Recovery of Aquatic Macroinvertebrate Communities Following a 500+ Year Flood Event in Shenandoah National Park

Zane B. Johnson and Craig D. Snyder

United States Geological Survey
Leetown Science Center
Aquatic Ecology Laboratory
Kearneysville, WV 25430

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EXECUTIVE SUMMARY

On June 27, 1995, heavy rains caused severe flooding and triggered massive debris flows in Madison County, Virginia, affecting several watersheds in Shenandoah National Park. The Staunton River watershed was particularly impacted, receiving an estimated 30 inches of rain in approximately 16 hours from a localized storm cell that stalled over the watershed (Morgan, et al. 1997). The extremely heavy rain combined with the steep terrain of the area caused major debris flows in the lower portion of the Staunton River watershed. The scouring and boulder deposition caused by these debris flows relocated and reconfigured the stream channel and removed a large portion of the riparian forest over a 2.1 km section of the lower portion of the watershed. In much of the affected area, the stream-riparian corridor was replaced with a 100 m wide boulder field. A qualitative stream survey made one-month post-flood found fish to be entirely absent and aquatic macroinvertebrates to be limited to very few individuals of flood-tolerant taxa. Consequently, this flood disturbance was atypical in that, not only were organisms killed and displaced, but the fundamental controls that structure headwater streams were altered. The magnitude and novelty of the event provided an opportunity to conduct research aimed at fostering a better understanding of the ecological processes that govern the assembly of communities and the evolution of stream ecosystems.

The present study was designed to assess responses of aquatic macroinvertebrate assemblages to the catastrophic flood and associated debris flows that occurred on the Staunton River on June 27-28, 1995. We began the study in October 1998, over three years post-flood. Consequently, the study was not designed to assess the immediate impacts of the disturbance on stream communities. Rather, the goal was to determine the extent to which flood-induced changes in stream and riparian habitats caused long-term changes in the structure and productivity of benthic macroinvertebrate assemblages. We derived inferences regarding flood effects by conducting temporal (pre-flood vs. post-flood) and spatial (impacted reaches/streams vs. un-impacted reaches/streams) comparisons of several measures of community structure and productivity. This study was determined to be a high priority need of the National Park Service within the BRD NRPP process and involved collaboration with the University of Virginia (UVA) and the Virginia Polytechnic Institute (VPI) to document other changes and recovery of the stream ecosystem and its biota.

We conducted synoptic surveys in the fall of 1998, spring of 1999, fall of 2000, and spring of 2001 at 10 sites on the Staunton River (five sites above and five sites within the zone of impact) and eight sites on White Oak Canyon Run, a similar stream that was not noticeably affected by the flood. We used the data from the surveys along with data collected prior to the flood by Shenandoah National Park personnel to draw inferences regarding long-term effects of the flood on commonly used measures of community structure including taxa richness, total abundance, trophic composition, and community stability. We also conducted intensive sampling (12 sample dates) between January and November 1999 to estimate and compare community production at two sites on the Staunton River, one above and one within the zone of impact.

Based on temporal (pre-flood vs. post-flood) and spatial (impacted vs. unimpacted sites) comparisons of the survey data, we concluded that measures of benthic community structure were relatively insensitive and inconsistent indicators of long-term responses to the June 1995

catastrophic disturbance. We believe the relative ineffectiveness of these measures were due to three important reasons. First, despite great efforts to control for temporal factors in our sampling design, our seasonal surveys were nevertheless snapshots in time. Consequently, between-site or between-year differences in habitat, such as warmer water temperatures at impacted sites, may have resulted in our sampling populations at different times in their life cycles making spatial and temporal comparisons tenuous. Second, structural measures are notoriously hyper-variable and highly responsive to local habitat conditions. In particular, substratum characteristics varied widely even among sites within reference or impacted zones. As a result, within-zone variation was high, reducing our power to detect differences among reference and impacted zones. Finally, count data may not be effective at addressing ecological questions relating to trophic controls. Although the relative amounts of autochthonous and allochthonous energy sources changed dramatically as a result of the flood, there nevertheless was some energy associated with each type available for organisms. Although abundance and relative abundance data are often used to infer trophic responses, there is considerable evidence that population density and secondary production do not correlate well.

In contrast, comparisons of productivity between impacted and unimpacted sites indicated the flood and associated debris flows did have long-term consequences to benthic communities. Although total community production was similar between sites, we hypothesize that additional energy sources provided by reduced shading had a stimulatory effect on productivity at the impacted site that was offset by reduced channel bed stability and possibly increased predation pressure from fish. However, there were clear between-site differences in production among trophic groups. In particular, scraper-grazer production was higher and shredder-detritivore production was lower at the impacted site. Such changes were clearly responses to flood-induced changes in riparian vegetation that increased light and stimulated instream algal production. The data suggest a functional shift toward a community more indicative of those found in typical eastern mid-reach streams, where streams tend to widen allowing more sunlight to reach the stream bottom.

Based on our findings, we believe that the flood and associated debris flow caused changes similar in pattern and magnitude to some human-induced disturbances. In particular, clear-cut logging provides a useful comparison because there have been numerous long-term studies designed to evaluate benthic responses to, and recovery from, catchment logging. Assuming the similarities persist, we can expect a very gradual recovery of benthic communities to pre-flood conditions. Distinct functional changes associated with logging have been found to persist decades post-disturbance. Moreover, we can expect a dynamic recovery pattern with distinct successional stages and biological adjustments through time. For example, inputs of large woody debris will increase relatively sharply within the next decade as fallen logs decompose and enter the stream. This would likely increase the retention of leaf packs and nutrients available to shredder-detritivores, while at the same time the reduced shading will persist which will continue to stimulate primary production and the production of the scraper-grazer guild. Consequently, over the next few years, we might expect a large increase in total community production that will taper down to pre-flood levels over the long-term.

Introduction

Disturbances play a major role in structuring biological communities (White and Pickett 1985). A disturbance is defined as a discrete event that disrupts population, community, or ecosystem structure by changing resource abundance or the physical environment (Sousa 1984, Resh, et al. 1988). The kind of disturbance and other attributes such as frequency, magnitude, and predictability of disturbances determine the effects on communities (White and Pickett 1985). Disturbances of low severity and frequent occurrence may have the effect of increasing species diversity (Kimmerer and Allen 1982) or reducing diversity at small spatial scales (Robinson and Minshall 1986), whereas large magnitude, highly unpredictable events may greatly impinge on systems. Studies of large magnitude, large expanse disturbances such as the 1980 eruption of Mount St. Helens have provided data on pervasive long-term changes to plant communities (Zobel and Antos 1997), stream insect communities (Anderson 1992), and mammals (Andersen and MacMahon 1985). The heterogeneous nature of large, infrequent disturbances result in high variability in the number and types of resultant successional stages (Turner, et al. 1997; 1998).

There have been numerous phenomenological accounts of aquatic invertebrate responses to flood disturbances (e.g., Molles 1985, Sagar 1986, Scrimgeour, et al. 1988). This evidence suggests that aquatic invertebrate assemblages are highly adapted to floods, as illustrated by the relatively short times required for population densities and community structure to return to pre-flood conditions. Recovery of benthic faunas in Appalachian streams is aided by refugia, deep interstitial habitats, and tributaries (Angradi 1997). Rapid community recovery has even been found with severe floods where the entire stream bottom was scoured and available refugia were limited (Hendricks, et al. 1995). Due to the infrequency of such large magnitude floods and debris flows as the ones of June 1995, there are comparatively few studies of the biological responses to such events. Lamberti, et al (1991) studied recovery of an Oregon stream in the Cascade Mountains for three years following a flood and debris flows of comparable magnitude to the Staunton River flood. However, the frequency of large magnitude debris flows tends to be higher in the Pacific Northwest due to a variety of land-use practices that reduce hillslope stability (Swanson, et al. 1987). In Madison County, Virginia, which was first settled in the early 18th century, there is no historic record of debris flows (Wieczorek, et al. 2000), while the geological evidence indicates the pervasive influence of debris flows in the Blue Ridge Mountain Range throughout the Holocene and Pleistocene Epochs (Clark 1992). Thus, the return interval, the amount of time in between such large debris flows in the eastern United States may occur on a much larger temporal scale of thousands or tens of thousands of years.

The primary effect of most floods is to kill and displace organisms and redistribute habitat units within the stream channel. Although the initial impact on invertebrates may be severe and major habitat features are altered, resulting habitats are still available for recolonization. However, in the Staunton River flood, debris flows completely changed the energy pathways and structure of instream habitats over a 2.1 km segment of the stream. The stream was relocated and its riparian zone was removed. A boulder field up to 100 m in width replaced both. A brief qualitative survey made one month after the flood found few invertebrates and no fish in impacted portions of the river (National Park Service, unpublished report). The degree of scouring and channel reconfiguration is hypothesized to have eliminated normal instream sources for recolonization (refugia and deep interstices) of the Staunton River impacted zone. Recovery would therefore be

limited to colonization from above the impacted segments through invertebrate drift or through aerial dispersal from adjacent streams. Moreover, the structural changes in riparian vegetation and stream channel morphology is expected to take decades to return to pre-flood conditions. Thus, we believe it is likely that invertebrate assemblages re-colonizing impacted reaches will differ substantially from pre-flood assemblages, and that these differences will persist long-term.

The present study was designed to assess responses of aquatic macroinvertebrate assemblages to the catastrophic flood and associated debris flows that occurred on the Staunton River on June 27-28,1995. We began the study in October 1998, over three years post-flood. Consequently, the study was not intended to assess the immediate impacts of the disturbance on stream communities. Rather, the goal was to determine the extent to which flood-induced changes to stream channel and riparian habitats caused long-term changes in the structure and productivity of benthic macroinvertebrate assemblages. Because some detailed pre-flood hydrologic, geologic, and biologic data are available on this stream, this study presents a unique opportunity not only to document the reestablishment of stream communities following a catastrophic disturbance, but also to evaluate system evolution by comparison to earlier baselines. Although floods of varying severity are known to occur approximately every 20-30 years somewhere within the Blue Ridge Mountains, the establishment of new ecological baselines to track system resilience and recovery has never been attempted in the Appalachians.

Materials and Methods

General design

Inferences regarding the effects of the flood were derived by comparative study of temporal (pre- vs. post-flood) and spatial (impacted sites vs. unimpacted sites) trends in benthic macroinvertebrate assemblage structure and productivity. Temporal comparisons were based on samples collected before and after the June 1995 flood at several sites on the Staunton River. Spatial assessments were derived from comparisons of aquatic macroinvertebrate responses among sites above and below the impacted zone on the Staunton River, as well as among sites on White Oak Canyon Run, a similar stream that was not noticeably impacted by the flood.

The study consisted of two components: 1) Seasonal surveys conducted at ten sites on the Staunton River and eight sites on White Oak Canyon Run in the fall of 1998, spring of 1999, fall of 2000, and spring of 2001; and 2) intensive sampling (12 sample dates between January and November 1999) at two sites on the Staunton River (one above the impact of debris flows and one site below the impact of the debris flows). The seasonal surveys were used to test hypotheses regarding the effects of the catastrophic disturbance to aquatic invertebrate community structure metrics such as taxa richness, total invertebrate abundance, trophic composition, and stability of community composition through time (Morisita's Similarity Index). The intensive sampling in 1999 was used to evaluate disturbance effects on secondary productivity and mean annual biomass.

Hypotheses

Streams are increasingly being viewed from a more holistic perspective that recognizes lateral (riparian-stream) and longitudinal (upstream-downstream) linkages. Of particular significance is the River Continuum Concept (RCC) (Vannote et al. 1980) which views stream systems as a continuously integrating series of physical gradients and associated biotic adjustments (Minshall et al. 1985). The concept relates the changes in geomorphology as streams progress from headwaters to mouth to patterns of organic matter supply, aquatic invertebrate community structure, and trophic composition.

We used the data collected in this study to test a series of hypotheses based on the RCC. Specifically, we hypothesized that sites in the impacted zone on the Staunton River would differ significantly in terms of community structure, trophic composition, and secondary productivity because of flood-induced changes in riparian vegetation and stream channel morphology and stability. The removal of mature riparian vegetation reduces shading and increases the amount of light available to stream periphyton communities. These changes in light regime would alter the relative contribution of allochthonous (leaf material) and autochthonous (instream algae and diatoms) energy sources available to benthic macroinvertebrate assemblages. Moreover, reduced shading causes increases in stream temperature with consequent affects on individual growth rates and ultimately secondary productivity. In addition, flood-induced changes to the stream channel could cause changes in substratum characteristics and stability that would influence macroinvertebrate communities. Based on these flood-induced changes to the lateral and longitudinal linkages in the Staunton River watershed, we tested the following specific hypotheses:

1) In terms of community structure, we hypothesized that taxa richness would be lower at sites in the impacted zone (Fig. 1A), and that sites in the impacted zone would be less stable in terms of community composition. Specifically, annual variation in taxonomic composition would be higher (i.e., community similarity will be lower) at sites within the impacted zone (Fig. 1B).

2) In terms of trophic composition, we hypothesized that the proportion of individuals as filterers would be higher at sites in the impacted zone (Fig. 1D), the proportion of individuals as scrapers would be higher at sites in the impacted zone (Fig. 1E) and the proportion of indiviudals as shredders would be lower at sites in the impacted zone (Fig. 1F).

3) Finally, in terms of productivity, we hypothesized that the sites in the impacted zone on the Staunton River would be more productive (Fig. 1H). Moreover, we hypothesize that between-site differences in production would have a trophic basis, with filterer and scraper trophic groups having higher production at sites in the impacted zone, whereas the shredder trophic group would be less productive at sites in the impacted zone (Fig. 1I). We did not expect to see dramatic differences in production between the gatherer, and predator trophic groups (Fig. 1I).

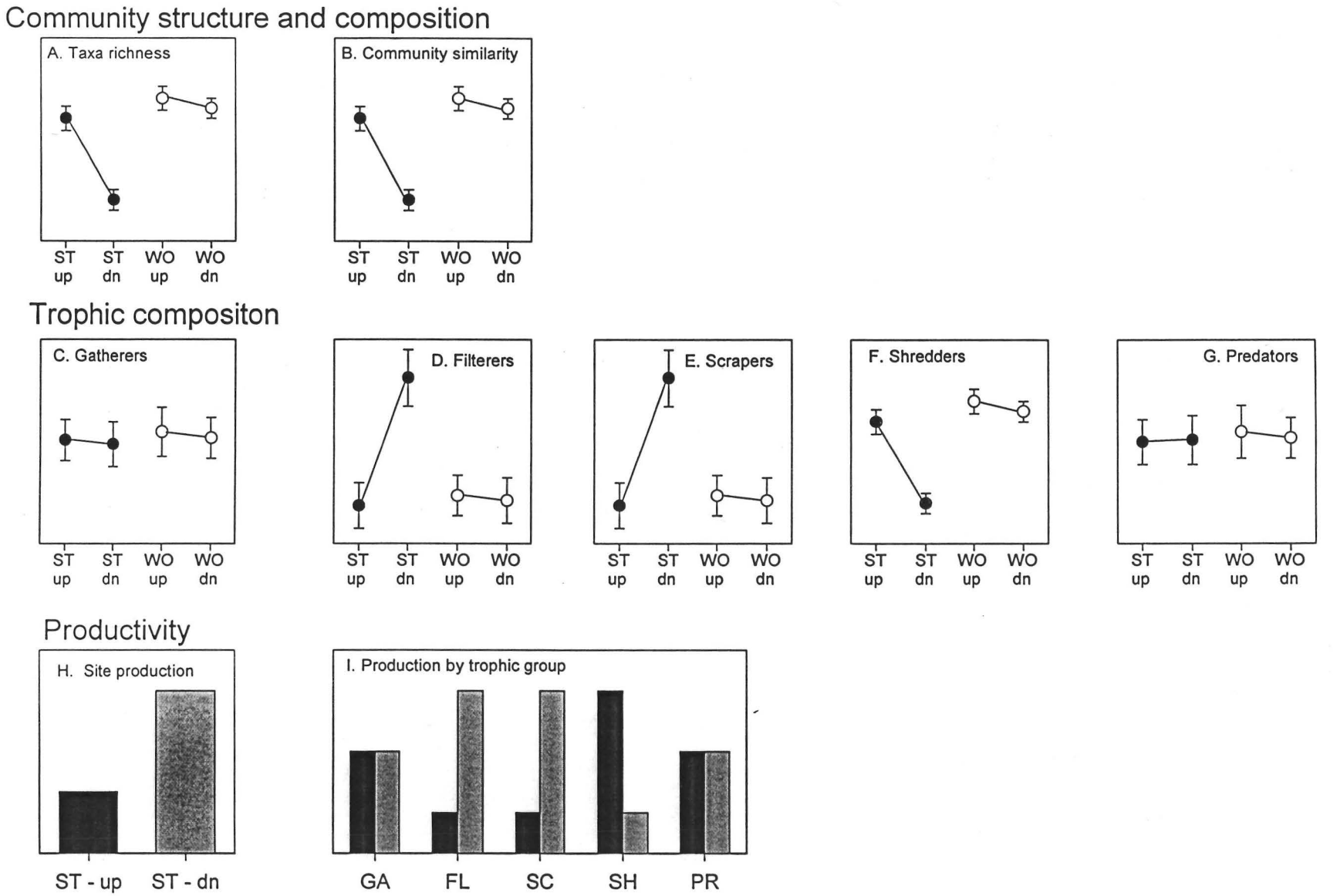


Fig. 1. Hypothesized responses of aquatic invertebrate assemblages to the flood of 1995. For community structure (A, B) and trophic composition (C, D, E, F, G), each graph shows the relative mean response for sites in the unimpacted (ST-up) and impacted (ST-dn) zones on the Staunton R., as well as comparable upstream (WO-up) and downstream (WO-dn) zones on the White Oak Run. Production graphs compare total community production (H) and production between trophic groups (I) between sites ST-up and ST-dn.

Description of Study Area

The Study Rivers are cascading trout streams located in the Shenandoah National Park, Madison Co., Virginia . The Staunton River is a second order tributary of the Rapidan River, with headwaters at 3,180 feet above sea level. The river is 6.2 km in length and joins the Rapidan River at 980 feet above sea level. The Staunton River drains a total land area of 1066.32 hectares at the bottom-most site, near its confluence with the Rapidan River. We sampled second and third order reaches of Whiteoak Canyon Run, a tributary of the Robinson River. Whiteoak has three headwater tributaries ranging in elevation from 3400 to 3550 feet above sea level. The Whiteoak is a total 6.3 km in length (excluding the length of its un-sampled headwater tributaries that result in a total length of 9.47 km) from its headwaters to where it joins with Cedar Run, draining a land area of 1111.14 hectares at our most down river site. Whiteoak Canyon Run was selected as a reference stream because of its overall similarity to the Staunton River. Both streams have an eastern facing aspect and are similar in geology and riparian cover.

The underlying geology of the Staunton River and Whiteoak Canyon Run watersheds are largely granitic and Precambrian in age (Conners 1988). Most of the Staunton River is underlain by middle Precambrian Pedlar Formation (mostly quartz monzonite and gneiss) with the lower portion near its confluence with the Rapidan River flowing through middle Precambrian Old Rag Granite (Conners 1988). Whiteoak Canyon Run is underlain by late Precambrian Catoctin Formation (greenstone and associated volcanic rocks). The basaltic Catoctin deposits give streams in this area an acid buffering capacity of 150 microequivalents, twice that of streams underlain by the Pedlar Formation (Rick Webb, personal comm.). Despite such differences in the geological mediation of water chemistry, selection of Whiteoak Canyon Run as the reference stream for this study was based on closest overall similarity to the Staunton River.

Riparian cover in the region consists of mixed hardwoods, with stands of hemlock (*Tsuga canadensis* (L.) Carr.) and mountain laurel (*Kalmia latifolia* L.) prevalent in the upper reaches of both streams at the time of field sampling. In a study of 30 1st and 2nd order streams in the Delaware Water Gap Natural Recreation Area (Snyder, et al. 2002), streams draining hemlock-dominated watersheds were shown to have significantly higher aquatic macroinvertebrate diversity than hardwood stand streams.

The flood-impacted segment of Staunton River (N 38°27' W 78°22') begins at an elevation of 1480 feet above sea level. The impacted zone has a substratum comprised of granitic boulders interspersed with areas of cobble, pebble, and sand. Boulders predominate and, combined with a steep gradient, create numerous cascades in the segment. Habitat types range from turbulent riffles and cascades to deep pools, resulting in a very visibly heterogeneous river. The area lacks the dense hardwood riparian cover characteristic of the upstream areas.

Selection of sample site locations

We selected ten sites on the Staunton River and eight sites on White Oak Canyon Run to conduct seasonal surveys. Since we wanted sample unimpacted and impacted sites with the same level of effort, we put five sites in the 4.1 km zone above the impacts of the debris flows, and five sites in the 2.1 km zone impacted by the debris flows. Consequently, upstream sites were 1 km apart

and downstream sites were 0.5 km apart. The two sites nearest the transition of unimpacted and impacted segments were within 100 m of the disturbance boundary. Selection of reference sites on White Oak Canyon Run was based on locating sites of comparable basin area to those already selected on the Staunton. That is, we wanted to ensure that we sampled the same portion of the river continuum for both streams. We used the Spatial Analyst tool in ArcView (Version 3.2) to define basin area above points along the length of White Oak Canyon Run. We then selected eight sites that corresponded to eight of the sites we selected on the Staunton River in terms of drainage area. These sites were not placed equidistantly as they were on the Staunton River, and two site matches could not be made due to the influence of tributaries dramatically increasing basin area. Nevertheless, along with similarities in geology, watershed aspect, and forest cover, our ability to locate a number of sites with similar basin areas was a main reason for selecting White Oak Canyon Run as a reference watershed for this component of the study. Summary statistics for each site are shown in Table 1.

Table 1. Basin area (h), elevation (ft), and UTM (*x* and *y*) coordinates for sites in the Staunton River and White Oak Canyon Run.

Staunton River				White Oak Canyon Run			
Site	Area	Elevation	UTM	Site	Area	Elevation	UTM
S01	86.22	2980	0725118 4260692	W01	82.08	3180	0728829 4272773
S02	210.15	2500	0725944 4260137	---	---	---	---
S03	324.18	2150	0726742 4259649	W03	336.69	3080	0729080 4272685
S04	619.38	1800	0727695 4259812	W04	606.24	2100	0729909 4271174
S05	719.37	1500	0728573 4259444	W05	710.73	1950	0730252 4270982
S06	734.13	1450	0728638 4259349	W06	738.63	1880	0730289 4270935
S07	758.43	1380	0728718 4258941	W07	761.49	1680	0730486 4270701
S08	822.42	1280	0728790 4258508	W08	771.21	1550	0730662 4270572
S09	1017.54	1100	0729127 4258264	---	---	---	---
S10	1066.32	980	0729506 4258159	W10	1111.14	1500	0730722 4270511

We also considered the location of pre-flood samples in our site selection process. As part of long-term stream monitoring programs in Shenandoah National Park (SHEN), aquatic macroinvertebrate surveys had been conducted at several sites on the Staunton River between 1986 and 1995 by SHEN personnel. Among the sites routinely surveyed were six sites that we also sampled as part of this study. Therefore, there are some pre-flood data we can compare with our results to draw inferences about the effects of the catastrophic flood. Four of the sites (SNP site numbers: 2L306, 2F076, SR13, and 2F074) were located in the zone upstream of the flood and debris flow impacts and correspond to our site numbers 1, 2, 3, and 5. The other two sites (SNP site numbers: 2F073 and SR04) were located within the flood/debris flow impacted zone and correspond to our sites 7 and 9.

Samples for the intensive secondary production component were taken at two sites: site five (upstream reference) and site seven (impacted zone) on the Staunton River. These sites were chosen because they corresponded to sites where scientists from VPI conducted studies of fish production and scientists from UVA collected water chemistry data. This common-site strategy will ultimately facilitate integration of this study with other investigations and provide a holistic context for the study. A site was defined as a 20 m long reach of stream for both components of the study.

Data collection and analysis

Habitat

Habitat measurements included water temperature and substratum. We did not measure other important attributes such as water chemistry and flow because other groups (UVA and VPI) were conducting intensive sampling involving those parameters at the same sites. Water temperature was measured at the two sites on each stream where intensive sampling occurred (i.e., sites 5 and 7 for both streams). Water temperature was measured each hour with Onset StowAway® temperature loggers. Temperature data were analyzed graphically by comparing the mean daily temperatures between upstream and downstream sites on each stream.

Substratum assessments were done at the location of each invertebrate sample site (n=20) for each site on each survey date) at all 18 sampling sites during the four spring and fall surveys. At each location, substratum was classified into one of nine substrate types (Table 2). The mean percent of the total stream bottom occupied by each of the nine substratum types (+/- SE) was determined for each zone and compared graphically.

Table 2. Substrate classification used to define microhabitat. Percentages of the total stream bottom associated with each substratum is reported for each zone on each stream.

	Staunton River		White Oak Canyon	
Substrate type	Upstream	Downstream	Upstream	Downstream
Organic				
CPOM (sticks and logs)	1.06	0.50	0.31	0.94
Leaf packs	1.88	0.50	2.50	3.13
Moss	0.81	0.00	0.00	0.31
Mineral				
Silt/detritus (not mineral) (<6.4 mm dia.)	0.31	0.75	0.62	0.62
Sand (<6.4 mm)	6.19	6.75	1.56	1.25
Gravel (6.4 – 50 mm)	15.44	20.00	21.56	7.50
Cobble (50 – 200 mm)	34.69	29.25	36.88	31.56
Boulder (200 – 1000 mm)	34.13	36.50	26.56	42.19
Bedrock (>1000 mm)	5.50	5.75	10.00	12.50

Benthic macroinvertebrate community structure – seasonal surveys

For each of the four seasonal surveys, 20 samples were taken at each of the 18 sample sites (ten sites for the Staunton River and eight sites for White Oak Canyon Run). We used a systematic random sampling approach to select macroinvertebrate sampling locations within each sample site. Transects perpendicular to stream flow were placed one m apart along the 20 m reach of stream delineating a sample site. The width in feet of each transect was measured and subsequently a 1 square foot location was selected at random along the length of each transect. This ensured that we sampled the entire length of the sample site as well as enabled us to maintain the random sampling requirement of parametric statistics. Benthic samples were collected with a standard D-frame kicknet (243 μm mesh). Sampling consisted of 30-second kicks over an area of 0.02 m^2 at each selected location. We subsequently composited all 20 samples into 1-liter nalgene jars and preserved them in the field with 10% formalin.

In the laboratory, fall and spring survey samples were processed in three phases. A washing/floating phase was used to separate larger debris from the sample and separate mineral and organic fractions. The splitting phase was to partition the remaining sample into smaller units. The third phase was the sorting of macroinvertebrates from remaining debris. Each phase is described in more detail below.

Washing/floating phase - Samples were poured into a large pan and the larger leaves and stones were washed over a 150 μm sieve. The remaining sample in the pan and contents of the sieve were placed into a pan modified with an opening at one end. The 150 μm sieve was placed at the opening of the pan. A water stream was introduced into the pan and the contents were stirred. This procedure floated the lighter portions of the sample, macroinvertebrates and organic debris, through the opening of the pan and into the sieve. The heavier inorganic portion of the sample remained in the pan. The organic and inorganic (mineral) fractions were preserved separately in 80% ethanol.

Splitting phase. For macroinvertebrate counts and identifications only a portion of each sample was sorted. The organic portion of each sample was split into four equal parts by volume using a sample-splitter consisting of a hinged bucket, a wedge and two collecting receptacles. Samples were placed into the hinged bucket and poured over the splitting wedge. Each subsample was collected from its receptacle and split again. The subsample for sorting and the remaining portions were preserved separately in 80% ethanol. The quarter subsample to be sorted for identification was selected randomly.

Sorting and identification. Macroinvertebrates from selected subsamples were sorted from debris using binocular dissecting microscopes. Identifications were done to the lowest practical taxon, in many cases generic and specific levels. Organisms too immature for generic and specific level identification were identified to the family level. Most non-insect taxa were identified only to higher levels (e.g., Phylum, Class, or Order).

Secondary Production

Sampling for secondary production assessments occurred at two sites (site 5 and site 7) on the Staunton River. Six D-frame kicknet samples (mesh size 243 μm) were taken at both sites on 12 sample dates at randomly selected locations within each site. Sampling frequency was highest (i.e., approximately biweekly) during the summer when production is highest, and lower (i.e., approximately every eight weeks) during the winter (Morin, et al. 1987). Samples were field preserved in a solution of 10% formaldehyde.

In the laboratory, samples were rinsed with water and re-preserved in 80% ethanol. Aquatic insect larvae were separated from sample debris using binocular dissecting microscopes. Organisms were identified to the lowest practical taxon as part of the preparation process for being measured. For estimates of individual insect biomass, body lengths of larvae were measured with an image analysis system (SigmaScan Pro v. 5.0). The system was calibrated for each magnification at which larvae were measured. Numbers of organisms per sample were adjusted based on the standard area of 1 m^2. Body lengths were converted to dry mass estimates using published regressions of length on dry mass for a variety of aquatic insect species and genera (Benke, et al. 1999). In cases where there wasn't a published regression available for a taxon, an appropriate equation was substituted based on relatedness and similarity of body shape and maximum size attained.

For most taxa, the size-frequency method (Hynes and Coleman 1968), as modified by Hamilton (1969) and Benke (1979), was used to calculate secondary production from density and mean

individual growth rates. In most cases, taxa were sufficiently abundant at both sites to use the size-frequency method. In cases where numbers were too low to effectively use the size-frequency method for one site, we used the mean annual P/B ratio calculated from the other site, where the taxon was sufficiently abundant, and mean biomass estimates from the site with low abundances to calculate production (Smock, et al. 1985). Finally, for taxa that were not sufficiently abundant at either site, we assumed a mean annual P/B ratio of 5.0 for univoltine species and 10.0 for multivoltine species (Waters 1977).

We calculated production at the genus level for most taxa. For others, the numbers of individuals of some genera were not sufficiently abundant and so we lumped genera and calculated production at the family, subfamily, or tribe level. However, we only did this when life history data suggested that there were no extreme differences in maximum size and cohort production intervals between component genera (Benke 1993). We also tried to avoid lumping genera that differed in feeding habits (i.e., trophic class) so that we could calculate and compare production estimates of different trophic classes.

RESULTS

Habitat

Mean daily water temperature patterns for the Staunton River and White Oak Canyon Run showed typical seasonal patterns (Fig. 2). However, there were clear seasonal differences in water temperature between upstream and downstream sites on the two streams. On the Staunton River, the downstream (impacted zone) site was significantly warmer in the spring, summer and fall but not significantly different from the upstream (reference) site in the winter. In contrast, differences in water temperature between sites on White Oak Canyon Run were not significant for any season and the trends showed the opposite pattern for spring and fall (i.e., downstream site cooler). This suggests that the opening of the canopy by the debris flows resulted in higher temperatures at sites within the impacted zone on the Staunton River.

Substratum composition was similar for both streams with cobble and boulder substrata most frequently encountered (Fig. 3). Gravel and bedrock were the next most common substrata, particularly on White Oak Canyon Run. However, we observed between-site differences in substratum composition on both streams. Percent wood, CPOM (leaf packs) and cobble were significantly higher in the upstream sites on the Staunton River. On White Oak Canyon Run, cobble was also occurred more frequently at the upstream sites, but between-site differences were not significant for wood or leaf packs. Boulders occurred more frequently at sites in the downstream zone on White Oak Canyon Run (Fig. 3). These patterns suggest that sites in the downstream (impacted) zone on the Staunton River maybe less retentive in terms of leaf packs and wood, two important substrata for many aquatic invertebrates.

Benthic community structure

Pre- and Post-flood Comparison of the Macroinvertebrate Fauna

In general, there were relatively few differences between the benthic fauna collected from sites on the Staunton River before and after the flood (Table 3). However, some of the differences may be ecologically relevant and conform to proposed hypotheses. Taxa apparently "lost" from the impacted zone sites were Dixidae, Eubriidae, Gerridae, and Limnephilidae. The absence of Gerridae (water striders) from the spring 1999 survey was probably a function of sampling. Our benthic sampling method was not intended to collect epineustic forms such as water striders. The fly family Dixidae is rare on the Staunton River, occurring in low numbers. Thus, its absence from the post-flood spring survey may be due to chance. In contrast, the loss of Eubriidae and Limnephilidae from the impacted sites may be ecologically significant. Eubriidae, or the false water pennies (*Ectopria* spp.), tend to be found in shaded, small order streams. They were collected in several of the upstream (un-impacted) sites in several post-flood surveys. The Limnephilidae were represented by the genera *Pycnopsyche* and *Neophylax* in the NPS survey. A change in classification places the genus *Neophylax* in the family Uenoidae (Wiggins, et al. 1985), which is how we classified this grazing caddisfly in our study. *Neophylax* spp. was present in our surveys of the impacted sites. Thus it was only *Pycnopsyche*, a shredder-detritivore caddisfly, which was absent from the spring 1999 post-flood survey. Families absent

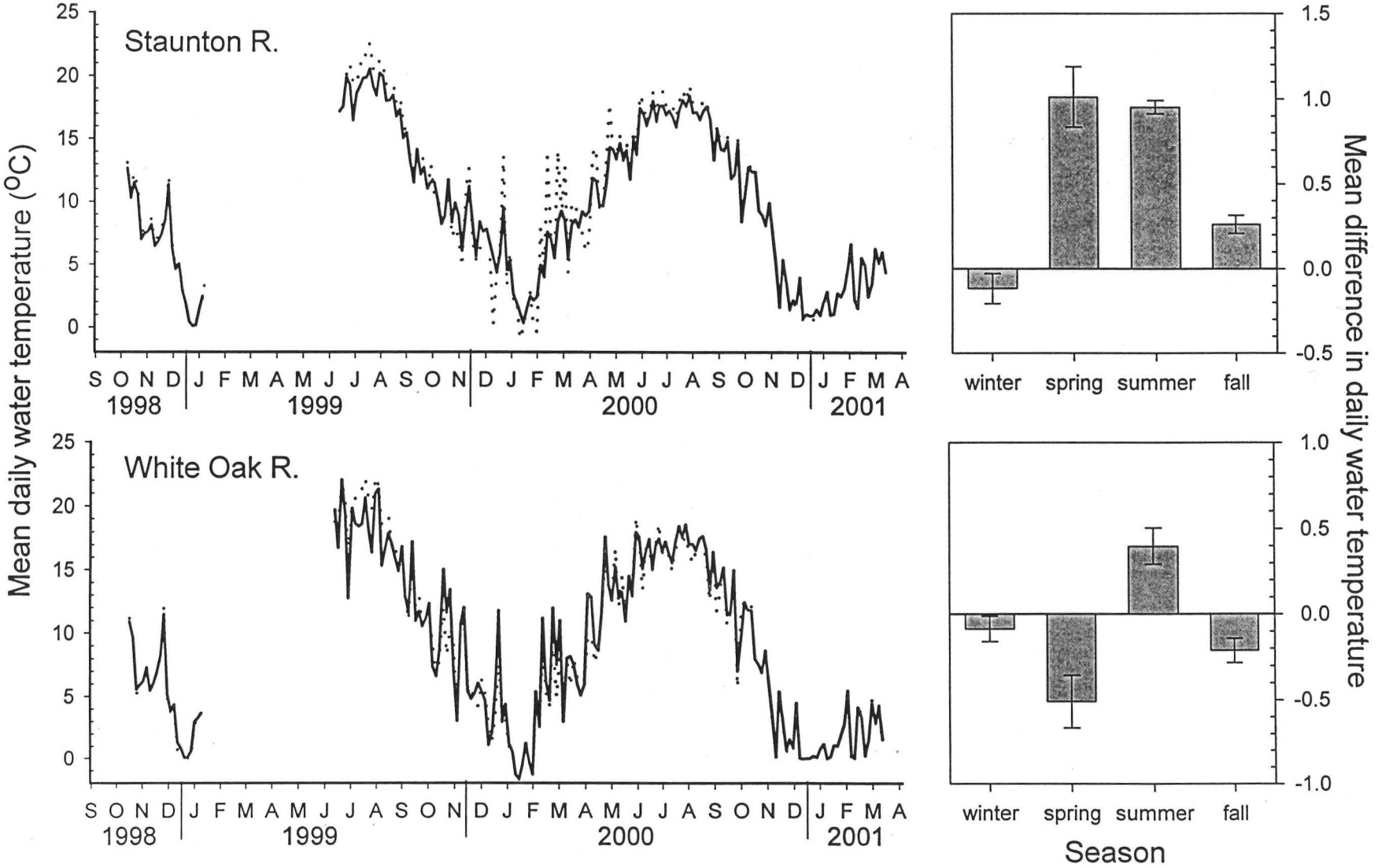


Fig. 2. Comparison of water temperature between upstream (solid lines) and downstream (dotted lines) on the Staunton River and White Oak Canyon Run. Panels on the left show mean temperature throughout the study period. Panels on the right show mean daily differences (+/- SE) between upstream and downstream sites for each season (Winter = Dec, Jan, Feb; spring = Mar, Apr, May; summer = Jun, Jul, Aug; and fall = Sep, Oct, Nov). For each day within a season, mean daily temperature at upstream sites were subtracted from those at downstream sites. Thus, positive differences indicate the downstream site was warmer.

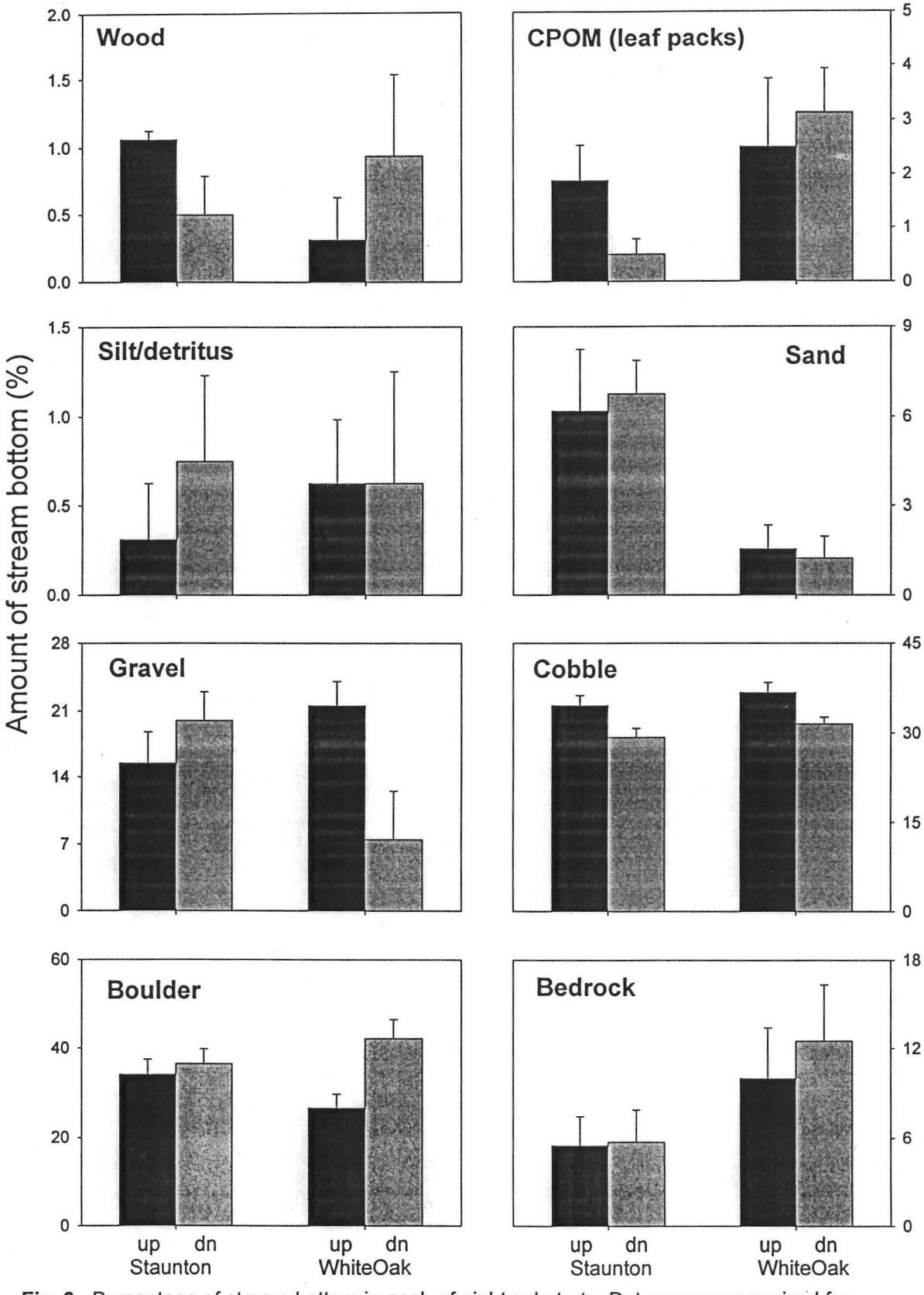


Fig. 3. Percentage of stream bottom in each of eight substrata. Data were summarized for the upstream and downstream zones on each river. Data represent the mean (+/- SE) derived from the 20 randomly selected sample sites where aquatic invertebrate samples were taken during the four seasonal surveys.

from the impacted zone prior to the flood but collected post-flood were Isonychiidae, Hydroptilidae, and Odontoceridae. The caddisflies, *Hydroptila* sp. (Hydroptilidae), and *Psilotreta labida* (Odontoceridae) fill grazing niches. *Isonychia* spp. (Ephemeroptera: Isonychiidae) is a specialized filter feeder usually indicative of mid-reach streams. The post-flood appearance of these taxa in disturbed sites may be evidence of a fundamental change in the energetic resources of the lower Staunton River.

Table 3. Comparison of aquatic insect families collected in Staunton River surveys before and after the June 1995 flood. Shenandoah National Park personnel collected pre-flood data on May 24-25, 1995. Post-flood data were collected as part of this study on March 29-31, 1999. The two surveys had six sites in common (four sites in the un-impacted zone and two sites in the impacted zone).

Reach/Zone	Taxa found before but not after the flood	Taxa found after but not before the flood
Impacted Zone (downstream)	Dixidae Eubriidae Gerridae Limnephilidae	Hydroptilidae Isonychiidae Odontoceridae
Un-impacted Zone (upstream)	Corydalidae Psephenidae Sialidae	Capniidae

Spatial Comparisons of Assemblage Structure – seasonal surveys

Macroinvertebrate surveys conducted in fall 1998, spring 1999, fall 2000, and spring 2001 resulted in the identification of 143 aquatic insect genera from the Staunton River and White Oak Canyon Run (Appendix I-VIII). Ninety-eight species were identified within these genera. Many Diptera were identified only to generic level while specific level identifications were made for many Ephemeroptera, Plecoptera, Trichoptera, and Coleoptera. The ability to identify aquatic insects to species depended on the maturity of specimens and the availability of adequate taxonomic references. Seventeen non-insect invertebrate taxa were also collected and identified from the surveys. Most of these organisms were identified to ordinal and familial levels.

Taxa richness was highly variable among sites, seasons, and years for both streams (Fig. 4). On the Staunton River, generic richness ranged from a low of 34 genera at site 9 during the fall 1998 survey to a high of 73 genera at site 3 during the fall 2000 survey. Generic richness on White Oak Canyon Run ranged from 40 genera at site 4 during the fall 2000 survey to 74 at site 10 during the fall 1998 survey (Fig. 4).

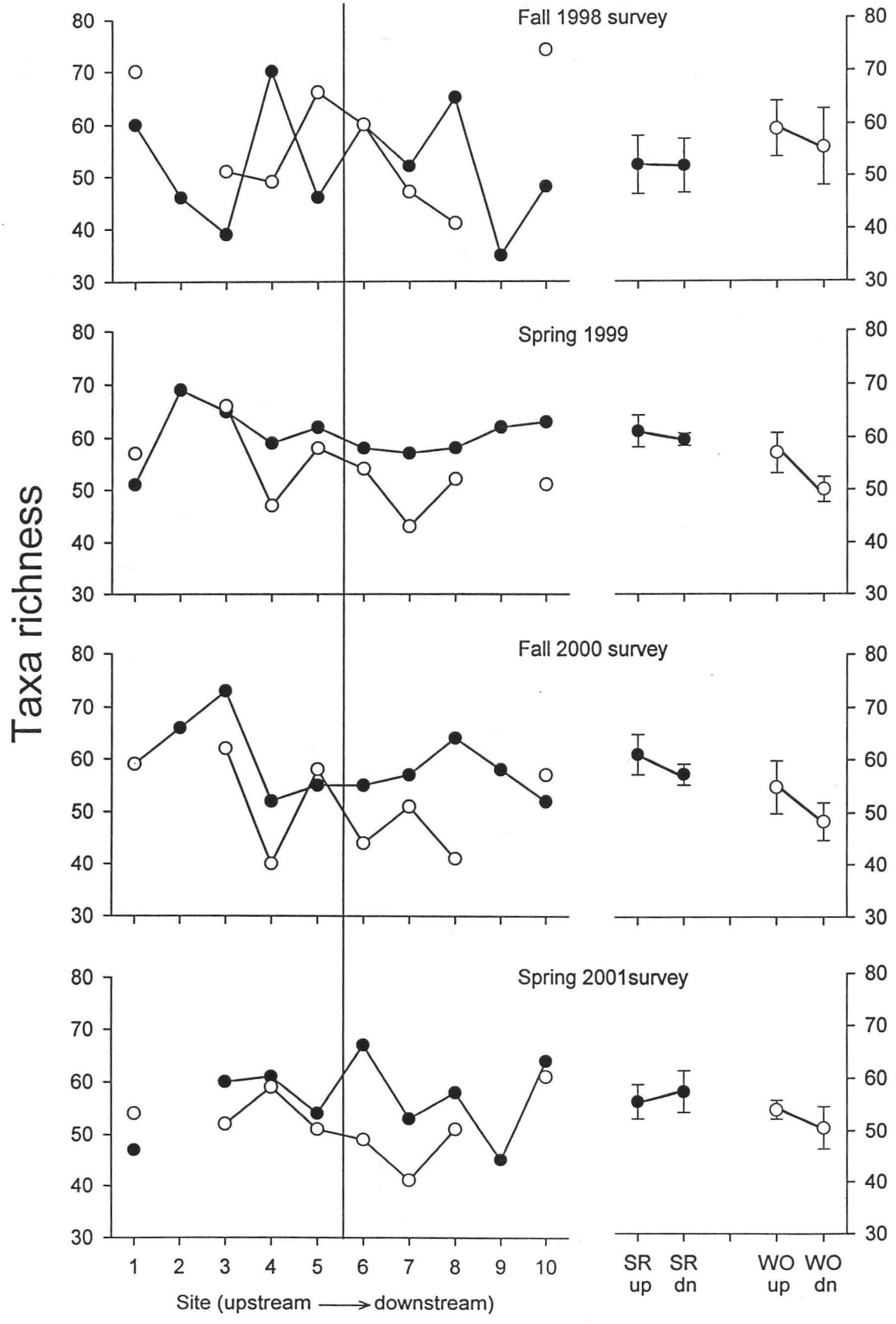


Fig. 4. Comparison of generic richness among sites on the Staunton River and White Oak Canyon Run. Panels on the left show values for each site and panels on the right show mean values (+/- SE) among zones within each stream.

We hypothesized that sites within the impacted zone on the Staunton River would support fewer species than similar sites in the upstream zone and sites on White Oak Canyon Run (Fig. 1A). However, we found that generic richness patterns were not different between sites on the Staunton River (Fig. 4, right panels). Moreover, generic richness was equally variable at sites within both zones on White Oak Canyon Run (Fig. 4).

Total abundances also varied dramatically among sites and sample dates on both streams (Fig. 5). The range of abundances for the Staunton River was from a low of 980 individuals at site 3 during the fall 1998 survey to a high of 15048 at site 2 during the spring 1999 survey. For Whiteoak Canyon Run, numbers ranged from a low of 588 at site 8 during the fall 2000 survey to a high of 8264 at site 5 during spring 1999. High among-site variances were observed for each stream for all surveys. In addition, we observed no distinct longitudinal (i.e., upstream-downstream) patterns in total abundance for either site on either stream. This suggests that reaches (i.e., sites) were more representative of replicate reaches in headwater stream systems than of distinct reaches along the river continuum. This was somewhat expected as all study sites were either first or second order. As with taxa richness, we observed no clear trends when we compared mean abundance in the unimpacted and impacted zones (Fig. 5). Between-site variances seem to swamp out any trends that might be evident. These data suggest that either richness and abundance measures are relatively insensitive to the flood-induced changes to riparian and channel conditions, or that these metrics are controlled more by local factors such as substratum and terrain and the processes that they influence such as flow and nutrient availability.

We also saw no clear between-site or longitudinal trends in terms of community stability. That is, some sites were remarkably similar in terms of taxonomic composition from year to year and others were very different, and this pattern was consistent in both the upstream and downstream zones on both streams, and for both fall and spring seasons (Fig. 6). Moreover, there was no consistent trend in terms of site stability. That is, sites that were found to support similar communities in the fall, did not necessarily support similar communities in the spring. For example, site 8 on the Staunton River was very stable from fall 1998 to fall 2000 (i.e., had very similar communities as indicated by a high Morisita's Index), whereas the community at that site was very different between spring 1999 and spring 2001 surveys (Fig. 6). We made no effort to compare community similarity among seasons because communities of aquatic invertebrates are expected to be very different between seasons.

We hypothesized that communities at sites within the impacted zone on the Staunton River would be less stable in terms of community composition than sites within the upstream (reference) zone on the Staunton, or than sites within both zones on White Oak Canyon (reference stream) (Fig. 1B). Data from the two fall surveys did not conform to our hypothesis (Fig. 6, top right panel). However, the between-zone trend observed in the spring surveys did conform to our hypothesis although differences were not significant (Fig. 6, bottom right panel). Mean community similarity was lower in the impacted zone on the Staunton than in the upstream zone on the Staunton, and than both zones on White Oak Canyon Run.

In terms of trophic composition, we hypothesized significant between-zone differences for three of the five trophic groups (Fig. 1C – 2G). Specifically, we hypothesized that the proportion of

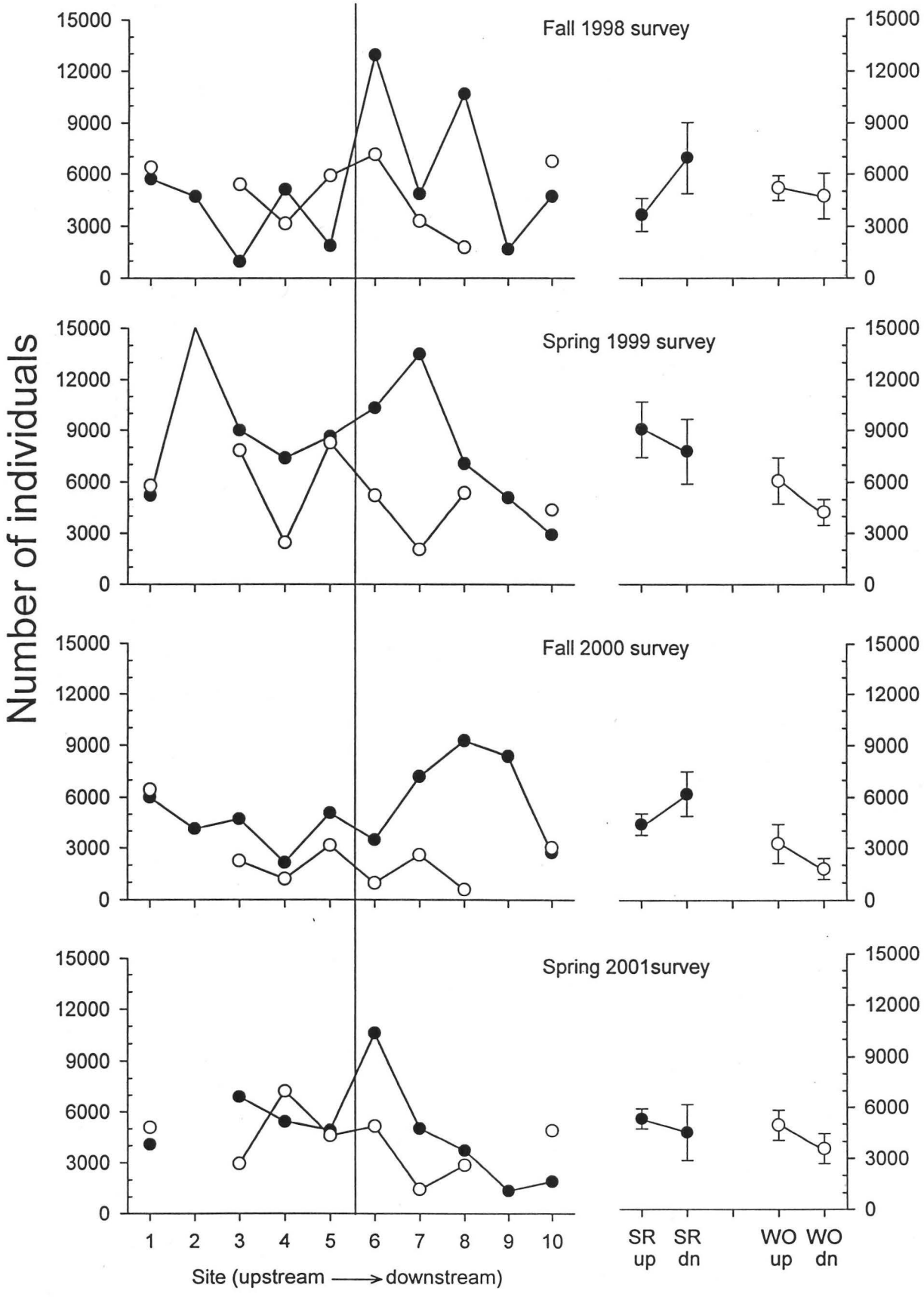


Fig. 5. Comparison of macroinvertebrate abundance among sites on the Staunton River (solid symbols) and White Oak Canyon Run (open symbols). Panels on the left show values for each site and panels on the right show mean values (+/- SE) among zones (upstream vs. downstream sites) in each stream.

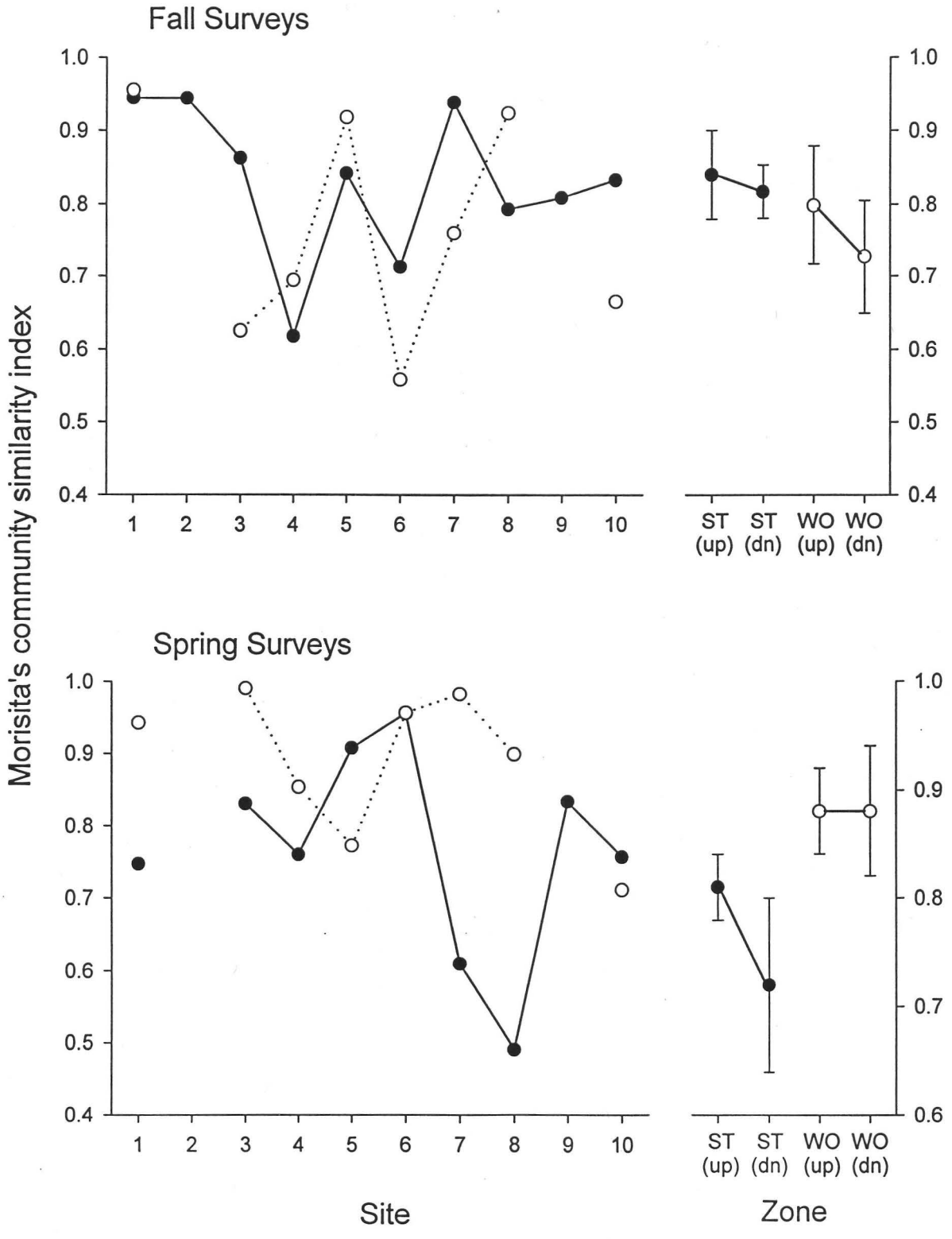


Fig. 6. Comparison of Morisita's community similarity index among sites and seasons for the Staunton River (black symbols) and White Oak Canyon Run (open symbols). For each site, taxonomic composition is compared between the two surveys conducted for a given season (see Methods). Panels on the left show the results for each site and the panels on the right show the mean value (+/- SE) for sites within the upstream and downstream zones (see Methods).

individuals as filterers and scrapers would increase at sites in the impacted zone on the Staunton, and the proportion of individuals as shredders would decrease. Some observed patterns conformed to our expectations while others did not, and there appeared to be a seasonal basis for our observations. Gatherers were the dominant trophic group throughout all of the surveys at all sites (Figs. 8-11). This was largely due to their generalized feeding mechanisms and flexible food requirements. Specialized feeders such as filterers and scrapers were more restricted by habitat requirements. In most of our surveys, collector-filterers increased and shredder-detritivores decreased in the impacted zone although differences were probably not significant for most surveys (Figs. 8-11). Although diminishing proportionately, shredding detritivores tended not to show strong seasonal patterns as a guild, but some taxa such as the stonefly *Paracapnia* sp., were abundant at all sites during the fall 2000 survey but absent from the Staunton River during the spring 2000 survey. This genus has a life cycle geared towards using abundant fall leaf litter as a food source in its latter growth stages, emerging in winter (February through March), and reproducing. Hatching of new cohorts is in April for many Appalachian populations of *Paracapnia angulata* (Griffith, et al. 1993).

The scraper trophic group showed a clear trend of diminishing proportionately in the impacted sites during the fall surveys (Fig. 7 and Fig. 9), but increasing in relative abundance during the spring (Fig. 8 and Fig. 10). Algal scraping caddisflies (Trichoptera) such as *Psilotreta labida* (Odontoceridae), *Hydroptila* sp. (Hydroptilidae) and *Glossosoma* sp. (Glossosomatidae) were numerically more abundant in the open canopy (disturbed) sites during both fall and spring surveys. Two of these families (Odontoceridae and Hydroptilidae) were not collected in pre-flood surveys of lower Staunton River sites conducted by the National Park Service in May 1995 (Table 3). Having become established in the impacted zone, however, *P. labida* has colonized more upstream segments and was found in un-impacted sites 4 and 5.

Examining finer scale, taxa-specific, changes reveals some predictable trends in species composition. Examples include the transition from *Ectopria* in the upper sites to replacement by *Psephenus herricki* in the lower sites (Fig. 11B), diminishment of Peltoperlidae (Fig. 11A), and some apparent longitudinal shifts in the species composition of Hydropsychidae. Some species were restricted to one or two sites and in some cases found only seasonally. Among the caddisflies, site-restricted species were common. *Adicrophleps hitchcocki* (Brachycentridae) and *Parapsyche apicalis* (Hydropsychidae) were found only at Staunton site 1. *Palaeagapetus celsus* (Hydroptilidae) was collected only from upper Staunton River sites as well. These species are documented to occur mainly in small spring-fed streams and tend to diminish in occurrence with distance from the spring source (McCabe and Sykora 2000). Other species, such as *Goera* spp. (Limnephilidae), *Lype diversa* (Psychomyiidae), *Molanna blenda* (Molannidae), and *Fattigia pele* (Sericostomatidae) were too rare to make any inferences about their biology in the present study, but were collected mainly from un-impacted sites and known to occur in proximity to spring sources (McCabe and Sykora 2000). Taken together, our data suggest that trophic composition, at least as summarized at the guild level, did not consistently conform to our hypothesized responses. However, some groups did show seasonal patterns that were consistent with our expectations and there were clear patterns for some taxa within guilds.

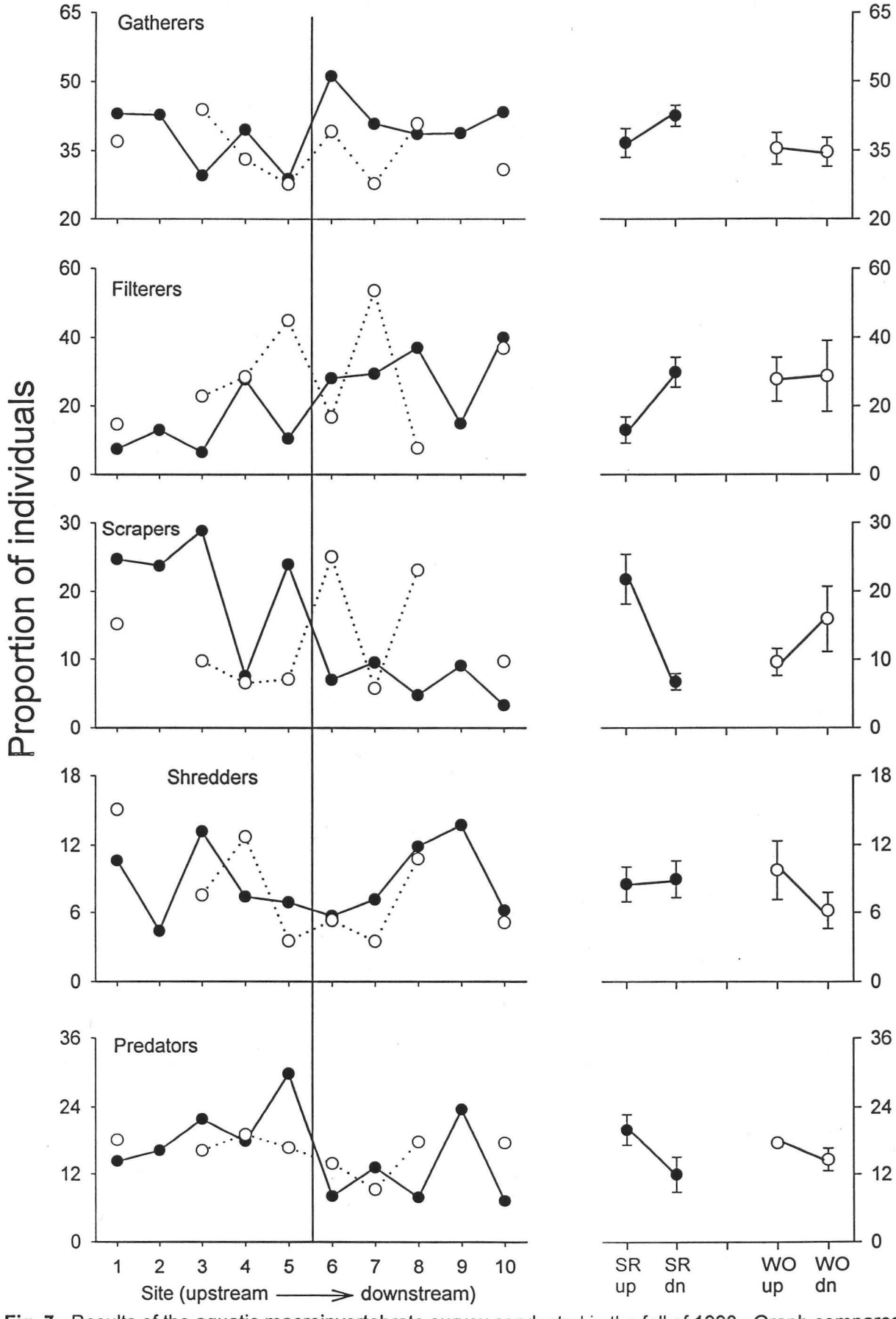


Fig. 7. Results of the aquatic macroinvertebrate survey conducted in the fall of 1998. Graph compares macroinvertebrate trophic structure between sites on the Staunton River (solid symbols) and White Oak Canyon Run (open symbols). Panels on the left show proportions of individuals in each trophic group and panels on the right show the mean values (+/- SE) for sites within the upstream and downstream zones.

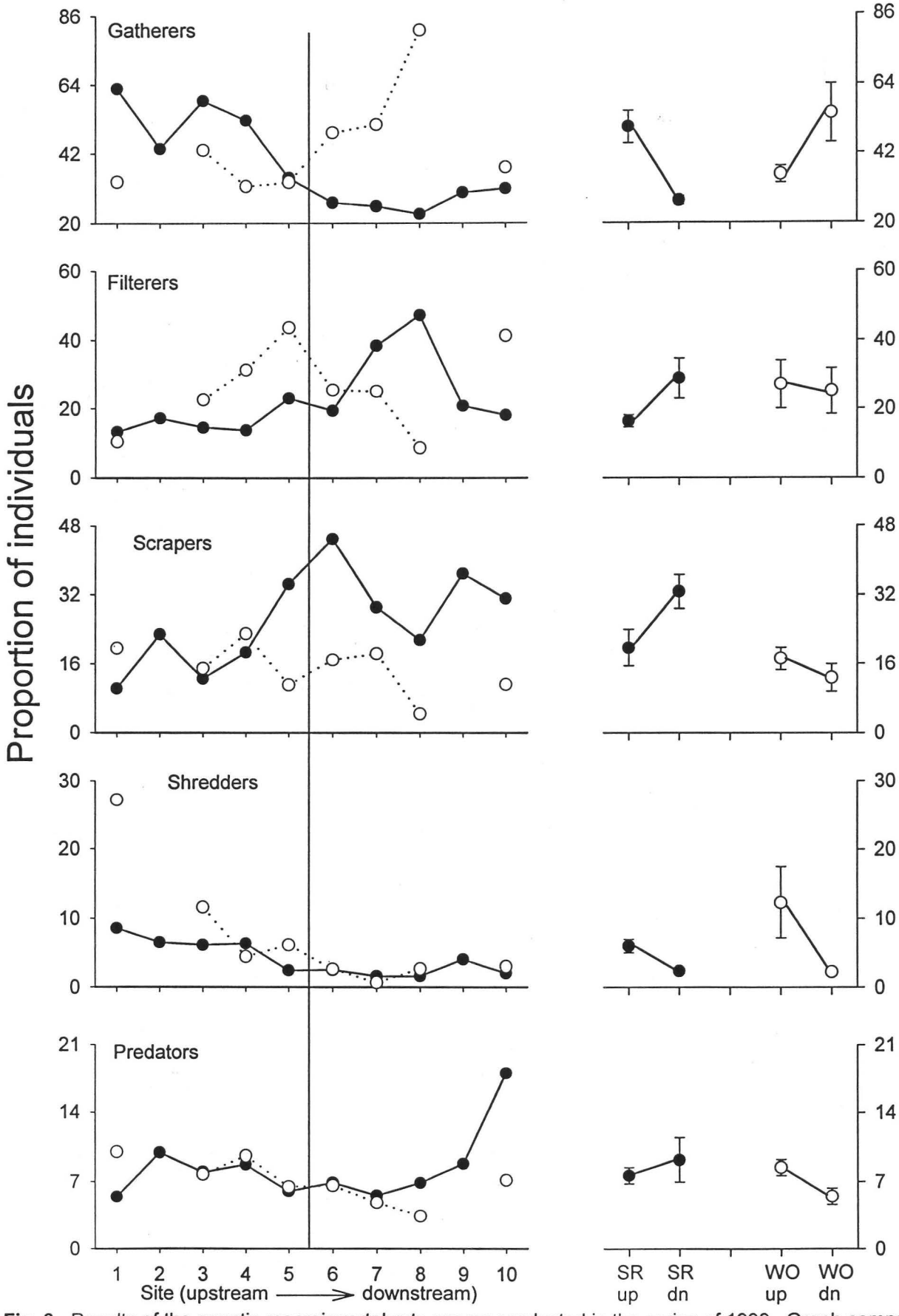


Fig. 8. Results of the aquatic macroinvertebrate survey conducted in the spring of 1999. Graph compares macroinvertebrate trophic structure between sites on the Staunton River (solid symbols) and White Oak Canyon Run (open symbols). Panels on the left show proportions of individuals in each trophic group and panels on the right show the mean values (+/- SE) for sites within the upstream and downstream zones.

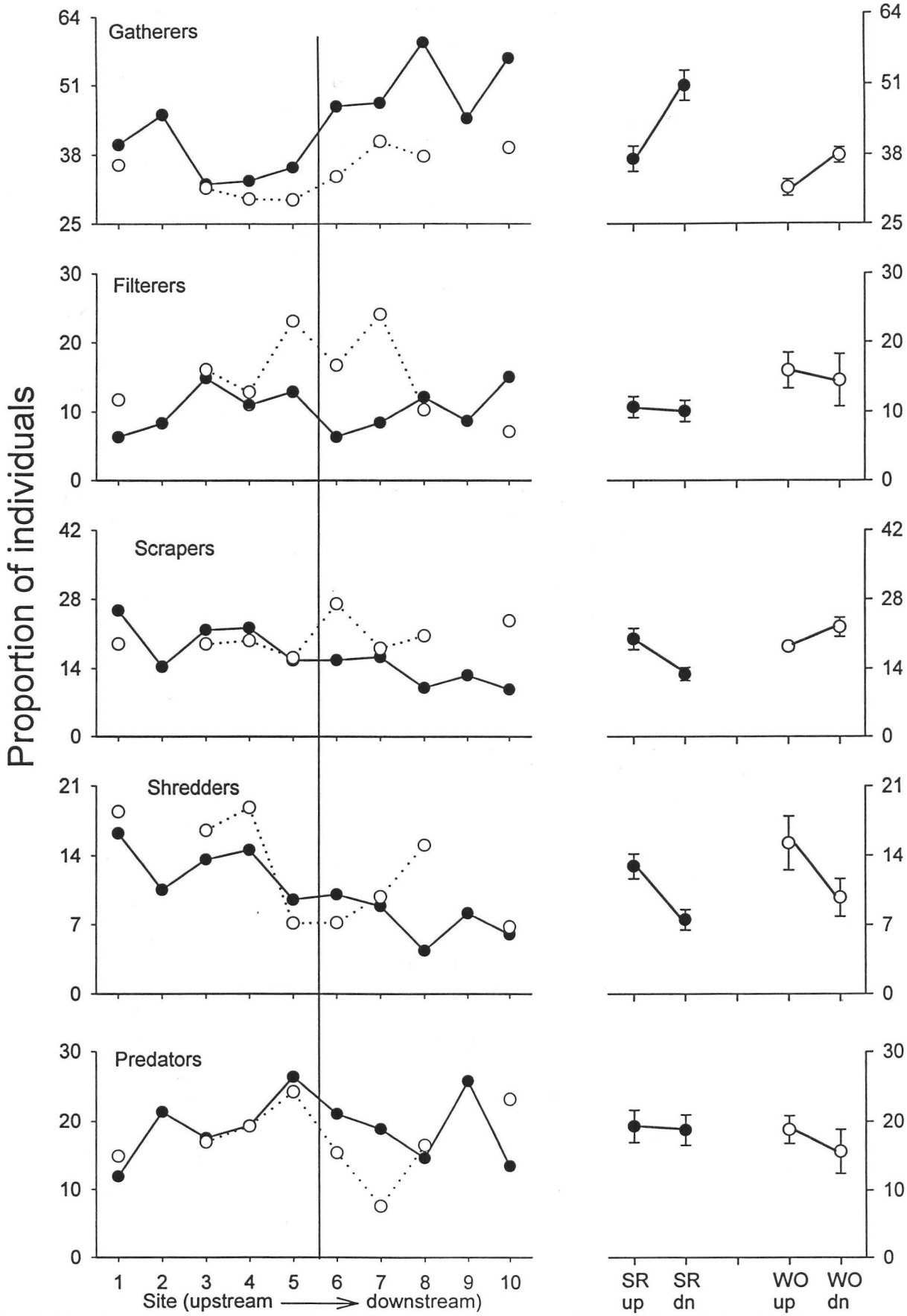


Fig. 9. Results of the aquatic macroinvertebrate survey conducted in the fall of 2000. Graph compares macroinvertebrate trophic structure between sites on the Staunton River (solid symbols) and White Oak Canyon Run (open symbols). Panels on the left show proportion of individuals in each trophic group and panels on the right show the mean values (+/- SE) for sites within the upstream and downstream zones.

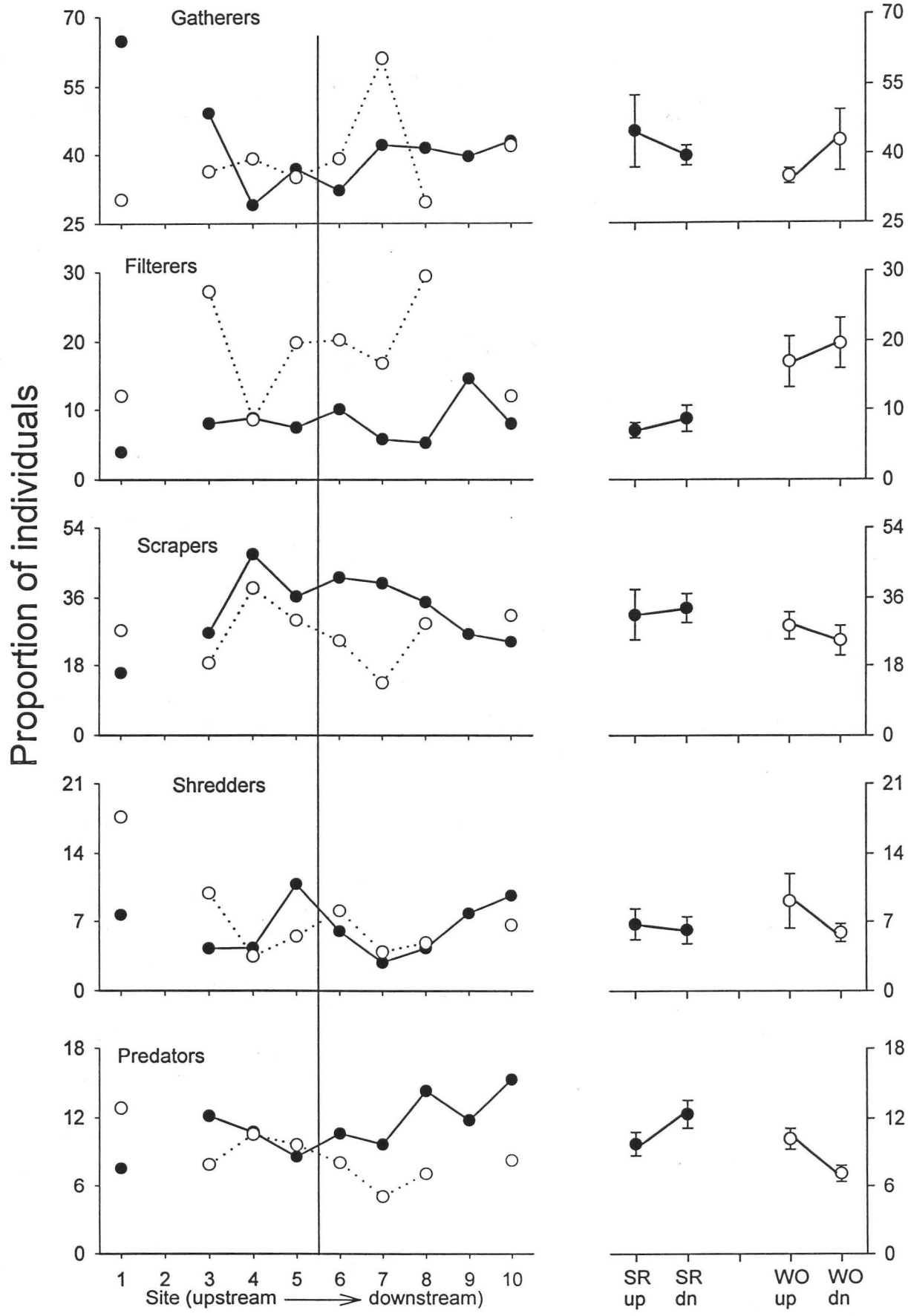


Fig. 10. Results of the aquatic macroinvertebrate survey conducted in the spring of 2001. Graph compares macroinvertebrate trophic structure between sites on the Staunton River (solid symbols) and White Oak Canyon Run (open symbols). Panels on the left show proportions of individuals in each trophic group and panels on the right show the mean (+/- SE) for sites within the upstream and downstream zones.

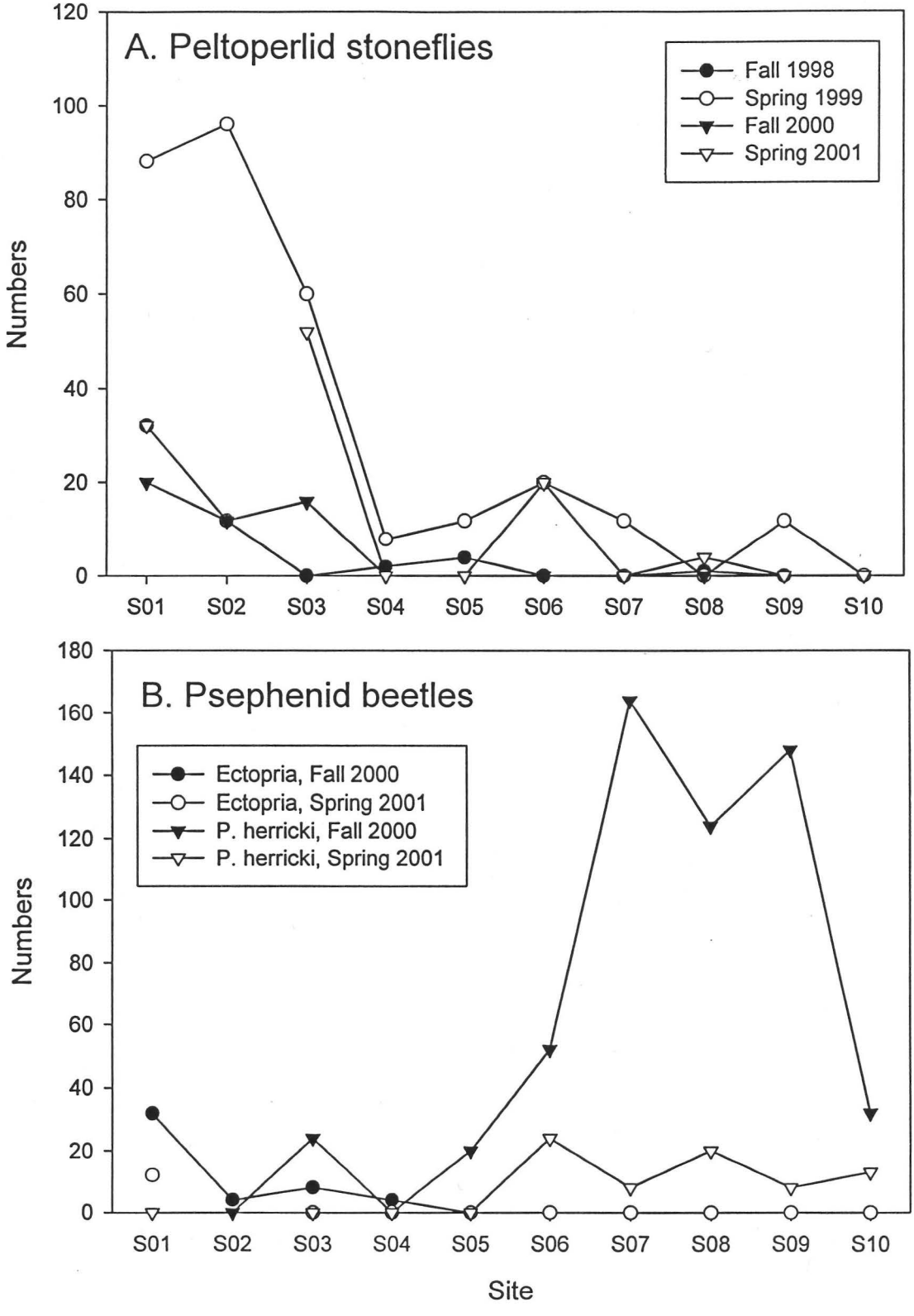


Fig. 11. Abundance of peltoperlid stoneflies (A) and two genera of Psephenid beetles (B) at each site on the Staunton River. Abundance for the Peltoperlid stoneflies are summarized for all four surveys and abundance of Psephenid beetles are summarized for the Fall 2000 and Spring 2001 surveys only.

Secondary Production

Community Production

Secondary production was calculated for 52 taxonomic groups, most of which were collected at both sites used in production sampling. Exceptions were *Isonychia* spp. (Ephemeroptera: Isonychiidae) and *Hydroptila* spp. (Trichoptera: Hydroptilidae) found only at site 7 and *Acroneuria* spp. (Plecoptera: Perlidae) and *Haploperla brevis* (Plecoptera: Perlodidae) from site 5. The cohort production interval (CPI) in months for each taxon (Table 4) was calculated based on size distribution data over time from the organisms measured in this study and was supported by data from Smock, et al. (1985) and Wallace and Anderson (1996). Some infrequently collected taxa were not used in the analysis due to difficulties in calculating production based on only one or a few individuals. Community production for each site was the sum of annual production values for all of the taxa.

We hypothesized that the open canopy conditions of the impacted site (site 7) would promote higher overall productivity of aquatic insects as a result of increased algal production in addition to allochthonous food sources transported from upstream, and from higher individual growth rates resulting from higher stream temperatures (Fig. 1H). However, we found that total community production was actually slightly higher at site 5 (Table 5).

Annual P/B Ratios

The range of annual P/B ratios for this study was 2.5 to 30.2 and was comparable to the range of values reported by Smock, et al. (1985) for a second-order blackwater stream in South Carolina. Annual P/B ratios for univoltine mayflies were generally not much higher than 5.0, although as a high as 12.1 for *Eurylophella* spp., and were the lowest for *Drunella* spp. due to its life cycle in the Staunton River that may involve a long egg diapause. For bivoltine mayflies annual P/B ratios were mostly close to 10.0 as predicted by Waters (1977), although were much higher for *Stenonema* spp. This was possibly due to the contributions of several species and many overlapping generations developing asynchronously. Among the Plecoptera, some of the semivoltine taxa such as predatory *Sweltsa* sp. (Chloroperlidae) (3.2 and 3.3) and *Agnetina capitata* (Perlidae) had the lowest P/B ratios (3.9 and 2.9), as did the semivoltine predator *Nigronia serricornis* (Megaloptera: Corydalidae) with a P/B ratio of 2.5.

Trichoptera annual P/B ratios exhibited the best overall conformity to expectations based on voltinism. Univoltine species had annual P/B ratios ranging from 3.5-7.4. Bivoltine species had annual P/B ratios all of which exceeded 10.0, ranging from 10.8-17.3. On the higher end of that range was *Hydropsyche* spp., (Hydropsychidae) net-spinning caddisflies known for high productivity in streams and rivers, although most studies report annual P/B ratios of 4.4-8.8 (e.g., Cudney and Wallace 1980; MacFarlane and Waters 1982; Benke, et al. 1984; Smock, et al. 1985) and as high as 10.8 for *H. bifida* in the Mississippi River (Payne and Miller 1996). Among the non-chironomid Diptera with univoltine and semivoltine life cycles, annual P/B ratios seldom exceeded 5.0, while bivoltine Diptera such as *Probezzia* spp. (Ceratopogonidae) and *Antocha* spp. (Tipulidae) generally had P/B ratios nearing 10.0. Simuliidae had high annual P/B ratios at both sites, mainly due to their 3-month CPI indicative of short generation times.

Table 4. Cohort production interval (CPI) and trophic group assignment used for annual production estimates of Staunton River macroinvertebrates.

Taxon	CPI (mo)	Trophic group*
Ephemeroptera		
Ameletus spp.	12	SC
Acentrella ampla	6	GA
Baetis spp.	6	SC
Caenis spp.	6	GA
Drunella spp.	12	SC
Eurylophella spp.	12	GA
Ephemerella spp.	12	GA
Epeorus spp.	12	SC
Stenonema spp.	6	GA
Isonychia spp.	6	FL
Paraleptophlebia spp.	10	GA
Plecoptera		
Paracapnia spp.	12	SH
Haploperla brevis	12	PR
Sweltsa spp.	24	PR
Leuctra spp.	12	SH
Amphinemura/Nemoura spp.	12	SH
Acroneuria spp.	12	PR
Agnetina capitata	24	PR
Isoperla spp.	12	PR
Allonarcys proteus	24	SH
Megaloptera		
Nigronia serricornis	24	PR
Trichoptera		
Agapetus spp.	12	SC
Glossosoma spp.	6	SC
Diplectrona modesta	12	FL
Hydropsyche spp.	6	FL
Hydroptila spp.	6	SC
Lepidostoma spp.	12	SH
Limnephilidae (multiple genera)	12	SH
Psilotreta labida	12	SC
Dolophilodes spp.	6	FL
Polycentropus spp.	12	PR
Rhyacophila spp.	12	PR
Neophylax spp.	12	SC
Coleoptera		
Elmidae (larvae)	12	SC
Elmidae (adults)	12	SC
Psephenus herricki	12	SC
Diptera		
Blepharicera sp.	12	SC
Probezzia sp.	6	PR
Demicryptochironomus spp.	4	GA
Microtendipes pedellus	4	FL
Polypedilum spp.	3	GA
Constempellina spp.	6	GA
Tanytarsini (multiple genera)	3	FL
Diamesa spp.	6	GA
Corynonura/Thienemanniella spp.	3.5	GA
Orthocladiini (multiple genera)	3	GA
Parachaetocladius spp.	12	GA
Tanypodinae (multiple genera)	3.5	PR
Empididae (multiple genera).	6	PR
Simuliidae (multiple genera)	3	FL
Antocha sp.	6	GA
Dicranota sp.	12	PR
Hexatoma/Limnophila spp.	24	PR

* FL = collector-filterer; GA = collector-gatherer; PR = predator; SC = scraper; SH = shredder. Taken from Merritt and Cummins (1996).

Table 5. Annual production, mean annual biomass, and annual production/biomass ratios for macroinvertebrate taxa from sites upstream (site 5) and downstream (site 7) of the effects of the June 1995 flood and associated debris flows.

	Site 5 (upstream – reference)			Site 7 (downstream – impacted)		
Taxon	Production ($mg \cdot m^{-2} \cdot yr^{-1}$)	Biomass ($mg \cdot m^{-2}$)	Annual P/B	Production ($mg \cdot m^{-2} \cdot yr^{-1}$)	Biomass ($mg \cdot m^{-2}$)	Annual P/B
Ephemeroptera						
Ameletus spp.	62.36	10.79	5.78	19.78	3.11	6.36
Acentrella ampla	4.29	0.45	9.61	12.07	0.87	13.86
Baetis spp.	45.83	4.52	10.15	161.01	14.85	10.84
Caenis spp.	0.22[a]	0.02	11.00	79.23	6.78	11.68
Drunella spp.	156.42	28.36	5.52	119.91	27.56	4.35
Eurylophella spp.	19.31	1.84	10.48	262.46	21.72	12.08
Ephemerella spp.	173.00	23.13	7.48	116.48	19.55	5.96
Epeorus spp.	151.07	16.13	9.37	134.21	15.49	8.67
Stenonema spp.	963.08	50.84	18.94	395.57	29.66	13.34
Isonychia spp.	0.00	0.00		8.96	0.75	11.96
Paraleptophlebia spp.	104.65	20.04	5.22	77.54	8.95	8.67
Plecoptera						
Paracapnia spp.	1.77	0.44	4.05	0.62	0.16	3.97
Haploperla brevis	54.37	8.80	6.18	0.00	0.00	
Sweltsa spp.	26.11	8.23	3.17	33.11	10.06	3.29
Leuctra spp.	26.31	3.59	7.34	21.15	2.69	7.87
Amphinemura/Nemoura spp.	0.78	0.15	5.28	0.09[a]	0.02	5.28
Acroneuria spp.	262.30	36.79	7.13	0.00	0.00	
Agnetina capitata	89.19	23.16	3.85	212.85	73.98	2.88
Isoperla spp.	14.95	2.61	5.73	21.35	3.37	6.34
Allonarcys proteus	402.33	87.10	4.62	1.72[a]	0.37	4.62
Megaloptera						
Nigronia serricornis	15.10[b]	6.04	2.50	35.70[b]	14.28	2.50

Table 5 (continued).

Taxon	Site 5 (upstream – reference) Production ($mg \cdot m^{-2} \cdot yr^{-1}$)	Biomass ($mg \cdot m^{-2}$)	Annual P/B	Site 7 (downstream – impacted) Production ($mg \cdot m^{-2} \cdot yr^{-1}$)	Biomass ($mg \cdot m^{-2}$)	Annual P/B
Trichoptera						
Agapetus spp.	1.12	0.32	3.47	6.67	1.40	4.76
Glossosoma spp.	34.72	3.02	11.49	25.87	2.13	12.15
Diplectrona modesta	76.40	10.32	7.40	0.22[a]	0.03	7.40
Hydropsyche spp.	467.65	27.00	17.32	103.20	7.71	13.34
Hydroptila spp.	0.00	0.00		18.95	1.63	11.61
Lepidostoma spp.	4.81	0.89	5.39	5.62	0.99	5.66
Limnephilidae (multiple genera)	80.37	20.03	3.99	0.49[a]	0.12	3.99
Psilotreta labida	71.20	11.79	6.04	181.03	42.63	4.25
Dolophilodes spp.	75.05	5.61	13.38	73.09	6.75	10.84
Polycentropus spp.	16.93	2.36	7.16	7.12	0.97	7.32
Rhyacophila spp.	10.56	1.69	6.23	15.04	2.59	5.80
Neophylax spp.	3.73	0.52	7.15	3.83	0.41	9.34
Coleoptera						
Elmidae	26.41	5.60	4.72[c]	136.62	25.20	5.42
Psephenus herricki	30.82	3.76	8.20	216.64	25.39	8.53
Diptera						
Blepharicera sp.	13.78	1.91	7.20	8.25	1.62	5.05
Probezzia sp.	42.59	4.88	8.73	44.65	5.53	8.07
Demicryptochironomus spp.	13.53	0.58	23.53	108.36	3.61	28.50
Microtendipes pedellus	5.61[a]	0.29	19.08	77.91	4.08	19.08
Polypedilum spp.	37.00	1.58	23.40	28.69	0.95	30.16

Table 5 (continued).

Taxon	Site 5 (upstream – reference) Production ($mg \cdot m^{-2} \cdot yr^{-1}$)	Biomass ($mg \cdot m^{-2}$)	Annual P/B	Site 7 (downstream – impacted) Production ($mg \cdot m^{-2} \cdot yr^{-1}$)	Biomass ($mg \cdot m^{-2}$)	Annual P/B
Constempellina spp.	0.96	0.09	11.19	0.92	0.10	8.78
Tanytarsini (multiple genera)	193.56	6.52	29.69	111.01	5.83	19.02
Diamesa spp.	0.30[a]	0.02	12.98	5.09	0.39	12.98
Corynonura/Thienemanniella	14.52	0.69	21.07	17.55	1.04	16.91
Orthocladiini (multiple genera)	100.60	4.90	20.40	84.57	3.59	23.58
Parachaetocladius spp.	16.43	0.62	26.37	27.71	1.64	16.94
Tanypodinae (multiple genera)	228.57	11.62	19.68	259.35	15.26	17.00
Empididae (multiple genera)	0.98	0.08	12.47	9.46	0.86	11.03
Simuliidae (multiple genera)	13.23	0.50	26.53	25.56	0.97	26.27
Antocha sp.	3.57	0.50	7.13	2.42	0.35	6.84
Dicranota sp.	3.84	0.72	5.32	0.07[a]	0.01	5.32
Hexatoma/Limnophila spp.	145.71	34.97	4.17	275.34	84.97	3.24
TOTALS	**4307.99**	**496.31**		**3595.11**	**502.92**	

[a] Production calculated by multiplying the annual P/B ratio calculated for the other site by the biomass measured.

[b] Production calculated by assuming a P/B ratio of 2.5 for semivoltine life cycle.

[c] Annual P/B ratio and biomass estimates include adult elmid beetles which also have an aquatic phase. However, production estimates do not include adults because the adult life stage is non-growing (Benke 1984).

Annual P/B ratios for the Chironomidae (Diptera) were generally the highest of those calculated for the study. Although the bivoltine genera *Constempellina* and *Diamesa* had annual P/B ratios around 10.0, most of the midges had values ranging from 16.9-30.2. The reciprocal of the annual P/B, whose unit is inverse time (yr^{-1}), is the biomass turnover rate or the time required to replace the biomass of the population (Benke 1984). Such annual P/B ratios indicate that even in cold mountain streams midge populations are replacing their biomass every 12-21 days. So, while Chironomidae mean standing stock biomass accounted for only 5.4% and 7.3% of the total at sites 5 and 7 respectively, the midge percent contribution to annual production accounted for 14.2% and 20.1% of the community total.

Trophic Group-Based Production

In contrast to patterns of trophic composition based on abundance data (see above), trophic composition patterns based on secondary production generally conformed to our *a priori* hypotheses (Fig. 1I). At the impacted site, production of the assemblage of insects morphologically and behaviorally adapted to be scrapers (grazers) of algae and diatoms was nearly twice as high at the un-impacted site comprising nearly 30% of the total community production compared with less than 15% at the upstream site (Fig. 12). The annual production of *Baetis* spp. (Ephemeroptera: Baetidae), *Psilotreta labida* (Trichoptera: Odontoceridae) and *Psephenus herricki* (Coleoptera: Psephenidae) were all dramatically higher at site 7, accounting for a combined 54.1% of scraper production. At site 5 these taxa accounted for only 24.7% of combined scraper production. The mayfly *Ameletus* spp. (Ameletidae) had higher production at site 5 than at site 7, while other Ephemeroptera such as *Drunella* spp. (Ephemerellidae) and *Epeorus* spp. (Heptageniidae) did not differ much in their actual annual production between sites. Beetles of the family Elmidae are also scrapers and are represented in the Staunton River by *Optioservus* spp. and *Oulimnius latiusculus*. These scrapers also had notably higher productivity in the impacted site despite the fact that in our fall and spring surveys Elmidae abundances were often higher in upstream sites and diminished downstream (Appendix I-VIII).

The proportion of community production represented by the shredder trophic group also conformed to predictions (Fig. 1I). Specifically, shredder production was much lower at the impacted site comprising less than 1% of the total community production compared with about 12% at the upstream site (Fig. 12). Among shredder-detritivores, *Allonarcys proteus* (Plecoptera: Pteronarcyidae) and Limnephilidae (Trichoptera) accounted for 77.9% and 15.5% respectively of unimpacted site shredder production. Annual production of shredders in the impacted zone was very small at 29.7 $mg/m^2/yr$ (0.8% of the site 7 total).

In contrast to patterns observed for the other trophic groups, the proportion of production associated with the filterer trophic group did not conform to our expectations. We hypothesized that filterer production would be higher at the impacted site (Fig. 1I). However, filterer production was actually lower at the impacted site (site 7) (Fig. 12). Collector-filterer production was mainly a result of the combined contribution of *Hydropsyche* spp. (Trichoptera: Hydropsychidae) and Tanytarsini (Diptera: Chironomidae) that accounted for 79.5% of filterer production at site 5 and 53.6% at site 7. A small amount of collector-filterer production was provided by *Isonychia* sp., a morphologically specialized mayfly that was found only in the

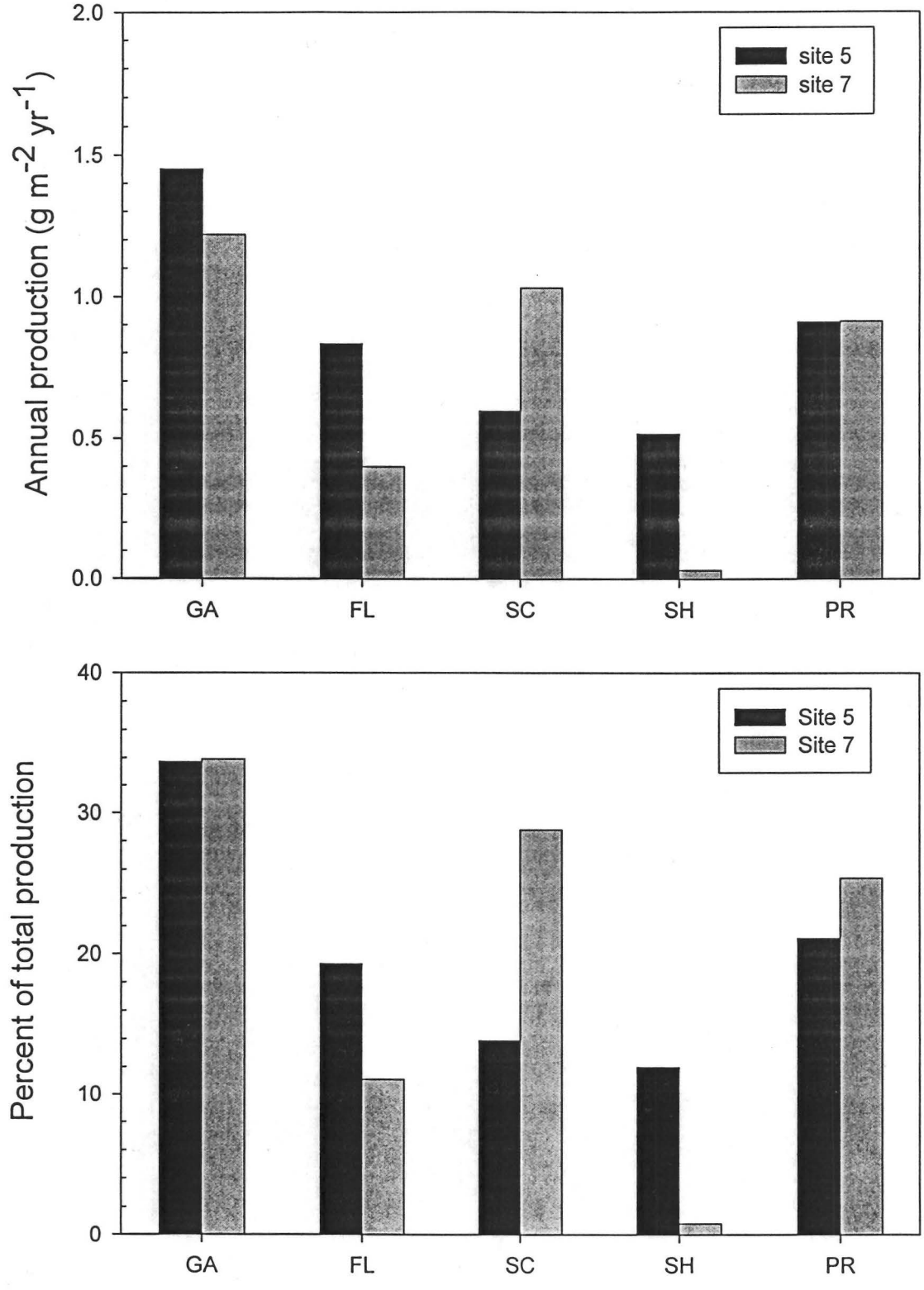


Figure 12. Comparison of Staunton River macroinvertebrate trophic group production between sites. Top panel shows production estimates for each trohic group (GA = collector-gatherers; FL = collector-filterers; SC = scrapers; SH = shredders; PR = predators) and each site (black bar = site 5; grey bar = site 7). Bottom panel compares the percentage of the total production associated with each trophic group.

impacted zone. The midge larva *Microtendipes pedellus* was the only filter-feeding taxon with annual productivity substantially higher at the impacted site.

Other notable patterns were observed. For example, the secondary production of *Eurylophella* spp. (Ephemeroptera: Ephemerellidae) was 13.5 times higher at site 7 with 262.46 mg/m^2/year compared with 19.31 mg/m^2/year at site 5. *Eurylophella*, represented by the species *E. funeralis* and *E. temporalis* in the Staunton River, are generally regarded as shredder-detritivores and collector-gatherers respectively. However, it is possible that these taxa may be more capable than other generalist feeders of taking advantage of increased algal productivity when it occurs.

As expected, the proportion of production represented by the gatherer and predator trophic groups was not substantially different between sites (Fig. 11). Collector-gatherers tend to contribute highly to community production estimates because many species can be assigned to that trophic group because of their generalized feeding habits. Smock, et al (1985) reported that collector-gatherers, including species of *Eurylophella* and *Polypedilum*, comprised 40-53% of total stream macroinvertebrate production in a South Carolina blackwater stream. Collector-gatherers made up 33.7% (site 5) and 33.9% (site 7) of community production in this study. Dominant collector-gatherers at both sites were the mayflies *Ephemerella* spp. (Ephemerellidae), *Stenonema* spp. (Heptageniidae), and *Paraleptophlebia* spp. (Leptophlebiidae) and midge larvae of the Tribe Orthocladiini, which in the present study included an approximate eight genera. Taxa that were much more productive in the impacted site included *Caenis* spp. (Ephemeroptera: Caenidae), *Demicryptochironomus* spp. (Diptera: Chironomidae), and *Eurylophella* spp. (discussed above).

For some collector-gatherer taxa, secondary production was considerably higher at the un-impacted site. A notable case is that of the mayfly *Stenonema* spp., whose production at site 5 (963.1 mg/m^2/year) was more than twice that of site 7 (395.6 mg/m^2/year). *Stenonema* accounted for 66.4% of the total collector-gatherer production at site 5. Much of the production at the un-impacted site was due to a combination of higher numbers and higher numbers of larger individuals compared to the impacted site.

Predatory insects also showed little difference in productivity between the two sites (Fig. 12) and comprised 21.1% of the total community production at site 5 and 25.4% at site 7. The proportion of predator mean biomass was even higher at 28.6% and 42.0%. This was higher than expected based on relationships between stream size and macroinvertebrate functional group occurrence that assert that predators make up about 10% of invertebrate biomass consistently along the river continuum (Vannote, et al. 1980). It is possible that some of these predators, such as *Isoperla bilineata* (Plecoptera: Perlodidae), may function more as omnivores than as strict predators (Shapas and Hilsenhoff 1976) and therefore we have overestimated predator annual production. An additional consideration is that the high biomass turnover rates of prey such as Hydropsychidae and Chironomidae can support such a predator component. Two genera of stoneflies (Perlidae), Tanypodinae (Diptera: Chironomidae), and *Hexatoma/Limnophila* spp. (Diptera: Tipulidae), were the most productive taxa. These taxa combined contributed 79.6% (site 5) and 81.8% (site 7) of predator secondary production. These taxa also serve as good examples of how the different life history strategies of aquatic insects inhabiting dynamic lotic systems can be revealed by secondary production research. Perlidae and many Tipulidae have

comparatively long (univoltine and often semivoltine) life cycles and achieve large body sizes. This is reflected in their low annual P/B ratios. Univoltine *Acroneuria* spp. had a P/B ratio of 7.1, while the semivoltine *Agnetina capitata* had annual P/B ratios of 3.8 and 2.9 in this study. The crane fly larvae (*Hexatoma/Limnophila* spp.) had annual P/B ratios of 4.2 and 3.2 and were also semivoltine. The Tanypodinae, to the contrary, had annual P/B ratios of 19.7 and 17.0 typical of the chironomid strategy of short life cycles, smaller body sizes, and high biomass turnover rates.

DISCUSSION

Benthic community structure

The often-used structural metrics of taxonomic richness, abundance, and community similarity did little to reveal post-flood consequences to the Staunton River macroinvertebrate community. We predicted that flood impacted sites on the Staunton River would differ in regard to key structural elements. Specifically, we hypothesized that taxonomic richness and community similarity would both be reduced in downstream sites. The data indicate that taxa richness did not differ significantly, although in most surveys did decrease slightly from upstream to downstream sites. The reference stream, however, exhibited the same trend and did so more strongly. Thus, any decreases in taxonomic richness would be due to other factors. Aquatic insects as a group are highly vagile (Merritt and Cummins 1996) and consequently are capable of rapidly re-colonizing areas denuded by disturbance. Rapid re-colonization of numerous taxa has been shown to occur after even severe floods and debris flows (e.g., Hendricks et al. 1995, Lamberti et al. 1991). Since our assessment did not begin until three years post-disturbance, high taxa richness observed at impacted sites may not be remarkable.

In terms of total invertebrate abundance, we observed that numbers of individuals decreased between upstream and downstream sites on White Oak Canyon Run (reference stream), while patterns observed on the Staunton River were more seasonably variable, increasing in the fall and decreasing in the spring. It is possible that lower spring densities reflect some difference in the timing of emergence of impacted zone insects. Thermal differences between more shaded upstream sites and more exposed downstream sites could account for such a phenomenon by reducing the size at maturity and stimulating earlier emergence for some taxa (Sweeney and Vannote 1978, Sweeney 1986). That is, if water temperatures stimulated earlier emergence at sites within the impacted zone, then our between-site abundance comparisons may have been compromised.

Our hypothesis that communities at sites in the impacted zone would be less stable (i.e., less similar from year to year within a season) was only partially supported. Specifically, the data from the two spring surveys showed the expected trends (i.e., lower community similarity at sites within the downstream zone) whereas data from the fall surveys did not. The observed higher variability in community similarity between spring surveys may be a result of less stable instream substratum resulting from the reconfiguration of the stream channel during the June 1995 debris flows. During spring high flows there would be a higher tendency toward movement of substratum. Many studies suggest that the degree of bed movement, more than just high water, constitute disturbances to benthic communities (Cobb and Flannagan 1990; Giberson and Cobb 1995; Biggs, et al. 1999; Duncan, et al. 1999). It has also been shown that stream bed disturbance associated with channelization results in long-term substrate instability (Shields and Hoover 1991). We hypothesize that the deep scouring and repositioning of the lower Staunton stream channel would result in a less embedded substratum leaving the stream bottom and its communities more susceptible to subsequent disturbances for a period of years. This explanation may also explain seasonal patterns in abundance (see above).

Some changes in macroinvertebrate trophic structure were evident in the impacted reach of the Staunton River. In general, the proportions of scrapers and collector-filterers increased and shredders decreased in the impacted sites on the Staunton River. However, the trends were not consistent among surveys and often were not significant compared with proportionate occurrence in upstream sites. There was much site-to-site variation and we attribute much of the observed patterns to local-scale habitat differences among sites. For example, sites 8 and 10 had larger proportions of bedrock than more upstream sites such as 5, 6, and 7 that had predominantly cobble and boulder substrata. Such differences will influence available food sources, local flow conditions, spatial heterogeneity and ultimately assemblage structure (Minshall 1984). Local geomorphology has been demonstrated to be an important determinant of functional group secondary production in Appalachian streams (Haefner and Wallace 1981; Gurtz and Wallace 1986; Huryn and Wallace 1987). Therefore, we infer that it has similar influences on structural components of the community, such as composition and diversity. We hypothesize that the lack of apparent broad longitudinal patterns in species composition and changes to structural metrics (i.e., taxonomic diversity and abundance) along the stream gradient were the result of overriding geomorphologic attributes.

Community production

Our prediction of higher community production in the impacted site did not hold true. Annual productivity at site 5 exceeded that of site 7 by nearly 713 $mg/m^2/yr$, although mean standing stock biomass was almost equal between the two sites. Thus, our data suggest that any stimulatory effects associated with increased light, increased primary production, and higher water temperatures may have been neutralized by other flood-induced changes such as reduced substratum stability. Another possible explanation is that predation pressure may have increased in the impacted zone from increasing fish densities. Dolloff and scientists from VPI found that trout density and mean size of juvenile fish increased significantly in the impacted zone (Dolloff, personal communication).

The contribution of the major aquatic insect trophic groups did however provide a picture more consistent with hypothesized patterns of post-disturbance productivity. The most profound observation was that the secondary production of shredder-detritivores was lower and secondary production of scrapers was higher in the impacted zone site. Higher productivity among primary producers (algae and diatoms) was very likely in the impacted zone due to the positive relationship between solar input and algal growth (Tait, et al. 1994). The effects of macroinvertebrate grazing on algal biomass and production are variable with some caddisflies reducing biomass and productivity, while stimulating turnover rates (Lamberti, et al. 1995), while mayfly feeding seems to have less of an impact on algae (Hill and Knight 1988; Lamberti, et al. 1995). Differences in life histories of grazing macroinvertebrates may allow coexistence and reduce competition (Lamberti, et al. 1995). Variability in patterns of Staunton River grazer production may be explained by similar life history strategies. *Ameletus* spp. was the only grazing taxa whose higher productivity in the upstream site was substantially higher than in the downstream site. This may be attributed to habitat requirements, particularly substratum and flow preferences, which differed between the two sites.

The contribution of the shredder-detritivore guild accounted for less than 1% of annual production in the impacted site. This was probably due to a reduction in leaf litter and other sources of coarse particulate organic matter (CPOM). Such sources of allochthonous productivity would be limited by the lack of a riparian zone. Upstream sites would still contribute some CPOM to the lower Staunton River. However some additional factors will affect the fate of that CPOM contribution. One is the degree of retention of leaf packs by the impacted site substrata. We hypothesize that the particle stability and degree of imbeddedness were both reduced as a consequence of the intense scouring and repositioning of the stream channel by debris flows. This long-term consequence for the stream bottom may hinder retention of leaf packs compared with upstream locations. A second factor pertains to the vagility of large leaf-shredding insects like *Allonarcys proteus* and *Pycnopsyche* spp. that provided the majority of shredder production at site 5, but were almost absent from site 7. These large insects, which in some cases have semivoltine life cycles and low biomass turnover, may be slow to re-colonize severely disturbed areas. At site 7, 71% of shredder production was from *Leuctra* spp., a small stonefly more likely to colonize through larval drift and adult dispersal flights.

Contrary to predictions, annual production of collector-filterers was higher in the un-impacted site than in the impacted one. The prediction that collector-filterer production would be higher in downstream site was based on the tendency for communities in mid-order reaches, or in this case a simulated mid-order reach, to be increasingly dependent on fine particulate organic matter (FPOM) from upstream sources (Vannote, et al. 1980). The reduction in CPOM in the impacted zone would not only contribute to a lack of shredders, but also increase available habitats for other trophic guilds, such as filter feeders. About 74% of the filterer production at site 5 was from net-spinning caddisflies (Hydropsychidae and Philopotamidae). Net-spinning caddisflies are documented to produce different sizes of food capture mesh (Fuller and Mackay 1980) and tend to be distributed longitudinally along stream gradients based on the mesh size, food particle size ranges, and current velocities (Wallace 1975; Malas and Wallace 1977). *Diplectrona modesta* constructs a coarse capture net and feeds on detritus fragments in its late instars, whereas *Dolophilodes* spp. specializes on FPOM and constructs a fine capture net (Malas and Wallace 1977). *Dolophilodes* spp. production was nearly equal at the two sites and tends to be collected in low current velocities. *Hydropsyche* spp., mainly represented by *H. slossonae* in our study, build capture nets of intermediate sizes and tend to be generalist feeders, consuming animal material and a variety of other organic particulates. Substratum and flow conditions probably account for higher abundances and higher productivity of *Hydropsyche*, which is 4.5 times higher at site 5 than at site 7. The upstream site has more boulder and cobble substrata with more variable flow conditions and presumably higher degrees of particle heterogeneity and interstitial space. This combination of habitat attributes promotes high numbers of coexisting net-spinning caddisflies species that partition space on rocks and in a variety of flow conditions. A higher proportion of collector-filterer productivity at site 7 (47%) was contributed by *Microtendipes pedellus* and Tanytarsini spp. (Chironomidae).

Effectiveness of Structural vs. Functional Metrics

The results of this study indicate that secondary production data provide a picture more consistent with predictions of stream responses to disturbance and particularly riparian removal than do abundances and taxonomic composition. One reason for this is that synoptic surveys do not have the power of secondary production analyses that integrate data from an entire year. Fall and spring surveys, no matter how well timed their implementation, are still snapshots in the lives of the populations that comprise communities. The season in which field collections or experiments are conducted is important. Seasonal variation in community structure may be greater than the effects of disturbances such as short recurrence interval floods (Angradi 1997) or experimental manipulations of substratum (Robinson and Minshall 1986). Moreover, surveys rely on taxonomic composition and numbers, without regard to the size or developmental stage of the organisms. For example, 100 tiny *Drunella* may not have the combined biomass of a single mature individual collected prior to emergence. Secondary production combines a year's worth of information on growth, development, biomass, and mortality into a functional measure that addresses the energetic state of ecosystems. Count data are less effective at addressing ecological questions where trophic control of the ecosystem is an issue. Lugthart and Wallace (1992) determined that abundance data greatly underestimated the impact of insecticide treatment disturbances in an Appalachian mountain stream, while secondary production provided a more accurate assessment of disturbance effects. In other comparative studies of streams in undisturbed catchments and clear-cut catchments in the Appalachian Mountains there were a wider range of results. Filter feeding caddisflies (Hydropsychidae) showed higher production in a disturbed catchment stream (Haefner and Wallace 1981). Benthic densities of leaf-shredding stoneflies (Peltoperlidae) in an undisturbed stream were more than twice that from a disturbed catchment stream, but secondary production was not significantly different (O'Hop, et al. 1984). These studies were each conducted 10 years post-disturbance and show not only the strength of secondary production data in assessing disturbance effects, but that the long-term effects of disturbances on streams may be as varied as the streams themselves. Perhaps more importantly, structural measures based on snapshots may not be sensitive enough to detect important long-term changes in stream communities.

Debris Flow Effects as an Analogue to Human Induced Disturbances

In the short-term, a disturbance such as removal of the riparian zone tends to favor increases in benthic community abundances. In Quartz Creek, a third-order Oregon stream, densities of macroinvertebrates exceeded those from the pre-flood state within 6 months of a major debris flow (Lamberti, et al. 1991). The opening of the canopy initially results in a shift in the trophic base of production as more instream primary productivity favors populations of grazing invertebrates (Murphy, et al. 1981; Lamberti, et al. 1991). Reductions in the amount of leaf litter will be followed by reductions in organisms reliant on coarse organic matter. Differences in the abundances and the secondary production of scrapers and shredders between Staunton River sites 5 and 7 were the most profound post-flood effects we found in this study. Data from studies of post-logging succession in stream catchments provide insight into how the lower Staunton community may develop.

Stone and Wallace (1998) found an increase in the proportion of shredders and a decrease in scraper-grazers in a disturbed stream 16 years after clear-cutting. Leaf litter processing rates and shredding macroinvertebrate abundances were higher in a stream draining a catchment that had been logged 20 years prior than in one that had been undisturbed for 80 years (Griffith and Perry 1991). This was attributed to the tree species in the disturbed catchment that had fast decomposing leaves that, in turn, promoted a large assemblage of detritivorous invertebrates (Griffith and Perry 1991). Such studies point to the strong impact riparian communities have on stream processes such as macroinvertebrate community structure and function (Hynes 1975).

In all likelihood, the major post-disturbance events of colonization and community re-assembly in the lower Staunton River happened within the first year. Aquatic insects re-colonize flood disturbed substrata quickly (e.g., Reice 1985), even in cases of severe floods (Hendricks, et al. 1995). In the above-mentioned Oregon stream impacted by a large debris flow, macroinvertebrate densities equaled those from un-impacted reaches after 9 months, although population densities fluctuated for 3 years post-flood (Lamberti, et al. 1991). The beginning of this study, three years after the event, missed all of the initial recovery. However, the continued "fine-tuning" of macroinvertebrate assemblage structure and succession of the riparian community can be studied for decades. Some studies of Appalachian mountain streams focused on catchments in various stages of succession following clear-cutting (Gurtz and Wallace 1986; Stone and Wallace 1998). Viewing the impact to the lower Staunton River as analogous to clear-cut logging, we can make predictions on how aquatic macroinvertebrate communities will change over time as the riparian forest recovers.

An indirect effect of the loss of riparian cover may be stream bank instability and the likelihood of increased erosion and sedimentation impacts on aquatic communities (Culp and Davies 1983). Sedimentation interferes with respiration and with the feeding mechanisms of collector-filterer insects. Sedimentation has been demonstrated to affect substratum availability and reduce benthic density (Lenat, et al. 1981). Increased light penetration in the stream that influences temperature regimes and promotes growth of diatoms and algae is another likely long-term consequence. Temperature data from the Staunton River indicate that mean daily temperatures in the impacted zone are warmer than in upstream sites. Thermal effects are known to have consequences for growth and maturation of aquatic insects (Sweeney, et al. 1986). Data on size distributions of Staunton River mayflies suggest that impacted site organisms achieve larger body sizes and emerge earlier than their upstream congeners. Consequently thermal effects are likely. Instream sources of primary productivity were not measured in this study, but secondary production of scrapers at site 7 was nearly twice that from site 5 and suggests that algal production likely accounts for the difference.

The aftermath of the lower Staunton River debris flows left large amounts of large woody debris (LWD). Our observations indicate that the majority of this LWD is located outside of the stream channel, in most cases suspended over the channel. However, it is likely that this LWD will ultimately find its way into the stream channel as the wood decays and future storms dislodge logs and branches. The introduction of large amounts of wood into the lower Staunton River would serve as a source of CPOM for bacterial, fungal, and macroinvertebrate processing and create debris dams that retain organic materials (Ehrman and Lamberti 1992; Webster 1994). In logged catchments lacking debris dams there is accelerated turnover and depletion of benthic

organic material (Golladay et al. 1987; Webster, at al. 1990). Debris dams are known to enhance stream habitats for shredding macroinvertebrates, which exhibit higher densities and productivity in debris dams than in other substrata (Roeding and Smock 1989), although their impact on macroinvertebrate communities in high gradient streams is unclear (Hilderbrand, et al. 1997).

Periodic assessments using the methodologies described in this study, i.e., biotic surveys and community production, will be useful in tracking macroinvertebrate community succession in the lower Staunton River. As a more full riparian community develops, instream processes will gradually return to a pre-flood state of trophic structure based on allochthonous inputs. A stable riparian community will also ameliorate the impacts of future small-scale floods on physical habitat and aquatic communities. Differences in the contribution of aquatic insect trophic groups to total community production may also lesson as the impacted reaches approach a pre-flood state. Local geomorphology will continue to be a pervasive structuring mechanism on aquatic macroinvertebrate communities regardless of the stage of riparian or instream succession.

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Appendix I. Fall survey 1998 taxa list for Staunton River in Shenandoah National Park, Madison County, Virginia.

	S01	S02	S03	S04	S05	S06	S07	S08	S09	S10
Ephemeroptera										
Ameletidae										
Ameletus sp. Eaton 1885	280	0	0	0	4	92	4	0	0	0
Ameletus cryptostimulus Carle 1978	0	0	0	0	0	0	0	0	0	0
Ameletus lineatus Traver 1932	0	0	0	0	0	0	0	0	0	0
Baetidae										
Acentrella ampla Traver 1932	92	24	8	13	0	4	8	12	0	20
Baetis sp. Leach 1815	0	0	20	20	28	20	40	84	64	12
Baetis brunneicolor McDunnough 1925	0	0	0	0	0	0	0	0	0	0
Baetis flavistriga McDunnough 1921	0	0	0	0	0	0	0	0	0	0
Baetis cf. *intercalaris* McDunnough 1921	0	0	0	0	0	0	0	0	0	0
Baetis tricaudatus Dodds 1923	24	88	0	2	0	8	0	0	0	0
Baetiscidae										
Baetisca carolina Traver 1931	0	0	0	0	0	0	0	0	0	4
Caenidae										
Caenis sp. Stephens 1835	0	0	0	0	0	0	0	0	0	0
Ephemerellidae										
Drunella sp. Needham 1905	0	0	0	0	0	0	0	0	0	0
Drunella cf. *lata* (Morgan 1911)	0	0	0	0	0	0	0	0	0	0
Ephemerella sp. Walsh 1862	0	0	0	0	0	32	104	1	0	16
Ephemerella dorothea Needham 1908	0	0	0	0	0	0	0	0	0	0
Ephemerella hispida Allen and Edmunds 1965	0	0	0	0	0	0	0	0	0	0
Ephemerella rossi Allen and Edmunds 1965	0	0	0	0	0	0	0	0	0	0
Ephemerella cf. *subvaria* McDunnough 1925	0	0	0	1	104	32	24	1	12	0
Eurylophella sp. Tiensuu 1935	1056	744	56	581	136	4980	1144	2167	144	584
Eurylophella funeralis (McDunnough 1925)	0	0	0	0	0	0	0	0	0	0
Eurylophella temporalis (McDunnough 1924)	0	0	0	1	0	0	0	0	0	0
unidentified Ephemerellidae	0	0	0	0	0	0	0	0	80	0
Ephemeridae										
Ephemera sp. Linnaeus 1758	0	0	0	0	0	0	0	0	0	0
Ephemera simulans Walker 1853	0	0	0	0	0	0	0	0	0	0
Heptageniidae										
Cinygmula subaequalis (Banks 1914)	0	0	0	0	0	0	0	0	0	0
Epeorus sp. Eaton 1881	380	372	16	24	8	48	32	9	0	32
Epeorus (Iron) dispar (Traver 1935)	0	0	0	0	0	0	0	0	0	0

Appendix I. Continued.

	S01	S02	S03	S04	S05	S06	S07	S08	S09	S10
Ephemeroptera (continued)										
Heptageniidae (continued)										
Epeorus (Iron) pleuralis (Banks 1910)	0	0	0	0	0	0	0	0	0	0
Epeorus (Iron) rubidus (Traver 1933)	0	0	0	0	0	0	0	0	0	0
Heptagenia sp. Walsh 1863	0	0	0	0	0	0	0	0	0	0
Leucrocuta sp. Flowers 1980	0	0	0	0	0	24	0	0	0	0
Rhithrogena sp. Eaton 1881	0	0	0	0	0	0	0	0	0	0
Stenacron sp. Jensen 1974	120	112	36	1	0	0	20	0	0	8
Stenacron cf. *pallidum* (Traver 1933)	0	0	0	0	0	0	0	0	0	0
Stenonema sp. Traver 1933	4	0	4	32	76	28	0	17	16	0
Stenonema femoratum (Say 1823)	0	0	0	0	0	0	0	0	0	0
Stenonema meririvulanum Carle and Lewis 1978	0	0	0	0	0	0	0	0	0	0
Stenonema pudicum (Hagen 1861)	0	0	0	0	8	24	36	0	0	0
Stenonema vicarium (Walker 1853)	0	0	0	0	0	0	0	0	0	0
unidentified Heptageniidae	0	0	0	0	0	0	0	0	0	0
Isonychiidae										
Isonychia sp. Eaton 1871	0	0	0	0	0	0	0	0	0	0
Leptophlebiidae										
Habrophlebia vibrans Needham 1908	0	0	0	0	0	0	0	0	0	0
Paraleptophlebia sp. Lestage 1917	328	280	76	36	16	180	68	44	16	92
Paraleptophlebia adoptiva (McDunnough 1929)	0	0	0	0	0	0	0	0	0	0
Paraleptophlebia cf. *mollis* (Eaton 1871)	0	0	0	0	0	0	0	0	0	0
Odonata										
Aeshnidae										
Boyeria grafiana Williamson 1907	0	0	0	0	0	0	0	0	0	0
Calopterygidae										
Hetaerina sp. Hagen 1854	0	0	0	0	0	0	0	0	0	0
Cordulegastridae										
Cordulegaster sp. Leach 1815	0	0	0	0	0	0	0	0	0	0
Gomphidae										
Lanthus parvulus (Selys 1854)	16	4	0	2	0	8	0	3	0	0
Lanthus vernalis Carle 1980	0	0	0	0	0	0	0	0	0	0
cf. *Stylogomphus albistylus* (Hagen 1878)	0	0	0	0	0	0	0	0	0	0
unidentified Gomphidae	0	0	0	0	0	0	0	0	0	0

Appendix I. Continued.

	S01	S02	S03	S04	S05	S06	S07	S08	S09	S10
Plecoptera										
Capniidae										
Paracapnia sp. Hanson 1946	144	72	68	144	104	596	232	1079	88	200
Chloroperlidae										
Haploperla brevis (Banks 1895)	204	212	52	153	176	304	112	351	192	12
Sweltsa sp. Ricker 1943	0	0	0	0	0	0	0	0	0	0
Leuctridae										
Leuctra sp. Stephens 1836	144	92	44	63	16	32	28	39	104	4
Zealeuctra sp. Ricker 1952	0	0	0	0	0	0	0	0	0	0
Nemouridae										
Amphinemura sp. Ris 1902	76	24	8	18	0	0	0	0	0	0
Amphinemura nigritta (Provancher 1876)	0	0	0	0	0	0	0	0	0	0
Amphinemura wui (Claassen 1936)	0	0	0	0	0	0	0	0	0	0
Nemoura sp. Latreille 1796	0	0	0	0	0	0	0	0	0	0
Peltoperlidae										
Peltoperla sp. Needham 1905	32	12	0	2	0	0	0	1	0	0
cf. *Tallaperla* sp. Stark and Stewart 1981	0	0	0	0	4	0	0	0	0	0
Perlidae										
Acroneuria sp. Pictet 1841	0	0	0	0	36	0	0	0	0	0
Acroneuria abnormis (Newman 1838)	0	0	0	0	0	0	4	0	0	0
Acroneuria carolinensis (Banks 1905)	0	0	0	0	0	0	0	0	0	0
Agnetina capitata (Pictet 1841)	0	0	0	0	0	32	0	8	12	0
Eccoptura xanthenes (Newman 1828)	0	0	0	0	0	0	0	0	0	0
Paragnetina sp. Klapálek 1907	0	0	0	0	0	4	24	0	0	0
Paragnetina immarginata (Say 1823)	0	0	0	0	0	0	0	0	0	0
unidentified Perlidae	4	4	0	1	0	4	0	13	0	0
Perlodidae										
Isogenoides hansoni (Ricker 1952)	0	0	0	0	0	0	0	1	0	0
Isoperla sp. Banks 1906	164	304	44	133	52	320	248	1	52	180
Isoperla bilineata (Say 1823)	0	0	0	0	0	0	0	0	0	0
Isoperla cf. *cotta* Ricker 1952	0	0	0	0	0	0	0	0	0	0
Isoperla lata Frison 1942	0	0	0	0	0	0	0	0	0	0
Isoperla marlynia Needham and Claassen 1925	0	0	0	0	0	0	0	0	4	0
Isoperla similis (Hagen 1861)	0	0	0	0	0	0	0	0	0	0
Malirekus hastatus (Banks 1920)	0	0	0	0	0	0	0	0	0	0
Yugus sp. Ricker 1952	0	0	0	0	0	0	0	0	0	0

Appendix I. Continued.

	S01	S02	S03	S04	S05	S06	S07	S08	S09	S10
Plecoptera (continued)										
Pteronarcyidae										
Allonarcys sp. Needham and Claassen 1925	0	0	0	1	0	28	0	0	0	0
Allonarcys proteus (Newman 1838)	0	0	0	1	0	0	0	0	0	0
Taeniopterygidae										
Taeniopteryx sp. Pictet 1841	0	0	0	0	0	0	0	0	0	20
Hemiptera										
Gerridae										
Gerris sp. Fabricius 1794	4	0	0	0	0	0	0	0	0	0
Veliidae										
Rhagovelia sp. Mayr 1865	0	0	0	0	0	0	0	0	0	0
Megaloptera										
Corydalidae										
Nigronia sp. Banks 1908	0	0	0	0	0	0	0	0	0	0
Nigronia serricornis (Say 1824)	0	0	0	0	0	0	0	6	0	0
Sialidae										
Sialis sp. Latreille 1802	0	0	0	0	0	0	0	0	0	0
Trichoptera										
Brachycentridae										
Adicrophleps hitchcocki Flint 1965	56	0	0	0	0	0	0	0	0	0
Glossosomatidae										
Agapetus sp. Curtis 1834	0	0	0	0	0	4	0	0	0	0
Glossosoma sp. Curtis 1834	0	0	0	0	0	28	12	0	0	4
Hydropsychidae										
Cheumatopsyche sp. Wallengren 1891	0	0	0	0	0	0	0	3	0	140
Diplectrona metaqui Ross 1970	0	0	0	0	0	0	0	0	0	0
Diplectrona modesta Banks 1908	44	64	4	0	0	4	4	0	0	0
Hydropsyche sp. Pictet 1834	0	0	0	6	8	8	0	13	24	0
Hydropsyche alhedra Ross 1939	0	0	0	0	0	0	0	0	0	0
Hydropsyche bronta Ross 1938	0	0	0	0	0	0	0	0	0	0
Hydropsyche slossonae Banks 1905	8	8	0	0	0	36	40	12	0	0
Hydropsyche sparna Ross 1938	4	0	0	0	0	0	0	1	0	0
Parapsyche apicalis (Banks 1908)	0	0	0	0	0	0	0	0	0	0

Appendix I. Continued.

	S01	S02	S03	S04	S05	S06	S07	S08	S09	S10
Trichoptera (continued)										
Hydroptilidae										
Hydroptila sp. Dalman 1819	0	0	0	0	0	0	8	132	0	64
Ochrotrichia sp. Mosely 1934	0	0	0	0	0	0	0	4	0	0
Palaeagapetus celsus (Ross 1938)	4	0	0	0	0	0	0	0	0	0
Lepidostomatidae										
Lepidostoma sp. Rambur 1842	28	0	0	0	4	44	72	109	32	36
Leptoceridae										
Nectopsyche sp. Müller 1879	0	0	4	0	0	0	0	0	0	4
Limnephilidae										
Apatania sp. Kolenati 1848	0	84	84	0	24	96	32	0	20	0
Goera sp. Stephens 1829	0	0	0	0	0	0	0	0	0	0
Goera calcarata Banks 1899	0	0	0	0	0	0	0	0	0	0
Goera fuscula Banks 1905	0	0	0	0	0	0	0	0	0	0
Hydatophylax argus (Harris 1869)	48	0	4	23	0	0	0	0	0	0
Pycnopsyche sp. Banks 1905	0	0	0	0	0	0	0	0	0	0
unidentified Limnephilidae	60	0	0	90	0	16	0	0	0	8
Molannidae										
Molanna blenda Sibley 1926	0	0	0	2	0	0	0	0	0	0
Odontoceridae										
Psilotreta labida Ross 1944	0	0	0	14	12	12	24	43	16	0
Philopotamidae										
Dolophilodes sp. Ulmer 1909	0	0	4	1	0	48	0	0	4	0
Dolophilodes distinctus (Walker 1852)	12	0	0	0	0	0	0	0	0	0
Wormaldia sp. MacLaclan 1865	16	0	0	0	0	0	0	0	0	0
Polycentropodidae										
Nyctiophylax sp. Brauer 1865	0	4	0	9	0	0	0	0	0	0
Polycentropus sp. Curtis 1835	40	12	4	25	44	40	44	19	0	8
Psychomyiidae										
Lype diversa (Banks 1914)	0	0	0	0	0	0	0	0	0	0
Rhyacophilidae										
Rhyacophila spp. Pictet 1834	0	0	0	1	32	0	0	1	8	0
Rhyacophila acutiloba Morse and Ross 1971	0	0	0	0	0	0	0	0	0	0
Rhyacophila amicis Ross 1956	0	0	0	1	0	0	0	0	0	0
Rhyacophila atrata Banks 1911	0	0	0	0	0	0	0	0	0	0
Rhyacophila banksi Ross 1944	4	0	0	0	0	0	0	0	0	0

Appendix I. Continued.

	S01	S02	S03	S04	S05	S06	S07	S08	S09	S10
Trichoptera (continued)										
Rhyacophilidae (continued)										
Rhyacophila carolina Banks 1911	80	44	4	3	0	0	0	5	0	0
Rhyacophila fuscula (Walker 1852)	4	8	0	0	0	0	0	4	0	0
Rhyacophila minor Banks 1924	76	64	12	9	0	8	0	0	0	0
Rhyacophila cf. *nigrita* Banks 1907	0	0	0	1	0	0	0	0	0	0
Rhyacophila torva Hagen 1861	0	0	0	14	0	0	0	1	0	0
Sericostomatidae										
Fattigia pele (Ross 1938)	0	0	0	0	0	0	0	0	0	0
Uenoidae										
Neophylax sp. MacLachlan 1871	100	4	4	0	0	0	0	0	0	0
Neophylax consimilis Betten 1934	0	4	0	0	0	0	0	0	0	0
Neophylax mitchelli Carpenter 1933	16	0	0	0	0	0	0	0	0	0
Neophylax oligius Ross 1938	0	0	0	0	0	0	0	0	0	0
Lepidoptera										
Pyralidae										
Petrophila sp. Guilding 1830	4	0	0	0	0	0	0	0	0	0
Coleoptera										
Dryopidae										
Helichus sp. Erichson 1847	0	0	0	1	4	0	12	7	0	4
Helichus cf. *fastigiatus* (Say 1824)	0	0	0	0	0	0	0	0	0	0
Elmidae										
Dubiraphia sp. Sanderson 1954	0	0	0	0	0	0	0	0	0	4
cf. *Dubiraphia vittata* (Melsheimer 1844)	0	0	0	0	0	0	0	2	0	0
Optioservus sp. Sanderson 1954	484	436	148	283	340	472	200	203	44	24
Optioservus immunis (Fall 1925)	0	0	0	0	0	0	0	1	0	0
Optioservus ovalis (LeConte 1863)	8	16	0	1	4	4	0	0	0	0
Optioservus trivittatus (Brown 1930)	0	0	0	0	0	0	0	1	0	0
Oulimnius latiusculus (LeConte 1866)	72	72	4	6	20	60	20	2	0	0
Promoresia sp. Sanderson 1954	0	0	0	0	0	0	0	0	4	0
Promoresia elegans (LeConte 1852)	0	0	0	0	0	0	0	0	0	0
Promoresia tardella (Fall 1925)	0	0	0	0	0	0	0	0	0	0

Appendix I. Continued.

	S01	S02	S03	S04	S05	S06	S07	S08	S09	S10
Coleoptera (continued)										
Hydrophilidae										
Cymbiodyta vindicata Fall 1924	0	0	0	0	0	0	0	0	0	0
Psephenidae										
Ectopria sp. LeConte 1853	8	8	4	0	0	0	0	0	0	0
Psephenus herricki (DeKay 1844)	0	0	0	0	0	20	56	17	0	4
Ptilodactylidae										
Anchytarsus bicolor (Melsheimer 1846)	0	0	0	0	0	0	0	0	0	0
Diptera										
Athericidae										
Atherix cf. *lantha* Webb 1977	0	0	0	0	0	0	0	0	0	0
Blephariceridae										
Blepharicera sp. Macquart 1843	0	0	0	0	0	0	0	0	0	0
Ceratopogonidae										
Ceratopogoninae										
Ceratopogonini										
Ceratopogon sp. Meigen 1803	0	0	0	0	0	0	0	0	0	0
Palpomyiini										
Bezzia sp. Kieffer 1899/*Palpomyia* sp. Meigen 1818	8	4	8	27	0	0	0	50	0	28
Sphaeromiini										
Probezzia sp. Kieffer 1906	40	0	0	0	24	44	32	0	0	0
Forcipomyiinae										
Forcipomyiini										
Atrichopogon sp. Kieffer 1906	0	0	0	0	0	0	0	0	0	0
Chironomidae										
Chironominae										
Chironomini										
Demicryptochironomus sp. Lenz 1941	0	0	0	39	4	4	8	87	0	32
Dicrotendipes sp. Kieffer 1913	0	0	0	1	0	0	0	3	0	0
Dicrotendipes neomodestus (Malloch 1915)	0	0	0	0	0	0	0	1	0	0
Microtendipes pedellus group (de Geer 1776)	20	0	0	40	12	356	184	309	132	84
Nilothauma sp. Kieffer 1921	0	0	0	0	0	0	0	4	0	20
Polypedilum (Polypedilum) spp. Kieffer 1913	12	44	12	517	40	132	92	206	8	456
Polypedilum (P.) aviceps Townes 1945	0	0	0	0	0	0	0	0	0	4
Polypedilum (P.) fallax (Johannsen 1905)	0	0	0	1	0	0	0	0	0	0

Appendix I. Continued.

	S01	S02	S03	S04	S05	S06	S07	S08	S09	S10
Diptera (continued)										
Chironomidae (continued)										
Chironominae (continued)										
Chironomini (continued)										
Polypedilum (P.) scalaenum group (Schrank 1803)	0	0	0	0	0	0	0	0	0	0
Robackia demeijerei (Kruseman 1933)	0	0	4	0	0	0	0	0	0	8
Stenochironomus sp. Kieffer 1919	0	0	0	17	0	0	0	0	0	0
cf. *Tribelos* sp. Townes 1945	0	0	0	1	0	0	0	1	0	0
Tanytarsini										
Constempellina sp. Brundin 1947	64	108	4	197	8	76	36	103	0	28
Rheotanytarsus sp. Bause 1913	0	0	0	0	0	0	0	0	0	0
Sublettea sp. Roback 1975	12	64	8	89	24	152	60	110	24	108
Tanytarsus sp. van der Wulp 1874	304	460	48	1155	152	2936	1080	3379	60	1424
Diamesinae										
Diamesini										
Diamesa sp. Meigen 1835	20	56	0	1	4	48	20	0	36	136
Orthocladiinae										
Corynoneurini										
Corynoneura sp. Winnertz 1846	388	112	4	106	32	316	168	375	100	64
Rheosmittia sp. Brundin 1956	0	0	0	0	0	0	0	0	0	0
Thienemanniella sp. Kieffer 1911	28	28	12	22	16	116	4	25	0	60
Orthocladiini										
Brillia sp. Kieffer 1913	0	0	0	0	0	0	0	0	0	0
Cricotopus spp./*Orthocladius* spp. van der Wulp 1874	188	300	12	122	24	320	104	777	160	320
Cricotopus spp. van der Wulp 1874	0	0	0	0	0	0	0	0	0	0
Epoicocladius sp. Zavrel 1924	0	0	0	0	0	0	0	0	0	0
Heterotrissocladius marcidus group (Walker 1856)	0	0	0	0	0	0	0	0	0	0
Limnophyes sp. Eaton 1875	0	0	0	6	0	0	0	17	0	0
Orthocladius (Eudactylocladius) spp. Thienemann 1935	0	0	0	41	0	60	8	61	16	0
Orthocladius (Orthocladius) spp. van der Wulp 1874	0	0	0	0	0	0	0	0	0	0
Parachaetocladius sp. Wülker 1959	4	40	16	29	40	4	28	43	8	4
Parametriocnemus sp. Goetghebuer 1932	0	0	0	2	0	0	0	0	0	0
Psectrocladius sp. Kieffer 1906	0	0	0	0	0	0	0	5	0	0
Psilometriocnemus sp. Saether 1969	40	20	0	21	4	24	0	0	0	4
Rheocricotopus sp. Thienemann and Harnisch 1932	0	0	0	0	0	0	0	0	0	0
Synorthocladius sp. Thienemann 1935	20	28	0	17	12	48	12	33	32	16

I. Continued.

	S01	S02	S03	S04	S05	S06	S07	S08	S09	S10
ɔntinued)										
hironomidae (continued)										
Prodiamesinae										
Prodiamesa sp. Kieffer 1906	0	0	0	0	0	0	0	0	0	0
Tanypodinae										
Macropelopiini										
Brundiniella sp. Roback 1978	0	16	44	271	100	12	12	22	0	0
Pentaneurini										
Ablabesmyia cf. *mallochi* (Walley 1925)	0	0	0	11	0	0	0	88	0	0
Larsia sp. Fittkau 1962	12	0	0	0	8	0	0	0	4	0
Thienemannimyia sp. Fittkau 1957	12	4	8	90	0	64	20	103	52	16
unidentified Tanypodinae	28	48	20	40	20	96	64	74	12	52
ixidae										
Dixa sp. Meigen 1818	8	0	0	2	0	0	4	2	4	0
mpididae										
Chelifera sp. Macquart 1823	28	8	0	4	0	4	0	9	0	0
Clinocera sp. Meigen 1803	0	0	0	0	0	0	0	0	0	0
Hemerodromia sp. Meigen 1822	0	0	0	0	0	0	0	0	0	4
phydridae										
Scatophila sp. Becker 1896	0	0	0	0	0	0	4	0	0	0
sychodidae										
Pericoma sp. Walker 1856	0	0	0	0	0	0	0	0	0	0
Telmatoscopus sp. Eaton 1904	0	0	0	0	0	0	0	0	0	0
imuliidae										
Prosimulium sp. Roubaud 1906	0	0	0	1	0	0	0	0	0	0
Simulium sp. Latreille 1802	0	0	0	0	0	0	0	1	0	0
Stegopterna mutata (Malloch 1914)	0	0	0	0	0	0	0	0	0	0
tratiomyidae										
cf. *Nemotelus* sp. Geoffroy 1762	0	0	0	0	0	0	0	0	0	0
abanidae										
Chrysops sp. Meigen 1803	0	0	0	0	0	0	0	0	0	0
haumaleidae										
Thaumalea americana Bezzi 1913	0	0	0	0	0	0	0	0	0	0

Appendix I. Continued.

	S01	S02	S03	S04	S05	S06	S07	S08	S09	S10
Diptera (continued)										
Tipulidae										
Antocha sp. Osten Sacken 1859	24	56	44	42	12	8	8	12	0	28
Dicranota sp. Zetterstedt 1838	16	0	0	0	4	16	0	0	8	0
cf. *Erioptera* sp. Meigen 1803	0	0	0	0	0	0	0	0	0	0
Hexatoma sp. Latreille 1809	48	4	16	25	56	52	44	25	36	16
Limnophila sp. Macquart 1834	0	0	0	8	0	4	0	26	0	0
Pedicia sp. Latreille 1809	0	0	0	0	0	0	0	0	0	0
Pseudolimnophila sp. Alexander 1919	0	0	0	1	0	0	0	0	0	0
Tipula sp. Linnaeus 1758	0	0	0	0	0	0	0	0	0	0
Collembola										
Isotomidae/Entomobryidae	80	20	4	128	4	36	0	27	0	0
Sminthuridae	4	0	0	0	0	0	24	2	0	8
Acarina										
Lebertiidae										
Lebertia sp. Viets 1909	0	24	0	38	24	0	0	154	48	50
unidentified Acarina	28	4	0	4	0	196	112	1	0	0
Amphipoda										
Gammaridae										
Gammarus minus Say 1818	0	0	0	1	0	0	0	2	0	0
Decapoda										
Cambaridae	0	0	0	2	4	0	0	0	0	0
Isopoda	0	0	0	0	0	0	0	0	0	0
Ostracoda	0	16	4	5	0	24	0	42	0	56
Cnidaria	0	0	0	0	0	0	0	1	0	0
Turbellaria	4	0	0	3	0	8	4	0	4	0
Nematoda	8	8	0	43	0	28	8	30	0	36

Appendix I. Continued.

	S01	S02	S03	S04	S05	S06	S07	S08	S09	S10
Oligochaeta										
Naididae	8	36	0	204	4	28	40	44	0	156
Tubificidae	0	0	0	0	0	0	0	0	0	0
Branchiobdellida	0	0	0	1	0	0	0	0	0	0
Mollusca										
Physidae	0	0	0	0	0	4	0	0	0	0
Planorbidae	0	0	0	1	0	0	0	0	0	0
Sphaeriidae	0	0	0	3	0	0	0	0	0	0

Appendix II. Fall survey 1998 taxa list for Whiteoak Canyon Run in Shenandoah National Park, Madison County, Virginia.

	W01	W03	W04	W05	W06	W07	W08	W10
Ephemeroptera								
Ameletidae								
Ameletus sp. Eaton 1885	0	16	0	18	0	0	0	0
Ameletus cryptostimulus Carle 1978	0	0	0	0	0	0	0	0
Ameletus lineatus Traver 1932	0	0	8	0	0	0	0	0
Baetidae								
Acentrella ampla Traver 1932	9	52	8	20	72	0	16	12
Baetis sp. Leach 1815	72	8	0	20	156	12	116	31
Baetis brunneicolor McDunnough 1925	0	0	8	4	20	0	0	0
Baetis flavistriga McDunnough 1921	0	0	0	0	0	0	0	0
Baetis cf. *intercalaris* McDunnough 1921	0	0	0	0	0	0	0	0
Baetis tricaudatus Dodds 1923	0	0	0	0	0	0	0	0
Baetiscidae								
Baetisca carolina Traver 1931	0	0	0	0	0	0	0	0
Caenidae								
Caenis sp. Stephens 1835	0	0	0	0	0	0	0	0
Ephemerellidae								
Drunella sp. Needham 1905	0	0	0	0	0	0	0	0
Drunella cf. *lata* (Morgan 1911)	0	0	0	0	0	0	0	0
Ephemerella sp. Walsh 1862	0	0	0	0	0	4	0	0
Ephemerella dorothea Needham 1908	0	0	0	0	0	0	0	0
Ephemerella hispida Allen and Edmunds 1965	0	0	0	0	0	0	0	0
Ephemerella rossi Allen and Edmunds 1965	0	0	0	0	0	0	0	0
Ephemerella cf. *subvaria* McDunnough 1925	0	0	0	0	0	0	0	0
Eurylophella sp. Tiensuu 1935	315	16	48	0	796	4	12	652
Eurylophella funeralis (McDunnough 1925)	0	12	0	0	0	0	0	0
Eurylophella temporalis (McDunnough 1924)	2	0	0	34	0	0	0	44
unidentified Ephemerellidae	0	340	72	140	0	108	12	0
Ephemeridae								
Ephemera sp. Linnaeus 1758	0	0	0	4	0	0	0	13
Ephemera simulans Walker 1853	0	0	20	0	16	0	0	0
Heptageniidae								
Cinygmula subaequalis (Banks 1914)	0	0	0	6	0	0	0	0
Epeorus sp. Eaton 1881	294	80	36	90	1092	76	84	333
Epeorus (Iron) dispar (Traver 1935)	0	16	0	0	56	0	0	0

Appendix II. Continued.

	W01	W03	W04	W05	W06	W07	W08	W10
Ephemeroptera (continued)								
Heptageniidae (continued)								
Epeorus (Iron) pleuralis (Banks 1910)	0	20	0	0	64	0	0	0
Epeorus (Iron) rubidus (Traver 1933)	0	0	0	0	0	0	0	0
Heptagenia sp. Walsh 1863	0	0	0	0	0	0	0	0
Leucrocuta sp. Flowers 1980	0	0	16	28	40	28	32	86
Rhithrogena sp. Eaton 1881	0	0	0	0	0	0	0	0
Stenacron sp. Jensen 1974	7	0	0	22	0	16	0	0
Stenacron cf. *pallidum* (Traver 1933)	0	0	0	0	0	0	0	0
Stenonema sp. Traver 1933	66	28	12	44	36	16	20	64
Stenonema femoratum (Say 1823)	0	0	0	0	8	0	0	0
Stenonema meririvulanum Carle and Lewis 1978	0	0	0	0	0	0	0	0
Stenonema pudicum (Hagen 1861)	0	0	0	0	24	12	0	0
Stenonema vicarium (Walker 1853)	0	0	0	6	12	0	0	0
unidentified Heptageniidae	0	84	84	148	188	88	52	0
Isonychiidae								
Isonychia sp. Eaton 1871	0	0	0	0	0	0	0	0
Leptophlebiidae								
Habrophlebia vibrans Needham 1908	0	0	0	8	0	8	0	0
Paraleptophlebia sp. Lestage 1917	339	112	52	114	360	64	88	241
Paraleptophlebia adoptiva (McDunnough 1929)	0	0	0	0	4	0	0	0
Paraleptophlebia cf. *mollis* (Eaton 1871)	0	0	0	0	0	0	0	0
Odonata								
Aeshnidae								
Boyeria grafiana Williamson 1907	0	0	4	2	0	0	0	0
Calopterygidae								
Hetaerina sp. Hagen 1854	0	0	0	0	0	0	0	0
Cordulegastridae								
Cordulegaster sp. Leach 1815	0	0	0	0	0	0	0	0
Gomphidae								
Lanthus parvulus (Selys 1854)	14	4	0	0	4	0	0	5
Lanthus vernalis Carle 1980	0	0	0	0	0	0	0	0
cf. *Stylogomphus albistylus* (Hagen 1878)	0	0	0	0	0	0	0	2
unidentified Gomphidae	0	0	0	0	0	0	0	0

Appendix II. Continued.

	W01	W03	W04	W05	W06	W07	W08	W10
Plecoptera								
Capniidae								
Paracapnia sp. Hanson 1946	28	56	268	104	216	76	96	108
Chloroperlidae								
Haploperla brevis (Banks 1895)	148	172	288	418	336	44	132	421
Sweltsa sp. Ricker 1943	0	0	0	0	0	0	0	0
Leuctridae								
Leuctra sp. Stephens 1836	682	176	48	42	112	8	20	35
Zealeuctra sp. Ricker 1952	0	0	0	0	0	0	0	0
Nemouridae								
Amphinemura sp. Ris 1902	4	0	0	2	12	0	0	1
Amphinemura nigritta (Provancher 1876)	0	0	0	0	0	0	0	0
Amphinemura wui (Claassen 1936)	0	0	0	0	0	0	0	0
Nemoura sp. Latreille 1796	0	0	0	0	0	0	0	0
Peltoperlidae								
Peltoperla sp. Needham 1905	61	0	0	0	0	8	40	0
cf. *Tallaperla* sp. Stark and Stewart 1981	0	52	16	0	0	0	0	0
Perlidae								
Acroneuria sp. Pictet 1841	0	8	0	0	56	0	20	0
Acroneuria abnormis (Newman 1838)	0	0	0	0	8	0	0	1
Acroneuria carolinensis (Banks 1905)	0	0	0	2	0	20	8	3
Agnetina capitata (Pictet 1841)	0	0	0	0	0	0	0	0
Eccoptura xanthenes (Newman 1828)	0	0	0	0	0	0	0	0
Paragnetina sp. Klapálek 1907	0	0	0	0	0	0	0	0
Paragnetina immarginata (Say 1823)	0	0	0	0	0	0	0	1
unidentified Perlidae	7	24	12	16	76	0	12	15
Perlodidae								
Isogenoides hansoni (Ricker 1952)	0	0	0	0	0	0	0	0
Isoperla sp. Banks 1906	298	100	0	22	108	4	12	136
Isoperla bilineata (Say 1823)	0	0	0	0	0	0	0	0
Isoperla cf. *cotta* Ricker 1952	0	0	0	0	0	0	0	0
Isoperla lata Frison 1942	0	0	0	0	0	0	0	0
Isoperla marlynia Needham and Claassen 1925	0	0	0	0	0	0	0	0
Isoperla similis (Hagen 1861)	0	0	0	0	0	0	0	0
Malirekus hastatus (Banks 1920)	0	0	0	0	0	0	0	0
Yugus sp. Ricker 1952	0	0	0	0	0	0	0	0

Appendix II. Continued.

	W01	W03	W04	W05	W06	W07	W08	W10
Plecoptera (continued)								
Pteronarcyidae								
Allonarcys sp. Needham and Claassen 1925	14	40	12	0	12	8	16	4
Allonarcys proteus (Newman 1838)	6	0	0	0	0	0	0	0
Taeniopterygidae								
Taeniopteryx sp. Pictet 1841	0	0	0	0	0	0	0	0
Hemiptera								
Gerridae								
Gerris sp. Fabricius 1794	0	0	0	0	0	0	0	2
Veliidae								
Rhagovelia sp. Mayr 1865	0	0	0	0	0	0	0	0
Megaloptera								
Corydalidae								
Nigronia sp. Banks 1908	0	0	0	0	0	0	0	0
Nigronia serricornis (Say 1824)	0	0	0	10	0	4	0	7
Sialidae								
Sialis sp. Latreille 1802	2	0	0	0	0	0	0	0
Trichoptera								
Brachycentridae								
Adicrophleps hitchcocki Flint 1965	0	0	0	0	0	0	0	0
Glossosomatidae								
Agapetus sp. Curtis 1834	0	0	0	0	0	0	0	0
Glossosoma sp. Curtis 1834	0	12	4	0	0	0	0	2
Hydropsychidae								
Cheumatopsyche sp. Wallengren 1891	0	0	0	0	8	0	0	0
Diplectrona metaqui Ross 1970	0	0	0	0	0	0	0	0
Diplectrona modesta Banks 1908	19	20	8	0	64	0	28	20
Hydropsyche sp. Pictet 1834	188	0	0	0	16	0	12	8
Hydropsyche alhedra Ross 1939	0	44	0	0	0	0	0	0
Hydropsyche bronta Ross 1938	0	0	0	0	0	0	0	0
Hydropsyche slossonae Banks 1905	17	0	0	2	0	0	0	0
Hydropsyche sparna Ross 1938	0	0	0	0	0	0	0	0
Parapsyche apicalis (Banks 1908)	0	0	0	0	0	0	0	0

Appendix II. Continued.

	W01	W03	W04	W05	W06	W07	W08	W10
Trichoptera (continued)								
Hydroptilidae								
Hydroptila sp. Dalman 1819	0	0	0	40	4	16	0	41
Ochrotrichia sp. Mosely 1934	0	0	0	0	0	0	0	0
Palaeagapetus celsus (Ross 1938)	0	0	0	0	0	0	0	0
Lepidostomatidae								
Lepidostoma sp. Rambur 1842	12	0	4	14	8	4	8	117
Leptoceridae								
Nectopsyche sp. Müller 1879	0	0	0	0	0	0	0	3
Limnephilidae								
Apatania sp. Kolenati 1848	0	0	0	4	36	4	0	0
Goera sp. Stephens 1829	1	0	0	0	0	0	0	0
Goera calcarata Banks 1899	0	0	0	0	0	0	0	0
Goera fuscula Banks 1905	0	0	0	0	0	0	0	0
Hydatophylax argus (Harris 1869)	0	0	0	0	0	0	0	0
Pycnopsyche sp. Banks 1905	0	0	0	0	0	0	0	0
unidentified Limnephilidae	101	56	8	36	0	0	4	60
Molannidae								
Molanna blenda Sibley 1926	0	0	0	0	4	0	0	0
Odontoceridae								
Psilotreta labida Ross 1944	0	0	0	0	0	0	0	9
Philopotamidae								
Dolophilodes sp. Ulmer 1909	1	0	0	0	148	4	4	14
Dolophilodes distinctus (Walker 1852)	0	0	0	0	0	0	0	0
Wormaldia sp. MacLaclan 1865	0	0	0	0	0	0	0	0
Polycentropodidae								
Nyctiophylax sp. Brauer 1865	4	0	0	0	0	0	0	0
Polycentropus sp. Curtis 1835	23	20	16	76	40	28	0	57
Psychomyiidae								
Lype diversa (Banks 1914)	0	0	0	0	0	0	0	0
Rhyacophilidae								
Rhyacophila spp. Pictet 1834	26	48	44	0	28	0	12	11
Rhyacophila acutiloba Morse and Ross 1971	0	0	0	0	0	0	0	0
Rhyacophila amicis Ross 1956	0	0	0	0	0	0	0	0
Rhyacophila atrata Banks 1911	0	8	0	0	0	0	0	0
Rhyacophila banksi Ross 1944	0	0	0	0	0	0	0	0

Appendix II. Continued.

	W01	W03	W04	W05	W06	W07	W08	W10
Trichoptera (continued)								
Rhyacophilidae (continued)								
Rhyacophila carolina Banks 1911	0	0	0	0	0	0	0	0
Rhyacophila fuscula (Walker 1852)	0	0	0	2	12	0	12	1
Rhyacophila minor Banks 1924	155	0	0	6	24	0	4	3
Rhyacophila cf. *nigrita* Banks 1907	0	0	0	0	0	0	0	0
Rhyacophila torva Hagen 1861	0	0	0	2	0	0	8	2
Sericostomatidae								
Fattigia pele (Ross 1938)	0	0	0	0	0	0	0	0
Uenoidae								
Neophylax sp. MacLachlan 1871	7	0	0	0	0	0	0	0
Neophylax consimilis Betten 1934	0	0	0	0	0	0	0	0
Neophylax mitchelli Carpenter 1933	0	0	0	0	0	0	0	0
Neophylax oligius Ross 1938	0	0	0	0	0	0	0	0
Lepidoptera								
Pyralidae								
Petrophila sp. Guilding 1830	0	0	4	0	0	0	0	0
Coleoptera								
Dryopidae								
Helichus sp. Erichson 1847	0	0	0	0	0	0	0	3
Helichus cf. *fastigiatus* (Say 1824)	0	0	0	0	0	0	0	0
Elmidae								
Dubiraphia sp. Sanderson 1954	0	0	0	0	0	0	0	4
cf. *Dubiraphia vittata* (Melsheimer 1844)	0	0	0	0	0	0	0	0
Optioservus sp. Sanderson 1954	512	312	80	100	148	32	76	80
Optioservus immunis (Fall 1925)	0	0	0	0	0	0	0	0
Optioservus ovalis (LeConte 1863)	4	4	0	0	0	0	0	1
Optioservus trivittatus (Brown 1930)	0	0	0	0	0	0	0	0
Oulimnius latiusculus (LeConte 1866)	20	12	28	70	48	4	8	18
Promoresia sp. Sanderson 1954	0	12	0	12	4	0	68	0
Promoresia elegans (LeConte 1852)	0	0	0	0	0	0	0	0
Promoresia tardella (Fall 1925)	0	0	0	0	0	0	8	0

Appendix II. Continued.

	W01	W03	W04	W05	W06	W07	W08	W10
Coleoptera (continued)								
Hydrophilidae								
Cymbiodyta vindicata Fall 1924	0	0	0	0	0	0	0	0
Psephenidae								
Ectopria sp. LeConte 1853	1	0	0	2	0	0	4	0
Psephenus herricki (DeKay 1844)	0	0	0	6	20	0	0	24
Ptilodactylidae								
Anchytarsus bicolor (Melsheimer 1846)	0	0	0	0	0	0	0	0
Diptera								
Athericidae								
Atherix cf. *lantha* Webb 1977	0	0	0	2	0	0	0	0
Blephariceridae								
Blepharicera sp. Macquart 1843	0	0	0	0	0	0	0	0
Ceratopogonidae								
Ceratopogoninae								
Ceratopogonini								
Ceratopogon sp. Meigen 1803	0	0	0	0	0	0	0	0
Palpomyiini								
Bezzia sp. Kieffer 1899/*Palpomyia* sp. Meigen 1818	43	28	20	50	0	0	0	0
Sphaeromiini								
Probezzia sp. Kieffer 1906	1	0	0	0	28	24	0	19
Forcipomyiinae								
Forcipomyiini								
Atrichopogon sp. Kieffer 1906	0	0	0	0	0	0	0	0
Chironomidae								
Chironominae								
Chironomini								
Demicryptochironomus sp. Lenz 1941	8	8	4	26	32	24	0	76
Dicrotendipes sp. Kieffer 1913	0	0	0	0	0	0	0	0
Dicrotendipes neomodestus (Malloch 1915)	0	0	0	0	0	0	0	0
Microtendipes pedellus group (de Geer 1776)	44	524	280	1244	292	272	44	1036
Nilothauma sp. Kieffer 1921	0	0	0	0	0	0	0	3
Polypedilum (Polypedilum) spp. Kieffer 1913	105	292	36	232	320	172	20	328
Polypedilum (P.) aviceps Townes 1945	0	0	0	0	0	0	0	0
Polypedilum (P.) fallax (Johannsen 1905)	0	0	0	0	0	0	0	0

Appendix II. Continued.

	W01	W03	W04	W05	W06	W07	W08	W10
Diptera (continued)								
Chironomidae (continued)								
Chironominae (continued)								
Chironomini (continued)								
Polypedilum (P.) scalaenum group (Schrank 1803)	0	0	0	0	0	0	0	0
Robackia demeijerei (Kruseman 1933)	0	0	0	0	0	0	0	0
Stenochironomus sp. Kieffer 1919	0	0	0	0	0	0	0	1
cf. *Tribelos* sp. Townes 1945	1	0	0	2	0	0	0	0
Tanytarsini								
Constempellina sp. Brundin 1947	69	24	24	42	8	4	12	2
Rheotanytarsus sp. Bause 1913	0	0	0	0	0	0	0	0
Sublettea sp. Roback 1975	106	260	140	196	76	736	16	208
Tanytarsus sp. van der Wulp 1874	506	292	372	1066	520	576	20	1110
Diamesinae								
Diamesini								
Diamesa sp. Meigen 1835	1	0	8	78	36	8	168	5
Orthocladiinae								
Corynoneurini								
Corynoneura sp. Winnertz 1846	245	116	44	124	92	96	32	136
Rheosmittia sp. Brundin 1956	0	0	0	0	0	0	0	0
Thienemanniella sp. Kieffer 1911	217	220	76	138	208	44	112	53
Orthocladiini								
Brillia sp. Kieffer 1913	0	0	0	0	0	0	0	6
Cricotopus spp./*Orthocladius* spp. van der Wulp 1874	590	668	356	118	380	120	144	321
Cricotopus spp. van der Wulp 1874	0	0	0	0	0	0	0	0
Epoicocladius sp. Zavrel 1924	0	0	0	6	8	8	0	1
Heterotrissocladius marcidus group (Walker 1856)	0	0	0	0	0	0	0	0
Limnophyes sp. Eaton 1875	0	0	0	0	0	0	0	0
Orthocladius (Eudactylocladius) spp. Thienemann 1935	13	48	0	118	20	0	0	9
Orthocladius (Orthocladius) spp. van der Wulp 1874	0	0	0	0	0	0	0	0
Parachaetocladius sp. Wülker 1959	1	20	12	8	0	0	8	5
Parametriocnemus sp. Goetghebuer 1932	0	0	0	0	0	0	0	0
Psectrocladius sp. Kieffer 1906	0	0	0	0	0	0	0	0
Psilometriocnemus sp. Saether 1969	84	124	72	84	32	28	0	21
Rheocricotopus sp. Thienemann and Harnisch 1932	0	0	0	0	0	0	0	0
Synorthocladius sp. Thienemann 1935	21	8	12	20	4	0	0	10

Appendix II. Continued.

	W01	W03	W04	W05	W06	W07	W08	W10
Diptera (continued)								
Chironomidae (continued)								
Prodiamesinae								
Prodiamesa sp. Kieffer 1906	0	0	0	0	0	0	0	0
Tanypodinae								
Macropelopiini								
Brundiniella sp. Roback 1978	7	136	24	6	0	4	0	3
Pentaneurini								
Ablabesmyia cf. *mallochi* (Walley 1925)	0	0	0	0	0	0	0	0
Larsia sp. Fittkau 1962	183	36	8	8	12	0	0	152
Thienemannimyia sp. Fittkau 1957	98	132	84	90	60	32	56	58
unidentified Tanypodinae	37	80	20	192	100	100	24	203
Dixidae								
Dixa sp. Meigen 1818	1	0	0	0	0	0	0	0
Empididae								
Chelifera sp. Macquart 1823	35	0	4	6	12	0	0	17
Clinocera sp. Meigen 1803	0	0	0	0	0	0	0	0
Hemerodromia sp. Meigen 1822	0	0	0	0	0	0	0	2
Ephydridae								
Scatophila sp. Becker 1896	0	0	0	0	0	0	0	0
Psychodidae								
Pericoma sp. Walker 1856	0	0	0	0	0	0	0	0
Telmatoscopus sp. Eaton 1904	2	0	0	0	0	0	0	0
Simuliidae								
Prosimulium sp. Roubaud 1906	5	12	0	14	12	0	8	0
Simulium sp. Latreille 1802	0	0	0	0	0	0	0	0
Stegopterna mutata (Malloch 1914)	0	0	0	0	0	0	0	0
Stratiomyidae								
cf. *Nemotelus* sp. Geoffroy 1762	0	0	0	0	0	0	0	1
Tabanidae								
Chrysops sp. Meigen 1803	0	0	0	0	0	0	0	0
Thaumaleidae								
Thaumalea americana Bezzi 1913	0	0	0	0	4	0	0	0

Appendix II. Continued.

	W01	W03	W04	W05	W06	W07	W08	W10
Diptera (continued)								
Tipulidae								
Antocha sp. Osten Sacken 1859	131	44	8	16	12	0	4	12
Dicranota sp. Zetterstedt 1838	3	8	0	2	0	8	0	0
cf. *Erioptera* sp. Meigen 1803	1	0	0	0	0	0	0	0
Hexatoma sp. Latreille 1809	4	12	12	12	36	4	4	19
Limnophila sp. Macquart 1834	3	0	0	8	0	0	0	2
Pedicia sp. Latreille 1809	1	0	0	0	0	0	0	0
Pseudolimnophila sp. Alexander 1919	0	0	0	0	0	0	0	1
Tipula sp. Linnaeus 1758	0	0	0	0	0	0	0	0
Collembola								
Isotomidae/Entomobryidae	50	24	56	18	28	4	0	34
Sminthuridae	2	0	0	0	0	0	0	0
Acarina								
Lebertiidae								
Lebertia sp. Viets 1909	49	40	12	80	92	72	12	31
unidentified Acarina	7	16	4	14	12	16	4	3
Amphipoda	0	0	0	0	0	0	0	2
Gammaridae								
Gammarus minus Say 1818	0	0	0	0	0	0	0	0
Decapoda								
Cambaridae	7	0	0	4	4	0	0	1
Isopoda	0	0	0	0	0	0	0	0
Ostracoda	32	108	68	62	40	24	0	15
Cnidaria	1	0	0	0	0	0	0	0
Turbellaria	5	0	0	2	8	0	0	3
Nematoda	62	40	84	70	36	96	12	2

Appendix II. Continued.

	W01	W03	W04	W05	W06	W07	W08	W10
Oligochaeta								
Naididae	77	72	92	26	56	60	12	106
Tubificidae	0	0	0	0	0	0	0	0
Branchiobdellida	44	8	0	0	0	0	0	1
Mollusca								
Physidae	9	4	8	16	44	64	40	22
Planorbidae	0	0	0	0	0	0	0	0
Sphaeriidae	3	0	0	0	0	0	0	0

Appendix III. Spring survey 1999 taxa list for Staunton River in Shenandoah National Park, Madison County, Virginia.

	S01	S02	S03	S04	S05	S06	S07	S08	S09	S10
Ephemeroptera										
Ameletidae										
Ameletus sp. Eaton 1885	104	184	60	40	232	168	400	100	36	16
Ameletus cryptostimulus Carle 1978	0	12	4	0	0	0	0	0	0	0
Ameletus lineatus Traver 1932	12	56	12	0	0	36	68	112	16	0
Baetidae										
Acentrella ampla Traver 1932	8	4	16	20	20	28	20	8	116	34
Baetis sp. Leach 1815	12	12	48	32	24	24	56	8	0	6
Baetis brunneicolor McDunnough 1925	4	0	24	0	0	36	0	0	12	0
Baetis flavistriga McDunnough 1921	0	0	0	0	0	0	0	0	0	0
Baetis cf. *intercalaris* McDunnough 1921	0	0	0	0	0	0	0	0	0	0
Baetis tricaudatus Dodds 1923	0	0	0	0	0	0	0	0	20	22
Baetiscidae										
Baetisca carolina Traver 1931	0	0	0	0	0	0	0	0	0	0
Caenidae										
Caenis sp. Stephens 1835	0	0	0	0	0	0	0	0	0	0
Ephemerellidae										
Drunella sp. Needham 1905	4	68	0	20	72	496	232	0	80	4
Drunella cf. *lata* (Morgan 1911)	0	0	4	0	0	0	0	0	0	0
Ephemerella sp. Walsh 1862	0	0	16	0	592	0	72	148	200	246
Ephemerella dorothea Needham 1908	132	172	272	184	64	472	544	340	280	102
Ephemerella hispida Allen and Edmunds 1965	0	0	0	0	0	0	0	0	0	8
Ephemerella rossi Allen and Edmunds 1965	0	0	0	0	0	0	0	0	0	0
Ephemerella cf. *subvaria* McDunnough 1925	0	0	0	0	0	0	0	0	0	12
Eurylophella sp. Tiensuu 1935	4	4	0	0	64	0	396	52	0	22
Eurylophella funeralis (McDunnough 1925)	0	0	0	4	0	0	0	0	0	2
Eurylophella temporalis (McDunnough 1924)	0	0	0	0	0	0	0	120	20	50
unidentified Ephemerellidae	44	132	108	200	752	1392	876	0	144	0
Ephemeridae										
Ephemera sp. Linnaeus 1758	0	0	0	0	0	0	0	0	0	0
Ephemera simulans Walker 1853	0	0	0	0	0	0	0	0	0	0
Heptageniidae										
Cinygmula subaequalis (Banks 1914)	60	380	72	204	220	740	432	200	348	184
Epeorus sp. Eaton 1881	176	1676	472	752	1956	2384	2204	736	1028	258
Epeorus (Iron) dispar (Traver 1935)	0	16	4	0	0	0	0	0	0	0

Appendix III. Continued.

	S01	S02	S03	S04	S05	S06	S07	S08	S09	S10
Ephemeroptera (continued)										
Heptageniidae (continued)										
Epeorus (Iron) pleuralis (Banks 1910)	36	200	88	48	40	124	28	64	144	72
Epeorus (Iron) rubidus (Traver 1933)	0	0	0	0	0	0	0	0	0	0
Heptagenia sp. Walsh 1863	0	0	12	0	16	0	0	0	0	0
Leucrocuta sp. Flowers 1980	28	44	20	8	0	0	0	0	4	0
Rhithrogena sp. Eaton 1881	0	0	0	0	0	0	0	0	0	2
Stenacron sp. Jensen 1974	0	0	0	0	0	0	0	4	0	0
Stenacron cf. *pallidum* (Traver 1933)	0	4	4	0	0	0	0	0	0	0
Stenonema sp. Traver 1933	0	0	0	0	4	0	4	4	0	0
Stenonema femoratum (Say 1823)	0	0	0	0	0	0	0	0	0	0
Stenonema meririvulanum Carle and Lewis 1978	0	0	0	0	0	0	0	0	0	0
Stenonema pudicum (Hagen 1861)	0	4	4	0	0	0	8	8	0	18
Stenonema vicarium (Walker 1853)	0	0	0	0	0	0	0	0	0	0
unidentified Heptageniidae	20	24	136	192	504	228	40	56	44	12
Isonychiidae										
Isonychia sp. Eaton 1871	0	0	0	0	0	0	0	0	4	0
Leptophlebiidae										
Habrophlebia vibrans Needham 1908	0	0	0	0	0	0	0	0	0	0
Paraleptophlebia sp. Lestage 1917	56	84	52	44	52	44	44	0	12	10
Paraleptophlebia adoptiva (McDunnough 1929)	8	32	28	8	0	4	20	16	20	26
Paraleptophlebia cf. *mollis* (Eaton 1871)	0	0	0	0	0	0	0	0	0	0
Odonata										
Aeshnidae										
Boyeria grafiana Williamson 1907	0	0	0	0	0	0	0	0	0	0
Calopterygidae										
Hetaerina sp. Hagen 1854	0	0	0	0	0	0	0	0	0	0
Cordulegastridae										
Cordulegaster sp. Leach 1815	0	0	0	0	0	0	0	0	0	0
Gomphidae										
Lanthus parvulus (Selys 1854)	8	0	0	4	4	0	0	0	0	0
Lanthus vernalis Carle 1980	0	0	0	0	0	0	0	0	0	0
cf. *Stylogomphus albistylus* (Hagen 1878)	0	0	0	0	0	0	0	0	0	0
unidentified Gomphidae	0	0	0	0	0	0	0	0	0	0

Appendix III. Continued.

	S01	S02	S03	S04	S05	S06	S07	S08	S09	S10
Plecoptera										
Capniidae										
Paracapnia sp. Hanson 1946	4	0	0	8	0	4	0	0	0	6
Chloroperlidae										
Haploperla brevis (Banks 1895)	16	472	80	76	96	132	84	100	32	14
Sweltsa sp. Ricker 1943	0	24	36	16	36	36	0	0	40	20
Leuctridae										
Leuctra sp. Stephens 1836	176	632	256	308	132	76	148	88	76	22
Zealeuctra sp. Ricker 1952	0	0	0	0	0	0	0	0	0	0
Nemouridae										
Amphinemura sp. Ris 1902	24	12	68	8	8	0	0	8	92	2
Amphinemura nigritta (Provancher 1876)	0	0	8	0	0	0	4	0	0	0
Amphinemura wui (Claassen 1936)	0	0	0	0	0	0	0	0	0	0
Nemoura sp. Latreille 1796	0	0	0	0	0	0	0	0	0	0
Peltoperlidae										
Peltoperla sp. Needham 1905	88	84	0	8	12	20	12	0	12	0
cf. *Tallaperla* sp. Stark and Stewart 1981	0	12	60	0	0	0	0	0	0	0
Perlidae										
Acroneuria sp. Pictet 1841	0	0	0	0	0	0	0	0	4	0
Acroneuria abnormis (Newman 1838)	0	0	0	4	0	0	0	0	0	0
Acroneuria carolinensis (Banks 1905)	0	0	0	0	0	0	0	0	0	0
Agnetina capitata (Pictet 1841)	0	0	0	0	0	20	0	0	0	12
Eccoptura xanthenes (Newman 1828)	0	0	0	0	0	0	0	0	0	0
Paragnetina sp. Klapálek 1907	0	0	0	0	0	0	0	0	36	0
Paragnetina immarginata (Say 1823)	0	0	0	0	0	0	0	0	0	0
unidentified Perlidae	24	232	32	20	16	88	52	20	16	34
Perlodidae										
Isogenoides hansoni (Ricker 1952)	0	0	0	0	0	0	0	0	0	2
Isoperla sp. Banks 1906	44	96	140	52	84	84	76	24	44	16
Isoperla bilineata (Say 1823)	0	12	0	12	8	8	56	20	48	34
Isoperla cf. *cotta* Ricker 1952	0	0	8	0	0	0	0	0	0	0
Isoperla lata Frison 1942	0	0	4	0	0	0	0	0	0	0
Isoperla marlynia Needham and Claassen 1925	4	0	0	0	0	0	0	0	0	0
Isoperla similis (Hagen 1861)										
Malirekus hastatus (Banks 1920)	0	0	0	0	0	0	0	0	0	0
Yugus sp. Ricker 1952	0	4	0	0	0	0	0	0	0	0

dix III. Continued.

	S01	S02	S03	S04	S05	S06	S07	S08	S09	S10
tera (continued)										
Pteronarcyidae										
Allonarcys sp. Needham and Claassen 1925	28	72	40	16	24	8	20	4	8	2
Allonarcys proteus (Newman 1838)	0	0	0	0	0	0	0	0	0	0
Taeniopterygidae										
Taeniopteryx sp. Pictet 1841	0	0	0	0	0	0	0	0	0	0
tera										
Gerridae										
Gerris sp. Fabricius 1794	0	0	0	0	0	0	0	0	0	0
Veliidae										
Rhagovelia sp. Mayr 1865	0	0	0	0	0	0	0	0	0	0
ɔptera										
Corydalidae										
Nigronia sp. Banks 1908	0	0	0	0	0	0	0	0	0	0
Nigronia serricornis (Say 1824)	0	0	0	0	0	0	0	0	0	0
Sialidae										
Sialis sp. Latreille 1802	0	0	0	0	0	0	0	0	0	0
ptera										
Brachycentridae										
Adicrophleps hitchcocki Flint 1965	0	0	0	0	0	0	0	0	0	0
Glossosomatidae										
Agapetus sp. Curtis 1834	0	0	0	0	0	0	0	4	0	44
Glossosoma sp. Curtis 1834	0	0	0	0	8	0	0	0	8	0
Hydropsychidae										
Cheumatopsyche sp. Wallengren 1891	0	0	0	0	0	0	0	0	0	0
Diplectrona metaqui Ross 1970	0	0	0	0	0	0	0	0	0	0
Diplectrona modesta Banks 1908	0	72	36	4	8	4	0	4	16	4
Hydropsyche sp. Pictet 1834	0	0	0	0	0	0	0	0	8	8
Hydropsyche alhedra Ross 1939	0	20	0	4	0	0	0	0	0	0
Hydropsyche bronta Ross 1938	0	0	0	0	0	0	0	0	0	0
Hydropsyche slossonae Banks 1905	0	4	0	8	16	24	4	0	8	0
Hydropsyche sparna Ross 1938	0	0	0	0	0	0	0	0	0	0
Parapsyche apicalis (Banks 1908)	0	0	0	0	0	0	0	0	0	0

Appendix III. Continued.

	S01	S02	S03	S04	S05	S06	S07	S08	S09	S10
Trichoptera (continued)										
Hydroptilidae										
Hydroptila sp. Dalman 1819	0	0	0	0	0	0	0	4	4	0
Ochrotrichia sp. Mosely 1934	0	0	0	0	0	0	0	0	0	0
Palaeagapetus celsus (Ross 1938)	4	0	0	0	0	0	0	0	0	0
Lepidostomatidae										
Lepidostoma sp. Rambur 1842	4	4	32	8	12	12	20	8	12	28
Leptoceridae										
Nectopsyche sp. Müller 1879	0	0	0	0	0	0	0	0	0	0
Limnephilidae										
Apatania sp. Kolenati 1848	0	0	0	0	0	0	0	0	0	0
Goera sp. Stephens 1829	0	0	0	0	0	0	0	0	0	0
Goera calcarata Banks 1899										
Goera fuscula Banks 1905	0	0	0	0	0	0	0	0	0	0
Hydatophylax argus (Harris 1869)	0	0	0	0	0	0	0	0	0	0
Pycnopsyche sp. Banks 1905	0	4	0	0	0	4	0	0	0	0
unidentified Limnephilidae	108	100	16	52	0	120	0	0	0	0
Molannidae										
Molanna blenda Sibley 1926	0	0	0	0	0	0	0	0	0	0
Odontoceridae										
Psilotreta labida Ross 1944	0	0	0	0	0	0	8	0	40	8
Philopotamidae										
Dolophilodes sp. Ulmer 1909	0	0	0	0	8	0	0	4	24	4
Dolophilodes distinctus (Walker 1852)	0	0	0	0	0	0	0	0	0	0
Wormaldia sp. MacLaclan 1865	0	0	0	0	0	0	0	0	0	0
Polycentropodidae										
Nyctiophylax sp. Brauer 1865	0	0	12	0	0	0	0	0	0	0
Polycentropus sp. Curtis 1835	0	20	28	28	12	4	8	16	4	0
Psychomyiidae										
Lype diversa (Banks 1914)	0	4	0	0	0	4	0	0	0	0
Rhyacophilidae										
Rhyacophila spp. Pictet 1834	16	12	20	0	12	0	0	0	0	0
Rhyacophila acutiloba Morse and Ross 1971	0	0	0	0	0	0	0	0	0	0
Rhyacophila amicis Ross 1956	0	0	0	0	0	0	0	0	0	0
Rhyacophila atrata Banks 1911	0	0	0	0	0	0	0	0	0	0
Rhyacophila banksi Ross 1944	0	0	0	0	0	0	0	0	0	0

Appendix III. Continued.

	S01	S02	S03	S04	S05	S06	S07	S08	S09	S10
Trichoptera (continued)										
Rhyacophilidae (continued)										
Rhyacophila carolina Banks 1911	0	0	0	0	0	0	0	0	0	0
Rhyacophila fuscula (Walker 1852)	0	24	4	0	12	0	4	0	0	6
Rhyacophila minor Banks 1924	16	20	8	20	4	0	0	0	0	0
Rhyacophila cf. *nigrita* Banks 1907	0	0	0	0	0	0	0	0	0	0
Rhyacophila torva Hagen 1861	0	0	0	0	4	0	0	0	0	0
Sericostomatidae										
Fattigia pele (Ross 1938)	0	4	0	0	0	0	0	0	0	0
Uenoidae										
Neophylax sp. MacLachlan 1871	0	8	0	16	0	0	128	68	0	18
Neophylax consimilis Betten 1934	0	0	0	0	0	0	0	0	0	0
Neophylax mitchelli Carpenter 1933	0	0	4	0	96	4	4	0	24	0
Neophylax oligius Ross 1938	0	0	0	0	0	0	0	0	0	0
Lepidoptera										
Pyralidae										
Petrophila sp. Guilding 1830	0	0	0	0	0	0	0	0	0	0
Coleoptera										
Dryopidae										
Helichus sp. Erichson 1847	0	0	0	0	0	0	0	0	0	0
Helichus cf. *fastigiatus* (Say 1824)	0	0	0	0	0	0	0	0	0	0
Elmidae										
Dubiraphia sp. Sanderson 1954	0	0	0	0	0	0	0	0	0	0
cf. *Dubiraphia vittata* (Melsheimer 1844)	0	0	0	0	0	0	0	0	0	0
Optioservus sp. Sanderson 1954	40	536	164	136	204	316	264	52	16	36
Optioservus immunis (Fall 1925)	0	0	0	0	0	0	0	0	0	0
Optioservus ovalis (LeConte 1863)	0	24	12	0	0	4	0	0	0	0
Optioservus trivittatus (Brown 1930)	0	0	0	0	0	0	0	0	0	0
Oulimnius latiusculus (LeConte 1866)	24	120	36	24	52	112	64	120	12	4
Promoresia sp. Sanderson 1954	0	0	0	0	0	0	0	0	0	0
Promoresia elegans (LeConte 1852)	0	0	0	0	0	0	0	0	0	0
Promoresia tardella (Fall 1925)	0	0	0	0	0	0	0	0	0	0

Appendix III. Continued.

	S01	S02	S03	S04	S05	S06	S07	S08	S09	S10
Coleoptera (continued)										
Hydrophilidae										
Cymbiodyta vindicata Fall 1924	0	0	0	0	0	0	0	0	4	0
Psephenidae										
Ectopria sp. LeConte 1853	0	4	0	0	0	0	0	0	0	0
Psephenus herricki (DeKay 1844)	0	0	0	0	0	4	4	12	4	2
Ptilodactylidae										
Anchytarsus bicolor (Melsheimer 1846)	0	0	0	0	0	0	0	0	0	0
Diptera										
Athericidae										
Atherix cf. *lantha* Webb 1977	0	0	0	0	0	0	0	0	0	0
Blephariceridae										
Blepharicera sp. Macquart 1843	20	28	68	40	16	100	12	24	44	322
Ceratopogonidae										
Ceratopogoninae										
Ceratopogonini										
Ceratopogon sp. Meigen 1803	0	0	0	0	0	0	0	0	0	0
Palpomyiini										
Bezzia sp. Kieffer 1899/*Palpomyia* sp. Meigen 1818	12	60	0	0	4	0	0	0	0	2
Sphaeromiini										
Probezzia sp. Kieffer 1906	0	0	28	0	0	28	88	32	48	8
Forcipomyiinae										
Forcipomyiini										
Atrichopogon sp. Kieffer 1906	4	0	0	0	0	0	0	0	0	0
Chironomidae										
Chironominae										
Chironomini										
Demicryptochironomus sp. Lenz 1941	0	0	0	0	0	8	36	4	0	12
Dicrotendipes sp. Kieffer 1913	0	0	0	0	0	0	0	0	0	0
Dicrotendipes neomodestus (Malloch 1915)	0	0	0	0	0	0	0	0	0	0
Microtendipes pedellus group (de Geer 1776)	0	12	16	20	0	128	100	456	12	94
Nilothauma sp. Kieffer 1921	0	0	0	0	0	0	0	0	0	0
Polypedilum (Polypedilum) spp. Kieffer 1913	0	68	148	224	120	84	188	68	132	104
Polypedilum (P.) aviceps Townes 1945	0	0	0	0	0	0	0	0	0	0
Polypedilum (P.) fallax (Johannsen 1905)	0	0	0	0	0	0	0	0	0	0

Appendix III. Continued.

	S01	S02	S03	S04	S05	S06	S07	S08	S09	S10
Diptera (continued)										
Chironomidae (continued)										
Chironominae (continued)										
Chironomini (continued)										
Polypedilum (P.) scalaenum group (Schrank 1803)	0	0	0	0	0	0	0	0	0	0
Robackia demeijerei (Kruseman 1933)	0	0	0	0	0	0	0	12	0	10
Stenochironomus sp. Kieffer 1919	0	0	0	0	0	0	0	0	0	0
cf. *Tribelos* sp. Townes 1945	0	0	0	0	0	0	0	0	0	0
Tanytarsini										
Constempellina sp. Brundin 1947	12	220	84	100	92	68	72	40	4	0
Rheotanytarsus sp. Bause 1913	12	32	72	16	8	4	0	0	20	0
Sublettea sp. Roback 1975	0	0	0	0	0	16	92	292	20	6
Tanytarsus sp. van der Wulp 1874	276	2232	816	848	1900	1616	4900	2248	896	384
Diamesinae										
Diamesini										
Diamesa sp. Meigen 1835	608	700	344	104	4	12	40	44	56	66
Orthocladiinae										
Corynoneurini										
Corynoneura sp. Winnertz 1846	32	140	184	172	92	44	312	60	112	16
Rheosmittia sp. Brundin 1956	168	76	8	16	8	0	0	0	0	0
Thienemanniella sp. Kieffer 1911	32	556	88	92	20	28	52	16	24	6
Orthocladiini										
Brillia sp. Kieffer 1913	0	32	56	36	16	12	8	0	0	4
Cricotopus spp./*Orthocladius* spp. van der Wulp 1874	616	860	1180	284	84	48	220	112	144	72
Cricotopus spp. van der Wulp 1874	0	176	424	188	36	48	80	172	72	10
Epoicocladius sp. Zavrel 1924	0	0	0	0	0	0	0	0	0	0
Heterotrissocladius marcidus group (Walker 1856)	24	228	48	28	16	0	60	12	0	6
Limnophyes sp. Eaton 1875	0	0	0	0	0	4	0	0	0	0
Orthocladius (Eudactylocladius) spp. Thienemann 1935	1208	2180	1460	1256	36	60	104	88	60	114
Orthocladius (Orthocladius) spp. van der Wulp 1874	0	0	0	0	0	0	8	104	0	0
Parachaetocladius sp. Wülker 1959	96	24	12	4	0	4	8	4	4	0
Parametriocnemus sp. Goetghebuer 1932	4	80	36	260	4	20	12	12	20	10
Psectrocladius sp. Kieffer 1906	0	0	0	0	0	0	0	0	0	0
Psilometriocnemus sp. Saether 1969	24	120	60	136	24	0	60	8	0	2
Rheocricotopus sp. Thienemann and Harnisch 1932	48	160	464	192	316	84	116	36	16	6
Synorthocladius sp. Thienemann 1935	44	296	4	0	4	0	8	44	4	4

Appendix III. Continued.

	S01	S02	S03	S04	S05	S06	S07	S08	S09	S10
Diptera (continued)										
Chironomidae (continued)										
Prodiamesinae										
Prodiamesa sp. Kieffer 1906	0	0	0	0	0	0	0	0	0	0
Tanypodinae										
Macropelopiini										
Brundiniella sp. Roback 1978	0	48	8	4	12	4	8	0	0	10
Pentaneurini										
Ablabesmyia cf. *mallochi* (Walley 1925)	0	0	0	0	0	0	0	0	0	0
Larsia sp. Fittkau 1962	0	0	0	0	0	0	0	0	0	0
Thienemannimyia sp. Fittkau 1957	0	40	44	32	20	48	68	56	28	18
unidentified Tanypodinae	56	200	112	280	120	36	168	60	20	32
Dixidae										
Dixa sp. Meigen 1818	0	0	0	0	4	0	0	0	0	0
Empididae										
Chelifera sp. Macquart 1823	28	32	24	0	0	24	4	32	0	2
Clinocera sp. Meigen 1803	0	0	0	0	24	0	52	48	16	6
Hemerodromia sp. Meigen 1822	0	0	0	0	0	0	0	0	0	0
Ephydridae										
Scatophila sp. Becker 1896	0	0	0	0	0	0	0	0	0	0
Psychodidae										
Pericoma sp. Walker 1856	0	0	0	0	0	0	0	0	0	0
Telmatoscopus sp. Eaton 1904	0	0	0	0	0	0	0	0	0	0
Simuliidae										
Prosimulium sp. Roubaud 1906	380	160	344	68	24	176	52	284	32	158
Simulium sp. Latreille 1802	0	0	0	0	0	0	0	0	0	0
Stegopterna mutata (Malloch 1914)	0	0	0	0	0	0	0	0	0	0
Stratiomyidae										
cf. *Nemotelus* sp. Geoffroy 1762	0	0	4	0	0	0	0	0	0	0
Tabanidae										
Chrysops sp. Meigen 1803	0	0	0	0	0	0	0	0	0	0
Thaumaleidae										
Thaumalea americana Bezzi 1913	0	0	0	0	0	0	0	0	0	0

Appendix III. Continued.

	S01	S02	S03	S04	S05	S06	S07	S08	S09	S10
Diptera (continued)										
Tipulidae										
Antocha sp. Osten Sacken 1859	0	84	32	12	12	4	4	4	0	6
Dicranota sp. Zetterstedt 1838	32	28	32	0	0	4	0	0	4	0
cf. *Erioptera* sp. Meigen 1803	0	0	0	0	0	0	0	0	0	0
Hexatoma sp. Latreille 1809	0	104	16	28	24	80	48	40	32	38
Limnophila sp. Macquart 1834	0	8	0	0	0	0	12	0	0	0
Pedicia sp. Latreille 1809	0	0	0	0	0	0	0	0	0	0
Pseudolimnophila sp. Alexander 1919	0	0	0	0	0	0	0	4	40	0
Tipula sp. Linnaeus 1758	0	0	4	0	0	0	0	0	0	0
Collembola										
Isotomidae/Entomobryidae	80	132	116	88	20	40	12	16	8	20
Sminthuridae	0	0	0	0	0	0	0	0	4	0
Acarina										
Lebertiidae										
Lebertia sp. Viets 1909	32	28	4	0	16	72	28	16	16	4
unidentified Acarina	8	0	0	4	4	0	16	4	16	0
Amphipoda										
Gammaridae										
Gammarus minus Say 1818	0	0	0	0	0	0	0	0	0	2
Decapoda										
Cambaridae	0	4	4	0	0	0	0	0	0	0
Isopoda	0	0	0	0	0	0	0	0	0	0
Ostracoda	0	4	44	76	28	48	0	12	48	0
Cnidaria	0	0	0	0	0	0	0	0	0	0
Turbellaria	8	4	4	0	4	16	0	8	12	0
Nematoda	20	40	48	44	4	4	8	4	16	2

Appendix III. Continued.

	S01	S02	S03	S04	S05	S06	S07	S08	S09	S10
Oligochaeta										
Naididae	20	104	4	124	32	96	36	56	24	8
Tubificidae	0	0	0	0	0	0	0	0	0	0
Branchiobdellida	0	8	4	4	4	0	0	0	0	0
Mollusca										
Physidae	0	0	0	4	0	0	0	0	0	0
Planorbidae	0	0	0	0	0	0	0	0	0	0
Sphaeriidae	0	0	0	0	4	0	0	0	0	0

Appendix IV. Spring survey 1999 taxa list for Whiteoak Canyon Run in Shenandoah National Park, Madison County, Virginia.

	W01	W03	W04	W05	W06	W07	W08	W10
Ephemeroptera								
Ameletidae								
Ameletus sp. Eaton 1885	28	20	16	36	44	8	4	4
Ameletus cryptostimulus Carle 1978	0	0	0	4	0	0	0	0
Ameletus lineatus Traver 1932	0	0	0	0	4	0	4	8
Baetidae								
Acentrella ampla Traver 1932	4	8	16	28	68	32	24	16
Baetis sp. Leach 1815	4	24	52	88	108	56	52	24
Baetis brunneicolor McDunnough 1925	0	0	0	0	0	0	0	0
Baetis flavistriga McDunnough 1921	0	0	0	0	0	0	0	0
Baetis cf. *intercalaris* McDunnough 1921	0	0	0	0	0	0	0	0
Baetis tricaudatus Dodds 1923	0	0	52	8	20	28	0	12
Baetiscidae								
Baetisca carolina Traver 1931	0	0	0	0	0	0	0	0
Caenidae								
Caenis sp. Stephens 1835	0	0	0	0	0	0	0	0
Ephemerellidae								
Drunella sp. Needham 1905	0	0	0	0	0	0	0	4
Drunella cf. *lata* (Morgan 1911)	0	0	0	0	0	0	0	0
Ephemerella sp. Walsh 1862	24	28	8	168	64	20	40	60
Ephemerella dorothea Needham 1908	0	0	0	0	0	0	0	0
Ephemerella hispida Allen and Edmunds 1965	0	0	0	0	0	0	0	0
Ephemerella rossi Allen and Edmunds 1965	0	0	0	0	0	0	0	0
Ephemerella cf. *subvaria* McDunnough 1925	0	0	0	0	0	0	0	0
Eurylophella sp. Tiensuu 1935	0	4	0	0	0	0	4	0
Eurylophella funeralis (McDunnough 1925)	4	8	0	0	4	16	0	0
Eurylophella temporalis (McDunnough 1924)	0	0	0	0	0	0	0	0
unidentified Ephemerellidae	72	120	16	60	56	0	60	28
Ephemeridae								
Ephemera sp. Linnaeus 1758	0	0	0	0	4	4	0	0
Ephemera simulans Walker 1853	0	0	0	0	0	0	0	0
Heptageniidae								
Cinygmula subaequalis (Banks 1914)	228	224	8	92	28	20	20	32
Epeorus sp. Eaton 1881	416	392	304	380	436	76	88	220
Epeorus (Iron) dispar (Traver 1935)	0	0	0	0	0	0	0	0

Appendix IV. Continued.

	W01	W03	W04	W05	W06	W07	W08	W10
Ephemeroptera (continued)								
Heptageniidae (continued)								
Epeorus (Iron) pleuralis (Banks 1910)	40	16	24	40	52	56	12	64
Epeorus (Iron) rubidus (Traver 1933)	0	0	0	0	0	0	0	0
Heptagenia sp. Walsh 1863	0	0	0	0	0	0	0	0
Leucrocuta sp. Flowers 1980	4	160	8	12	8	4	0	16
Rhithrogena sp. Eaton 1881	0	0	0	0	0	0	0	0
Stenacron sp. Jensen 1974	0	0	0	0	0	0	0	0
Stenacron cf. *pallidum* (Traver 1933)	0	0	0	0	0	0	0	0
Stenonema sp. Traver 1933	0	4	12	8	0	0	0	4
Stenonema femoratum (Say 1823)	0	0	0	0	0	0	0	0
Stenonema meririvulanum Carle and Lewis 1978	0	0	0	4	0	0	0	0
Stenonema pudicum (Hagen 1861)	0	0	0	0	0	0	0	0
Stenonema vicarium (Walker 1853)	0	0	0	0	0	0	0	0
unidentified Heptageniidae	84	96	80	156	112	12	60	24
Isonychiidae								
Isonychia sp. Eaton 1871	0	0	0	0	0	0	0	0
Leptophlebiidae								
Habrophlebia vibrans Needham 1908	0	4	0	20	12	36	4	4
Paraleptophlebia sp. Lestage 1917	192	72	24	88	16	12	92	4
Paraleptophlebia adoptiva (McDunnough 1929)	0	0	12	28	24	4	0	12
Paraleptophlebia cf. *mollis* (Eaton 1871)	0	20	0	0	0	0	0	0
Odonata								
Aeshnidae								
Boyeria grafiana Williamson 1907	0	0	0	0	0	0	0	0
Calopterygidae								
Hetaerina sp. Hagen 1854	0	0	0	0	0	0	0	0
Cordulegastridae								
Cordulegaster sp. Leach 1815	0	0	0	0	0	0	0	0
Gomphidae								
Lanthus parvulus (Selys 1854)	0	0	0	0	0	0	0	0
Lanthus vernalis Carle 1980	0	0	4	0	0	0	0	0
cf. *Stylogomphus albistylus* (Hagen 1878)	0	0	0	0	0	0	0	0
unidentified Gomphidae	0	0	0	0	0	0	0	0

Appendix IV. Continued.

	W01	W03	W04	W05	W06	W07	W08	W10
Plecoptera								
Capniidae								
Paracapnia sp. Hanson 1946	12	0	0	0	0	0	0	0
Chloroperlidae								
Haploperla brevis (Banks 1895)	104	84	72	108	68	12	12	44
Sweltsa sp. Ricker 1943	0	16	16	28	20	8	24	24
Leuctridae								
Leuctra sp. Stephens 1836	1292	532	56	96	76	4	36	72
Zealeuctra sp. Ricker 1952	4	0	0	0	0	0	0	0
Nemouridae								
Amphinemura sp. Ris 1902	20	4	0	4	0	0	8	4
Amphinemura nigritta (Provancher 1876)	0	0	0	0	0	0	0	0
Amphinemura wui (Claassen 1936)	0	4	0	16	0	0	0	0
Nemoura sp. Latreille 1796	0	0	0	0	0	0	0	0
Peltoperlidae								
Peltoperla sp. Needham 1905	148	208	0	72	12	0	0	28
cf. *Tallaperla* sp. Stark and Stewart 1981	0	0	0	0	0	0	8	0
Perlidae								
Acroneuria sp. Pictet 1841	0	0	0	0	0	0	0	0
Acroneuria abnormis (Newman 1838)	0	0	0	4	4	0	4	0
Acroneuria carolinensis (Banks 1905)	0	0	0	0	0	0	0	0
Agnetina capitata (Pictet 1841)	0	0	0	0	0	0	0	0
Eccoptura xanthenes (Newman 1828)	0	0	0	0	0	0	0	0
Paragnetina sp. Klapálek 1907	0	0	0	0	0	0	0	0
Paragnetina immarginata (Say 1823)	0	0	0	0	0	0	0	0
unidentified Perlidae	12	16	12	16	4	0	12	32
Perlodidae								
Isogenoides hansoni (Ricker 1952)	0	0	0	0	0	0	0	0
Isoperla sp. Banks 1906	32	24	24	80	48	8	24	24
Isoperla bilineata (Say 1823)	4	0	0	0	0	0	0	0
Isoperla cf. *cotta* Ricker 1952	0	0	0	0	0	0	0	0
Isoperla lata Frison 1942	0	0	0	0	0	0	0	0
Isoperla marlynia Needham and Claassen 1925	4	4	0	0	16	0	0	0
Isoperla similis (Hagen 1861)	0	0	0	0	0	0	0	0
Malirekus hastatus (Banks 1920)	0	4	0	0	4	0	0	0
Yugus sp. Ricker 1952	0	0	0	0	0	0	0	0

Appendix IV. Continued.

	W01	W03	W04	W05	W06	W07	W08	W10
Plecoptera (continued)								
Pteronarcyidae								
Allonarcys sp. Needham and Claassen 1925	16	84	28	256	28	4	60	8
Allonarcys proteus (Newman 1838)	0	0	0	0	0	0	0	0
Taeniopterygidae								
Taeniopteryx sp. Pictet 1841	0	0	0	0	0	0	0	0
Hemiptera								
Gerridae								
Gerris sp. Fabricius 1794	0	0	0	0	0	0	0	0
Veliidae								
Rhagovelia sp. Mayr 1865	0	0	0	0	0	0	0	0
Megaloptera								
Corydalidae								
Nigronia sp. Banks 1908	0	0	0	0	0	0	0	0
Nigronia serricornis (Say 1824)	0	0	0	0	0	0	0	0
Sialidae								
Sialis sp. Latreille 1802	0	0	0	0	0	0	0	0
Trichoptera								
Brachycentridae								
Adicrophleps hitchcocki Flint 1965	0	0	0	0	0	0	0	0
Glossosomatidae								
Agapetus sp. Curtis 1834	0	0	0	0	0	0	0	0
Glossosoma sp. Curtis 1834	0	0	0	0	0	0	0	0
Hydropsychidae								
Cheumatopsyche sp. Wallengren 1891	0	0	0	0	0	0	0	0
Diplectrona metaqui Ross 1970	0	0	0	0	0	0	4	0
Diplectrona modesta Banks 1908	12	16	0	4	4	0	32	0
Hydropsyche sp. Pictet 1834	0	12	0	16	0	0	8	0
Hydropsyche alhedra Ross 1939	0	16	4	4	0	0	0	0
Hydropsyche bronta Ross 1938	0	0	0	0	0	0	0	0
Hydropsyche slossonae Banks 1905	0	0	0	0	0	0	0	0
Hydropsyche sparna Ross 1938	0	0	0	0	0	0	0	0
Parapsyche apicalis (Banks 1908)	0	0	0	0	0	0	0	0

Appendix IV. Continued.

	W01	W03	W04	W05	W06	W07	W08	W10
Trichoptera (continued)								
Hydroptilidae								
Hydroptila sp. Dalman 1819	0	0	0	28	0	0	0	8
Ochrotrichia sp. Mosely 1934	0	0	0	0	0	0	0	0
Palaeagapetus celsus (Ross 1938)	0	0	0	0	0	0	0	0
Lepidostomatidae								
Lepidostoma sp. Rambur 1842	16	20	0	16	4	4	16	0
Leptoceridae								
Nectopsyche sp. Müller 1879	0	0	0	0	0	0	0	0
Limnephilidae								
Apatania sp. Kolenati 1848	0	0	0	0	0	0	0	0
Goera sp. Stephens 1829	0	0	0	0	0	0	0	0
Goera calcarata Banks 1899	0	0	0	0	0	0	0	0
Goera fuscula Banks 1905	0	0	0	0	0	0	0	0
Hydatophylax argus (Harris 1869)	0	0	0	0	0	0	0	0
Pycnopsyche sp. Banks 1905	0	0	0	0	0	0	0	0
unidentified Limnephilidae	32	36	12	16	8	0	8	8
Molannidae								
Molanna blenda Sibley 1926	0	0	0	0	0	0	0	0
Odontoceridae								
Psilotreta labida Ross 1944	0	0	0	0	0	0	4	0
Philopotamidae								
Dolophilodes sp. Ulmer 1909	0	0	0	4	0	0	8	0
Dolophilodes distinctus (Walker 1852)	0	0	0	0	0	0	0	0
Wormaldia sp. MacLaclan 1865	0	0	0	0	0	0	0	0
Polycentropodidae								
Nyctiophylax sp. Brauer 1865	0	0	0	0	0	0	0	0
Polycentropus sp. Curtis 1835	0	0	0	0	0	0	0	4
Psychomyiidae								
Lype diversa (Banks 1914)	0	0	0	0	0	0	0	0
Rhyacophilidae								
Rhyacophila spp. Pictet 1834	0	8	0	8	0	0	20	0
Rhyacophila acutiloba Morse and Ross 1971	0	0	0	0	0	0	0	0
Rhyacophila amicis Ross 1956	0	0	0	0	0	0	0	0
Rhyacophila atrata Banks 1911	0	0	0	0	0	0	0	0
Rhyacophila banksi Ross 1944	0	0	0	0	0	0	0	0

Appendix IV. Continued.

	W01	W03	W04	W05	W06	W07	W08	W10
Trichoptera (continued)								
Rhyacophilidae (continued)								
Rhyacophila carolina Banks 1911	0	0	0	0	0	0	0	0
Rhyacophila fuscula (Walker 1852)	0	0	0	0	4	0	0	4
Rhyacophila minor Banks 1924	4	0	0	0	0	0	0	0
Rhyacophila cf. *nigrita* Banks 1907	0	0	0	0	0	0	0	0
Rhyacophila torva Hagen 1861	0	0	4	0	0	0	4	0
Sericostomatidae								
Fattigia pele (Ross 1938)	0	0	0	0	0	0	0	0
Uenoidae								
Neophylax sp. MacLachlan 1871	0	0	0	0	0	0	0	0
Neophylax consimilis Betten 1934	0	0	0	0	0	0	0	0
Neophylax mitchelli Carpenter 1933	0	0	0	0	0	0	0	0
Neophylax oligius Ross 1938	0	0	0	0	0	0	0	0
Lepidoptera								
Pyralidae								
Petrophila sp. Guilding 1830	0	0	0	0	0	0	0	0
Coleoptera								
Dryopidae								
Helichus sp. Erichson 1847	0	0	0	0	0	0	0	0
Helichus cf. *fastigiatus* (Say 1824)	0	0	0	0	0	0	4	0
Elmidae								
Dubiraphia sp. Sanderson 1954	0	0	0	0	0	0	0	0
cf. *Dubiraphia vittata* (Melsheimer 1844)	0	0	0	0	0	0	0	0
Optioservus sp. Sanderson 1954	312	236	36	76	20	4	16	4
Optioservus immunis (Fall 1925)	0	0	0	0	0	0	0	0
Optioservus ovalis (LeConte 1863)	0	0	0	0	0	0	0	0
Optioservus trivittatus (Brown 1930)	0	0	0	0	0	0	0	0
Oulimnius latiusculus (LeConte 1866)	92	64	20	28	4	0	0	0
Promoresia sp. Sanderson 1954	0	0	0	0	88	76	20	0
Promoresia elegans (LeConte 1852)	0	0	0	32	0	8	0	0
Promoresia tardella (Fall 1925)	0	0	0	0	4	4	0	0

IV. Continued.

	W01	W03	W04	W05	W06	W07	W08	W10
a (continued)								
Hydrophilidae								
Cymbiodyta vindicata Fall 1924	0	0	0	0	0	0	0	0
Psephenidae								
Ectopria sp. LeConte 1853	0	0	0	0	4	0	0	0
Psephenus herricki (DeKay 1844)	0	0	0	0	0	0	0	0
Ptilodactylidae								
Anchytarsus bicolor (Melsheimer 1846)	0	0	0	0	0	0	0	0
Athericidae								
Atherix cf. *lantha* Webb 1977	0	0	0	0	0	0	0	0
Blephariceridae								
Blepharicera sp. Macquart 1843	0	8	8	52	48	16	4	80
Ceratopogonidae								
Ceratopogoninae								
Ceratopogonini								
Ceratopogon sp. Meigen 1803	8	0	0	0	0	0	0	0
Palpomyiini								
Bezzia sp. Kieffer 1899/*Palpomyia* sp. Meigen 1818	0	0	0	0	0	0	0	0
Sphaeromiini								
Probezzia sp. Kieffer 1906	36	12	4	12	0	0	0	20
Forcipomyiinae								
Forcipomyiini								
Atrichopogon sp. Kieffer 1906	4	0	0	0	0	0	0	0
Chironomidae								
Chironominae								
Chironomini								
Demicryptochironomus sp. Lenz 1941	0	8	4	8	4	4	4	0
Dicrotendipes sp. Kieffer 1913	0	0	0	0	0	0	0	0
Dicrotendipes neomodestus (Malloch 1915)	0	0	0	0	0	0	0	0
Microtendipes pedellus group (de Geer 1776)	4	16	0	28	8	8	0	12
Nilothauma sp. Kieffer 1921	0	0	0	0	0	0	0	0
Polypedilum (Polypedilum) spp. Kieffer 1913	124	516	28	276	76	148	136	68
Polypedilum (P.) aviceps Townes 1945	0	0	0	0	4	0	0	0
Polypedilum (P.) fallax (Johannsen 1905)	0	0	0	0	0	0	0	0

Appendix IV. Continued.

	W01	W03	W04	W05	W06	W07	W08	W10
Diptera (continued)								
Chironomidae (continued)								
Chironominae (continued)								
Chironomini (continued)								
Polypedilum (P.) scalaenum group (Schrank 1803)	0	0	0	0	0	0	0	0
Robackia demeijerei (Kruseman 1933)	0	0	0	0	0	0	0	0
Stenochironomus sp. Kieffer 1919	0	0	0	0	0	4	0	0
cf. *Tribelos* sp. Townes 1945	0	0	0	0	0	0	0	0
Tanytarsini								
Constempellina sp. Brundin 1947	52	48	16	64	4	0	32	0
Rheotanytarsus sp. Bause 1913	12	68	0	0	0	0	0	0
Sublettea sp. Roback 1975	4	212	16	104	4	40	12	212
Tanytarsus sp. van der Wulp 1874	500	844	220	984	232	128	88	320
Diamesinae								
Diamesini								
Diamesa sp. Meigen 1835	60	344	16	48	116	68	432	152
Orthocladiinae								
Corynoneurini								
Corynoneura sp. Winnertz 1846	76	20	44	88	140	44	128	220
Rheosmittia sp. Brundin 1956	0	0	0	0	0	0	0	0
Thienemanniella sp. Kieffer 1911	560	560	88	324	128	128	84	180
Orthocladiini								
Brillia sp. Kieffer 1913	12	4	4	8	4	0	4	8
Cricotopus spp./*Orthocladius* spp. van der Wulp 1874	200	720	136	620	304	152	828	356
Cricotopus spp. van der Wulp 1874	16	8	8	112	8	0	280	52
Epoicocladius sp. Zavrel 1924	0	0	0	0	0	0	0	0
Heterotrissocladius marcidus group (Walker 1856)	60	284	20	24	36	44	0	4
Limnophyes sp. Eaton 1875	0	0	0	0	0	0	0	0
Orthocladius (Eudactylocladius) spp. Thienemann 1935	92	104	100	288	1060	184	2068	192
Orthocladius (Orthocladius) spp. van der Wulp 1874	0	0	0	0	0	0	0	0
Parachaetocladius sp. Wülker 1959	8	8	0	0	0	0	0	0
Parametriocnemus sp. Goetghebuer 1932	168	196	48	40	88	20	28	28
Psectrocladius sp. Kieffer 1906	0	0	0	0	0	0	0	0
Psilometriocnemus sp. Saether 1969	56	56	28	24	44	0	4	20
Rheocricotopus sp. Thienemann and Harnisch 1932	12	24	16	92	88	56	36	160
Synorthocladius sp. Thienemann 1935	16	12	16	36	28	4	4	24

Appendix IV. Continued.

	W01	W03	W04	W05	W06	W07	W08	W10
Diptera (continued)								
Chironomidae (continued)								
Prodiamesinae								
Prodiamesa sp. Kieffer 1906	0	4	0	0	0	0	0	0
Tanypodinae								
Macropelopiini								
Brundiniella sp. Roback 1978	0	64	0	0	0	0	0	4
Pentaneurini								
Ablabesmyia cf. *mallochi* (Walley 1925)	132	68	0	0	0	4	0	0
Larsia sp. Fittkau 1962	0	0	0	0	0	0	0	0
Thienemannimyia sp. Fittkau 1957	68	60	36	96	60	8	20	52
unidentified Tanypodinae	136	200	44	140	88	52	16	68
Dixidae								
Dixa sp. Meigen 1818	0	0	0	0	0	0	0	0
Empididae								
Chelifera sp. Macquart 1823	12	20	4	20	16	0	20	12
Clinocera sp. Meigen 1803	0	0	0	0	0	0	0	4
Hemerodromia sp. Meigen 1822	0	0	0	0	4	0	0	0
Ephydridae								
Scatophila sp. Becker 1896	0	0	0	0	0	0	0	0
Psychodidae								
Pericoma sp. Walker 1856	0	0	0	0	0	0	0	0
Telmatoscopus sp. Eaton 1904	0	0	0	0	0	0	0	0
Simuliidae								
Prosimulium sp. Roubaud 1906	60	548	480	2320	1056	308	300	1120
Simulium sp. Latreille 1802	0	0	0	0	0	0	0	0
Stegopterna mutata (Malloch 1914)	0	0	0	0	0	0	0	0
Stratiomyidae								
cf. *Nemotelus* sp. Geoffroy 1762	0	0	0	0	0	0	0	0
Tabanidae								
Chrysops sp. Meigen 1803	0	0	0	0	0	0	0	0
Thaumaleidae								
Thaumalea americana Bezzi 1913	0	0	0	0	0	0	0	0

Appendix IV. Continued.

	W01	W03	W04	W05	W06	W07	W08	W10
Diptera (continued)								
Tipulidae								
Antocha sp. Osten Sacken 1859	0	32	0	8	0	0	0	0
Dicranota sp. Zetterstedt 1838	8	0	0	0	0	0	4	0
cf. *Erioptera* sp. Meigen 1803	0	0	0	0	0	0	0	0
Hexatoma sp. Latreille 1809	8	8	0	0	20	0	16	12
Limnophila sp. Macquart 1834	4	4	0	0	0	0	0	0
Pedicia sp. Latreille 1809	0	0	0	0	0	0	0	0
Pseudolimnophila sp. Alexander 1919	0	0	0	0	0	0	0	0
Tipula sp. Linnaeus 1758	0	0	0	0	0	0	0	0
Collembola								
Isotomidae/Entomobryidae	12	4	40	52	52	12	8	12
Sminthuridae	0	0	0	0	0	0	0	0
Acarina								
Lebertiidae								
Lebertia sp. Viets 1909	0	28	16	108	16	8	16	12
unidentified Acarina	0	0	0	0	0	0	0	0
Amphipoda								
Gammaridae								
Gammarus minus Say 1818	0	0	0	0	0	0	0	0
Decapoda								
Cambaridae	0	4	0	4	0	0	0	0
Isopoda	0	0	0	0	0	0	12	0
Ostracoda	0	24	0	0	0	0	0	0
Cnidaria	0	0	0	0	0	0	0	0
Turbellaria	4	28	20	96	0	4	0	0
Nematoda	20	12	24	20	4	60	0	4

Appendix IV. Continued.

	W01	W03	W04	W05	W06	W07	W08	W10
Oligochaeta								
Naididae	20	40	40	32	36	8	16	64
Tubificidae	0	4	0	0	0	0	0	4
Branchiobdellida	8	4	0	0	0	0	0	0
Mollusca								
Physidae	0	4	0	4	0	0	16	8
Planorbidae	0	0	0	0	0	0	0	0
Sphaeriidae	0	0	0	0	0	0	0	0

Appendix V. Fall survey 2000 taxa list for Staunton River in Shenandoah National Park, Madison County, Virginia.

	S01	S02	S03	S04	S05	S06	S07	S08	S09	S10
Ephemeroptera										
Ameletidae										
Ameletus sp. Eaton 1885	116	12	72	12	20	20	56	0	20	0
Ameletus cryptostimulus Carle 1978	0	0	0	0	0	0	0	0	0	0
Ameletus lineatus Traver 1932	0	0	0	0	0	0	0	0	0	0
Baetidae										
Acentrella ampla Traver 1932	12	64	88	44	52	52	108	116	448	12
Baetis sp. Leach 1815	32	40	48	100	100	80	8	88	40	44
Baetis brunneicolor McDunnough 1925	0	0	0	0	0	0	0	0	0	0
Baetis flavistriga McDunnough 1921	0	0	0	0	20	0	76	0	0	0
Baetis cf. *intercalaris* McDunnough 1921	0	0	28	0	8	4	0	4	0	0
Baetis tricaudatus Dodds 1923	0	16	72	48	20	52	28	0	8	0
Baetiscidae										
Baetisca carolina Traver 1931	0	0	0	0	0	0	0	0	0	0
Caenidae										
Caenis sp. Stephens 1835	0	0	0	0	0	0	4	4	0	0
Ephemerellidae										
Drunella sp. Needham 1905	0	0	0	0	0	0	0	0	0	0
Drunella cf. *lata* (Morgan 1911)	0	0	0	0	0	0	0	0	0	0
Ephemerella sp. Walsh 1862	0	0	4	0	0	0	428	0	0	0
Ephemerella dorothea Needham 1908	0	0	0	0	0	0	0	0	0	0
Ephemerella hispida Allen and Edmunds 1965	0	0	0	0	0	0	0	0	0	0
Ephemerella rossi Allen and Edmunds 1965	0	0	0	0	0	4	0	0	0	0
Ephemerella cf. *subvaria* McDunnough 1925	0	0	12	0	8	24	28	0	24	0
Eurylophella sp. Tiensuu 1935	0	4	8	0	124	24	1016	2180	432	660
Eurylophella funeralis (McDunnough 1925)	0	0	0	0	0	0	0	0	0	0
Eurylophella temporalis (McDunnough 1924)	0	0	0	0	0	0	0	0	0	0
unidentified Ephemerellidae	1028	280	68	140	588	248	84	996	544	88
Ephemeridae										
Ephemera sp. Linnaeus 1758	0	0	0	0	0	0	0	0	0	0
Ephemera simulans Walker 1853	0	0	0	0	0	0	0	0	0	0
Heptageniidae										
Cinygmula subaequalis (Banks 1914)	0	0	0	0	0	0	0	0	0	0
Epeorus sp. Eaton 1881	252	124	284	128	120	80	72	24	228	12
Epeorus (Iron) dispar (Traver 1935)	8	0	0	0	0	0	0	0	0	0

Appendix V. Continued.

	S01	S02	S03	S04	S05	S06	S07	S08	S09	S10
Ephemeroptera (continued)										
Heptageniidae (continued)										
Epeorus (Iron) pleuralis (Banks 1910)	0	0	12	12	12	0	0	0	0	0
Epeorus (Iron) rubidus (Traver 1933)	0	0	0	0	0	0	0	0	0	0
Heptagenia sp. Walsh 1863	0	0	0	0	0	0	0	0	0	0
Leucrocuta sp. Flowers 1980	24	0	56	8	40	56	76	16	36	8
Rhithrogena sp. Eaton 1881	0	0	0	0	0	0	0	0	0	0
Stenacron sp. Jensen 1974	0	0	0	0	0	0	0	0	0	0
Stenacron cf. *pallidum* (Traver 1933)	0	0	0	0	0	0	0	0	0	0
Stenonema sp. Traver 1933	0	0	8	4	16	24	0	0	0	0
Stenonema femoratum (Say 1823)	0	0	0	0	0	0	0	0	0	0
Stenonema meririvulanum Carle and Lewis 1978	0	0	0	0	0	0	0	0	0	0
Stenonema pudicum (Hagen 1861)	0	0	8	12	4	4	16	16	8	8
Stenonema vicarium (Walker 1853)	0	0	0	0	0	0	0	0	0	0
unidentified Heptageniidae	204	120	68	44	120	0	8	20	124	4
Isonychiidae										
Isonychia sp. Eaton 1871	0	0	0	0	0	0	0	0	16	0
Leptophlebiidae										
Habrophlebia vibrans Needham 1908	0	0	0	0	4	0	0	0	0	0
Paraleptophlebia sp. Lestage 1917	296	136	388	128	216	220	180	80	368	88
Paraleptophlebia adoptiva (McDunnough 1929)	0	0	0	0	0	0	0	0	0	0
Paraleptophlebia cf. *mollis* (Eaton 1871)	0	0	0	0	0	0	0	0	0	0
Odonata										
Aeshnidae										
Boyeria grafiana Williamson 1907	0	0	0	0	0	0	0	0	0	0
Calopterygidae										
Hetaerina sp. Hagen 1854	0	0	0	0	0	0	0	0	0	4
Cordulegastridae										
Cordulegaster sp. Leach 1815	0	0	0	0	0	0	0	4	0	0
Gomphidae										
Lanthus parvulus (Selys 1854)	0	0	0	0	0	0	0	0	0	0
Lanthus vernalis Carle 1980	4	0	0	0	0	0	0	0	0	0
cf. *Stylogomphus albistylus* (Hagen 1878)	0	0	0	0	0	0	0	0	0	0
unidentified Gomphidae	0	0	0	0	0	0	4	0	8	0

Appendix V. Continued.

	S01	S02	S03	S04	S05	S06	S07	S08	S09	S10
Plecoptera										
Capniidae										
Paracapnia sp. Hanson 1946	304	76	244	212	300	184	572	240	384	80
Chloroperlidae										
Haploperla brevis (Banks 1895)	60	140	112	28	60	16	48	40	28	4
Sweltsa sp. Ricker 1943	56	76	68	52	40	72	56	32	160	20
Leuctridae										
Leuctra sp. Stephens 1836	388	80	248	36	80	112	16	128	124	4
Zealeuctra sp. Ricker 1952	0	0	4	0	0	0	0	0	0	0
Nemouridae										
Amphinemura sp. Ris 1902	84	44	36	28	12	12	0	0	0	0
Amphinemura nigritta (Provancher 1876)	0	0	0	0	0	0	0	0	0	0
Amphinemura wui (Claassen 1936)	0	0	0	0	0	0	0	0	0	0
Nemoura sp. Latreille 1796	0	4	4	0	0	0	0	0	0	0
Peltoperlidae										
Peltoperla sp. Needham 1905	20	12	16	0	0	0	0	0	0	0
cf. *Tallaperla* sp. Stark and Stewart 1981	0	0	0	0	0	0	0	0	0	0
Perlidae										
Acroneuria sp. Pictet 1841	0	0	4	0	4	0	0	0	4	0
Acroneuria abnormis (Newman 1838)	0	0	0	0	0	0	0	0	0	0
Acroneuria carolinensis (Banks 1905)	0	0	0	0	0	4	0	0	4	0
Agnetina capitata (Pictet 1841)	0	0	0	4	12	32	16	4	4	0
Eccoptura xanthenes (Newman 1828)	0	0	0	0	0	0	0	0	0	0
Paragnetina sp. Klapálek 1907	0	0	0	0	0	0	0	0	0	0
Paragnetina immarginata (Say 1823)	0	0	0	0	0	4	0	4	0	0
unidentified Perlidae	24	16	68	60	280	252	184	200	504	28
Perlodidae										
Isogenoides hansoni (Ricker 1952)	0	0	0	0	0	4	0	0	8	4
Isoperla sp. Banks 1906	176	340	216	88	416	236	736	536	1004	100
Isoperla bilineata (Say 1823)	0	0	0	0	0	0	0	0	0	0
Isoperla cf. *cotta* Ricker 1952	0	0	0	0	0	0	0	0	0	0
Isoperla lata Frison 1942	0	0	0	0	0	0	0	0	0	0
Isoperla marlynia Needham and Claassen 1925	0	0	0	0	0	0	0	0	0	0
Isoperla similis (Hagen 1861)	0	0	0	0	0	0	0	0	0	0
Malirekus hastatus (Banks 1920)	16	0	4	0	0	0	0	0	0	0
Yugus sp. Ricker 1952	0	8	0	0	0	0	0	0	0	0

Appendix V. Continued.

	S01	S02	S03	S04	S05	S06	S07	S08	S09	S10
Plecoptera (continued)										
Pteronarcyidae										
Allonarcys sp. Needham and Claassen 1925	0	0	0	0	0	0	0	4	32	0
Allonarcys proteus (Newman 1838)	0	0	4	0	0	4	0	0	0	0
Taeniopterygidae										
Taeniopteryx sp. Pictet 1841	0	0	0	0	0	0	0	0	0	0
Hemiptera										
Gerridae										
Gerris sp. Fabricius 1794	0	0	0	0	0	0	0	0	0	0
Veliidae										
Rhagovelia sp. Mayr 1865	0	0	0	0	0	0	0	4	0	0
Megaloptera										
Corydalidae										
Nigronia sp. Banks 1908	0	0	0	0	0	0	0	0	0	0
Nigronia serricornis (Say 1824)	0	0	0	0	0	0	0	0	0	0
Sialidae										
Sialis sp. Latreille 1802	0	0	0	0	0	0	0	0	0	0
Trichoptera										
Brachycentridae										
Adicrophleps hitchcocki Flint 1965	36	0	0	0	0	0	0	0	0	0
Glossosomatidae										
Agapetus sp. Curtis 1834	0	0	0	0	0	0	0	0	0	0
Glossosoma sp. Curtis 1834	4	0	0	0	0	0	48	0	0	0
Hydropsychidae										
Cheumatopsyche sp. Wallengren 1891	0	0	0	8	4	8	24	24	20	0
Diplectrona metaqui Ross 1970	0	0	0	0	0	0	0	0	0	0
Diplectrona modesta Banks 1908	120	76	208	76	92	64	0	12	44	0
Hydropsyche sp. Pictet 1834	12	20	64	8	84	36	52	428	312	12
Hydropsyche alhedra Ross 1939	36	16	0	0	0	0	0	4	4	0
Hydropsyche bronta Ross 1938	0	0	0	0	0	0	0	0	12	0
Hydropsyche slossonae Banks 1905	0	4	36	20	28	28	20	24	12	0
Hydropsyche sparna Ross 1938	0	0	0	0	0	0	0	0	0	0
Parapsyche apicalis (Banks 1908)	20	0	0	0	0	0	0	0	0	0

Appendix V. Continued.

	S01	S02	S03	S04	S05	S06	S07	S08	S09	S10
Trichoptera (continued)										
Hydroptilidae										
Hydroptila sp. Dalman 1819	0	0	0	0	0	0	32	140	16	36
Ochrotrichia sp. Mosely 1934	0	0	0	0	0	0	0	0	4	8
Palaeagapetus celsus (Ross 1938)	32	0	0	0	0	0	0	0	0	0
Lepidostomatidae										
Lepidostoma sp. Rambur 1842	28	16	8	12	24	16	16	16	88	44
Leptoceridae										
Nectopsyche sp. Müller 1879	0	0	0	0	0	0	0	0	0	4
Limnephilidae										
Apatania sp. Kolenati 1848	0	4	40	24	92	32	12	24	8	4
Goera sp. Stephens 1829	0	0	0	0	0	0	0	0	0	0
Goera calcarata Banks 1899	0	0	0	0	0	0	0	0	0	0
Goera fuscula Banks 1905	0	4	0	4	0	0	0	0	0	0
Hydatophylax argus (Harris 1869)	24	120	36	16	8	0	0	0	0	0
Pycnopsyche sp. Banks 1905	0	0	0	0	0	0	0	0	0	0
unidentified Limnephilidae	40	64	0	0	40	8	8	0	40	20
Molannidae										
Molanna blenda Sibley 1926	0	0	8	4	0	0	0	0	0	0
Odontoceridae										
Psilotreta labida Ross 1944	0	0	8	4	0	8	28	32	24	4
Philopotamidae										
Dolophilodes sp. Ulmer 1909	36	8	12	12	8	16	0	4	36	0
Dolophilodes distinctus (Walker 1852)	0	0	0	0	0	0	0	0	0	0
Wormaldia sp. MacLaclan 1865	0	0	0	0	0	0	0	0	0	0
Polycentropodidae										
Nyctiophylax sp. Brauer 1865	0	0	4	4	0	0	0	0	0	0
Polycentropus sp. Curtis 1835	20	16	40	12	24	12	36	36	16	4
Psychomyiidae										
Lype diversa (Banks 1914)	0	12	4	0	0	0	4	0	0	0
Rhyacophilidae										
Rhyacophila spp. Pictet 1834	104	60	16	4	224	8	4	40	84	0
Rhyacophila acutiloba Morse and Ross 1971	0	0	0	0	0	0	0	0	0	0
Rhyacophila amicis Ross 1956	0	0	0	0	0	0	0	0	0	0
Rhyacophila atrata Banks 1911	0	0	0	0	0	0	0	0	20	0
Rhyacophila banksi Ross 1944	0	0	0	0	0	0	0	0	0	0

Appendix V. Continued.

	S01	S02	S03	S04	S05	S06	S07	S08	S09	S10
Trichoptera (continued)										
Rhyacophilidae (continued)										
Rhyacophila carolina Banks 1911	16	0	8	0	0	0	0	0	0	0
Rhyacophila fuscula (Walker 1852)	0	8	8	16	0	0	40	20	84	4
Rhyacophila minor Banks 1924	40	36	100	112	68	8	0	4	24	0
Rhyacophila cf. *nigrita* Banks 1907	0	0	0	0	0	0	0	0	0	0
Rhyacophila torva Hagen 1861	0	16	4	16	8	28	0	4	20	0
Sericostomatidae										
Fattigia pele (Ross 1938)	4	0	0	0	0	0	0	0	0	0
Uenoidae										
Neophylax sp. MacLachlan 1871	4	12	0	0	0	0	0	4	0	0
Neophylax consimilis Betten 1934	0	0	0	0	0	0	0	0	0	0
Neophylax mitchelli Carpenter 1933	0	0	4	0	0	0	0	0	0	0
Neophylax oligius Ross 1938	4	0	0	0	0	0	0	0	0	0
Lepidoptera										
Pyralidae										
Petrophila sp. Guilding 1830	0	0	0	0	0	0	0	0	0	0
Coleoptera										
Dryopidae										
Helichus sp. Erichson 1847	0	0	0	0	0	0	0	0	0	4
Helichus cf. *fastigiatus* (Say 1824)	0	0	0	0	0	0	0	0	0	0
Elmidae										
Dubiraphia sp. Sanderson 1954	0	0	0	0	0	0	0	0	0	0
cf. *Dubiraphia vittata* (Melsheimer 1844)	0	0	0	0	0	0	0	0	0	0
Optioservus sp. Sanderson 1954	660	216	156	64	216	104	296	232	244	56
Optioservus immunis (Fall 1925)	8	0	0	0	0	0	0	0	0	0
Optioservus ovalis (LeConte 1863)	20	16	12	12	8	4	16	0	20	0
Optioservus trivittatus (Brown 1930)	0	0	0	0	0	0	0	0	0	0
Oulimnius latiusculus (LeConte 1866)	348	108	120	52	88	44	208	132	136	40
Promoresia sp. Sanderson 1954	0	0	4	4	0	0	0	80	0	4
Promoresia elegans (LeConte 1852)	0	0	0	0	0	0	0	0	0	0
Promoresia tardella (Fall 1925)	0	0	0	0	0	0	0	0	0	0

Appendix V. Continued.

	S01	S02	S03	S04	S05	S06	S07	S08	S09	S10
Coleoptera (continued)										
Hydrophilidae										
Cymbiodyta vindicata Fall 1924	0	0	0	0	0	0	0	0	0	0
Psephenidae										
Ectopria sp. LeConte 1853	32	4	8	4	0	0	0	0	0	0
Psephenus herricki (DeKay 1844)	0	0	24	0	20	52	164	124	148	32
Ptilodactylidae										
Anchytarsus bicolor (Melsheimer 1846)	0	0	0	0	0	0	0	0	0	0
Diptera										
Athericidae										
Atherix cf. *lantha* Webb 1977	0	0	0	0	0	0	0	0	0	0
Blephariceridae										
Blepharicera sp. Macquart 1843	0	0	0	0	0	0	0	0	0	0
Ceratopogonidae										
Ceratopogoninae										
Ceratopogonini										
Ceratopogon sp. Meigen 1803	0	16	0	0	0	0	8	20	4	12
Palpomyiini										
Bezzia sp. Kieffer 1899/*Palpomyia* sp. Meigen 1818	0	0	0	0	0	0	0	0	12	0
Sphaeromiini										
Probezzia sp. Kieffer 1906	48	28	44	4	28	12	60	84	48	56
Forcipomyiinae										
Forcipomyiini										
Atrichopogon sp. Kieffer 1906	4	4	0	0	0	0	0	0	0	0
Chironomidae										
Chironominae										
Chironomini										
Demicryptochironomus sp. Lenz 1941	0	8	4	0	0	0	0	8	0	16
Dicrotendipes sp. Kieffer 1913	0	0	0	0	0	0	0	0	0	0
Dicrotendipes neomodestus (Malloch 1915)	0	0	0	0	0	0	0	0	0	0
Microtendipes pedellus group (de Geer 1776)	28	12	16	4	0	0	16	108	36	244
Nilothauma sp. Kieffer 1921	0	0	0	0	0	0	0	0	0	0
Polypedilum (Polypedilum) spp. Kieffer 1913	4	24	24	8	60	28	44	132	40	72
Polypedilum (P.) aviceps Townes 1945	0	0	0	0	0	0	0	0	0	0
Polypedilum (P.) fallax (Johannsen 1905)	0	0	0	0	0	0	0	0	0	0

Appendix V. Continued.

	S01	S02	S03	S04	S05	S06	S07	S08	S09	S10
Diptera (continued)										
Chironomidae (continued)										
Chironominae (continued)										
Chironomini (continued)										
Polypedilum (P.) scalaenum group (Schrank 1803)	0	0	0	0	0	0	0	0	0	0
Robackia demeijerei (Kruseman 1933)	0	0	0	0	0	0	0	0	0	8
Stenochironomus sp. Kieffer 1919	0	4	8	0	0	0	0	0	0	0
cf. *Tribelos* sp. Townes 1945	0	0	0	0	0	0	0	0	0	0
Tanytarsini										
Constempellina sp. Brundin 1947	16	300	144	44	260	32	296	452	88	32
Rheotanytarsus sp. Bause 1913	36	32	12	0	0	0	0	0	0	0
Sublettea sp. Roback 1975	0	0	8	0	0	0	12	144	104	20
Tanytarsus sp. van der Wulp 1874	72	92	296	96	400	52	456	332	100	100
Diamesinae										
Diamesini										
Diamesa sp. Meigen 1835	0	64	36	0	4	0	0	0	4	0
Orthocladiinae										
Corynoneurini										
Corynoneura sp. Winnertz 1846	56	20	32	0	48	16	100	112	100	64
Rheosmittia sp. Brundin 1956	32	4	0	0	0	0	0	0	0	0
Thienemanniella sp. Kieffer 1911	36	28	72	0	52	168	144	196	404	68
Orthocladiini										
Brillia sp. Kieffer 1913	0	8	0	4	0	4	0	8	0	0
Cricotopus spp./*Orthocladius* spp. van der Wulp 1874	412	384	320	76	24	484	456	380	536	120
Cricotopus spp. van der Wulp 1874	44	24	0	0	0	0	0	0	0	4
Epoicocladius sp. Zavrel 1924	0	0	0	0	0	0	0	0	0	0
Heterotrissocladius marcidus group (Walker 1856)	0	8	0	0	0	0	0	0	0	0
Limnophyes sp. Eaton 1875	0	0	0	0	0	0	0	0	0	0
Orthocladius (Eudactylocladius) spp. Thienemann 1935	116	284	48	152	20	140	236	272	292	40
Orthocladius (Orthocladius) spp. van der Wulp 1874	0	0	0	0	0	0	0	0	0	0
Parachaetocladius sp. Wülker 1959	20	12	16	4	52	52	52	40	64	28
Parametriocnemus sp. Goetghebuer 1932	0	0	4	0	20	0	0	0	0	0
Psectrocladius sp. Kieffer 1906	0	0	0	0	0	0	0	0	0	0
Psilometriocnemus sp. Saether 1969	28	8	28	4	16	4	4	4	0	8
Rheocricotopus sp. Thienemann and Harnisch 1932	0	4	0	0	0	0	0	0	0	0
Synorthocladius sp. Thienemann 1935	0	8	4	0	0	4	0	4	0	0

Appendix V. Continued.

	S01	S02	S03	S04	S05	S06	S07	S08	S09	S10
Diptera (continued)										
Chironomidae (continued)										
Prodiamesinae										
Prodiamesa sp. Kieffer 1906	0	0	0	0	0	0	0	0	0	0
Tanypodinae										
Macropelopiini										
Brundiniella sp. Roback 1978	0	12	8	0	0	0	4	8	0	0
Pentaneurini										
Ablabesmyia cf. *mallochi* (Walley 1925)	0	16	8	0	4	0	0	4	0	0
Larsia sp. Fittkau 1962	0	0	0	0	0	0	0	0	0	0
Thienemannimyia sp. Fittkau 1957	0	12	0	0	44	0	8	20	12	4
unidentified Tanypodinae	76	16	48	4	20	4	68	164	44	84
Dixidae										
Dixa sp. Meigen 1818	16	0	0	0	0	0	0	0	4	0
Empididae										
Chelifera sp. Macquart 1823	16	0	0	0	0	0	0	12	0	0
Clinocera sp. Meigen 1803	0	0	0	0	0	0	0	0	0	0
Hemerodromia sp. Meigen 1822	0	0	0	0	0	0	0	0	0	0
Ephydridae										
Scatophila sp. Becker 1896	0	0	0	0	0	0	0	0	0	0
Psychodidae										
Pericoma sp. Walker 1856	0	0	0	0	0	0	0	0	0	0
Telmatoscopus sp. Eaton 1904	0	0	0	0	0	0	0	0	0	0
Simuliidae										
Prosimulium sp. Roubaud 1906	12	0	0	0	0	0	0	0	0	0
Simulium sp. Latreille 1802	0	0	0	0	0	12	0	0	4	0
Stegopterna mutata (Malloch 1914)	0	76	4	8	12	0	0	0	8	0
Stratiomyidae										
cf. *Nemotelus* sp. Geoffroy 1762	0	0	4	0	0	0	0	0	0	0
Tabanidae										
Chrysops sp. Meigen 1803	0	0	0	0	0	0	0	0	0	0
Thaumaleidae										
Thaumalea americana Bezzi 1913	0	4	0	0	0	0	0	0	0	0

Appendix V. Continued.

	S01	S02	S03	S04	S05	S06	S07	S08	S09	S10
Diptera (continued)										
Tipulidae										
Antocha sp. Osten Sacken 1859	28	40	36	8	44	20	72	252	180	72
Dicranota sp. Zetterstedt 1838	8	4	0	0	4	4	0	4	0	0
cf. *Erioptera* sp. Meigen 1803	0	0	0	0	0	0	0	0	0	0
Hexatoma sp. Latreille 1809	36	20	8	4	40	8	20	4	20	12
Limnophila sp. Macquart 1834	0	8	4	0	8	16	4	52	0	0
Pedicia sp. Latreille 1809	0	0	0	4	0	0	0	0	0	0
Pseudolimnophila sp. Alexander 1919	0	12	0	0	0	0	0	0	0	0
Tipula sp. Linnaeus 1758	0	0	0	0	0	4	0	0	0	0
Collembola										
Isotomidae/Entomobryidae	0	20	4	0	8	12	0	0	0	0
Sminthuridae	0	0	0	0	0	0	0	0	0	0
Acarina										
Lebertiidae										
Lebertia sp. Viets 1909	0	0	20	4	32	4	40	28	16	16
unidentified Acarina	0	0	16	4	60	0	16	60	40	40
Amphipoda										
Gammaridae										
Gammarus minus Say 1818	0	0	0	0	0	0	16	4	0	0
Decapoda										
Cambaridae	0	0	0	0	4	0	0	0	0	0
Isopoda	0	0	0	0	0	0	0	0	0	0
Ostracoda	0	0	164	12	0	0	104	8	0	0
Cnidaria	0	0	0	0	0	0	0	0	0	0
Turbellaria	0	4	4	0	8	0	20	4	0	0
Nematoda	0	20	40	4	16	16	28	100	16	24

Appendix V. Continued.

	S01	S02	S03	S04	S05	S06	S07	S08	S09	S10
Oligochaeta										
Naididae	0	48	20	4	72	20	76	108	104	144
Tubificidae	0	0	4	0	0	0	0	0	0	0
Branchiobdellida	0	0	16	0	0	0	4	0	0	0
Mollusca										
Physidae	0	0	4	4	0	0	4	0	0	0
Planorbidae	0	0	0	0	0	0	0	0	0	0
Sphaeriidae	0	0	0	0	0	0	4	4	0	0

Appendix VI. Fall survey 2000 taxa list for Whiteoak Canyon Run in Shenandoah National Park, Madison County, Virginia.

	W01	W03	W04	W05	W06	W07	W08	W10
Ephemeroptera								
Ameletidae								
Ameletus sp. Eaton 1885	0	4	0	0	12	0	0	0
Ameletus cryptostimulus Carle 1978	0	0	0	0	0	0	0	0
Ameletus lineatus Traver 1932	0	0	0	0	0	0	0	0
Baetidae								
Acentrella ampla Traver 1932	20	38	4	44	16	128	8	20
Baetis sp. Leach 1815	20	30	12	100	20	56	16	168
Baetis brunneicolor McDunnough 1925	0	0	0	0	0	0	0	0
Baetis flavistriga McDunnough 1921	0	0	0	0	0	0	0	0
Baetis cf. *intercalaris* McDunnough 1921	0	0	0	0	0	0	0	0
Baetis tricaudatus Dodds 1923	4	21	0	28	12	40	4	40
Baetiscidae								
Baetisca carolina Traver 1931	0	0	0	0	0	0	0	0
Caenidae								
Caenis Stephens 1835	0	0	0	0	0	0	0	0
Ephemerellidae								
Drunella sp. Needham 1905	0	0	0	0	0	0	0	0
Drunella cf. *lata* (Morgan 1911)	0	0	0	0	0	0	0	0
Ephemerella sp. Walsh 1862	0	0	0	0	0	0	0	0
Ephemerella dorothea Needham 1908	0	0	0	0	0	0	0	0
Ephemerella hispida Allen and Edmunds 1965	0	0	0	0	0	0	0	0
Ephemerella rossi Allen and Edmunds 1965	0	0	0	0	0	0	0	0
Ephemerella cf. *subvaria* McDunnough 1925	0	0	0	0	0	0	0	0
Eurylophella sp. Tiensuu 1935	48	8	0	20	4	28	12	4
Eurylophella funeralis (McDunnough 1925)	0	6	8	0	0	4	0	0
Eurylophella temporalis (McDunnough 1924)	0	0	0	0	0	0	0	0
unidentified Ephemerellidae	112	17	48	92	8	40	0	128
Ephemeridae								
Ephemera sp. Linnaeus 1758	0	0	8	4	0	0	4	4
Ephemera simulans Walker 1853	0	0	0	0	0	0	0	0
Heptageniidae								
Cinygmula subaequalis (Banks 1914)	0	0	0	0	0	0	0	0
Epeorus sp. Eaton 1881	352	111	104	236	52	256	44	388
Epeorus (Iron) dispar (Traver 1935)	32	14	0	0	0	0	0	0

Appendix VI. Continued.

	W01	W03	W04	W05	W06	W07	W08	W10
Ephemeroptera (continued)								
Heptageniidae (continued)								
Epeorus (Iron) pleuralis (Banks 1910)	0	13	0	4	0	4	4	0
Epeorus (Iron) rubidus (Traver 1933)	0	0	0	0	0	0	0	4
Heptagenia sp. Walsh 1863	0	0	0	0	0	0	0	0
Leucrocuta sp. Flowers 1980	36	20	28	16	32	28	24	12
Rhithrogena sp. Eaton 1881	0	0	0	0	0	0	0	0
Stenacron sp. Jensen 1974	0	0	0	0	0	0	0	0
Stenacron cf. *pallidum* (Traver 1933)	0	0	0	0	0	0	0	0
Stenonema sp. Traver 1933	8	31	0	8	0	12	4	32
Stenonema femoratum (Say 1823)	0	0	0	0	0	0	0	0
Stenonema meririvulanum Carle and Lewis 1978	0	0	0	0	0	0	0	0
Stenonema pudicum (Hagen 1861)	0	19	0	0	0	12	0	0
Stenonema vicarium (Walker 1853)	0	1	0	4	8	8	4	12
unidentified Heptageniidae	196	60	64	76	84	72	12	132
Isonychiidae								
Isonychia sp. Eaton 1871	0	0	0	0	0	0	0	0
Leptophlebiidae								
Habrophlebia vibrans Needham 1908	0	0	0	0	0	0	4	0
Paraleptophlebia sp. Lestage 1917	332	50	52	56	40	56	60	240
Paraleptophlebia adoptiva (McDunnough 1929)	0	0	0	0	0	0	0	0
Paraleptophlebia cf. *mollis* (Eaton 1871)	0	0	0	0	0	0	0	0
Odonata								
Aeshnidae								
Boyeria grafiana Williamson 1907	0	0	0	0	0	0	0	0
Calopterygidae								
Hetaerina sp. Hagen 1854	0	0	0	0	0	0	0	0
Cordulegastridae								
Cordulegaster sp. Leach 1815	0	0	0	0	0	0	0	0
Gomphidae								
Lanthus parvulus (Selys 1854)	4	4	0	0	0	0	0	0
Lanthus vernalis Carle 1980	0	0	0	0	0	0	0	0
cf. *Stylogomphus albistylus* (Hagen 1878)	0	0	0	0	0	0	0	0
unidentified Gomphidae	12	0	0	4	0	0	0	4

Appendix VI. Continued.

	W01	W03	W04	W05	W06	W07	W08	W10
Plecoptera								
Capniidae								
Paracapnia sp. Hanson 1946	32	27	100	84	48	160	56	132
Chloroperlidae								
Haploperla brevis (Banks 1895)	12	19	16	88	0	0	0	12
Sweltsa sp. Ricker 1943	104	105	88	120	28	36	24	156
Leuctridae								
Leuctra sp. Stephens 1836	944	266	16	76	12	12	0	20
Zealeuctra sp. Ricker 1952	0	0	0	0	0	0	0	0
Nemouridae								
Amphinemura sp. Ris 1902	16	0	0	20	0	12	4	8
Amphinemura nigritta (Provancher 1876)	0	0	0	0	0	0	0	0
Amphinemura wui (Claassen 1936)	0	0	0	0	0	0	0	0
Nemoura sp. Latreille 1796	0	0	0	0	0	0	0	0
Peltoperlidae								
Peltoperla sp. Needham 1905	36	25	0	0	0	0	0	0
cf. *Tallaperla* sp. Stark and Stewart 1981	0	0	0	0	0	0	0	0
Perlidae								
Acroneuria sp. Pictet 1841	0	0	0	0	0	0	0	0
Acroneuria abnormis (Newman 1838)	0	0	0	4	0	0	0	0
Acroneuria carolinensis (Banks 1905)	0	1	4	0	0	0	0	0
Agnetina capitata (Pictet 1841)	0	0	0	0	0	0	0	0
Eccoptura xanthenes (Newman 1828)	4	0	0	0	0	0	0	0
Paragnetina sp. Klapálek 1907	0	0	0	0	0	0	0	0
Paragnetina immarginata (Say 1823)	0	0	0	0	0	0	0	8
unidentified Perlidae	12	0	12	4	0	16	4	48
Perlodidae								
Isogenoides hansoni (Ricker 1952)	0	0	0	0	0	0	0	0
Isoperla sp. Banks 1906	168	15	16	12	24	16	20	240
Isoperla bilineata (Say 1823)	0	0	0	0	0	0	0	0
Isoperla cf. *cotta* Ricker 1952	0	0	0	0	0	0	0	0
Isoperla lata Frison 1942	0	0	0	0	0	0	0	0
Isoperla marlynia Needham and Claassen 1925	0	0	0	0	0	0	0	0
Isoperla similis (Hagen 1861)	0	0	0	0	0	0	0	0
Malirekus hastatus (Banks 1920)	20	6	0	0	0	0	0	0
Yugus sp. Ricker 1952	0	0	0	0	0	0	0	0

Appendix VI. Continued.

	W01	W03	W04	W05	W06	W07	W08	W10
Plecoptera (continued)								
Pteronarcyidae								
Allonarcys sp. Needham and Claassen 1925	44	15	0	0	0	8	4	0
Allonarcys proteus (Newman 1838)	0	0	0	0	0	0	0	0
Taeniopterygidae								
Taeniopteryx sp. Pictet 1841	0	0	0	0	0	0	0	0
Hemiptera								
Gerridae								
Gerris sp. Fabricius 1794	0	0	0	0	0	0	0	0
Veliidae								
Rhagovelia sp. Mayr 1865	0	0	0	0	0	0	0	0
Megaloptera								
Corydalidae								
Nigronia sp. Banks 1908	0	0	0	0	0	0	0	0
Nigronia serricornis (Say 1824)	0	0	0	0	0	8	8	4
Sialidae								
Sialis sp. Latreille 1802	0	0	0	0	0	0	0	0
Trichoptera								
Brachycentridae								
Adicrophleps hitchcocki Flint 1965	0	0	0	0	0	0	0	0
Glossosomatidae								
Agapetus sp. Curtis 1834	0	0	0	0	0	0	0	0
Glossosoma sp. Curtis 1834	4	6	0	0	0	0	0	0
Hydropsychidae								
Cheumatopsyche sp. Wallengren 1891	0	0	0	4	0	0	0	16
Diplectrona metaqui Ross 1970	0	0	0	0	0	0	0	0
Diplectrona modesta Banks 1908	328	36	64	76	32	28	0	28
Hydropsyche sp. Pictet 1834	160	27	4	0	12	72	8	28
Hydropsyche alhedra Ross 1939	16	0	0	0	0	0	0	0
Hydropsyche bronta Ross 1938	0	0	0	0	0	0	0	0
Hydropsyche slossonae Banks 1905	0	0	0	8	0	16	0	4
Hydropsyche sparna Ross 1938	0	0	0	0	0	0	0	0
Parapsyche apicalis (Banks 1908)	0	0	0	0	0	0	0	0

VI. Continued.

	W01	W03	W04	W05	W06	W07	W08	W10
a (continued)								
Hydroptilidae								
Hydroptila sp. Dalman 1819	0	0	0	12	0	8	0	16
Ochrotrichia sp. Mosely 1934	0	0	0	0	0	0	0	0
Palaeagapetus celsus (Ross 1938)	0	0	0	0	0	0	0	0
Lepidostomatidae								
Lepidostoma sp. Rambur 1842	44	2	4	28	0	40	24	24
Leptoceridae								
Nectopsyche sp. Müller 1879	0	0	0	0	0	0	4	0
Limnephilidae								
Apatania sp. Kolenati 1848	0	4	0	24	8	0	0	4
Goera sp. Stephens 1829	0	0	0	0	0	0	0	0
Goera calcarata Banks 1899	0	2	0	0	0	0	0	0
Goera fuscula Banks 1905	0	0	0	0	0	0	0	0
Hydatophylax argus (Harris 1869)	28	9	84	0	0	0	0	0
Pycnopsyche sp. Banks 1905	0	0	0	0	0	0	0	0
unidentified Limnephilidae	0	4	8	8	0	4	0	4
Molannidae								
Molanna blenda Sibley 1926	0	0	0	0	0	0	0	0
Odontoceridae								
Psilotreta labida Ross 1944	0	0	0	0	0	8	8	0
Philopotamidae								
Dolophilodes sp. Ulmer 1909	40	2	0	0	4	12	0	4
Dolophilodes distinctus (Walker 1852)	0	0	0	0	0	0	0	0
Wormaldia sp. MacLaclan 1865	0	0	0	0	0	0	0	0
Polycentropodidae								
Nyctiophylax sp. Brauer 1865	0	0	0	0	0	0	0	0
Polycentropus sp. Curtis 1835	20	22	12	16	0	4	4	20
Psychomyiidae								
Lype diversa (Banks 1914)	0	0	0	0	4	0	0	0
Rhyacophilidae								
Rhyacophila spp. Pictet 1834	144	101	32	204	28	40	8	100
Rhyacophila acutiloba Morse and Ross 1971	0	1	0	0	0	0	0	0
Rhyacophila amicis Ross 1956	0	0	0	0	0	0	0	0
Rhyacophila atrata Banks 1911	0	0	0	0	0	0	0	0
Rhyacophila banksi Ross 1944	0	0	0	0	0	0	0	0

Appendix VI. Continued.

	W01	W03	W04	W05	W06	W07	W08	W10
Trichoptera (continued)								
Rhyacophilidae (continued)								
Rhyacophila carolina Banks 1911	8	0	0	0	0	0	0	0
Rhyacophila fuscula (Walker 1852)	0	2	0	0	0	4	0	8
Rhyacophila minor Banks 1924	28	2	0	0	0	0	0	0
Rhyacophila cf. *nigrita* Banks 1907	8	0	0	0	0	0	0	0
Rhyacophila torva Hagen 1861	0	0	4	0	4	12	0	8
Sericostomatidae								
Fattigia pele (Ross 1938)	0	0	0	0	0	0	0	0
Uenoidae								
Neophylax sp. MacLachlan 1871	0	0	0	0	0	0	0	0
Neophylax consimilis Betten 1934	0	0	0	0	0	0	0	0
Neophylax mitchelli Carpenter 1933	4	0	0	0	0	0	0	0
Neophylax oligius Ross 1938	4	0	0	0	0	0	0	0
Lepidoptera								
Pyralidae								
Petrophila sp. Guilding 1830	0	0	0	0	0	0	0	0
Coleoptera								
Dryopidae								
Helichus sp. Erichson 1847	0	0	0	0	0	0	0	4
Helichus cf. *fastigiatus* (Say 1824)	0	0	0	0	0	0	0	0
Elmidae								
Dubiraphia sp. Sanderson 1954	0	0	0	0	0	0	0	0
cf. *Dubiraphia vittata* (Melsheimer 1844)	0	0	0	0	0	0	0	0
Optioservus sp. Sanderson 1954	196	67	44	12	8	8	0	4
Optioservus immunis (Fall 1925)	0	0	0	0	0	0	0	0
Optioservus ovalis (LeConte 1863)	24	2	0	0	0	0	0	0
Optioservus trivittatus (Brown 1930)	0	0	0	0	0	0	0	0
Oulimnius latiusculus (LeConte 1866)	496	104	24	36	4	16	8	12
Promoresia sp. Sanderson 1954	0	0	0	8	80	8	0	0
Promoresia elegans (LeConte 1852)	0	0	0	0	0	0	0	0
Promoresia tardella (Fall 1925)	0	0	0	0	0	0	0	0

Appendix VI. Continued.

	W01	W03	W04	W05	W06	W07	W08	W10
Coleoptera (continued)								
Hydrophilidae								
Cymbiodyta vindicata Fall 1924	0	0	0	0	0	0	0	0
Psephenidae								
Ectopria sp. LeConte 1853	0	1	8	0	0	0	0	0
Psephenus herricki (DeKay 1844)	0	0	0	8	8	12	12	40
Ptilodactylidae								
Anchytarsus bicolor (Melsheimer 1846)	0	0	0	0	4	0	0	0
Diptera								
Athericidae								
Atherix cf. *lantha* Webb 1977	0	0	0	0	0	4	0	4
Blephariceridae								
Blepharicera sp. Macquart 1843	0	0	0	0	0	0	0	0
Ceratopogonidae								
Ceratopogoninae								
Ceratopogonini								
Ceratopogon sp. Meigen 1803	0	0	0	0	0	0	0	0
Palpomyiini								
Bezzia sp. Kieffer 1899/*Palpomyia* sp. Meigen 1818	0	0	0	0	0	0	0	0
Sphaeromiini								
Probezzia sp. Kieffer 1906	28	7	0	24	12	0	4	8
Forcipomyiinae								
Forcipomyiini								
Atrichopogon sp. Kieffer 1906	0	0	0	0	0	0	0	0
Chironomidae								
Chironominae								
Chironomini								
Demicryptochironomus sp. Lenz 1941	8	7	0	20	4	0	4	4
Dicrotendipes sp. Kieffer 1913	0	0	0	0	0	0	0	0
Dicrotendipes neomodestus (Malloch 1915)	0	0	0	0	0	0	0	0
Microtendipes pedellus group (de Geer 1776)	48	30	4	84	8	44	16	4
Nilothauma sp. Kieffer 1921	0	0	0	0	0	0	0	0
Polypedilum (Polypedilum) spp. Kieffer 1913	52	50	36	68	28	48	4	8
Polypedilum (P.) aviceps Townes 1945	0	0	0	0	0	0	0	0
Polypedilum (P.) fallax (Johannsen 1905)	0	0	0	0	0	0	0	0

Appendix VI. Continued.

	W01	W03	W04	W05	W06	W07	W08	W10
Diptera (continued)								
Chironomidae (continued)								
Chironominae (continued)								
Chironomini (continued)								
Polypedilum (P.) scalaenum group (Schrank 1803)	0	0	0	0	0	0	0	0
Robackia demeijerei (Kruseman 1933)	0	0	0	0	0	0	0	0
Stenochironomus sp. Kieffer 1919	0	0	0	0	0	0	0	4
cf. *Tribelos* sp. Townes 1945	0	0	0	0	0	0	0	0
Tanytarsini								
Constempellina sp. Brundin 1947	48	0	12	52	0	20	0	8
Rheotanytarsus sp. Bause 1913	24	21	4	24	4	16	0	16
Sublettea sp. Roback 1975	4	10	0	160	28	360	8	80
Tanytarsus sp. van der Wulp 1874	96	12	56	300	32	8	20	12
Diamesinae								
Diamesini								
Diamesa sp. Meigen 1835	0	0	0	4	4	20	4	20
Orthocladiinae								
Corynoneurini								
Corynoneura sp. Winnertz 1846	64	0	28	68	12	108	8	20
Rheosmittia sp. Brundin 1956	0	0	0	0	0	0	0	0
Thienemanniella sp. Kieffer 1911	52	39	20	44	16	128	32	136
Orthocladiini								
Brillia sp. Kieffer 1913	0	1	0	0	0	12	0	12
Cricotopus spp./*Orthocladius* spp. van der Wulp 1874	1032	165	48	160	64	260	44	192
Cricotopus spp. van der Wulp 1874	0	0	0	0	0	0	0	0
Epoicocladius sp. Zavrel 1924	0	0	0	0	0	0	0	0
Heterotrissocladius marcidus group (Walker 1856)	0	1	0	4	0	0	0	0
Limnophyes sp. Eaton 1875	0	0	0	0	0	0	0	0
Orthocladius (Eudactylocladius) spp. Thienemann 1935	12	10	4	72	0	12	4	80
Orthocladius (Orthocladius) spp. van der Wulp 1874	0	0	0	0	0	0	0	0
Parachaetocladius sp. Wülker 1959	20	0	0	0	0	0	0	0
Parametriocnemus sp. Goetghebuer 1932	24	7	0	8	4	4	4	0
Psectrocladius sp. Kieffer 1906	0	0	0	0	0	0	0	0
Psilometriocnemus sp. Saether 1969	80	28	4	60	4	0	4	4
Rheocricotopus sp. Thienemann and Harnisch 1932	0	0	0	0	0	0	4	0
Synorthocladius sp. Thienemann 1935	0	1	0	4	0	4	0	4

Appendix VI. Continued.

	W01	W03	W04	W05	W06	W07	W08	W10
Diptera (continued)								
Chironomidae (continued)								
Prodiamesinae								
Prodiamesa sp. Kieffer 1906	0	0	0	0	0	0	0	0
Tanypodinae								
Macropelopiini								
Brundiniella sp. Roback 1978	0	3	0	0	0	0	0	0
Pentaneurini								
Ablabesmyia cf. *mallochi* (Walley 1925)	0	0	4	0	0	0	0	0
Larsia sp. Fittkau 1962	0	0	0	0	0	0	0	0
Thienemannimyia sp. Fittkau 1957	24	10	4	16	0	8	4	12
unidentified Tanypodinae	244	53	16	228	36	36	12	32
Dixidae								
Dixa sp. Meigen 1818	4	0	0	0	0	0	0	0
Empididae								
Chelifera sp. Macquart 1823	36	0	8	4	4	4	0	0
Clinocera sp. Meigen 1803	0	0	0	0	0	0	0	0
Hemerodromia sp. Meigen 1822	0	0	0	0	0	0	0	0
Ephydridae								
Scatophila sp. Becker 1896	0	0	0	0	0	0	0	0
Psychodidae								
Pericoma sp. Walker 1856	0	0	0	0	0	0	0	0
Telmatoscopus sp. Eaton 1904	0	0	0	0	0	0	0	0
Simuliidae								
Prosimulium sp. Roubaud 1906	0	1	0	0	0	0	0	0
Simulium sp. Latreille 1802	12	200	12	40	28	40	8	16
Stegopterna mutata (Malloch 1914)	0	0	0	0	0	0	0	0
Stratiomyidae								
cf. *Nemotelus* sp. Geoffroy 1762	0	0	0	0	0	0	0	0
Tabanidae								
Chrysops sp. Meigen 1803	0	0	0	0	0	0	0	0
Thaumaleidae								
Thaumalea americana Bezzi 1913	0	0	0	4	0	0	0	0

Appendix VI. Continued.

	W01	W03	W04	W05	W06	W07	W08	W10
Diptera (continued)								
Tipulidae								
Antocha sp. Osten Sacken 1859	120	128	4	20	4	40	0	104
Dicranota sp. Zetterstedt 1838	28	0	0	0	0	0	0	0
cf. *Erioptera* sp. Meigen 1803	4	0	0	0	0	0	0	0
Hexatoma sp. Latreille 1809	12	5	0	4	0	0	8	8
Limnophila sp. Macquart 1834	4	0	0	0	0	0	0	8
Pedicia sp. Latreille 1809	0	0	0	0	0	0	0	0
Pseudolimnophila sp. Alexander 1919	0	0	0	0	0	0	0	0
Tipula sp. Linnaeus 1758	0	1	0	0	0	0	0	0
Collembola								
Isotomidae/Entomobryidae	56	6	40	44	40	36	0	60
Sminthuridae	0	0	0	0	0	0	0	0
Acarina								
Lebertiidae								
Lebertia sp. Viets 1909	20	2	0	24	0	12	0	8
unidentified Acarina	0	0	0	0	0	0	0	0
Amphipoda								
Gammaridae								
Gammarus minus Say 1818	0	0	0	0	0	0	0	0
Decapoda								
Cambaridae	0	4	0	0	0	0	0	0
Isopoda	0	0	0	0	0	0	0	0
Ostracoda	0	0	0	12	0	0	0	0
Cnidaria	0	0	0	0	0	0	0	0
Turbellaria	40	10	0	0	0	0	0	8
Nematoda	16	2	4	16	4	0	0	0

Appendix VI. Continued.

	W01	W03	W04	W05	W06	W07	W08	W10
Oligochaeta								
Naididae	64	83	20	16	8	12	4	4
Tubificidae	0	0	0	0	0	0	0	0
Branchiobdellida	44	6	8	0	4	0	0	0
Mollusca								
Physidae	0	3	0	12	8	48	0	0
Planorbidae	0	0	0	0	0	0	0	0
Sphaeriidae	0	16	0	0	0	0	0	0

Appendix VII. Spring survey 2001 taxa list for Staunton River in Shenandoah National Park, Madison County, Virginia.

	S01	S02	S03	S04	S05	S06	S07	S08	S09	S10
Ephemeroptera										
Ameletidae										
Ameletus sp. Eaton 1885	72	-	80	92	176	96	216	18	56	28
Ameletus cryptostimulus Carle 1978	0	-	8	8	0	0	4	0	0	0
Ameletus lineatus Traver 1932	0	-	16	100	28	44	236	6	8	7
Baetidae										
Acentrella ampla Traver 1932	176	-	200	40	116	124	0	6	0	4
Baetis sp. Leach 1815	0	-	48	36	96	228	24	80	12	16
Baetis brunneicolor McDunnough 1925	0	-	0	0	0	0	0	0	0	0
Baetis flavistriga McDunnough 1921	0	-	0	0	0	0	0	0	0	0
Baetis cf. *intercalaris* McDunnough 1921	0	-	0	0	0	0	0	0	0	0
Baetis tricaudatus Dodds 1923	0	-	16	36	28	24	48	12	0	3
Baetiscidae										
Baetisca carolina Traver 1931	0	-	0	0	0	0	0	0	0	0
Caenidae										
Caenis sp. Stephens 1835	0	-	0	0	0	0	0	0	0	0
Ephemerellidae										
Drunella sp. Needham 1905	4	-	104	84	36	636	0	126	24	42
Drunella cf. *lata* (Morgan 1911)	0	-	0	0	0	0	0	0	0	0
Ephemerella sp. Walsh 1862	956	-	356	0	336	452	860	248	60	70
Ephemerella dorothea Needham 1908	0	-	0	232	0	0	120	0	0	0
Ephemerella hispida Allen and Edmunds 1965	0	-	0	0	0	12	0	12	0	5
Ephemerella rossi Allen and Edmunds 1965	0	-	0	0	0	0	0	0	0	0
Ephemerella cf. *subvaria* McDunnough 1925	0	-	0	0	0	0	4	0	0	0
Eurylophella sp. Tiensuu 1935	0	-	0	4	40	12	588	46	236	196
Eurylophella funeralis (McDunnough 1925)	0	-	8	0	0	0	24	0	4	0
Eurylophella temporalis (McDunnough 1924)	0	-	0	0	0	0	84	0	0	0
unidentified Ephemerellidae	120	-	508	0	512	1888	0	804	56	275
Ephemeridae										
Ephemera sp. Linnaeus 1758	0	-	0	0	0	0	0	0	0	0
Ephemera simulans Walker 1853	0	-	0	0	0	0	0	0	0	0
Heptageniidae										
Cinygmula subaequalis (Banks 1914)	96	-	368	932	768	1264	840	562	104	124
Epeorus sp. Eaton 1881	232	-	624	600	324	1244	308	198	28	52
Epeorus (Iron) dispar (Traver 1935)	4	-	4	0	0	0	0	0	0	0

x VII. Continued.

	S01	S02	S03	S04	S05	S06	S07	S08	S09	S10
:optera (continued)										
Heptageniidae (continued)										
Epeorus (Iron) pleuralis (Banks 1910)	52	-	232	284	128	296	68	42	16	2
Epeorus (Iron) rubidus (Traver 1933)	0	-	0	0	0	0	0	0	0	0
Heptagenia sp. Walsh 1863	0	-	0	0	0	0	0	0	0	0
Leucrocuta sp. Flowers 1980	0	-	76	128	12	52	48	14	16	23
Rhithrogena sp. Eaton 1881	0	-	0	0	0	0	0	0	0	0
Stenacron sp. Jensen 1974	0	-	0	0	0	0	0	0	0	0
Stenacron cf. *pallidum* (Traver 1933)	0	-	0	0	0	0	0	0	0	0
Stenonema sp. Traver 1933	4	-	0	20	4	0	20	2	0	4
Stenonema femoratum (Say 1823)	0	-	0	0	0	0	0	0	0	0
Stenonema meririvulanum Carle and Lewis 1978	0	-	0	8	0	0	0	0	0	0
Stenonema pudicum (Hagen 1861)	0	-	0	24	12	4	24	4	4	0
Stenonema vicarium (Walker 1853)	0	-	0	0	0	0	0	0	0	0
unidentified Heptageniidae	4	-	16	0	64	156	48	62	8	20
Isonychiidae										
Isonychia sp. Eaton 1871	0	-	0	0	0	32	0	2	12	21
Leptophlebiidae										
Habrophlebia vibrans Needham 1908	0	-	0	4	0	4	0	0	0	0
Paraleptophlebia sp. Lestage 1917	56	-	284	16	212	48	36	38	32	42
Paraleptophlebia adoptiva (McDunnough 1929)	0	-	0	212	0	48	112	20	8	8
Paraleptophlebia cf. *mollis* (Eaton 1871)	0	-	0	0	0	0	0	0	0	0
Aeshnidae										
Boyeria grafiana Williamson 1907	0	-	0	0	0	0	0	0	0	0
Calopterygidae										
Hetaerina sp. Hagen 1854	0	-	0	0	0	0	0	0	0	0
Cordulegastridae										
Cordulegaster sp. Leach 1815	0	-	0	0	0	0	0	0	0	0
Gomphidae										
Lanthus parvulus (Selys 1854)	8	-	0	0	0	0	0	0	0	0
Lanthus vernalis Carle 1980	0	-	0	0	0	0	0	0	0	0
cf. *Stylogomphus albistylus* (Hagen 1878)	0	-	0	0	0	0	0	0	4	0
unidentified Gomphidae	0	-	0	0	0	0	0	0	0	1

Appendix VII. Continued.

	S01	S02	S03	S04	S05	S06	S07	S08	S09	S10
Plecoptera										
Capniidae										
Paracapnia sp. Hanson 1946	0	-	0	0	0	0	0	0	0	0
Chloroperlidae										
Haploperla brevis (Banks 1895)	32	-	88	216	116	192	68	80	28	22
Sweltsa sp. Ricker 1943	0	-	40	36	12	116	92	20	20	5
Leuctridae										
Leuctra sp. Stephens 1836	108	-	56	176	392	460	80	106	92	160
Zealeuctra sp. Ricker 1952	0	-	0	0	0	0	0	0	0	0
Nemouridae										
Amphinemura sp. Ris 1902	80	-	32	4	8	8	0	4	4	7
Amphinemura nigritta (Provancher 1876)	0	-	0	0	0	0	0	0	0	0
Amphinemura wui (Claassen 1936)	12	-	20	0	32	16	0	0	0	0
Nemoura sp. Latreille 1796	0	-	0	0	0	0	0	0	0	0
Peltoperlidae										
Peltoperla sp. Needham 1905	32	-	52	0	0	20	0	4	0	0
cf. *Tallaperla* sp. Stark and Stewart 1981	0	-	0	0	0	0	0	0	0	0
Perlidae										
Acroneuria sp. Pictet 1841	0	-	0	0	4	0	0	0	0	0
Acroneuria abnormis (Newman 1838)	0	-	0	0	0	12	0	0	4	0
Acroneuria carolinensis (Banks 1905)	0	-	0	0	0	0	0	0	0	0
Agnetina capitata (Pictet 1841)	0	-	0	0	0	12	12	6	0	1
Eccoptura xanthenes (Newman 1828)	0	-	0	0	0	0	0	0	0	0
Paragnetina sp. Klapálek 1907	0	-	0	0	0	4	0	0	0	0
Paragnetina immarginata (Say 1823)	0	-	0	0	0	0	0	0	0	2
unidentified Perlidae	12	-	60	16	12	68	44	30	28	31
Perlodidae										
Isogenoides hansoni (Ricker 1952)	0	-	0	0	0	0	0	2	0	0
Isoperla sp. Banks 1906	60	-	348	28	92	448	28	98	12	15
Isoperla bilineata (Say 1823)	28	-	108	68	32	56	116	156	20	40
Isoperla cf. *cotta* Ricker 1952	0	-	0	0	0	0	0	0	0	0
Isoperla lata Frison 1942	0	-	0	0	0	0	0	0	0	0
Isoperla marlynia Needham and Claassen 1925	0	-	0	0	0	0	0	0	0	0
Isoperla similis (Hagen 1861)	0	-	16	0	8	0	0	0	0	0
Malirekus hastatus (Banks 1920)	12	-	16	8	0	0	0	0	0	0
Yugus sp. Ricker 1952	0	-	0	0	0	0	0	0	0	0

Appendix VII. Continued.

	S01	S02	S03	S04	S05	S06	S07	S08	S09	S10
Plecoptera (continued)										
Pteronarcyidae										
Allonarcys sp. Needham and Claassen 1925	12	-	36	8	0	36	0	2	0	0
Allonarcys proteus (Newman 1838)	0	-	0	0	0	0	0	0	0	0
Taeniopterygidae										
Taeniopteryx sp. Pictet 1841	0	-	0	0	0	0	0	0	0	0
Hemiptera										
Gerridae										
Gerris sp. Fabricius 1794	0	-	0	0	0	0	0	0	0	0
Veliidae										
Rhagovelia sp. Mayr 1865	0	-	0	0	0	0	0	0	0	0
Megaloptera										
Corydalidae										
Nigronia sp. Banks 1908	0	-	0	0	0	0	0	0	0	0
Nigronia serricornis (Say 1824)	0	-	0	4	0	0	0	2	0	12
Sialidae										
Sialis sp. Latreille 1802	0	-	0	0	0	0	0	0	0	0
Trichoptera										
Brachycentridae										
Adicrophleps hitchcocki Flint 1965	36	-	0	0	0	0	0	0	0	0
Glossosomatidae										
Agapetus sp. Curtis 1834	0	-	0	0	0	0	0	0	0	0
Glossosoma sp. Curtis 1834	-	-	0	0	0	0	0	0	0	0
Hydropsychidae										
Cheumatopsyche sp. Wallengren 1891	0	-	0	0	0	24	8	10	0	0
Diplectrona metaqui Ross 1970	0	-	0	0	0	0	0	0	0	0
Diplectrona modesta Banks 1908	20	-	124	24	16	56	4	0	4	22
Hydropsyche sp. Pictet 1834	8	-	4	0	8	68	8	30	4	2
Hydropsyche alhedra Ross 1939	0	-	4	0	8	8	0	4	0	0
Hydropsyche bronta Ross 1938	0	-	0	0	0	0	0	0	0	1
Hydropsyche slossonae Banks 1905	0	-	0	12	0	48	20	10	0	0
Hydropsyche sparna Ross 1938	0	-	0	0	0	0	0	0	0	0
Parapsyche apicalis (Banks 1908)	16	-	0	0	0	0	0	0	0	0

Appendix VII. Continued.

	S01	S02	S03	S04	S05	S06	S07	S08	S09	S10
Trichoptera (continued)										
Hydroptilidae										
Hydroptila sp. Dalman 1819	0	-	0	0	0	0	20	0	0	32
Ochrotrichia sp. Mosely 1934	0	-	0	0	0	0	0	0	0	0
Palaeagapetus celsus (Ross 1938)	28	-	4	0	0	0	0	0	0	0
Lepidostomatidae										
Lepidostoma sp. Rambur 1842	0	-	40	20	48	56	24	38	8	5
Leptoceridae										
Nectopsyche sp. Müller 1879	0	-	0	0	0	0	0	0	0	0
Limnephilidae										
Apatania sp. Kolenati 1848	0	-	0	0	0	0	0	0	0	0
Goera sp. Stephens 1829	0	-	0	0	0	0	0	0	0	0
Goera calcarata Banks 1899	4	-	0	0	0	0	0	0	0	0
Goera fuscula Banks 1905	0	-	0	0	0	0	0	0	0	0
Hydatophylax argus (Harris 1869)	0	-	0	0	0	0	0	0	0	5
Pycnopsyche sp. Banks 1905	0	-	0	12	0	20	36	0	0	0
unidentified Limnephilidae	4	-	0	0	16	12	0	0	0	6
Molannidae										
Molanna blenda Sibley 1926	0	-	0	0	0	0	0	0	0	0
Odontoceridae										
Psilotreta labida Ross 1944	0	-	0	0	4	4	32	8	4	9
Philopotamidae										
Dolophilodes sp. Ulmer 1909	4	-	4	4	12	0	0	0	0	0
Dolophilodes distinctus (Walker 1852)	0	-	0	0	0	0	0	0	0	0
Wormaldia sp. MacLaclan 1865	0	-	0	0	0	0	0	0	0	0
Polycentropodidae										
Nyctiophylax sp. Brauer 1865	0	-	0	0	0	0	0	0	0	0
Polycentropus sp. Curtis 1835	8	-	0	20	8	4	12	6	0	11
Psychomyiidae										
Lype diversa (Banks 1914)	0	-	4	0	0	0	0	0	0	0
Rhyacophilidae										
Rhyacophila spp. Pictet 1834	40	-	24	4	12	20	0	26	4	2
Rhyacophila acutiloba Morse and Ross 1971	0	-	0	0	0	0	0	0	0	0
Rhyacophila amicis Ross 1956	0	-	0	0	0	0	0	0	0	0
Rhyacophila atrata Banks 1911	0	-	0	0	0	0	0	0	0	0
Rhyacophila banksi Ross 1944	0	-	0	0	0	0	0	0	0	0

Appendix VII. Continued.

	S01	S02	S03	S04	S05	S06	S07	S08	S09	S10
Trichoptera (continued)										
Rhyacophilidae (continued)										
Rhyacophila carolina Banks 1911	24	-	8	16	0	0	0	0	0	0
Rhyacophila fuscula (Walker 1852)	0	-	20	20	0	28	12	18	0	2
Rhyacophila minor Banks 1924	4	-	0	0	0	0	0	0	0	0
Rhyacophila cf. *nigrita* Banks 1907	0	-	0	0	0	0	0	0	0	0
Rhyacophila torva Hagen 1861	8	-	0	4	0	0	0	0	0	0
Sericostomatidae										
Fattigia pele (Ross 1938)	0	-	0	0	0	0	0	0	0	0
Uenoidae										
Neophylax sp. MacLachlan 1871	0	-	0	0	0	0	0	0	0	0
Neophylax consimilis Betten 1934	0	-	0	0	0	0	0	0	0	0
Neophylax mitchelli Carpenter 1933	32	-	16	12	0	8	20	2	0	11
Neophylax oligius Ross 1938	0	-	0	0	0	0	0	0	0	0
Lepidoptera										
Pyralidae										
Petrophila sp. Guilding 1830	0	-	0	0	0	0	0	0	0	0
Coleoptera										
Dryopidae										
Helichus sp. Erichson 1847	0	-	0	0	0	4	0	0	0	2
Helichus cf. *fastigiatus* (Say 1824)	0	-	0	0	0	0	0	0	0	0
Elmidae										
Dubiraphia sp. Sanderson 1954	0	-	0	0	0	0	0	0	0	0
cf. *Dubiraphia vittata* (Melsheimer 1844)	0	-	0	0	0	0	0	0	0	0
Optioservus sp. Sanderson 1954	80	-	68	48	68	212	28	80	24	34
Optioservus immunis (Fall 1925)	0	-	0	0	0	0	0	0	0	0
Optioservus ovalis (LeConte 1863)	4	-	24	16	0	16	0	6	0	3
Optioservus trivittatus (Brown 1930)	0	-	0	0	0	0	0	0	0	0
Oulimnius latiusculus (LeConte 1866)	56	-	76	116	64	148	80	86	36	55
Promoresia sp. Sanderson 1954	0	-	0	0	0	0	0	0	0	0
Promoresia elegans (LeConte 1852)	0	-	0	0	0	0	0	0	0	0
Promoresia tardella (Fall 1925)	0	-	0	0	0	0	0	0	0	0

Appendix VII. Continued.

	S01	S02	S03	S04	S05	S06	S07	S08	S09	S10
Coleoptera (continued)										
Hydrophilidae										
Cymbiodyta vindicata Fall 1924	0	-	0	0	0	0	0	0	0	0
Psephenidae										
Ectopria sp. LeConte 1853	12	-	0	0	0	0	0	0	0	0
Psephenus herricki (DeKay 1844)	0	-	0	0	0	24	8	20	8	13
Ptilodactylidae										
Anchytarsus bicolor (Melsheimer 1846)	0	-	0	0	0	0	0	0	0	0
Diptera										
Athericidae										
Atherix cf. *lantha* Webb 1977	0	-	0	0	0	0	0	0	0	0
Blephariceridae										
Blepharicera sp. Macquart 1843	0	-	52	16	0	8	0	22	12	1
Ceratopogonidae										
Ceratopogoninae										
Ceratopogonini										
Ceratopogon sp. Meigen 1803	0	-	4	0	8	4	4	0	0	6
Palpomyiini										
Bezzia sp. Kieffer 1899/*Palpomyia* sp. Meigen 1818	0	-	0	0	0	0	0	0	0	14
Sphaeromiini										
Probezzia sp. Kieffer 1906	24	-	4	8	4	12	4	4	0	44
Forcipomyiinae										
Forcipomyiini										
Atrichopogon sp. Kieffer 1906	0	-	0	0	0	0	0	0	0	0
Chironomidae										
Chironominae										
Chironomini										
Demicryptochironomus sp. Lenz 1941	0	-	0	0	4	8	0	2	8	1
Dicrotendipes sp. Kieffer 1913	0	-	0	0	0	0	0	0	0	0
Dicrotendipes neomodestus (Malloch 1915)	0	-	0	0	0	0	0	0	0	0
Microtendipes pedellus group (de Geer 1776)	0	-	8	12	0	0	4	12	20	6
Nilothauma sp. Kieffer 1921	0	-	0	0	0	0	0	0	0	0
Polypedilum (Polypedilum) spp. Kieffer 1913	0	-	12	32	28	44	16	6	20	8
Polypedilum (P.) aviceps Townes 1945	0	-	0	0	0	0	0	0	0	0
Polypedilum (P.) fallax (Johannsen 1905)	0	-	0	0	0	0	0	0	0	0

Appendix VII. Continued.

	S01	S02	S03	S04	S05	S06	S07	S08	S09	S10
Diptera (continued)										
Chironomidae (continued)										
Chironominae (continued)										
Chironomini (continued)										
Polypedilum (P.) scalaenum group (Schrank 1803)	0	-	0	0	0	0	0	0	0	0
Robackia demeijerei (Kruseman 1933)	0	-	0	0	0	4	0	0	0	4
Stenochironomus sp. Kieffer 1919	0	-	0	0	0	0	0	0	0	0
cf. *Tribelos* sp. Townes 1945	0	-	0	0	0	0	0	0	0	0
Tanytarsini										
Constempellina sp. Brundin 1947	16	-	12	8	20	64	32	20	4	24
Rheotanytarsus sp. Bause 1913	0	-	0	4	0	0	0	8	0	0
Sublettea sp. Roback 1975	4	-	4	0	8	24	0	56	16	9
Tanytarsus sp. van der Wulp 1874	56	-	372	400	296	780	240	58	136	87
Diamesinae										
Diamesini										
Diamesa sp. Meigen 1835	0	-	0	8	0	4	4	20	4	4
Orthocladiinae										
Corynoneurini										
Corynoneura sp. Winnertz 1846	0	-	28	12	28	16	16	2	0	3
Rheosmittia sp. Brundin 1956	4	-	0	8	8	0	0	0	0	0
Thienemanniella sp. Kieffer 1911	8	-	188	252	88	108	16	20	8	20
Orthocladiini										
Brillia sp. Kieffer 1913	0	-	48	8	24	0	0	4	0	0
Cricotopus spp./*Orthocladius* spp. van der Wulp 1874	148	-	428	160	40	96	24	98	16	19
Cricotopus spp. van der Wulp 1874	0	-	72	0	12	28	0	4	8	1
Epoicocladius sp. Zavrel 1924	0	-	0	0	0	0	0	0	0	0
Heterotrissocladius marcidus group (Walker 1856)	0	-	8	0	16	0	24	4	0	0
Limnophyes sp. Eaton 1875	0	-	0	0	0	0	0	0	0	0
Orthocladius (Eudactylocladius) spp. Thienemann 1935	1024	-	376	200	32	144	20	48	28	54
Orthocladius (Orthocladius) spp. van der Wulp 1874	0	-	0	0	0	0	0	0	0	0
Parachaetocladius sp. Wülker 1959	0	-	0	0	0	0	4	0	0	0
Parametriocnemus sp. Goetghebuer 1932	0	-	64	20	20	8	0	0	0	2
Psectrocladius sp. Kieffer 1906	0	-	0	0	0	0	0	0	0	0
Psilometriocnemus sp. Saether 1969	16	-	24	72	16	24	4	4	12	4
Rheocricotopus sp. Thienemann and Harnisch 1932	24	-	724	184	128	56	8	4	4	0
Synorthocladius sp. Thienemann 1935	0	-	0	8	4	0	0	0	0	0

Appendix VII. Continued.

	S01	S02	S03	S04	S05	S06	S07	S08	S09	S10
Diptera (continued)										
Chironomidae (continued)										
Prodiamesinae										
Prodiamesa sp. Kieffer 1906	0	-	0	0	0	0	0	0	0	0
Tanypodinae										
Macropelopiini										
Brundiniella sp. Roback 1978	0	-	4	0	0	0	16	0	0	1
Pentaneurini										
Ablabesmyia cf. *mallochi* (Walley 1925)	0	-	0	0	0	0	12	0	0	0
Larsia sp. Fittkau 1962	0	-	0	0	0	0	0	0	0	0
Thienemannimyia sp. Fittkau 1957	0	-	8	0	16	16	32	12	8	33
unidentified Tanypodinae	20	-	60	84	80	52	4	32	40	27
Dixidae										
Dixa sp. Meigen 1818	0	-	0	4	8	0	0	2	0	5
Empididae										
Chelifera sp. Macquart 1823	0	-	0	4	0	20	0	10	0	5
Clinocera sp. Meigen 1803	0	-	12	0	0	4	0	0	0	4
Hemerodromia sp. Meigen 1822	0	-	0	0	0	0	0	0	0	3
Ephydridae										
Scatophila sp. Becker 1896	0	-	0	0	0	0	0	0	0	0
Psychodidae										
Pericoma sp. Walker 1856	16	-	0	0	0	0	0	0	0	0
Telmatoscopus sp. Eaton 1904	0	-	0	4	0	0	0	0	0	0
Simuliidae										
Prosimulium sp. Roubaud 1906	52	-	16	12	0	12	0	0	0	0
Simulium sp. Latreille 1802	0	-	12	0	8	0	4	4	0	3
Stegopterna mutata (Malloch 1914)	0	-	0	0	0	0	0	0	0	0
Stratiomyidae										
cf. *Nemotelus* sp. Geoffroy 1762	0	-	0	0	0	0	0	0	0	0
Tabanidae										
Chrysops sp. Meigen 1803	0	-	0	0	0	0	4	0	0	0
Thaumaleidae										
Thaumalea americana Bezzi 1913	0	-	0	0	0	0	0	0	0	0

Appendix VII. Continued.

	S01	S02	S03	S04	S05	S06	S07	S08	S09	S10
Diptera (continued)										
Tipulidae										
Antocha sp. Osten Sacken 1859	68	-	24	16	16	24	4	52	4	35
Dicranota sp. Zetterstedt 1838	4	-	8	4	0	0	0	0	0	0
cf. *Erioptera* sp. Meigen 1803	0	-	8	0	0	0	0	0	0	0
Hexatoma sp. Latreille 1809	24	-	0	24	4	32	16	24	0	7
Limnophila sp. Macquart 1834	0	-	0	8	4	12	8	0	4	0
Pedicia sp. Latreille 1809	0	-	0	0	0	4	0	0	0	0
Pseudolimnophila sp. Alexander 1919	0	-	0	0	0	0	0	0	0	0
Tipula sp. Linnaeus 1758	0	-	0	0	0	0	0	0	0	0
Collembola										
Isotomidae/Entomobryidae	8	-	12	16	92	32	0	0	0	5
Sminthuridae	0	-	0	0	0	0	0	0	0	0
Acarina										
Lebertiidae										
Lebertia sp. Viets 1909	0	-	4	0	0	24	0	8	4	3
unidentified Acarina	0	-	0	4	0	0	0	10	0	0
Amphipoda										
Gammaridae										
Gammarus minus Say 1818	0	-	0	0	0	0	0	0	0	0
Decapoda										
Cambaridae	0	-	4	4	0	0	0	0	0	0
Isopoda	0	-	0	0	0	0	0	0	0	0
Ostracoda	0	-	0	0	0	0	0	0	0	0
Cnidaria	0	-	0	0	0	0	0	0	0	0
Turbellaria	0	-	24	20	4	20	0	0	0	0
Nematoda	0	-	8	32	8	12	4	2	8	1

Appendix VII. Continued.

	S01	S02	S03	S04	S05	S06	S07	S08	S09	S10
Oligochaeta										
Naididae	8	-	4	8	4	16	4	0	32	17
Tubificidae	0	-	0	0	0	0	0	0	0	0
Branchiobdellida	0	-	4	0	0	4	0	0	0	0
Mollusca										
Physidae	0	-	0	0	0	0	0	0	0	0
Planorbidae	0	-	0	0	0	0	0	0	0	0
Sphaeriidae	0	-	0	0	0	0	0	0	0	0

: **VIII.** Spring survey 2001 taxa list for Whiteoak Canyon Run in Shenandoah National Park, Madison County, Virginia.

	W01	W03	W04	W05	W06	W07	W08	W10
ptera								
ameletidae								
Ameletus sp. Eaton 1885	0	4	52	36	72	4	28	172
Ameletus cryptostimulus Carle 1978	0	0	8	0	8	0	0	0
Ameletus lineatus Traver 1932	0	0	0	0	0	0	4	4
Baetidae								
Acentrella ampla Traver 1932	84	76	120	184	72	68	36	176
Baetis sp. Leach 1815	16	48	192	52	476	40	40	144
Baetis brunneicolor McDunnough 1925	0	0	0	0	0	0	0	0
Baetis flavistriga McDunnough 1921	0	0	0	0	0	0	0	0
Baetis cf. *intercalaris* McDunnough 1921	0	0	0	0	0	0	0	0
Baetis tricaudatus Dodds 1923	0	0	4	0	4	8	24	48
Baetiscidae								
Baetisca carolina Traver 1931	0	0	0	0	0	0	0	0
Caenidae								
Caenis sp. Stephens 1834	0	0	0	0	0	0	0	0
Ephemerellidae								
Drunella sp. Needham 1905	0	0	0	0	0	0	8	0
Drunella cf. *lata* (Morgan 1911)	0	0	0	0	0	0	0	0
Ephemerella sp. Walsh 1862	8	12	36	104	40	32	36	172
Ephemerella dorothea Needham 1908	0	0	0	0	0	0	0	0
Ephemerella hispida Allen and Edmunds 1965	0	0	0	0	0	0	0	0
Ephemerella rossi Allen and Edmunds 1965	0	0	0	0	0	0	0	0
Ephemerella cf. *subvaria* McDunnough 1925	0	0	0	0	0	0	0	0
Eurylophella sp. Tiensuu 1935	0	4	0	0	0	12	4	20
Eurylophella funeralis (McDunnough 1925)	0	0	4	0	4	0	0	12
Eurylophella temporalis (McDunnough 1924)	0	0	0	0	0	0	0	0
unidentified Ephemerellidae	120	56	168	132	104	36	0	292
Ephemeridae								
Ephemera sp. Linnaeus 1758	0	0	8	0	0	0	0	0
Ephemera simulans Walker 1853	0	0	0	0	0	0	0	0
Heptageniidae								
Cinygmula subaequalis (Banks 1914)	456	148	268	188	92	4	160	372
Epeorus sp. Eaton 1881	400	176	1484	828	340	64	376	468
Epeorus (Iron) dispar (Traver 1935)	0	0	4	0	0	0	0	0

Appendix VIII. Continued.

	W01	W03	W04	W05	W06	W07	W08	W10
Ephemeroptera (continued)								
Heptageniidae (continued)								
Epeorus (Iron) pleuralis (Banks 1910)	124	24	304	180	216	64	80	180
Epeorus (Iron) rubidus (Traver 1933)	0	0	0	0	0	0	0	0
Heptagenia sp. Walsh 1863	0	0	0	0	0	0	0	0
Leucrocuta sp. Flowers 1980	12	12	80	52	16	0	24	60
Rhithrogena sp. Eaton 1881	0	0	0	0	0	0	0	0
Stenacron sp. Jensen 1974	0	0	0	0	0	0	0	4
Stenacron cf. *pallidum* (Traver 1933)	0	0	0	0	0	0	0	0
Stenonema sp. Traver 1933	4	0	4	8	4	4	0	4
Stenonema femoratum (Say 1823)	0	0	0	0	0	0	0	0
Stenonema meririvulanum Carle and Lewis 1978	0	0	0	0	0	0	0	0
Stenonema pudicum (Hagen 1861)	0	8	8	0	0	4	0	8
Stenonema vicarium (Walker 1853)	0	0	0	20	4	0	0	4
unidentified Heptageniidae	92	28	216	80	56	4	0	52
Isonychiidae								
Isonychia sp. Eaton 1871	0	0	0	0	0	0	0	12
Leptophlebiidae								
Habrophlebia vibrans Needham 1908	0	0	0	0	0	4	0	4
Paraleptophlebia sp. Lestage 1917	108	16	116	100	44	20	24	136
Paraleptophlebia adoptiva (McDunnough 1929)	0	0	4	28	24	0	52	112
Paraleptophlebia cf. *mollis* (Eaton 1871)	0	0	0	0	0	0	0	0
Odonata								
Aeshnidae								
Boyeria grafiana Williamson 1907	0	0	0	0	0	0	0	4
Calopterygidae								
Hetaerina sp. Hagen 1854	0	0	0	0	0	0	0	0
Cordulegastridae								
Cordulegaster sp. Leach 1815	0	0	0	0	0	0	0	0
Gomphidae								
Lanthus parvulus (Selys 1854)	16	8	0	0	0	0	0	4
Lanthus vernalis Carle 1980	0	0	0	0	0	0	0	0
cf. *Stylogomphus albistylus* (Hagen 1878)	0	0	0	0	0	0	0	0
unidentified Gomphidae	0	0	0	0	0	0	0	0

Appendix VIII. Continued.

	W01	W03	W04	W05	W06	W07	W08	W10
Plecoptera								
Capniidae								
Paracapnia sp. Hanson 1946	0	0	0	0	0	0	0	0
Chloroperlidae								
Haploperla brevis (Banks 1895)	52	24	292	88	52	0	36	80
Sweltsa sp. Ricker 1943	28	44	36	40	44	8	20	64
Leuctridae								
Leuctra sp. Stephens 1836	636	180	156	112	92	0	88	48
Zealeuctra sp. Ricker 1952	0	0	0	0	0	0	0	0
Nemouridae								
Amphinemura sp. Ris 1902	48	28	0	8	12	0	12	44
Amphinemura nigritta (Provancher 1876)	0	0	0	0	0	0	0	0
Amphinemura wui (Claassen 1936)	0	4	28	36	164	28	4	76
Nemoura sp. Latreille 1796	0	0	0	0	0	0	0	0
Peltoperlidae								
Peltoperla sp. Needham 1905	80	40	16	16	28	0	0	4
cf. *Tallaperla* sp. Stark and Stewart 1981	0	0	0	0	0	0	0	0
Perlidae								
Acroneuria sp. Pictet 1841	0	0	0	0	0	0	0	0
Acroneuria abnormis (Newman 1838)	0	0	0	0	12	0	0	0
Acroneuria carolinensis (Banks 1905)	0	0	4	0	0	0	4	0
Agnetina capitata (Pictet 1841)	0	0	0	0	0	0	0	0
Eccoptura xanthenes (Newman 1828)	0	0	0	0	0	0	0	0
Paragnetina sp. Klapálek 1907	0	0	0	0	0	0	0	0
Paragnetina immarginata (Say 1823)	0	4	0	32	0	0	0	8
unidentified Perlidae	48	8	24	4	12	4	8	44
Perlodidae								
Isogenoides hansoni (Ricker 1952)	0	0	0	0	0	0	0	0
Isoperla sp. Banks 1906	64	0	172	24	64	8	0	68
Isoperla bilineata (Say 1823)	76	12	0	0	0	0	12	32
Isoperla cf. *cotta* Ricker 1952	0	0	0	0	0	0	0	0
Isoperla lata Frison 1942	0	0	0	0	0	0	0	0
Isoperla marlynia Needham and Claassen 1925	0	0	0	0	0	0	0	0
Isoperla similis (Hagen 1861)	0	0	0	0	0	0	0	4
Malirekus hastatus (Banks 1920)	8	4	0	0	0	0	0	0
Yugus sp. Ricker 1952	0	0	0	0	0	0	0	0

Appendix VIII. Continued.

	W01	W03	W04	W05	W06	W07	W08	W10
Plecoptera (continued)								
Pteronarcyidae								
Allonarcys sp. Needham and Claassen 1925	68	24	20	64	20	4	4	12
Allonarcys proteus (Newman 1838)	0	0	0	0	0	0	0	0
Taeniopterygidae								
Taeniopteryx sp. Pictet 1841	0	0	0	0	0	0	0	0
Hemiptera								
Gerridae								
Gerris sp. Fabricius 1794	0	0	0	0	0	0	0	0
Veliidae								
Rhagovelia sp. Mayr 1865	0	0	0	0	0	0	0	0
Megaloptera								
Corydalidae								
Nigronia sp. Banks 1908	0	0	0	0	0	0	0	0
Nigronia serricornis (Say 1824)	0	0	0	0	4	0	4	4
Sialidae								
Sialis sp. Latreille 1802	0	4	0	0	0	0	0	0
Trichoptera								
Brachycentridae								
Adicrophleps hitchcocki Flint 1965	0	0	0	0	0	0	0	0
Glossosomatidae								
Agapetus sp. Curtis 1834	0	0	0	0	0	0	0	0
Glossosoma sp. Curtis 1834	0	0	4	0	0	0	0	4
Hydropsychidae								
Cheumatopsyche sp. Wallengren 1891	0	0	0	0	12	0	0	8
Diplectrona metaqui Ross 1970	0	0	0	0	0	0	0	0
Diplectrona modesta Banks 1908	112	52	20	36	100	8	0	48
Hydropsyche sp. Pictet 1834	32	20	12	0	12	0	4	44
Hydropsyche alhedra Ross 1939	32	0	0	0	0	0	0	0
Hydropsyche bronta Ross 1938	0	0	0	0	0	0	0	0
Hydropsyche slossonae Banks 1905	0	0	0	0	0	0	12	0
Hydropsyche sparna Ross 1938	0	0	0	0	0	0	0	0
Parapsyche apicalis (Banks 1908)	0	0	0	0	0	0	0	0

Appendix VIII. Continued.

	W01	W03	W04	W05	W06	W07	W08	W10
Trichoptera (continued)								
Hydroptilidae								
Hydroptila sp. Dalman 1819	0	0	0	4	0	4	0	20
Ochrotrichia sp. Mosely 1934	0	0	0	0	0	0	0	0
Palaeagapetus celsus (Ross 1938)	0	0	0	0	0	0	0	0
Lepidostomatidae								
Lepidostoma sp. Rambur 1842	20	8	8	12	36	12	28	108
Leptoceridae								
Nectopsyche sp. Müller 1879	0	0	0	0	0	0	0	0
Limnephilidae								
Apatania sp. Kolenati 1848	0	0	0	0	0	0	0	0
Goera sp. Stephens 1829	0	0	0	0	0	0	0	0
Goera calcarata Banks 1899	0	0	0	0	0	0	0	0
Goera fuscula Banks 1905	0	8	0	0	0	0	0	0
Hydatophylax argus (Harris 1869)	0	0	0	0	0	0	0	0
Pycnopsyche sp. Banks 1905	0	0	0	0	28	12	0	28
unidentified Limnephilidae	28	8	0	0	0	0	0	0
Molannidae								
Molanna blenda Sibley 1926	0	0	0	0	0	0	0	0
Odontoceridae								
Psilotreta labida Ross 1944	0	0	0	0	0	0	4	4
Philopotamidae								
Dolophilodes sp. Ulmer 1909	12	8	0	0	20	0	0	0
Dolophilodes distinctus (Walker 1852)	0	0	0	0	0	0	0	0
Wormaldia sp. MacLaclan 1865	0	0	8	0	0	0	0	0
Polycentropodidae								
Nyctiophylax sp. Brauer 1865	0	0	0	0	0	0	0	0
Polycentropus sp. Curtis 1835	0	8	24	16	4	0	0	0
Psychomyiidae								
Lype diversa (Banks 1914)	0	0	0	0	0	0	4	0
Rhyacophilidae								
Rhyacophila spp. Pictet 1834	56	24	20	20	48	0	4	8
Rhyacophila acutiloba Morse and Ross 1971	8	0	0	0	0	0	0	0
Rhyacophila amicis Ross 1956	0	0	0	0	0	0	0	0
Rhyacophila atrata Banks 1911	0	0	0	0	0	0	0	0
Rhyacophila banksi Ross 1944	0	0	0	0	0	0	0	0

ix VIII. Continued.

	W01	W03	W04	W05	W06	W07	W08	W10
tera (continued)								
Rhyacophilidae (continued)								
Rhyacophila carolina Banks 1911	40	0	0	0	0	0	0	0
Rhyacophila fuscula (Walker 1852)	0	0	0	0	12	4	8	4
Rhyacophila minor Banks 1924	0	0	0	0	0	0	0	0
Rhyacophila cf. *nigrita* Banks 1907	0	0	0	0	0	0	0	0
Rhyacophila torva Hagen 1861	0	0	0	0	0	0	0	0
Sericostomatidae								
Fattigia pele (Ross 1938)	0	0	0	0	0	0	0	0
Uenoidae								
Neophylax sp. MacLachlan 1871	0	0	0	0	0	0	0	0
Neophylax consimilis Betten 1934	0	0	0	0	0	0	0	0
Neophylax mitchelli Carpenter 1933	12	0	0	0	0	0	4	16
Neophylax oligius Ross 1938	0	0	0	0	0	0	0	0
ptera								
Pyralidae								
Petrophila sp. Guilding 1830	0	0	0	0	0	0	0	0
tera								
Dryopidae								
Helichus sp. Erichson 1847	0	0	0	0	0	0	0	0
Helichus cf. *fastigiatus* (Say 1824)	0	0	0	0	0	0	0	0
Elmidae								
Dubiraphia sp. Sanderson 1954	0	0	0	0	0	0	0	0
cf. *Dubiraphia vittata* (Melsheimer 1844)	0	0	0	0	0	0	0	0
Optioservus sp. Sanderson 1954	204	60	68	8	0	0	4	8
Optioservus immunis (Fall 1925)	0	0	0	0	0	0	0	0
Optioservus ovalis (LeConte 1863)	4	0	0	0	0	0	0	0
Optioservus trivittatus (Brown 1930)	0	0	0	0	0	0	0	0
Oulimnius latiusculus (LeConte 1866)	152	64	76	12	12	4	8	28
Promoresia sp. Sanderson 1954	0	0	0	4	4	0	0	0
Promoresia elegans (LeConte 1852)	0	0	0	0	0	0	0	0
Promoresia tardella (Fall 1925)	0	0	0	0	8	0	0	0

Appendix VIII. Continued.

	W01	W03	W04	W05	W06	W07	W08	W10
Coleoptera (continued)								
Hydrophilidae								
Cymbiodyta vindicata Fall 1924	0	0	0	0	0	0	0	0
Psephenidae								
Ectopria sp. LeConte 1853	0	0	0	0	0	0	0	0
Psephenus herricki (DeKay 1844)	0	0	4	4	0	0	0	0
Ptilodactylidae								
Anchytarsus bicolor (Melsheimer 1846)	0	0	0	0	0	0	0	0
Diptera								
Athericidae								
Atherix cf. *lantha* Webb 1977	0	0	0	0	0	0	0	0
Blephariceridae								
Blepharicera sp. Macquart 1843	0	0	0	0	0	0	16	0
Ceratopogonidae								
Ceratopogoninae								
Ceratopogonini								
Ceratopogon sp. Meigen 1803	4	0	4	0	0	0	0	0
Palpomyiini								
Bezzia sp. Kieffer 1899/*Palpomyia* sp. Meigen 1818	0	0	0	0	0	0	0	0
Sphaeromiini								
Probezzia sp. Kieffer 1906	44	8	12	8	8	4	4	4
Forcipomyiinae								
Forcipomyiini								
Atrichopogon sp. Kieffer 1906	0	0	0	0	0	0	0	0
Chironomidae								
Chironominae								
Chironomini								
Demicryptochironomus sp. Lenz 1941	0	0	12	20	0	0	8	0
Dicrotendipes sp. Kieffer 1913	0	0	0	0	0	0	0	0
Dicrotendipes neomodestus (Malloch 1915)	0	0	0	0	0	0	0	0
Microtendipes pedellus group (de Geer 1776)	8	12	4	44	0	12	12	12
Nilothauma sp. Kieffer 1921	0	0	0	0	0	0	0	0
Polypedilum (Polypedilum) spp. Kieffer 1913	24	144	132	140	132	44	96	96
Polypedilum (P.) aviceps Townes 1945	0	0	0	0	0	0	0	0
Polypedilum (P.) fallax (Johannsen 1905)	0	0	0	0	0	0	0	0

Appendix VIII. Continued.

	W01	W03	W04	W05	W06	W07	W08	W10
Diptera (continued)								
Chironomidae (continued)								
Chironominae (continued)								
Chironomini (continued)								
Polypedilum (P.) scalaenum group (Schrank 1803)	0	0	0	0	0	0	0	0
Robackia demeijerei (Kruseman 1933)	0	0	0	0	0	0	0	0
Stenochironomus sp. Kieffer 1919	0	0	0	0	0	0	0	8
cf. *Tribelos* sp. Townes 1945	0	0	0	0	0	0	0	0
Tanytarsini								
Constempellina sp. Brundin 1947	8	0	96	8	0	0	4	8
Rheotanytarsus sp. Bause 1913	0	12	4	0	0	16	0	4
Sublettea sp. Roback 1975	12	16	52	40	12	24	104	24
Tanytarsus sp. van der Wulp 1874	392	660	452	740	412	68	644	420
Diamesinae								
Diamesini								
Diamesa sp. Meigen 1835	0	32	72	4	16	12	8	32
Orthocladiinae								
Corynoneurini								
Corynoneura sp. Winnertz 1846	4	4	12	16	84	40	28	52
Rheosmittia sp. Brundin 1956	0	0	0	0	0	0	0	0
Thienemanniella sp. Kieffer 1911	252	92	144	80	112	40	220	148
Orthocladiini								
Brillia sp. Kieffer 1913	8	0	0	4	4	0	0	4
Cricotopus spp./*Orthocladius* spp. van der Wulp 1874	184	200	256	200	508	276	100	212
Cricotopus spp. van der Wulp 1874	60	4	32	76	80	0	44	76
Epoicocladius sp. Zavrel 1924	0	0	0	0	0	0	0	0
Heterotrissocladius marcidus group (Walker 1856)	0	20	8	16	0	12	4	0
Limnophyes sp. Eaton 1875	0	0	0	0	0	0	0	0
Orthocladius (Eudactylocladius) spp. Thienemann 1935	140	24	888	248	504	128	64	264
Orthocladius (Orthocladius) spp. van der Wulp 1874	0	0	0	0	0	0	0	0
Parachaetocladius sp. Wülker 1959	0	0	0	0	0	0	0	0
Parametriocnemus sp. Goetghebuer 1932	64	32	32	4	8	4	12	4
Psectrocladius sp. Kieffer 1906	0	0	0	0	0	0	0	0
Psilometriocnemus sp. Saether 1969	288	256	156	72	44	24	36	16
Rheocricotopus sp. Thienemann and Harnisch 1932	60	8	40	48	148	100	60	100
Synorthocladius sp. Thienemann 1935	0	0	8	0	0	4	0	4

Appendix VIII. Continued.

	W01	W03	W04	W05	W06	W07	W08	W10
Diptera (continued)								
Chironomidae (continued)								
Prodiamesinae								
Prodiamesa sp. Kieffer 1906	4	32	0	0	0	0	0	0
Tanypodinae								
Macropelopiini								
Brundiniella sp. Roback 1978	4	8	0	0	0	0	0	0
Pentaneurini								
Ablabesmyia cf. *mallochi* (Walley 1925)	0	0	0	0	0	0	0	0
Larsia sp. Fittkau 1962	0	0	0	0	0	0	0	0
Thienemannimyia sp. Fittkau 1957	40	0	0	32	8	8	24	12
unidentified Tanypodinae	140	72	80	160	128	36	68	48
Dixidae								
Dixa sp. Meigen 1818	0	0	0	0	0	0	0	0
Empididae								
Chelifera sp. Macquart 1823	4	0	4	12	8	0	4	0
Clinocera sp. Meigen 1803	0	0	0	0	0	0	0	0
Hemerodromia sp. Meigen 1822	0	0	0	0	0	0	0	0
Ephydridae								
Scatophila sp. Becker 1896	0	0	0	0	0	0	0	0
Psychodidae								
Pericoma sp. Walker 1856	0	0	0	0	0	0	0	0
Telmatoscopus sp. Eaton 1904	0	0	0	0	0	0	0	0
Simuliidae								
Prosimulium sp. Roubaud 1906	8	16	16	0	460	112	52	12
Simulium sp. Latreille 1802	0	0	0	40	0	0	0	0
Stegopterna mutata (Malloch 1914)	0	0	0	0	0	0	0	0
Stratiomyidae								
cf. *Nemotelus* sp. Geoffroy 1762	0	0	0	0	0	0	0	0
Tabanidae								
Chrysops sp. Meigen 1803	0	0	0	0	0	0	0	0
Thaumaleidae								
Thaumalea americana Bezzi 1913	0	0	0	0	0	0	0	0

Appendix VIII. Continued.

	W01	W03	W04	W05	W06	W07	W08	W10
Diptera (continued)								
Tipulidae								
Antocha sp. Osten Sacken 1859	24	16	16	8	0	4	0	20
Dicranota sp. Zetterstedt 1838	4	0	12	0	4	0	0	0
cf. *Erioptera* sp. Meigen 1803	4	0	0	0	0	0	0	4
Hexatoma sp. Latreille 1809	12	4	8	4	4	0	4	16
Limnophila sp. Macquart 1834	0	0	4	0	0	0	0	0
Pedicia sp. Latreille 1809	0	0	4	0	0	0	0	0
Pseudolimnophila sp. Alexander 1919	0	0	0	0	0	0	0	0
Tipula sp. Linnaeus 1758	0	0	0	0	0	0	0	0
Collembola								
Isotomidae/Entomobryidae	4	0	564	4	32	0	8	0
Sminthuridae	0	0	0	0	0	0	0	0
Acarina								
Lebertiidae								
Lebertia sp. Viets 1909	0	0	0	0	0	0	0	0
unidentified Acarina	0	0	0	0	0	0	4	0
Amphipoda								
Gammaridae								
Gammarus minus Say 1818	0	0	0	0	0	0	0	0
Decapoda								
Cambaridae	0	0	0	0	0	0	0	0
Isopoda	0	0	0	0	0	0	0	0
Ostracoda	0	4	0	0	0	0	0	0
Cnidaria	0	0	0	0	0	0	0	0
Turbellaria	0	0	0	0	0	0	0	4
Nematoda	0	0	16	0	0	0	0	0

Appendix VIII. Continued.

	W01	W03	W04	W05	W06	W07	W08	W10
Oligochaeta								
Naididae	8	4	12	4	4	4	12	8
Tubificidae	0	0	0	0	0	0	0	0
Branchiobdellida	0	0	0	0	0	0	0	0
Mollusca								
Physidae	0	0	0	0	0	0	0	0
Planorbidae	0	0	0	0	0	0	0	0
Sphaeriidae	0	0	0	0	0	0	0	0

United States Department of the Interior

U.S. GEOLOGICAL SURVEY
Leetown Science Center
Aquatic Ecology Branch
1700 Leetown Road
Kearneysville, West Virginia 25430
(304) 724-4460
FAX: (304) 724-4465

Wendy Cass
Shenandoah National Park
3655 US Highway 211-E
Luray, VA 22835-9036

April 3, 2002

Dear Wendy:

Enclosed is a copy of the final report describing the results of the study we conducted designed to determine long-term responses of benthic macroinvertebrate communities to the catastrophic flood and associated debris flows that occurred on the Staunton River (Shenandoah National Park) in June, 1995. I apologize for the tardiness of the report and confess that I underestimated the time it would take to process the invertebrate samples. We were pleased, and more than a little surprised, at some of our findings. I believe our results "inch the ball forward" in terms of our overall understanding of stream ecosystems and the communities they support.

I have also forwarded a copy to John Karish at Penn State. If you have any questions regarding this report or other research issues, please do not hesitate to drop me a line. Thanks again for all your support.

Sincerely,

Craig Snyder

Craig Snyder, Ph.D.
Research Ecologist

Enclosures (1)

N-231

TITLE: Long term aquatic recovery of a 500+ year flood event in Shenandoah National Park

OBJECTIVES/JUSTIFICATION:

Need: The objective of this investigation is to determine aquatic macroinvertebrate responses and recovery patterns to the June 1995 flood on the Staunton River. This will involve comparing invertebrate community structure and secondary production patterns in reaches within and outside the impacted zone of the Staunton River. This study has been determined to be a high priority need of the National Park Service within the BRD NRPP process and will involve collaboration with the University of Virginia and the Virginia Polytechnic Institute to document other changes and recovery of the stream ecosystem and its biota (see attached proposal).

Background: On June 27-28, 1995, heavy rains and floods profoundly altered streams and habitats in several watersheds in Shenandoah National Park, VA. Particularly impacted were portions of the Staunton River watershed, which received an estimated 30 inches of rain from a stalled storm cell over the watershed. Massive debris flows relocated and reconfigured the stream channel of the Staunton and removed its riparian corridor.

There have been numerous phenomenological accounts of aquatic invertebrate responses to floods (e.g. Molles 1985, Sagar 1986, Scrimgeour et al. 1988, Hendricks et al. 1995). This evidence suggests that aquatic invertebrate assemblages are highly adapted to floods as illustrated by the relatively short amount of time required for population densities and community structure to return to pre-flood levels. This has been found to be true even with severe floods where the entire stream bottom is scoured and available refugia were limited (Hendricks et al. 1995). However, there has been no documented study of biological responses to floods of the magnitude that occurred on the Staunton River in June, 1996. 5

The primary effect of most floods is to kill and displace organisms and redistribute habitat units within the stream channel. Thus, although the initial impact on invertebrates may be quite severe and major habitat features altered, habitats result that are still available for recolonization. In the Staunton, however, flooding completely changed the structure and energy pathways of instream habitats over a 1.5 mile stretch of the stream. The stream was relocated and its riparian zone was removed. Both were replaced by a boulder field up to 100 m in width. A brief qualitative survey made one month after the flood found few invertebrates and no fish in impacted portions of the river.

Because some detailed pre-flood hydrologic, geologic, and biologic data are available on this stream, the proposed studies by LSC, UVA, and VPI represent a unique opportunity not only to document the reestablishment of stream communities following this catastrophic disturbance, but also to evaluate system evolution by comparison to the earlier baselines. Though floods of varying severity are known to occur

approximately every 20-30 years somewhere within the Blue Ridge Mountains, the establishment of new ecological baselines to track system resilience and recovery has never been attempted. in the Appalachians.

PROCEDURES/METHODS:

A common site strategy will be employed in which invertebrate sampling will be conducted in riffle habitats within reaches currently being sampled by investigators for water chemistry and hydrology (UVA) and fish community structure, production, and habitat (VPI) (see attached proposal). Spring and fall invertebrate surveys will be conducted at 10 sites on the Staunton and at 10 sites on the Piney River, a nearby stream that was relatively unaffected by the June, 1995 storm. Comparisons of species occurrence, species diversity, and relative abundance will be made for the two streams. GPS coordinates and water quality data will be taken at each site during sampling.

— how to compare to our samples?

Invertebrates will be sampled quantitatively with a Hess sampler. A total of six replicate samples will be taken at each sample site on each sample date. Invertebrates will be picked and identified to the lowest practical taxonomic unit; this will be to genus for most taxa, to family for dipterans, and to class for oligochaetes.

In a second component of this investigation, we will measure and compare secondary production at two sites on the Staunton, one within the impacted zone and one upstream of the impacted zone coincident with fish production sampling conducted by VPI. Six Hess samples will be taken at both sites on each of 12 sample dates. Sampling frequency will be highest (i.e., approximately biweekly) during the summer when production is highest, and lower (i.e., approximately every eight weeks) during the winter (see Morin et al. 1987). Invertebrates will be picked and identified as described above. A cohort-based method such as the removal-summation method (Benke 1984) will be used to calculate secondary production from density and mean individual growth rates. Boot-strapping will be used to calculate confidence intervals for production estimates (Morin et al. 1987) and to facilitate statistical comparisons between sites.

EXPECTED PRODUCTS:

Expected products include progress and final reports to Shenandoah National Park and peer-reviewed articles in the scientific literature.

TECHNOLOGY/INFORMATION TRANSFER:

Users of this information include personnel at Shenandoah National Park, other federal and state natural resources managers, and the peer scientific community. Data and metadata are made available through direct transfer to the park on diskette and on LSC, UVA, and VPI URLs, as appropriate.

PERSONNEL:

Ecologist, GS-12: Project planning, oversight, analysis
Fishery Biologist, GS-11: Data collection, analysis
(2) Biological Technician, GS-6: Data collection, entry

COOPERATORS/PARTNERS:

National Park Service: Logistical support, consulting

Mr. Bob Krumenaker
Mr. Tom Blount
Shenandoah National Park
3655 U.S. Hwy 211E
Luray, VA 22835
(540) 999-3491
Fax: (540) 999-3693

University of Virginia: Water chemistry, hydrologic, geologic studies; Cooperative Agreement
Dr. Art Bulger
Dr. Tanya Furman
University of Virginia
Department of Environmental Sciences
Clark Hall
Charlottesville, VA 22903
(804) 924-0531
ajb8s@virginia.edu (Bulger)

Virginia Polytechnic University: Fish ecology, production, stream habitat studies; subcontract through University of Virginia

Dr. Andy Dolloff
Department of Fish and Wildlife
Cheatham Hall
Virginia Polytechnic University
Blacksburg, VA 24061-0321
(540) 231-4864
Fax: (540) 231-7580
adoll@vt.edu

QUALIFICATIONS OF PROJECT PERSONNEL: (See attached).

Dr. Craig Snyder - Principal Investigator
Research Ecologist

David Lemarie - Principal Investigator

Fisheries Biologist

BRD PRINCIPAL CONTACT:

Dr. Edward Pendleton
Chief Aquatic Ecology Laboratory
Leetown Science Center
1700 Leetown Road
Kearneysville, WV 25430
(304) 725-8461, ext 362
Fax: (304) 728-6509
edward_pendleton@usgs.gov

FACILITIES/EQUIPMENT/STUDY AREA(S):

The work described in this proposal will be conducted at the Aquatic Ecology Laboratory, Leetown Science Center, Leetown, WV and at study sites within the Shenandoah National Park. Project metadata will comply with FGDC standards and will be served on LSC's web site (URL: http://www.lsc.usgs.gov). Project data will also be transferred to Shenandoah National Park data bases.

LEGAL AND POLICY-SENSITIVE ASPECTS: All work will be conducted on National Park Service Lands. Scientific collecting permits will be obtained from the Commonwealth of Virginia and Shenandoah National Park.

BUDGET:

Category	FY 1998	FY 1999	FY 2000
Salary:			
Term Post Doc	42451	43866	45481
Term Biological Technician GS6	10428	10748	11068
1 x 0.3 FTE			
	500	500	500
Travel			
	2600	2600	2600
Supplies/Materials			
	2150	1000	0
Equipment			
	99520	98505	102978
UVA/VPI (see attached)			
TOTAL	157649	157219	162627

WORK AND REPORTING SCHEDULE:

Dec. 1997	Site Selection and georeferencing (GPS)
Apr.98	Year 1 spring survey
Apr.98 - Mar.99	Year 1 secondary production sampling
Oct.98	Year 1 fall survey
Apr.99	Year 2 spring survey
Apr.99 - Mar.00	Year 2 secondary production sampling
Oct.99	Year 2 fall survey
Apr.00	Year 3 spring survey
Oct.00	Year 3 fall survey
Mar. 2001	Draft report
Jun. 2001	Final report

References:

Benke, A. C. 1984. Secondary production of aquatic insects. Pages 289-322. In V. H. Resh and D. M. Rosenberg (editors). The ecology of aquatic insects. Praeger Press.

Hendricks, A. C., L. D. Willis, and C. D. Snyder. 1995. Impact of flooding on the densities of selected aquatic insects. Hydrobiologia 299:241-247.

Molles, M. C. 1985. Recovery of a stream invertebrate community from a flash flood in Tesuque Creek, New Mexico. The Southwestern Naturalist 30:279-287.

Morin, A., T. A. Mousseau, and D. A. Roff. 1987. Accuracy and precision of secondary production estimates. Limnology and Oceanography 32:1342-1352.

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