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Benthic Macroinvertebrate Pilot Protocol Summary Report

Mid-Atlantic Network (2009–2014)

Natural Resource Report NPS/MIDN/NRR—2019/1953



ON THE COVER
Benthic macroinvertebrate sampling on the Appomattox River, Appomattox Court House National Historical Park
Image courtesy of NPS / Mark Johnson

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Abstract

The Mid-Atlantic Network (MIDN) pilot benthic macroinvertebrate monitoring protocol was implemented to assess proposed methods for the collection of long-term monitoring data on aquatic resources for the National Park Service's (NPS) Inventory and Monitoring Program (I&M; MIDN 2015). This pilot protocol was implemented in eight of ten MIDN parks from 2009–2018. This report includes a summary of data from 2009–2014 , a critical review of the pilot protocol, and explanations for why MIDN ultimately modified pilot methods and began implementing state methods for the MIDN benthic macroinvertebrate monitoring protocol.

From 2009–2014, the MIDN pilot effort resulted in the collection of 140 taxa of benthic macroinvertebrates. Taxa richness in individual parks ranged from 49 to 85. Importantly, pilot methods often resulted in the collection of samples that had too few individual macroinvertebrates to allow for the use of state-established thresholds of stream impairment. Multi-metric scores of stream ecological health using MIDN pilot methods were also highly variable over time at individual sites. In general, multi-metric scores were not trending over time.

Given the high temporal variability and the lower sample sizes of individuals per sample using MIDN methods (thus precluding the utilization of state thresholds of stream impairment), MIDN pilot methods were ultimately deemed unsuitable for long-term objectives. As such, MIDN began utilizing state methods in 2015 and fully transitioned to state protocols in 2019. Broadly speaking, by switching to state protocols, MIDN began sampling a larger area to increase the representativeness and size (i.e. number of individuals) of the macroinvertebrate sample. In addition, as reflected in state protocols, MIDN began subsampling of the macroinvertebrate samples during laboratory processing.

As noted above, this report includes data collected from 2009–2014. From 2015–2018, MIDN pilot methods and state methods were utilized simultaneously at a subset of sampling sites. In 2019, only state methods were utilized and MIDN pilot methods were dropped completely. Future analyses will evaluate if a direct comparison between MIDN pilot data and data collected under state protocols during the transition years from 2015–2018 (and beyond) can be made.

Introduction

The Mid-Atlantic Network (MIDN) pilot benthic macroinvertebrate monitoring protocol was implemented to evaluate proposed methods for the collection of long-term monitoring data on aquatic resources for the National Park Service's (NPS) Inventory and Monitoring (I&M) Program (Voshell and Hiner 2015). The MIDN consists of ten parks in Pennsylvania and Virginia: Appomattox Court House National Historical Park (APCO), Booker T. Washington National Monument (BOWA), Eisenhower National Historic Site (EISE), Fredericksburg and Spotsylvania National Military Park (FRSP), Gettysburg National Military Park (GETT), Hopewell Furnace National Historic Site (HOFU), Petersburg National Battlefield (PETE), Richmond National Battlefield Park (RICH), Shenandoah National Park (SHEN), and Valley Forge National Historical Park (VAFO).

Natural resource monitoring in MIDN parks has a limited history, except for at SHEN where comprehensive natural resource monitoring has been conducted since the mid-1980s (Olson et al. 2010). The pilot monitoring protocol described in this document was designed for long-term monitoring of benthic macroinvertebrate communities at eight MIDN parks. SHEN and VAFO were not included because comprehensive benthic macroinvertebrate monitoring is ongoing at SHEN (Wofford et al. 2018), while at VAFO, extensive monitoring has been conducted (and is continuing) by other partners over the past decade (Reif 2002, D'Antonio and Jantz 2008). Nevertheless, one year of sampling did occur in VAFO during the first year of this pilot monitoring protocol, and these data are included herein.

The purpose of natural resource monitoring by I&M is to determine the status and trends in the condition of specific park resources, also known as ecological "vital signs." Monitoring vital signs, including benthic macroinvertebrates, is intended to inform park management by providing scientifically sound information on the status and long-term trends of park natural resources. In addition, vital signs are expected to provide an early warning of impending threats and provide a basis for understanding and identifying meaningful change in complex, variable natural systems (Fancy and Bennetts 2012, NPS 2012). Vital signs monitoring tracks physical, chemical, and biological components of park ecosystems.

Streams are one of the most important and conspicuous natural resources in MIDN national parks, and benthic macroinvertebrate communities are a critical component of these resources. Benthic macroinvertebrates are aquatic invertebrate animals that are larger than microscopic size (can be seen with the unaided eye) and live on the bottom or on objects protruding from the bottom of streams and lakes. Because these animals are vital to the natural ecological function of stream systems and are highly suitable for biomonitoring, they are often used as indicators of ecological integrity (Voshell et al. 1997, Barbour et al. 1999, Carter et al. 2006).

An independent review by scientists and park managers indicated that, out of 43 potential vital signs that were assessed during vital signs development for the Mid-Atlantic Network, macroinvertebrate communities ranked third based on combined ecological, management, and policy interests (Comiskey and Callahan 2008).

The pilot macroinvertebrate protocol was implemented in MIDN parks from 2009–2018. This report includes a summary of data from 2009–2014, a critical review of the pilot protocol, and explanations for why MIDN ultimately dropped pilot methods and transitioned to state protocols for its benthic macroinvertebrate collection protocols.

From 2015–2018, MIDN pilot methods and state methods were utilized simultaneously at sampling sites. In 2019, only state methods were utilized and MIDN pilot methods were dropped completely. Future analyses will evaluate if a direct comparison between MIDN pilot data and data collected under state protocols during the transition years from 2015–2018 (and beyond) can be made.

Pilot Objectives

To be relevant to current management issues and anticipated future threats, monitoring programs must produce quality data that are readily accessible and explicitly linked to management decision-making processes. The overarching goal of the benthic macroinvertebrate monitoring program is to provide data for estimating long-term changes in the stream condition of MIDN parks. The following specific objectives were established for that purpose:

1. Determine the status and trends in the composition (diversity and abundance) of benthic macroinvertebrate communities in selected streams within MIDN parks.
2. Determine the status and trends in habitat condition in selected streams within MIDN parks.

To meet objective one, data were collected to describe genus and family-level richness and relative abundance of macroinvertebrate taxa at MIDN sites. These data are used to evaluate the change in the mean, maximum, and minimum values of macroinvertebrate metrics over time.

To meet objective two, data were collected to describe a variety of structural and additional biological stream attributes (i.e. other than macroinvertebrate community). These data provide information about stream habitat function and stability, and can be used to help in the interpretation of benthic macroinvertebrate data.

Pilot Methods

Sampling Design

This pilot study was implemented in eight parks associated with the MIDN (all parks except SHEN and VAFO). These parks contain a varied number and length of streams as well as diverse mix of land-use patterns in their contributing watersheds (see Dammeyer and Weed (2017) for a full description of stream resources and land cover patterns).

In order to support an improved understanding of ecological conditions, colocation of benthic monitoring sites with other MIDN monitoring activities was deemed to be high priority. Thus, all sites selected for benthic sampling also had ongoing water quality monitoring.

This pilot study employed semi-quantitative field collection methods as is common in benthic macroinvertebrate studies in the region (VADEQ 2008, Shull and Lookenbill 2018) and across the nation (Moulton et al. 2002). Pilot field methods typically focused on a wide variety of microhabitats but a reduced sample area within those habitats and a reduced total area sampled across microhabitats compared to many other monitoring protocols. Simplicity was desired in the design, and the pilot methods were applied uniformly across all ecoregions. Samples were collected using a D-frame dip net (500 μm mesh; D-nets) which was used to sample multiple microhabitat types at a given site. At each site, organisms from riffle, root mats/undercut banks, leaf packs, macrophytes, and log microhabitats were collected and preserved separately. Sampling a wide variety of habitats allowed for a larger pool of potential taxa available for collection, however, the smaller area sampled likely reduced the number of individuals to be collected as well as the taxa richness (Vinson and Hawkins 1996).

During protocol development, it was recognized that it would be mutually beneficial to employ a sampling design that was similar to that used by state regulatory agencies in Virginia (Virginia Department of Environmental Quality) and Pennsylvania (Pennsylvania Department of Environmental Protection). This would facilitate data sharing, which would be especially useful for rating the ecological condition of MIDN streams (i.e., status) and for determining the causes of impaired conditions. Importantly, the methods outlined herein have similarities to state methods but depart from these methods in potentially critical ways (e.g., area sampled).

Site Selection

Sampling reaches were subjectively selected from within the population of water quality monitoring locations established in the MIDN water quality monitoring protocol (Dammeyer and Weed 2017). These reaches were selected in streams of significant interest to park managers. The number of sites sampled was determined by the spatial extent and number of streams in each park. Collocation of benthic macroinvertebrate sampling sites with water quality sites was seen as critical to obtain a robust understanding of the ecological conditions of park streams.

The benthic macroinvertebrate monitoring sites were designated as 100-m reaches of selected streams, a length that was assumed to be sufficient to include all of the possible macroinvertebrate microhabitats without excessive redundancy (approximately 2-3 meander wavelengths). The primary

purpose of this design is to make inferences about the ecological condition of individual streams within each park. It was recognized that a non-randomized approach limits inferences only to sites where the samples are taken, and cannot be extrapolated to larger spatial scales. Nevertheless, in most situations, the entire length of associated streams within individual parks is usually small, and hence the limited inference does not pose a significant concern. All parks included in this protocol have at least one sample site and the design does provide sufficient power for detecting trends at the site scale (Dammeyer 2018).

Sampling Frequency and Replication

Benthic macroinvertebrate monitoring was conducted each year in late winter to early spring (March through early April), within the index period accepted by state agencies.

Recommended Number and Location of Sampling Sites

It was originally determined that 24 sites for benthic macroinvertebrate monitoring could be established based on sampling needs and available funding levels. The 24 sites were distributed among the eight MIDN parks approximately according to the areas of the parks and the number of streams contained within their boundaries. Following the first few years of data collection, additional constraints of funding and logistics resulted in a reduction in the number of sites to 18 as follows: APCO (1), BOWA (2), EISE (1), FRSP (4), GETT (3), HOFU (1), PETE (2), and RICH (4). For this report, we include all data collected from 2009–2014.

Details of Sampling in the Field

Sampling was conducted during base-flow conditions. At each macroinvertebrate sampling site, three primary tasks were completed in sequence: demarcation of the 100-m reach, collection of the macroinvertebrate samples, and characterization of the stream and riparian habitat.

Demarcation of the Reach

Upon arrival at each sampling site, the first task was establishing the upstream and downstream boundaries of the 100-m reach that comprises the sampling site. This was done in relation to the tree tag that marks the site, as documented in protocol site descriptions (Dammeyer and Weed 2017, Dammeyer 2018). A 100-m tape was extended along the center of the stream channel to demarcate the reach.

Collecting Samples

Separate macroinvertebrate samples were taken in each microhabitat within each 100-m reach. Five potential microhabitats were identified in the pilot protocol: riffles (RIF), root mats/undercut banks (RMUB), leaf packs (LP), macrophytes (M), and logs (LG). Not all microhabitats occurred at all sites. Samples were collected with a D-frame dip net (500 μm mesh) at each microhabitat except the leaf pack, which was collected by hand. Samples were collected with the D-net from multiple locations of each microhabitat; the microhabitat samples were therefore composites of multiple microhabitat locations, but each individual microhabitat composite was stored and processed separately. Ultimately, MIDN sampling resulted in a cumulative sample area of ~0.3m^2 for riffles and ~1.3m^2 for non-riffle habitat.

Storing, Labeling, Preserving Samples

Following collection, each microhabitat sample was transferred from the D-net to a plastic storage bag. A label containing the necessary information to distinguish the sample, including the park abbreviation, site number, microhabitat abbreviation, and date, was placed in the storage bag, and undiluted ethanol (95%) was added for sample preservation.

Characterizing Stream Habitat

Stream habitat was characterized using habitat parameters developed by the U.S. Environmental Protection Agency (EPA) Rapid Bioassessment Protocol (RBP) for high and low-gradient streams (Barbour et al. 1999). Habitat information may help interpret benthic macroinvertebrate data and assist in determining the ecological condition of MIDN streams. Habitat parameters that were measured included a number of metrics assessing instream physical conditions, channel morphology, bank structural features, and riparian vegetation (Barbour et al. 1999). The parameters were evaluated for an entire sampling reach and given a score from 0 (poor condition) to 20 (optimal condition). In all, ten parameters are assessed and summed to give a single stream-condition rating for the sampling site.

MIDN sampling also included characterization of stream width, depth, substrate, and water quality. Stream width and depth were measured at three locations (left side of channel, center of channel, right side of channel) across five transects which are distributed every 25 meters in the site. Substrate size and embeddedness were visually estimated at these locations as well. In addition, water and air temperature (°C), DO (% and mg/L), pH, and turbidity (visually estimated and scaled 0-4) were recorded prior to each sampling event. For purposes of brevity, these data, along with the stream habitat data are not assessed in this report.

Laboratory Sample Processing

Processing of laboratory samples and macroinvertebrate identification was completed by S. Hiner and R. Voshell at the Virginia Polytechnic Institute, as follows:

Removing Macroinvertebrates from Samples

Benthic macroinvertebrate samples contain debris and other unwanted organic and inorganic material that must be separated from that sample (sorted) before the macroinvertebrates can be identified and counted. To exclude this debris, the samples were first rinsed over a fine meshed screen (500 μm mesh), and then small increments of the sample were examined to find and remove the macroinvertebrates by hand. Ultimately, the entire sample was examined and all macroinvertebrates were removed; there was no sub-sampling. When the sample was completely sorted, all macroinvertebrates, along with the original label, were placed in a jar containing 70% ethanol.

Identifying, Counting, and Recording the Macroinvertebrates

All organisms contained in the sample were identified to the lowest practical taxonomic level (typically genus) and the number of specimens of each taxon were counted. Identification was accomplished using a stereomicroscope with magnification up to at least 40X and assistance from the most recent taxonomic publications. Ambiguous taxa were later resolved using the DPAC-GK method as outlined in Cuffney et al. (2007).

Quality Control (QC) for Sorting and Identification

Quality control checks of sorting effectiveness were performed on a random selection of 5% of the annual samples. In addition, QC checks of identification accuracy were performed on a random selection of 5% of the annual samples by a qualified co-worker. Counts within 10% of the original were deemed acceptable, with only 25% of samples being allowed to fail before additional QC was required.

Comparison to State Methods

During the development of the pilot protocol, attempts were made to produce a field sampling protocol that was uniform across all MIDN sites but was similar to that employed by state regulatory agencies. A general comparison between MIDN methods and state methods is outlined in Table 1.

It is important to note that MIDN pilot macroinvertebrate field collection methods differ somewhat from relevant state DEQ methods. Most notably, the area of sampled stream benthic habitat is less in MIDN methods (Table 1). MIDN pilot methods also diverged from state methods where riffles were disturbed using hand washing of cobble as well as disturbing finer particles (e.g., gravels) with hands as opposed to kicking these habitats. In an attempt for uniformity, MIDN methods also include multi-microhabitat sampling in all sites. State methods require only riffle samples in sites that utilize the Virginia Stream Condition Index (VSCI) or Pennsylvania Riffle/Run Index of Biotic Integrity (PARRIBI). In addition, in Virginia Coastal Plain sites, state methods result in sampling that is proportional to micro-habit availability in the site. In contrast, MIDN methods utilized equitable sampling effort per micro-habitat regardless of availability. Since MIDN planned to use some state multi-metric indices and state thresholds of stream impairment, these differences in sampling procedures are important for critical assessments of the pilot protocol.

Table 1. Comparison of pilot MIDN methods to state methods.

Method	Micro habitats sampled	Effort (approximate sample area for riffles, # of jabs and approximate area for other habitats)	Taxonomic identification level for most taxa
VADEQ –Piedmont[1,2]	Riffles	~2 m^2	Family
VADEQ-Coastal Plain[1,2]	All available microhabitats (sampling effort proportional to habitat availability)	20 jabs (distributed proportionally to microhabitats; ~3.1 m^2 cumulative via jabs)	Family
PADEP-Riffle/Run[3]	Riffles	~6 m^2	Genus
PADEP-Multihabitat[3]	All available microhabitats	10 jabs (2 per microhabitat or distributed proportionally; ~2.3 m^2 cumulative via jabs)	Genus
MIDN pilot[4]	All available microhabitats at all sites	~0.3 m^2 (riffles), plus a maximum of 13 jabs (~1.3 m^2 cumulative via jabs)	Genus

[1] Barbour et al. (1999)

[2] VADEQ (2008)

[3] Shull and Lookenbill (2018)

[4] MIDN (2015)

Data Analysis

In order to characterize how well pilot methods inventoried taxonomic diversity in parks, taxa accumulation curves and estimates of total taxa richness were calculated using "specaccum" (via the random permutations method) and "specpool" function, respectively, from the R package "vegan" (Oksanen et al. 2017, R. Core Team 2017). Each microhabitat collection (i.e., riffle, etc.) was utilized as a sample in the taxa accumulation curves. For calculations of estimated total taxa richness, the "jack1" estimate was utilized as recommended by Basualdo (2011).

Many states utilize multi-metric indices for assessing stream ecological health, and the Environmental Protection Agency supports the use of multi-metric scores in stream assessments (Stribling and Dressing 2015). The primary approach to analyzing MIDN pilot macroinvertebrate data was to calculate multi-metric indices (MMIs) that were developed by the Virginia Department of Environmental Quality (DEQ) and the Pennsylvania Department of Environmental Protection (DEP). These MMIs include the following:

1. Riffle-Run Index of Biotic Integrity for wadeable freestone streams in Pennsylvania (PARRIBI; Shull and Lookenbill 2018)

2. Multi-habitat Index of Biotic Integrity for low-gradient streams in Pennsylvania (PAMHIBI; Shull and Lookenbill 2018)
3. Stream Condition Index for Virginia non-coastal streams (VSCI; Burton and Gerritsen 2003)
4. Coastal Plain Macroinvertebrate Index (CPMI; Dail et al. 2013)

Each MMI requires the calculation of a number of sub-metrics that are then normalized and averaged to determine a total MMI score. Table 2 includes a summary of MMI sub-metrics for relevant parks. MIDN sample sites were assigned a particular MMI based upon their geographic location in each Commonwealth or based upon local habitat conditions.

Table 2. MMI sub-metrics utilized for data analysis.

MMI	Park	Sub-metrics assessed	Taxonomic assessment level	Relevant microhabitats
PARRIBI	GETT, HOFU	Total taxa richness, EPT* taxa richness, Beck's Index (3), Shannon diversity, Hilsenhoff Biotic Index, % sensitive individuals	Genus	Riffle
PAMHIBI	EISE	% EPT*, Total taxa richness, Shannon diversity, Beck's Index (4), Ephemeroptera richness, Trichoptera richness	Genus	Multi-habitat
VSCI	APCO, BOWA, FRSP	Total taxa richness, EPT* taxa richness, % Ephemeroptera, %Plecoptera plus Trichoptera minus Hydropsychidae, % Scrapers, % Chironomidae, % Top 2 Dominant, Hilsenhoff Biotic Index	Family	Riffle
CPMI	PETE, RICH	Total taxa richness, EPT* taxa richness, % Ephemeroptera, %Plecoptera plush Trichoptera minus Hydropsychidae, Hilsenhoff Biotic Index, % Intolerant taxa, % Clingers minus Hydropsychidae and Simuliidae, % Scrapers	Family	Multi-habitat

* EPT = Ephemeroptera, Plecoptera, Trichoptera

In the analyses that follow, when a MMI is calculated or referenced, only the relevant microhabitats (as noted in Table 1) are included in those analyses. For example, when the VSCI is calculated, only riffle data are included. When the PAMHIBI is calculated, macroinvertebrate information from all microhabitats is included. Details on sub-metric calculations can be found in individual state MMI documents as cited in Table 1. Lastly, the VSCI and CPMI currently utilize family-level taxonomic information for all calculations. The PARRIBI and PAMHIBI utilize genus-level data.

Pennsylvania DEP and Virginia DEQ protocols require a certain number of individual macroinvertebrates to be included in the MMI calculation (i.e., 99-121 individuals for Virginia and 180-220 individuals for Pennsylvania; VADEQ 2008, Shull and Lookenbill 2018). As such, state methods generally require taking a relatively large sample of macroinvertebrates and then subsampling those individuals in the laboratory to reach the required number of individuals. Though

we do utilize state MMIs to characterize MIDN data herein, because MIDN samples often did not contain the required minimum number of individuals (see Results), we do not utilize these MMIs in this report for making determinations about stream health (i.e., use of state-defined thresholds of stream impairment). Additionally, since a comparison to state thresholds was not appropriate for many sites due to low individual macroinvertebrate counts, instead of sub-sampling in sites where > 121 (VA) or > 240 (PA) individuals were collected, we utilized the full count of individuals in a sample for all MMI calculations across all sites.

Trends in MMI were assessed using a Mann-Kendall trend test. Temporal stability in MMI was assessed in a similar method to how state MMIs were assessed during their development (i.e. via calculations of coefficients of variation (CV) or root square mean errors (RSME); Burton and Gerritsen 2003, PADEP 2007, 2015). These measures can quantify metric variability at a site across years. All analyses were conducted using R version 3.4.2 (R. Core Team 2017).

Pilot Results

The first objective of the pilot protocol is to "Determine the status and trends in the composition (diversity and abundance) of benthic macroinvertebrate communities in selected streams within MIDN parks." A number of MIDN parks had incomplete background information on benthic communities in general, so we first report on basic sample and taxa characteristics. To evaluate the status and trends at individual sites, we utilized appropriate state multi-metric indices (MMI) as noted above, though we reiterate that state thresholds of impairment were not appropriate given the limited number of macroinvertebrates in many MIDN samples.

Sampling Summary

Each park had at least one sample site and sites were generally sampled every year. A list of pilot sites, the years when collections occurred, the number of individuals collected, and relevant MMIs can be found in Table 3. A few sites were discontinued in 2010 as a result of logistical and cost constraints. In addition, the single VAFO site was also discontinued in 2010 due to extensive benthic macroinvertebrate sampling already occurring in VAFO by various partners (D'Angelo et al. 1997, Reif 2002).

Fifty-eight percent of the MIDN samples failed to meet the required number of sampled individuals for state macroinvertebrate monitoring protocols at least once over the six year pilot period (Table 3). These failures occurred in both PA and VA, with an average of 63% and 56% of sites failing to meet minimum requirements at least once, respectively. Some sites never had a sample collection that reached the state MMI required minimum number of macroinvertebrates despite, at times, six years of data collection (e.g., FRSP 08, RICH 02).

Taxa Richness

The MIDN pilot protocol does not have a specific and defined objective of inventorying benthic macroinvertebrate taxa. Nevertheless, establishing a strong program that would assist in documenting taxa richness in MIDN parks was conceptually important during protocol development. Including all sampling data, the MIDN pilot effort resulted in the collection of 46,464 individual macroinvertebrates composing 140 taxa (Table 4). Within individual parks, taxa richness ranged from 49 (RICH) to 85 taxa (BOWA; Table 4, Appendix A). Due to limited effort at VAFO, it is excluded from this taxa richness discussion. It is important to note that sampling effort varied dramatically between parks and direct comparisons across parks should not be made. For example, the data reported for APCO includes eight site-years of sampling (i.e., one site sampled for two years plus another site sampled for six years). In contrast, efforts in FRSP included more than three times the effort (i.e., 26 site-years).

Table 3. Pilot site list and sample information. Includes years sampled, the number of individuals captured per sample, relevant MMI, number of individuals necessary for MMI calculation, and the percent failure rate of a site to meet the required number of individuals every year over the six year sample period.

Park	Site	2009	2010	2011	2012	2013	2014	MMI	Minimum number of required individuals	Percent failure over six year period
APCO	01	267	429	NA	NA	NA	NA	VSCI	100	0.0
APCO	02	239	600	360	221	200	113	VSCI	100	0.0
BOWA	02	197	35	68	39	51	103	VSCI	100	66.7
BOWA	04	259	118	129	114	221	61	VSCI	100	16.7
EISE	04	1114	466	358	284	535	206	PAMHIBI	160	0.0
FRSP	01	1127	563	324	264	787	709	VSCI	100	0.0
FRSP	06	51	42	NA	NA	NA	NA	VSCI	100	100.0
FRSP	08	17	9	17	16	15	8	VSCI	100	100.0
FRSP	13	200	218	138	173	138	79	VSCI	100	16.7
FRSP	17	206	118	160	295	203	276	VSCI	100	0.0
GETT	01	211	105	236	124	243	156	PARRIBI	160	50.0
GETT	02	87	105	NA	NA	NA	NA	PARRIBI	160	100.0
GETT	06	149	221	36	254	126	142	PARRIBI	160	66.7
GETT	07	309	268	249	266	351	NA	PARRIBI	160	0.0
HOFU	01	80	107	66	99	280	130	PARRIBI	160	83.3
HOFU	02	640	86	NA	NA	133	160	PARRIBI	160	50.0
PETE	03	342	96	123	223	82	125	CPMI	100	33.3
PETE	10	776	807	32	119	219	321	CPMI	100	16.7
RICH	02	6	16	14	41	7	8	CPMI	100	100.0
RICH	03	185	133	107	139	NA	NA	CPMI	100	0.0
RICH	04	289	179	302	403	119	104	CPMI	100	0.0
RICH	05	550	264	242	232	232	48	CPMI	100	16.7
RICH	07	100	182	NA	NA	NA	NA	CPMI	100	0.0
VAFO	01	295	NA	NA	NA	NA	NA	PARRIBI	160	0.0

Note: For this assessment, only data from riffle samples are included for sites utilizing riffle MMIs (VSCI and PARRIBI sites). Sites using multi-habitat MMIs (PAMHIBI and CPMI sites) include counts of all individuals from all habitats. NA's indicate no data were collected during that year.

Table 4. Observed and estimated taxa richness per park including number of individuals captured and richness in the most common taxonomic orders.

Park	Measured richness	Estimated richness	# of ind. captured	Col.	Dip.	Ephem.	Odon.	Plec.	Trich.	Other Ins.	Other Non-Ins.
APCO	75	90	4664	11	10	14	9	10	12	3	6
BOWA	85	105	3685	12	14	16	9	12	14	3	5
EISE	37	46	2963	7	7	5	1	3	6	0	8
FRSP	80	101	11501	11	11	12	8	11	14	4	9
GETT	72	85	8537	12	11	10	7	6	13	2	11
HOFU	81	94	6616	9	13	13	9	11	17	2	7
PETE	41	49	3265	2	8	6	6	7	8	0	4
RICH	82	99	3902	13	11	10	8	7	17	5	11
VAFO*	18	24	1055	2	7	1	0	0	3	0	5

Note: Col. = Coleoptera, Dip. = Diptera, Ephem. = Ephemeroptera, Odon. = Odonata, Plec. = Plecoptera, Trich. = Trichoptera, Ins. = Insecta.

* VAFO includes only a very small sample size and is not included in discussion (5 microhabitat samples from 1 site during 1 year).

Estimated taxa richness values, as calculated (the total number of taxa predicted to be in a park, including those not yet observed), ranged from 46 (EISE) to 105 (BOWA; Table 4). A comparison between measured and estimated richness indicates that sampling to date has captured a mean of 82.7% of taxa likely to be found at MIDN sites.

As expected, the majority of taxa were from the Insecta class. Within parks, the percent of taxa in Insecta ranged from 78% (EISE) to 95% (BOWA). The most common taxa across MIDN parks were Trichoptera (mean = 12.6 taxa per park), Ephemeroptera (mean = 10.8 per park), and Diptera (mean = 10.6 per park). A full taxa list for each park can be found in Appendix A.

In order to visualize how well pilot sampling captured the full taxonomic diversity of park benthic macroinvertebrate communities, taxa accumulation curves were utilized. These curves provide a visual assessment of how rapidly new taxa are discovered over time. As additional samples are collected, accumulation curves generally begin to flatten, indicating that relatively few additional taxa remain to be discovered by future sampling (Gotelli and Colwell 2001). Accumulation curves for each park can be seen in Figure 1. Though calculated by a different analytical procedure, conceptually speaking these accumulation curves would eventually reach an asymptote near the estimated taxa richness values noted in Table 4. Again, VAFO was excluded due to low sample size.

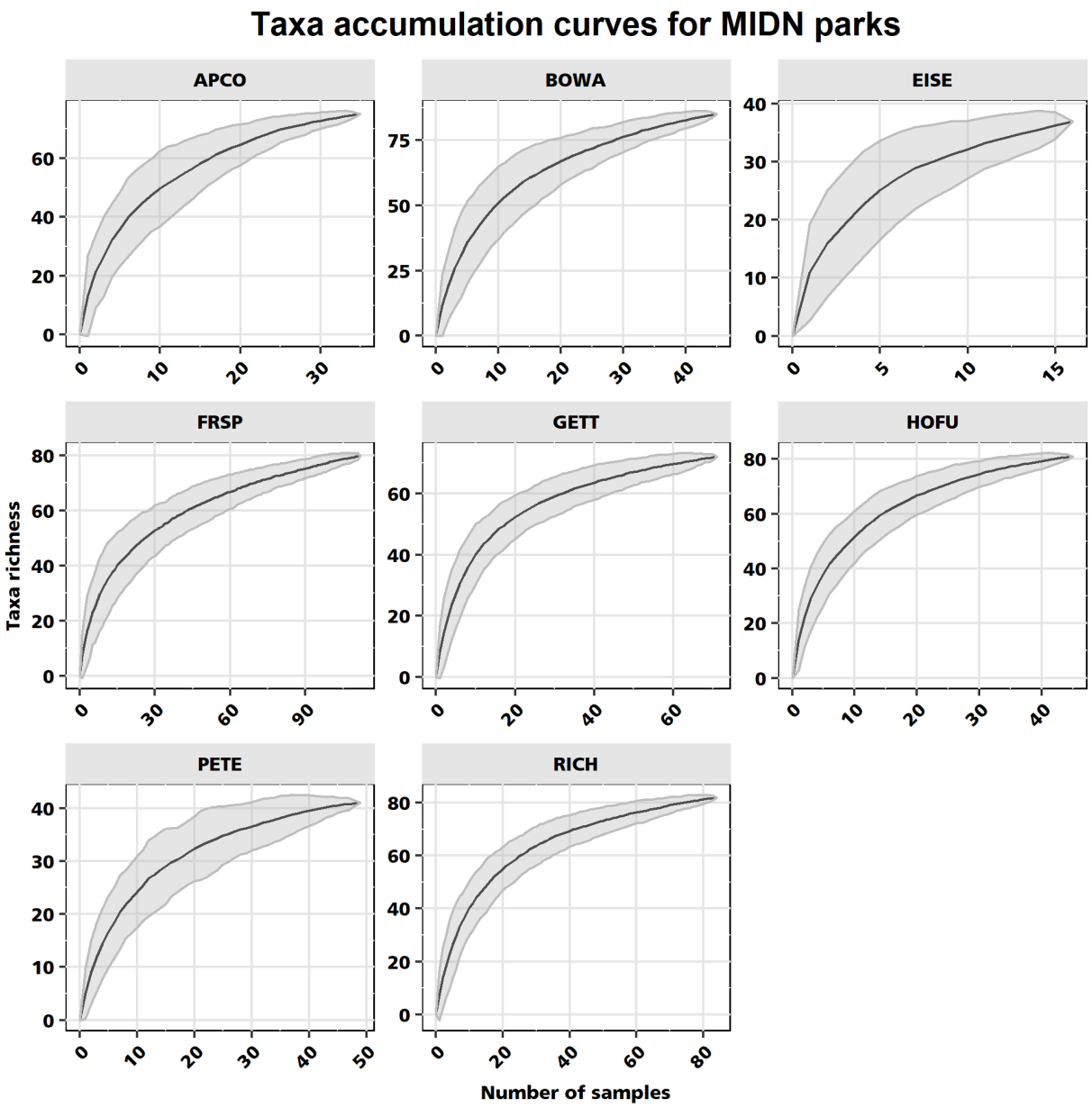


Figure 1. Taxa accumulation curves for MIDN parks. Gray area represents error around the curve (± 2 standard deviations). Note: Both X and Y axis scaling is independent, so direct comparisons between parks should not be made.

Multi-metric Scores

Relevant MMIs were calculated for each year for all MIDN sites. As noted above, much of the sampling in MIDN parks failed to capture the minimum number of individuals required by state protocols. As such, interpretation of the MMI scores should be done with caution. And, without minimum counts being met, MIDN sites cannot be characterized within the context of state impairment thresholds.

In general, multi-metric scores were both temporally variable across years and spatially variable within parks (Figures 2-5, Appendix B). In some cases scores varied by as much as 100% between consecutive years (e.g., BOWA 02, 2011-2012). MMI mean coefficients of variation (CV; i.e., on average, how variable were the MMIs at individual sites across sample years) ranged from a low of 1.4% (GETT 02) to a high of 63.7% (RICH 07; Table 5). A Mann-Kendall test failed to detect a significant trend ($p < 0.10$) at any of the sites. Several sites were excluded from the trend analysis due to limited data (<5 yrs.; i.e., APCO 01, FRSP 06, RICH 03, RICH 07, GETT 02, HOFU 02, and VAFO 01).

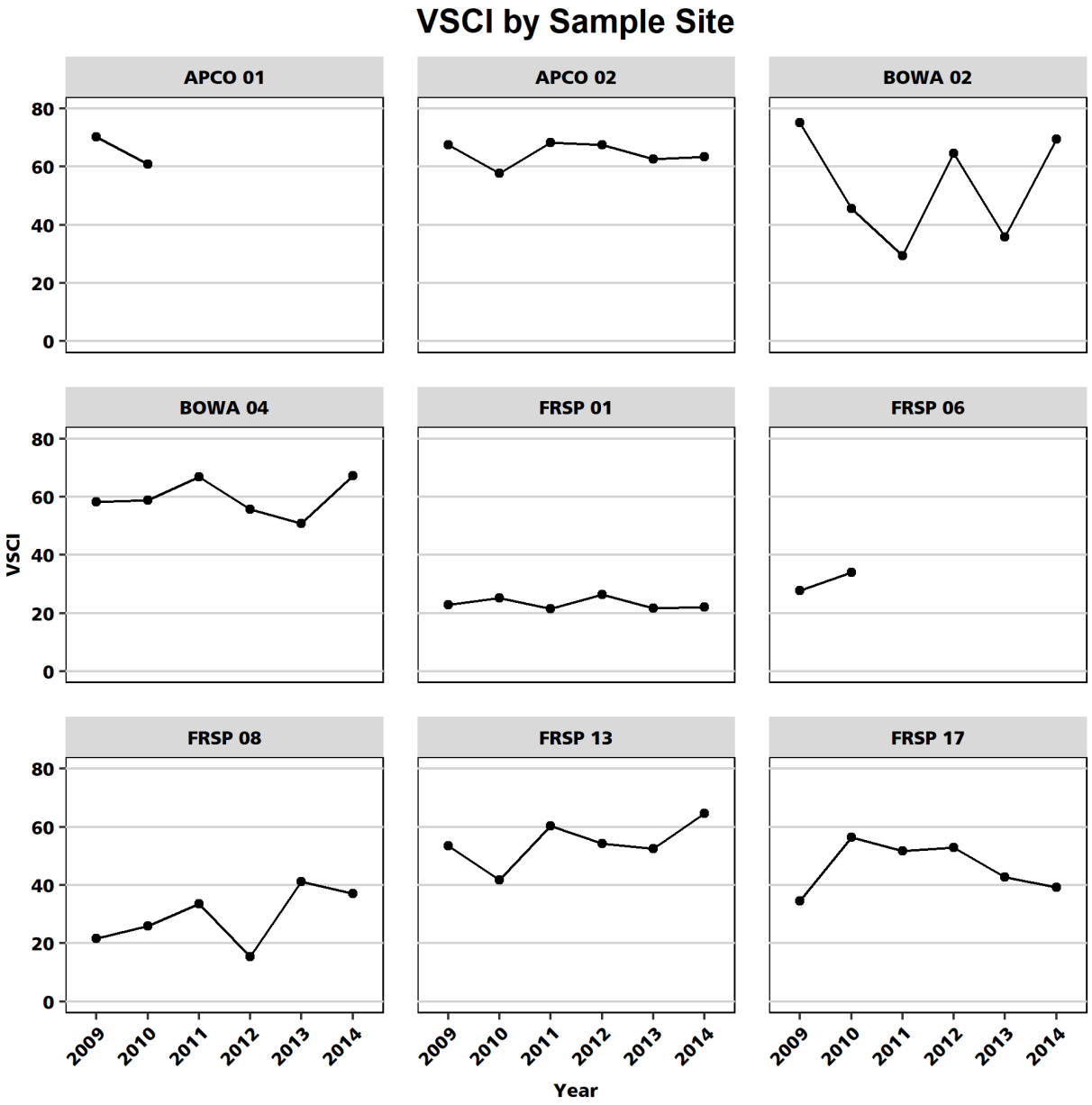


Figure 2. VSCI scores for Virginia piedmont sites (2009–2014).

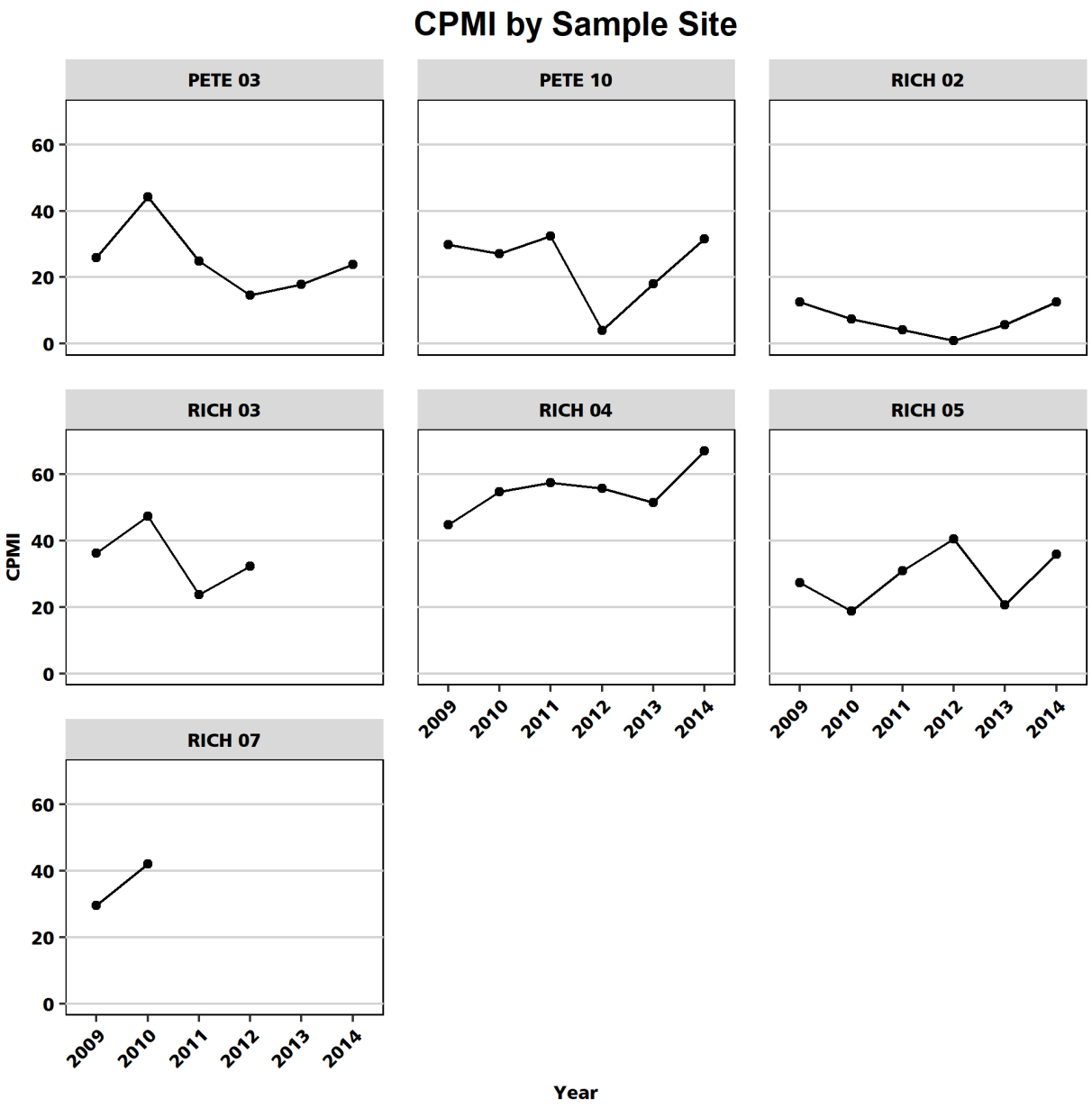


Figure 3. CPMI scores for Virginia coastal plain sites (2009–2014).

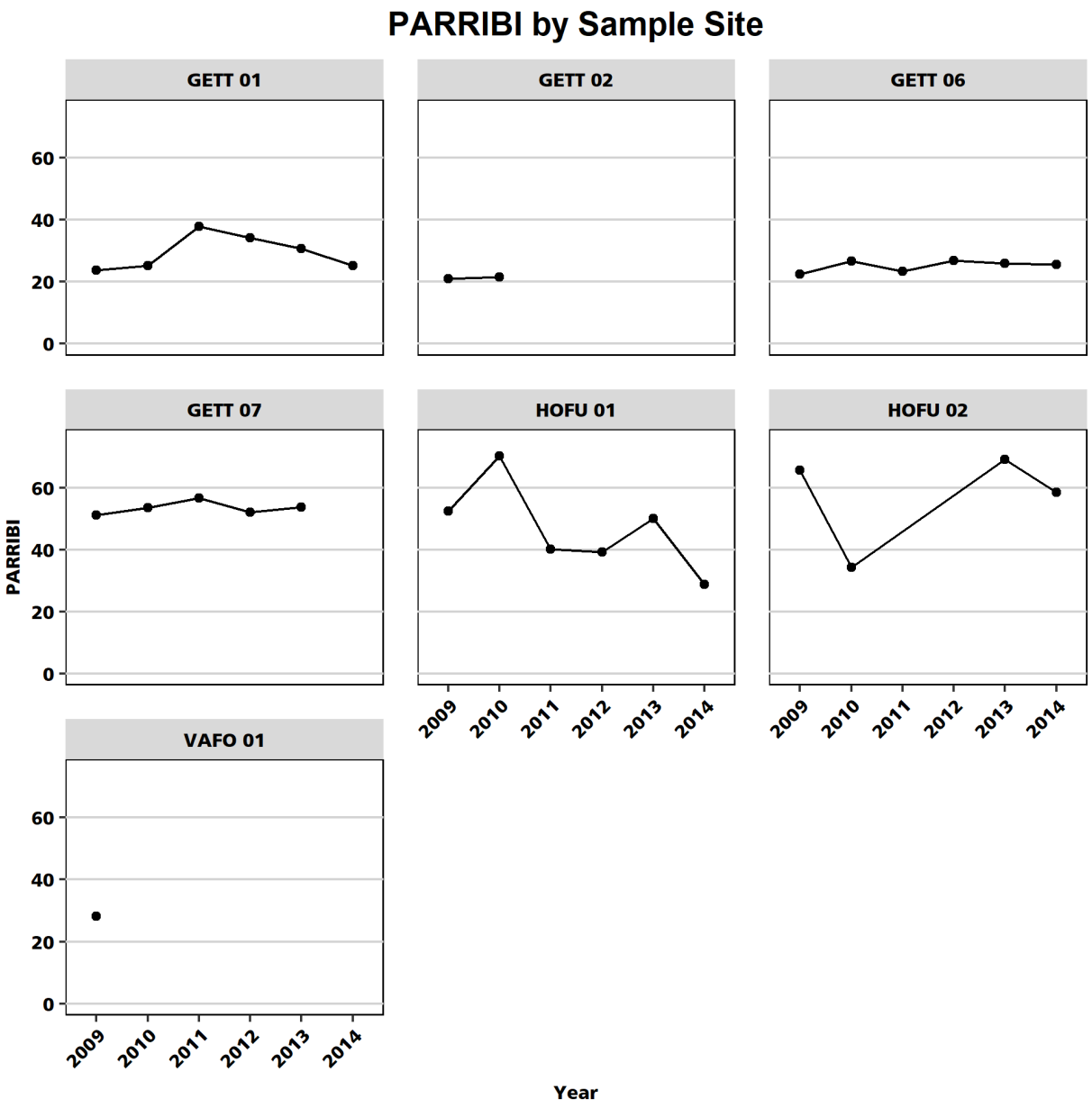


Figure 4. PARRIBI scores for Pennsylvania riffle/run sites (2009–2014).

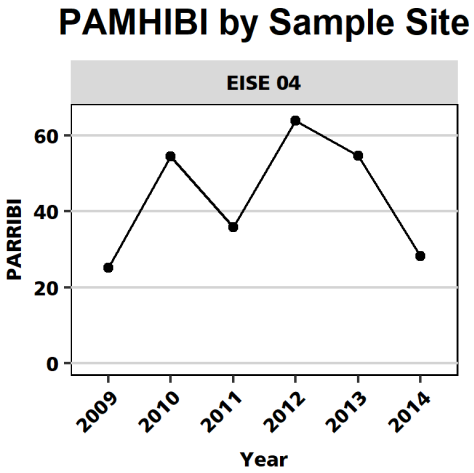


Figure 5. PAMHIBI scores for Pennsylvania pool/run sites (2009–2014).

Table 5. Temporal variability of MMI scores.

MMI	Mean CV	CV range
VSCI	17.0%	6.4–35.5%
CPMI	35.1%	13.1–63.7%
PARRIBI	15.0%	1.4–30.4%
PAMHIBI*	36.7%	NA

* During PAMHIBI development (PADEP 2007) , the root square mean error was reported. For the one MIDN site utilizing the PAMHIIBI (EISE 04), the RSME using the MIDN sampling protocol was 18.3.

Water Quality and Stream Habitat Assessments

The MIDN pilot protocol included the collection of 10 habitat metrics during site visits along with water quality observations. These metrics included visual estimation of channel substrates, velocity and depth, habitat variability, channel alterations and structure, bank stability, and riparian vegetation characteristics (Barbour et al. 1999). Although relationships between stream habitat and benthic macroinvertebrate indices where explored, these comparisons are not presented herein.

Pilot Design Assessment

MMIs and Sample Characteristics

The objectives of this pilot study were focused on characterizing the status and trends of macroinvertebrate communities and instream habitat, and in doing so, determining the feasibility of the pilot methods for long-term monitoring. The draft MIDN protocol (Voshell and Hiner 2015) indicates that state impairment thresholds will be utilized for assessing the status of MIDN streams and that habitat data will be utilized to help interpret benthic macroinvertebrate trends. However, a number of shortcomings are apparent with the pilot methods when state thresholds are utilized.

As noted in Voshell and Hiner (2015), attempts were made to ensure that the pilot MIDN protocol methods were similar to state methodologies. This was done to "facilitate data sharing, which would be especially useful for rating the ecological condition of MIDN stream as acceptable versus impaired" (Voshell and Hiner 2015). Pilot sample results suggest that the pilot protocol was not fully successful at meeting this goal. Though MIDN methods are similar to state methods, in general, the sampling effort (i.e., sample area) associated with the MIDN protocol is substantially less than state methodologies. In terms of sample area, pilot MIDN protocol sample areas are ~3–20 times smaller than state sample areas, depending on the specific comparison. The size difference is most substantial in riffle habitats. For example, the PARRIBI would be calculated from a sample of $0.3m^2$ of benthic habitat under MIDN methods, but $6.0m^2$ under PADEQ methods—more than an order of magnitude difference.

Sample area is certainly correlated with the number of macroinvertebrates collected in a sample and with taxa richness, though the increase may be non-uniform (Larson and Herlihy 1998). In addition, benthic macroinvertebrates can be patchily distributed, leading some protocols to focus on large sample areas with associated subsampling of the macroinvertebrates collected (Shull and Lookenbill 2018). Even so, it is possible that the sample area difference would not be a limitation of the pilot protocol if MIDN samples consistently resulted in the collection of enough individuals to utilize state thresholds for rating the ecological condition of park streams. Because of the high failure rate of MIDN samples to reach the required count of macroinvertebrates, the utilization of state thresholds was precluded. Indeed, it's possible that the use of the MMI as a trend indicator is subject to caution because MMIs were developed under conditions not met by the MIDN samples (i.e., minimum counts). Given that MMIs are difficult to develop and that MIDN is interested in utilizing state thresholds of impairment (Voshell and Hiner 2015), this failure to collect the required minimum number of individuals is a major flaw in the pilot sampling methodology.

On a positive note, the pilot MIDN protocol was successful at documenting the presence of a large percentage of the invertebrate taxa likely present at MIDN sites over a relatively short timeframe. It is possible that the MIDN pilot methods of sampling across a broad suite of habitats at all sites was more effective in taxa inventories than the more focused state methods may have been (i.e., only riffle sampling). Though the MIDN protocol did not have a specific objective targeting taxa inventories, the pilot protocol does appear to have been very successful in developing relatively full lists of benthic macroinvertebrate taxa for lotic sites in most MIDN parks.

Annual Variability of MMIs

Ideally, any temporal variability in an ecological index should be representative of ecological change and not representative of sampling variability. As such, annual variability of an ecological index should be small assuming ideal methods and no ecological change. State protocols have characterized "expected" or "normal" temporal variability under state protocol methods (Burton and Gerritsen 2003, PADEP 2007, 2015). Importantly, MMI temporal variability under the MIDN protocol is higher than published values for state methods (Table 6).

Table 6. Temporal variability of state methods vs. MIDN methods.

MMI	State reported measure of temporal variability	MIDN measure of temporal variability
VSCI	12.0 (CV)[1]	17.0 (CV)
CPMI	NA[2]	35.1 (CV)
PARRIBI	8.8 (CV)[3]	15.0 (CV)
PAMHIBI	6.6 (RSME)[4]	18.3 (RSME)

[1] Burton and Gerritsen (2003), [2]we were unable to find published values of CPMI temporal variability, [3]PADEP (2015), [4]PADEP (2007)

Utilizing the MIDN protocol, the mean CV for the VSCI at MIDN sites was 17.0%; 42% higher than that reported by VADEQ. Likewise, with Pennsylvania MMIs, MIDN measures of annual variability were higher. PARRIBI temporal variation (i.e., CV) under the MIDN protocol was 70% higher than the PADEP value. Similarly, for the PAMHIBI, MIDN temporal variation (i.e., RSME) was almost 200% higher than the PADEP measure. In this specific case, the MIDN value includes only one site (EISE 04), so caution in interpretation is warranted. Nevertheless, the difference is striking.

It should be noted that the comparisons between state published measures of temporal variability and MIDN values did not occur on identical streams or between the same years of sampling. It is possible that natural or environmentally induced variation was higher at MIDN sites or during the years that MIDN sampling occurred. We believe this to be unlikely given the number of sites and years included in the MIDN sampling and that every MMI assessed had a relatively high temporal variation when compared to state methods. In addition, all MIDN sites have some portion of their watersheds protected by national parks where increased ecosystem function and ecological stability would be expected (Meffe et al. 1997). Most likely, spatial variability in the macroinvertebrate community within individual sites (i.e., patchiness) in combination with a relatively small sample area (i.e., lack of sample representativeness) resulted in the increased temporal variation in MMI scores between sampling events (Merritt and Cummins 1996). Indeed, the positive relationship between area sampled and the number of organisms, as well as taxa richness is well established (Barbour and Gerritsen 1996). State methods that include a larger sample area may more effectively characterize the macroinvertebrate community and thus increase the representativeness of the sample, reduce the impacts of spatial variation, reduce total variation between sampling events, and therefore improve the ability to detect trends (Barbour and Gerritsen 1996, Vinson and Hawkins

1996, Sovell and Vondracek 1999). Although power analyses indicate that MIDN methods are sufficient for detecting trends (Dammeyer 2018), an improvement in this capability (i.e., power), in conjunction with an ability to use state thresholds of impairment is certainly desirable.

Water Quality and Stream Habitat

Water quality observations and stream habitat assessments are commonly included in aquatic monitoring programs (Bain and Stevenson 1999) and are required by both Pennsylvania and Virginia benthic macroinvertebrate monitoring protocols. In terms of habitat, both states require some version of the EPA RBP. Although EPA RBP habitat scores can be relatively imprecise (Kaufmann et al. 1999), numerous studies have documented the correlation of physical stream habitat (including the EPA RBP utilized in the MIDN pilot protocol) with benthic ecological health (Richards et al. 1996, Roth et al. 1996, Wood and Armitage 1997, Yuan and Norton 2003). In addition, we find value in these habitat assessments even if correlations of these measures with multi-metric indices are not significant. For example, a stream could score high in aggregate with a cumulative habitat score > 150 (i.e., “optimal”; Barbour et al (1999)) and still have individual habitat characteristics (e.g., high embeddedness) or other drivers (e.g., metals pollution) that negatively affect components of the benthic community. Even though these measures were not evaluated in this report, the benefit of collecting these data is well established and recognized here.

Modifications for Final Protocol

It is likely that the MIDN pilot methods are capable of generally meeting the objectives as defined in the pilot protocol, with a few important exceptions. Current methods have allowed for a characterization of the macroinvertebrate community and associated stream habitat. In addition, power analyses suggest that the sampling is adequate to detect trends (Dammeyer 2018). That said, under pilot methods, utilization of state thresholds of impairment is unsuitable due to the failure of these methods to collect an adequate number of individual macroinvertebrates in many samples. Indeed, the use of state MMIs in general (i.e., for trend assessments), as well as data sharing with states, may be precluded with low counts of individual macroinvertebrates because state protocols utilized minimum counts during MMI development. If pilot methods were continued, MIDN would need to develop its own MMI and establish its own thresholds of stream impairment in order to characterize the "health status" of streams. And, even if a MIDN MMI was developed, the potential problem of data sharing with the states would not be resolved. This is the primary deficiency identified in the MIDN pilot protocol analysis. Low individual counts are likely a result of less effort during MIDN field sampling events (i.e., sample area and number of jabs are low relative to state methods).

Another consequence of the low individual count may be increased temporal variation of MMIs under MIDN pilot methods. This increased variation would lower the ability of the monitoring program to detect trends in the macroinvertebrate community (Ramsey and Schafer 1997).

Creating new MMIs (and associated thresholds of impairment) would require a major effort that is beyond the capability of MIDN staff, and the utility of state MMIs and state thresholds of impairment are greatly valued. In addition, a large sample area with associated subsampling, as occurs in state protocols, may better maximize the efficiency of trend detection (Vinson and Hawkins 1996, Barbour et al. 1999, Sovell and Vondracek 1999). Due to these conclusions, MIDN decided to fully adopt state protocols for macroinvertebrate monitoring (Dammeyer 2018). The use of state protocol methods will allow for seamless integration with state benthic monitoring programs, including use of MMIs and thresholds of impairment.

In Virginia, state protocols require sampling of ~2m^2 riffle area via six d-net samples of 1/3m^2 each in piedmont locations and 20 jabs in coastal plain sites (VADEQ 2008). Following collection, macroinvertebrates are subsampled to 100 individuals, though Virginia plans to begin subsampling to 200 individuals in the near future (Jason Hill, VADEQ, personal communication). In Pennsylvania high-gradient streams (all MIDN current sampling locations are high-gradient streams), sampling occurs via six ~1m^2 riffle d-net samples for a total of ~6m^2 sample area. With Pennsylvania protocols, following collection, macroinvertebrates are subsampled to 200 individuals (Shull and Lookenbill 2018). MIDN now follows these collection methods, with only a minor deviation. During macroinvertebrate identification, MIDN will subsample to 300 individuals. Prior to analyses these 300 can be further subsampled to state minimum requirements. Subsampling to 300 individuals instead of the lower requirements of states, will allow MIDN to utilize current data even if states decide to increase minimum counts in the future.

A full description of current MIDN benthic macroinvertebrate sampling protocols can be found in Dammeyer (2018).

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Appendix A. Taxa list by park

Table A-1. APCO taxa list.

Park	Class	Order	Family	Genus	Species
APCO	Bivalvia	Veneroida	Sphaeriidae	NA	NA
APCO	Clitellata	NA	NA	NA	NA
APCO	Gastropoda	NA	Pleuroceridae	NA	NA
APCO	Insecta	Coleoptera	Dryopidae	Helichus	NA
APCO	Insecta	Coleoptera	Elmidae	Ancyronyx	NA
APCO	Insecta	Coleoptera	Elmidae	Dubiraphia	NA
APCO	Insecta	Coleoptera	Elmidae	Macronychus	NA
APCO	Insecta	Coleoptera	Elmidae	Microcylloepus	NA
APCO	Insecta	Coleoptera	Elmidae	Optioservus	NA
APCO	Insecta	Coleoptera	Elmidae	Oulimnius	latiusculus
APCO	Insecta	Coleoptera	Elmidae	Stenelmis	NA
APCO	Insecta	Coleoptera	Hydrophilidae	Tropisternus	NA
APCO	Insecta	Coleoptera	Psephenidae	Psephenus	herricki
APCO	Insecta	Coleoptera	Ptilodactylidae	Anchytarsus	NA
APCO	Insecta	Diptera	Ceratopogonidae	NA	NA
APCO	Insecta	Diptera	Chironomidae	NA	NA
APCO	Insecta	Diptera	Empididae	Chelifera	NA
APCO	Insecta	Diptera	Empididae	Hemerodromia	NA
APCO	Insecta	Diptera	Physidae	NA	NA
APCO	Insecta	Diptera	Simuliidae	Prosimulium	NA
APCO	Insecta	Diptera	Simuliidae	Simulium	NA
APCO	Insecta	Diptera	Tabanidae	NA	NA
APCO	Insecta	Diptera	Tipulidae	Antocha	NA
APCO	Insecta	Diptera	Tipulidae	Tipula	NA
APCO	Insecta	Ephemeroptera	Ameletidae	Ameletus	NA
APCO	Insecta	Ephemeroptera	Baetidae	Baetis	NA
APCO	Insecta	Ephemeroptera	Baetidae	Centroptilum	NA
APCO	Insecta	Ephemeroptera	Baetiscidae	Baetisca	NA
APCO	Insecta	Ephemeroptera	Caenidae	Caenis	NA

Park	Class	Order	Family	Genus	Species
APCO	Insecta	Ephemeroptera	Ephemerellidae	Ephemerella	NA
APCO	Insecta	Ephemeroptera	Ephemerellidae	Eurylophella	NA
APCO	Insecta	Ephemeroptera	Heptageniidae	Epeorus	NA
APCO	Insecta	Ephemeroptera	Heptageniidae	Leucrocuta	NA
APCO	Insecta	Ephemeroptera	Heptageniidae	Maccaffertium	NA
APCO	Insecta	Ephemeroptera	Heptageniidae	Stenacron	NA
APCO	Insecta	Ephemeroptera	Isonychiidae	Isonychia	NA
APCO	Insecta	Ephemeroptera	Leptophlebiidae	Leptophlebia	NA
APCO	Insecta	Ephemeroptera	Leptophlebiidae	Paraleptophlebia	NA
APCO	Insecta	Lepidoptera	Crambidae	Petrophila	NA
APCO	Insecta	Megaloptera	Corydalidae	Corydalus	cornutus
APCO	Insecta	Megaloptera	Corydalidae	Nigronia	serricornis
APCO	Insecta	Odonata	Aeshnidae	Boyeria	NA
APCO	Insecta	Odonata	Calopterygidae	Calopteryx	NA
APCO	Insecta	Odonata	Coenagrionidae	Argia	NA
APCO	Insecta	Odonata	Cordulegastridae	Cordulegaster	NA
APCO	Insecta	Odonata	Corduliidae	Macromia	NA
APCO	Insecta	Odonata	Gomphidae	Gomphus	NA
APCO	Insecta	Odonata	Gomphidae	Lanthus	NA
APCO	Insecta	Odonata	Gomphidae	Stylogomphus	NA
APCO	Insecta	Odonata	Libellulidae	Libellula	NA
APCO	Insecta	Plecoptera	Capniidae	Allocapnia	NA
APCO	Insecta	Plecoptera	Leuctridae	Leuctra	NA
APCO	Insecta	Plecoptera	Nemouridae	Amphinemura	NA
APCO	Insecta	Plecoptera	Nemouridae	Ostrocerca	NA
APCO	Insecta	Plecoptera	Peltoperlidae	Tallaperla	NA
APCO	Insecta	Plecoptera	Perlidae	Acroneuria	NA
APCO	Insecta	Plecoptera	Perlidae	Eccoptura	xanthenes
APCO	Insecta	Plecoptera	Perlodidae	Clioperla	clio
APCO	Insecta	Plecoptera	Perlodidae	Isoperla	NA
APCO	Insecta	Plecoptera	Taeniopterygidae	Oemopteryx	NA

Park	Class	Order	Family	Genus	Species
APCO	Insecta	Trichoptera	Hydropsychidae	Cheumatopsyche	NA
APCO	Insecta	Trichoptera	Hydropsychidae	Hydropsyche	NA
APCO	Insecta	Trichoptera	Lepidostomatidae	Lepidostoma	NA
APCO	Insecta	Trichoptera	Leptoceridae	Mystacides	NA
APCO	Insecta	Trichoptera	Leptoceridae	Triaenodes	NA
APCO	Insecta	Trichoptera	Limnephilidae	Ironoquia	NA
APCO	Insecta	Trichoptera	Limnephilidae	Pycnopsyche	NA
APCO	Insecta	Trichoptera	Philopotamidae	Chimarra	NA
APCO	Insecta	Trichoptera	Polycentropodidae	Polycentropus	NA
APCO	Insecta	Trichoptera	Psychomyiidae	Lype	diversa
APCO	Insecta	Trichoptera	Rhyacophilidae	Rhyacophila	NA
APCO	Insecta	Trichoptera	Uenoidae	Neophylax	NA
APCO	Malacostraca	Amphipoda	Crangonyctidae	Crangonyx	NA
APCO	Malacostraca	Decapoda	Cambaridae	NA	NA
APCO	Malacostraca	Isopoda	Asellidae	Caecidotea	NA

Table A-2. BOWA taxa list.

Park	Class	Order	Family	Genus	Species
BOWA	Bivalvia	Veneroida	Corbiculidae	Corbicula	NA
BOWA	Bivalvia	Veneroida	Sphaeriidae	NA	NA
BOWA	Clitellata	NA	NA	NA	NA
BOWA	Gastropoda	NA	Pleuroceridae	NA	NA
BOWA	Insecta	Coleoptera	Dryopidae	Helichus	NA
BOWA	Insecta	Coleoptera	Elmidae	Ancyronyx	NA
BOWA	Insecta	Coleoptera	Elmidae	Dubiraphia	NA
BOWA	Insecta	Coleoptera	Elmidae	Macronychus	NA
BOWA	Insecta	Coleoptera	Elmidae	Optioservus	NA
BOWA	Insecta	Coleoptera	Elmidae	Oulimnius	latiusculus
BOWA	Insecta	Coleoptera	Elmidae	Promoresia	NA
BOWA	Insecta	Coleoptera	Elmidae	Stenelmis	NA
BOWA	Insecta	Coleoptera	Gyrinidae	Dineutus	NA
BOWA	Insecta	Coleoptera	Psephenidae	Ectopria	NA
BOWA	Insecta	Coleoptera	Psephenidae	Psephenus	herricki
BOWA	Insecta	Coleoptera	Ptilodactylidae	Anchytarsus	NA
BOWA	Insecta	Diptera	Blephariceridae	Blepharicera	NA
BOWA	Insecta	Diptera	Ceratopogonidae	NA	NA
BOWA	Insecta	Diptera	Chironomidae	NA	NA
BOWA	Insecta	Diptera	Dixidae	Dixa	NA
BOWA	Insecta	Diptera	Empididae	Chelifera	NA
BOWA	Insecta	Diptera	Empididae	Hemerodromia	NA
BOWA	Insecta	Diptera	Physidae	NA	NA
BOWA	Insecta	Diptera	Simuliidae	Prosimulium	NA
BOWA	Insecta	Diptera	Simuliidae	Simulium	NA
BOWA	Insecta	Diptera	Tabanidae	NA	NA
BOWA	Insecta	Diptera	Tipulidae	Antocha	NA
BOWA	Insecta	Diptera	Tipulidae	Dicranota	NA
BOWA	Insecta	Diptera	Tipulidae	Hexatoma	NA
BOWA	Insecta	Diptera	Tipulidae	Tipula	NA
BOWA	Insecta	Ephemeroptera	Ameletidae	Ameletus	NA

Park	Class	Order	Family	Genus	Species
BOWA	Insecta	Ephemeroptera	Baetidae	Acentrella	NA
BOWA	Insecta	Ephemeroptera	Baetidae	Baetis	NA
BOWA	Insecta	Ephemeroptera	Baetidae	Centroptilum	NA
BOWA	Insecta	Ephemeroptera	Ephemerellidae	Ephemerella	NA
BOWA	Insecta	Ephemeroptera	Ephemerellidae	Eurylophella	NA
BOWA	Insecta	Ephemeroptera	Ephemerellidae	Serratella	NA
BOWA	Insecta	Ephemeroptera	Ephemeridae	Hexagenia	NA
BOWA	Insecta	Ephemeroptera	Heptageniidae	Epeorus	NA
BOWA	Insecta	Ephemeroptera	Heptageniidae	Maccaffertium	NA
BOWA	Insecta	Ephemeroptera	Heptageniidae	Rhithrogena	NA
BOWA	Insecta	Ephemeroptera	Heptageniidae	Stenacron	NA
BOWA	Insecta	Ephemeroptera	Isonychiidae	Isonychia	NA
BOWA	Insecta	Ephemeroptera	Leptophlebiidae	Leptophlebia	NA
BOWA	Insecta	Ephemeroptera	Leptophlebiidae	Paraleptophlebia	NA
BOWA	Insecta	Ephemeroptera	Metretopodidae	Siphloplecton	NA
BOWA	Insecta	Megaloptera	Corydalidae	Corydalus	cornutus
BOWA	Insecta	Megaloptera	Corydalidae	Nigronia	serricornis
BOWA	Insecta	Megaloptera	Sialidae	Sialis	NA
BOWA	Insecta	Odonata	Aeshnidae	Boyeria	NA
BOWA	Insecta	Odonata	Calopterygidae	Calopteryx	NA
BOWA	Insecta	Odonata	Coenagrionidae	Argia	NA
BOWA	Insecta	Odonata	Cordulegastridae	Cordulegaster	NA
BOWA	Insecta	Odonata	Corduliidae	Macromia	NA
BOWA	Insecta	Odonata	Gomphidae	Gomphus	NA
BOWA	Insecta	Odonata	Gomphidae	Lanthus	NA
BOWA	Insecta	Odonata	Gomphidae	Ophiogomphus	NA
BOWA	Insecta	Odonata	Gomphidae	Stylogomphus	NA
BOWA	Insecta	Plecoptera	Capniidae	Allocapnia	NA
BOWA	Insecta	Plecoptera	Chloroperlidae	Haploperla	brevis
BOWA	Insecta	Plecoptera	Leuctridae	Leuctra	NA
BOWA	Insecta	Plecoptera	Nemouridae	Amphinemura	NA

Park	Class	Order	Family	Genus	Species
BOWA	Insecta	Plecoptera	Nemouridae	Ostrocerca	NA
BOWA	Insecta	Plecoptera	Peltoperlidae	Tallaperla	NA
BOWA	Insecta	Plecoptera	Perlidae	Eccoptura	xanthenes
BOWA	Insecta	Plecoptera	Perlodidae	Clioperla	clio
BOWA	Insecta	Plecoptera	Perlodidae	Diploperla	NA
BOWA	Insecta	Plecoptera	Perlodidae	Isoperla	NA
BOWA	Insecta	Plecoptera	Taeniopterygidae	Oemopteryx	NA
BOWA	Insecta	Plecoptera	Taeniopterygidae	Strophopteryx	NA
BOWA	Insecta	Trichoptera	Hydropsychidae	Cheumatopsyche	NA
BOWA	Insecta	Trichoptera	Hydropsychidae	Diplectrona	modesta
BOWA	Insecta	Trichoptera	Hydropsychidae	Hydropsyche	NA
BOWA	Insecta	Trichoptera	Hydroptilidae	Hydroptila	NA
BOWA	Insecta	Trichoptera	Leptoceridae	Oecetis	NA
BOWA	Insecta	Trichoptera	Leptoceridae	Triaenodes	NA
BOWA	Insecta	Trichoptera	Limnephilidae	Ironoquia	NA
BOWA	Insecta	Trichoptera	Limnephilidae	Pycnopsyche	NA
BOWA	Insecta	Trichoptera	Philopotamidae	Chimarra	NA
BOWA	Insecta	Trichoptera	Phryganeidae	Ptilostomis	NA
BOWA	Insecta	Trichoptera	Polycentropodidae	Polycentropus	NA
BOWA	Insecta	Trichoptera	Psychomyiidae	Lype	diversa
BOWA	Insecta	Trichoptera	Psychomyiidae	Psychomyia	NA
BOWA	Insecta	Trichoptera	Uenoidae	Neophylax	NA
BOWA	Malacostraca	Decapoda	Cambaridae	NA	NA

Table A-3. EISE taxa list.

Park	Class	Order	Family	Genus	Species
EISE	Bivalvia	Veneroida	Corbiculidae	Corbicula	NA
EISE	Bivalvia	Veneroida	Sphaeriidae	NA	NA
EISE	Clitellata	NA	NA	NA	NA
EISE	Gastropoda	Basommatophora	Planorbidae	NA	NA
EISE	Insecta	Coleoptera	Elmidae	Dubiraphia	NA
EISE	Insecta	Coleoptera	Elmidae	Microcylloepus	NA
EISE	Insecta	Coleoptera	Elmidae	Stenelmis	NA
EISE	Insecta	Coleoptera	Hydrophilidae	Berosus	NA
EISE	Insecta	Coleoptera	Psephenidae	Ectopria	NA
EISE	Insecta	Coleoptera	Psephenidae	Psephenus	herricki
EISE	Insecta	Coleoptera	Scirtidae	Scirtes	NA
EISE	Insecta	Diptera	Chironomidae	NA	NA
EISE	Insecta	Diptera	Empididae	Hemerodromia	NA
EISE	Insecta	Diptera	Lymnaeidae	NA	NA
EISE	Insecta	Diptera	Physidae	NA	NA
EISE	Insecta	Diptera	Simuliidae	Prosimulium	NA
EISE	Insecta	Diptera	Simuliidae	Simulium	NA
EISE	Insecta	Diptera	Stratiomyidae	NA	NA
EISE	Insecta	Ephemeroptera	Baetidae	Baetis	NA
EISE	Insecta	Ephemeroptera	Caenidae	Caenis	NA
EISE	Insecta	Ephemeroptera	Heptageniidae	Stenonema	femoratum
EISE	Insecta	Ephemeroptera	Isonychiidae	Isonychia	NA
EISE	Insecta	Ephemeroptera	Leptophlebiidae	Paraleptophlebia	NA
EISE	Insecta	Odonata	Coenagrionidae	Argia	NA
EISE	Insecta	Plecoptera	Capniidae	Allocapnia	NA
EISE	Insecta	Plecoptera	Nemouridae	Amphinemura	NA
EISE	Insecta	Plecoptera	Perlidae	Perlesta	NA
EISE	Insecta	Trichoptera	Hydropsychidae	Cheumatopsyche	NA
EISE	Insecta	Trichoptera	Hydropsychidae	Hydropsyche	NA
EISE	Insecta	Trichoptera	Hydroptilidae	Hydroptila	NA
EISE	Insecta	Trichoptera	Limnephilidae	Ironoquia	NA

Park	Class	Order	Family	Genus	Species
EISE	Insecta	Trichoptera	Philopotamidae	Chimarra	NA
EISE	Insecta	Trichoptera	Uenoidae	Neophylax	NA
EISE	Malacostraca	Amphipoda	Crangonyctidae	Crangonyx	NA
EISE	Malacostraca	Amphipoda	Hyalellidae	Hyalella	azteca
EISE	Malacostraca	Decapoda	Cambaridae	NA	NA
EISE	Trepaxonemata	Neoophora	Planariidae	NA	NA

Table A-4. FRSP taxa list.

Park	Class	Order	Family	Genus	Species
FRSP	Arachnida	NA	NA	NA	NA
FRSP	Bivalvia	Veneroida	Corbiculidae	Corbicula	NA
FRSP	Bivalvia	Veneroida	Sphaeriidae	NA	NA
FRSP	Clitellata	NA	NA	NA	NA
FRSP	Insecta	Coleoptera	Dryopidae	Helichus	NA
FRSP	Insecta	Coleoptera	Dytiscidae	NA	NA
FRSP	Insecta	Coleoptera	Elmidae	Ancyronyx	NA
FRSP	Insecta	Coleoptera	Elmidae	Dubiraphia	NA
FRSP	Insecta	Coleoptera	Elmidae	Macronychus	NA
FRSP	Insecta	Coleoptera	Elmidae	Optioservus	NA
FRSP	Insecta	Coleoptera	Elmidae	Oulimnius	latiusculus
FRSP	Insecta	Coleoptera	Elmidae	Stenelmis	NA
FRSP	Insecta	Coleoptera	Gyrinidae	Dineutus	NA
FRSP	Insecta	Coleoptera	Gyrinidae	Gyrinus	NA
FRSP	Insecta	Coleoptera	Scirtidae	Scirtes	NA
FRSP	Insecta	Diptera	Ceratopogonidae	NA	NA
FRSP	Insecta	Diptera	Chironomidae	NA	NA
FRSP	Insecta	Diptera	Empididae	Chelifera	NA
FRSP	Insecta	Diptera	Empididae	Hemerodromia	NA
FRSP	Insecta	Diptera	Physidae	NA	NA
FRSP	Insecta	Diptera	Simuliidae	Prosimulium	NA
FRSP	Insecta	Diptera	Simuliidae	Simulium	NA
FRSP	Insecta	Diptera	Tabanidae	NA	NA
FRSP	Insecta	Diptera	Tipulidae	Antocha	NA
FRSP	Insecta	Diptera	Tipulidae	Hexatoma	NA
FRSP	Insecta	Diptera	Tipulidae	Tipula	NA
FRSP	Insecta	Ephemeroptera	Ameletidae	Ameletus	NA
FRSP	Insecta	Ephemeroptera	Baetidae	Acentrella	NA
FRSP	Insecta	Ephemeroptera	Baetidae	Acerpenna	NA
FRSP	Insecta	Ephemeroptera	Baetidae	Baetis	NA
FRSP	Insecta	Ephemeroptera	Baetidae	Centroptilum	NA

Park	Class	Order	Family	Genus	Species
FRSP	Insecta	Ephemeroptera	Caenidae	Caenis	NA
FRSP	Insecta	Ephemeroptera	Ephemerellidae	Ephemerella	NA
FRSP	Insecta	Ephemeroptera	Heptageniidae	Leucrocuta	NA
FRSP	Insecta	Ephemeroptera	Heptageniidae	Maccaffertium	NA
FRSP	Insecta	Ephemeroptera	Leptophlebiidae	Leptophlebia	NA
FRSP	Insecta	Ephemeroptera	Leptophlebiidae	Paraleptophlebia	NA
FRSP	Insecta	Ephemeroptera	Siphlonuridae	Siphlonurus	NA
FRSP	Insecta	Hemiptera	Gerridae	Aquarius	NA
FRSP	Insecta	Hemiptera	Nepidae	Ranatra	NA
FRSP	Insecta	Megaloptera	Corydalidae	Corydalus	cornutus
FRSP	Insecta	Megaloptera	Sialidae	Sialis	NA
FRSP	Insecta	Odonata	Aeshnidae	Boyeria	NA
FRSP	Insecta	Odonata	Calopterygidae	Calopteryx	NA
FRSP	Insecta	Odonata	Coenagrionidae	Argia	NA
FRSP	Insecta	Odonata	Cordulegastridae	Cordulegaster	NA
FRSP	Insecta	Odonata	Gomphidae	Gomphus	NA
FRSP	Insecta	Odonata	Gomphidae	Lanthus	NA
FRSP	Insecta	Odonata	Gomphidae	Progomphus	NA
FRSP	Insecta	Odonata	Libellulidae	Libellula	NA
FRSP	Insecta	Plecoptera	Capniidae	Allocapnia	NA
FRSP	Insecta	Plecoptera	Chloroperlidae	Haploperla	brevis
FRSP	Insecta	Plecoptera	Leuctridae	Leuctra	NA
FRSP	Insecta	Plecoptera	Nemouridae	Amphinemura	NA
FRSP	Insecta	Plecoptera	Nemouridae	Ostrocerca	NA
FRSP	Insecta	Plecoptera	Perlidae	Eccoptura	xanthenes
FRSP	Insecta	Plecoptera	Perlidae	Perlesta	NA
FRSP	Insecta	Plecoptera	Perlodidae	Clioperla	clio
FRSP	Insecta	Plecoptera	Perlodidae	Diploperla	NA
FRSP	Insecta	Plecoptera	Perlodidae	Isoperla	NA
FRSP	Insecta	Plecoptera	Taeniopterygidae	Taeniopteryx	NA
FRSP	Insecta	Trichoptera	Hydropsychidae	Cheumatopsyche	NA

Park	Class	Order	Family	Genus	Species
FRSP	Insecta	Trichoptera	Hydropsychidae	Diplectrona	modesta
FRSP	Insecta	Trichoptera	Hydropsychidae	Hydropsyche	NA
FRSP	Insecta	Trichoptera	Hydroptilidae	Oxyethira	NA
FRSP	Insecta	Trichoptera	Lepidostomatidae	Lepidostoma	NA
FRSP	Insecta	Trichoptera	Leptoceridae	Ceraclea	NA
FRSP	Insecta	Trichoptera	Leptoceridae	Triaenodes	NA
FRSP	Insecta	Trichoptera	Limnephilidae	Ironoquia	NA
FRSP	Insecta	Trichoptera	Limnephilidae	Pycnopsyche	NA
FRSP	Insecta	Trichoptera	Philopotamidae	Chimarra	NA
FRSP	Insecta	Trichoptera	Phryganeidae	Ptilostomis	NA
FRSP	Insecta	Trichoptera	Psychomyiidae	Lype	diversa
FRSP	Insecta	Trichoptera	Rhyacophilidae	Rhyacophila	NA
FRSP	Insecta	Trichoptera	Uenoidae	Neophylax	NA
FRSP	Malacostraca	Amphipoda	Crangonyctidae	Crangonyx	NA
FRSP	Malacostraca	Amphipoda	Hyalellidae	Hyalella	azteca
FRSP	Malacostraca	Decapoda	Cambaridae	NA	NA
FRSP	Malacostraca	Isopoda	Asellidae	Asellus	NA
FRSP	Trepaxonemata	Neoophora	Planariidae	NA	NA

Table A-5. GETT taxa list.

Park	Class	Order	Family	Genus	Species
GETT	Bivalvia	Veneroida	Corbiculidae	Corbicula	NA
GETT	Bivalvia	Veneroida	Sphaeriidae	NA	NA
GETT	Clitellata	NA	NA	NA	NA
GETT	Gastropoda	Basommatophora	Ancylidae	Ferrissia	NA
GETT	Gastropoda	Basommatophora	Planorbidae	NA	NA
GETT	Insecta	Coleoptera	Dytiscidae	NA	NA
GETT	Insecta	Coleoptera	Elmidae	Ancyronyx	NA
GETT	Insecta	Coleoptera	Elmidae	Dubiraphia	NA
GETT	Insecta	Coleoptera	Elmidae	Macronychus	NA
GETT	Insecta	Coleoptera	Elmidae	Optioservus	NA
GETT	Insecta	Coleoptera	Elmidae	Stenelmis	NA
GETT	Insecta	Coleoptera	Halipilidae	Peltodytes	NA
GETT	Insecta	Coleoptera	Hydrophilidae	Enochrus	NA
GETT	Insecta	Coleoptera	Hydrophilidae	Tropisternus	NA
GETT	Insecta	Coleoptera	Psephenidae	Ectopria	NA
GETT	Insecta	Coleoptera	Psephenidae	Psephenus	herricki
GETT	Insecta	Coleoptera	Scirtidae	Scirtes	NA
GETT	Insecta	Diptera	Ceratopogonidae	NA	NA
GETT	Insecta	Diptera	Chironomidae	NA	NA
GETT	Insecta	Diptera	Empididae	Hemerodromia	NA
GETT	Insecta	Diptera	Lymnaeidae	NA	NA
GETT	Insecta	Diptera	Physidae	NA	NA
GETT	Insecta	Diptera	Simuliidae	Prosimulium	NA
GETT	Insecta	Diptera	Simuliidae	Simulium	NA
GETT	Insecta	Diptera	Tabanidae	NA	NA
GETT	Insecta	Diptera	Tipulidae	Antocha	NA
GETT	Insecta	Diptera	Tipulidae	Hexatoma	NA
GETT	Insecta	Diptera	Tipulidae	Tipula	NA
GETT	Insecta	Ephemeroptera	Ameletidae	Ameletus	NA
GETT	Insecta	Ephemeroptera	Baetidae	Acentrella	NA
GETT	Insecta	Ephemeroptera	Baetidae	Baetis	NA

Park	Class	Order	Family	Genus	Species
GETT	Insecta	Ephemeroptera	Baetidae	Centroptilum	NA
GETT	Insecta	Ephemeroptera	Caenidae	Caenis	NA
GETT	Insecta	Ephemeroptera	Ephemerellidae	Eurylophella	NA
GETT	Insecta	Ephemeroptera	Heptageniidae	Maccaffertium	NA
GETT	Insecta	Ephemeroptera	Heptageniidae	Stenonema	femoratum
GETT	Insecta	Ephemeroptera	Leptophlebiidae	Leptophlebia	NA
GETT	Insecta	Ephemeroptera	Leptophlebiidae	Paraleptophlebia	NA
GETT	Insecta	Megaloptera	Corydalidae	Corydalus	cornutus
GETT	Insecta	Megaloptera	Corydalidae	Nigronia	serricornis
GETT	Insecta	Odonata	Aeshnidae	Anax	NA
GETT	Insecta	Odonata	Aeshnidae	Boyeria	NA
GETT	Insecta	Odonata	Calopterygidae	Calopteryx	NA
GETT	Insecta	Odonata	Coenagrionidae	Argia	NA
GETT	Insecta	Odonata	Coenagrionidae	NA	NA
GETT	Insecta	Odonata	Gomphidae	Gomphus	NA
GETT	Insecta	Odonata	Libellulidae	Libellula	NA
GETT	Insecta	Plecoptera	Capniidae	Allocapnia	NA
GETT	Insecta	Plecoptera	Leuctridae	Leuctra	NA
GETT	Insecta	Plecoptera	Nemouridae	Amphinemura	NA
GETT	Insecta	Plecoptera	Perlidae	Perlesta	NA
GETT	Insecta	Plecoptera	Perlodidae	Clioperla	clio
GETT	Insecta	Plecoptera	Perlodidae	Isoperla	NA
GETT	Insecta	Trichoptera	Hydropsychidae	Cheumatopsyche	NA
GETT	Insecta	Trichoptera	Hydropsychidae	Hydropsyche	NA
GETT	Insecta	Trichoptera	Hydroptilidae	Hydroptila	NA
GETT	Insecta	Trichoptera	Hydroptilidae	Ochrotrichia	NA
GETT	Insecta	Trichoptera	Limnephilidae	Ironoquia	NA
GETT	Insecta	Trichoptera	Limnephilidae	Limnephilus	NA
GETT	Insecta	Trichoptera	Limnephilidae	Pycnopsyche	NA
GETT	Insecta	Trichoptera	Limnephilidae	NA	NA
GETT	Insecta	Trichoptera	Philopotamidae	Chimarra	NA

Park	Class	Order	Family	Genus	Species
GETT	Insecta	Trichoptera	Phryganeidae	Ptilostomis	NA
GETT	Insecta	Trichoptera	Polycentropodidae	Polycentropus	NA
GETT	Insecta	Trichoptera	Rhyacophilidae	Rhyacophila	NA
GETT	Insecta	Trichoptera	Uenoidae	Neophylax	NA
GETT	Malacostraca	Amphipoda	Crangonyctidae	Crangonyx	NA
GETT	Malacostraca	Amphipoda	Hyalellidae	Hyalella	azteca
GETT	Malacostraca	Decapoda	Cambaridae	NA	NA
GETT	Malacostraca	Isopoda	Asellidae	Asellus	NA
GETT	Malacostraca	Isopoda	Asellidae	Caecidotea	NA
GETT	Trepaxonemata	Neoophora	Planariidae	NA	NA

Table A-6. HOFU taxa list.

Park	Class	Order	Family	Genus	Species
HOFU	Arachnida	NA	NA	NA	NA
HOFU	Bivalvia	Veneroida	Corbiculidae	Corbicula	NA
HOFU	Bivalvia	Veneroida	Sphaeriidae	NA	NA
HOFU	Clitellata	NA	NA	NA	NA
HOFU	Gastropoda	NA	Pleuroceridae	NA	NA
HOFU	Insecta	Coleoptera	Dryopidae	Helichus	NA
HOFU	Insecta	Coleoptera	Elmidae	Ancyronyx	NA
HOFU	Insecta	Coleoptera	Elmidae	Dubiraphia	NA
HOFU	Insecta	Coleoptera	Elmidae	Macronychus	NA
HOFU	Insecta	Coleoptera	Elmidae	Optioservus	NA
HOFU	Insecta	Coleoptera	Elmidae	Oulimnius	latiusculus
HOFU	Insecta	Coleoptera	Elmidae	Promoresia	NA
HOFU	Insecta	Coleoptera	Elmidae	Stenelmis	NA
HOFU	Insecta	Coleoptera	Ptilodactylidae	Anchytarsus	NA
HOFU	Insecta	Diptera	Ceratopogonidae	NA	NA
HOFU	Insecta	Diptera	Chironomidae	NA	NA
HOFU	Insecta	Diptera	Empididae	Chelifera	NA
HOFU	Insecta	Diptera	Empididae	Hemerodromia	NA
HOFU	Insecta	Diptera	Lymnaeidae	NA	NA
HOFU	Insecta	Diptera	Physidae	NA	NA
HOFU	Insecta	Diptera	Simuliidae	Prosimulium	NA
HOFU	Insecta	Diptera	Simuliidae	Simulium	NA
HOFU	Insecta	Diptera	Tabanidae	NA	NA
HOFU	Insecta	Diptera	Tipulidae	Antocha	NA
HOFU	Insecta	Diptera	Tipulidae	Dicranota	NA
HOFU	Insecta	Diptera	Tipulidae	Hexatoma	NA
HOFU	Insecta	Diptera	Tipulidae	Tipula	NA
HOFU	Insecta	Ephemeroptera	Ameletidae	Ameletus	NA
HOFU	Insecta	Ephemeroptera	Baetidae	Acentrella	NA
HOFU	Insecta	Ephemeroptera	Baetidae	Baetis	NA
HOFU	Insecta	Ephemeroptera	Baetidae	Callibaetis	NA

Park	Class	Order	Family	Genus	Species
HOFU	Insecta	Ephemeroptera	Ephemerellidae	Ephemerella	NA
HOFU	Insecta	Ephemeroptera	Ephemerellidae	Eurylophella	NA
HOFU	Insecta	Ephemeroptera	Ephemerellidae	Serratella	NA
HOFU	Insecta	Ephemeroptera	Heptageniidae	Cinygmula	subaequalis
HOFU	Insecta	Ephemeroptera	Heptageniidae	Epeorus	NA
HOFU	Insecta	Ephemeroptera	Heptageniidae	Maccaffertium	NA
HOFU	Insecta	Ephemeroptera	Isonychiidae	Isonychia	NA
HOFU	Insecta	Ephemeroptera	Leptophlebiidae	Leptophlebia	NA
HOFU	Insecta	Ephemeroptera	Leptophlebiidae	Paraleptophlebia	NA
HOFU	Insecta	Megaloptera	Corydalidae	Nigronia	serricornis
HOFU	Insecta	Megaloptera	Sialidae	Sialis	NA
HOFU	Insecta	Odonata	Aeshnidae	Basiaeschna	NA
HOFU	Insecta	Odonata	Aeshnidae	Boyeria	NA
HOFU	Insecta	Odonata	Calopterygidae	Calopteryx	NA
HOFU	Insecta	Odonata	Coenagrionidae	Argia	NA
HOFU	Insecta	Odonata	Cordulegastridae	Cordulegaster	NA
HOFU	Insecta	Odonata	Corduliidae	Macromia	NA
HOFU	Insecta	Odonata	Gomphidae	Gomphus	NA
HOFU	Insecta	Odonata	Gomphidae	Lanthus	NA
HOFU	Insecta	Odonata	Gomphidae	Ophiogomphus	NA
HOFU	Insecta	Plecoptera	Capniidae	Allocapnia	NA
HOFU	Insecta	Plecoptera	Leuctridae	Leuctra	NA
HOFU	Insecta	Plecoptera	Nemouridae	Amphinemura	NA
HOFU	Insecta	Plecoptera	Nemouridae	Ostrocerca	NA
HOFU	Insecta	Plecoptera	Peltoperlidae	Tallaperla	NA
HOFU	Insecta	Plecoptera	Perlidae	Perlesta	NA
HOFU	Insecta	Plecoptera	Perlodidae	Clioperla	clio
HOFU	Insecta	Plecoptera	Perlodidae	Diploperla	NA
HOFU	Insecta	Plecoptera	Perlodidae	Isoperla	NA
HOFU	Insecta	Plecoptera	Taeniopterygidae	Strophopteryx	NA
HOFU	Insecta	Plecoptera	Taeniopterygidae	Taeniopteryx	NA

Park	Class	Order	Family	Genus	Species
HOFU	Insecta	Trichoptera	Brachycentridae	Brachycentrus	NA
HOFU	Insecta	Trichoptera	Glossosomatidae	Glossosoma	NA
HOFU	Insecta	Trichoptera	Hydropsychidae	Cheumatopsyche	NA
HOFU	Insecta	Trichoptera	Hydropsychidae	Diplectrona	modesta
HOFU	Insecta	Trichoptera	Hydropsychidae	Hydropsyche	NA
HOFU	Insecta	Trichoptera	Hydroptilidae	Oxyethira	NA
HOFU	Insecta	Trichoptera	Lepidostomatidae	Lepidostoma	NA
HOFU	Insecta	Trichoptera	Leptoceridae	Triaenodes	NA
HOFU	Insecta	Trichoptera	Limnephilidae	Hydatophylax	NA
HOFU	Insecta	Trichoptera	Limnephilidae	Ironoquia	NA
HOFU	Insecta	Trichoptera	Limnephilidae	Pycnopsyche	NA
HOFU	Insecta	Trichoptera	Philopotamidae	Chimarra	NA
HOFU	Insecta	Trichoptera	Phryganeidae	Ptilostomis	NA
HOFU	Insecta	Trichoptera	Polycentropodidae	Polycentropus	NA
HOFU	Insecta	Trichoptera	Psychomyiidae	Lype	diversa
HOFU	Insecta	Trichoptera	Rhyacophilidae	Rhyacophila	NA
HOFU	Insecta	Trichoptera	Uenoidae	Neophylax	NA
HOFU	Malacostraca	Amphipoda	Crangonyctidae	Crangonyx	NA
HOFU	Malacostraca	Decapoda	Cambaridae	NA	NA

Table A-7. PETE taxa list.

Park	Class	Order	Family	Genus	Species
PETE	Clitellata	NA	NA	NA	NA
PETE	Insecta	Coleoptera	Dytiscidae	NA	NA
PETE	Insecta	Coleoptera	Elmidae	Ancyronyx	NA
PETE	Insecta	Diptera	Ceratopogonidae	NA	NA
PETE	Insecta	Diptera	Chironomidae	NA	NA
PETE	Insecta	Diptera	Lymnaeidae	NA	NA
PETE	Insecta	Diptera	Physidae	NA	NA
PETE	Insecta	Diptera	Simuliidae	Prosimulium	NA
PETE	Insecta	Diptera	Simuliidae	Simulium	NA
PETE	Insecta	Diptera	Tipulidae	Hexatoma	NA
PETE	Insecta	Diptera	Tipulidae	Tipula	NA
PETE	Insecta	Ephemeroptera	Ameletidae	Ameletus	NA
PETE	Insecta	Ephemeroptera	Baetidae	Baetis	NA
PETE	Insecta	Ephemeroptera	Baetidae	Centroptilum	NA
PETE	Insecta	Ephemeroptera	Ephemerellidae	Ephemerella	NA
PETE	Insecta	Ephemeroptera	Ephemerellidae	Eurylophella	NA
PETE	Insecta	Ephemeroptera	Heptageniidae	Maccaffertium	NA
PETE	Insecta	Odonata	Aeshnidae	Boyeria	NA
PETE	Insecta	Odonata	Calopterygidae	Calopteryx	NA
PETE	Insecta	Odonata	Cordulegastridae	Cordulegaster	NA
PETE	Insecta	Odonata	Gomphidae	Gomphus	NA
PETE	Insecta	Odonata	Gomphidae	Progomphus	NA
PETE	Insecta	Odonata	Libellulidae	Libellula	NA
PETE	Insecta	Plecoptera	Capniidae	Allocapnia	NA
PETE	Insecta	Plecoptera	Leuctridae	Leuctra	NA
PETE	Insecta	Plecoptera	Nemouridae	Amphinemura	NA
PETE	Insecta	Plecoptera	Nemouridae	Ostrocerca	NA
PETE	Insecta	Plecoptera	Perlidae	Perlesta	NA
PETE	Insecta	Plecoptera	Perlodidae	Clioperla	clio
PETE	Insecta	Plecoptera	Perlodidae	Isoperla	NA
PETE	Insecta	Trichoptera	Hydropsychidae	Cheumatopsyche	NA

Park	Class	Order	Family	Genus	Species
PETE	Insecta	Trichoptera	Lepidostomatidae	Lepidostoma	NA
PETE	Insecta	Trichoptera	Limnephilidae	Ironoquia	NA
PETE	Insecta	Trichoptera	Limnephilidae	Pycnopsyche	NA
PETE	Insecta	Trichoptera	Philopotamidae	Wormaldia	NA
PETE	Insecta	Trichoptera	Phryganeidae	Ptilostomis	NA
PETE	Insecta	Trichoptera	Polycentropodidae	Polycentropus	NA
PETE	Insecta	Trichoptera	Rhyacophilidae	Rhyacophila	NA
PETE	Malacostraca	Amphipoda	Crangonyctidae	Crangonyx	NA
PETE	Malacostraca	Decapoda	Cambaridae	NA	NA
PETE	Malacostraca	Isopoda	Asellidae	Caecidotea	NA

Table A-8. RICH taxa list.

Park	Class	Order	Family	Genus	Species
RICH	Bivalvia	Veneroida	Corbiculidae	Corbicula	NA
RICH	Bivalvia	Veneroida	Sphaeriidae	NA	NA
RICH	Clitellata	NA	NA	NA	NA
RICH	Gastropoda	Architaenioglossa	Viviparidae	NA	NA
RICH	Gastropoda	Basommatophora	Ancylidae	Ferrissia	NA
RICH	Gastropoda	NA	Pleuroceridae	NA	NA
RICH	Insecta	Coleoptera	Dryopidae	Helichus	NA
RICH	Insecta	Coleoptera	Dytiscidae	NA	NA
RICH	Insecta	Coleoptera	Elmidae	Ancyronyx	NA
RICH	Insecta	Coleoptera	Elmidae	Dubiraphia	NA
RICH	Insecta	Coleoptera	Elmidae	Macronychus	NA
RICH	Insecta	Coleoptera	Elmidae	Microcylloepus	NA
RICH	Insecta	Coleoptera	Elmidae	Optioservus	NA
RICH	Insecta	Coleoptera	Elmidae	Stenelmis	NA
RICH	Insecta	Coleoptera	Gyrinidae	Dineutus	NA
RICH	Insecta	Coleoptera	Gyrinidae	Gyrinus	NA
RICH	Insecta	Coleoptera	Halipilidae	Peltodytes	NA
RICH	Insecta	Coleoptera	Hydrophilidae	Tropisternus	NA
RICH	Insecta	Coleoptera	Ptilodactylidae	Anchytarsus	NA
RICH	Insecta	Diptera	Ceratopogonidae	NA	NA
RICH	Insecta	Diptera	Chironomidae	NA	NA
RICH	Insecta	Diptera	Empididae	Chelifera	NA
RICH	Insecta	Diptera	Empididae	Hemerodromia	NA
RICH	Insecta	Diptera	Physidae	NA	NA
RICH	Insecta	Diptera	Simuliidae	Prosimulium	NA
RICH	Insecta	Diptera	Simuliidae	Simulium	NA
RICH	Insecta	Diptera	Tabanidae	NA	NA
RICH	Insecta	Diptera	Tipulidae	Dicranota	NA
RICH	Insecta	Diptera	Tipulidae	Hexatoma	NA
RICH	Insecta	Diptera	Tipulidae	Tipula	NA
RICH	Insecta	Ephemeroptera	Baetidae	Acerpenna	NA

Park	Class	Order	Family	Genus	Species
RICH	Insecta	Ephemeroptera	Baetidae	Baetis	NA
RICH	Insecta	Ephemeroptera	Baetidae	Callibaetis	NA
RICH	Insecta	Ephemeroptera	Baetidae	Centroptilum	NA
RICH	Insecta	Ephemeroptera	Caenidae	Caenis	NA
RICH	Insecta	Ephemeroptera	Ephemerellidae	Eurylophella	NA
RICH	Insecta	Ephemeroptera	Heptageniidae	Leucrocuta	NA
RICH	Insecta	Ephemeroptera	Heptageniidae	Maccaffertium	NA
RICH	Insecta	Ephemeroptera	Leptophlebiidae	Leptophlebia	NA
RICH	Insecta	Ephemeroptera	Siphlonuridae	Siphlonurus	NA
RICH	Insecta	Hemiptera	Corixidae	NA	NA
RICH	Insecta	Hemiptera	Gerridae	Aquarius	NA
RICH	Insecta	Lepidoptera	NA	NA	NA
RICH	Insecta	Megaloptera	Corydalidae	Nigronia	serricornis
RICH	Insecta	Megaloptera	Sialidae	Sialis	NA
RICH	Insecta	Odonata	Aeshnidae	Basiaeschna	NA
RICH	Insecta	Odonata	Aeshnidae	Boyeria	NA
RICH	Insecta	Odonata	Calopterygidae	Calopteryx	NA
RICH	Insecta	Odonata	Coenagrionidae	Argia	NA
RICH	Insecta	Odonata	Coenagrionidae	NA	NA
RICH	Insecta	Odonata	Cordulegastridae	Cordulegaster	NA
RICH	Insecta	Odonata	Gomphidae	Gomphus	NA
RICH	Insecta	Odonata	Libellulidae	Libellula	NA
RICH	Insecta	Plecoptera	Capniidae	Allocapnia	NA
RICH	Insecta	Plecoptera	Leuctridae	Leuctra	NA
RICH	Insecta	Plecoptera	Nemouridae	Amphinemura	NA
RICH	Insecta	Plecoptera	Perlidae	Acroneuria	NA
RICH	Insecta	Plecoptera	Perlidae	Eccoptura	xanthenes
RICH	Insecta	Plecoptera	Perlodidae	Clioperla	clio
RICH	Insecta	Plecoptera	Perlodidae	Isoperla	NA
RICH	Insecta	Trichoptera	Brachycentridae	Brachycentrus	NA
RICH	Insecta	Trichoptera	Dipseudopsidae	Phylocentropus	NA

Park	Class	Order	Family	Genus	Species
RICH	Insecta	Trichoptera	Hydropsychidae	Cheumatopsyche	NA
RICH	Insecta	Trichoptera	Hydropsychidae	Diplectrona	modesta
RICH	Insecta	Trichoptera	Hydropsychidae	Hydropsyche	NA
RICH	Insecta	Trichoptera	Lepidostomatidae	Lepidostoma	NA
RICH	Insecta	Trichoptera	Leptoceridae	Mystacides	NA
RICH	Insecta	Trichoptera	Leptoceridae	Oecetis	NA
RICH	Insecta	Trichoptera	Leptoceridae	Triaenodes	NA
RICH	Insecta	Trichoptera	Limnephilidae	Hydatophylax	NA
RICH	Insecta	Trichoptera	Limnephilidae	Ironoquia	NA
RICH	Insecta	Trichoptera	Limnephilidae	Pycnopsyche	NA
RICH	Insecta	Trichoptera	Philopotamidae	Wormaldia	NA
RICH	Insecta	Trichoptera	Phryganeidae	Ptilostomis	NA
RICH	Insecta	Trichoptera	Polycentropodidae	Nyctiophylax	NA
RICH	Insecta	Trichoptera	Polycentropodidae	Polycentropus	NA
RICH	Insecta	Trichoptera	Psychomyiidae	Lype	diversa
RICH	Malacostraca	Amphipoda	Crangonyctidae	Crangonyx	NA
RICH	Malacostraca	Amphipoda	Gammaridae	Gammarus	NA
RICH	Malacostraca	Amphipoda	Hyalellidae	Hyalella	azteca
RICH	Malacostraca	Decapoda	Cambaridae	NA	NA
RICH	Malacostraca	Isopoda	Asellidae	Caecidotea	NA

Table A-9. VAFO taxa list.

Park	Class	Order	Family	Genus	Species
VAFO	Clitellata	NA	NA	NA	NA
VAFO	Insecta	Coleoptera	Elmidae	Optioservus	NA
VAFO	Insecta	Coleoptera	Elmidae	Stenelmis	NA
VAFO	Insecta	Diptera	Chironomidae	NA	NA
VAFO	Insecta	Diptera	Empididae	Chelifera	NA
VAFO	Insecta	Diptera	Empididae	Hemerodromia	NA
VAFO	Insecta	Diptera	Simuliidae	Simulium	NA
VAFO	Insecta	Diptera	Tipulidae	Antocha	NA
VAFO	Insecta	Diptera	Tipulidae	Dicranota	NA
VAFO	Insecta	Diptera	Tipulidae	Tipula	NA
VAFO	Insecta	Ephemeroptera	Baetidae	Baetis	NA
VAFO	Insecta	Trichoptera	Hydropsychidae	Cheumatopsyche	NA
VAFO	Insecta	Trichoptera	Hydropsychidae	Hydropsyche	NA
VAFO	Insecta	Trichoptera	Philopotamidae	Chimarra	NA
VAFO	Malacostraca	Amphipoda	Gammaridae	Gammarus	NA
VAFO	Malacostraca	Decapoda	Cambaridae	NA	NA
VAFO	Malacostraca	Isopoda	Asellidae	Asellus	NA
VAFO	Trepaxonemata	Neoophora	Planariidae	NA	NA

Appendix B. Table of macroinvertebrate submetrics and MMI scores

Table B-1. Sites utilizing the Virginia Stream Condition Index (VSCI).

Park	Site	Year	# of Ind. Captured	Taxa Richness	EPT Taxa Richness	% Ephem.	% Plec. and Trich. minus Hydro.	HBI	% Top 2	%Chir.	%Scrap.	MMI score
APCO	01	2009	267	18	9	47.19	10.49	4.06	46.82	13.11	20.97	70.23
APCO	01	2010	429	18	10	22.14	7.93	5.07	51.05	11.89	12.82	60.92
APCO	02	2009	239	21	12	17.57	25.52	4.41	56.07	17.15	8.37	67.58
APCO	02	2010	600	18	12	6.33	20.17	4.98	72.67	10.50	5.00	57.66
APCO	02	2011	360	22	12	24.44	18.89	4.60	55.56	11.94	10.83	68.21
APCO	02	2012	221	15	8	34.84	30.32	3.91	52.49	23.08	11.76	67.60
APCO	02	2013	200	19	10	22.00	15.00	4.67	49.50	21.00	8.00	62.64
APCO	02	2014	113	14	9	11.50	30.09	4.25	55.75	8.85	9.73	63.41
BOWA	02	2009	197	23	13	13.71	10.15	4.22	44.16	9.14	48.22	75.11
BOWA	02	2010	35	9	4	0.00	11.43	4.74	57.14	17.14	17.14	45.59
BOWA	02	2011	68	9	3	2.94	1.47	5.53	77.94	61.76	11.76	29.47
BOWA	02	2012	39	11	7	48.72	10.26	4.21	41.03	20.51	23.08	64.57
BOWA	02	2013	51	12	5	9.80	1.96	5.35	74.51	66.67	13.73	35.83
BOWA	02	2014	103	15	9	46.60	8.74	4.38	66.99	25.24	51.46	69.43
BOWA	04	2009	259	18	10	21.24	11.97	5.02	66.80	5.41	4.63	58.23
BOWA	04	2010	118	15	8	29.66	13.56	4.75	44.92	27.12	6.78	58.77
BOWA	04	2011	129	21	9	50.39	2.33	4.63	44.96	14.73	13.18	66.91
BOWA	04	2012	114	14	8	48.25	3.51	4.71	63.16	23.68	7.02	55.73

Park	Site	Year	# of Ind. Captured	Taxa Richness	EPT Taxa Richness	% Ephem.	% Plec. and Trich. minus Hydro.	HBI	% Top 2	%Chir.	%Scrap.	MMI score
BOWA	04	2013	221	11	5	43.89	1.36	4.97	55.20	19.46	8.60	50.84
BOWA	04	2014	61	13	8	21.31	29.51	4.28	31.15	11.48	8.20	67.19
FRSP	01	2009	1127	7	1	0.00	0.00	6.00	99.11	18.63	0.00	22.80
FRSP	01	2010	563	8	1	0.00	0.00	6.04	91.83	13.68	0.00	25.23
FRSP	01	2011	324	5	0	0.00	0.00	6.02	97.53	12.65	0.00	21.52
FRSP	01	2012	264	7	2	0.00	0.38	6.05	95.08	4.55	0.00	26.47
FRSP	01	2013	787	4	0	0.00	0.00	6.00	99.62	4.07	0.00	21.69
FRSP	01	2014	709	4	0	0.00	0.00	6.01	99.44	1.55	0.00	22.02
FRSP	06	2009	51	7	2	1.96	0.00	5.82	82.35	25.49	3.92	27.78
FRSP	06	2010	42	6	1	0.00	0.00	5.12	64.29	38.10	26.19	34.05
FRSP	08	2009	17	4	2	0.00	5.88	5.82	88.24	58.82	0.00	21.56
FRSP	08	2010	9	4	1	0.00	0.00	6.00	77.78	11.11	0.00	25.89
FRSP	08	2011	17	5	4	5.88	17.65	5.29	76.47	52.94	0.00	33.56
FRSP	08	2012	16	4	1	0.00	0.00	6.00	87.50	81.25	0.00	15.36
FRSP	08	2013	15	7	3	0.00	13.33	4.60	53.33	26.67	6.67	41.20
FRSP	08	2014	8	5	2	0.00	12.50	5.50	62.50	0.00	0.00	37.05
FRSP	13	2009	200	13	8	3.50	30.00	4.87	73.00	51.50	22.00	53.43
FRSP	13	2010	218	10	8	5.50	20.64	5.12	80.28	70.18	10.09	41.84
FRSP	13	2011	138	16	10	7.25	35.51	4.38	65.94	40.58	8.70	60.42
FRSP	13	2012	173	12	7	1.73	64.16	3.19	74.57	27.75	2.31	54.31
FRSP	13	2013	138	10	7	5.80	62.32	3.15	82.61	28.26	2.17	52.45

Park	Site	Year	# of Ind. Captured	Taxa Richness	EPT Taxa Richness	% Ephem.	% Plec. and Trich. minus Hydro.	HBI	% Top 2	%Chir.	%Scrap.	MMI score
FRSP	13	2014	79	11	7	10.13	44.30	3.90	51.90	11.39	20.25	64.66
FRSP	17	2009	206	10	5	0.00	3.88	5.88	89.32	2.91	0.49	34.48
FRSP	17	2010	118	11	6	0.00	44.07	3.96	55.08	6.78	0.00	56.44
FRSP	17	2011	160	11	4	0.00	34.38	4.30	64.38	6.25	1.25	51.80
FRSP	17	2012	295	11	5	0.00	49.15	3.68	70.85	7.80	0.00	52.84
FRSP	17	2013	203	9	4	0.00	23.15	4.86	77.83	7.88	0.00	42.75
FRSP	17	2014	276	14	6	1.45	3.99	5.75	85.14	3.99	0.72	39.13

Note: # of Ind. Captured = total number of individuals captured, Taxa Richness = total number of taxa in the sample, EPT Taxa Richness = number taxa of Ephemeroptera, Trichoptera, or Plecoptera, % Ephem. = % of individuals of the Order Ephemeroptera, % Plec. and Trich. minus Hydro. = % of individuals of the Order Plecoptera and Trichoptera but not including those of the Family Hydropsychidae, HBI = Hilsenhoff Biotic Index, % Top 2 = % of individuals in the two most common taxa, % Chir. = % of individuals in the Family Chironomidae, % Scrap. = % of individuals in the “scraper” functional feeding group, MMI score = multi-metric index score.

Table B-2. Sites utilizing the Virginia Coastal Plain Index (CPMI).

Park	Site	Year	# of Ind. Captured	Taxa Richness	EPT Taxa Richness	% Ephem.	% Plec. and Trich. minus Hydro.	HBI	%Clingers minus Hyd. and Sim.	% Scrap	% Intolerant	MMI Score
PETE	03	2009	342	16	8	2.63	3.51	5.83	2.92	5.26	5.56	25.87
PETE	03	2010	96	13	6	3.13	32.29	3.85	16.67	1.04	55.21	44.21
PETE	03	2011	123	8	5	19.51	10.57	5.14	3.25	0.00	11.38	24.92
PETE	03	2012	223	9	4	0.00	7.62	5.65	3.14	0.45	7.62	14.63
PETE	03	2013	82	11	5	3.66	6.10	5.61	2.44	0.00	7.32	17.84
PETE	03	2014	125	15	7	3.20	4.00	5.45	1.60	0.80	9.60	23.78
PETE	10	2009	776	13	6	0.00	19.33	5.26	1.68	0.00	18.81	29.89
PETE	10	2010	807	12	5	0.00	18.84	5.24	1.98	0.00	17.84	27.16
PETE	10	2011	32	8	3	0.00	62.50	3.97	9.38	0.00	62.50	32.47
PETE	10	2012	119	7	2	0.00	0.84	5.95	0.84	0.00	1.68	4.02
PETE	10	2013	219	11	4	0.00	10.50	5.56	0.91	0.00	10.50	17.99
PETE	10	2014	321	12	7	0.00	19.00	5.20	7.17	0.00	18.07	31.46
RICH	02	2009	6	3	0	0.00	0.00	4.50	0.00	0.00	50.00	12.50
RICH	02	2010	16	3	0	0.00	0.00	5.44	0.00	0.00	18.75	7.49
RICH	02	2011	14	4	1	0.00	0.00	5.79	0.00	0.00	7.14	4.23
RICH	02	2012	41	4	0	0.00	0.00	5.88	0.00	0.00	2.44	0.97
RICH	02	2013	7	4	0	0.00	0.00	5.57	0.00	0.00	14.29	5.70
RICH	02	2014	8	3	0	0.00	0.00	3.75	0.00	0.00	75.00	12.50
RICH	03	2009	185	25	10	2.16	5.95	5.85	9.19	5.95	8.11	36.25
RICH	03	2010	133	20	6	1.50	24.06	4.46	11.28	9.77	26.32	47.41

Park	Site	Year	# of Ind. Captured	Taxa Richness	EPT Taxa Richness	% Ephem.	% Plec. and Trich. minus Hydro.	HBI	%Clingers minus Hyd. and Sim.	% Scrap	% Intolerant	MMI Score
RICH	03	2011	107	15	6	2.80	9.35	5.79	2.80	1.87	5.61	23.77
RICH	03	2012	139	17	5	3.60	12.95	5.08	9.35	5.76	13.67	32.32
RICH	04	2009	289	23	8	5.54	20.07	4.87	5.19	0.00	22.49	44.89
RICH	04	2010	179	21	12	3.91	65.92	2.49	13.97	1.12	60.89	54.72
RICH	04	2011	302	22	13	8.61	50.00	3.29	13.91	1.99	48.68	57.54
RICH	04	2012	403	26	13	4.22	74.69	1.91	13.65	1.74	69.98	55.80
RICH	04	2013	119	18	7	10.08	52.10	3.09	15.13	0.00	44.54	51.48
RICH	04	2014	104	23	11	23.08	25.96	4.07	28.85	7.69	28.85	66.98
RICH	05	2009	550	20	6	2.00	1.45	5.87	10.36	10.00	1.45	27.33
RICH	05	2010	264	13	5	1.89	2.27	5.82	9.09	6.44	1.52	18.89
RICH	05	2011	242	18	7	10.33	3.72	5.55	10.33	7.44	3.31	30.90
RICH	05	2012	232	22	9	11.21	3.88	5.60	15.52	11.64	3.88	40.46
RICH	05	2013	232	15	4	2.59	4.74	5.77	7.76	4.74	4.31	20.70
RICH	05	2014	48	13	5	10.42	10.42	5.88	20.83	18.75	8.33	35.84
RICH	07	2009	100	10	3	12.00	2.00	5.63	10.00	22.00	18.00	29.47
RICH	07	2010	182	21	7	30.22	1.10	5.27	7.69	12.64	7.14	42.06

Note: # of Ind. Captured = total number of individuals captured, Taxa Richness = total number of taxa in the sample, EPT Taxa Richness = number taxa of Ephemeroptera, Trichoptera, or Plecoptera, % Ephem. = % of individuals of the Order Ephemeroptera, % Plec. and Trich. minus Hydro. = % of individuals of the Order Plecoptera or Trichoptera but not including those of the Family Hydropsychidae, HBI = Hilsenhoff Biotic Index, % Clingers minus Hyd. And Sim. = % of individuals with “clinger” behavior but not including those of the Family Hydropsychidae or Simuliidae, % Scrap. = % of individuals in the “scraper” functional feeding group, % Intolerant = % of individuals with a tolerance score < 4, MMI score = multi-metric index score.

Table B-3. Sites utilizing the Pennsylvania Riffle/Run Index (PARRIBI).

Park	Site	Year	# of Ind. Captured	Taxa Richness	EPT Taxa Richness	HBI	Modified Becks	Shannon Index	% Intolerant Indv.	MMI Score
GETT	01	2009	211	10	2	5.71	1	1.23	2.84	23.78
GETT	01	2010	105	11	3	5.76	1	1.29	1.90	25.22
GETT	01	2011	236	21	5	5.65	1	2.10	6.36	37.85
GETT	01	2012	124	15	4	5.19	2	2.10	0.81	34.24
GETT	01	2013	243	13	4	4.88	0	1.72	0.41	30.72
GETT	01	2014	156	10	2	5.52	1	0.96	16.03	25.21
GETT	02	2009	87	9	1	6.46	1	1.20	4.60	21.01
GETT	02	2010	105	9	2	6.60	0	1.33	1.90	21.44
GETT	06	2009	149	10	1	5.85	0	1.37	0.00	22.42
GETT	06	2010	221	13	1	5.57	1	1.62	0.90	26.61
GETT	06	2011	36	8	0	5.44	1	1.53	2.78	23.31
GETT	06	2012	254	16	2	5.81	0	1.43	0.00	26.77
GETT	06	2013	126	12	1	5.63	0	1.68	0.79	25.88
GETT	06	2014	142	12	2	5.68	0	1.49	0.70	25.50
GETT	07	2009	309	15	8	4.10	8	1.83	51.78	51.11
GETT	07	2010	268	18	6	3.91	10	1.91	56.72	53.57
GETT	07	2011	249	17	7	3.82	12	2.17	57.43	56.67
GETT	07	2012	266	20	9	4.57	8	2.06	37.22	52.00
GETT	07	2013	351	17	5	3.28	6	1.87	68.09	53.78
HOFU	01	2009	80	15	7	3.86	8	2.14	51.25	52.40
HOFU	01	2010	107	23	12	3.33	19	2.55	56.07	70.12

Park	Site	Year	# of Ind. Captured	Taxa Richness	EPT Taxa Richness	HBI	Modified Becks	Shannon Index	% Intolerant Indv.	MMI Score
HOFU	01	2011	66	10	3	3.89	4	1.43	50.00	40.17
HOFU	01	2012	99	16	4	5.07	4	1.93	23.23	39.31
HOFU	01	2013	280	13	6	2.89	4	1.16	76.07	49.99
HOFU	01	2014	130	8	2	5.09	2	1.31	22.31	28.76
HOFU	02	2009	639	20	9	2.32	16	1.39	87.48	65.57
HOFU	02	2010	86	15	4	5.23	3	1.64	12.79	34.28
HOFU	02	2013	133	21	9	2.08	17	1.90	80.45	69.17
HOFU	02	2014	160	15	7	2.43	7	1.63	86.88	58.52
VAFO	01	2009	295	14	1	5.60	0	1.86	1.36	28.08

Note: # of Ind. Captured = total number of individuals captured, Taxa Richness = total number of taxa in the sample, EPT Taxa Richness = number taxa of Ephemeroptera, Trichoptera, or Plecoptera, HBI = Hilsenhoff Biotic Index, Modified Becks = Beck's Biotic Index (version 3), Shannon Index = Shannon's Diversity Index %, Intolerant Indv. = % of individuals with a tolerance score < 3, MMI score = multi-metric index score.

Table B-4. Sites utilizing the Pennsylvania Multi-habitat index (PAMHIBI).

Park	Site	Year	# of Ind. Captured	Taxa Richness	EPT Taxa Richness	Modified Becks	Shannon Index	Trichoptera Richness	Ephemeroptera Richness	MMI Score
EISE	04	2009	1114	12	3	4	1.85	2	0	25.10
EISE	04	2010	466	21	5	8	2.27	2	3	54.47
EISE	04	2011	358	16	4	5	2.04	2	1	35.84
EISE	04	2012	284	22	8	7	2.72	3	4	63.86
EISE	04	2013	535	20	6	6	2.56	3	3	54.51
EISE	04	2014	206	15	2	5	2.10	1	0	28.21

Note: # of Ind. Captured = total number of individuals captured, Taxa Richness = total number of taxa in the sample, EPT Taxa Richness = number taxa of Ephemeroptera, Trichoptera, or Plecoptera, Modified Becks = Beck's Biotic Index (version 4), Shannon Index = Shannon's Diversity Index, Trichoptera Richness = number taxa of Trichoptera, Ephemeroptera Richness = number of taxa of Ephemeroptera, MMI score = multi-metric index score.

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