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Inventory and Assessment of Primary Headwater Streams in Cleveland Metroparks: Preliminary Analysis of Data from the Rocky River Watershed

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ABSTRACT

Primary headwaters are small streams that perform a variety of important ecological functions within a watershed. In Ohio, current laws that protect waterways do not apply to primary headwaters, even though these streams are subject to a variety of negative impacts. Cleveland Metroparks began surveying primary headwaters in 2003 with the goal of inventorying and evaluating the health of all the small streams in Park District reservations. A total of 408 streams were surveyed in the Rocky River watershed between 2007-2011; 32 in Rocky River Reservation, 130 in Mill Stream Run Reservation, 6 in Big Creek Reservation, 10 in Brecksville Reservation, and 230 in Hinckley Reservation. Using an Ohio EPA assessment methodology that predicts stream classes based on habitat features and both richness and relative abundance of aquatic life, streams were scored as Class I, II, or III. Class I are the lowest scoring streams due to their ephemeral flow and low biotic diversity and Class III are the highest scoring due to perennial flow and year-round presence of cool-water adapted species. While physical stream habitats were similar between the five reservations, with average scores that classified them as Class II primary headwaters, there were significant differences between biological communities. On average, biotic communities in the four reservations that represent the mid-lower watershed region scored a full class lower than what could be expected by stream habitat and had minimal to no populations of stream-dwelling salamanders and EPT taxa. In contrast, average biotic scores in Hinckley Reservation, representing the upper region of the watershed, scored in the same or a higher class than expected by stream habitat and had abundant populations of stream-dwelling salamanders and EPT taxa. These results are likely due to differences in levels of fragmentation, amount of a given stream's watershed protected by park land, surrounding land use, and degree of urbanization and development between the mid-lower and upper regions of the Rocky River watershed. Primary headwater data collected in Cleveland Metroparks will be used to assist in park management decisions, land acquisition, impact evaluation, and the establishment of a long-term monitoring program of the ecological integrity of watersheds within the park.

INTRODUCTION

Primary headwaters are small streams that have a defined bed and bank, continuous or periodic flow, pools no deeper than 40 centimeters, and a watershed area of one square mile or less (Ohio EPA 2012). These streams provide numerous important functions within their watersheds, including acting as flood control by containing and slowing waters during rainfall events, processing nutrients, reducing sediments, and providing habitat for unique native fauna, such as amphibians and aquatic insects, in both their waters and surrounding riparian areas (Gomi et al. 2002; Hession et al. 2000; Perkins and Hunter 2006; Smith and Lamp 2008). Primary headwaters serve as the origins of larger streams and rivers and therefore play an essential role in the health of these watersheds (Lowe and Likens 2005; Smith and Lamp 2008).

Primary headwaters are divided into three classes based on differences in flow regime, water temperature, and biotic community (Ohio EPA 2012). Class I primary headwaters have ephemeral or intermittent flow, generally containing water only after precipitation events or snowmelt. The stream channel is typically dry and contains a low diversity of seasonally present aquatic life. Class II primary headwaters have perennial or intermittent flow and annual pools that provide habitat for warm water adapted aquatic life. Class III primary headwaters have perennial flow that is typically groundwater fed and provide year-round habitat for cool and cold-water adapted aquatic life.

The Clean Water Act of 1972 allowed states to establish designated uses that offer legal protection against degradation to larger streams and rivers (Barbour et al. 2000; Lowe and Likens 2005). Primary headwaters are too small to fall under current designated uses and, because they do not have the same protections as larger streams, are subject to a wide variety of negative impacts, the most common including channelization and culverting, habitat destruction, and pollution (Blakely et al. 2006; Hession et al. 2000; Miltner and Rankin 1998; Muotka et al. 2002; Price et al. 2006). These impacts are prevalent in urban and rapidly developing areas, where small streams are often incorporated into stormwater drainage systems or destroyed completely (Smith and Lamp 2008). Collectively, these impacts experienced by small streams in intensively developed areas are known as the "urban stream syndrome" and have been found worldwide to exhibit a consistent set of symptoms, including water quality degradation, channel alterations, flashier hydrology, reduced species richness, and increased tolerant taxa (Walsh et al. 2005).

Small streams account for over 70% of waterways within Ohio and 75% in the United States overall (Lowe and Liken 2005; Ohio EPA 2012; Smith and Lamp 2008). A growing body of evidence suggests that small streams have far-reaching effects on downstream water bodies (Muotka et al 2002). A recent study suggests that even small patches of human alteration, such as deforestation near a stream bank, can result in significant changes in factors ranging from the benthic community to energy input and consumption patterns (England and Rosemond 2004). Conducting ecological assessments of primary headwaters is both necessary and important to better understand and protect these unique natural resources.

Cleveland Metroparks, established in 1917, is the oldest park district in the state of Ohio and has sixteen reservations totaling over 21,000 acres (Figure 1). The majority of the reservations are located in Cuyahoga County, with holdings extending into adjacent portions of Geauga, Lake, Lorain, Medina, and Summit counties. Cleveland

Metroparks is one of the largest streamside landowner in the state, with the majority of reservations containing portions of large rivers- the Chagrin, Cuyahoga, and Rocky, and several of their major tributaries- and therefore a multitude of the small streams that make up these watersheds. One of Cleveland Metroparks' priorities is the conservation and protection of essential natural resources, which includes the unique native wildlife and habitats found in primary headwater streams.

Cleveland Metroparks Division of Natural Resources initiated a primary headwaters research project in 2003 to survey all of the small streams within its reservations. During the 2007-2011 field seasons primary headwater streams in the Rocky River watershed, consisting of the entirety of Hinckley, Mill Stream Run, and Rocky River reservations, as well as portions of Big Creek and Brecksville reservations, were inventoried and assessed (Figure 2). These five reservations are some of the oldest in the park system, with land acquisitions beginning in the 1920's, and represent a gradient of human development and disturbances to both small streams and the surrounding lands that make up their watersheds- from rural Hinckley Reservation to suburban Mill Stream Run and Brecksville reservations to mixed urban and suburban Big Creek and Rocky River reservations (Table 1, Figure 3).

The mid-lower region of the Rocky River watershed is represented by some or all of the Rocky River, Mill Stream Run, Big Creek, and Brecksville Reservations, which, per in-house GIS resources, contain 11.5 miles of the main river, a short stretch of the lower west branch, and 14.95 miles of the lower-middle east branch (Figure 2). These four reservations can be characterized as relatively long, narrow parcels interspersed in some areas with large, unfragmented blocks of land surrounded by either suburban or urban development (Figure 3). All four reservations are located in the western portion of Cuyahoga County and are essentially contiguous (Figure 2).

The upper region of the Rocky River watershed is represented by Hinckley Reservation, which includes Rising Valley area north of State Route 303 (Figure 2). This reservation contains a 4.4 mile stretch of the upper east branch of the Rocky River and is a blocky, relatively unfragmented area located in Medina County, with the eastern edge of its holdings entering Summit County (Figure 2). Land use surrounding the reservation is predominantly rural, though the rate of development is increasing as farms and woodlands are converted into housing and commercial areas (Figure 3).

MATERIALS AND METHODS

Fieldwork was conducted from May-October during the 2007-11 field seasons by Cleveland Metroparks Division of Natural Resources staff. Potential streams were inferred using both topographic maps with 2 and 10 foot contour lines and county soil maps with hydrology layers to ensure that the smallest drainages were accounted for. Maps for field navigation were generated using ArcView GIS v3.2 and streams were reached by hiking from the nearest accessible park trail or road. A handheld Garmin 60 GPS unit was carried, both for navigation assistance and to take points at the center (100 foot mark) of each survey reach to allow accurate relocation of the same stream reach for future visits and GIS-level analysis.

Surveys of primary headwater streams were carried out using a protocol from the Ohio EPA (2012) that was designed to predict stream classes in the state of Ohio, as outlined in *The Field Evaluation Manual for Ohio's Primary Headwater Habitat*

Streams. It consists of minimally invasive, rapid field assessment methodologies to evaluate both the physical habitat and biotic community of a stream. Field crews can be quickly trained to become competent at assessments and the equipment needed is relatively inexpensive. Surveys can be conducted year-round; however, the preferred timeframe is June-September when streams are typically at base flow and biotic communities are most stable.

The Headwater Habitat Evaluation Index (HHEI) is a rapid assessment of stream habitat (Appendix A). The HHEI score range is from 0-100 points and it is calculated using three metrics- substrate composition, maximum pool depth, and bankfull width. The substrate composition metric has a maximum score of 40 points and substrate types are scored depending on the quality of aquatic habitat they provide. The overall substrate metric score is calculated by the score of the two most predominant substrate types plus the total number of substrate types present in the survey reach. Maximum pool depth is determined by measurement with a rigid wooden ruler, in centimeters, of the deepest pool within the survey reach. This metric has a maximum of 30 points and is scored by the depth range the measurement falls within. Bankfull width is based on the average of three measurements using a field survey measuring tape, in meters, preferably taken in straight riffle, run, or glide areas. Banks are determined by the start of terrestrial vegetation or morphological features of the streambed, such as point bars or exposed root mats. The bankfull width metric ranges are assigned different points, with a maximum score of 30.

Surveys for fish and salamanders are conducted throughout the stream reach. Fish are caught with dip nets or seines (whichever is more appropriate for the habitat present), with the species and number collected noted. Adult and juvenile salamanders are found via visual surveys, conducted by searching beneath substrate within the stream and on the banks. Salamander larvae are collected in the water by using various netting techniques or kick seining (whichever is most appropriate for the habitat present). The species, number found, and age classes are noted for salamanders. This more detailed data collection for salamanders, as compared to that used for fish, occurs because evidence of reproducing populations of stream-dwelling salamander species are considered indicators of stream class.

The Headwater Macroinvertebrate Field Evaluation Index (HMFEI) predicts stream class based on a rapid assessment of benthic macroinvertebrates that are collected using small aquarium dip nets, kick nets, and/or kick seines (whichever is deemed most appropriate for the habitat type) in all water present within the stream reach (Appendix A). Macroinvertebrates are identified to order or family level, depending on the particular group, and are assigned 1-3 points, depending on their correlation to cool water habitats and the number of EPT taxa present (Table 2). EPT taxa are the orders Ephemeroptera (mayflies), Plecoptera (stoneflies), and Trichoptera (caddisflies) and each family identified within these orders is worth 3 points. These three orders are used worldwide as indicators of aquatic health because of their low overall pollution tolerances and specific habitat requirements, such as cool water temperature and high dissolved oxygen content (Ohio EPA 1987). Relative abundance of each macroinvertebrate group is noted, based on the number of individuals, ranging from rare (<3), common (3-9), abundant (10-50), and very abundant (>50). The HMFEI score has a minimum of zero and no upper score limit due to the regional variability in the number of EPT taxa that may be present in a given stream within the state.

The scores generated by the HHEI and HMFEI are broken down into ranges that indicate stream class (Table 3). For the HHEI, a score of <30 indicates Class I, 30-70 Class II, and >70 Class III (Table 3). The HMFEI is similarly divided, with a score of <7 indicating Class I, 7-19 Class II, and >19 Class III (Table 3). Ideally the scores for both the HHEI and the HMFEI fall into the same stream class range, implying the primary headwater is physically, chemically, and biologically intact. When the HHEI predicts a higher stream class then what is found with the HMFEI, this is considered a strong indication that something is negatively impacting the water quality of that primary headwater, preventing the expected aquatic life from occurring there.

In streams where the HMFEI predicts a higher stream class score then the HHEI, it may indicate that the stream in question is a unique aquatic habitat known as a rheocrene stream, where groundwater emerges as a spring and creates a flowing seepage habitat with a small watershed area of <0.1 mi^2. The HHEI cannot accurately predict a stream class for rheocrene habitats because it was not calibrated for streams with such a small drainage area; however, both the HMFEI and salamander populations are considered accurate assessments to assign stream class.

The HMFEI score and/or presence of a breeding population of stream class indicator salamander species overrule the HHEI score in final stream class prediction in all primary headwaters, because the biological community is considered the true indicator of the class of a stream.

Field crews consisted of 2-3 people, for both efficiency in conducting stream surveys and safety, since much of the work was done in relatively isolated areas with challenging terrain. Once a primary headwater was located a representative area was chosen to survey and a 200-foot reach was measured out, following the thalweg when possible, and marked at the start (0 ft.), middle (100 ft.), and end point (200 ft.) with flags. When streams were too short to attain the 200-foot reach a minimum survey length of 150 feet was established. Any stream whose total length was less than 150 feet was designated a non-stream waterway and was not assessed.

HHEI data was collected first, with habitat features noted and measurements for substrate, maximum pool depth, and bankfull width obtained. The survey reach was photographed and water chemistry measurements, consisting of temperature, dissolved oxygen, pH, and conductivity, were taken and recorded if water was present. Macroinvertebrates, larval salamanders, and fish were collected in any water-containing aquatic habitat present within the reach, sorted, and recorded on the HMFEI and vertebrate survey data sheets. Finally, a rapid visual assessment of the survey reach for adult and juvenile salamanders was conducted and the survey paperwork was completed. While this is not the standard protocol given in the Ohio EPA field manual, which only requires biotic evaluations to be conducted when stream class is uncertain after conducting the HHEI, for the purposes of this study full biological surveys were completed whenever possible to provide a more detailed assessment. Average time spent surveying per stream varied from 20 minutes to 3 hours depending on stream size, amount of water present, and the diversity of taxa collected.

Statistical analysis was conducted with MiniTab 15 statistical software. Watershed areas were calculated using the USGS Ohio StreamStats program, available at http://streamstats.usgs.gov/ohiostreamstats. Streams were named according to river codes and river miles were determined using USGS quadrangles from the Ohio EPA.

RESULTS

A total of 434 surveys of 408 streams were conducted within the Rocky River watershed in the five Cleveland Metroparks' reservations (Figure 4), with a small number of streams undergoing repeated surveys for impact assessments or because they were originally misidentified as separate streams due to mapping errors. Rocky River (n=32), Mill Stream Run (n=130), Big Creek (n=6), and Brecksville (n=10) are essentially contiguous reservations in the mid-lower watershed region and were combined to provide a more comparable sample size (n=178) to the upper watershed region in Hinckley Reservation (n=230) (Figure 5).

The average watershed size for a stream in this study was 0.099 mi^2. Watershed sizes ranged from 0.00035-0.96 mi^2 and means were significantly different between the three stream classes- increasing in size from Class I to Class III streams when classified by both HHEI (p=0.000) and HMFEI (p=0.017) scores (Table 4). Over a third (n=147) of the streams surveyed were not recognized by the Ohio StreamStats program due to their small size or subtle topography and their watershed areas could not be calculated, therefore they were excluded from watershed area statistical calculations. There was a significant difference (p=0.000) in watershed area between the two watershed regions, with streams in the mid-lower region averaging larger drainage basins, 0.17 mi^2, compared to the upper region's average of 0.06 mi^2.

Headwater Habitat Evaluation Index (HHEI) scores had an overall range of 9-96 points (Figure 6) and an average score of 49 points, falling into the Class II category (Table 5). At the watershed region level both the four combined reservations in the mid-lower region and Hinckley in the upper region had similar HHEI score ranges (Figure 7) and their average scores fell within the Class II stream category (Figure 8, Table 5).

Class II habitats accounted for nearly two thirds of streams surveyed (65.2%) (Figure 9). Class I (17.7%) and Class III (17.1%) categories combined represented just over one third of the remaining streams (Figure 9). At the regional level Class II streams still remained the dominant habitat type in both the mid-lower region (60.5%) and in Hinckley (68.9%) (Figure 10). Class I streams represented 15.3% of habitat types in the four contiguous reservations and 19.7% in Hinckley Reservation (Figure 10). Class III streams accounted for 24.2% of habitat types in the mid-lower region and 11.5% in the upper region (Figure 10).

Overall, average HHEI scores by stream class were 21 points for Class I, 50 points for Class II, and 77 points for Class III (Table 6). The combined reservations of the mid-lower region had average HHEI scores of 24 points for Class I, 51 points for Class II, and 76 points for Class III streams (Table 6). The upper region in Hinckley Reservation had average HHEI scores of 20 points for Class I, 49 points for Class II, and 78 points for Class III (Table 6). There was a significant difference (p=0.001) in HHEI scores between the two regions, with Hinckley tending to have slightly lower habitat scores compared to the contiguous reservations.

Headwater Macroinvertebrate Field Evaluation Index (HMFEI) scores, generated by surveying aquatic macroinvertebrate populations, had an overall range of 0-59 points (Figure 11) and average of 14 points, which is within the Class II stream category (Table 5). Hinckley had a wider range of HMFEI scores than the combined reservations, with a top score of 59 points attained in one of its streams, compared to a high score of 34 points in the combined reservations (Figure 12). Both the combined reservations, with an average HMFEI score of 7 points and Hinckley Reservation, with an average HMFEI score of 20 points, fall into the Class II stream category (Figure 13, Table 5). HMFEI scores were significantly different ($p<0.000$) between the watershed regions.

Overall, the majority of HMFEI scores tended to cluster in the low ranges that qualify as Class I streams (0-6 points), with Class II (7-19 points) and Class III (>20 points) streams occurring less frequently (Figure 14). Class I streams (40.6%), based on biology, were predominant by a small margin over Class II streams (32.5%) and Class III streams (27.0%) (Figure 14). This trend towards biological scores in the lower two stream class categories was also revealed in the combined reservations, where Class I biological communities dominated (56.8%), followed by Class II (37.9%) streams (Figure 15). Class III biological communities accounted for only 5.3% of streams in the mid-lower region (Figure 15). The predominant stream class found in Hinckley Reservation was a reversal in trends compared to that found both overall and in the mid-lower region, with Class III streams accounting for nearly half of biological communities (43.9%), followed by Class I (27.9%) and Class II (28.3%) (Figure 15).

Average HMFEI scores for Class I and II streams, both overall and by watershed region, were very similar (Table 7). Class I streams scored an average of 2 points and Class II streams averaged 13 points exactly (Table 7). Differences appeared when comparing average scores for Class III streams- the HMFEI for the entire watershed and the upper region scored very closely with 35 and 36 points, respectively, while the mid-lower region had an average score of 25 points (Table 7).

The number of family-level taxa identified per stream within the orders comprising the EPT taxa is an important submetric of the HMFEI score. Although an overall average of 4 families of EPT taxa were found per stream, the number of EPT taxa per stream differed significantly between the watershed regions (p=0.000) (Table 8). The average number of EPT taxa found per stream in the reservations in the mid-lower watershed region was 2, with a high of 6 families found in a single stream (Table 8). 14 total families of EPT taxa were found throughout the mid-lower region- with six families of caddisfly (Order Trichoptera), five families of mayfly (Order Ephemeroptera), and three families of stonefly (Order Plecoptera) found in streams in the combined reservations (Table 9). The average number of EPT taxa found per stream in Hinckley Reservation was 5, with a high of 14 families found in a single stream (Table 8). 24 total families of EPT taxa were found throughout Hinckley, with a total of 7 families of Ephemeroptera, 5 families of Plecoptera, and 12 families of Trichoptera identified in its streams (Table 9).

Four species of stream class indicator salamanders were found in the streams surveyed in the five reservations in the Rocky River watershed- northern dusky (*Desmognathus fuscus*), two-lined (*Eurycea bislineata*), long-tailed (*Eurycea longicauda*), and northern red (*Pseudotriton ruber*). Northern dusky salamanders are considered a Class II indicator species due to their comparatively brief gilled larval stage. Two-lined and northern red salamanders are both considered Class III indicators because they have a multi-year gilled larval stage. Long-tailed salamanders have variable duration to their gilled larval stage and can be either a Class II or Class III indicator species depending on the number of age classes of gilled larvae found in a particular stream.

Of the 408 streams surveyed, 113 had evidence of reproducing populations of stream class indicator salamander species (Table 10). The vast majority (107) of these streams contained either Class III species alone or a mixture of Class III and Class II species and only 6 streams contained only Class II indicator species (Table 10). Out of the 178 streams surveyed in the combined reservations 31 streams had breeding population of class indicator salamander species. All of these streams had two-lined salamanders- no other stream-breeding salamander species were found in the mid-lower watershed region (Table 10). Out of the 230 streams surveyed in Hinckley Reservation, 82 streams had breeding populations of class indicator salamander species (Table 10). The majority (76) of these streams had breeding two-lined and/or northern red salamanders, which are Class III species, and 6 had breeding northern dusky alone, which are Class II species (Table 10). There were 5 streams in Hinckley that also contained adult long-tailed salamanders, but no larval or juvenile specimens were found.

Seven species of fish were found throughout the three field seasons- creek chub (*Semotilus atromaculatus*), western blacknose dace (*Rhinichthys atratulus*), common shiner (*Luxilus cornutus*), green sunfish (*Lepomis cyanellus*), rainbow darter (*Etheostoma caeruleum*), barred fantail darter (*Etheostoma flabellare*), and Johnny darter (*Etheostoma nigrum*), in addition to fish fry that were too early in their development for accurate identification (Table 11). Overall, 44 of the 408 streams surveyed contained fish. Blacknose dace, creek chubs, green sunfish, and unidentified fry were found in primary headwater streams in both the mid-lower and upper regions of the Rocky River watershed (Table 11). Common shiners were only found in the reservations in the mid-lower region of the watershed (Table 11). Johnny darters, fantail darters, and rainbow darters were found only in the upper watershed in Hinckley Reservation (Table 11).

DISCUSSION

Primary headwater streams in the Rocky River watershed in Cleveland Metroparks reservations appear to be in good condition overall, with both the average physical habitat and biological community falling within the Class II category. However, when the streams were analyzed by their position within the watershed, it became apparent that there are significant differences between biological communities in the mid-lower and upper regions. While physical habitat, as evidenced by HHEI scores, are similar throughout the two regions (Figure 16), the biological communities, documented by HMFEI scores that characterize the aquatic macroinvertebrate communities (Figure 17) and vertebrate surveys of fish and stream-dwelling salamanders, are quite different.

There were nearly twice as many Class III stream habitats, as categorized by the HHEI scores, surveyed in the mid-lower region (24.2%), as compared to the upper region (11.5%) (Figure 10). While these percentages by themselves, when compared to the overall number of Class III primary headwater habitats (17.1%), do not present a striking discrepancy, it highlights two important differences between the watershed regions (Figure 9). First, the upper watershed contains many rheocrene stream habitats, which tend to have narrow channels, shallow pools, and predominantly fine substrates. Due to these habitat features rheocrenes tend to score within the Class II range in the HHEI assessment, even though their biology is that of a Class III stream. Second, the upper region in Hinckley Reservation contains many complete subwatersheds, meaning that streams with ephemeral or seasonal flow that make up the upper portions of those watersheds are numerically dominant. In contrast, the reservations in the mid-lower region tend to cluster much closer to the Rocky River and contain comparatively more of the larger, perennial Class III habitat streams that serve as the mainstems of those subwatersheds.

The higher levels of urbanization and development surrounding the reservations that occupy the mid-lower region of the Rocky River watershed are likely causes of low biological scores in their streams (Figure 3). While streams within the park generally have intact riparian zones and are buffered by mature forests, the majority of the subwatersheds of these small streams are often partially located within heavily developed areas outside of the protection of Cleveland Metroparks. A review of literature on urban streams by Carter et al. (2009) found that in all studies, regardless of the metrics used, areas with the highest levels of urbanization had the poorest environmental quality.

Primary headwaters in the upper region of the Rocky River watershed were typically home to the expected biological communities given the habitats present. This is likely due in large part to the fact that, unlike the mid-lower region reservations, Hinckley Reservation consists of a largely unfragmented parcel of land, located in a predominantly rural setting, and contains many watersheds that are largely or entirely protected within park land. While this area occasionally had streams with impacts related to land use changes, the most commonly encountered issues involved illicit or off-trail use by park visitors, and, in general, streams were relatively undisturbed. The main body of Hinckley Reservation also houses unique geological formations of Sharon conglomerate sandstone ledges, which are not found in the other four reservations in the watershed, and contain a large number of rheocrene habitats. Rheocrene streams tended to have outstanding biological communities; with HMFEI scores one or even two stream class categories higher than what would be expected from the habitat. This is due to large numbers of EPT taxa and breeding populations of class indictor salamander species.

The average watershed size of streams surveyed in this study fell slightly below the minimum drainage area of 0.10 mi^2, established by the Ohio EPA for a strict primary headwater stream (Ohio EPA 2012). While the HHEI was not calibrated to be used in streams below the 0.10 mi^2 cutoff, the HMFEI and vertebrate surveys are considered an accurate assessment tool for streams with much smaller watershed sizes (Ohio EPA 2012). Because the goal of Cleveland Metroparks primary headwaters project is an assessment of all small streams in its reservations and all streams surveyed had biotic evaluations done, watershed area was not considered a limiting criterion during site selection.

Aquatic macroinvertebrates are commonly used as indicators of the effects of human activity on stream communities (Woodcock and Huyrn 2007). Studies have found that in urban streams sensitive species are either less abundant or lost entirely, and there are significant decreases in the macroinvertebrate community as a whole (Gresens et al. 2007; Walsh et al. 2005; Walsh et al. 2007; Woodcock and Huyrn 2007). A study conducted by Smith and Lamp (2008) in the Piedmont region of Maryland, which sought to characterize the patterns of taxon loss from headwater streams in urbanized watersheds by comparing insect communities in streams of both urban and rural drainages shed light on why the largely developed watersheds in the mid-lower watershed region had good stream habitat, but poor biological communities overall. The study found that insect communities in urban streams were less diverse than those found in rural streams, however, insects in urban streams were not solely a subset of tolerant taxa found in rural streams and both habitat and water quality measurements were not significantly different (Smith and Lamp 2008). This suggests that the effects of urbanization on stream invertebrate communities cannot be entirely explained by factors like habitat degradation and water quality impairment, but may also include factors like the presence of population pools in neighboring streams and changes to the surrounding landscape limiting dispersal and repopulation by adult insects (Smith and Lamp 2008).

The occurrence of EPT taxa, in particular, clearly illustrates the gradient of anthropogenic impact between the mid-lower and upper regions of the watershed. On average only two families of EPT taxa and fourteen families total were found in streams in the mid-lower Rocky River watershed, which is subject to the highest degree of human activity in and around its streams. Plecoptera, which as an order is considered one of the most disturbance-sensitive aquatic organisms, and Ephemeroptera, which is often the first order to disappear when pollution occurs (Ohio EPA 1987), were both rare within that region of the watershed. Hinckley Reservation, representing the least impacted upper region of the Rocky River watershed in Cleveland Metroparks, contained twenty-four families of EPT taxa, which were common and abundant throughout the reservation and averaged five families per stream.

The distribution of salamander species is reflective of the gradient of human disturbance between the five reservations in the watershed- with only one species, the two-lined, found in the mid-lower watershed, compared to three additional species- the northern dusky, northern red, and long-tailed, in the upper watershed. The abundance of streams throughout the Rocky River watershed with breeding two-lined and northern dusky salamanders is expected, as they are two of the most common and widespread stream side species in northeastern Ohio (Pfingsten and Downs 1989). Studies have found that the two-lined range many meters from the water as an adult and are dependent on a large forested buffer zone around the stream for feeding, habitat, and reproduction (Crawford and Semlitsch 2007; Pfingsten and Downs 1989; Willson and Dorcas 2003). In contrast, the northern dusky tends to stay within a few meters of the stream margin and are thought to be more strongly affected by chemical changes in water quality than the size of the riparian zone (Crawford and Semlitsch 2007; Grant et al 2005; Pfingsten and Downs 1989; Willson and Dorcas 2003). These differences between the needs of the two species may explain why only the two-lined was found in the mid-lower region, since those four reservation still have ample forested buffers in most of their holdings, but whose streams flow through developed areas before reaching the park and likely have more water quality stressors that prevent the northern dusky from occurring there.

However, the presence of any stream-dwelling salamanders in the primary headwaters of the mid-lower Rocky River watershed is an encouraging sign. Salamanders are known to be good indicators of both forest and stream ecosystem integrity and demonstrate that, despite the urban and suburban landscapes surrounding the four reservations in the mid-lower watershed, the protection Cleveland Metroparks provides to the natural landscape is helping to preserve the health of the streams and woodlands (Perkins and Hunter 2006).

The occurrence of northern red and long-tailed salamanders in the upper Rocky River watershed is not surprising, given the habitat available. Northern red salamanders, during all their life stages, are found in and around springs emerging from sandstone geology in eastern Ohio, where water temperature and flow are relatively stable year round (Pfingsten and Downs 1989). Long-tailed salamanders, although they may range far from water as adults, prefer to breed and lay their eggs in underground streams and caves with springs or seepages (Pfingsten and Downs 1989). These habitats are common in Hinckley, occurring in and around two areas of Sharon conglomerate sandstone ledges, and are not found in the other four reservations. The lack of juvenile and larval long-tailed salamanders found during primary headwater surveys in Hinckley does not mean that there are no breeding populations of the species in the reservation. The preference of the long-tailed towards reproducing in isolated areas that are not accessible during stream surveys and the similarity in appearance between its larvae and that of the two-lined, which shares the same genus (Pfingsten and Downs 1989), may explain why only adults were identified.

The limited occurrence of fish is not surprising- the small size and often ephemeral or interstitial nature of streams surveyed in this study do not provide the necessary habitat for well-balanced fish communities and salamanders tend to replace them as top vertebrate predators in primary headwaters (Ohio EPA 2012). The Ohio EPA classifies fish species based on their tolerances to physical and chemical disturbances in streams, ranging along a gradient from tolerant to intolerant (Ohio EPA 1987). Western blacknose dace and creek chubs are both listed as tolerant (Ohio EPA 1987). In addition, blacknose dace are considered a headwater species and creek chub are considered a pioneering species, meaning that both are well suited to the limited habitat offered by small streams and are often the only fish species present, regardless of stream health

(Ohio EPA 2012). Darters, as a group, are considered indicators of good water quality because they are habitat specialists and insectivores, requiring an intact stream environment to thrive (Ohio EPA 2012).

Even with this small data set, comparisons can be made between the fish communities found in primary headwaters in the two regions in the watershed. Studies have found that stream fish communities in urban environments show a reduction or loss of sensitive species and a dominance of disturbance tolerant species (Walsh et al 2005). Primary headwater streams in the mid-lower Rocky River, although many offered ample appropriate habitat, yielded mainly tolerant species of fish, reflecting the impacted nature of its often urban watersheds. The three darter species were found only in the upper watershed in Hinckley, which is not surprising, given the relatively intact nature of its watersheds compared to those in the other four reservations. It should be noted that the common shiners recorded in the mid-lower region could very well reflect a misidentification of the striped shiner (*Luxilus chrysocephalus*). Common shiners are predominantly found in the upper reaches of the East Branch of the Rocky River, while striped shiners are common throughout the lower East Branch and main river (Trautman 1986).

Studies have found that, even when the riparian zone is intact, the presence of impervious surfaces in a stream's drainage basin can still negatively impact water quality (Walsh et al. 2007). England and Rosemond (2004) found that even a small stretch of riparian deforestation can significantly alter the biological community well downstream by changing energy input and consumption patterns. This effect likely explains observations in the four reservations within the mid-lower Rocky River, where the majority of the catchments of the small streams often contain a large percentage of impervious surfaces (Figure 3). Despite having intact buffer zones surrounding the stream reaches that flow through Cleveland Metropark's property, the lack of intact riparian zones upstream are still influencing the health of these primary headwaters. This effect was mirrored in a study by Harding et al. (2006), who found that forest fragments along streams provided little to no mitigation of impacts from developed areas upstream.

The importance of even limited stretches of riparian zones, however, cannot be discounted. Riparian zones provide a multitude of services to small streams and lotic habitats in general. The soils in these zones prevent excess sediments from reaching streams and filter out pollutants, as well as slowing surface flow during precipitation events (Madden et al. 2007). Vegetation stabilizes stream banks, preventing erosion and providing organic matter, and shading helps cool water temperature (Madden et al. 2007; Walsh et al. 2005). As transitional areas between aquatic and upland communities the riparian zone is an important habitat for amphibian species, which are sensitive to any alterations or disturbances occurring there (Perkins and Hunter 2006). While riparian buffers may not fully protect small streams from the negative impacts of surrounding land uses, their presence helps to mitigate many potential impacts before they reach the stream's water. Without this function, primary headwaters, as well as larger streams and rivers, would be left with little protection and the loss of riparian forests may seriously limit the potential of these streams to recover (Madden et al. 2007; Walsh et al. 2005; Walsh et al. 2007).

Aquatic ecosystems are some of the most endangered habitats on earth and streams, in particular, are extremely vulnerable to the effects of human activities

(Johnson et al. 2006; Smith and Lamp 2008; Spanhoff and Arle 2007). As the most prevalent type of waterway, the protection of small streams is an essential component in keeping aquatic ecosystems and the world's water supply healthy and sustainable (Lowe and Likens 2005; Smith and Lamp 2008). Small streams cannot be considered discrete, individual units- like all other aquatic resources they are inherently interconnected ecosystems (Vannote et al. 1980). The health of a stream can only be fully evaluated when the watershed as a whole is taken into consideration, as it is dependent on a multitude of factors, ranging from the land that drains into the stream to the waterways that it eventually flows into (Heino et al. 2007; Spanhoff and Arle 2007; Vannote et al. 1980).

Protection and restoration of small streams must be done at the watershed level to be successful (Walsh et al. 2005). Simply restoring stream habitat or mitigating inputs that compromise water quality is often not enough to bring back the biological community because recolonization by macroinvertebrates, fish, and salamanders is not possible if surrounding streams also lack healthy populations (Spanhoff and Arle 2007).

Furthermore, there is still much to be learned by examining in greater depth what factors are responsible for both degrading and preserving primary headwaters in all five of the reservations. In particular, the primary headwaters in the mid-lower watershed that contain or exceed the expected biological communities may shed light on the essential elements necessary to protect small streams in developed watersheds.

The scope of data being collected in this primary headwaters project is rare, and the comprehensive inventory and assessment on all small streams in its reservations being carried out by Cleveland Metroparks is among the first of its kind. The information being collected during this initial suite of surveys will serve as a baseline for a long-term monitoring program of the health of aquatic resources in Cleveland Metroparks. These initial surveys and future resurveys will continue to provide important information as anthropogenic development continues around Cleveland Metroparks, as both predevelopment and long-term biological data are otherwise rare (Carter et al. 2009). In addition, this data can be utilized in a variety of ways, both by Cleveland Metroparks and other organizations, including watershed groups, non-profits, academia, and other government agencies from the local to national level. Information from these surveys has already proved useful to Cleveland Metroparks when investigating stream impacts from construction, assessing the aquatic resources of potential land acquisitions, and assisting with management decisions such as trail planning and construction.

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Table 1. Characteristics of Cleveland Metroparks Reservations within the Rocky River Watershed.

Reservation	Size (ac)	County	Subwatershed	Watershed Region	Surrounding Land	# Streams Surveyed
Big Creek (south block)	713 (400)	Cuyahoga	East Branch	Mid-Lower	urban/suburban	6
Brecksville (parkway)	3,488 (336)	Cuyahoga	East Branch	Mid-Lower	suburban	10
Hinckley	2,812	Medina, Summit	East Branch	Upper	rural	230
Mill Stream Run	3,168	Cuyahoga	East Branch	Mid-Lower	suburban	130
Rocky River	2,587	Cuyahoga	Main, East, West Branch	Mid-Lower	urban/suburban	32

Table 2. HMFEI groupings of macroinvertebrate taxa. Group 1 taxa are given a score of 1 point. Group 2 taxa are given a score of 2 points. Group 3 taxa are given a score of 3 points and each family of EPT taxa (mayfly, stonefly, and caddisfly) receives 3 points.

Group 1	Group 2	Group 3
Sessile Animals	Crayfish	Fishfly Larvae
Aquatic Worms	Dragonfly Nymphs	Water Penny Beetles
Sow Bugs	Riffle Beetles	Cranefly Larvae
Scuds		Mayfly Nymphs
Water Mites		Stonefly Nymphs
Damselfly Nymphs		Caddisfly Larvae
Alderfly Larvae		
Other Beetles		
Larvae of other Flies		
Midges		
Snails		
Clams		

Table 3. Primary headwater stream class assignment by habitat (HHEI) and aquatic macroinvertebrate (HMFEI) assessment score ranges.

	Class I	Class II	Class III
HHEI Score	0 - 29	30 - 70	71 – 100
HMFEI Score	0 - 6	7 - 19	> 20

Table 4. Mean watershed area (square miles) for each primary headwater stream class when classified by both habitat (HHEI) and aquatic macroinvertebrate (HMFEI) score.

	Class I	Class II	Class III
HHEI Score	0.02	0.06	0.25
HMFEI Score	0.06	0.12	0.11

Table 5. Mean stream habitat (HHEI) scores for primary headwater streams within the Rocky River watershed in Cleveland Metroparks Reservations.

	Overall Watershed	Mid-Lower Watershed	Upper Watershed
HHEI Score	49	53	47
HMFEI Score	14	7	20

Table 6. Mean HHEI (HMFEI) scores for primary headwater streams within the Rocky River watershed in Cleveland Metroparks Reservations when classified by habitat (HHEI).

	Overall Watershed	Mid-Lower Watershed	Upper Watershed
Class I	21 (2)	24 (0)	20 (2)
Class II	50 (16)	51 (6)	49 (22)
Class III	77 (23)	76 (14)	78 (37)

Table 7. Mean HHEI (HMFEI) scores for primary headwater streams within the Rocky River watershed on Cleveland Metroparks Reservations when classified by aquatic macroinvertebrate community (HMFEI).

	Overall Watershed	Mid-Lower Watershed	Upper Watershed
Class I	37 (2)	44 (2)	27 (2)
Class II	55 (13)	64 (13)	45 (13)
Class III	61 (35)	74 (25)	60 (36)

Table 8. Mean number of EPT found in primary headwater streams throughout the Rocky River watershed.

	Overall Watershed	Mid-Lower Watershed	Upper Watershed
All EPT Taxa	4	2	5
Ephemeroptera	2	1	2
Plecoptera	2	1	2
Trichoptera	3	1	3

Table 9. List of families of EPT (mayfly, stonefly, and caddisfly) taxa identified in primary headwater streams within the Rocky River watershed.

	Mid-Lower Watershed	Upper Watershed
Ephemeroptera		
Ameletidae	x	x
Baetidae	x	x
Caenidae	x	x
Ephemeridae		x
Heptageniidae	x	x
Leptohyphidae		x
Leptophlebiidae	x	x
Plecoptera		
Chloroperlidae		x
Leuctridae	x	x
Nemouridae	x	x
Perlidae	x	x
Perlodidae		x
Trichoptera		
Glossosomatidae		x
Hydropsychidae	x	x
Hydroptilidae		x
Lepidostomatidae	x	x
Limnephilidae	x	x
Molannidae		x
Odontoceridae		x
Philopotamidae	x	x
Phryganeidae		x
Polycentropodidae	x	x
Rhyacophilidae		x
Uenoidae	x	x

Table 10. Number of primary headwater streams containing breeding populations of class-indicator salamander species.

	Overall Watershed	Mid-Lower Watershed	Upper Watershed
Class II	6	0	6
Class III	107	31	76
Total	113	31	82

Table 11. Fish species found in primary headwater streams in the Rocky River by watershed region.

Species	Mid-Lower Watershed	Upper Watershed
blacknose dace [1,2]	x	x
common shiner	x	
creek chub [2,3]	x	x
fantail darter [1]		x
green sunfish [2]	x	x
johnny darter [3]		x
rainbow darter		x
unidentified fry	x	x

[1] headwater species
[2] tolerant species
[3] pioneering species

Department of Planning, Design and Natural Resources
Division of Natural Resources
Division of Planning

Department of Park Operations
Division of Outdoor Education
Division of Parks

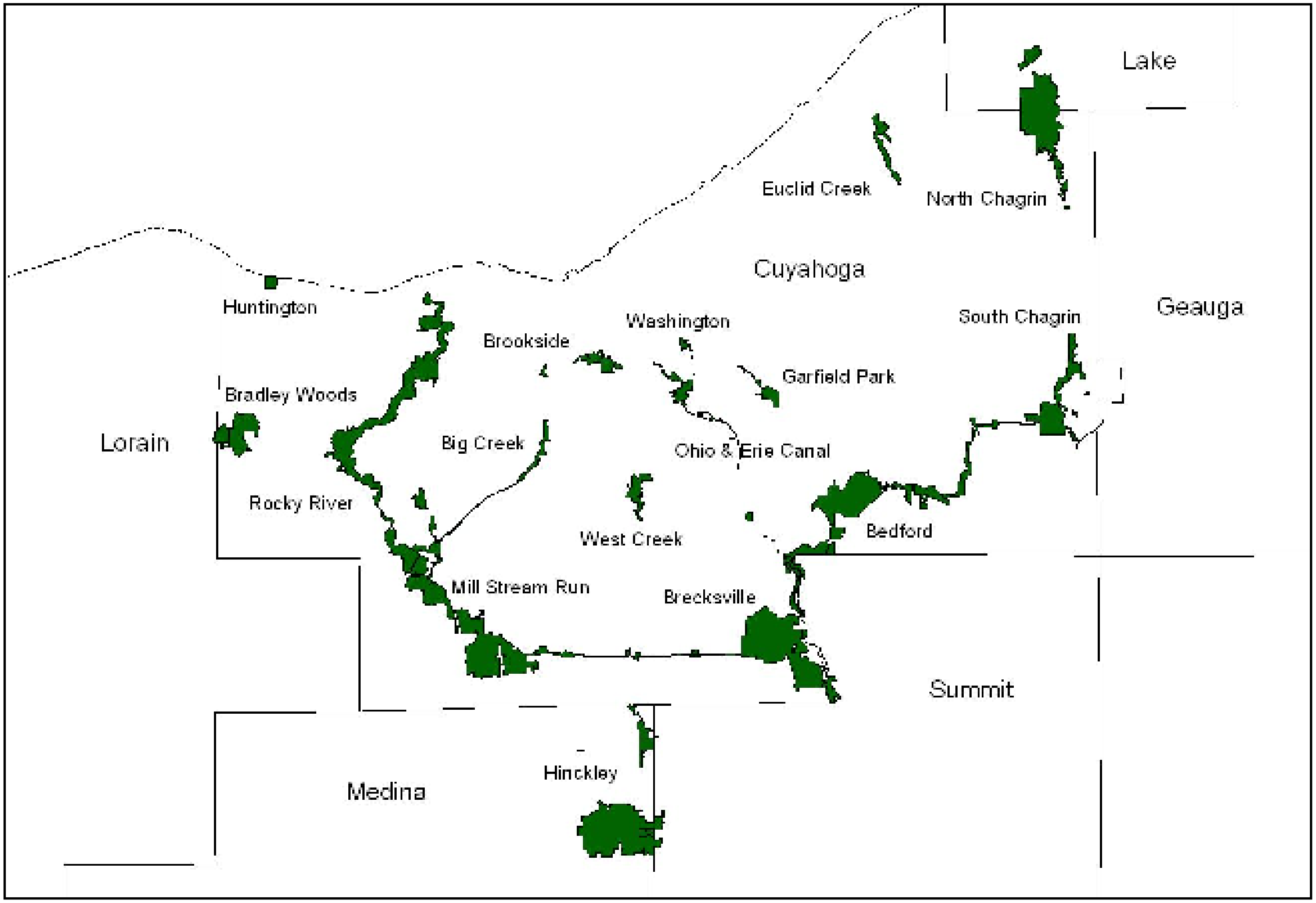

Figure 1. Map of Cleveland Metroparks Reservations.

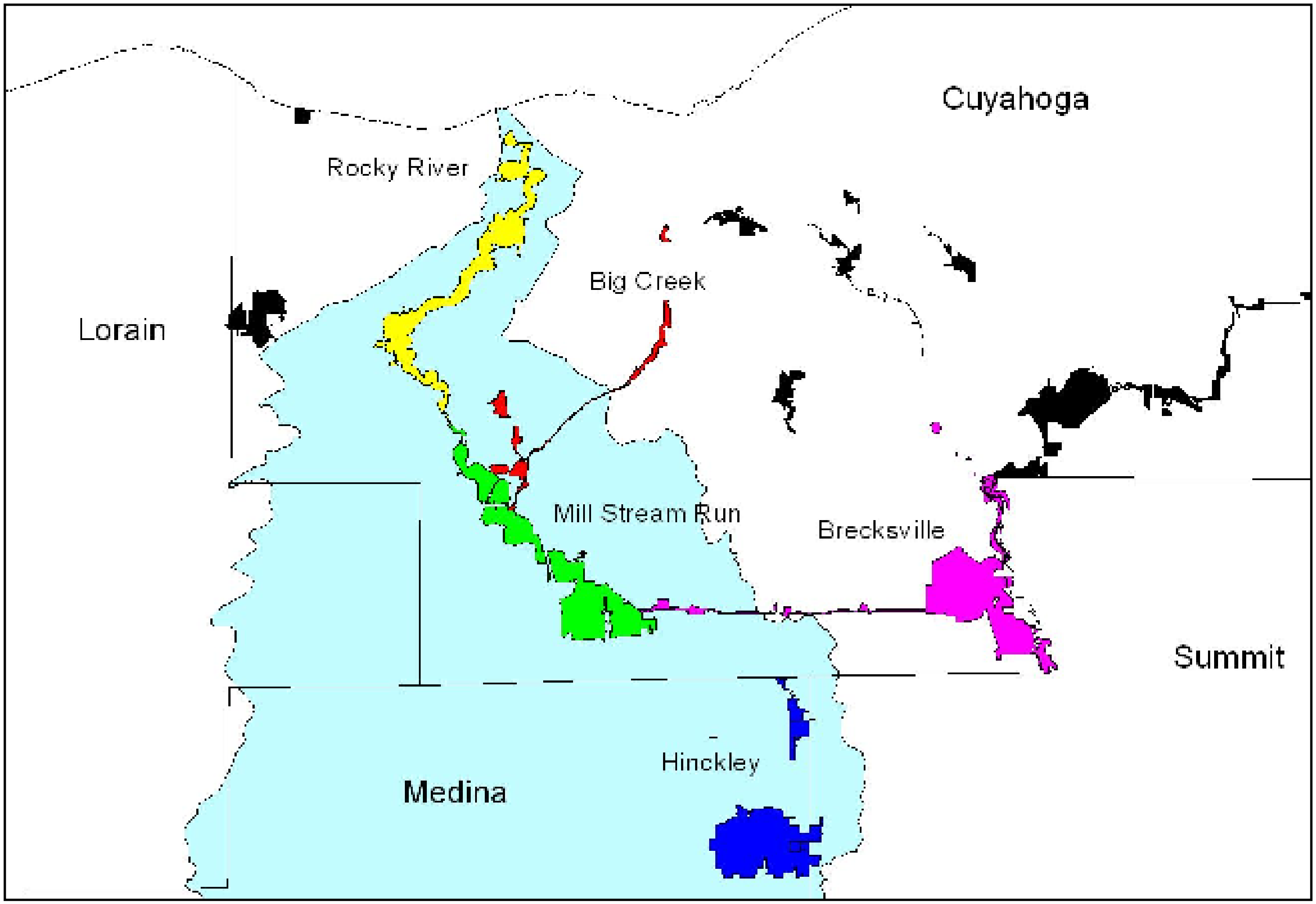

Figure 2. Map of the portions of Cleveland Metroparks Reservations located in the Rocky River watershed.

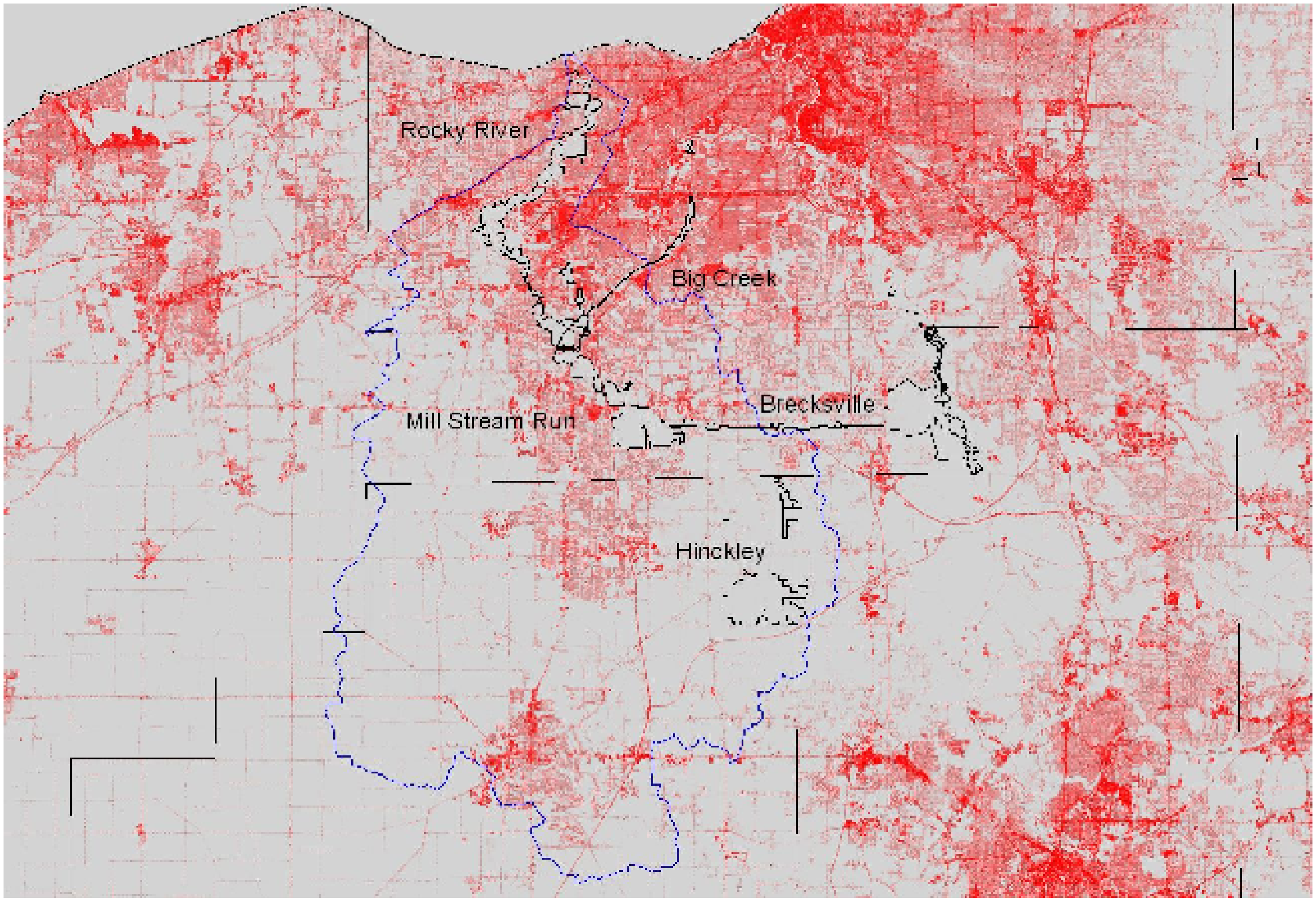

Figure 3. Map of impervious surface around Cleveland Metroparks Reservations within the Rocky River watershed. Increasing coloration from white to red indicates increasing percentage of impervious cover.

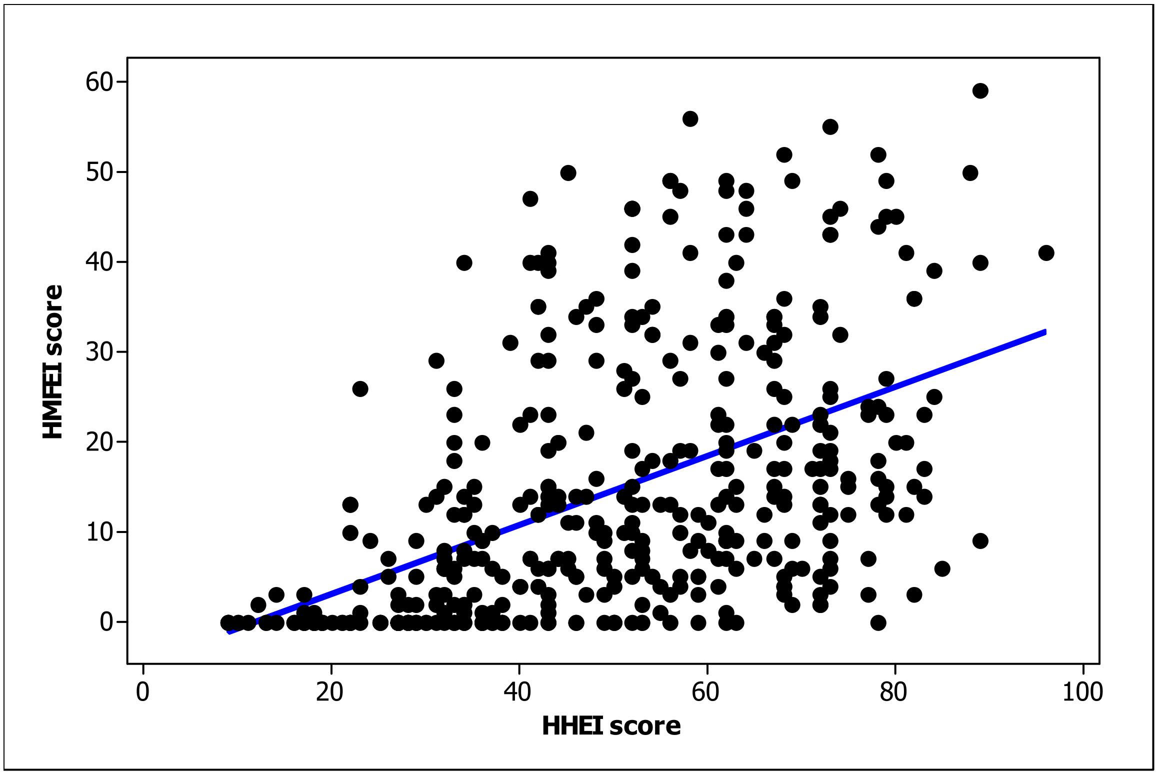

Figure 4. Scatterplot of primary headwater streams in Cleveland Metroparks Reservations in the Rocky River watershed with regression fit.

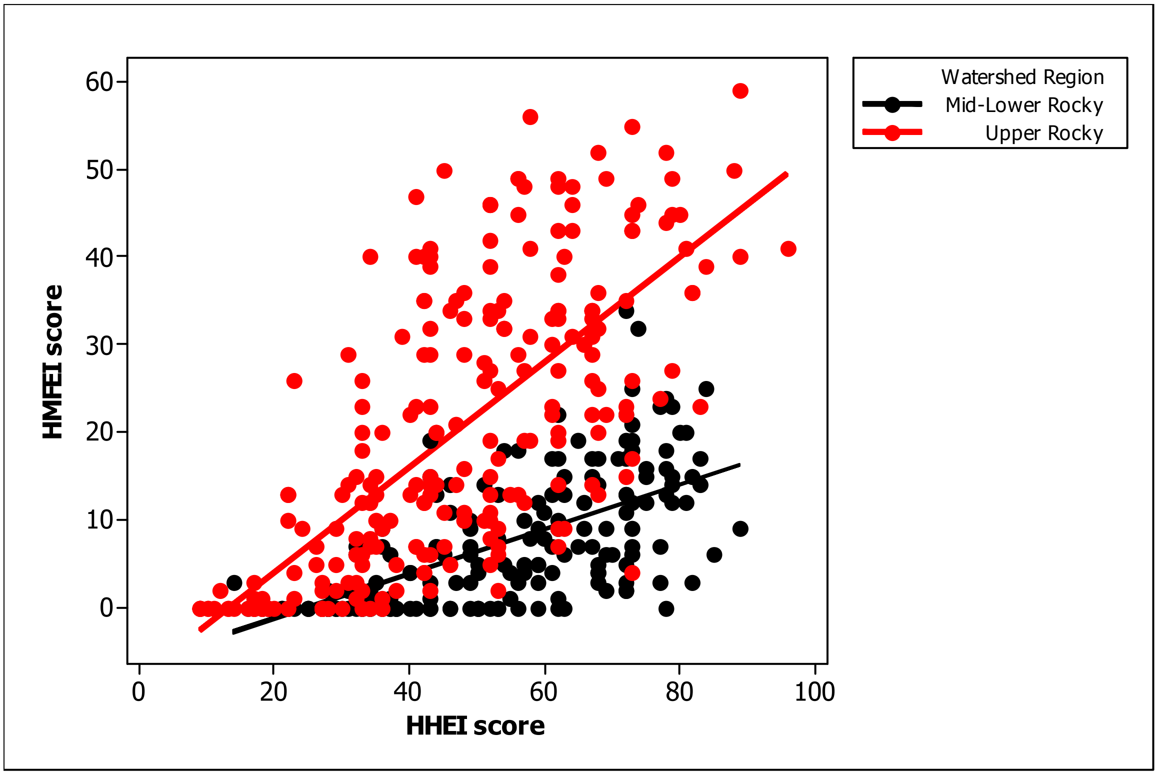

Figure 5. Scatterplot of primary headwater streams in Cleveland Metroparks Reservations in the Rocky River watershed by watershed region with regression fits.

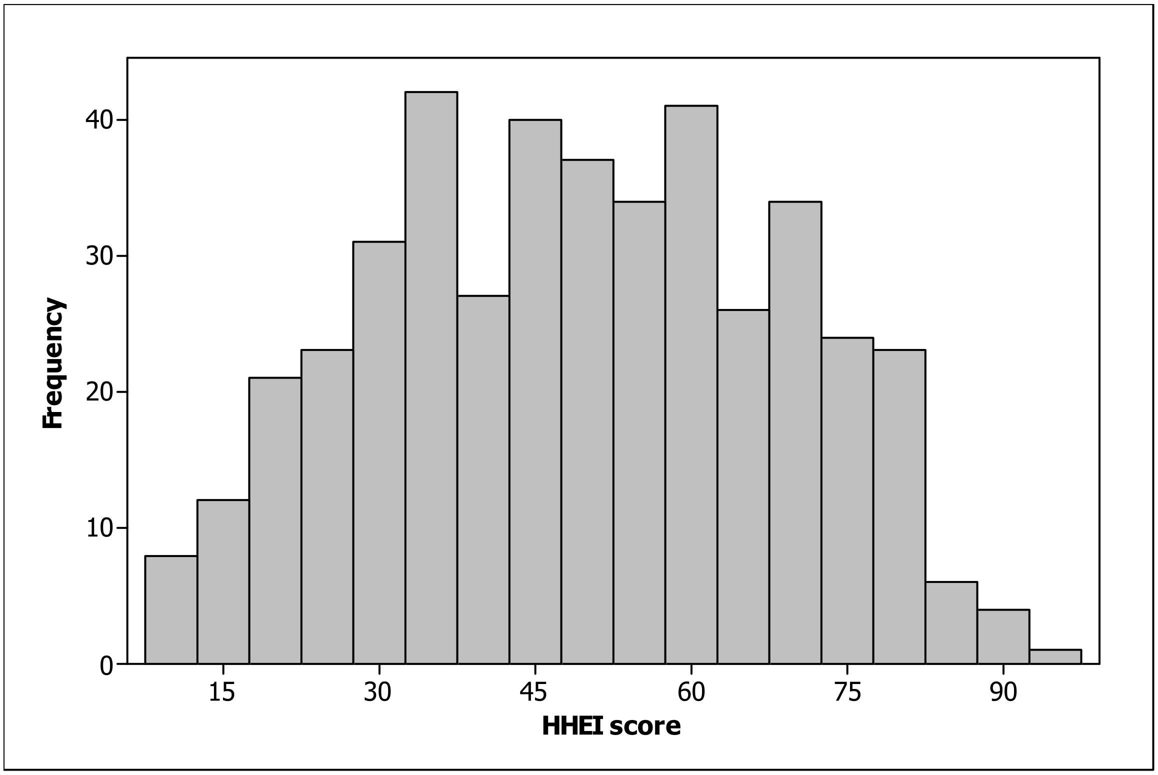

Figure 6. Frequency histogram of stream habitat (HHEI) scores in Cleveland Metroparks Reservations in the Rocky River watershed.

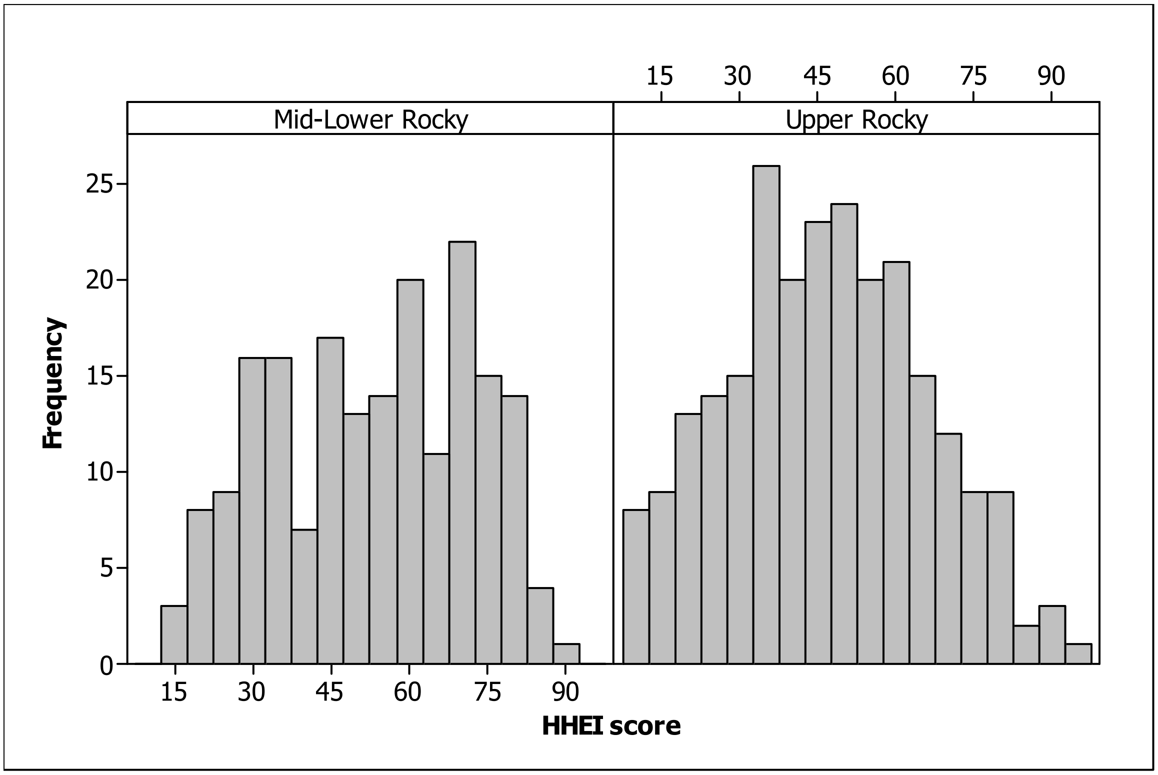

Figure 7. Frequency histogram of stream habitat (HHEI) scores in Cleveland Metroparks Reservations in the Rocky River watershed by watershed region.

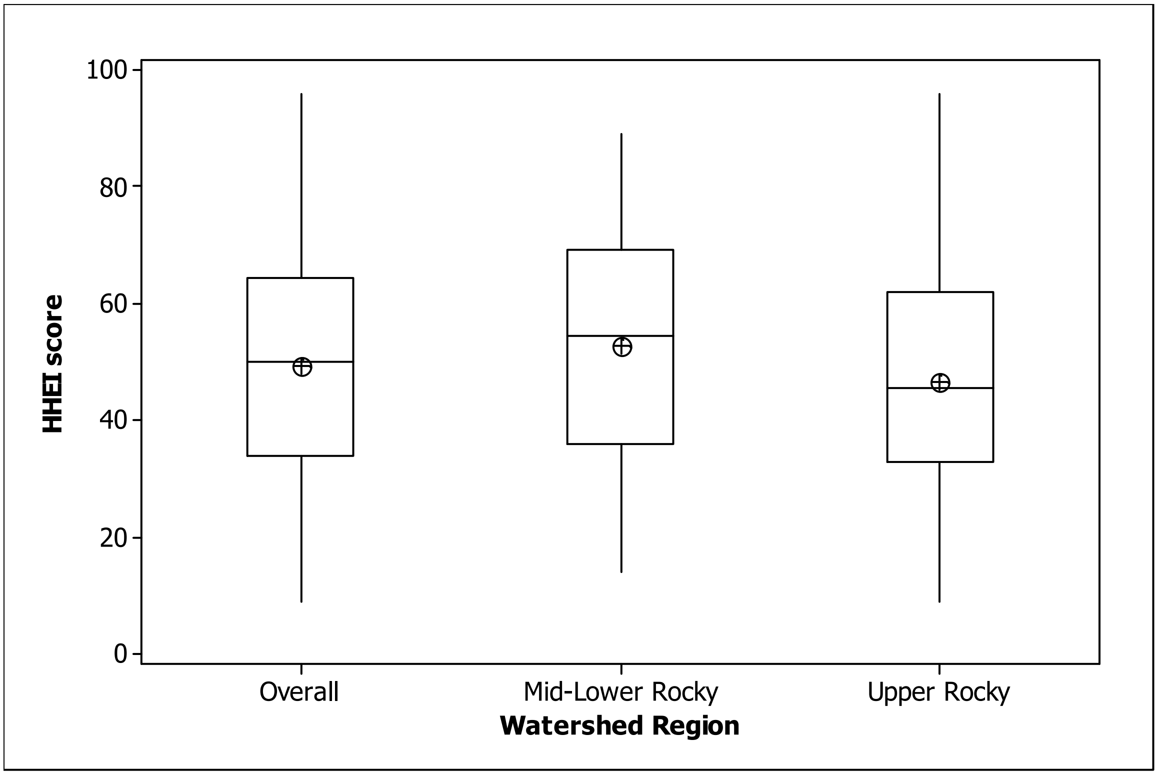

Figure 8. Box and whisker plot of stream habitat (HHEI scores) in Cleveland Metroparks Reservations in the Rocky River watershed overall and by watershed region.

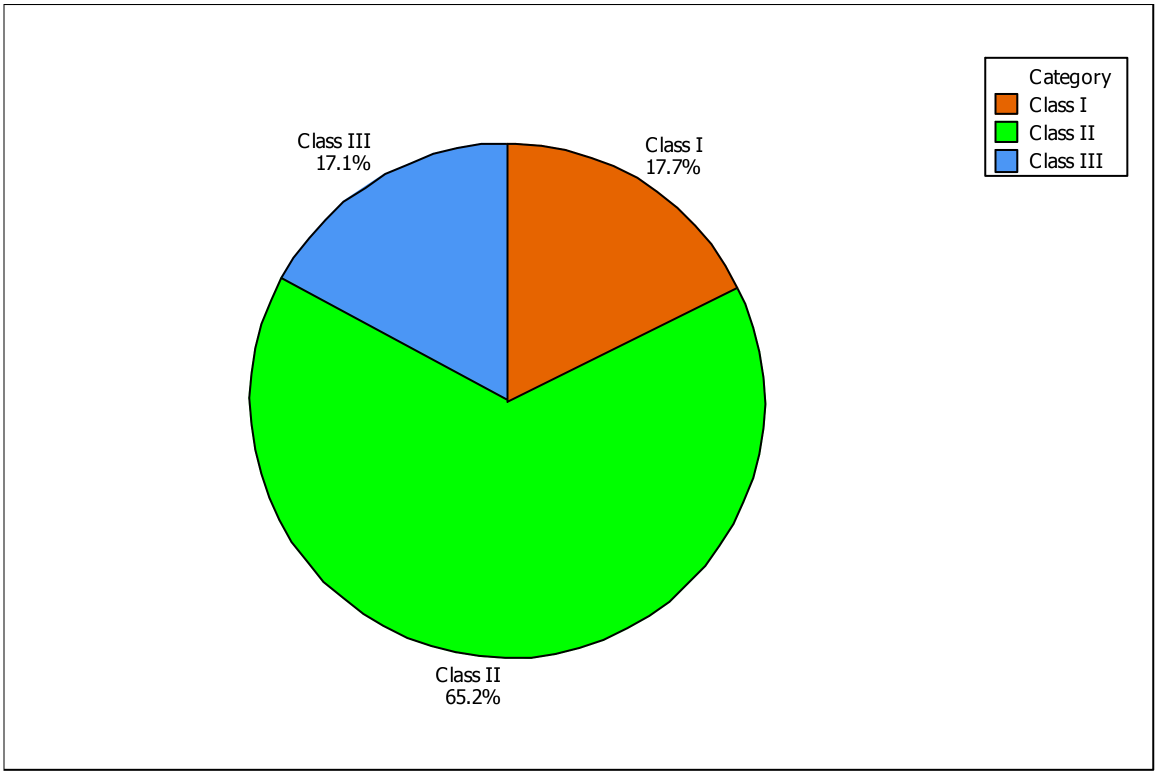

Figure 9. Pie chart of the distribution of primary headwater stream classes by stream habitat (HHEI) score for Cleveland Metroparks Reservations in the Rocky River watershed.

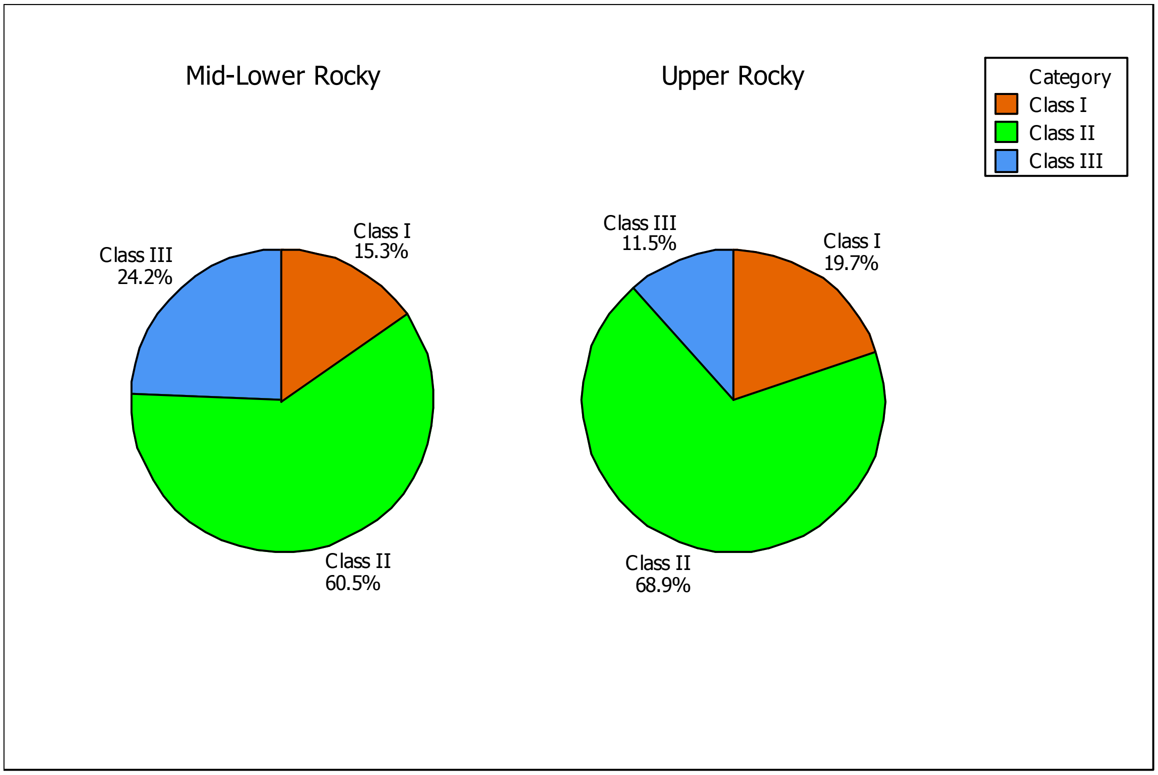

Figure 10. Pie chart of the distribution of primary headwater stream classes by stream habitat (HHEI) score for Cleveland Metroparks Reservations in the Rocky River watershed by watershed region.

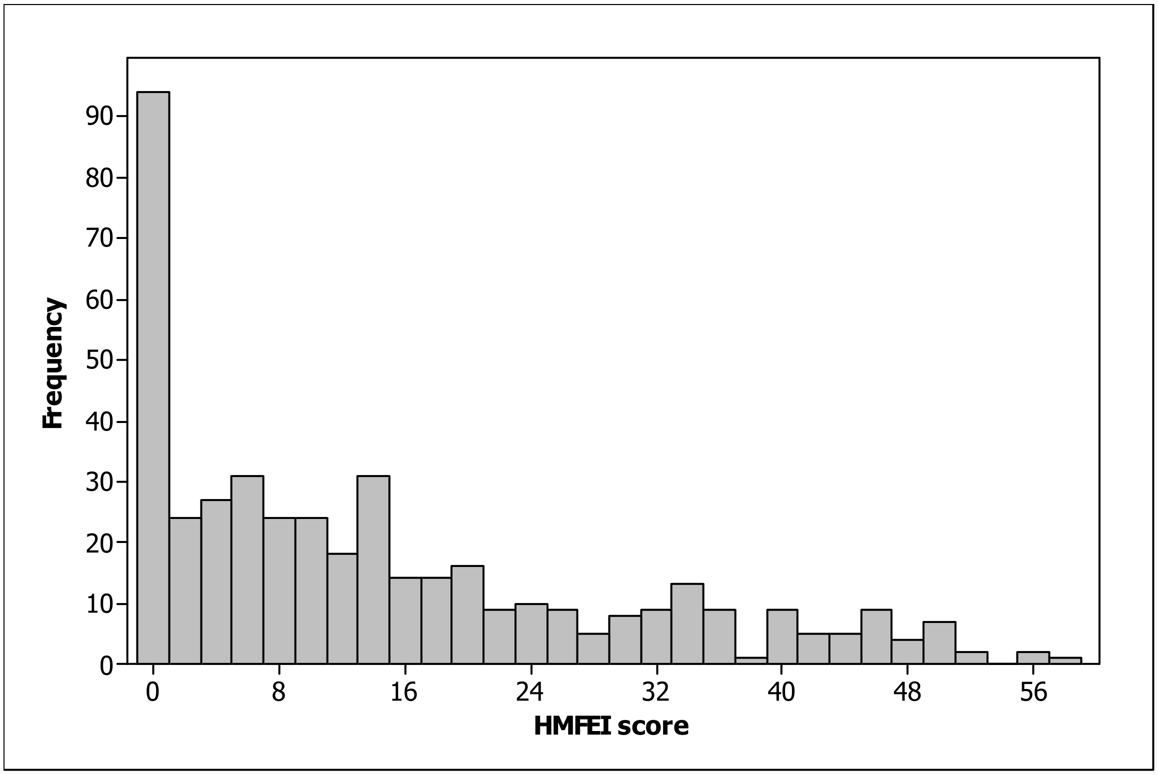

Figure 11. Frequency histogram of aquatic macroinvertebrate (HMFEI) scores in Cleveland Metroparks Reservations in the Rocky River watershed.

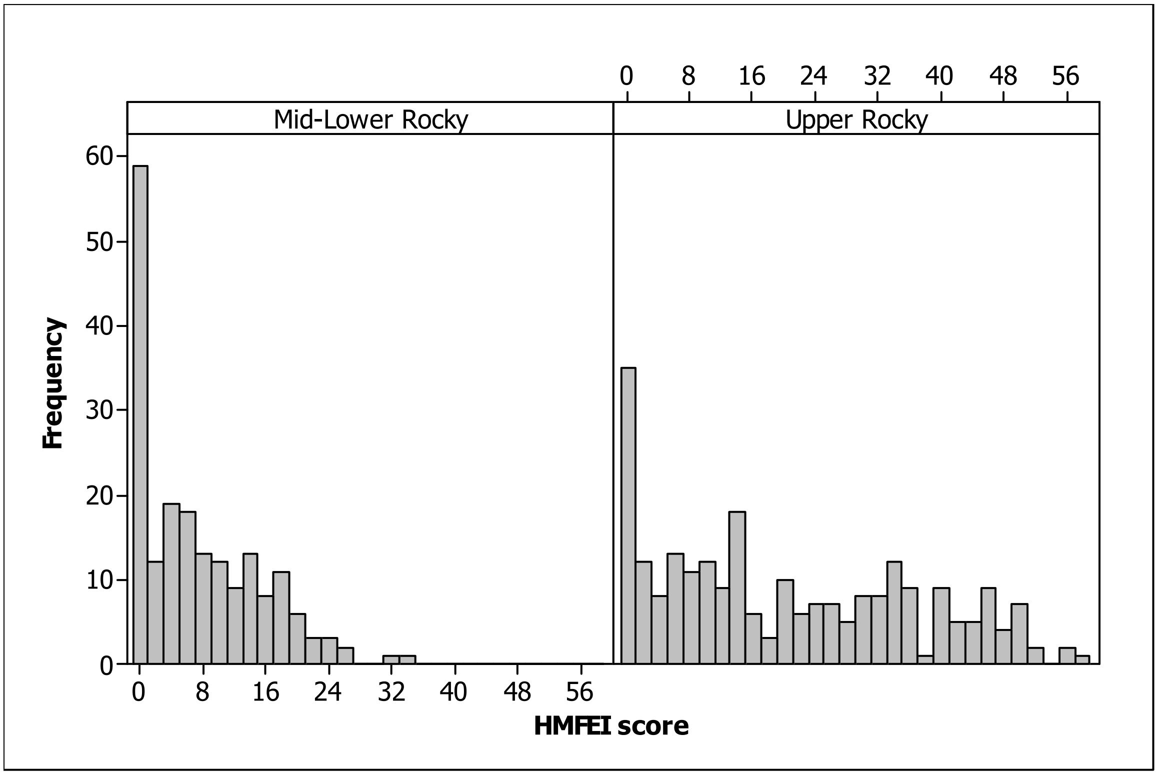

Figure 12. Frequency histogram of aquatic macroinvertebrate (HMFEI) scores in Cleveland Metroparks Reservations in the Rocky River watershed by watershed region.

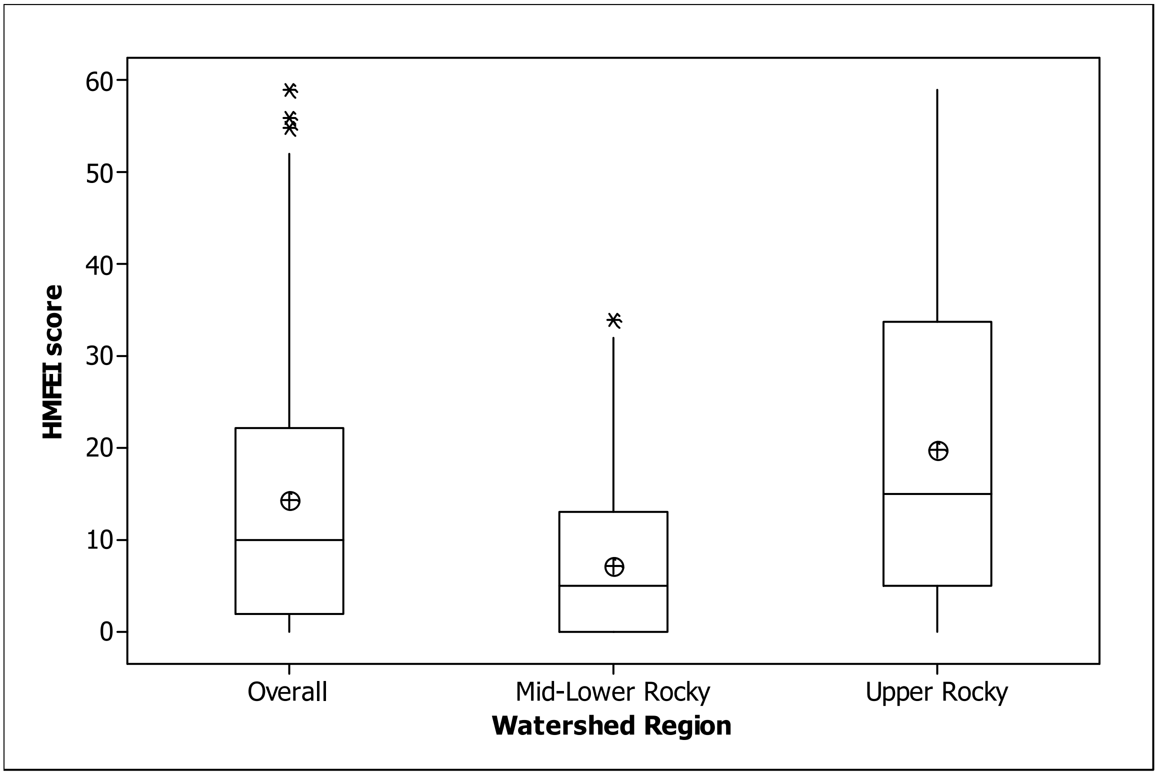

Figure 13. Box and whisker plot of aquatic macroinvertebrate (HMFEI scores) in Cleveland Metroparks Reservations in the Rocky River watershed overall and by watershed region.

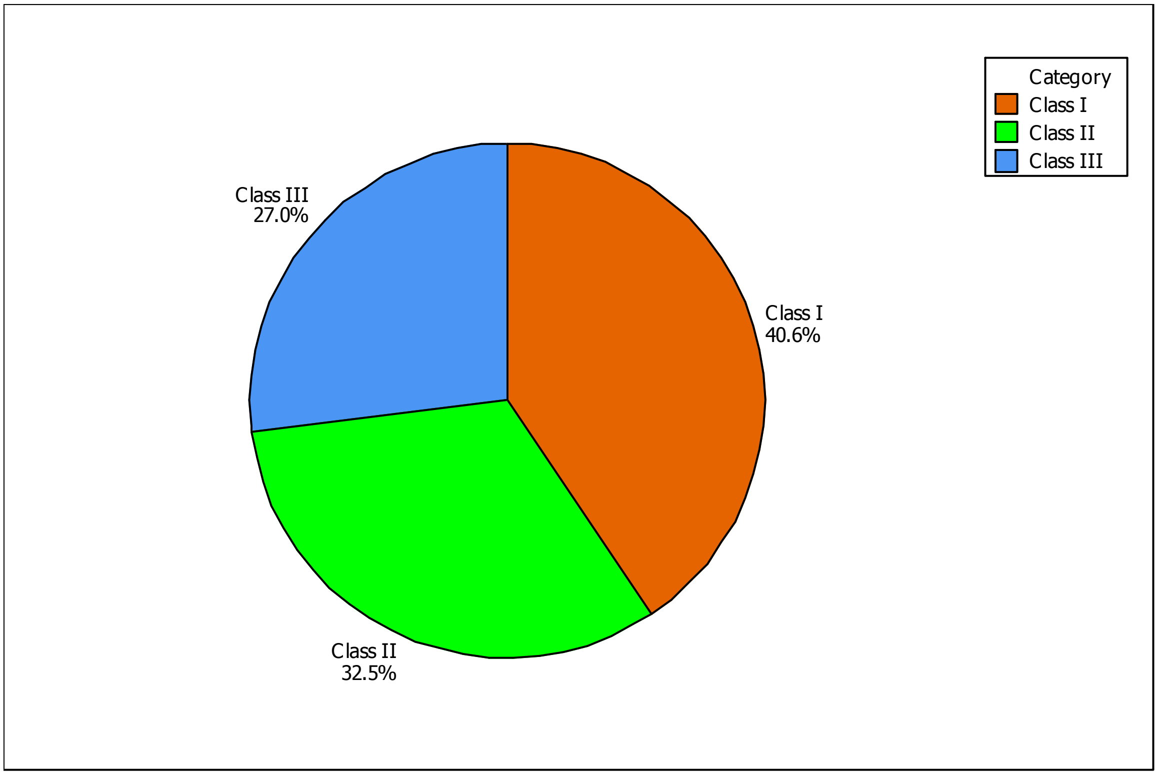

Figure 14. Pie chart of the distribution of primary headwater stream classes by aquatic macroinvertebrate (HMFEI) score for Cleveland Metroparks Reservations in the Rocky River watershed.

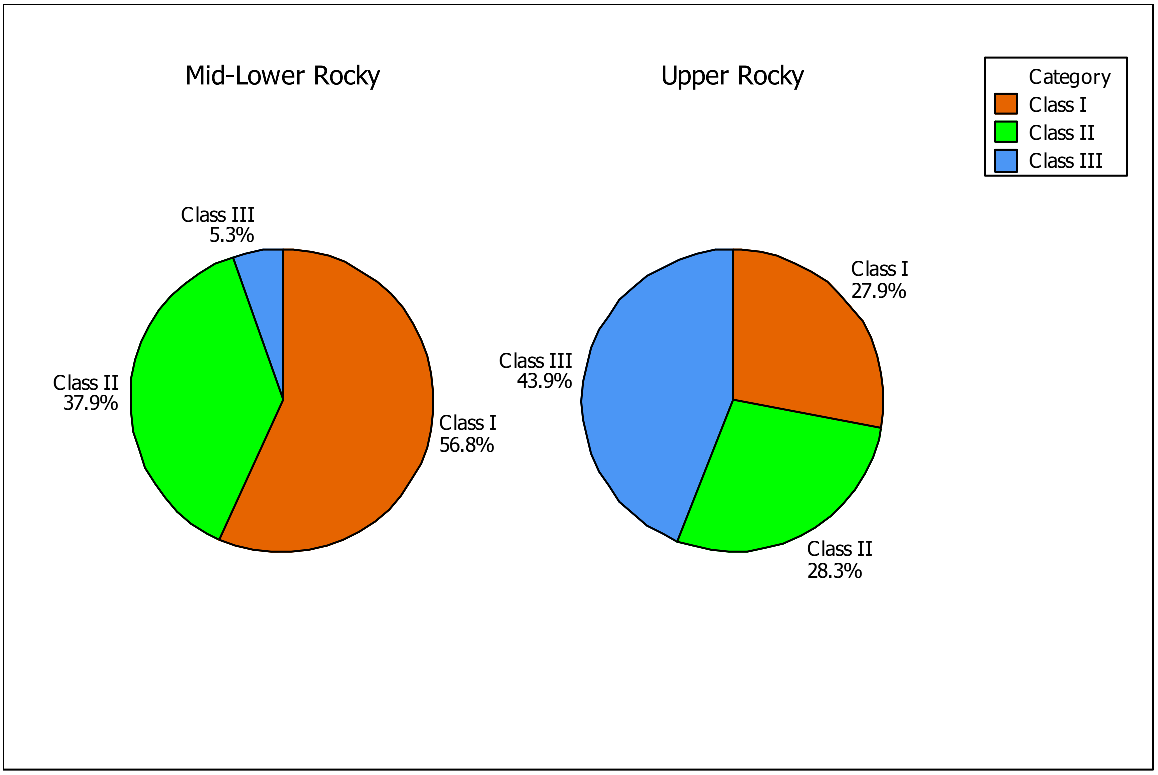

Figure 15. Pie chart of the distribution of primary headwater stream classes by aquatic macroinvertebrate (HMFEI) score for Cleveland Metroparks Reservations in the Rocky River watershed by watershed region.

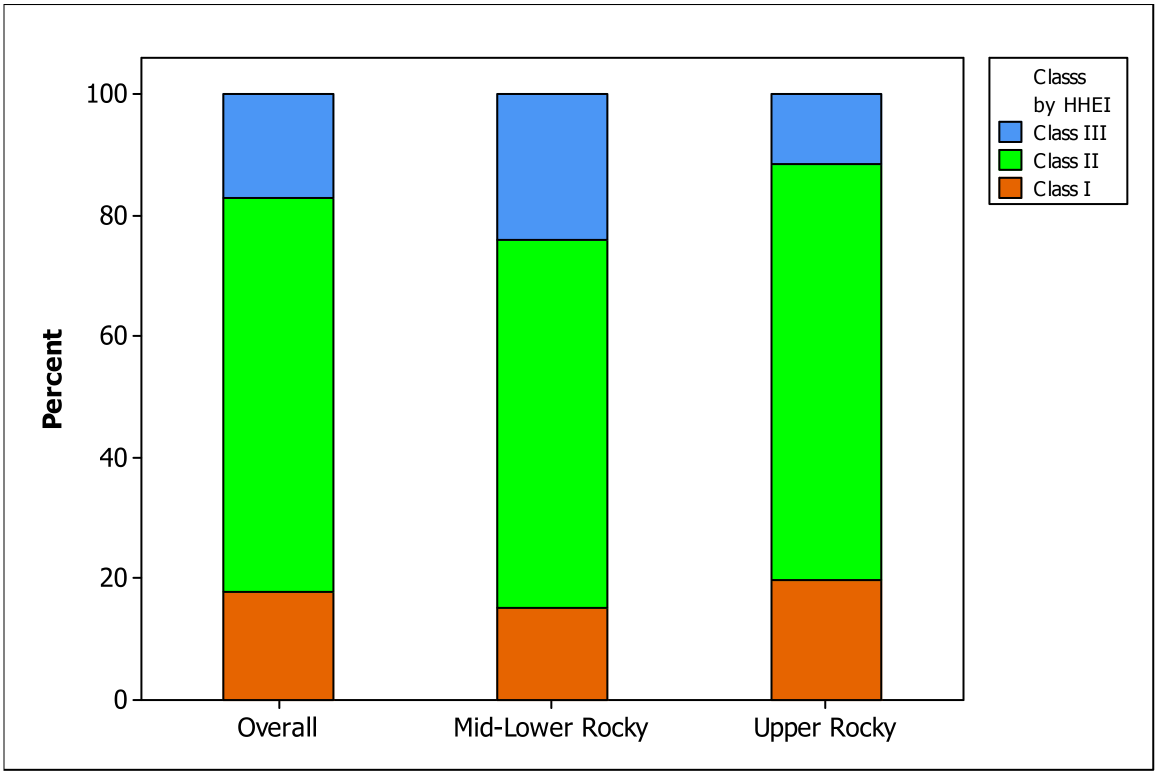

Figure 16. Chart of percent stream class by stream habitat (HHEI) scores for Cleveland Metroparks Reservations in the Rocky River watershed overall and by watershed region.

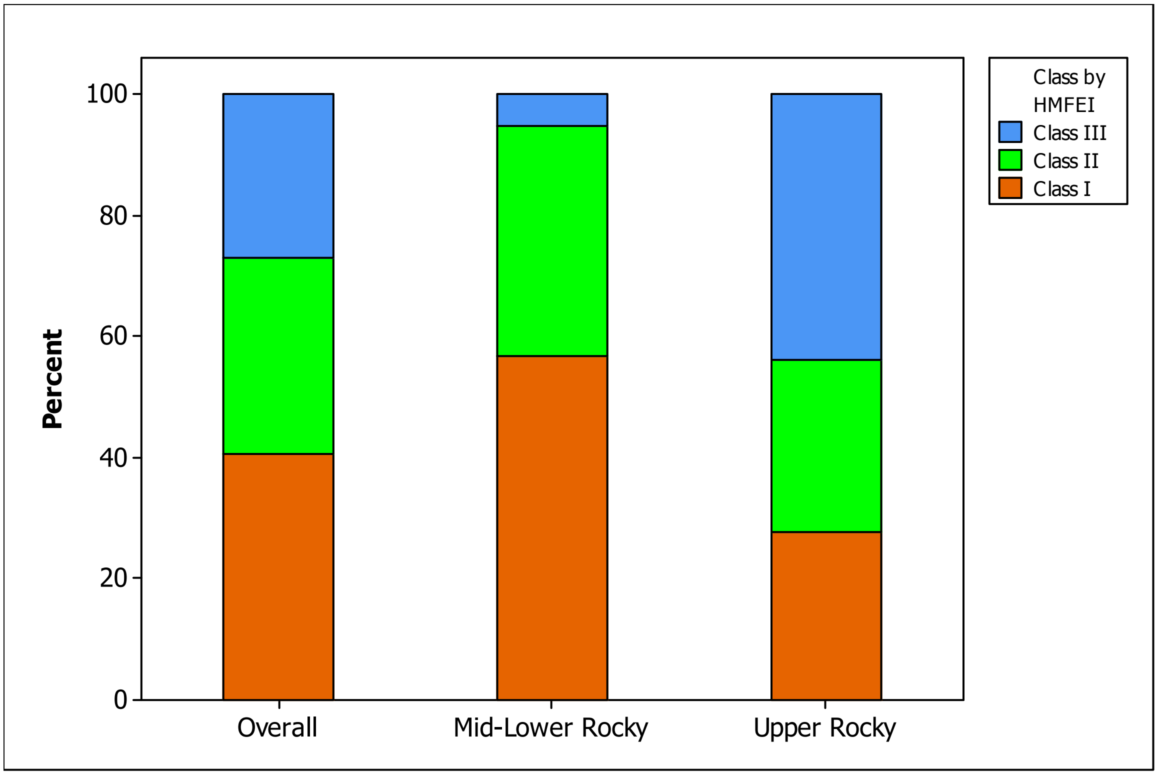

Figure 17. Chart of percent stream class by aquatic macroinvertebrate (HMFEI) scores for Cleveland Metroparks Reservations in the Rocky River watershed overall and by watershed region.

APPENDIX A: FIELD DATA SHEETS

OhioEPA Primary Headwater Habitat Evaluation Form

HHEI Score (sum of metrics 1, 2, 3) : ☐

SITE NAME/LOCATION ____________________

____________ SITE NUMBER ________ RIVER BASIN ____________ DRAINAGE AREA (mi^2) ________

LENGTH OF STREAM REACH (ft) ________ LAT. ________ LONG. ________ RIVER CODE ________ RIVER MILE ________

DATE ________ SCORER ________ COMMENTS ____________

NOTE: Complete All Items On This Form - Refer to "Field Evaluation Manual for Ohio's PHWH Streams" for Instructions

STREAM CHANNEL MODIFICATIONS: ☐ NONE / NATURAL CHANNEL ☐ RECOVERED ☐ RECOVERING ☐ RECENT OR NO RECOVERY

HHEI Metric Points

1. **SUBSTRATE (Estimate percent of every type of substrate present.** Check *ONLY* two predominant substrate *TYPE* boxes (Max of 40). Add total number of significant substrate types found (Max of 8). Final metric score is sum of boxes A & B.

TYPE		PERCENT	TYPE		PERCENT
☐☐	BLDR SLABS [16 pts]	______	☐☐	SILT [3 pt]	______
☐☐	BOULDER (>256 mm) [16 pts]	______	☐☐	LEAF PACK/WOODY DEBRIS [3 pts]	______
☐☐	BEDROCK [16 pt]	______	☐☐	FINE DETRITUS [3 pts]	______
☐☐	COBBLE (65-256 mm) [12 pts]	______	☐☐	CLAY or HARDPAN [0 pt]	______
☐☐	GRAVEL (2-64 mm) [9 pts]	______	☐☐	MUCK [0 pts]	______
☐☐	SAND (<2 mm) [6 pts]	______	☐☐	ARTIFICIAL [3 pts]	______

Total of Percentages of Bldr Slabs, Boulder, Cobble, Bedrock ______

SCORE OF TWO MOST PREDOMINATE SUBSTRATE TYPES: (A) ☐ **TOTAL NUMBER OF SUBSTRATE TYPES:** (B) ☐

Substrate Max = 40 ☐ A + B

2. **Maximum Pool Depth** ***(Measure the maximum pool depth within the 61 meter (200 ft)*** evaluation reach at the time of evaluation. Avoid plunge pools from road culverts or storm water pipes) (Check *ONLY* one box):

- ☐ > 30 centimeters [20 pts]
- ☐ > 22.5 - 30 cm [30 pts]
- ☐ > 10 - 22.5 cm [25 pts]
- ☐ > 5 cm - 10 cm [15 pts]
- ☐ < 5 cm [5 pts]
- ☐ NO WATER OR MOIST CHANNEL [0 pts]

COMMENTS ____________ **MAXIMUM POOL DEPTH (centimeters):** ☐

Pool Depth Max = 30 ☐

3. **BANK FULL WIDTH (Measured as the average of 3-4 measurements)** (Check *ONLY* one box):

- ☐ > 4.0 meters (> 13') [30 pts]
- ☐ > 3.0 m - 4.0 m (> 9' 7" - 13') [25 pts]
- ☐ > 1.5 m - 3.0 m (> 4' 8" - 9' 7") [20 pts]
- ☐ > 1.0 m - 1.5 m (> 3' 3" - 4' 8") [15 pts]
- ☐ ≤ 1.0 m (≤ 3' 3") [5 pts]

COMMENTS ____________ **AVERAGE BANKFULL WIDTH (meters)** ☐

Bankfull Width Max=30 ☐

This information must also be completed

RIPARIAN ZONE AND FLOODPLAIN QUALITY ☆NOTE: River Left (L) and Right (R) as looking downstream☆

L R	RIPARIAN WIDTH (Per Bank)	L R	FLOODPLAIN QUALITY (Most Predominant per Bank)	L R	
☐☐	Wide >10m	☐☐	Mature Forest, Wetland	☐☐	Conservation Tillage
☐☐	Moderate 5-10m	☐☐	Immature Forest, Shrub or Old Field	☐☐	Urban or Industrial
☐☐	Narrow <5m	☐☐	Residential, Park, New Field	☐☐	Open Pasture, Row Crop
☐☐	None	☐☐	Fenced Pasture	☐☐	Mining or Construction

COMMENTS ____________

FLOW REGIME *(At Time of Evaluation)* (Check *ONLY* one box):

- ☐ Stream Flowing
- ☐ Subsurface flow with isolated pools (Interstitial)
- ☐ Moist Channel, isolated pools, no flow (Intermittent)
- ☐ Dry channel, no water (Ephemeral)

COMMENTS ____________

SINUOSITY (Number of bends per 61 m (200 ft) of channel) (Check *ONLY* one box):

☐ None ☐ 0.5 ☐ 1.0 ☐ 1.5 ☐ 2.0 ☐ 2.5 ☐ 3.0 ☐ >3

STREAM GRADIENT ESTIMATE

☐ Flat (0.5 ft/100 ft) ☐ Flat to Moderate ☐ Moderate (2 ft/100 ft) ☐ Moderate to Severe ☐ Severe (10 ft/100 ft)

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ADDITIONAL STREAM INFORMATION (This Information Must Also be Completed):

QHEI PERFORMED? - ☐ Yes ☐ No QHEI Score ________ (If Yes, Attach Completed QHEI Form)

DOWNSTREAM DESIGNATED USE(S)

☐ WWH Name: ________________________________ Distance from Evaluated Stream ___________
☐ CWH Name: ________________________________ Distance from Evaluated Stream ___________
☐ EWH Name: ________________________________ Distance from Evaluated Stream ___________

MAPPING: ATTACH COPIES OF MAPS, INCLUDING THE ENTIRE WATERSHED AREA. CLEARLY MARK THE SITE LOCATION

USGS Quadrangle Name:______________________ NRCS Soil Map Page:______ NRCS Soil Map Stream Order ______

County: __________________________ Township / City:______________________________

MISCELLANEOUS

Base Flow Conditions? (Y/N):_______ Date of last precipitation:_______________ Quantity:___________

Photograph Information: ____

Elevated Turbidity? (Y/N): ________ Canopy (% open): ___________

Were samples collected for water chemistry? (Y/N): ______ (Note lab sample no. or id. and attach results) Lab Number:_______________

Field Measures: Temp (°C)______ Dissolved Oxygen (mg/l) ________ pH (S.U.) _______ Conductivity (µmhos/cm) _____________

Is the sampling reach representative of the stream (Y/N)_____ If not, please explain:_________________________________

____

Additional comments/description of pollution impacts:____

____

BIOTIC EVALUATION

Performed? (Y/N): _______ (If Yes, Record all observations. Voucher collections optional. NOTE: all voucher samples must be labeled with the site ID number. Include appropriate field data sheets from the Primary Headwater Habitat Assessment Manual)

Fish Observed? (Y/N)_____ Voucher? (Y/N)_____ Salamanders Observed? (Y/N)_____ Voucher? (Y/N)_____
Frogs or Tadpoles Observed? (Y/N)____ Voucher? (Y/N)____ Aquatic Macroinvertebrates Observed? (Y/N)____ Voucher? (Y/N)____

Comments Regarding Biology:____

____

____

DRAWING AND NARRATIVE DESCRIPTION OF STREAM REACH (This must be completed):

Include important landmarks and other features of interest for site evaluation and a narrative description of the stream's location

FLOW ➜

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PHWH STREAM BIOLOGICAL CHARACTERISTICS FIELD SHEET:

1. Fish: Voucher Specimens Retained? (circle) Y / N Time Spent (minutes):______
Sample Method _____________ Stream Length Assessed (meters) ____________

Species	Number Caught	Notes

2. Salamanders: Voucher Specimens Retained? (circle) Y / N Time Spent (minutes):_______
Sample Method ________________ Stream Length Assessed (meters) _________

Species *(Genus)*	# Larvae	# Juveniles/Adults	Total Number
Mountain Dusky (*Desmognathus ochrophaeus*)			
Northern Dusky (*Desmognathus fuscus*)			
Two-lined *(Eurycea bislineata)*			
Long-tailed *(Eurycea longicauda)*			
Cave *(Eurycea lucifuga)*			
Red *(Pseudotriton ruber)*			
Mud *(Pseudotriton montanus)*			
Spring *(Gyrinophilus porphyriticus)*			
Mole spp. *(Ambystoma spp.)*			
Four-toed *(Hemidactylium scutatum)*			
Other (name)			
Total			

Notes on Vertebrates: ____

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3. Macroinvertebrate Scoring Sheet:

THE HEADWATER MACROINVERTEBRATE FIELD EVALUATION INDEX (HMFEI) SCORING SHEET

Indicate Abundance of Each Taxa Above each White Box.
Record HMFEI Scoring Value Points Within each Box.
For EPT taxa, also indicate the different taxa present.

Key: V = Very Abundant (> 50); A = Abundant (10 -50); C = Common (3 -9); R = Rare (< 3)

Sessile Animals (**Porifera, Cnidaria, Bryozoa**) (HMFEI pts = 1)	Crayfish (**Decapoda**) (HMFEI pts = 2)	Fishfly Larvae (**Corydalidae**) (HMFEI pts = 3)
Aquatic Worms (**Turbellaria, Oligochaeta, Hirudinea**) (HMFEI pts = 1)	Dragonfly Nymphs (**Anisoptera**) (HMFEI pts = 2)	Water Penny Beetles (**Psephenidae**) (HMFEI pts = 3)
Sow Bugs (**Isopoda**) (HMFEI pts = 1)	Riffle Beetles (**Dryopidae, Elimidae, Ptilodactylidae**) (HMFEI pts = 2)	Cranefly Larvae (**Tipulidae**) (HMFEI pts = 3)
Scuds (**Amphipoda**) (HMFEI pts = 1)	Larvae of other Flies (**Diptera**) Name: (HMFEI pts = 1)	**EPT TAXA*** Total No. EPT Taxa = ______
Water Mites (**Hydracarina**) (HMFEI pts = 1)	Midges (**Chironomidae**) (HMFEI pts = 1)	Mayfly Nymphs (**Ephemeroptera**) Taxa Present: [HMFEI pts = No. Taxa (x) 3]
Damselfly Nymphs (**Zygoptera**) (HMFEI pts = 1)	Snails (**Gastropoda**) (HMFEI pts = 1)	
Alderfly Larvae (**Sialidae**) (HMFEI pts = 1)	Clams (**Bivalvia**) (HMFEI pts = 1)	Stonefly Nymphs (**Plecoptera**) Taxa Present: [HMFEI pts = No. Taxa (x) 3]
Other Beetles (**Coleoptera**) (HMFEI pts = 1)	Other Taxa :	
Other Taxa:	Other Taxa:	Caddisfly Larvae (**Trichoptera**) Taxa Present: [HMFEI pts = No. Taxa (x) 3]
Other Taxa:	Other Taxa	

*Note: EPT identification based upon Family or Genus level of taxonomy

Voucher Sample ID________________________ Time Spent (minutes):________________________

Notes on Macroinvertebrates: (Predominant Organisms; Other Common Organisms; Diversity Estimate)

Final HMFEI Calculated Score (Sum of All White Box Scores) =

IF Final HMFEI Score is > 19, Then CLASS III PHWH STREAM
IF Final HMFEI Score is 7 to 19, Then CLASS II PHWH STREAM
IF Final HMFEI Score is < 7, Then CLASS I PHWH STREAM

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