20	30	50
Stratiomyidae	*Neopachygaster*	*reniformis*	0	1	1
	Sargus	*decorus*	0	1	1
Syrphidae	*Chrysotoxum*	*perplexum*	0	1	1
	Toxomerus	*marginatus*	2	0	2
Tabanidae	*Tabanus*	*calens*	0	1	1
	T.	*sackeni*	0	2	2
Tachinidae	*Blondelia*	*hyphantriae*	2	0	2
	Clausicella	*sp nr setigera*	3	0	3
	Phytomyptera	*nigra*	1	0	1
	P.	sp.	0	1	1
	Ptilodexia	*rufipennis*	1	0	1
	Strongygaster	*triangulifer*	0	1	1
Tephritidae	*Trypeta*	*tortilis*	0	2	2
Tipulidae	*Dicranoptycha*	*septemtrionis*	1	0	1
	Erioptera	sp.	1	0	1
	Gonomyia	*kansensis*	2	0	2

Table B32. Order Diptera (Phylum Arthropoda, Class Insecta; flies) collected at Shenandoah National Park in August 1997 (LL=Limberlost, MA=Matthews Arm) (continued).

Family	Genus (subgenus)	species	LL specimens	MA specimens	Totals
Tipulidae	*Hexatoma*	*brevioricornis*	2	1	3
	Limnophila	*novaeangliae*	0	1	1
	L.	*angustula*	2	1	3
	L.	sp.	3	0	3
	Limonia	*indigena*	0	2	2
	L.	*lecontei*	2	0	2
	Molophilus	*huron*	5	3	8
	Ormosia	*mesocera*	0	1	1
	O.	*monticola*	13	20	33
	Pedicia	*inconstans*	1	2	3
	P.	*margarita*	2	0	2
	Tipula	*algonquin*	0	1	1
	T.	*duplex*	1	0	1
	T.	*hermania*	2	7	9
	Ulomorpha	*pilosella*	8	0	8
	Morpho	sp. 1	1	2	3
Xylophagidae	*Dialysis*	*elongata*	1	0	1
Undetermined	Gen.	sp. (immatures)	52	65	117
Totals					
	Number of families identified		27	31	38
	Number of genera identified		67	77	100
	Number of species identified		75	87	112
	New species discovered		4	7	10
	Number of specimens		2859	2662	5521

Table B33. Order Trichoptera (Phylum Arthropoda, Class Insecta; caddisflies) collected at Shenandoah National Park in August 1997 (LL=Limberlost, MA=Matthews Arm).

Family	Genus	species	LL specimens	MA specimens	Total
Lepidostomatidae	Morpho	sp. 1	10	22	32
Limnephilidae	Morpho	sp. 1	48	28	76
	Morpho	sp. 2	0	1	1
Philopotamidae	Morpho	sp. 1	2	2	4
Polycentropodidae	Morpho	sp. 1	6	0	6
	Morpho	sp. 2	2	1	3
Psychomyiidae	Morpho	sp. 1	47	23	70
Rhyacophilidae	Morpho	sp. 1	12	20	32
	Morpho	sp. 2	0	21	21
.	Morpho	sp. 3	0	1	1
Undetermined	Morpho	sp. 1	1	0	1
Totals					
Number of families identified			6	6	6
Number of genera identified			0	0	0
Number of species identified			0	0	0
Number of specimens			128	119	247

Table B34. Order Lepidoptera (Phylum Arthropoda, Class Insecta; moths, butterflies) collected at Shenandoah National Park in August 1997 (LL=Limberlost, MA=Matthews Arm).

Family	Genus	species	LL specimens	MA specimens	Total
Agonoxenidae	*Chrysoclista*	*linneella*	1	0	1
Arctiidae	*Clemensia*	*albata*	1	0	1
	Holomelina	*opella*	1	0	1
	Spilosoma	*virginica*	2	0	2
	Morpho	sp. 1	0	1	1
	Morpho	sp. 2 (immature)	0	5	5
	Morpho	sp. 3 (immature)	0	1	1
Drepanidae	*Drepana*	*arcuata*	9	0	9
Epiplemidae	*Calledapteryx*	*dryoptera*	0	1	1
Gelechiidae	Morpho	sp. 1	1	0	1
	Morpho	sp. 2	1	0	1
	Morpho	sp. 3	2	0	2
	Morpho	sp. 4	1	0	1
Geometridae	*Anacamptodes*	*defectaria*	1	0	1
	Antepione	*thisoaria*	0	2	2
	Besma	*quercivoraria*	1	1	2
	Biston	*betularia*	16	1	17
	Campaea	*perlata*	0	1	1
	Caripeta	*divisata*	2	19	21
	Drepanulatrix	*foeminoria*	0	1	1
	Epimecis	*hortaria*	1	0	1
	Epirrhoe	*alternata*	1	0	1
	Euphyia	*unangulata intermedia*	8	3	11
	Hydrelia	*inornata*	2	0	2
	Hypagyrtis	*unipuncta*	10	1	11
	Iridopsis	*larvaria*	27	7	34
	Itame	*pustularia*	21	1	22
	Lambdina	*feridaria*	1	0	1
	Melanolophia	*canadaria*	49	47	96
	Pero	*honestaria*	4	0	4
	Plagodis	*alcoolaria*	0	2	2
	Probole	*amicaria*	0	1	1
	Prochoerodes	*transversata*	0	1	1
	Scopula	*limboundata*	5	0	5
	Semiothisa	*aemulataria*	1	0	1
	Trichodezia	*albovittata*	1	0	1
	Morpho	sp. 1	1	0	1
	Morpho	sp. 2	2	0	2
	Morpho	sp. 3	0	1	1
	Morpho	sp. 4	0	1	1
	Morpho	sp. 5	0	1	1
	Morpho	sp. 6	0	1	1
	Morpho	sp. 7	0	1	1

Table B34. Order Lepidoptera (Phylum Arthropoda, Class Insecta; moths, butterflies) collected at Shenandoah National Park in August 1997 (LL=Limberlost, MA=Matthews Arm) (continued).

Family	Genus	species	LL specimens	MA specimens	Total
Geometridae	Morpho	sp. 8	0	2	2
	Morpho	sp. 9	2	0	2
	Morpho	sp. 10	0	1	1
	Morpho	sp. 11	0	1	1
	Morpho	sp. 12	0	1	1
	Morpho	sp. 13	0	1	1
	Morpho	sp. 14 (immature)	4	0	4
	Morpho	sp. 15 (immature)	0	2	2
	Morpho	sp. 16 (immature)	0	1	1
	Morpho	sp. 17 (immature)	3	0	3
	Morpho	sp. 18 (immature)	0	1	1
	Morpho	sp. 19 (immature)	11	1	12
Gracillariidae	*Caloptilia*	*serotinella*	1	0	1
	Morpho	sp. 1	1	0	1
	Morpho	sp. 2	1	0	1
	Morpho	sp. 3	1	0	1
Limacodidae	Morpho	sp. 1 (immature)	0	2	2
Lymantriidae	*Lymantria*	*dispar*	1	3	4
	Morpho	sp.1	1	0	1
Noctuidae	*Abagrotis*	*alternata*	3	0	3
	Acronicta	sp. 1	1	0	1
	A.	sp. 2	1	0	1
	Agrotis	*ipsilon*	0	1	1
	Amphipyra	*pyramidoides*	0	1	1
	Anathix	*ralla*	2	1	3
	Apamea	*helva*	0	1	1
	Callopistra	*mollissima*	0	1	1
	Catocala	*ultronia*	1	0	1
	C.	sp.1	1	0	1
	C.	sp.2	1	0	1
	Colocasia	*propinquilinea*	17	1	18
	Euparthenos	*nubilis*	1	0	1
	Euplexia	*benesimilis*	1	0	1
	Hypena	*edictalis*	14	1	15
	H.	*palparia*	2	0	2
	Idia	*aemula*	0	1	1
	I.	*americalis*	8	1	9
	I.	*rotundalis*	8	3	11
	Lacinipolia	*olivacea*	0	1	1
	Leucania	sp.	0	1	1
	Ochropleura	*plecta*	1	0	1
	Pangrapta	*decoralis*	1	0	1
	Panopoda	*carneicosta*	0	1	1

Table B34. Order Lepidoptera (Phylum Arthropoda, Class Insecta; moths, butterflies) collected at Shenandoah National Park in August 1997 (LL=Limberlost, MA=Matthews Arm) (continued).

Family	Genus	species	LL specimens	MA specimens	Total
Noctuidae	*Phalaenophana*	*pyramusalis*	1	0	1
	Phalaenostola	*larentioides*	4	0	4
	Phlogophora	*periculosa*	1	2	3
	Xestia	*dolosa*	2	1	3
	X.	*smithii*	2	0	2
	X.	sp.	0	1	1
	Zanclognatha	*laevigata*	3	0	3
	Morpho	sp. 1	1	0	1
	Morpho	sp. 2	0	2	2
	Morpho	sp. 3	0	1	1
	Morpho	sp. 4	0	1	1
	Morpho	sp. 5	0	1	1
	Morpho	sp. 6	0	1	1
	Morpho	sp. 7	0	1	1
	Morpho	sp. 8	0	1	1
	Morpho	sp. 9	0	1	1
	Morpho	sp. 10	0	1	1
	Morpho	sp. 11	0	1	1
	Morpho	sp. 12	0	5	5
	Morpho	sp. 13	0	1	1
	Morpho	sp. 14	0	1	1
	Morpho	sp. 15	0	1	1
	Morpho	sp. 16	0	1	1
	Morpho	sp. 17	0	1	1
	Morpho	sp. 18	0	1	1
	Morpho	sp. 19	0	1	1
	Morpho	sp. 20	0	1	1
	Morpho	sp. 21	0	1	1
	Morpho	sp. 22	0	1	1
	Morpho	sp. 23	0	1	1
	Morpho	sp. 24	0	1	1
	Morpho	sp. 25	0	1	1
	Morpho	sp. 26	0	1	1
	Morpho	sp. 27	1	0	1
	Morpho	sp. 28	1	0	1
	Morpho	sp. 29 (immature)	0	1	1
	Morpho	sp. 30 (immature)	0	1	1
	Morpho	sp. 31 (immature)	0	1	1
	Morpho	sp. 32 (immature)	3	2	5
	Morpho	sp. 33 (immature)	2	13	15
	Morpho	sp. 34 (immature)	0	2	2
	Morpho	sp. 35 (immature)	2	11	13

Table B34. Order Lepidoptera (Phylum Arthropoda, Class Insecta; moths, butterflies) collected at Shenandoah National Park in August 1997 (LL=Limberlost, MA=Matthews Arm) (continued).

Family	Genus	species	LL specimens	MA specimens	Total
Notodontidae	*Dasylophia*	*anguina*	1	0	1
	Ellida	*caniplago*	0	1	1
	Lochmaeus	*manteo*	1	0	1
	Macrurocampa	*marthesia*	0	2	2
	M.	sp.	0	1	1
	Nadata	*gibbosa*	2	1	3
	Oligocentra	*semirufescens*	1	0	1
	Schizura	*ipomaeae*	1	0	1
	Morpho	sp. 1 (immature)	0	5	5
	Morpho	sp. 2 (immature)	0	3	3
	Morpho	sp. 3 (immature)	0	2	2
	Morpho	sp. 4 (immature)	0	1	1
	Morpho	sp. 5 (immature)	0	1	1
Oecophoridae	Morpho	sp. 1	1	0	1
	Morpho	sp. 2	0	1	1
Pyralidae	*Acrobasis*	*normella*	1	0	1
	Aglossa	*caprealis*	0	1	1
	Apogeshna	*stenialis*	0	1	1
	Arta	*statalis*	0	1	1
	Herpetogramma	*pertexalis*	0	1	1
	Oreana	*unicolorella*	0	1	1
	Pantographa	*limata*	4	1	5
	Pyrausta	*generosa*	0	1	1
	Pyrausta	sp.	10	0	10
	Vitula	*broweri*	1	0	1
	V.	*edmandsii*	2	0	2
Saturniidae	*Actias*	*luna*	0	1	1
Thyatiridae	Morpho	sp. 1 (immature)	1	0	1
Tineidae	*Monopis*	*dorsistrigella*	1	0	1
	Morpho	sp. 1	1	0	1
	Morpho	sp. 2 (mmature)	0	1	1
Tortricidae	*Ancylis*	*platanana*	1	0	1
	Archips	*fervidana*	0	2	2
	Pandemis	*lamprosana*	0	1	1
	Ptycholoma	*peritana*	2	0	2
	Sparganothis	*reticulatana*	0	1	1
Yponomeutidae	*Swammerdamia*	*caesiella*	1	0	1
Undetermined	Morpho	sp. 1	1	0	1
	Morpho	sp. 2	18	6	24
	Morpho	sp. 3	1	0	1
	Morpho	sp. 4	0	3	3
	Morpho	sp. 5	1	12	13
	Morpho	sp. 6	2	11	13

Table B34. Order Lepidoptera (Phylum Arthropoda, Class Insecta; moths, butterflies) collected at Shenandoah National Park in August 1997 (LL=Limberlost, MA=Matthews Arm) (continued).

Family	Genus	species	LL specimens	MA specimens	Total
Undetermined	Morpho	sp. 7	0	1	1
	Morpho	sp. 8	0	4	4
	Morpho	sp. 9	1	2	3
	Morpho	sp. 10	6	3	9
	Morpho	sp. 11	1	1	2
	Morpho	sp. 12	16	2	18
	Morpho	sp. 13	0	1	1
	Morpho	sp. 14	1	0	1
	Morpho	sp. 15	1	0	1
	Morpho	sp. 16	1	0	1
	Morpho	sp. 17	1	0	1
	Morpho	sp. 18	1	0	1
	Morpho	sp. 19	1	0	1
	Morpho	sp. 20	2	0	2
	Morpho	sp. 21 (immature)	3	5	8
	Morpho	sp. 22 (immature)	0	3	3
	Morpho	sp. 23 (immature)	2	2	4
	Morpho	sp. 24 (immature)	0	1	1
	Morpho	sp. 25 (immature)	0	1	1
	Morpho	sp. 26 (immature)	2	2	4
	Morpho	sp. 27 (immature)	0	2	2
	Morpho	sp. 28 (immature)	0	1	1
	Morpho	sp. 29 (immature)	1	3	4
Totals					
	Number of families identified		15	14	18
	Number of genera identified		51	43	79
	Number of species identified		54	44	81
	Number of specimens		380	294	674

Table B35. Order Hymenoptera (Phylum Arthropoda, Class Insecta; sawflies, parastic wasps, ants, wasps, bees) collected at Shenandoah National Park in August 1997 (LL=Limberlost, MA=Matthews Arm).

Family	Genus	species	LL specimens	MA specimens	Total
Apidae	*Bombus*	sp.	0	1	1
Braconidae	Morpho	sp. 1	1	11	12
	Morpho	sp. 2	1	7	8
	Morpho	sp. 3	1	2	3
	Morpho	sp. 4	2	2	4
	Morpho	sp. 5	2	0	2
	Morpho	sp. 6	0	2	2
	Morpho	sp. 7	0	2	2
	Morpho	sp. 8	0	1	1
	Morpho	sp. 9	1	0	1
	Morpho	sp. 10	0	1	1
	Morpho	sp. 11	1	0	1
	Morpho	sp. 12	0	1	1
	Morpho	sp. 13	1	0	1
	Morpho	sp. 14	0	1	1
	Morpho	sp. 15	1	0	1
	Morpho	sp. 16	0	1	1
	Morpho	sp. 17	1	0	1
	Morpho	sp. 18	0	1	1
Ceraphronidae	Morpho	sp. 1	2	2	4
	Morpho	sp. 2	0	1	1
	Morpho	sp. 3	0	1	1
Cynipidae	Morpho	sp. 1	1	0	1
	Morpho	sp. 2	0	1	1
Diapriidae	Morpho	sp. 1	10	41	51
	Morpho	sp. 2	0	3	3
	Morpho	sp. 3	2	83	85
Eulophidae	Morpho	sp. 1	1	0	1
	Morpho	sp. 2	0	1	1
Figitidae	*Anacharis*	sp.	1	0	1
	Morpho	sp. 1	1	1	2
	Morpho	sp. 2	0	2	2
	Morpho	sp. 3	0	1	1
Formicidae	*Aphaenogaster*	sp.	0	69	69
	Camponotus	sp.	5	8	13
	Lasius	sp.	6	26	32
	Myrmecina	sp.	0	6	6
	Stenamma	sp.	53	20	73
	Morpho	sp. 1	0	5	5
	Morpho	sp. 2	0	3	3
	Morpho	sp. 3	0	6	6
	Morpho	sp. 4	6	14	20

Table B35. Order Hymenoptera (Phylum Arthropoda, Class Insecta; sawflies, parastic wasps, ants, wasps, bees) collected at Shenandoah National Park in August 1997 (LL=Limberlost, MA=Matthews Arm) (continued).

Family	Genus	species	LL specimens	MA specimens	Total
Heloridae	*Helorus*	*anomalipes*	1	1	2
Ichneumonidae	Morpho	sp. 1	11	9	20
	Morpho	sp. 2	2	0	2
	Morpho	sp. 3	0	2	2
	Morpho	sp. 4	0	1	1
	Morpho	sp. 5	10	1	11
	Morpho	sp. 6	0	1	1
	Morpho	sp. 7	0	1	1
	Morpho	sp. 8	0	2	2
	Morpho	sp. 9	1	0	1
	Morpho	sp. 10	1	0	1
	Morpho	sp. 11	1	0	1
	Morpho	sp. 12	0	5	5
	Morpho	sp. 13	1	0	1
	Morpho	sp. 14	2	2	4
	Morpho	sp. 15	2	0	2
	Morpho	sp. 16	0	3	3
	Morpho	sp. 17	4	3	7
	Morpho	sp. 18	0	2	2
	Morpho	sp. 19	0	4	4
	Morpho	sp. 20	19	11	30
	Morpho	sp. 21	0	3	3
	Morpho	sp. 22	0	1	1
	Morpho	sp. 23	6	1	7
	Morpho	sp. 24	0	1	1
	Morpho	sp. 25	0	1	1
	Morpho	sp. 26	0	1	1
	Morpho	sp. 27	0	1	1
	Morpho	sp. 28	1	5	6
	Morpho	sp. 29	0	2	2
	Morpho	sp. 30	0	1	1
	Morpho	sp. 31	1	0	1
	Morpho	sp. 32	1	0	1
	Morpho	sp. 33	1	1	2
	Morpho	sp. 34	1	1	2
	Morpho	sp. 35	0	4	4
	Morpho	sp. 36	1	2	3
	Morpho	sp. 37	0	1	1
	Morpho	sp. 38	0	5	5
	Morpho	sp. 39	0	1	1
	Morpho	sp. 40	0	2	2
	Morpho	sp. 41	1	1	2

Table B35. Order Hymenoptera (Phylum Arthropoda, Class Insecta; sawflies, parastic wasps, ants, wasps, bees) collected at Shenandoah National Park in August 1997 (LL=Limberlost, MA=Matthews Arm) (continued).

Family	Genus	species	LL specimens	MA specimens	Total
Ichneumonidae	Morpho	sp. 42	0	6	6
	Morpho	sp. 43	1	0	1
	Morpho	sp. 44	1	0	1
	Morpho	sp. 45	1	0	1
	Morpho	sp. 46	0	1	1
	Morpho	sp. 47	2	0	2
	Morpho	sp. 48	1	0	1
	Morpho	sp. 49	1	2	3
	Morpho	sp. 50	2	0	2
Megaspilidae	Morpho	sp. 1	2	1	3
	Morpho	sp. 2	1	2	3
Mymaridae	*Ooctonus*	sp.	0	1	1
Ormyridae	*Ormyus*	sp.	1	0	1
Platygastridae	Morpho	sp. 1	1	2	3
Pompilidae	Morpho	sp. 1	3	0	3
Proctotrupidae	Morpho	sp. 1	0	11	11
Pteromalidae	*Alloterra*	sp.	1	1	2
	Cecidostiba	sp.	0	1	1
	Lariophagus	sp.	1	0	1
	Pteromalus	sp.	2	0	2
	Quercanus	sp.	1	0	1
	Morpho	sp. 1	0	1	1
Scelionidae	Morpho	sp. 1	0	3	3
Sphecidae	*Trypoxylon*	sp.	0	1	1
Tenthredinidae	*Ametastegia*	*recens*	0	1	1
	Nematus	*carpini*	1	0	1
	Morpho	sp. 1	1	2	3
Tiphiidae	Morpho	sp. 1	0	1	1
Vespidae	Morpho	sp. 1	0	16	16
	Morpho	sp. 2	0	6	6
Undetermined	Morpho	sp. 1	0	1	1
Totals					
	Number of families identified		15	21	22
	Number of genera identified		11	12	18
	Number of species identified		2	2	3
	Number of specimens		192	470	662

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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