Summer 2018

Comparison of Three Benthic Macroinvertebrate Passive Sampling Devices for Non-Wadeable Streams

Kelsey A. Laymon

COMPARISON OF THREE BENTHIC MACROINVERTEBRATE PASSIVE SAMPLING DEVICES FOR NON-WADEABLE STREAMS

by

KELSEY A. LAYMON

(Under the Direction of J. Checo Colón-Gaud)

ABSTRACT

Rivers and streams provide essential ecosystem services to the degree that the monitoring and maintenance of these systems becomes imperative. Biomonitoring provides managers and policymakers with the tools to make informed decisions, and macroinvertebrates are often the object of biomonitoring because they are ubiquitous in most systems and are known to be good indicators of water quality. However, methods for sampling macroinvertebrates in non-wadeable streams (i.e., large rivers) have not been standardized across states and regions and an established method for macroinvertebrate biomonitoring in large rivers of Georgia is not currently available. My study compared macroinvertebrates collected with three types of passive sampling devices to assess their suitability for sampling non-wadeable systems. Hester-Dendy samplers, mesh packs filled with swamp laurel oak (*Quercus laurifolia*) leaves (leaf samplers), and mesh packs filled with laurel oak sticks and twigs (wood samplers) were deployed at three sites on the Savannah River and three sites on the Ogeechee River for approximately 30 days during the fall of 2014. I examined mean, standard deviation, and variance components from 53 common bioassessment metrics and 2 multi-metric indices to identify differences in colonizing macroinvertebrates between the sampling devices. I estimated variance components using 2-way ANOVA to determine sources of variation (e.g., sites or devices). I further compared assemblages colonizing sampling devices using Permutational Multivariate Analysis

(PERMANOVA) followed by Similarity Percentages (SIMPER) analysis. The abundance of true flies (Order: Diptera), the abundance of midges (Family: Chironomidae) and 9 of the 53 metrics (i.e., Diptera taxa, % Amphipoda, % Gastropoda, % Oligochaeta, % Dominant individuals, Dominant individuals, Collector taxa, % Predator, and % Burrower) were determined as significantly different between sampling devices based on a 2-way ANOVA. Macroinvertebrate assemblages colonizing the three sampling devices differed (PERMANOVA; $F_{14,37}$ =1.6078, P=0.001), and SIMPER results showed these differences were driven by the proportions of taxa collected by each device. Estimates of variance components attributed large percentage (i.e., >20%) of variability to sites, rather than devices, with the exception of % Predator and Diptera taxa. My study suggests all three sampler types are suitable for collecting macroinvertebrate from non-wadeable systems and determining the precision and overall efficiency of sampling devices is an important step towards developing standard operating procedures for the bioassessment of large rivers.

INDEX WORDS: Passive sampler, Non-wadeable stream, Artificial substrate, Hester-Dendy, Macroinvertebrates, Large rivers, Substrate selection, Savannah River, Ogeechee River

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KELSEY A. LAYMON

B.S., University of Alabama at Birmingham, 2013

A Thesis Submitted to the Graduate Faculty of Georgia Southern University in Partial

Fulfillment of the Requirements for the Degree

MASTER OF SCIENCE

STATESBORO, GEORGIA

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KELSEY A. LAYMON

Major Professor: J. Checo Colón-Gaud

Committee: C. Ray Chandler

Stephen P. Vives

Electronic Version Approved:

July 2018

ACKNOWLEDGMENTS

I would like to express my sincerest gratitude and thanks to my advisor, Dr. Checo Colón-Gaud for his guidance and support, my committee members Dr. Ray Chandler and Dr. Stephen Vives, and my family for their unconditional support and encouragement. I would also like to thank the members of the Checo lab, past and present, and those who directly or indirectly have lent a helping hand or words of encouragement in this venture.

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CHAPTER 1

INTRODUCTION

Lotic ecosystems are an exceptionally important resource, but also one of the most vulnerable. Rivers are necessary for the operations of large industries, such as textile manufacturing, wood and paper processing, nuclear power, drinking water, waste water and many others. However, the ecosystem services that rivers provide put them at great risk for disturbance. Anthropogenic impacts to lotic systems have largely been ignored and with a growing population and the potential for disturbance, the need for their preservation becomes imperative. To sustain and preserve these ecosystems and the services they provide, it is necessary to effectively monitor them. Biomonitoring has become a common approach towards understanding the communities that inhabit aquatic systems and the level of habitat stability, thus allowing for the sustainability of freshwater resources (Rosenberg and Resh 1993).

Biomonitoring began in its most elementary form before the 20th century, by way of fishermen, but has since evolved into several areas of biological interest. During the 20th century, biomonitoring studies began with the identification of species indicative of human degradation (i.e., indicators) and the biological classification of lakes (Rosenberg and Resh 1993). Biological response is effective in offering insight into habitat stability and perturbation and therefore, provides insight for quality control programs, policy making and management decisions.

Biomonitoring studies have included a variety of organisms such as fish (Karr 1981, Fausch et al. 1990, Roset et al. 2007), macroinvertebrates, and algae (Patrick 1973, Fore 2002). The use of macroinvertebrates to detect aquatic ecosystem alterations offers some advantages. First, macroinvertebrates, such as the order Chironomidae (i.e., midge flies), may have several generations within a year, whereas the orders Megaloptera (i.e., alderflies, dobsonflies, and fishflies), Odonata (i.e., dragonflies and damselflies) and Plecoptera (i.e., stoneflies) may live for several years (Rosenberg and Resh 1993). This gives insight into both rapid changes and long term changes, both natural and unnatural, within the ecosystem. Second, the structure of benthic macroinvertebrate communities offers insight into the state of the entire ecosystem. They are strongly linked as mid-level consumers in the community and are influenced by multiple trophic levels, from primary producers to upper-level consumers (Rosenberg and Resh 1993). In addition, aquatic invertebrates have limited mobility, high diversity, and are relatively easy to sample (Barbour et al. 1992, Bonada et al. 2006). However, consideration for other organisms and justification for the use of aquatic macroinvertebrates has been widely discussed within the biomonitoring field. Aquatic macroinvertebrates continue to be utilized as a tool for the assessment of water quality due to their practical nature; they are relatively long-lived, sensitive, sedentary organisms that are relatively easy to collect and identify (Cuffney et al. 1993, Resh 2008).

Biomonitoring, in combination with chemical and physical monitoring provides managers and policymakers with an understanding into the spatial and temporal complexity of freshwater ecosystems. Rosenberg and Resh (1993) summarized the developments in freshwater biomonitoring in relation to aquatic macroinvertebrates to include the development of robust statistics, metric calculations, and the use of passive samplers. Likewise, Bonada et al. (2006) summarized the subsequent years of development to include not only multivariate and multi-metric techniques, but also biomarkers, bioassays, asymmetry studies, estimates of secondary production, and leaf-litter decay at the ecosystem level.

Historically, qualitative sampling (e.g., dip-net sampling) could be used to summarize the status of a system relatively quickly (Bonada et al. 2006). However, more robust statistical methods were developed to include diversity indices and multivariate methods. This required scientists to acquire a more rigorous approach to standardizing collection methods, which in turn, has led to the development of artificial substrates (e.g., multi-plate samplers and tiles). Artificial substrates are meant to resemble naturally occurring substrates and provide sampling repeatability through the standardization of size (Rosenberg and Resh 1993).

Despite the rigorous investigations and advances in biomonitoring, research has continued to focus on wadeable streams and rivers. Emphasis on non-wadeable streams has largely been disregarded. Methods for macroinvertebrate field sampling in large rivers have only recently been established by the Environmental Protection Agency (USEPA 2013). This approach quantifies macroinvertebrate assemblages from transects along a targeted reach using D-frame dip nets (USEPA 2013). However, this approach can be largely qualitative and depend on the discretion of the sampler.

The main objective of this study was to evaluate differences between passive sampling devices, both in colonizing macroinvertebrate assemblages and in the ability to detect impairment for non-wadeable streams. Currently, in rivers of Georgia and much of the southeastern United States, biomonitoring is primarily focused within wadeable streams (Davis et al. 2003, GA DNR EPD 2007). I chose to assess macroinvertebrate colonization of three types of passive samplers; Hester-Dendy samplers, leaf samplers (i.e., leaf packs) and wood samplers (i.e., snags and twigs packs). I assessed sources of variability within the community through the comparison of 53 metrics and 2 multi-metric indices associated with biomonitoring programs.

CHAPTER 2

MACROINVERTEBRATE ASSEMBLAGES COLONIZING PASSIVE SAMPLERS WITHIN TWO COASTAL PLAIN RIVERS

INTRODUCTION

Rivers and streams in the United States exhibit varying levels of alteration and disturbance. As a result, it is necessary to develop proper and practical tools to monitor these systems. These biomonitoring tools include data analyses and techniques which are applicable at varying spatial scales to compliment physical-chemical characterizations (Friberg et al. 2011, Moya et al. 2011, Couceiro et al. 2012). I used metric scoring to evaluate passive sampler suitability and to further understand macroinvertebrate community colonization of passive sampling devices.

Bioassessment metrics allow for attributes of a community to be used to assess perturbation. Metrics incorporate characteristics of the biota that change in a predictable way with increased perturbations (Barbour et al. 1999, Flotemersch et al. 2006). Boyero (2003) found macroinvertebrate metrics, specifically Ephemeroptera Plecoptera Trichoptera (EPT) index, to vary between habitats. For metrics to have relevance, they must be applicable to the underlying program objectives and the biological community in question. The metrics used should also be sensitive to stressors with a response outside of natural variation (Flotemersch et al. 2006).

Singular metrics and indices can easily be derived from existing taxa lists, as these have been developed from the wealth of macroinvertebrate research available. According to Hering et al. (2006), there are four metric types that can be considered. These include (a) composition/enumeration metrics, (b) richness/diversity metrics, (c) sensitivity/tolerance metrics and (d) functional metrics (e.g., Functional Feeding Group Structure or Habit). These metrics represent aspects of the biotic community, such as (1) structure, (2) taxa richness (family-, genus- or species-level), (3) enumeration (e.g., number of individuals collected, proportion of individuals in certain orders), (4) community diversity (e.g., Shannon's Index, Margalef's Index, Simpson's Index), (5) function (e.g., proportion of individuals within the "Collector" category), (6) habitat preference (e.g., proportion of individuals within the "Clinger" category), or other characteristics of the biological assemblage (Barbour et al. 1999, Bonada et al. 2006). Each category of metrics provides insight into the current conditions and the level of degradation within a system. Metrics provides a technique for managers to compare varying spatial or temporal scales.

Further, multi-metric indices offer a robust and sensitive tool to assess the current conditions of a system exposed to anthropogenic stressors (Bonada et al. 2006). For example, the Index of Biotic Integrity (IBI) developed by Karr (1981), used fish as indicators of stream health and was one of the first multi-metric approaches developed. After its development, Karr's IBI has been modified for other organisms (e.g., macroinvertebrates, macrophytes, phytoplankton, etc.), environments and ecoregions (Karr 1981, Hering et al. 2006, Mereta et al. 2013, Chen et al. 2014, Melo et al. 2015). Multi-metric indices convert information into a single number and therefore have become popular for assessment and management of streams, rivers, wetlands, and lakes (Karr and Chu 1997, Chen et al. 2014).

During the 1960s and 1970s, the use and performance of passive artificial substrates to collect benthic macroinvertebrates received much attention (Rosenberg and Resh 1993, De Pauw et al. 1994, Czerniawska-Kusza 2004). This was primarily due to the development of statistical methods that required a more quantitative approach and the convenience of an artificial passive sampler where conventional sampling techniques might not be feasible (Rosenberg and Resh 1993). The development of a passive sampling device with varying levels of heterogeneity resulted in a series of calibration studies to determine the suitability of these samplers for collecting macroinvertebrates. These calibration studies included rock or limestone filled baskets (Mason et al. 1967), concrete cones in wire baskets (Benfield et al. 1974), multi-plate boards (Hilsenhoff 1969), barbecue baskets (Jacobi 1971), and others (Crossman and Cairns 1974)

From these substrate calibration studies, habitat selection by benthic macroinvertebrates was determined to be an important mechanism for determining invertebrate composition, richness, distribution, and density (Benfield et al. 1974, Magoulick 1998). It was determined that substrate type, particle size, texture, and mesh size are important parameters influencing macroinvertebrate distribution and structure (Magoulick 1998, Morin et al. 2004, Battle et al. 2007, Adamiak-Brud et al. 2015, Bergey and Cooper 2015). However, these comparisons were primarily performed in wadeable streams (Bell 1969, Meier et al. 1979, Brua et al. 2011, Florencio et al. 2012, Braccia et al. 2014).

Current macroinvertebrate bioassessment methods have been developed for wadeable streams and often those methods are utilized in non-wadeable systems (Flotemersch et al. 2001). Few studies have compared the effectiveness and suitability of these methods when employed in non-wadeable (i.e., large) rivers. Blocksom and Flotemersch (2005), examined six existing wadeable methods including drift nets, kick nets, multi-plate samplers, and D-frame nets in non-wadeable rivers and concluded that each of these methods performed similarly. However, they determined that Hester-Dendy samplers may be the only viable sampling option due to the difficultly of use of other methods, which was similar to findings by other authors (Battlegazzore et al. 1994, Pashkevich et al. 1996). Battegazzore et al. (1994), compared Hester-Dendy samplers, Petersen grabs, and hand-net sampling to conclude that artificial substrates provided a more appropriate technique for sampling in non-wadeable rivers. Battlegazzore et al. (1994) concluded Hester-Dendy samplers were more appropriate for large rivers because they collected taxa that hand net sampling did not. Pashkevich et al. (1996) concluded Hester-Dendy samplers performed similarly to other samplers, but allowed for spatial comparison more effectively than other samplers. Few of these studies have focused on the effects of substrate type in low gradient, sandy bottom rivers, where substrate can be a potential limiting factor.

My aim was to compare passive sampling devices in non-wadeable, sandy bottom coastal plain rivers to determine their suitability for bioassessments and biomonitoring. The effect of sampling devices on macroinvertebrate colonization requires investigation before biomonitoring programs are established. Large river bioassessment programs will further our knowledge of communities inhabiting these systems and assist in the decision making of how we monitor and manage them.

METHODS

Sampling Devices

I compared three types of passive sampling devices for monitoring macroinvertebrate assemblages. These included Masonite board (Hester-Dendy multi-plate samplers), mesh bags filled with leaves (leaf samplers) and mesh bags filled with snags, twigs, and logs (wood samplers). Hester-Dendy samplers were standardized by surface area (7.6cm x 7.6cm plates spaced with plastic washers for an approximate surface area of $0.16m^2$), leaf samplers were standardized by weight (~5 grams of leaves for each pack) and wood samplers were standardized by surface area (length and diameter measured for an approximate surface area of $0.16m^2$). Swamp Laurel Oak (*Quercus laurifolia*) leaves and sticks from a recently cut tree were used for the leaf and wood samplers. Hester-Dendy sampling devices were suspended approximately one foot below the water surface from a PVC sponge float. Weighted wood samplers were suspended below the Hester-Dendy and weighted leaf samplers suspended below the wood allowing sufficient space between devices to prevent these from making contact with each other. This design reduced the potential transfer of organic material between sampling devices and allowed for devices to maintain similar depth and location within the water column. Sampling devices were left for a thirty-day colonization period after which they were retrieved and field preserved in 95% ethanol.

Study Sites

I placed sampling devices at six sites; three sites on the Ogeechee River and three sites on the Savannah River. Both rivers occur in the Coastal Plain ecoregion of Georgia, U.S.A. The Savannah River is approximately 484 kilometers long and drains an area of 25,511 km^2 and forms the border between South Carolina and Georgia. The headwaters are located in the Blue Ridge, and approximately 60 percent occurs in the Blue Ridge and Piedmont ecoregions and approximately 30 percent occurs in the Coastal Plain ecoregion. The river has six major impoundments for the generation of electricity and recreation. The Ogeechee River, a blackwater river, is approximately 473 kilometers long and drains an area of 14,359 km^2. The Ogeechee River is located in southeast Georgia and is one of the state's few predominantly free-flowing rivers. The headwaters of the Ogeechee River occur in the Piedmont ecoregion, however, the majority of the river occurs in the Coastal Plain ecoregion. Three sites on the Savannah River (miles 190, 146, and 61 from the mouth of river; hereafter, river miles; Sites 1, 2, and 3, respectively) and three sites on the Ogeechee River (river miles 202, 162, and 119; Sites 3, 4, and 5, respectively) were used to place three replicates of each sampler (N=54). Two wood samplers were not recovered; one from Site 3 and one from Site 6. Of the samples remaining, 18 were Hester- Dendy, 18 were leaf, and 16 were wood for 52 samples.

Sampling Stations

River mile 190 (Site 1) of the Savannah River was upstream of New Savannah Bluff Lock and Dam and river miles 146 (Site 2) and 61 (Site 3) were below New Savannah Bluff Lock and Dam, in the free flowing section of the river. River mile 146 (Site 2) occurred in Burke County downstream of Vogtle Electric Generating Plant, and River mile 61 (Site 3) occurred in Effingham County downstream of Highway 119. River miles 204 (Site 4), 162 (Site 5), and 119 (Site 6) occurred on the Ogeechee River, which is almost entirely free flowing (Table 2.1). River mile 204 occurred upstream of Fenns Bridge Rd. in Jefferson County, river mile 146 (Site 5) was located upstream of Highway 78 in Burke County, and river mile 119 (Site 6) was located upstream of Rocky Ford Highway in Screven County.

Table 2.1: Schedule of sampling on the Savannah and Ogeechee River.

Site	Basin	River Mile	Latitude	Longitude	No. samplers recovered	Date Samplers Retrieved
Site 1	Savannah	190	33.3839097	-81.9317347	9	November 10, 2014
Site 2		146	33.1160790	-81.6977210	9	November 15, 2014
Site 3		61	32.5247390	-81.2623880	8	November 14, 2014

Site 4	Ogeechee	204	33.045143	-82.603880	9	October 17, 2014
Site 5		162	32.870162	-82.319312	9	October 23, 2014
Site 6		119	32.649137	-81.841297	8	October 30, 2014

Sampling devices were deployed for a minimum 30 day colonization period beginning September 15, 2014.

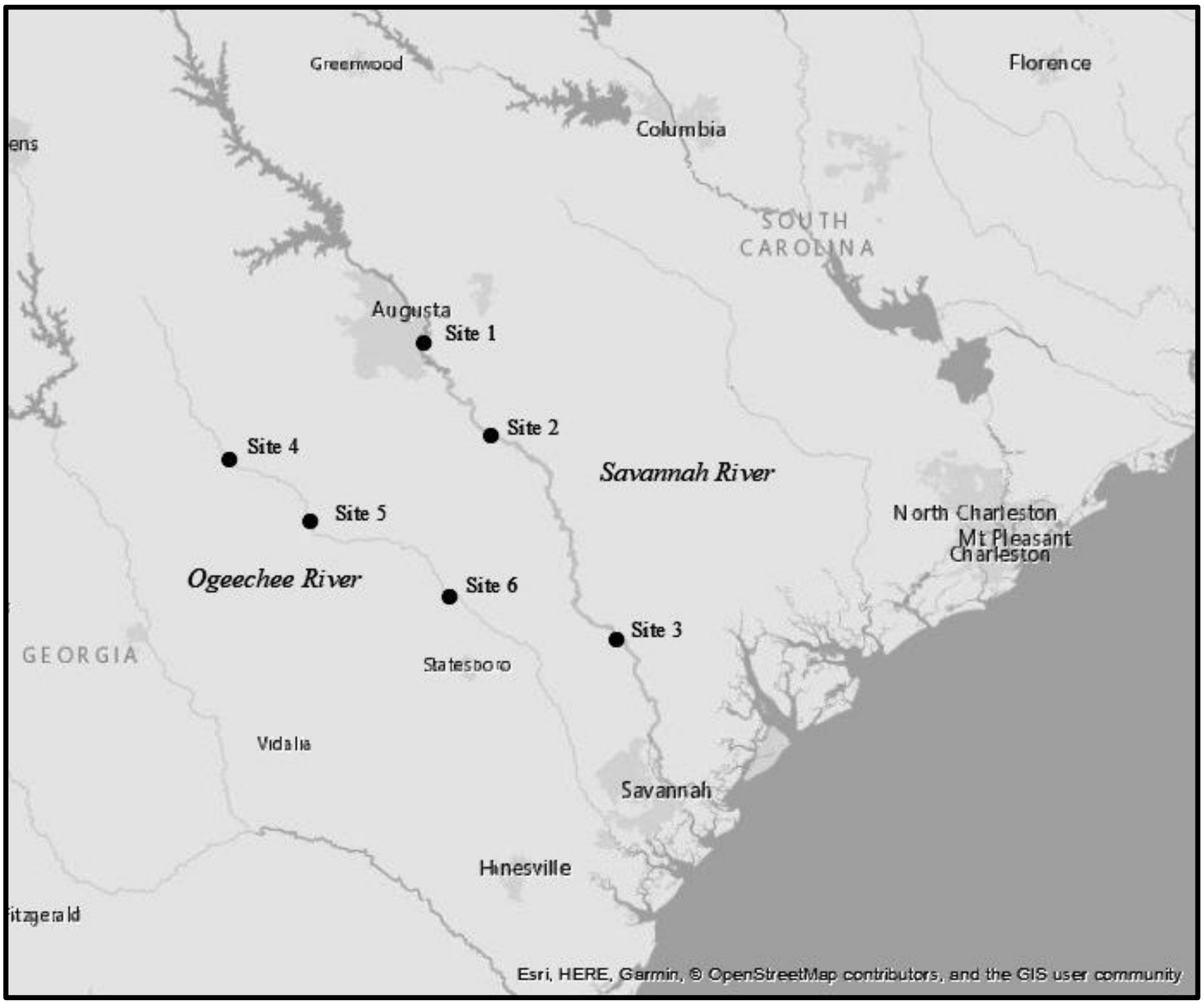

Figure 2.1: Study area: the Savannah River and the Ogeechee River in Georgia, U.S.A. Sampling stations 1, 2, and 3 are located on the Savannah River, and stations 4, 5, and 6 on the Ogeechee River.

Macroinvertebrates

Upon retrieval, I stored samplers in plastic bags, preserved in 95% ethanol, and transported to the laboratory for processing. In the laboratory, macroinvertebrates were washed from samplers and identified to lowest possible taxonomic level (i.e., usually genus for insects [except for Chironomidae which were identified to subfamily] and order for non-insects). All laboratory processing followed the U.S. Environmental Protection Agency standard operating procedures (USEPA 2008). Samples were washed with a 500-μm sieve and all individuals identified from each sampler. Wood samples were carefully washed and bark removed to extract any deeply burrowed organisms.

Metrics

Mean, standard deviation, and variance component estimates were calculated from 53 macroinvertebrate metrics and 2 multi-metric indices to quantify variation between devices and site for macroinvertebrate assemblages colonizing each sampling device. The 53 metrics were adopted from standard bioassessment protocols (i.e., Barbour et al. 1992, 1999, GA DNR EPD 2012) to include 9 richness, 17 composition, 9 tolerance, 10 Functional Feeding Group, and 8 Habit metrics (Table 2.2). In addition, I examined several regional multi-metric indices including the Florida Stream Condition Index (FSCI) and the Georgia multi-metric index (GAMMI), which were originally intended for use in wadeable streams. Tolerance values, Habit and Functional Feeding Groups were based on Georgia's Environmental Protection Division Taxa Lists from 2012. Tolerance values are based on a 0-10 scale, where 0 represents taxa incapable of enduring organic pollution and 10 represents taxa capable of withstand considerable organic pollution.

Tolerant taxa were defined as taxa having tolerance score ≥ 7 and intolerant taxa having tolerance score of ≤ 3. Hilsenhoff Biotic Index (HBI) and Beck's Biotic Index (BBI) used tolerance values obtained from GA DNR EPD (2012). HBI incorporates tolerance values from abundance of taxa in an assemblage, whereas BBI combines richness of taxa with tolerance values of ≥1 and values >1 and ≥ 4. NCBI is similar to Hilsenhoff Biotic Index, but uses tolerance values derived from North Carolina database. FSCI was calculated using Florida Department of Environmental Protection's Standard Operation Procedure for the northeast bioregion. GAMMI was calculated using the 65l-Atlantic Southern Loam Plains metric calculation guidelines and included Ephemeroptera Plecoptera and Trichoptera (EPT) taxa, Diptera taxa, % EPT, % Trichoptera, HBI, Predator Taxa and Clinger Taxa. Multi-metric scores of FSCI and GAMMI range between 0-100, where 0 represents the most degraded water quality and 100 represents the least degraded water quality.

Table 2.2: Common biomonitoring metrics adapted from GA DNR EPD (2012) used to assess differences between Hester-Dendy, leaf, and wood substrate samplers.

Richness Metric	Total taxa	Chironomidae taxa
	EPT taxa	Margalef's Index
	Plecoptera taxa	Shannon-Wiener Index
	Coleoptera taxa	Simpson's Diversity Index
	Diptera taxa	
Composition Metrics	% EPT	% Plecoptera

	% Amphipoda	% Tanytarsini
	% Chironomidae	% Oligochaeta
	% Coleoptera	% Trichoptera
	% Diptera	% Orthocladiinae/Total Chironomidae
	% Gastropoda	% Tanypodinae/Total Chironomidae
	% Isopoda	% Hydropsychidae/ Total Trichoptera
	% Non-Insect	% Hydropsychidae/ Total EPT
	% Odonata	
Tolerance Metrics	Tolerant Taxa	Dominant Individuals
	% Tolerant individuals	BBI
	Intolerant taxa	HBI
	% Intolerant individuals	NCBI
	% Dominant	
Feeding Group Metrics	% Scraper	Predator Taxa
	Scraper Taxa	% Shredder
	% Collector	Shredder Taxa
	Collector Taxa	% Filterer
	% Predator	Filterer Taxa

Habit Metrics	Clinger Taxa	Swimmer Taxa
	% Clinger	% Swimmer
	Burrower Taxa	Sprawler Taxa
	% Burrower	% Sprawler
Multi-Metric	GAMMI	FSCI

Data analysis

I explored how different substrates (i.e., samplers) reflected benthic macroinvertebrate community composition in two large rivers by characterizing the colonizing assemblages using common bioassessment metrics and multivariate statistics. Abundance was expressed as the number of individuals per sampler and richness was expressed as the number of taxa (genera, family, or order) in samplers. Richness, Composition, Tolerance, Functional Feeding Group (FFG), and Habitat Preference on each substrate treatment (i.e., sampling device) and at each site were statistically analyzed using a 2-Way Analysis of Variance (ANOVA) with a $P < 0.05$ significance level. For all statistical analyses, normality and homogeneity of variance were examined (Goodness of Fit Test and Levene's Test). Variance components were estimated to further identify sources of variation. Kendall's Concordance (W) test was used to determine similarity of taxa at the family level between sampling devices. Permutational Analysis of Variance (PERMANOVA, with Bray-Curtis Similarity) was used with a $P < 0.05$ significance level to determine differences in community structure between sampling devices. Nonmetric

Multi-Dimensional Scaling (NMDS using Bray-Curtis Similarity Matrix) was used to visualize patterns of assemblages between samplers. Similarity Percentage Analysis (SIMPER) was used to determine taxa driving differences between samplers. JMP statistical software (Pro version 12.0) was used to run ANOVA, estimates of variance components, Goodness of Fit Tests, and Levene Tests. PRIMER-E (version 7) was used to perform Permutational Analysis of Variance (PERMANOVA), Nonmetric Multi-Dimensional Scaling (NMDS), and Similarity Percentage Analysis (SIMPER).

RESULTS

A total of 34,648 individual belonging to 73 taxonomic groups were collected from all sampling devices (Appendix A). Hester-Dendy samplers collected 901 ± 1,008 (Mean ± SD, hereafter) individuals, leaf samplers collected 342 ± 377 individuals and wood samplers collected 689 ± 657 individuals (Figure 2.2). Aquatic worms (Order: Oligochaeta) were the most common taxon colonizing all samplers followed by midges (Diptera: Chironomidae) in the subfamily Orthocladiinae (22% and 18%, respectively).

Diptera abundance ($F_{10,34} = 4.62$, $P < 0.01$; Figure 2.3) and Chironomidae abundance ($F_{10, 34} = 4.70$, $P < 0.01$; Figure 2.4) were found to differ significantly between sampling devices by site. Wood samplers collected the most Diptera individuals, followed by Hester-Dendy and leaf samplers (mean: 330.6 ± 215.1, 304.7 ± 215.3, and 131.7 ± 122.7, respectively). Consequently, wood samplers also collected the most Chironomidae individuals, followed by Hester-Dendy and leaf samplers (mean: 323.5 ± 215.7, 300.0 ± 213.2, and 129.0 ± 121.6, respectively), because Chironomidae comprised 98% of all Dipterans.

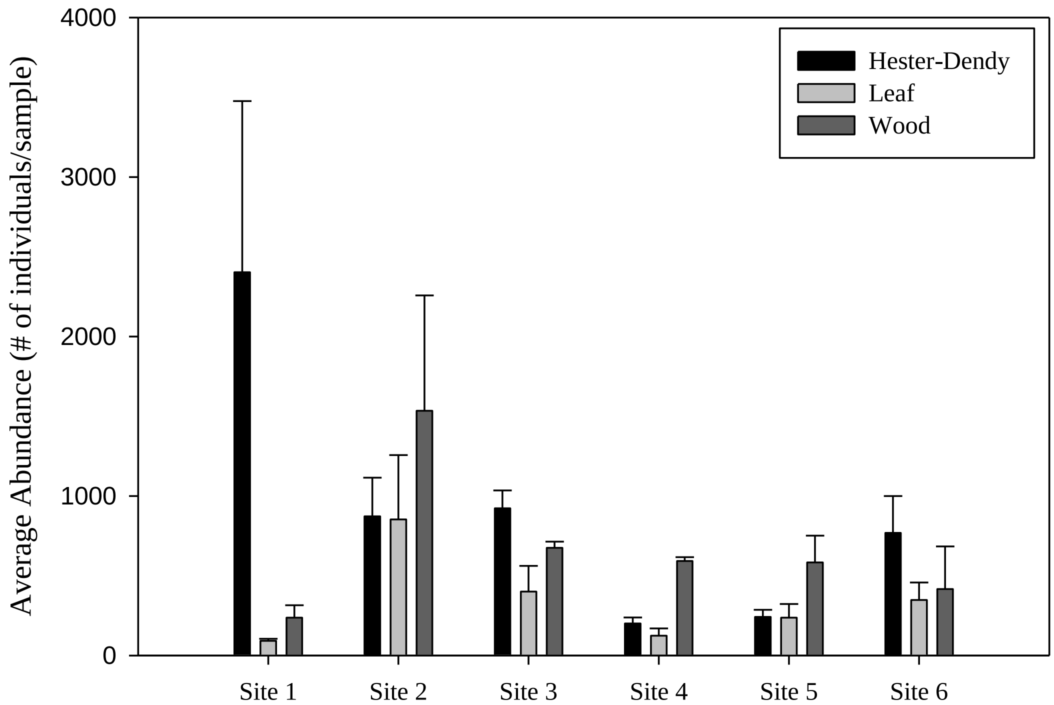

Figure 2.2: Mean total abundance (± SE) of Hester-Dendy, leaf, and wood sampler replicates within sites. Bars represent average total abundance (# of individuals/sampler) of replicate devices within sites and error bars represent standard error. Black bars represent Hester-Dendy samplers, light gray bars represent leaf samplers, and dark gray bars represents wood.

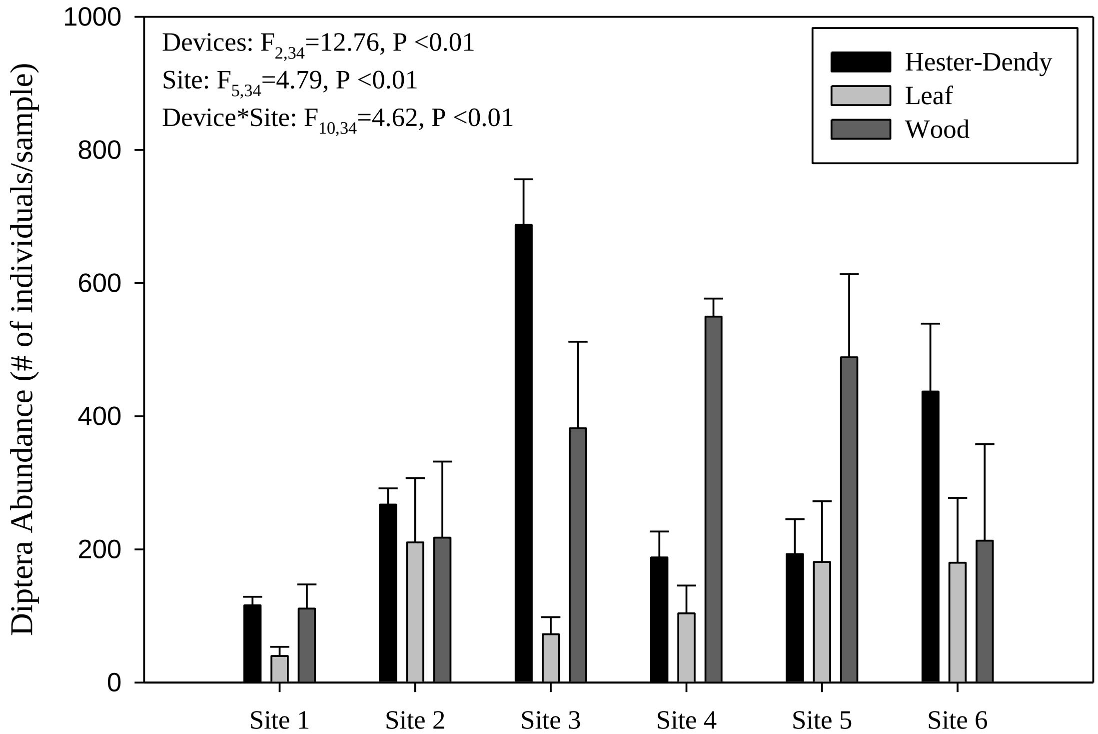

Figure 2.3: Mean Diptera abundance (± SE) within Hester-Dendy, leaf, and wood sampler replicates within sites. Diptera abundance was determined to be statistically significant (α=0.05) among samplers based on 2-way ANOVA (Device*Site: $F_{10,\ 34} = 4.62$, $P < 0.01$).

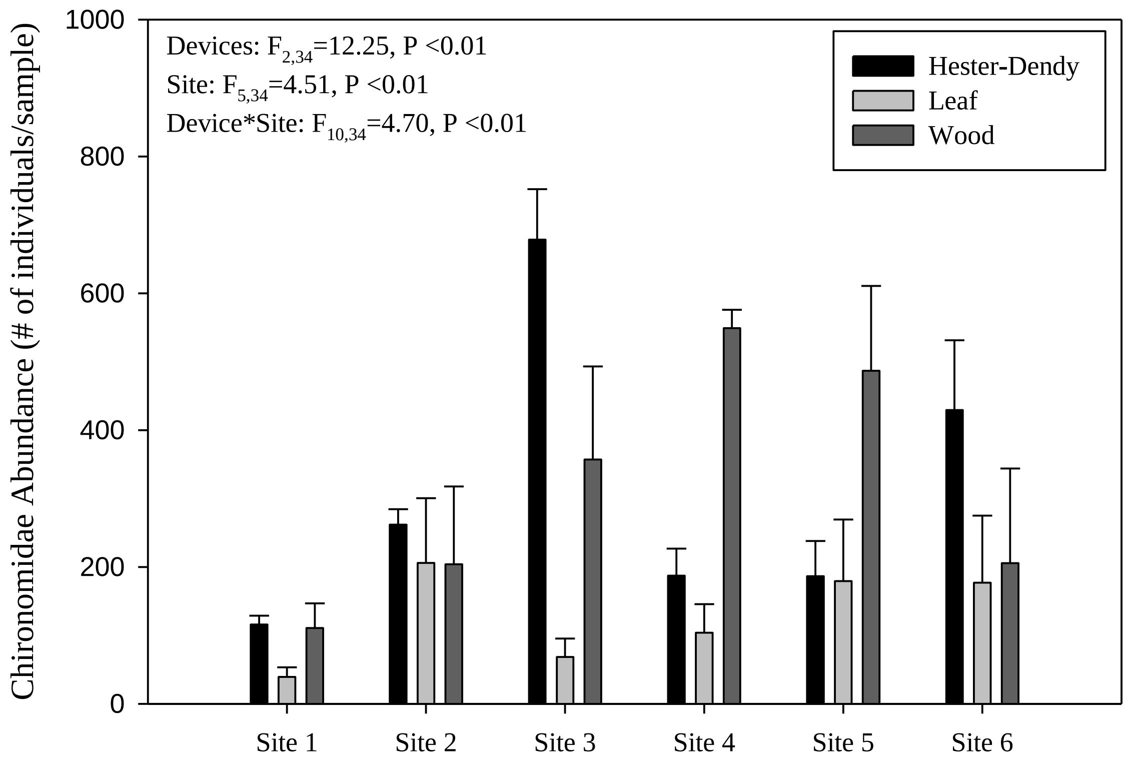

Figure 2.4: Mean Chironomidae abundance (± SE) within Hester-Dendy, leaf, and wood sampler replicates within sites. Chironomidae abundance was determined to be statistically significant (α=0.05) among samplers based on 2-way ANOVA (Device*Site: $F_{10, 34}$= 4.70, P < 0.01).

Richness Metrics

Richness metrics ranged from 0.2 ± 0.02 in Simpson's Diversity Index to 7.9 ± 1.0 in EPT taxa. EPT taxa, Plecoptera taxa and Chironomidae taxa averaged similarly between Hester-Dendy, leaf, and wood samplers (Table 2.3). EPT Taxa contributed to 45% of total richness in Hester-Dendy, 44% in leaf and 44% in wood samplers (mean: 7.5 ± 3.0, 7.9 ± 4.2, 7.9 ± 3.9, respectively). Coleoptera taxa colonizing wood samplers averaged 1.25 ± 0.9, Hester-Dendy samplers averaged 0.9 ± 1.1 and leaf samplers averaged 0.9 ±0.8. Further, Margalef's Index and Shannon-Wiener Index showed leaf samplers to average 2.8 ± 1.0 and 2.0 ± 0.4, respectively, alongside wood samplers averaging 2.8 ± 0.7 and 1.8 ±0.3, where Hester-Dendy samplers averaged 2.4 ± 0.7 and 1.7 ± 0.6. Simpson's Diversity Index showed Hester-Dendy samplers to average 0.3 ± 0.2, followed by wood samplers at 0.3 ± 0.1, with leaf samplers averaging 0.2 ± 0.1.

EPT taxa, Plecoptera taxa, Coleoptera taxa, Chironomidae taxa, Margalef's Index, Shannon-Wiener Index, and Simpson's Diversity Index were found to be similar between sampling devices based on a 2-way ANOVA. Diptera taxa ($F_{10,34}$=2.34, P=0.03; Figure 2.5) colonizing samplers were found to be significantly different between sampling devices by site with Hester-Dendy samplers collecting an average of 4.8 ± 1.0 taxa, leaf samplers collecting an average of 4.7 ± 1.0, and wood collecting an average of 3.9 ± 2.4 taxa across all replicates (Table 2.3). Site 5 wood samplers collected fewer Diptera taxa than Hester-Dendy or leaf samplers and could explain much of the metric variation (mean: 0.7, 5.7, and 4.7, respectively).

Estimates of variance components revealed much of the variation was associated to differences in sites, with EPT taxa attributing 71.5%, Plecoptera taxa attributing 58.9%, Coleoptera taxa attributing 28.5%, and Margalef's Index attributing 44.3% of variation to sites. However, Diptera taxa showed 34.2% of the total variation was attributed to the interaction and 0.0% attributed to devices and sites.

Table 2.3: Mean ± standard deviation and variance component estimates including Device, Site, Interaction (Device * Site) and Error for richness metrics calculated from macroinvertebrate assemblages colonizing Hester-Dendy (n=18), leaf (n=18), and wood (n=16) samplers.

				Variance Components			
Metric	Hester-Dendy	Leaf	Wood	Device	Site	Interaction	Error
Total Taxa	16.1 ± 4.5	16.4 ± 6.0	18.3 ± 4.9	3.1	55.3	0.4	41.2
EPT Taxa	7.5 ± 3.0	7.9 ± 4.2	7.9 ± 3.9	0.0	71.5	0.0	28.5
Plecoptera Taxa	1.1 ± 1.1	1.0 ± 1.3	0.8 ± 1.1	0.0	58.9	0.0	41.1
Coleoptera Taxa	0.9 ± 1.1	0.9 ± 0.8	1.3 ± 0.9	1.1	28.5	0.0	70.4
Diptera Taxa	4.8 ± 1.0	4.7 ± 1.0	3.9 ± 2.4	0.0	0.0	34.2	65.8
Chironomidae Taxa	3.9 ± 0.6	4.0 ± 0.5	4.1 ± 0.6	0.0	8.4	7.5	84.1
Margalef's Index	2.4 ± 0.7	2.8 ± 1.0	2.8 ± 0.7	6.7	44.3	0.0	49.0
Shannon-Wiener Index	1.7 ± 0.6	2.0 ± 0.4	1.8 ± 0.3	6.7	24.6	11.8	56.9
Simpson's Index	0.3 ± 0.2	0.2 ± 0.1	0.3 ± 0.1	5.2	6.0	24.5	64.3

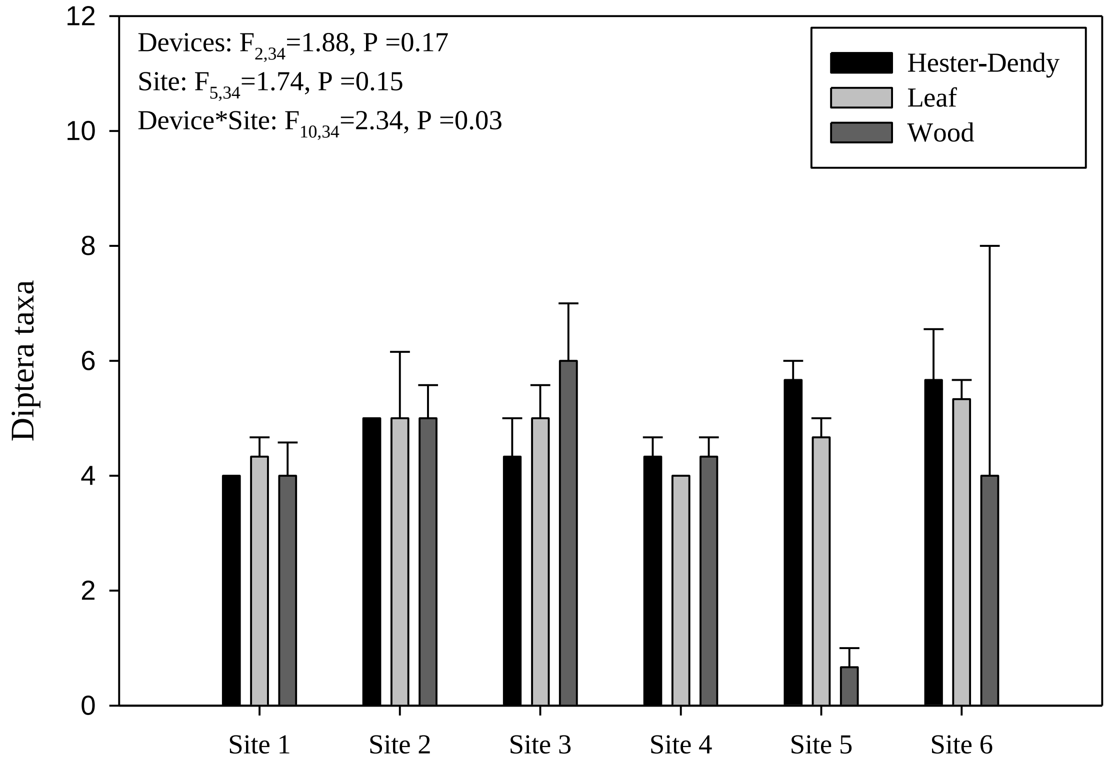

Figure 2.5: Mean Diptera taxa (± SE) within Hester-Dendy, leaf, and wood sampler replicates within sites. Diptera taxa was determined to be statistically significant (α=0.05) among samplers based on 2-way ANOVA (Device*Site: $F_{10,34}$=2.34, P=0.03).

Composition Metrics

Composition metrics ranged from 0% in % Isopoda to 90.5% in % Diptera and % Chironomidae (Table 2.4). % EPT taxa averaged similarly in Hester-Dendy and wood samplers (mean: 24.2 ± 21.1 and 24.9 ± 28.1), but 15% higher in leaf samplers (mean: 39.0 ± 31.4). EPT taxa for site 2 exhibited a 70% lower average than all other sites combined and also increased from site 4 to site 6 for each sampling device. % Chironomidae and % Diptera averaged similarly among assemblages colonizing sampling devices (Table 2.4). % Coleoptera, % Isopoda and % Odonata contributed little to overall composition. Coleoptera contributed 1.1% of composition in wood, 0.9% in leaf and 0.5% in Hester-Dendy samplers. Isopoda contributed to 0% of total composition in Hester-Dendy samplers and 0.03% in leaf and wood samplers. Further, % Odonata contributed to less than 1% of total composition for assemblages colonizing all devices. In contrast, % Orthocladiinae contributed to a large portion of the overall composition; contributing to as much as 92.7% of total composition in a Hester-Dendy sampler. % Trichoptera contributed to 15.6% of overall composition for Hester-Dendy samplers, 24% in leaf samplers and 17.5% in wood. % Trichoptera composition increased from site 1 to site 3 and from site 4 to site 6 in Hester-Dendy and wood samplers.

% EPT, % Chironomidae, % Diptera, % Non-insect, % Odonata, % Tanytarsini, % Trichoptera, % Orthocladiinae/Total Chironomidae, % Tanypodinae/Total Chironomidae, Hydropsychidae/Total Trichoptera and Hydropsychidae/Total EPT were similar between sampling devices and sites based on a 2-way ANOVA. % Amphipoda ($F_{10,34}$ =2.40, P=0.03; Figure 2.6), % Gastropoda ($F_{10,34}$=3.18, $P < 0.01$; Figure 2.7) and % Oligochaeta ($F_{10,34}$ =2.24, P = 0.04; Figure 2.8) were significantly different between assemblages colonizing sampling devices across sites. % Amphipoda averaged higher in leaf samplers at 0.8 ± 1.5% of total composition, whereas Hester-Dendy samplers averaged 0.2 ± 0.5% and wood samplers averaged 0.2 ± 0.4 %. Similarly, % Gastropoda averaged highest in leaf samplers at 4.2 ± 12.2 %, followed by wood samplers at 0.8 ± 1.4 % and Hester-Dendy samplers at 0.2 ± 0.5 %. In contrast, leaf samplers averaged the lowest in % Oligochaeta at 3.4 ± 8.2% and Hester-Dendy samplers averaged the highest at 15.0 ± 29.1 %, followed by wood at 11.3± 21.3%. % Oligochaeta averaged highest at Site 2; Hester-Dendy samplers averaged 89.3% higher, leaf samplers averaged 96.0% higher and wood samplers averaged 89.1% higher at Site 2.

According to estimates of variance components (Table 2.4) from % Amphipoda, devices contributed to 6.8% of total variance, sites 11.1%, interaction 26.9%, and error contributed to 55.2%. Estimates of variance components % Gastropoda showed devices to contribute to 0.0% of total variance, sites contributed to 5.8%, interaction contributed to 41.1%, and error contributed to 53.1%. % Oligochaeta estimates of variance components showed sites to contribute to the majority of variance at 46.7%, whereas devices contributed to 2.4%, interaction contributed 15.3%, and error contributed to 35.6%. Variance component estimates for % EPT, % Chironomidae, % Diptera, % Non-Insect, % Tanytarsini, % Trichoptera, % Orthocladiinae/ Total Chironomidae, and % Tanypodinae/ Total Chironomidae showed a large portion (i.e. > 50%) of total variation was attributed to sites.

Table 2.4: Mean ± standard deviation and variance component estimates including Device, Site, Interaction (Device * Site) and Error for composition metrics calculated from macroinvertebrate assemblages colonizing Hester-Dendy (n=18), leaf (n=18), and wood (n=16) samplers.

				Variance Components			
Metric	Hester-Dendy	Leaf	Wood	Device	Site	Interaction	Error
% EPT	24.2 ± 21.1	39.0 ± 31.4	24.9 ± 28.1	5.8	59.3	0.0	34.9
% Amphipoda	0.2 ± 0.5	0.8 ± 1.5	0.2 ± 0.4	6.8	11.1	26.9	55.2
% Chironomidae	58.4 ± 29.0	48.5 ± 28.0	51.9 ± 29.8	0.0	61.2	10.1	28.7
% Coleoptera	0.5 ± 0.9	0.9 ± 1.1	1.1 ± 1.4	4.6	18.0	2.6	74.8
% Diptera	59.4 ± 29.4	49.2 ± 27.6	52.6 ± 29.5	0.0	60.7	11.1	28.2
% Gastropoda	0.2 ± 0.5	4.2 ± 12.2	0.8 ± 1.4	0.0	5.8	41.1	53.1

% Isopoda	0.0 ± 0.0	0.0 ± 0.1	0.0 ± 0.1	0.0	0.0	0.0	100.0
% Non-Insect	15.7 ± 29.7	10.4 ± 17.1	13.7 ± 24.7	0.0	62.9	1.8	35.3
% Odonata	0.1 ± 0.2	0.2 ± 0.4	0.2 ± 0.5	0.0	0.0	6.5	93.5
% Tanytarsini	0.1 ± 0.1	0.1 ± 0.1	0.1 ± 0.1	0.2	85.5	0.0	14.3
% Oligochaeta	15.0 ± 29.1	3.4 ± 8.2	11.3 ± 21.3	2.4	46.7	15.3	35.6
% Trichoptera	15.8 ± 15.5	24.6 ± 24.9	17.5 ± 24.0	2.2	58.4	0.0	39.4
% Orthocladiinae/ Total Chironomidae	47.4 ± 26.5	44.5 ± 26.3	41.1 ± 24.4	0.0	45.8	0.0	54.2
% Tanypodinae/ Total Chironomidae	12.4 ± 12.9	16.9 ± 18.0	14.9 ± 18.7	0.0	50.1	0.5	49.4
% Hydropsychidae/ Total Trichoptera	31.7 ± 28.1	37.6 ± 30.3	31.4 ± 29.6	0.0	44.2	4.4	51.4
% Hydropsychidae/ Total EPT	21.7 ± 21.2	24.2 ± 20.8	23.3 ± 25.0	0.0	47.7	0.0	55.3

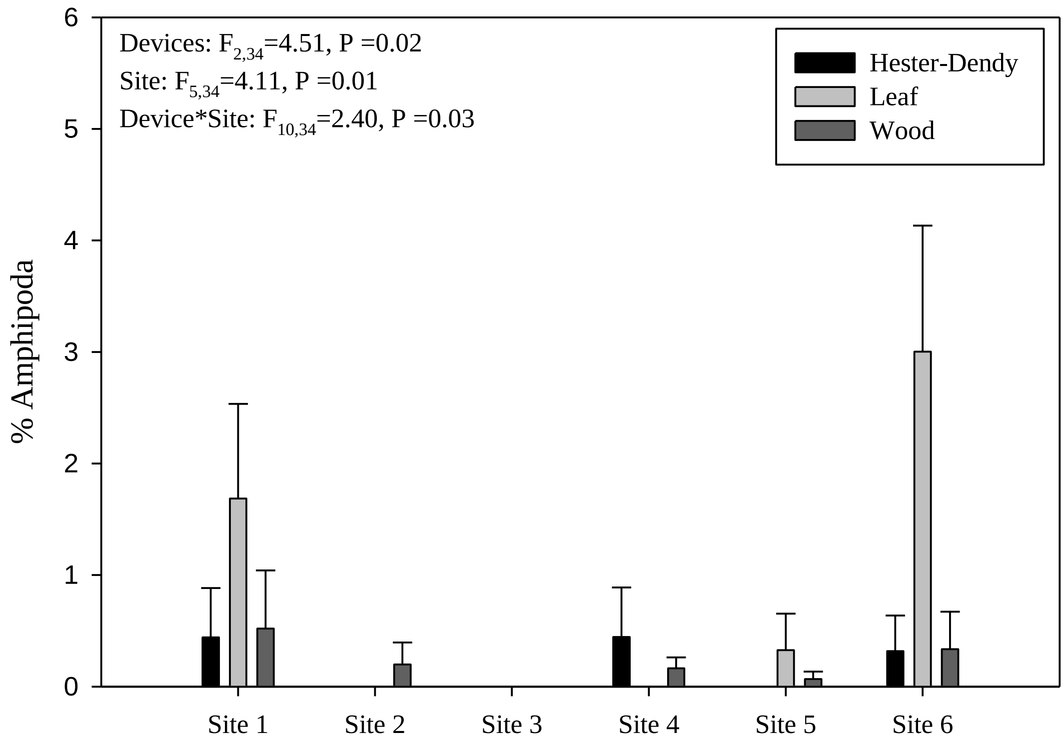

Figure 2.6: Mean % Amphipoda (± SE) within Hester-Dendy, leaf, and wood sampler replicates within sites. % Amphipoda was determined to be statistically significant (α=0.05) among samplers based on 2-way ANOVA (Device*Site: $F_{10, 34}$=2.40, P=0.03).

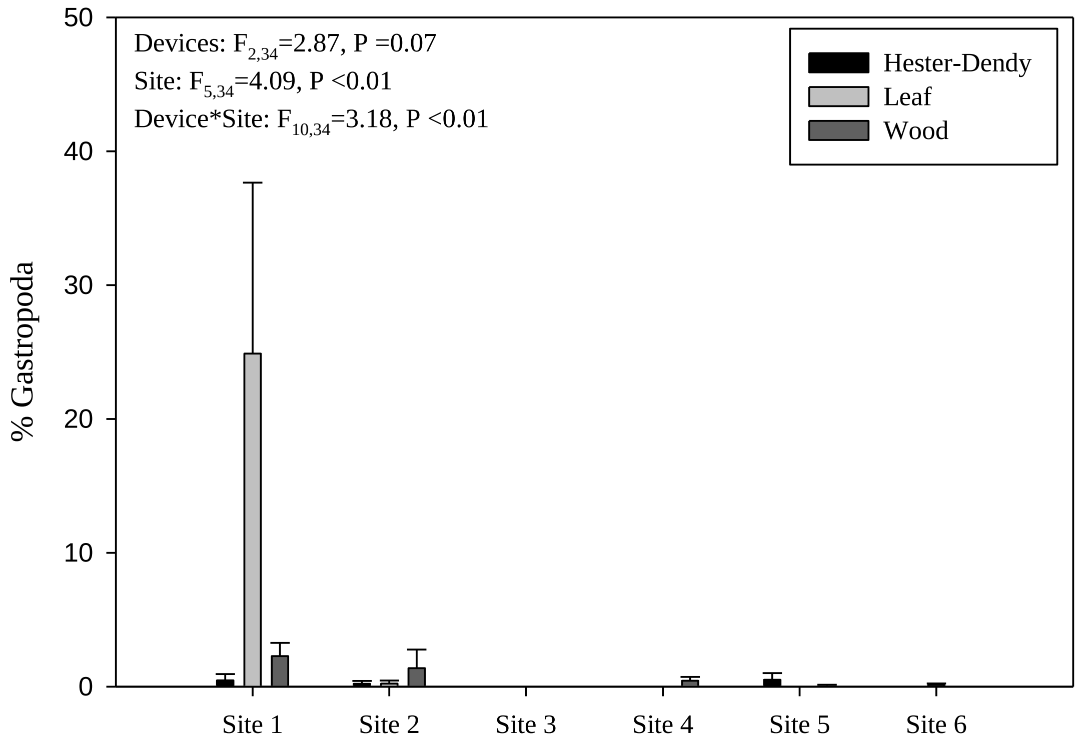

Figure 2.7: Mean % Gastropoda (± SE) within Hester-Dendy, leaf, and wood sampler replicates within sites. % Gastropoda was determined to be statistically significant (α=0.05) among samplers based on 2-way ANOVA (Device*Site: $F_{10,34}$=3.18, P < 0.01).

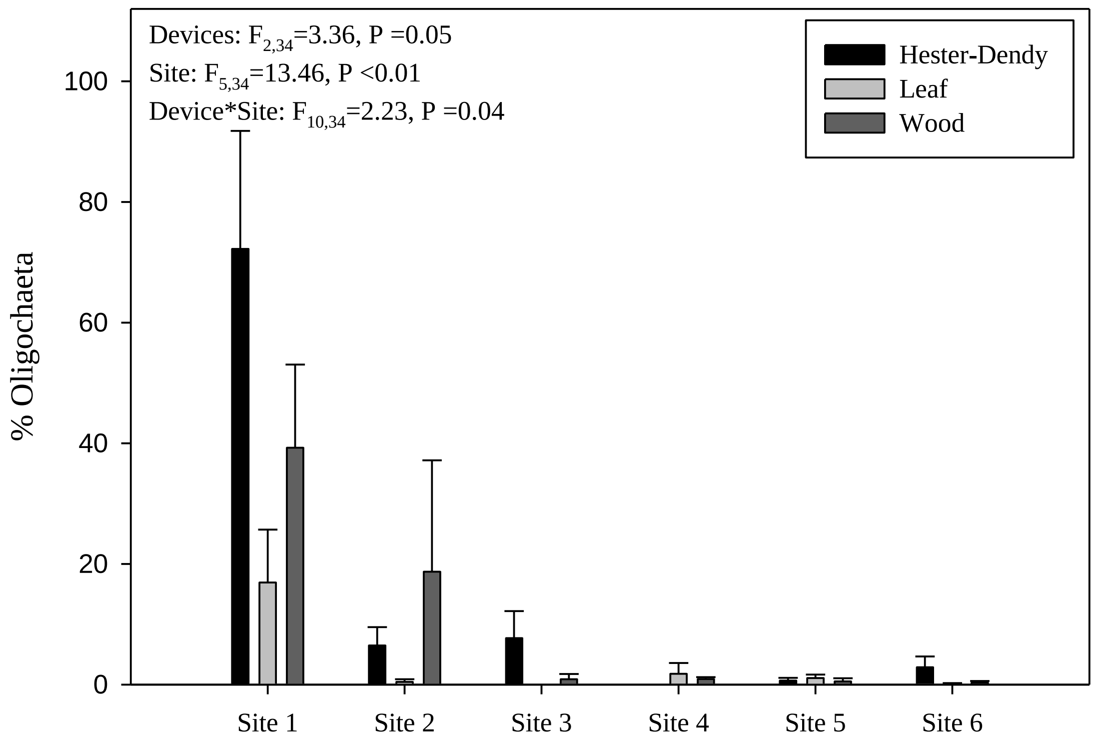

Figure 2.8: Mean % Oligochaeta (± SE) among Hester-Dendy, leaf, and wood sampler replicates within sites. % Oligochaeta was determined to be statistically significant (α=0.05) among samplers based on 2-way ANOVA (Device*Site: $F_{10,34}$=2.24, P=0.04).

Tolerance Metrics

Tolerance metrics ranged from1.7 in intolerant taxa to 381.2 in dominant individuals. Tolerant taxa averaged 1.9 ± 1.3 in Hester-Dendy, 2.1 ± 1.6 in leaf and 2.9 ± 1.7 in wood samplers, where intolerant taxa averaged 1.8 ± 1.4 in Hester-Dendy samplers, 1.8 ± 1.6 in leaf and 1.7 ± 1.4 in wood samplers (Table 2.5). Macroinvertebrate assemblages colonizing Hester-Dendy samplers exhibited the highest % tolerant individuals and the lowest % intolerant individuals, averaging 15.8 ± 29.6% and 3.3 ± 4.6%, respectively. Leaf samplers averaged 9.6 ±

14.1% tolerant individuals, and 5.4 ± 7.6% intolerant individuals, whereas wood averaged 14.0 ± 23.6% tolerant individuals and 4.0 ± 6.3% intolerant individuals. Hilsenhoff Biotic Index scores ranged from 4.7 to 8.1 and overall, macroinvertebrate assemblages colonizing Hester-Dendy and wood samplers averaged a score of 5.8 ± 1.0 and 5.8 ± 0.8, whereas assemblages colonizing leaf samplers averaged a score of 5.5 ± 0.6. BBI ranged from the lowest score of 0 to the highest score of 10 and assemblages colonizing leaf samplers averaged a score of 3.9 ± 2.4, whereas those colonizing wood samplers averaged a score of 2.9 ± 2.4 and Hester-Dendy samplers averaged 3.3 ± 1.8. NCBI averaged similarly among Hester-Dendy, leaf, and wood samplers (mean: 5.7 ± 1.0, 5.4 ± 0.6, 5.8 ± 0.8)

Tolerant taxa, % Tolerant individuals, Intolerant taxa, % Intolerant individuals, BBI, HBI and NCBI scored similarly among sampling devices. However, % Dominant individuals ($F_{10,34}$=2.24, P=0.04; Figure 2.9) and Dominant individuals ($F_{10,34}$ =3.64, $P < 0.01$; Figure 2.10) were found to differ significantly between assemblages colonizing sampling devices. % Dominant individuals averaged highest in Hester-Dendy samplers at 15.0 ± 29.1 followed by wood samplers at 11.3 ± 21.3 % and leaf samplers at 3.4 ± 8.2%. % Dominant individuals reflected % Oligochaeta, because Oligochaeta was the dominant individual. Dominant individuals average highest in Hester-Dendy samplers, followed by wood and leaf samplers (mean: 381.2 ± 1,027.0, 27.2 ± 52.2, 3.8 ± 7.4, respectively).

Estimates of variance components showed % Dominant individuals to mirror % Oligochaeta, with a large percentage of sites contributing to total variation, since Oligochaeta was the dominant individual (Table 2.9). Estimates of variance components for Dominant individuals revealed differences in devices to contribute 11.5% to total variance, sites contributed 23.8%, and 64.7% of variance was unexplained.

Table 2.5: Mean ± standard deviation and variance component estimates including Device, Site, Interaction (Device * Site) and Error for tolerance metrics calculated from macroinvertebrate assemblages colonizing Hester-Dendy (n=18), leaf (n=18), and wood (n=16) samplers.

				Variance Components			
Metric	Hester-Dendy	Leaf	Wood	Device	Site	Interaction	Error
Tolerant Taxa	1.9 ± 1.3	2.1 ± 1.6	2.9 ± 1.7	1.6	0.0	13.2	85.2
% Tolerant Individuals	15.8 ± 29.6	9.6 ± 14.1	14.0 ± 23.6	0.0	51.1	8.1	59.2
Intolerant Taxa	1.8 ± 1.4	1.8 ± 1.6	1.7 ± 1.4	0.0	64.5	0.0	35.5
% Intolerant Taxa	3.3 ± 4.6	5.4 ± 7.6	4.0 ± 6.3	1.6	56.7	0.0	58.3
% Dominant individuals	15.0 ± 29.1	3.4 ± 8.2	11.3 ± 21.3	2.4	46.7	15.3	35.6
Dominant individuals	381.2 ± 1,027.0	3.8 ± 7.4	27.2 ± 52.2	1.2	3.1	45.8	49.9
BBI	3.3 ± 1.8	3.9 ± 2.4	2.9 ± 2.4	2.3	66.3	0.0	31.4
HBI	5.8 ± 1.0	5.5 ± 0.6	5.9 ± 0.8	2.0	57.5	4.5	36.0
NCBI	5.7 ± 1.0	5.4 ± 0.6	5.8 ± 0.8	1.8	55.8	7.6	34.9

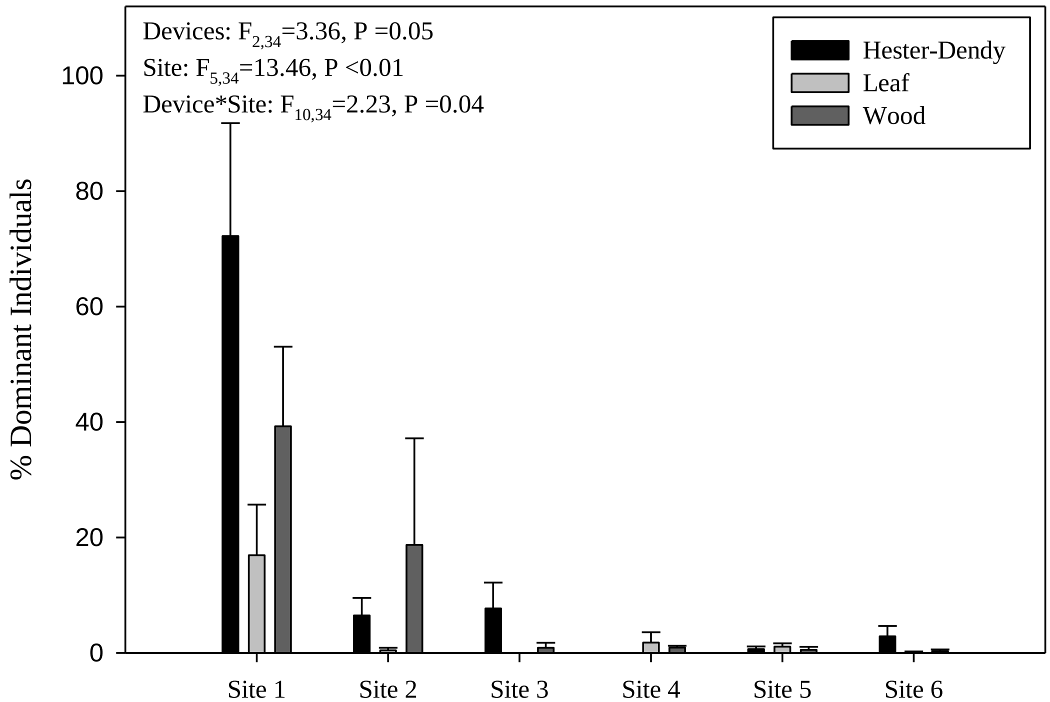

Figure 2.9: Mean % Dominant individuals (± SE) among Hester-Dendy, leaf, and wood sampler replicates within sites. % Dominant individuals was determined to be statistically significant (α=0.05) among samplers based on 2-way ANOVA (Device*Site: $F_{10,34}$=2.24, P=0.04).

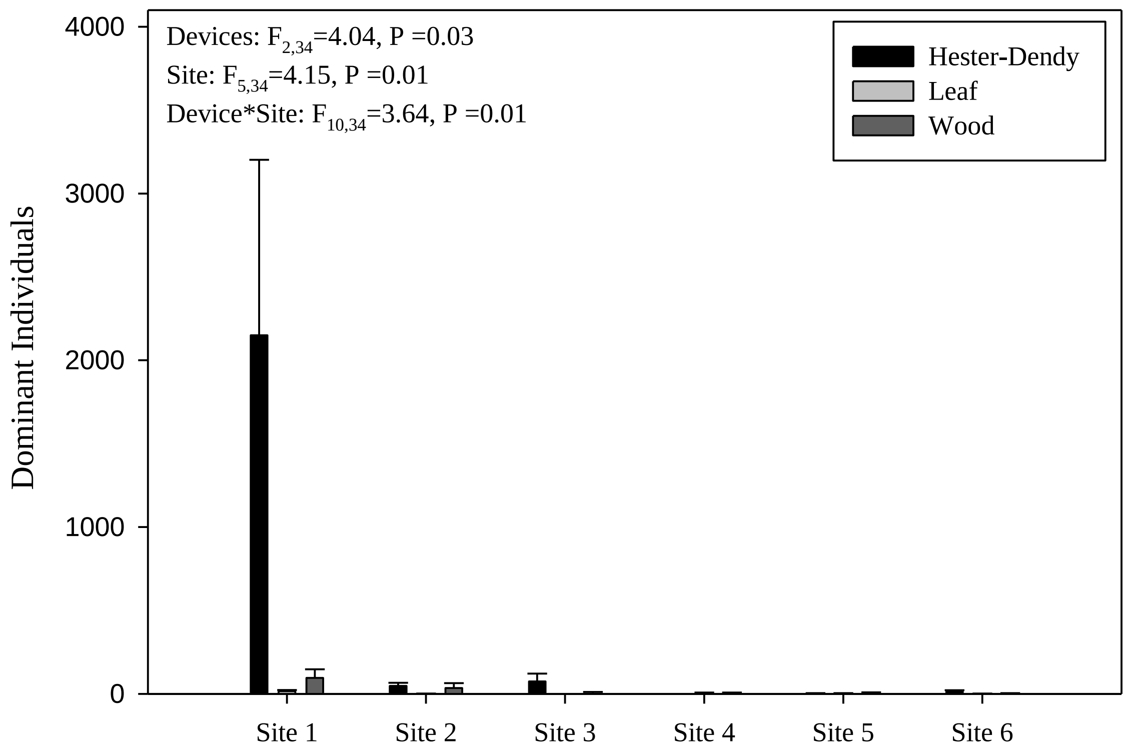

Figure 2.10: Mean Dominant individuals (± SE) among Hester-Dendy, leaf, and wood sampler replicates within sites. Dominant individuals was determined to be statistically significant (α=0.05) among samplers based on 2-way ANOVA (Device*Site: $F_{10,34}$=3.64, $P < 0.01$).

Functional Feeding Group Metrics

Functional Feeding Group metrics ranged from 0% contribution in % Scraper and % Shredder to 71.6% in % Collector. % Scraper contributed as much as 13.4 ± 8.5% of overall Function Feeding Group in leaf samplers to as little as 5.8 ± 2.3 % in wood samplers. However, Scraper taxa colonizing the different devices was similar (Table 2.6). % Collector contributed the largest percentage to overall Functional Feeding Group, averaging 56.5 ± 22.2% in Hester-Dendy samplers, 38.9 ± 18.9% in leaf samplers, and 42.8 ± 22.8% in wood samplers. Predator taxa, Shredder taxa, and Filterer taxa averaged similarly for each device (Table 2.6). % Shredders contributed little to overall Functional Feeding Group in Hester-Dendy samplers at 0.5 ± 1.6%, wood samplers at 1.3 ± 1.9% and leaf samplers at 3.2 ± 6.2%. % Filterers made up a large portion of total Functional Feeding Group in combination with % Collectors. % Filterers contributed to 25.1 ± 17.9 % in Hester-Dendy samplers, 31.3 ± 19.1% in leaf samplers, and 23.3 ± 24.4% in wood samplers.

% Scraper, Scraper taxa, % Collector, Predator taxa, % Shredder, Shredder taxa, Filterer and Filterer taxa was found to be similar among sampling devices based on a 2-way ANOVA. However, Collector taxa ($F_{10,34}$=2.23, P=0.04; Figure 2.11) and % Predator ($F_{10,34}$=3.53, $P < 0.01$; Figure 2.12) were found to be significantly different between sampling devices. Collector taxa averaged similarly in Hester-Dendy and leaf samplers, but wood samplers collected 20.6 % more Collector taxa than Hester-Dendy samplers and 18.6% more than leaf samplers (mean: 4.6 ± 0.4, 4.8 ± 0.4, 5.9 ± 0.4, respectively). Wood samplers collected 57.0% more % Predator than Hester-Dendy samplers and 37.3% more % Predator than leaf samplers.

Estimates of variance component for Collector taxa revealed 5.4% of variance was attributed to the devices, whereas 20.9% was attributed to sites and 22.1 was attributed to interaction, and 51.7% was unexplained as residual. Estimates of variance components for % Predator revealed 17.7% of variance was attributed to devices, 2.4% to the sites, 37.5% to the interaction, and 42.2% to error. Functional Feeding Group metrics estimates of variance components revealed large portions (i.e., >50%) of variation to be unexplained as error as seen in all metrics with the exception of % Predator and % Collector.

Table 2.6: Mean ± standard deviation and variance component estimates including Device, Site, Interaction (Device * Site) and Error for Functional Feeding Group metrics calculated from macroinvertebrate assemblages colonizing Hester-Dendy (n=18), leaf (n=18), and wood (n=16) samplers.

				Variance Components			
Metric	Hester-Dendy	Leaf	Wood	Device	Site	Interaction	Error
% Scraper	8.8 ± 6.5	13.4 ± 8.5	5.8 ± 9.2	9.5	27.6	8.8	54.2
Scraper Taxa	2.9 ± 1.2	3.0 ± 1.9	2.9 ± 1.3	0.0	33.5	0.0	66.5
% Collector	56.5 ± 22.2	39.0 ± 18.9	42.8 ± 22.8	11.9	26	12.2	49.9
Collector Taxa	4.7 ± 1.6	4.8 ± 1.5	5.9 ± 1.8	5.4	20.9	22.1	51.7
% Predator	8.6 ± 7.1	12.6 ± 9.6	20.0 ± 12.8	17.7	2.4	37.5	42.4
Predator Taxa	4.1 ± 1.5	3.8 ± 1.8	4.5 ± 1.5	2.3	26.8	0.0	70.9
% Shredder	0.5 ± 1.6	3.2 ± 6.2	1.3 ± 1.9	6.4	9.2	0.9	83.6
Shredder Taxa	0.3 ± 0.6	0.9 ± 0.9	0.9 ± 0.7	12.7	8.1	18.2	61
% Filterer	25.1 ± 17.9	31.3 ± 19.1	23.2 ± 24.4	0.9	41.1	0.7	57.2
Filterer Taxa	3.6 ± 1.5	3.5 ± 1.9	3.5 ± 1.8	0.0	47.6	0.0	52.4

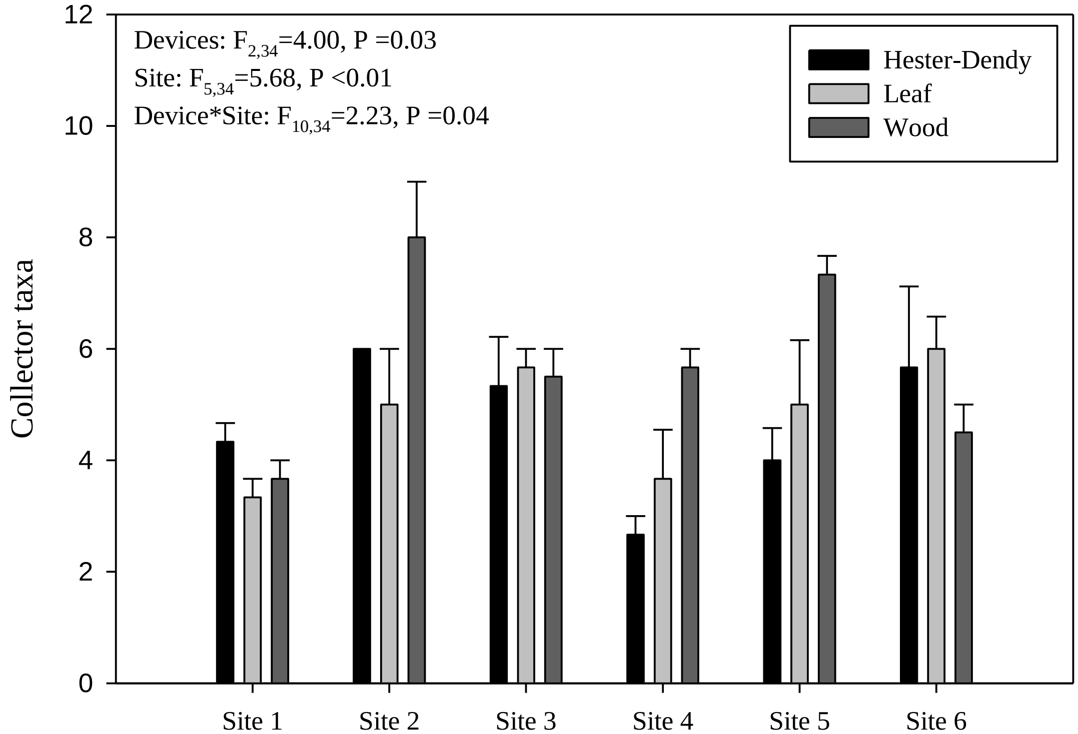

Figure 2.11: Mean Collector taxa (± SE) among Hester-Dendy, leaf, and wood sampler replicates within sites. Collector taxa was determined to be statistically significant (α=0.05) among samplers based on 2-way ANOVA (Device*Site: $F_{10,34}$=2.23, P=0.04).

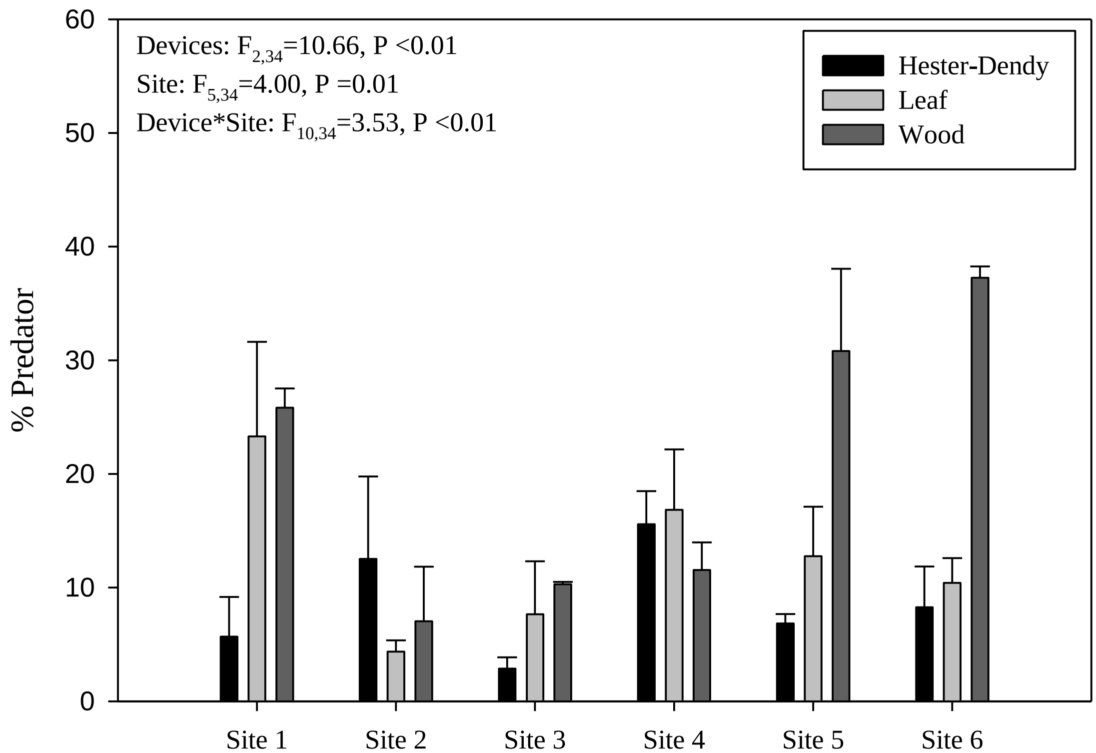

Figure 2.12: Mean % Predator (± SE) among Hester-Dendy, leaf, and wood sampler replicates within sites. Collector taxa was determined to be statistically significant (α=0.05) among samplers based on 2-way ANOVA (Device*Site: $F_{10,34}$=3.53, P < 0.01).

Habit Metrics

Habit metrics ranged from an average of 0.6 ± 0.8 in Swimmer taxa from leaf samplers to 37.4 ± 21.2% in % Burrower from wood samplers. Clinger taxa, Burrower taxa, and Sprawler taxa were similar among sampling devices. Average % Clinger was similar for Hester-Dendy and wood samplers at 21.0 ± 19.3% and 23.0 ± 27.5% whereas leaf samplers averaged 31.1 ± 26.3%. % Sprawler was also similar among Hester-Dendy and wood samplers at 1.4 ± 2.2% and

1.3 ±1.2%, with leaf samplers averaging 3.6 ±3.9. % Swimmer averaged similarly for Hester-Dendy and leaf samplers, with wood samplers averaging 29.2% higher.

% Burrower ($F_{10,34}$=2.27, P=0.04; Figure 2.4) colonizing each sampling device was determined as significantly different based on a 2-way ANOVA. % Burrower averaged similarly for leaf and wood samplers at 36.2 ± 20.6% and 37.4 ± 21.2%, but Hester-Dendy samplers averaged 45.1 ± 22.4%, 18.4% higher than leaf and wood samplers.

Estimates of variance components for % Burrower revealed 0.0% of variance was attributed to differences in devices, 21.4% was attributed to sites, 30.0% of variance was attributed to the interaction, and 48.6% of variance was unexplained as error. % Clinger and Clinger taxa showed a large portion of variance was attributed to differences in sites, and little was attributed to interaction or devices. Burrower taxa showed variance was almost entirely unexplained as error. % Sprawler, Sprawler taxa, % Swimmer, and Swimmer taxa showed variance was associated with sites, the interaction and error.

Table 2.7: Mean ± standard deviation and variance component estimates including Device, Site, Interaction (Device * Site) and Error for Habit metrics calculated from macroinvertebrate assemblages colonizing Hester-Dendy (n=18), leaf (n=18), and wood (n=16) samplers.

				Variance Components			
Metric	Hester-Dendy	Leaf	Wood	Device	Site	Interaction	Error
% Clinger	20.8 ± 19.3	31.1 ± 26.3	22.9 ± 27.5	2.2	56.2	0.0	41.6
Clinger Taxa	6.4 ± 3.0	6.2 ± 3.7	6.9 ± 3.8	0.2	60.4	0.0	39.4
% Burrower	45.1 ± 22.4	36.2 ± 20.6	37.4 ± 21.2	0.0	21.4	30.0	48.6
Burrower Taxa	3.8 ± 0.4	3.9 ± 0.3	4.0 ± 0.5	2.4	2.6	0.0	95.0

% Sprawler	1.4 ± 2.2	3.6 ± 3.9	1.3 ± 1.2	16.1	16.9	1.1	65.9
Sprawler Taxa	1.1 ± 1.0	1.2 ± 1.1	1.3 ± 1.1	0.0	37.4	15.3	47.3
% Swimmer	1.5 ± 2.4	1.5 ± 2.7	2.1 ± 2.6	0.0	21.1	15.4	63.5
Swimmer Taxa	1.0 ± 0.8	0.6 ± 0.8	0.8 ± 0.8	4.7	49.3	0.0	46.0

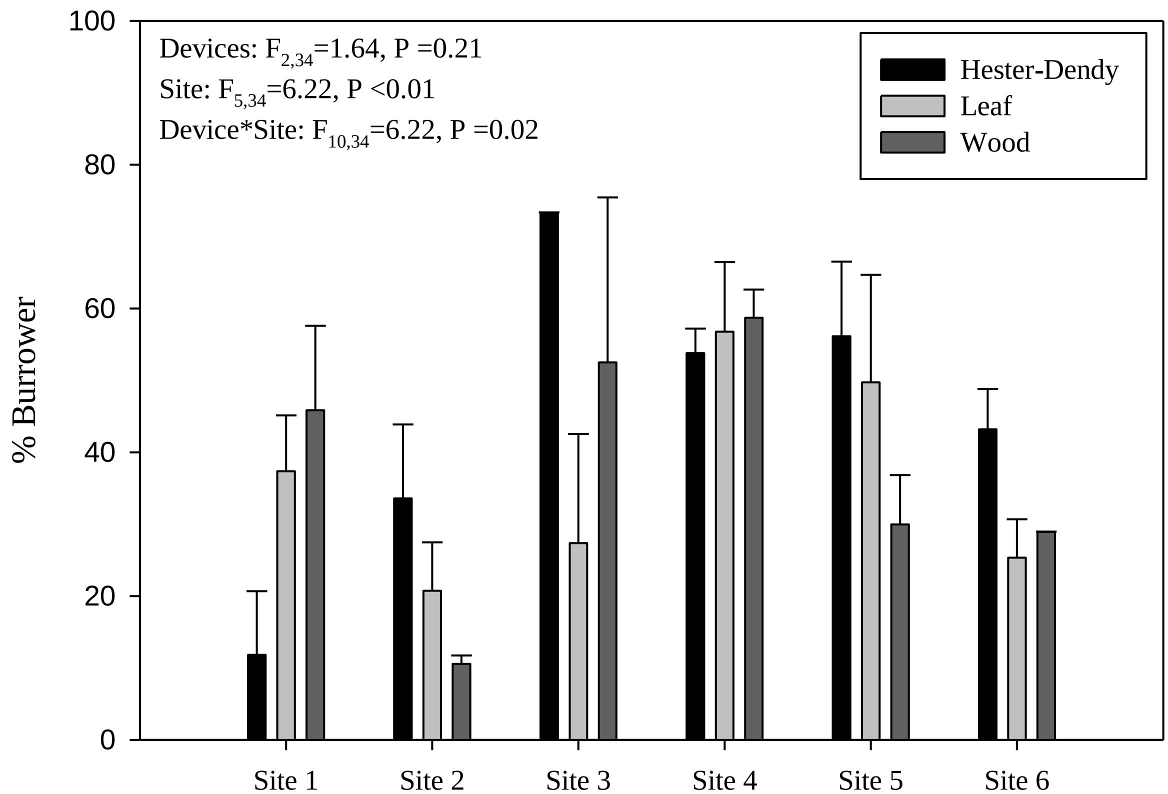

Figure 2.13: Mean % Burrower (± SE) within Hester-Dendy, leaf, and wood sampler replicates within sites. % Burrower was determined to be statistically significant (α=0.05) among samplers based on 2-way ANOVA (Device*Site: $F_{10,34}$=2.27, P=0.04).

Multi-metric Indices

Florida SCI and GAMMI were similar across sampling devices. Florida SCI averaged 47.1 ± 12.2 for Hester-Dendy samplers, 50.9 ± 15.5 for leaf samplers, and 47.3 ± 18.6 for wood samplers. Leaf samplers only exhibited a 7.1% difference between wood and Hester-Dendy samplers. GAMMI averaged 64.9 ± 13.9 for Hester-Dendy samplers, 63.1 ± 18.1 for leaf samplers, and 63.9 ± 16.6 for wood samplers (Table 2.8).

Estimates of variance components revealed no portion of variance was attributed to the interactions or devices. A large portion of the variance was attributed to differences in sites, and unexplained as error.

Table 2.8: Mean ± standard deviation and variance component estimates including Device, Site, Interaction (Device * Site) and Error for multi-metrics indices calculated from macroinvertebrate assemblages colonizing Hester-Dendy (n=18), leaf (n=18), and wood (n=16) samplers.

				Variance Components			
Metric	Hester-Dendy	Leaf	Wood	Device	Site	Interaction	Error
Florida SCI	47.1 ± 12.2	50.9 ± 15.4	47.3 ± 18.6	0.0	57.9	0.0	42.1
GAMMI	64.9 ± 13.9	63.1 ± 18.1	63.9 ± 16.6	0.0	75.2	0.0	24.8

Assemblage Structure

The top ten contributing taxa comprised 88% of the overall composition, which include the aforementioned Oligochaeta at 22% and Orthocladiinae 18%, *Cheumatopsyche* (Trichoptera: Hydropsychidae) at 14%, Chironomini (Diptera: Chironomidae) at 9%, Tanytarsini (Diptera: Chironomidae) at 7%, *Chimarra* (Trichoptera: Philopotamidae) at 5%, *Maccaffertium* (Ephemeroptera: Heptageniidae) at 4%, Tanypodinae (Diptera: Chironomidae) at 3%, Hydroptila

(Trichoptera: Hydroptilidae) at 2%, and *Baetis* (Ephemeroptera: Baetidae) at 1%. Of the 22% Oligochaeta collected, 84% were collected from Hester-Dendy samplers at Site 1. The top five taxa collected with Hester-Dendy samplers contributed to 80% of the total abundance collected and were comprised of Oligochaeta, Orthocladiinae, Chironomini, *Cheumatopsyche* and Tanytarsini, respectively. The top five taxa collected with leaf bags contributed to 63% of the total abundance and were comprised of Orthocladiinae, *Cheumatopsyche*, *Chimarra*, Tanytarsini, and *Maccaffertium*, respectively. The top five taxa collected with wood bags contributed to 70% of the total abundance and were comprised of *Cheumatopsyche*, Orthocladiinae, Chironomini, Tanytarsini and *Chimarra*, respectively.

Colonizing macroinvertebrates at family level were similar for each device according to Kendall's concordance (W_{42}=0.864, P<0.001). However, according to permutational analysis of variance (PERMANOVA) macroinvertebrate assemblages at the genus level were significantly different between sampling devices (pseudo-$F_{12, 34}$=1.60, P< 0.01) and tended to cluster by sampler type (Figure 2.14). Based on SIMPER analyses, Hester-Dendy, leaf, and wood samplers averaged closely in similarity of taxa with an overall average of 60.8 ± 9.0, 51.3 ± 4.8, and 57.1 ± 13.1, respectively. Average dissimilarity was highest between Hester-Dendy and leaf samplers at Site 1 (mean: 67.3 ± 5.0) and lowest between Hester-Dendy and leaf samplers at Site 5 (mean: 40.1 ± 1.1). Sampling devices collected similar taxa, however the proportions of certain taxa differed as seen by SIMPER analysis within sites (Appendix B). For example, *Cheumatopsyche* and *Chimarra* average abundance had the largest contribution to dissimilarity at Site 2, with Hester-Dendy samplers averaging 14.7, leaf samplers averaging 14.2, and wood samplers averaging 23.3.

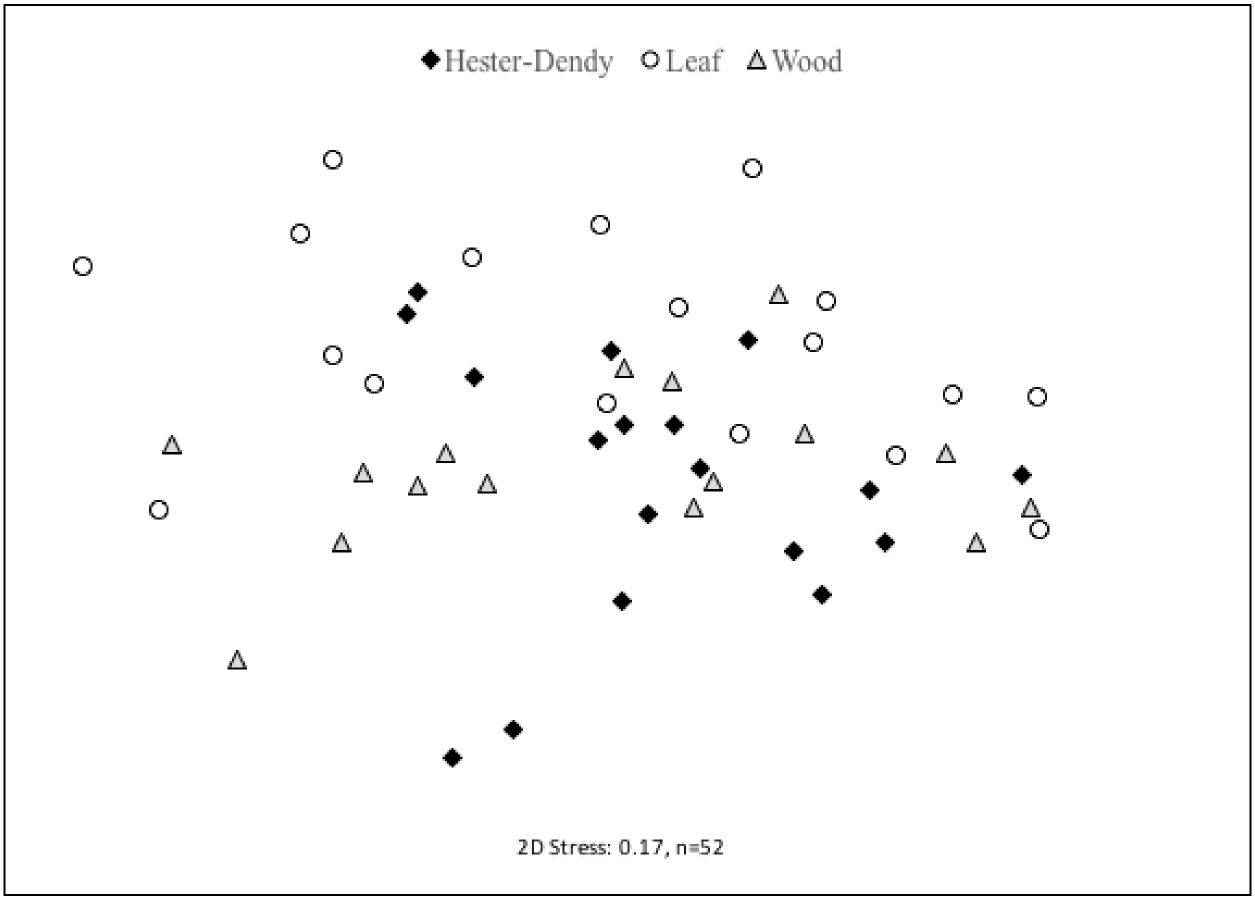

Figure 2.14: Non-metric multidimensional scaling (NMDS) ordination using Bray-Curtis similarity matrix for assemblages in Hester-Dendy, leaf, and wood samplers. Symbols represent assemblages colonizing Hester-Dendy, leaf, and wood samplers. Black diamonds represent Hester-Dendy samplers, white circles represent leaf samplers and gray triangles represent wood samplers. PERMANOVA indicted significant differences in assemblages among substrate samplers (pseudo-$F_{12, 34}$ = 1.6, $P < 0.01$). SIMPER analysis revealed taxa colonizing sampling devices were the same, however the proportion in which taxa contributed differed.

DISCUSSION

My study compares the efficiency and consistency of three passive samplers in non-wadeable streams (i.e., large rivers). Devices for sampling macroinvertebrates have been investigated in wadeable streams and rivers by many (Bell 1969, Meier et al. 1997, Brua 2011, Florencio et al. 2012, Braccia et al. 2014), but my study provides understanding of macroinvertebrate passive sampling methods in non-wadeable rivers in the Southeastern U.S.A.

I found differences in the abundances of Chironomidae and Diptera collected between sampling devices similar to Brua et al. (2011), which found differences in abundances of Chironomidae between Kick-net and U-net sampling. Wood and Hester-Dendy samplers collected almost twice the number of Chironomidae and Diptera individuals as leaf samplers. The inability of devices to collect similar number of individuals has been observed by many (De Pauw et al. 1994, Turner and Trexler 1997, Blocksom and Flotemersch 2005, Brua et al. 2011). Brua et al. (2011) hypothesized that semi-quantitative sampling methods collected more widespread animals (e.g., Chironomidae) rather than rare, narrowly distributed taxa because of the standardization of area sampled. De Pauw et al. (1994), hypothesized roughness and particle size to explain the differences seen in taxa diversity on two artificial substrates as has been demonstrated by other investigators (O'Conner 1991, Schmude et al. 1998, Downes et al. 2000, Bergey and Cooper 2015). However, De Pauw et al. (1994) further concluded the standardization of surface area, in terms of interstitial space and substrate roughness for use as microhabitats, could have attributed to the differences they observed in taxa diversity. Overall, abundances of leaf samplers were much lower than that of Hester-Dendy and wood samplers, which could indicate the sampling area or amount of habitat available for colonization by macroinvertebrates differed between sampling devices. My samplers were standardized by surface area (e.g., ind/m^2) for Hester-Dendy and wood samplers, and weight (e.g. ind/g) for leaf samplers. Further, Hester-Dendy samplers had a smooth surface, whereas wood contained many interstitial spaces between each slice of wood, spaces within the bark, and a rough surface for colonization and niche exploitation. Differences in the average number of individuals collected from my findings were most likely due to difference in standardization of surface area, similar to that hypothesized by De Pauw et al. (1994).

Diptera taxa exhibited differences between sampling devices, however, overall means for each sampler were similar. The differences observed originated with the inconsistency (i.e., high variance) of wood samplers, where wood replicates collected a large range of taxa. For instance, wood samplers collected 0 taxa within one replicate and 8 taxa within another at Site 6 and 0 taxa to 1 taxon at Site 5. The inconsistency shown in SD scoring further illustrated poor precision of sampler replicates. The poor precision could be attributed to microhabitat differences, where suitability of the wood habitat varied among replicates on a microhabitat scale (Magoulick 1998, Brooks et al. 2005). Textural differences, as seen by Downes et al. (2000), have been shown to increase species richness with more rough surfaces. The degree of roughness in our wood samples was not accounted for and could have varied between samples, which could have attributed to an underestimated surface area. Further, we found a large portion of variability in Diptera taxa to be unexplained and could indicate variability was not associated with sites or devices, but rather difference in microhabitat conditions (Brooks et al. 2005, Costa and Melo 2008).

Overall, % Amphipoda and % Gastropoda were relatively low in the number of individuals collected. Site 1 and Site 6 collected a large percentage of all Amphipoda and

Gastropoda, indicating variability (Downes et al. 2000, Li et al. 2001, Boyero 2003, Johnson et al. 2004) between sites. However, leaf samplers collected the majority of Amphipoda and Gastropoda individuals. Literature on Amphipoda functional feeding role is highly contentious due to their diet plasticity. They are considered collector-gatherers by GA DNR EPD (2012) taxa list; however, many authors view them as herbivorous shredders because of their preference for skeletonizing leaves and shredding allochthonous detritus (Cummins and Klug 1979, MacNeil et al. 1997, Kelly et al. 2002). Our observations of Amphipoda primarily colonizing leaves would be consistent with the shredder Functional Feeding Group. Snails in the family Planorbidae and Lymnaeidae made up the majority of Gastropoda collected and they feed by scraping algae off of hard surface. However, algivorous gastropods also consume leaf litter, as indicted by Lombardo and Cooke (2002) and Hoffman (2005). Leaves may provide a necessary food source as seen by Hoffman (2005) rather than just substrate and would explain the observations of Gastropoda colonizing leaf samplers in this study. The majority of % Oligochaeta contribution was observed at Sites 1, 2, and 3 with Sites 4, 5, and 6 contributing little to % Oligochaeta. Much of the differences in % Oligochaeta can be explained from differences between sites, and further could be attributed to differences between rivers, as Sites 1-3 are on the Savannah River, and Sites 4-6 are on the Ogeechee River. Downes et al. (2000) reported no distinguishable differences in variation between three rivers in the Acheron River Catchment. They did note however, that the rivers were not intrinsically different from each other to render such comparison, whereas our rivers might be different enough from each other. The Ogeechee River has regular flood pulses in which the floodplain is regularly in contact with the river channel (Meyer et al 1997), whereas the Savannah River has a regulated flow regime and less variable flood pulses (Bright et al. 2010) due to major impoundments along the river. Further, the Savannah River was channelized, with approximately 40 bends straightened and snags removed that has changed the hydrology and channel morphology. Additionally, leaf samplers consistently captured less oligochaetes than Hester-Dendy or wood samplers. O'Connor (1991) determined the number of individuals collected was attributed to roughness or particle size of substrates. Surface complexity (i.e., particle size or roughness) has been observed by many as affecting abundance and diversity (De Pauw et al. 1994, Downes et al. 2000, Adamiak-Brud et al. 2015, Bergey and Cooper 2015) due to the physically complex habitat which provides different niche exploitation to occur. Leaf samplers could have a less complex or rough surface than Hester-Dendy or wood samplers and may be a physically less complex habitat that would allow for less niche diversification to occur (Downes et al. 1998).

% Dominant individual was a redundant metric because the dominant individual was Oligochaeta and therefore, was identical to % Oligochaeta. In % Dominant individual, Hester-Dendy samplers collected a high abundance of oligochaetes at Site 1 and 3, as well as a much higher degree of variation, indicating poor precision. % Predators was lowest in Hester-Dendy samplers at Sites 1 and 3, where, for the most part, % Oligochaeta was highest, indicating Oligochaeta may not have been predated on as heavily, which could be attributed a poor trophic relationship.

Functional Feeding Group metrics showed differences in Collector taxa and % Predator, with wood collecting a higher number of collectors and a higher percentage of predators. Differences observed in Collector taxa could, again, be associated to texture, as seen in Downes et al. (2000), microhabitat (Cooper et al. 1998, Costa and Melo 2008), or local habitat variables (Lammert and Allan 1999, Johnson et al. 2004). % Predator was higher in wood samplers, which could be associated with foraging efficiency of fish, where species of Perch were shown to preferentially prey on macroinvertebrate predators by Diehl (1992). Habitat complexity has been shown to increase macroinvertebrate community richness and abundance (O'Conner 1991, Diehl 1992, Schmude et al. 1998) and wood habitat, in particular, has been shown to support high densities of macroinvertebrates (Benke et al. 1985, Smock et al. 1985). Wood samplers could provide a higher degree of habitat complexity than Hester-Dendy and leaf samplers, thus supporting an array of macroinvertebrate predators, that would otherwise be predated upon. A large portion of the variability was attributed to differences in devices, which would be consistent with the observations of this study.

High % Burrower was found on wood and Hester-Dendy samplers and low % Burrowers was found on leaf samplers. This observation could be attributed to the nature of the refuge and food source provided by sampling methods, allowing burrowing and small organisms to occupy refuge as shown by other investigators (Downes et al. 1998, Bergey and Cooper 2015). Wood samples could allow for Chironomidae taxa, which are classified as burrowers, to occupy natural habitats, as well as allow for a food source (Magoulick 1998, Merritt et al. 2008, Lyon et al. 2009). Hester-Dendy samplers are constructed of masonite board, which is pressure-molded wood fibers and were originally intended to be used where logs, twigs, and similar objects were numerous, thus mimicking wood habitat (Hester and Dendy 1962). This would create similar conditions for Chironomidae taxa to colonize and explain the similarity in % burrower between Hester-Dendy and wood samplers. Leaf samplers on the other hand would not be used as a food source for burrowing taxa, and thus would explain the low percentage of burrowers observed.

Multi-metric scoring for all sampling devices was relatively similar for Florida SCI and GAMMI. The similar scoring of different devices shows that each sampler can be used to assess stream health when applied to multi-metric indices. Maloney and Feminella (2006) compared singular and multi-metrics to show singular metrics to be highly variable, whereas multi-metrics were more robust, similar to other authors (Morais et al. 2004). My study has shown multi-metric indices to be robust to variability between passive samplers, scoring similarly in mean and CV.

Based on assemblage results, there were clear differences between sampling devices. Blocksom and Flotemersch (2005) found differences in sampling devices in NMDS ordination and attributed these to strong differences between sites and differences between sampling methods. My results were similar with Blocksom and Flotemersch (2005), exhibiting strong site-specific differences, but also within sampling device differences. Further, my results are comparable to findings by Brua et al. (2011), where assemblages collected were more similar from devices within sites rather than among sites. The differences in assemblages were not associated with samplers collecting different taxa, but rather differences in the proportions of taxa that contributed to the overall similarity. Other investigations (Florencio et al. 2012, Braccia et al. 2014), found specific taxa to contribute to differences in assemblages colonizing samplers rather than proportions. However, Florencio et al. (2012) found fyke nets captured nocturnal taxa which dip-netting did not. My study did not find specific taxa to contribute to the differences, which was likely because our samplers were placed at the same location and for the same duration of time.

Rivers provide much of the freshwater ecosystem services afforded, but are disproportionally managed. With the growing complexity of anthropogenic disturbance, monitoring, specifically biomonitoring, of our water resources becomes necessary. Each of the three sampling devices performed adequately in collecting assemblages of the macroinvertebrate community at the sites studied. This study emphasized sampling methodologies are crucial to calibrate and has provided a baseline for future studies. Extensions of this study into multiple ecoregions in a broader spatial context could be particularly insightful. Rivers and streams are important resources and consideration for how we manage them is crucial for the longevity of freshwater biodiversity, ecosystem services, and society.

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APPENDIX A

TAXA LIST

Macroinvertebrate taxa collected from Sites 1, 2, 3, 4, 5, and 6 during the study.

Phylum	Class (Subclass)	Order (Suborder	Family (Subfamily)	Genus/Tribe Final ID
Arthropoda	Insecta	Ephemeroptera	Baetidae	*Baetis*
				Baetisca
			Caenidae	*Caenis*
			Ephemerellidae	*Ephemerrella*
				Eurylophella
			Heptageniidae	*Heptagenia*
				Maccaffertium
				Stenacron
			Isonychiidae	*Isonychia*
			Leptohyphidae	*Tricorythodes*
		Odonata	Gomphidae	*Aphylla*
		(Anisoptera)	Corduliidae	*Neurocordulia*
		Odonata	Coenagrionidae	*Argia*
		(Zygoptera)		*Enallagma*
		Plecoptera	Perlidae	*Acroneuria*
				Neoperla
				Paragnetina

		Perlesta
	Perloidae	*Helopicus*
	Pteronarcyidae	*Pteronarcys*
	Taeniopterygidae	*Taeniopteryx*
Megaloptera	Corydalidae	*Corydalus*
Trichoptera	Brachycentridae	*Brachycentrus*
	Hydropyschidae	*Cheumatopsyche*
		Hydropsyche
		Macrostemum
	Hydroptilidae	*Hydroptila*
		Neotrichia
		Oxyethira
	Leptoceridae	*Ceraclea*
		Nectopsyche
		Oecetis
		Triaenodes
	Philopotamidae	*Chimarra*
	Psychomylidae	*Lype*
	Polycentropodidae	*Cyrnellus*
		Neureclipsis
		Nyctiophylax

	Coleoptera	Elmidae	*Anycronyx*
			Dubiraphia
			Machronychus
			Stenelmis
	Diptera	Ceratopogonidae	*Ceratopogon*
			Bezzia complex
		Chironomidae (Tanypodinae)	*Tanypodinae*
		Chironomidae (Orthocladiinae)	*Orthocladiinae*
		Chironomidae (Chironominae)	*Chironomini*
			Tanytarsini
		Chironomidae (Diamesinae)	*Diamesinae*
		Empididae	*Hemerodromia*
		Simuliidae	*Simulium*
Malacostraca	Amphipoda	Gammaridae	*Gammarus*
		Crangonyctidae	*Crangonyx*
		Hyalellidae	*Hyallella*
	Decapoda	Cambaridae	*Cambarus*
			Procambarus

			Palaemonidae	Palaemonidae
		Isopoda	Asellidae	Asellidae
	Arachnida	Trombidiformes		Hydrachnidia
Mollusca	Gastropoda	Basommatophora	Ancylidae	Ancylidae
			Lymnaeidae	Lymnaeidae
			Physidae	Physidae
			Planorbidae	Planorbidae
		Neotaenioglossa	Pleuroceridae	Pleuroceridae
Annelida	Clitellata (Hirundinae)			Hirudinea
	Clitellata (Oligochaeta)			Oligochaeta
Platyhelminthes	Turbellaria			Turbellaria

APPENDIX B

SIMPER RESULTS

One-way SIMPER results using Bray-Curtis Similarity matrix for Site 1 with 100.00% cut off for low contributions. Table include average similarity for Hester-Dendy, leaf, and wood samplers for replicates within sites as well as average dissimilarity for pairwise comparison of Hester-Dendy and leaf samplers, Hester-Dendy and wood samplers, and leaf and wood samplers. Similarity for Hester-Dendy, leaf and wood samplers includes average abundance, average similarity, similarity/standard deviation (SD), Contribution percentage (%), and Cumulative percentage (%). Pairwise comparison includes average abundance for group 1, average abundance for group 2, Dissimilarity/standard deviation (SD), contribution percentage (%), and cumulative percentage (%).

Group Hester					
Average similarity: 55.97					
Taxa	Average Abundance	Average Similarity	Similarity/SD	Contribution %	Cumulative %
Oligochaeta	40.82	25.12	1.15	44.89	44.89
Orthocladiinae	6.92	6.34	14.49	11.33	56.22
Tanypodinae	5.13	5.3	3.22	9.46	65.68
Hydroptila	6.75	4.79	2.19	8.55	74.23

Chironomini	4.25	4.21	4.99	7.52	81.76
Tanytarsini	4.15	3.46	2.56	6.18	87.94
Oecetis	1.58	1.46	2.30	2.60	90.54
Maccaffertium	2.24	1.45	2.34	2.60	93.14
Hirudinea	4.44	1.24	0.58	2.21	95.35
Tricorythodes	1.33	1.15	6.95	2.06	97.41
Neureclipsis	1.49	0.72	0.58	1.28	98.69
Cheumatopsyche	2.10	0.41	0.58	0.74	99.43
Trombidiformes	1.08	0.32	0.58	0.57	100.00

Group Leaf

Average similarity: 45.22

Taxa	Average Abundance	Average Similarity	Similarity/SD	Contribution %	Cumulative %
Oligochaeta	3.66	8.48	3.78	18.75	18.75
Orthocladiinae	3.4	8.11	2.48	17.94	36.69

Chironomini	2.37	7.3	34.74	16.14	52.82
Tanytarsini	1.87	5.22	5.25	11.54	64.37
Tanypodinae	3.32	5	0.58	11.05	75.42
Oecetis	1.73	4.17	4.19	9.22	84.63
Planorbidae	2.12	2.05	0.58	4.52	89.16
Hyallella	0.94	1.67	0.58	3.7	92.86
Polycentropus	0.67	1.18	0.58	2.62	95.48
Maccaffertium	1.15	1.02	0.58	2.26	97.74
Neureclipsis	0.67	1.02	0.58	2.26	100

Group Wood

Average similarity: 60.37

Taxa	Average Abundance	Average Similarity	Similarity/SD	Contribution %	Cumulative%
Oligochaeta	9.06	14.98	3.3	24.8	24.8
Tanypodinae	6.97	13.17	7.38	21.82	46.63
Chironomini	4.95	10.09	5.59	16.71	63.33

Orthocladiinae	4.95	7.02	1.66	11.63	74.96
Hydroptila	2.24	4.53	9.33	7.51	82.47
Planorbidae	1.99	3.85	3.62	6.38	88.85
Neureclipsis	2.38	3.78	9.73	6.25	95.1
Tanytarsini	1.05	1.12	0.58	1.86	96.96
Oecetis	1.63	1.04	0.58	1.72	98.68
Nectopsyche	0.67	0.79	0.58	1.32	100

Group Hester-Dendy & Leaf

Average dissimilarity = 67.33

	Group Hester-Dendy	Group Leaf				
Taxa	Average Abundance (1)	Average Abundance (2)	Average Dissimilarity	Dissimilarity/SD	Contribution %	Cumulative %
Oligochaeta	40.82	3.66	28.79	1.76	42.76	42.76

Hydroptila	6.75	0.33	5.17	2.72	7.67	50.43
Hirudinea	4.44	0	3.33	1.08	4.95	55.38
Orthocladiinae	6.92	3.4	2.95	1.67	4.38	59.75
Planorbidae	2.19	2.12	2.43	1.29	3.61	63.37
Tanytarsini	4.15	1.87	2.29	1.13	3.4	66.77
Cheumatopsyche	2.1	0.58	2.21	0.85	3.29	70.06
Tanypodinae	5.13	3.32	2.04	0.95	3.03	73.09
Lymnaeidae	0	2.03	1.91	0.64	2.84	75.93
Chironomini	4.25	2.37	1.84	1.44	2.73	78.66
Maccaffertium	2.24	1.15	1.6	0.99	2.38	81.04
Tricorythodes	1.33	0	1.28	1.6	1.9	82.94
Chimarra	0.94	0.33	1.14	0.8	1.69	84.64
Neureclipsis	1.49	0.67	1.04	1.99	1.55	86.18
Hyallella	0	0.94	0.85	1.24	1.26	87.44
Trombidiformes	1.08	0	0.81	1.11	1.2	88.64
Gammarus	0.67	0	0.78	0.67	1.16	89.8

Hydropsyche	0.67	0	0.78	0.67	1.16	90.96
Cyrnellus	0	0.88	0.76	0.64	1.12	92.08
Polycentropus	0	0.67	0.6	1.24	0.89	92.98
Stenacron	0	0.67	0.57	0.64	0.85	93.82
Oecetis	1.58	1.73	0.53	1.25	0.79	94.61
Oxyethira	0.67	0	0.5	0.67	0.74	95.35
Physidae	0	0.58	0.5	0.64	0.74	96.08
Nectopsyche	0	0.47	0.4	0.64	0.6	96.69
Corydalus	0.33	0	0.39	0.67	0.58	97.26
Baetis	0.47	0	0.36	0.67	0.53	97.79
Enallagma	0	0.33	0.31	0.64	0.47	98.26
Hemerodromia	0	0.33	0.31	0.64	0.47	98.73
Argia	0	0.33	0.29	0.64	0.42	99.15
Ceratopogon	0	0.33	0.29	0.64	0.42	99.58
Stenelmis	0	0.33	0.29	0.64	0.42	100

Groups Hester-Dendy & Wood

Average dissimilarity = 54.62

Taxa	Group Hester-Dendy Average Abundance	Group Wood Average Abundance	Average Dissimilarity	Dissimilarity/SD	Contribution %	Cumulative %
Oligochaeta	40.82	9.06	23.14	1.52	42.36	42.36
Hydroptila	6.75	2.24	3.26	1.57	5.97	48.33
Hirudinea	4.44	0.75	3	1.2	5.5	53.83
Tanytarsini	4.15	1.05	2.74	1.34	5.02	58.85
Orthocladiinae	6.92	4.95	2.33	1.28	4.27	63.11
Planorbidae	2.19	1.99	2.21	2.33	4.05	67.17
Cheumatopsyche	2.1	0	2.07	0.79	3.79	70.96
Maccaffertium	2.24	0	2.02	1.23	3.7	74.66
Tanypodinae	5.13	6.97	1.72	1.43	3.15	77.81
Neureclipsis	1.49	2.38	1.31	1.08	2.4	80.21

Tricorythodes	1.33	0	1.16	1.64	2.12	82.33
Oecetis	1.58	1.63	1.09	1.54	2	84.34
Chimarra	0.94	0	0.98	0.66	1.8	86.14
Chironomini	4.25	4.95	0.96	1.31	1.76	87.89
Turbellaria	0	1.05	0.77	0.65	1.4	89.3
Trombidiformes	1.08	0	0.75	1.11	1.37	90.67
Gammarus	0.67	0	0.7	0.66	1.27	91.94
Hydropsyche	0.67	0	0.7	0.66	1.27	93.21
Hyallella	0	0.82	0.59	0.65	1.09	94.3
Oxyethira	0.67	0.33	0.59	0.98	1.08	95.38
Nectopsyche	0	0.67	0.54	1.24	0.98	96.36
Corydalus	0.33	0	0.35	0.66	0.64	96.99
Baetis	0.47	0	0.33	0.66	0.6	97.6
Cambaridae	0	0.33	0.29	0.64	0.54	98.13
Enallagma	0	0.33	0.29	0.64	0.54	98.67
Asellidae	0	0.33	0.24	0.65	0.44	99.11

Bezzia	0	0.33	0.24	0.65	0.44	99.56
Polycentropus	0	0.33	0.24	0.65	0.44	100

Groups Leaf & Wood

Average dissimilarity = 51.22

Taxa	Group Leaf Average Abundance	Group Wood Average Abundance	Average Dissimilarity	Dissimilarity/SD	Contribution %	Cumulative %
Oligochaeta	3.66	9.06	7.65	1.51	14.94	14.94
Tanypodinae	3.32	6.97	5.28	1.44	10.31	25.26
Orthocladiinae	3.4	4.95	3.92	1.33	7.66	32.92
Chironomini	2.37	4.95	3.68	2.15	7.18	40.1
Lymnaeidae	2.03	0	3.26	0.66	6.36	46.46
Hydroptila	0.33	2.24	2.72	2.89	5.31	51.77
Neureclipsis	0.67	2.38	2.56	1.22	5	56.77
Planorbidae	2.12	1.99	2.43	1.58	4.74	61.51

Oecetis	1.73	1.63	2.06	1.54	4.03	65.54
Hyallella	0.94	0.82	1.62	1.52	3.17	68.71
Maccaffertium	1.15	0	1.6	1.05	3.13	71.84
Tanytarsini	1.87	1.05	1.31	1.03	2.57	74.41
Turbellaria	0	1.05	1.28	0.67	2.5	76.91
Hirudinea	0	0.75	1.25	0.66	2.43	79.34
Cyrnellus	0.88	0	1.21	0.66	2.37	81.71
Nectopsyche	0.47	0.67	1.01	1.33	1.97	83.68
Stenacron	0.67	0	0.92	0.66	1.79	85.47
Polycentropus	0.67	0.33	0.85	1.03	1.66	87.13
Cheumatopsyche	0.58	0	0.81	0.66	1.58	88.72
Physidae	0.58	0	0.8	0.66	1.55	90.27
Enallagma	0.33	0.33	0.68	0.84	1.33	91.6
Cambaridae	0	0.33	0.56	0.66	1.09	92.68
Oxyethira	0	0.33	0.56	0.66	1.09	93.77
Hemerodromia	0.33	0	0.54	0.66	1.05	94.82

Chimarra	0.33	0	0.47	0.66	0.91	95.73
Argia	0.33	0	0.46	0.66	0.9	96.63
Ceratopogon	0.33	0	0.46	0.66	0.9	97.52
Stenelmis	0.33	0	0.46	0.66	0.9	98.42
Asellidae	0	0.33	0.4	0.67	0.79	99.21
Bezzia	0	0.33	0.4	0.67	0.79	100

One-way SIMPER results using Bray-Curtis Similarity matrix for Site 2 with 100.00% cut off for low contributions. Table includes average similarity for Hester-Dendy, leaf, and wood samplers for replicates within sites as well as average dissimilarity for pairwise comparison of Hester-Dendy and leaf samplers, Hester-Dendy and wood samplers, and leaf and wood samplers. Similarity for Hester-Dendy, leaf and wood samplers includes average abundance, average similarity, similarity/standard deviation (SD), Contribution percentage (%), and Cumulative percentage (%). Pairwise comparison includes average abundance (1) for group 1, average abundance (2) for group 2, Dissimilarity/standard deviation (SD), contribution percentage (%), and cumulative percentage (%).

Group Hester-Dendy					
Average similarity: 60.12					
Taxa	Average Abundance	Average Similarity	Similarity/SD	Contribution %	Cumulative %
Cheumatopsyche	14.2	9.39	2.66	15.62	15.62
Orthocladiinae	11.07	8.78	19.07	14.61	30.23
Maccaffertium	10.45	8.12	15.13	13.5	43.74
Tanypodinae	7.65	6.24	2.26	10.38	54.12
Chironomini	6.83	5.58	1.81	9.28	63.4
Chimarra	8.68	5.16	1.19	8.59	71.98

Oligochaeta	6.47	4.73	2.14	7.87	79.85
Baetis	5.68	2.74	1.84	4.55	84.4
Tricorythodes	2.76	2.62	6.22	4.35	88.76
Isonychia	2.75	1.85	3.4	3.07	91.83
Tanytarsini	3.36	1.09	0.58	1.81	93.63
Heptagenia	2.19	0.82	0.58	1.37	95
Oecetis	1.67	0.76	0.58	1.26	96.27
Hydroptila	2.21	0.6	0.58	0.99	97.26
Caenis	2	0.58	0.58	0.97	98.22
Hemerodromia	1.15	0.38	0.58	0.63	98.86
Hydropsyche	1.28	0.34	0.58	0.57	99.43
Trombidiformes	1.28	0.34	0.58	0.57	100

Group Wood

Average similarity: 36.05

Taxa	Average Abundance	Average Similarity	Similarity/SD	Contribution %	Cumulative %

Cheumatopsyche	23.27	7.91	0.74	21.94	21.94
Orthocladiinae	10.12	5.03	1.78	13.96	35.9
Chimarra	12.95	4.08	0.58	11.32	47.21
Baetis	5.84	2.29	1.57	6.37	53.58
Oecetis	3.18	2.02	3.18	5.6	59.18
Maccaffertium	5.86	1.77	0.58	4.91	64.09
Tanypodinae	3.55	1.63	5.91	4.51	68.6
Chironomini	4.32	1.59	6.19	4.42	73.02
Macrostemum	3.87	1.17	0.58	3.25	76.27
Ancyronyx	1.67	1.13	6.19	3.12	79.39
Tricorythodes	2.76	1.13	6.19	3.12	82.52
Nectopsyche	3.51	1.08	0.58	2.98	85.5
Oligochaeta	4.17	1.02	0.58	2.82	88.32
Tanytarsini	4.32	0.99	0.58	2.74	91.07
Hydroptila	3.1	0.89	0.58	2.45	93.52
Caenis	2.49	0.77	0.58	2.13	95.65

Neoperla	1.61	0.44	0.58	1.23	96.88
Stenelmis	1.61	0.44	0.58	1.23	98.1
Simulium	2.22	0.36	0.58	1	99.1
Neureclipsis	1	0.32	0.58	0.9	100

Group Leaf

Average similarity: 48.59

Taxa	Average Abundance	Average Similarity	Similarity/SD	Contribution %	Cumulative %
Cheumatopsyche	14.7	10.41	4.21	21.43	21.43
Orthocladiinae	11.25	7.15	1.4	14.72	36.15
Chimarra	11.65	6.37	1.88	13.1	49.25
Maccaffertium	6.45	4.16	1.61	8.55	57.8
Nectopsyche	5.89	3.68	1.05	7.56	65.37
Tanypodinae	4.42	3.33	12.45	6.84	72.21
Tricorythodes	3.31	3.15	4.03	6.49	78.71
Tanytarsini	3.91	2.63	2.03	5.41	84.12

Oecetis	2.88	2.29	13	4.72	88.83
Baetis	3.8	1.37	0.58	2.83	91.66
Hydroptila	3.32	1.37	0.58	2.83	94.49
Chironomini	1.41	0.68	0.58	1.39	95.88
Isonychia	1.72	0.61	0.58	1.26	97.14
Simulium	1.39	0.48	0.58	0.98	98.12
Stenelmis	0.8	0.48	0.58	0.98	99.11
Heptagenia	1.53	0.43	0.58	0.89	100

Groups Hester-Dendy & Wood

Average dissimilarity = 50.55

	Group Hester	Group Wood				
Taxa	Average Abundance	Average Abundance	Average Similarity	Similarity/SD	Contribution %	Cumulative %
Cheumatopsyche	14.2	23.27	8.17	2.46	16.15	16.15
Chimarra	8.68	12.95	4.87	1.89	9.63	25.78
Maccaffertium	10.45	5.86	3.12	0.94	6.17	31.95

Orthocladiinae	11.07	10.12	2.68	1.23	5.3	37.25
Tanypodinae	7.65	3.55	2.56	1.2	5.06	42.31
Chironomini	6.83	4.32	2.14	1.09	4.23	46.54
Oligochaeta	6.47	4.17	2.11	1.65	4.17	50.71
Baetis	5.68	5.84	1.94	1.15	3.84	54.54
Tanytarsini	3.36	4.32	1.73	1.24	3.42	57.97
Nectopsyche	0.33	3.51	1.62	1.43	3.21	61.18
Macrostemum	1.63	3.87	1.5	1.13	2.97	64.15
Hydropsyche	1.28	2.58	1.35	1.11	2.68	66.83
Isonychia	2.75	1.63	1.27	1.98	2.51	69.34
Hydroptila	2.21	3.1	1.25	1.28	2.46	71.8
Simulium	0.94	2.22	1.07	1.18	2.13	73.93
Caenis	2	2.49	0.96	1.13	1.9	75.82
Heptagenia	2.19	0.94	0.92	1.04	1.82	77.64
Hirudinea	0	1.25	0.89	0.65	1.75	79.39
Tricorythodes	2.76	2.76	0.85	1.8	1.69	81.08

Oecetis	1.67	3.18	0.8	1.38	1.58	82.66
Ancyronyx	0	1.67	0.77	6.88	1.53	84.19
Neoperla	0	1.61	0.64	1.28	1.28	85.47
Stenelmis	0.47	1.61	0.63	1.37	1.24	86.7
Lymnaeidae	0	0.88	0.63	0.65	1.24	87.94
Hemerodromia	1.15	0.67	0.59	1.12	1.16	89.1
Trombidiformes	1.28	0.33	0.52	1.14	1.04	90.14
Macronychus	0.94	0.33	0.52	1.02	1.03	91.17
Neureclipsis	0.67	1	0.5	1.28	1	92.17
Argia	0.47	0.58	0.43	0.79	0.85	93.01
Planorbidae	0.94	0	0.42	0.64	0.82	93.83
Paragnetina	0	0.94	0.4	0.66	0.78	94.62
Stenelmis	0.47	0.67	0.38	0.91	0.75	95.37
Aphylla	0.58	0	0.34	0.62	0.68	96.05
Ceraclea	0	0.67	0.26	0.66	0.51	97.22
Ceratopogon	0	0.67	0.26	0.66	0.51	97.73

Ephemerella	0.33	0.33	0.24	0.82	0.48	98.2
Ancyronyx	0	0.33	0.24	0.65	0.47	98.67
Cambaridae	0	0.33	0.24	0.65	0.47	99.14
Hyallella	0	0.33	0.24	0.65	0.47	99.61
Bezzia	0.33	0	0.2	0.62	0.39	100

Groups Hester-Dendy & Leaf

Average dissimilarity = 44.52

	Group Hester	Group Leaves				
Taxa	Average Abundance	Average Abundance	Average Similarity	Similarity/SD	Contribution %	Cumulative %
Cheumatopsyche	14.2	14.7	3.87	1.22	8.7	8.7
Chimarra	8.68	11.65	3.82	1.26	8.58	17.27
Orthocladiinae	11.07	11.25	3.36	1.52	7.54	24.81
Oligochaeta	6.47	0.47	3.3	2.39	7.42	32.23
Chironomini	6.83	1.41	3.14	1.84	7.05	39.28
Nectopsyche	0.33	5.89	3.06	1.59	6.87	46.15

Maccaffertium	10.45	6.45	2.83	1.06	6.36	52.51
Tanypodinae	7.65	4.42	2.35	1.17	5.28	57.79
Baetis	5.68	3.8	2.3	1.31	5.16	62.95
Macrostemum	1.63	2.58	1.58	0.94	3.56	66.51
Tanytarsini	3.36	3.91	1.55	1.35	3.49	69.99
Hydroptila	2.21	3.32	1.46	1.36	3.29	73.28
Heptagenia	2.19	1.53	0.99	1.17	2.23	75.51
Isonychia	2.75	1.72	0.96	1.24	2.16	77.67
Caenis	2	0.67	0.93	1.12	2.09	79.76
Oecetis	1.67	2.88	0.86	1.59	1.93	81.69
Simulium	0.94	1.39	0.83	1.21	1.85	83.54
Neureclipsis	0.67	1	0.77	0.95	1.74	85.28
Hydropsyche	1.28	0	0.68	1.1	1.54	86.82
Trombidiformes	1.28	0	0.68	1.1	1.54	88.35
Hemerodromia	1.15	0.47	0.62	1.15	1.39	89.74
Planorbidae	0.94	0.33	0.57	1.01	1.27	91.02

Macronychus	0.94	0	0.46	0.65	1.03	92.05
Stenelmis	0.47	0.8	0.43	1.18	0.97	93.02
Aphylla	0.58	0	0.39	0.64	0.87	93.89
Tricorythodes	2.76	3.31	0.37	1.09	0.83	94.72
Ceraclea	0	0.47	0.34	0.65	0.77	96.25
Argia	0.47	0	0.25	0.65	0.57	96.82
Stenacron	0	0.47	0.24	0.66	0.54	97.37
Diamesinae	0	0.47	0.24	0.66	0.54	97.91
Dubiraphia	0	0.33	0.24	0.65	0.54	98.45
Eurylophella	0	0.33	0.24	0.65	0.54	98.99
Bezzia	0.33	0	0.22	0.64	0.5	99.5
Ephemerella	0.33	0	0.22	0.64	0.5	100

Groups Wood & Leaf

Average dissimilarity = 52.63

	Group Wood	Group Leaf

Taxa	Average Abundance	Average Abundance	Average Similarity	Similarity/SD	Contribution %	Cumulative %
Cheumatopsyche	23.27	14.7	8.84	2.14	16.8	16.8
Chimarra	12.95	11.65	5.36	1.31	10.19	26.99
Orthocladiinae	10.12	11.25	3.32	0.99	6.31	33.3
Oligochaeta	4.17	0.47	2.88	0.81	5.48	38.78
Maccaffertium	5.86	6.45	2.47	1.05	4.69	43.46
Nectopsyche	3.51	5.89	2.26	1.56	4.29	47.76
Baetis	5.84	3.8	2.2	1.43	4.19	51.94
Macrostemum	3.87	2.58	1.88	1.15	3.57	55.51
Tanytarsini	4.32	3.91	1.85	1.37	3.51	59.02
Chironomini	4.32	1.41	1.41	1.09	2.68	61.7
Hydroptila	3.1	3.32	1.38	0.97	2.63	64.33
Tanypodinae	3.55	4.42	1.32	1.3	2.51	66.84
Hydropsyche	2.58	0	1.16	0.65	2.21	69.05
Isonychia	1.63	1.72	1.09	1.26	2.07	71.12

Tricorythodes	2.76	3.31	1.07	1.47	2.03	73.16
Simulium	2.22	1.39	1.07	1.19	2.03	75.19
Caenis	2.49	0.67	1.05	1.42	1.99	77.17
Hirudinea	1.25	0	1.02	0.63	1.94	79.12
Ancyronyx	1.67	0	0.85	4.55	1.61	80.73
Neureclipsis	1	1	0.8	1.09	1.53	82.25
Heptagenia	0.94	1.53	0.76	1.11	1.45	83.7
Lymnaeidae	0.88	0	0.72	0.63	1.37	85.08
Oecetis	3.18	2.88	0.69	1.28	1.32	86.39
Neoperla	1.61	0	0.69	1.26	1.31	87.7
Stenelmis	1.61	0.47	0.67	1.34	1.28	88.98
Argia	0.58	0	0.47	0.63	0.9	90.88
Ceraclea	0.67	0.47	0.46	0.83	0.88	91.76
Paragnetina	0.94	0	0.42	0.65	0.81	92.57
Hemerodromia	0.67	0.47	0.41	0.89	0.77	93.34
Macronychus	0.47	0	0.39	0.63	0.73	94.08

Ceratopogon	0.67	0	0.27	0.66	0.52	94.6
Cambaridae	0.33	0	0.27	0.63	0.52	95.64
Ephemerella	0.33	0	0.27	0.63	0.52	96.15
Hyalella	0.33	0	0.27	0.63	0.52	96.67
Macronychus	0.33	0	0.27	0.63	0.52	97.19
Trombidiformes	0.33	0	0.27	0.63	0.52	97.71
Dubiraphia	0	0.33	0.24	0.6	0.46	98.17
Eurylophella	0	0.33	0.24	0.6	0.46	98.64
Planorbidae	0	0.33	0.24	0.6	0.46	99.1
Stenacron	0	0.47	0.24	0.63	0.45	99.55
Diamesinae	0	0.47	0.24	0.63	0.45	100

One-way SIMPER results using Bray-Curtis Similarity matrix for Site 3 with 100.00% cut off for low contributions. Table includes average similarity for Hester-Dendy, leaf, and wood samplers for replicates within sites as well as average dissimilarity for pairwise comparison of Hester-Dendy and leaf samplers, Hester-Dendy and wood samplers, and leaf and wood samplers. Similarity for Hester-Dendy, leaf and wood samplers includes average abundance, average similarity, similarity/standard deviation (SD), Contribution percentage (%), and Cumulative percentage (%). Pairwise comparison includes average abundance (1) for group 1, average abundance (2) for group 2, Dissimilarity/standard deviation (SD), contribution percentage (%), and cumulative percentage (%).

Group Hester					
Average similarity: 62.50					
Taxa	Average Abundance	Average Similarity	Similarity/SD	Contribution %	Cumulative %
Orthocladiinae	22.16	22.7	8.62	36.32	36.32
Chironomini	10.38	6.81	12.95	10.9	47.22
Maccaffertium	6.33	6.5	18.97	10.4	57.62
Oligochaeta	7.84	6.06	18.07	9.7	67.32
Hydroptila	6.26	5.09	3.55	8.14	75.46
Tanytarsini	3.79	3.32	2	5.32	80.78

Baetis	3.82	3.28	2.07	5.25	86.03
Paragnetina	2.79	2.86	9.37	4.58	90.61
Heptagenia	3.63	2.04	22.92	3.27	93.87
Acroneuria	1.14	1.18	22.92	1.89	95.76
Tricorythodes	1.96	0.78	0.58	1.25	97.01
Hydropsyche	2.37	0.68	0.58	1.08	98.09
Neureclipsis	1.08	0.41	0.58	0.66	98.75
Cheumatopsyche	1	0.39	0.58	0.62	99.38
Stenelmis (adult)	0.67	0.39	0.58	0.62	100

Group Leaf

Average similarity: 50.68

Taxa	Average Abundance	Average Similarity	Similarity/SD	Contribution %	Cumulative %
Maccaffertium	8.1	7.93	3.39	15.64	15.64
Orthocladiinae	6.62	7.23	3.16	14.26	29.9
Cheumatopsyche	7.56	4.25	0.94	8.39	38.29

Chironomini	3.12	3.4	6.74	6.71	45
Caenis	3.37	2.98	2.63	5.88	50.88
Hydropsyche	6.34	2.88	0.58	5.68	56.57
Tanytarsini	2.28	2.78	16.99	5.48	62.04
Hydroptila	2.73	2.68	4.34	5.29	67.33
Oecetis	1.41	2.06	4.32	4.06	71.39
Tricorythodes	1.58	1.72	12.8	3.39	74.78
Tanypodinae	1.75	1.69	2.51	3.33	78.12
Macrostemum	3.47	1.64	0.58	3.23	81.35
Isonychia	3.41	1.6	0.58	3.15	84.5
Nectopsyche	1.72	1.45	4.32	2.87	87.37
Chimarra	2.45	1.24	0.58	2.44	89.81
Baetis	2.43	1.01	0.58	1.99	91.81
Heptagenia	2.23	1.01	0.58	1.99	93.8
Dubiraphia	1.05	0.8	0.58	1.58	95.38
Stenelmis (larvae)	1.56	0.8	0.58	1.58	96.96

Neoperla	1.22	0.53	0.58	1.05	98.01
Helopicus	1.29	0.51	0.58	1	99
Hemerodromia	0.94	0.51	0.58	1	100

Group Wood

Average similarity: 54.91

Taxa	Average Abundance	Average Similarity	Similarity/SD	Contribution %	Cumulative %
Orthocladiinae	12.96	13.48		24.55	24.55
Maccaffertium	9.93	7.85		14.3	38.85
Chironomini	10.95	5.7		10.39	49.24
Baetis	4.37	3.35		6.1	55.34
Caenis	3.31	3.35		6.1	61.44
Paragnetina	3.93	3.35		6.1	67.54
Tanytarsini	3.87	3.35		6.1	73.63
Tanypodinae	4.46	3		5.46	79.09
Hydroptila	4.82	2.8		5.1	84.19

Hydropsyche	2.94	2.12		3.86	88.05	
Hemerodromia	3.65	1.83		3.34	91.39	
Stenelmis (adult)	2.8	1.83		3.34	94.73	
Tricorythodes	1.87	1.83		3.34	98.07	
Oecetis	1.5	1.06		1.93	100	

Groups Hester-Dendy & Leaf

Average dissimilarity = 59.41

Taxa	Group Hester-Dendy Average Abundance	Group Leaf Average Abundance	Average Similarity	Dissimilarity/SD	Contribution %	Cumulative %
Orthocladiinae	22.16	6.62	10.44	2.62	17.57	17.57
Oligochaeta	7.84	0	5.25	1.77	8.84	26.41
Chironomini	10.38	3.12	4.97	0.99	8.37	34.79
Cheumatopsyche	1	7.56	3.87	1.47	6.51	41.3

Hydropsyche	2.37	6.34	3.38	1.64	5.69	46.99
Hydroptila	6.26	2.73	2.46	1.18	4.15	51.14
Maccaffertium	6.33	8.1	2.12	2.49	3.57	54.71
Heptagenia	3.63	2.23	1.93	1.15	3.25	57.96
Macrostemum	0.47	3.47	1.92	1.47	3.23	61.19
Isonychia	0.33	3.41	1.88	1.46	3.17	64.35
Caenis	0.75	3.37	1.72	2.26	2.9	67.25
Tanypodinae	1.76	1.75	1.61	1.79	2.71	69.97
Baetis	3.82	2.43	1.61	1.05	2.71	72.68
Paragnetina	2.79	1.29	1.55	1.84	2.61	75.29
Chimarra	0.33	2.45	1.35	1.59	2.27	77.56
Tanytarsini	3.79	2.28	1.2	1.34	2.03	79.58
Nectopsyche	0	1.72	1.08	1.9	1.83	81.41
Tricorythodes	1.96	1.58	1	1.3	1.68	83.09
Simulium	1.15	0.94	0.97	0.82	1.63	84.72
Stenelmis (larvae)	0.33	1.56	0.85	1.52	1.43	86.16

Dubiraphia	0	1.05	0.78	1.17	1.32	87.47
Hemerodromia	0.88	0.94	0.78	1.09	1.32	88.79
Neoperla	0	1.22	0.78	1.23	1.31	90.1
Oecetis	0.33	1.41	0.74	1.8	1.24	91.34
Helopicus	0	1.29	0.73	1.19	1.23	92.57
Neureclipsis	1.08	0.33	0.67	1	1.13	93.7
Bezzia	0.94	0	0.63	0.64	1.07	94.77
Perlesta	0.58	0.33	0.49	1.03	0.83	95.59
Acroneuria	1.14	0.33	0.47	1.56	0.79	96.39
Stenelmis (adult)	0.67	0.47	0.46	1.29	0.78	97.16
Corydalus	0.47	0.33	0.39	0.82	0.65	97.82
Trombidiformes	0.33	0.33	0.28	0.81	0.48	98.29
Neurocordulia	0.33	0	0.22	0.64	0.38	98.67
Ancyronyx (larvae)	0.33	0	0.21	0.64	0.36	99.03

Macronychus (larvae)	0.33	0	0.21	0.64	0.36	99.38
Ancyronyx (Adult)	0	0.33	0.18	0.67	0.31	99.69
Eurylophella	0	0.33	0.18	0.67	0.31	100

Groups Hester-Dendy & Wood

Average dissimilarity = 41.12

Taxa	Group Hester-Dendy Average Abundance	Group Wood Average Abundance	Average Similarity	Dissimilarity/SD	Contribution %	Cumulative %
Orthocladiinae	22.16	12.96	5.13	2.43	12.48	12.48
Chironomini	10.38	10.95	3.75	1.12	9.12	21.59
Oligochaeta	7.84	1.66	3.4	1.43	8.27	29.87
Maccaffertium	6.33	9.93	2.02	1.46	4.92	34.78
Cheumatopsyche	1	3.81	2.02	1.24	4.92	39.7
Tanypodinae	1.76	4.46	2	1.5	4.87	44.57

Heptagenia	3.63	3.16	1.97	1.44	4.79	49.36
Hydroptila	6.26	4.82	1.68	1.38	4.09	53.45
Hemerodromia	0.88	3.65	1.65	1.68	4	57.45
Caenis	0.75	3.31	1.45	2.12	3.53	60.99
Hydropsyche	2.37	2.94	1.21	1.71	2.94	63.93
Taeniopteryx	0	2.29	1.19	0.91	2.89	66.82
Stenelmis (adult)	0.67	2.8	1.16	1.82	2.81	69.63
Stenelmis (larvae)	0.33	1.94	1.02	1.06	2.48	72.11
Simulium	1.15	1.5	0.95	1.01	2.31	74.42
Baetis	3.82	4.37	0.89	1.6	2.15	76.57
Bezzia	0.94	1.32	0.8	0.95	1.93	78.51
Trombidiforme	0.33	1.5	0.79	1.12	1.93	80.44
Tricorythodes	1.96	1.87	0.77	1.39	1.86	82.3
Oecetis	0.33	1.5	0.68	1.44	1.66	83.96
Tanytarsini	3.79	3.87	0.67	1.24	1.62	85.58
Macrostemun	0.47	1.22	0.65	1.11	1.59	87.17

Acroneuria	1.14	0	0.64	4.22	1.56	88.73
Paragnetina	2.79	3.93	0.64	1.38	1.56	90.3
Neureclipsis	1.08	0	0.61	1.08	1.49	91.79
Nectopsyche	0	0.87	0.52	0.91	1.27	93.06
Neurocordulia	0.33	0.87	0.51	1.09	1.24	94.3
Isonychia	0.33	0.87	0.46	1.11	1.13	95.42
Neoperla	0	0.87	0.45	0.91	1.09	96.52
Chimarra	0.33	0.71	0.38	1.1	0.93	97.45
Corydalus	0.47	0.5	0.36	1.02	0.86	98.31
Perlesta	0.58	0	0.34	0.64	0.82	99.13
Ancyronyx (larvae)	0.33	0	0.18	0.64	0.44	99.56
Macronychus (larvae)	0.33	0	0.18	0.64	0.44	100

Groups Leaf & Wood

Average dissimilarity = 49.15

Taxa	Group Leaf Average Abundance	Group Wood Average Abundance	Average Similarity	Dissimilarity/SD	Contribution %	Cumulative %
Chironomini	3.12	10.95	5.34	1.1	10.86	10.86
Orthocladiinae	6.62	12.96	4.08	2.08	8.29	19.15
Cheumatopsyche	7.56	3.81	3.55	1.36	7.23	26.38
Hydropsyche	6.34	2.94	3.16	2.53	6.43	32.81
Maccaffertium	8.1	9.93	2.46	1.24	5	37.81
Heptagenia	2.23	3.16	1.91	1.24	3.88	41.7
Paragnetina	1.29	3.93	1.9	1.49	3.86	45.55
Macrostemum	3.47	1.22	1.76	1.48	3.58	49.13
Isonychia	3.41	0.87	1.74	1.54	3.55	52.68
Tanypodinae	1.75	4.46	1.7	1.3	3.45	56.13
Hemerodromia	0.94	3.65	1.7	1.16	3.45	59.57
Baetis	2.43	4.37	1.64	1.07	3.33	62.91
Hydroptila	2.73	4.82	1.61	1.17	3.28	66.19

Stenelmis (adult)	0.47	2.8	1.46	1.62	2.98	69.17
Taeniopteryx	0	2.29	1.32	0.88	2.69	71.86
Chimarra	2.45	0.71	1.25	1.58	2.54	74.39
Stenelmis (larvae)	1.56	1.94	1.18	1.23	2.39	76.79
Oligochaeta	0	1.66	1.14	0.87	2.32	79.1
Tanytarsini	2.28	3.87	1.1	1.31	2.24	81.35
Simulium	0.94	1.5	1	0.87	2.03	83.37
Bezzia	0	1.32	0.91	0.87	1.85	85.22
Caenis	3.37	3.31	0.89	1.62	1.8	87.03
Trombidiformes	0.33	1.5	0.88	1	1.78	88.81
Nectopsyche	1.72	0.87	0.79	1.84	1.61	90.42
Dubiraphia	1.05	0	0.73	1.13	1.49	91.91
Neoperla	1.22	0.87	0.71	1.41	1.44	93.36
Helopicus	1.29	0	0.69	1.15	1.41	94.77
Neurocordulia	0	0.87	0.6	0.87	1.21	95.98
Oecetis	1.41	1.5	0.32	2.65	0.65	96.63

Corydalus	0.33	0.5	0.3	0.89	0.61	97.24
Tricorythodes	1.58	1.87	0.28	0.85	0.57	97.82
Acroneuria	0.33	0	0.27	0.64	0.56	98.38
Perlesta	0.33	0	0.27	0.64	0.56	98.93
Ancyronyx (Adult)	0.33	0	0.17	0.64	0.36	99.29
Eurylophella	0.33	0	0.17	0.64	0.36	99.64
Neureclipsis	0.33	0	0.17	0.64	0.36	100

One-way SIMPER results using Bray-Curtis Similarity matrix for Site 4 with 100.00% cut off for low contributions. Table includes average similarity for Hester-Dendy, leaf, and wood samplers for replicates within sites as well as average dissimilarity for pairwise comparison of Hester-Dendy and leaf samplers, Hester-Dendy and wood samplers, and leaf and wood samplers. Similarity for Hester-Dendy, leaf and wood samplers includes average abundance, average similarity, similarity/standard deviation (SD), Contribution percentage (%), and Cumulative percentage (%). Pairwise comparison includes average abundance (1) for group 1, average abundance (2) for group 2, Dissimilarity/standard deviation (SD), contribution percentage (%), and cumulative percentage (%).

Group Hester-Dendy					
Average similarity: 73.30					
Taxa	Average Abundance	Average Similarity	Similarity/SD	Contribution %	Cumulative%
Tanytarsini	8.82	22.63	8.67	30.87	30.87
Chironomini	6.28	16.05	6.72	21.89	52.76
Tanypodinae	5.18	13.68	10.46	18.66	71.42
Orthocladiinae	5.74	11.11	4.43	15.15	86.57
Neureclipsis	2.61	6.85	3.76	9.35	95.92
Maccaffertium	1.14	2.99	18.66	4.08	100

Group Wood

Average similarity: 73.45

Taxa	Average Abundance	Average Similarity	Similarity/SD	Contribution %	Cumulative%
Tanytarsini	14.2	21.77	28.93	29.65	29.65
Chironomini	13.67	18.6	4.06	25.33	54.97
Orthocladiinae	9.41	12.32	2.74	16.77	71.75
Tanypodinae	7.76	10.6	8.43	14.44	86.18
Oligochaeta	2.23	2.71	3.52	3.69	89.88
Oecetis	1.72	2.36	14.05	3.21	93.09
Cambaridae	1.28	1.79	3.86	2.43	95.52
Ephemerella	1.67	1.05	0.58	1.42	96.95
Neureclipsis	2.1	0.74	0.58	1.01	97.95
Hyallella	0.8	0.52	0.58	0.71	98.67
Stenelmis (adult)	0.8	0.49	0.58	0.67	99.33
Trombidiformes	0.8	0.49	0.58	0.67	100

Group Leaf

Average similarity: 50.88

Taxa	Average Abundance	Average Similarity	Similarity/SD	Contribution %	Cumulative%
Chironomini	5.13	16.86	10.73	33.14	33.14
Tanytarsini	5.86	14.35	10.07	28.2	61.34
Tanypodinae	4.5	9.98	2.52	19.61	80.95
Orthocladiinae	2.87	8.66	2.49	17.03	97.98
Argia	0.67	1.03	0.58	2.02	100

Groups Hester-Dendy & Wood

Average dissimilarity = 42.75

	Group Hester	Group Wood				
Taxa	Average Abundance	Average Abundance	Average Dissimilarity	Dissimilarity/SD	Contribution %	Cumulative%
Chironomini	6.28	13.67	7.6	2.59	17.78	17.78
Tanytarsini	8.82	14.2	5.55	3.08	12.99	30.77

Orthocladiinae	5.74	9.41	4.52	1.52	10.56	41.33
Tanypodinae	5.18	7.76	2.6	1.83	6.07	47.4
Oligochaeta	0	2.23	2.26	3.97	5.29	52.69
Neureclipsis	2.61	2.1	2.06	2.72	4.82	57.51
Ephemerella	0	1.67	1.7	1.3	3.98	61.48
Caenis	0	1.33	1.35	0.67	3.16	64.64
Cambaridae	0	1.28	1.32	4.72	3.09	67.73
Oecetis	0.67	1.72	1.29	1.67	3.01	70.74
Maccaffertium	1.14	0	1.17	4.57	2.75	73.48
Ancylidae	0	1.05	1.07	0.67	2.5	75.98
Hyallella	0	0.8	0.84	1.23	1.97	77.95
Stenelmis (adult)	0	0.8	0.8	1.26	1.87	79.82
Trombidiformes	0	0.8	0.79	1.29	1.85	81.66
Lymnaeidae	0	0.82	0.78	0.67	1.83	83.5
Macronychus (larvae)	0	0.67	0.68	0.67	1.58	85.08
Bezzia	0.47	0.47	0.64	0.84	1.5	86.58

Baetis	0.47	0.33	0.61	0.92	1.42	87.99
Hirudinea	0	0.58	0.58	0.67	1.37	89.36
Lype	0	0.47	0.52	0.67	1.22	90.58
Gammarus	0.47	0	0.5	0.66	1.17	91.75
Planorbidae	0	0.47	0.48	0.67	1.12	92.87
Argia	0	0.47	0.45	0.67	1.06	93.93
Cheumatopsyche	0	0.47	0.45	0.67	1.06	94.99
Neurocordulia	0.33	0.33	0.44	0.84	1.04	96.02
Acroneuria	0.33	0	0.34	0.66	0.81	96.83
Ancyronyx (adult)	0.33	0	0.34	0.66	0.81	97.64
Oxyethira	0.33	0	0.34	0.66	0.81	98.44
Sialis	0.33	0	0.34	0.66	0.81	99.25
Stenelmis (larvae)	0	0.33	0.32	0.67	0.75	100

Groups Hester-Dendy & Leaf

Average dissimilarity = 41.07

Taxa	Group Hester-Dendy Average Abundance	Group Leaf Average Abundance	Average Dissimilarity	Dissimilarity/SD	Contribution %	Cumulative%
Tanytarsini	8.82	5.86	7.02	1.5	17.1	17.1
Orthocladiinae	5.74	2.87	4.96	1.21	12.09	29.19
Tanypodinae	5.18	4.5	3.81	1.26	9.28	38.48
Neureclipsis	2.61	0.58	3.64	1.74	8.87	47.35
Chironomini	6.28	5.13	2.88	1.1	7.01	54.36
Ancylidae	0	1.73	2.79	0.67	6.79	61.15
Maccaffertium	1.14	0	1.99	3.31	4.85	66
Oligochaeta	0	1.11	1.59	0.67	3.88	69.88
Caenis	0	0.75	1.2	0.67	2.92	72.8
Oecetis	0.67	0	1.08	0.65	2.64	75.44
Argia	0	0.67	1.02	1.32	2.48	77.92
Baetis	0.47	0	0.87	0.65	2.11	80.02

Bezzia	0.47	0	0.87	0.65	2.11	82.13
Gammarus	0.47	0	0.87	0.65	2.11	84.24
Ephemerella	0	0.58	0.83	0.67	2.02	86.26
Cambaridae	0	0.47	0.76	0.67	1.85	88.11
Ancyronyx (adult)	0.33	0.33	0.74	0.82	1.81	89.92
Cheumatopsyche	0	0.47	0.68	0.67	1.65	91.58
Cyrnellus	0	0.47	0.68	0.67	1.65	93.23
Acroneuria	0.33	0	0.59	0.65	1.43	94.66
Oxyethira	0.33	0	0.59	0.65	1.43	96.09
Sialis	0.33	0	0.59	0.65	1.43	97.51
Neurocordulia	0.33	0	0.54	0.65	1.32	98.83
Stenacron	0	0.33	0.48	0.67	1.17	100

Groups Wood & Leaf

Average dissimilarity = 54.05

	Group Wood	Group Leaf

Taxa	Average Abundance	Average Abundance	Average Dissimilarity	Dissimilarity/SD	Contribution %	Cumulative%
Chironomini	13.67	5.13	9.76	2.55	18.05	18.05
Tanytarsini	14.2	5.86	9.69	2.22	17.93	35.98
Orthocladiinae	9.41	2.87	7.44	2.44	13.76	49.74
Tanypodinae	7.76	4.5	4.09	1.35	7.57	57.31
Ancylidae	1.05	1.73	2.29	0.94	4.24	61.55
Neureclipsis	2.1	0.58	2.16	1.05	3.99	65.54
Oligochaeta	2.23	1.11	2.12	2.06	3.92	69.46
Oecetis	1.72	0	1.92	6.92	3.55	73.01
Caenis	1.33	0.75	1.76	0.92	3.25	76.26
Ephemerella	1.67	0.58	1.67	1.21	3.09	79.35
Cambaridae	1.28	0.47	1.04	1.38	1.91	81.26
Hyallella	0.8	0	0.93	1.2	1.72	82.98
Stenelmis (adult)	0.8	0	0.87	1.24	1.61	84.59
Trombidiformes	0.8	0	0.86	1.27	1.6	86.19

Lymnaeidae	0.82	0	0.85	0.66	1.58	87.77
Argia	0.47	0.67	0.76	1.3	1.4	89.17
Macronychus (larvae)	0.67	0	0.74	0.66	1.37	90.54
Cheumatopsyche	0.47	0.47	0.67	0.84	1.24	91.78
Hirudinea	0.58	0	0.64	0.66	1.19	92.96
Lype	0.47	0	0.58	0.66	1.07	94.04
Planorbidae	0.47	0	0.52	0.66	0.97	95.01
Bezzia	0.47	0	0.49	0.66	0.91	95.92
Cyrnellus	0	0.47	0.47	0.66	0.87	96.79
Baetis	0.33	0	0.37	0.66	0.68	97.48
Neurocordulia	0.33	0	0.35	0.66	0.65	98.12
Stenelmis (larvae)	0.33	0	0.35	0.66	0.65	98.77
Ancyronyx (Adult)	0	0.33	0.33	0.66	0.62	99.38
Stenacron	0	0.33	0.33	0.66	0.62	100

One-way SIMPER results using Bray-Curtis Similarity matrix for Site 5 with 100.00% cut off for low contributions. Table includes average similarity for Hester-Dendy, leaf, and wood samplers for replicates within sites as well as average dissimilarity for pairwise comparison of Hester-Dendy and leaf samplers, Hester-Dendy and wood samplers, and leaf and wood samplers. Similarity for Hester-Dendy, leaf and wood samplers includes average abundance, average similarity, similarity/standard deviation (SD), Contribution percentage (%), and Cumulative percentage (%). Pairwise comparison includes average abundance (1) for group 1, average abundance (2) for group 2, Dissimilarity/standard deviation (SD), contribution percentage (%), and cumulative percentage (%).

Group Hester-Dendy

Average similarity: 66.31

Taxa	Average Abundance	Average Similarity	Similarity/SD	Contribution %	Cumulative %
Orthocladiinae	9.75	15.57	3.08	23.49	23.49
Tanytarsini	6.72	13.54	10.55	20.42	43.91
Chironomini	5.4	9.17	11.32	13.83	57.74
Maccaffertium	2.98	4.82	3.63	7.26	65
Hydroptila	2.9	4.73	7.22	7.14	72.14
Tanypodinae	2.56	4.28	3.62	6.46	78.6

Cheumatopsyche	2.8	3.99	2.53	6.02	84.62
Hemerodromia	1.99	3.84	6.62	5.79	90.4
Neoperla	1.14	2.1	13.74	3.17	93.57
Baetis	0.94	0.91	0.58	1.38	94.95
Acroneuria	0.8	0.71	0.58	1.07	96.01
Oligochaeta	1.08	0.71	0.58	1.07	97.08
Bezzia	1.15	0.65	0.58	0.97	98.05
Caenis	0.91	0.65	0.58	0.97	99.03
Isonychia	1	0.65	0.58	0.97	100

Group Leaves

Average similarity: 52.72

Taxa	Average Abundance	Average Similarity	Similarity/SD	Contribution %	Cumulative %
Tanytarsini	6.31	10.71	3.96	20.31	20.31
Tanypodinae	3.9	8.09	6.57	15.34	35.65

Maccaffertium	3.98	8.03	43.43	15.22	50.87
Orthocladiinae	8.36	7.91	2.45	15.01	65.89
Chironomini	3.91	7.61	3.56	14.44	80.33
Hydroptila	1.75	2.86	2.9	5.42	85.74
Caenis	2.53	2.62	0.58	4.98	90.72
Oligochaeta	1.22	1.09	0.58	2.06	92.78
Cheumatopsyche	2.2	0.94	0.58	1.78	94.56
Macronychus (larvae)	0.8	0.77	0.58	1.46	96.02
Oecetis	0.67	0.77	0.58	1.46	97.48
Bezzia	1	0.67	0.58	1.26	98.74
Paragnetina	0.67	0.67	0.58	1.26	100

Group Wood

Average similarity: 66.79

Taxa	Average Abundance	Average Similarity	Similarity/SD	Contribution %	Cumulative %
Chironomini	13.56	15.61	7.66	23.37	23.37

Orthocladiinae	12.28	13.67	5.09	20.46	43.83
Tanytarsini	10.18	9.78	5.19	14.64	58.47
Cheumatopsyche	4.93	4.29	3.61	6.43	64.89
Diamesinae	2.96	3.43	6.68	5.14	70.04
Tanypodinae	3.63	2.97	2.88	4.45	74.48
Maccaffertium	3.18	2.82	3.97	4.22	78.7
Oecetis	2.58	2.68	5.85	4.01	82.71
Hydroptila	3.22	2.42	7.47	3.63	86.34
Nectopsyche	2.1	2.23	4.12	3.34	89.68
Stenelmis (larvae)	1.95	2.12	6.33	3.18	92.86
Caenis	1.91	1.64	3.44	2.45	95.31
Neureclipsis	1.68	0.68	0.58	1.02	96.34
Hemerodromia	0.94	0.56	0.58	0.84	97.17
Acroneuria	0.67	0.53	0.58	0.8	97.97
Ancyronyx (adult)	0.67	0.53	0.58	0.8	98.77
Baetis	0.91	0.41	0.58	0.61	99.39

Stenelmis (adult)	0.67	0.41	0.58	0.61	100

Groups Hester-Dendy & Leaf

Average dissimilarity = 40.14

Taxa	Group Hester-Dendy Average Abundance	Group Leaf Average Abundance	Average Dissimilarity	Dissimilarity/SD	Contribution %	Cumulative %
Orthocladiinae	9.75	8.36	6.47	1.74	16.11	16.11
Caenis	0.91	2.53	2.43	1.62	6.05	22.15
Cheumatopsyche	2.8	2.2	2.37	1.61	5.91	28.06
Hemerodromia	1.99	0	2.16	5.23	5.37	33.43
Chironomini	5.4	3.91	1.69	1.4	4.22	37.65
Tanytarsini	6.72	6.31	1.61	1.2	4	41.65
Tanypodinae	2.56	3.9	1.46	1.73	3.64	45.29
Hydropsyche	1.37	0	1.45	0.66	3.62	48.91
Hydroptila	2.9	1.75	1.31	1.26	3.26	52.17

Maccaffertium	2.98	3.98	1.18	1.52	2.93	55.1
Bezzia	1.15	1	1.11	1.21	2.77	57.86
Oligochaeta	1.08	1.22	1.11	1.32	2.75	60.62
Chimarra	0.88	0.33	1.05	0.88	2.61	63.23
Neoperla	1.14	0.58	1.04	2.35	2.6	65.83
Isonychia	1	0.58	1.03	1.17	2.57	68.4
Stenelmis (larvae)	0.33	0.82	0.98	0.96	2.43	70.83
Polycentropus	0	0.82	0.83	0.66	2.07	72.9
Baetis	0.94	0.47	0.82	1.04	2.05	74.95
Acroneuria	0.8	0.33	0.77	1.11	1.91	76.86
Planorbidae	0.75	0	0.75	0.66	1.86	78.72
Macronychus (larvae)	0.33	0.8	0.73	1.2	1.83	80.55
Paragnetina	0	0.67	0.68	1.33	1.7	82.25
Ancylidae	0	0.58	0.68	0.66	1.7	83.95
Hirudinea	0	0.58	0.68	0.66	1.7	85.65
Oecetis	0.33	0.67	0.59	1.05	1.47	87.12

Cambaridae	0	0.47	0.48	0.66	1.2	88.32
Macronychus (adult)	0.33	0.33	0.47	0.84	1.17	89.49
Trombidiformes	0.33	0.33	0.46	0.84	1.15	90.64
Crangonyx	0	0.33	0.39	0.66	0.98	91.62
Neotrichia	0	0.33	0.39	0.66	0.98	92.6
Neureclipsis	0	0.33	0.39	0.66	0.98	93.58
Palaemonidae	0	0.33	0.39	0.66	0.98	94.56
Pleuroceridae	0	0.33	0.39	0.66	0.98	95.54
Triaenodes	0	0.33	0.39	0.66	0.98	96.52
Corydalus	0.33	0	0.35	0.66	0.88	97.4
Nectopsyche	0.33	0	0.35	0.66	0.88	98.28
Stenelmis (adult)	0.33	0	0.35	0.66	0.88	99.15
Tricorythodes	0	0.33	0.34	0.66	0.85	100

Groups Hester-Dendy & Wood

Average dissimilarity = 40.81

	Group Hester-Dendy	Group Wood

Taxa	Average Abundance	Average Abundance	Average Dissimilarity	Dissimilarity/SD	Contribution %	Cumulative %
Chironomini	5.4	13.56	6.55	3.79	16.06	16.06
Orthocladiinae	9.75	12.28	3.1	1.42	7.59	23.65
Tanytarsini	6.72	10.18	2.69	1.2	6.58	30.23
Diamesinae	0	2.96	2.4	9.72	5.89	36.12
Cheumatopsyche	2.8	4.93	1.91	1.39	4.69	40.8
Oecetis	0.33	2.58	1.75	3.38	4.28	45.08
Nectopsyche	0.33	2.1	1.47	2.08	3.59	48.67
Neureclipsis	0	1.68	1.36	1.06	3.33	52
Hydroptila	2.9	3.22	1.29	1.45	3.15	55.15
Stenelmis (larvae)	0.33	1.95	1.28	2.97	3.13	58.28
Oligochaeta	1.08	1.25	1.23	1.41	3.03	61.31
Tanypodinae	2.56	3.63	1.2	1.31	2.95	64.26
Hydropsyche	1.37	0	1.12	0.66	2.75	67.01
Maccaffertium	2.98	3.18	1.03	1.4	2.52	69.52

Hemerodromia	1.99	0.94	0.93	1.23	2.27	71.79
Caenis	0.91	1.91	0.91	1.28	2.23	74.02
Bezzia	1.15	0.33	0.85	1.04	2.07	76.1
Chimarra	0.88	0.47	0.83	0.85	2.03	78.12
Isonychia	1	0.33	0.74	1.06	1.81	79.93
Neoperla	1.14	0.47	0.69	1.64	1.69	81.63
Baetis	0.94	0.91	0.64	1.28	1.57	83.2
Ancyronyx (adult)	0	0.67	0.61	1.33	1.49	84.69
Planorbidae	0.75	0	0.58	0.66	1.43	86.12
Acroneuria	0.8	0.67	0.47	1.15	1.15	87.27
Stenelmis (adult)	0.33	0.67	0.45	1.02	1.11	88.39
Cambaridae	0	0.47	0.44	0.67	1.08	89.47
Tricorythodes	0	0.67	0.44	0.67	1.08	90.55
Trombidiformes	0.33	0.47	0.43	0.94	1.06	91.61
Macronychus (larvae)	0.33	0.33	0.38	0.83	0.94	92.55

Argia	0	0.58	0.38	0.67	0.94	93.49
Macronychus (adult)	0.33	0.33	0.38	0.83	0.93	94.42
Nyctiophylax	0	0.33	0.31	0.67	0.77	95.19
Asellidae	0	0.33	0.29	0.67	0.72	95.91
Eurylophella	0	0.33	0.29	0.67	0.72	96.63
Gammarus	0	0.33	0.29	0.67	0.72	97.35
Lymnaeidae	0	0.33	0.29	0.67	0.72	98.07
Taeniopteryx	0	0.33	0.29	0.67	0.72	98.79
Corydalus	0.33	0	0.27	0.66	0.67	99.46
Baetisca	0	0.33	0.22	0.67	0.54	100

Groups Leaf & Wood

Average dissimilarity = 48.73

	Group Leaf	Group Wood

Taxa	Average Abundance	Average Abundance	Average Dissimilarity	Dissimilarity/SD	Contribution %	Cumulative %
Chironomini	3.91	13.56	7.85	7.78	16.11	16.11
Orthocladiinae	8.36	12.28	5.75	1.81	11.81	27.92
Tanytarsini	6.31	10.18	3.34	1.35	6.84	34.76
Cheumatopsyche	2.2	4.93	2.79	1.7	5.73	40.49
Diamesinae	0	2.96	2.44	9.45	5.01	45.5
Nectopsyche	0	2.1	1.77	3	3.63	49.13
Caenis	2.53	1.91	1.61	2	3.31	52.44
Oecetis	0.67	2.58	1.5	2.67	3.08	55.52
Oligochaeta	1.22	1.25	1.32	1.54	2.71	58.23
Neureclipsis	0.33	1.68	1.31	1.18	2.69	60.92
Tanypodinae	3.9	3.63	1.27	1.89	2.61	63.53
Stenelmis (larvae)	0.82	1.95	1.24	1.86	2.53	66.07
Hydroptila	1.75	3.22	1.23	0.98	2.53	68.6
Maccaffertium	3.98	3.18	1.18	1.52	2.43	71.02

Bezzia	1	0.33	0.75	1.07	1.53	72.55
Hemerodromia	0	0.94	0.74	1.29	1.52	74.07
Baetis	0.47	0.91	0.68	1.3	1.39	75.47
Polycentropus	0.82	0	0.66	0.66	1.35	76.82
Neoperla	0.58	0.47	0.62	0.9	1.27	78.09
Ancyronyx (adult)	0	0.67	0.62	1.32	1.27	79.36
Tricorythodes	0.33	0.67	0.57	0.97	1.17	80.54
Macronychus (larvae)	0.8	0.33	0.57	1.18	1.17	81.71
Isonychia	0.58	0.33	0.55	0.86	1.12	82.82
Cambaridae	0.47	0.47	0.54	0.82	1.12	83.94
Stenelmis (adult)	0	0.67	0.54	1.27	1.11	85.05
Paragnetina	0.67	0	0.54	1.3	1.11	86.16
Ancylidae	0.58	0	0.52	0.65	1.07	87.24
Hirudinea	0.58	0	0.52	0.65	1.07	88.31
Acroneuria	0.33	0.67	0.49	1.03	1.01	89.32
Chimarra	0.33	0.47	0.44	0.94	0.91	90.22

Trombidiformes	0.33	0.47	0.44	0.94	0.91	91.13
Argia	0	0.58	0.39	0.67	0.8	91.92
Macronychus (adult)	0.33	0.33	0.39	0.82	0.79	92.71
Nyctiophylax	0	0.33	0.32	0.66	0.65	93.37
Crangonyx	0.33	0	0.3	0.65	0.62	93.99
Neotrichia	0.33	0	0.3	0.65	0.62	94.61
Palaemonidae	0.33	0	0.3	0.65	0.62	95.23
Pleuroceridae	0.33	0	0.3	0.65	0.62	95.85
Triaenodes	0.33	0	0.3	0.65	0.62	96.47
Asellidae	0	0.33	0.3	0.67	0.61	97.08
Eurylophella	0	0.33	0.3	0.67	0.61	97.7
Gammarus	0	0.33	0.3	0.67	0.61	98.31
Lymnaeidae	0	0.33	0.3	0.67	0.61	98.93
Taeniopteryx	0	0.33	0.3	0.67	0.61	99.54
Baetisca	0	0.33	0.22	0.67	0.46	100

One-way SIMPER results using Bray-Curtis Similarity matrix for Site 6 with 100.00% cut off for low contributions. Table includes average similarity for Hester-Dendy, leaf, and wood samplers for replicates within sites as well as average dissimilarity for pairwise comparison of Hester-Dendy and leaf samplers, Hester-Dendy and wood samplers, and leaf and wood samplers. Similarity for Hester-Dendy, leaf and wood samplers includes average abundance, average similarity, similarity/standard deviation (SD), Contribution percentage (%), and Cumulative percentage (%). Pairwise comparison includes average abundance (1) for group 1, average abundance (2) for group 2, Dissimilarity/standard deviation (SD), contribution percentage (%), and cumulative percentage (%).

Group Hester

Average similarity: 46.88

Taxa	Average Abundance	Average Similarity	Similarity/SD	Contribution%	Cumulative %
Orthocladiinae	14.19	9.57	2.9	20.41	20.41
Tanytarsini	9.06	8.71	3.9	18.58	38.99
Chironomini	8.25	6.24	1.85	13.32	52.31
Cheumatopsyche	8.5	5.56	2.56	11.86	64.17
Maccaffertium	5.1	3.49	1.67	7.44	71.62
Oecetis	3.51	1.67	0.58	3.56	75.17

Hydroptila	5.87	1.62	0.58	3.45	78.62
Oligochaeta	3.03	1.53	0.58	3.26	81.88
Tricorythodes	2.88	1.43	0.58	3.05	84.93
Tanypodinae	3	1.08	0.58	2.31	87.24
Nectopsyche	3.08	0.94	0.58	2	89.24
Diamesinae	2.11	0.94	0.58	2	91.23
Bezzia	1.61	0.76	0.58	1.63	92.86
Caenis	1.48	0.76	0.58	1.63	94.5
Neoperla	1.52	0.58	0.58	1.24	95.74
Macronychus (larvae)	1.14	0.54	0.58	1.15	96.89
Baetis	1.8	0.54	0.58	1.15	98.04
Hydropsyche	3.14	0.54	0.58	1.15	99.18
Acroneuria	0.8	0.38	0.58	0.82	100

Group Leaves

Average similarity: 59.68

Taxa	Average Abundance	Average Similarity	Similarity/SD	Contribution%	Cumulative %
Cheumatopsyche	6.42	8.85	3.54	14.83	14.83
Orthocladiinae	7.66	8.09	5.95	13.56	28.39
Tanytarsini	7.5	6.45	2.64	10.8	39.19
Maccaffertium	5.28	6.29	5.39	10.54	49.73
Chironomini	4.89	4.58	2.24	7.68	57.41
Hydroptila	3.96	3.97	3.85	6.65	64.06
Neoperla	3.5	3.42	2.77	5.73	69.79
Tricorythodes	3.4	3.19	1.79	5.34	75.13
Nectopsyche	2.68	2.87	5.9	4.81	79.94
Gammarus	3.09	2.78	7.42	4.65	84.6
Oecetis	2.16	2.21	1.86	3.71	88.3
Chimarra	1.85	1.28	0.58	2.14	90.44
Hydropsyche	1.46	0.99	0.58	1.66	92.1
Caenis	1.61	0.9	0.58	1.51	93.61

Hemerodromia	1.22	0.81	0.58	1.35	94.96
Tanypodinae	1.63	0.78	0.58	1.31	96.26
Taeniopteryx	1.29	0.64	0.58	1.07	97.33
Acroneuria	0.67	0.57	0.58	0.96	98.29
Stenelmis (larvae)	0.91	0.57	0.58	0.96	99.24
Diamesinae	1.97	0.45	0.58	0.76	100

Group Wood

Average similarity: 50.82

Taxa	Average Abundance	Average Similarity	Similarity/SD	Contribution%	Cumulative %
Orthocladiinae	10.31	9.59		18.88	18.88
Cheumatopsyche	8.16	7.31		14.39	33.27
Maccaffertium	4.62	6.21		12.21	45.48
Chironomini	4.4	4.85		9.55	55.03
Tanytarsini	6.95	4.85		9.55	64.57
Chimarra	3.15	4.14		8.14	72.72

Hydropsyche	2.83	4.14	8.14	80.86
Hydroptila	5.18	3.27	6.44	87.29
Tanypodinae	1.71	2.07	4.07	91.36
Hemerodromia	2.37	1.46	2.88	94.24
Macronychus (larvae)	1.21	1.46	2.88	97.12
Tricorythodes	2.08	1.46	2.88	100

Groups Hester-Dendy & Leaf

Average dissimilarity = 44.70

Taxa	Group Hester-Dendy Average Abundance	Group Leaf Average Abundance	Average Dissimilarity	Dissimilarity/SD	Contribution %	Cumulative %
Orthocladiinae	14.19	7.66	4.65	1.19	10.41	10.41
Hydroptila	5.87	3.96	3.01	1.42	6.73	17.14
Chironomini	8.25	4.89	2.79	1.43	6.24	23.38
Tanytarsini	9.06	7.5	2.43	1.6	5.43	28.81

Chimarra	3.27	1.85	2.42	1.26	5.41	34.21
Cheumatopsyche	8.5	6.42	2.22	1.11	4.96	39.17
Oligochaeta	3.03	0.47	1.89	1.3	4.24	43.41
Hydropsyche	3.14	1.46	1.82	1.12	4.07	47.48
Oecetis	3.51	2.16	1.81	1.82	4.06	51.54
Tanypodinae	3	1.63	1.58	1.26	3.54	55.08
Nectopsyche	3.08	2.68	1.54	1.51	3.44	58.52
Neoperla	1.52	3.5	1.46	1.07	3.26	61.78
Gammarus	0.67	3.09	1.45	1.5	3.24	65.01
Maccaffertium	5.1	5.28	1.42	1.46	3.17	68.18
Diamesinae	2.11	1.97	1.38	1.56	3.1	71.28
Tricorythodes	2.88	3.4	1.28	1.22	2.85	74.13
Baetis	1.8	0.47	1.03	1.04	2.31	76.44
Bezzia	1.61	0.47	0.96	1.2	2.16	78.6
Stenelmis (larvae)	1.15	0.91	0.92	1.44	2.06	80.65
Caenis	1.48	1.61	0.76	1.09	1.71	82.36

Macronychus (larvae)	1.14	0	0.75	1.22	1.68	84.04
Hemerodromia	0.58	1.22	0.72	1.17	1.61	85.65
Taeniopteryx	0.33	1.29	0.71	1.32	1.59	87.23
Trombidiformes	0.94	0.47	0.66	0.89	1.48	88.71
Stenelmis (adult)	0.94	0	0.66	0.66	1.47	90.18
Simulium	0.94	0	0.56	0.66	1.26	91.44
Turbellaria	0	0.94	0.52	0.66	1.17	92.61
Neotrichia	0.47	0.67	0.49	0.93	1.09	93.7
Acroneuria	0.8	0.67	0.36	1.14	0.81	94.51
Dubiraphia	0.47	0	0.33	0.66	0.74	95.25
Brachycentrus	0.47	0	0.28	0.66	0.64	95.88
Argia	0.33	0.33	0.28	0.83	0.63	96.52
Triaenodes	0	0.47	0.26	0.66	0.59	97.1
Lymnaeidae	0	0.33	0.22	0.66	0.5	97.6
Asellidae	0	0.33	0.22	0.66	0.5	98.1
Cambaridae	0	0.33	0.22	0.66	0.5	98.6

Hyallella	0	0.33	0.22	0.66	0.5	99.1
Ancylidae	0.33	0	0.2	0.66	0.45	99.55
Pteronarcys	0.33	0	0.2	0.66	0.45	100

Groups Hester-Dendy & Wood

Average dissimilarity = 46.18

	Group Hester-Dendy	Group Wood				
Taxa	Average Abundance	Average Abundance	Average Dissimilarity	Dissimilarity/SD	Contribution %	Cumulative %
Orthocladiinae	14.19	10.31	4.25	1.03	9.21	9.21
Hydroptila	5.87	5.18	3.36	1.43	7.27	16.48
Chironomini	8.25	4.4	2.91	1.28	6.3	22.78
Cheumatopsyche	8.5	8.16	2.84	1.31	6.15	28.93
Chimarra	3.27	3.15	2.78	2.37	6.01	34.94
Tanytarsini	9.06	6.95	2.62	1.13	5.67	40.61
Oecetis	3.51	2	1.99	0.99	4.31	44.91

Hydropsyche	3.14	2.83	1.98	1.87	4.28	49.2
Nectopsyche	3.08	2	1.9	1.14	4.1	53.3
Oligochaeta	3.03	1	1.85	1.18	4.01	57.32
Tanypodinae	3	1.71	1.55	1.45	3.36	60.67
Tricorythodes	2.88	2.08	1.49	1.37	3.24	63.91
Maccaffertium	5.1	4.62	1.45	2.03	3.15	67.06
Stenelmis (larvae)	1.15	2.45	1.43	1.07	3.09	70.15
Diamesinae	2.11	0	1.39	1.2	3	73.15
Hemerodromia	0.58	2.37	1.2	1.79	2.6	75.76
Bezzia	1.61	0	1.09	1.14	2.36	78.12
Baetis	1.8	0.5	1.01	1.15	2.2	80.31
Neoperla	1.52	1.41	0.91	1.07	1.98	82.29
Caenis	1.48	0.71	0.86	1.11	1.87	84.16
Acroneuria	0.8	1.41	0.86	1.73	1.85	86.01
Trombidiformes	0.94	0.71	0.72	0.96	1.55	87.56
Stenelmis (adult)	0.94	0	0.68	0.63	1.47	89.03

Simulium	0.94	0	0.58	0.63	1.25	90.28
Gammarus	0.67	0.5	0.58	1.21	1.25	91.53
Neureclipsis	0	1	0.53	0.91	1.16	92.69
Macronychus (larvae)	1.14	1.21	0.49	1.49	1.06	93.75
Corydalus	0	0.5	0.38	0.91	0.83	94.58
Heptagenia	0	0.5	0.38	0.91	0.83	95.41
Nyctiophylax	0	0.71	0.38	0.91	0.82	96.22
Dubiraphia	0.47	0	0.34	0.63	0.73	96.96
Brachycentrus	0.47	0	0.29	0.63	0.63	97.59
Neotrichia	0.47	0	0.29	0.63	0.63	98.22
Ancylidae	0.33	0	0.21	0.63	0.45	98.67
Argia	0.33	0	0.21	0.63	0.45	99.11
Taeniopteryx	0.33	0	0.21	0.63	0.45	99.56
Pteronarcys	0.33	0	0.2	0.63	0.44	100

Groups Leaf & Wood

Average dissimilarity = 38.91

Taxa	Group Leaf Average Abundance	Group Wood Average Abundance	Average Dissimilarity	Dissimilarity/SD	Contribution %	Cumulative %
Tanytarsini	7.5	6.95	3.11	1.22	7.99	7.99
Orthocladiinae	7.66	10.31	2.95	1.38	7.57	15.57
Cheumatopsyche	6.42	8.16	2.18	2.12	5.59	21.16
Hydroptila	3.96	5.18	2.08	1.38	5.35	26.5
Neoperla	3.5	1.41	2.07	1	5.33	31.83
Gammarus	3.09	0.5	1.78	1.72	4.59	36.42
Stenelmis (larvae)	0.91	2.45	1.66	1.66	4.27	40.68
Nectopsyche	2.68	2	1.66	1.28	4.26	44.95
Chironomini	4.89	4.4	1.56	1.56	4.01	48.95
Oecetis	2.16	2	1.55	1.88	3.99	52.95
Tricorythodes	3.4	2.08	1.48	1.25	3.79	56.74
Diamesinae	1.97	0	1.35	0.88	3.46	60.2
Hemerodromia	1.22	2.37	1.15	2.05	2.97	63.17

Chimarra	1.85	3.15	1.05	1.08	2.69	65.86
Caenis	1.61	0.71	1.04	1.18	2.68	68.54
Acroneuria	0.67	1.41	0.98	1.91	2.53	71.07
Hydropsyche	1.46	2.83	0.97	1.21	2.49	73.56
Taeniopteryx	1.29	0	0.92	1.18	2.38	75.94
Maccaffertium	5.28	4.62	0.9	2.09	2.32	78.26
Macronychus (larvae)	0	1.21	0.9	8	2.31	80.57
Tanypodinae	1.63	1.71	0.87	1.54	2.23	82.8
Oligochaeta	0.47	1	0.66	1.06	1.71	84.5
Turbellaria	0.94	0	0.62	0.63	1.59	86.09
Neureclipsis	0	1	0.61	0.91	1.57	87.65
Baetis	0.47	0.5	0.52	1.09	1.33	88.99
Trombidiformes	0.47	0.71	0.49	0.91	1.25	90.24
Corydalus	0	0.5	0.47	0.9	1.2	91.44
Heptagenia	0	0.5	0.47	0.9	1.2	92.64
Neotrichia	0.67	0	0.44	0.63	1.12	93.76

Nyctiophylax	0	0.71	0.43	0.91	1.11	94.86
Bezzia	0.47	0	0.31	0.63	0.79	95.66
Triaenodes	0.47	0	0.31	0.63	0.79	96.45
Lymnaeidae	0.33	0	0.28	0.62	0.71	97.16
Argia	0.33	0	0.28	0.62	0.71	97.87
Asellidae	0.33	0	0.28	0.62	0.71	98.58
Cambaridae	0.33	0	0.28	0.62	0.71	99.29
Hyallella	0.33	0	0.28	0.62	0.71	100