Determining Realistic Ecological Expectations in Urban Stream Restorations

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Executive Summary
Because of the limited evidence that urban stream restorations improve ecological uplift, methods that can provide more realistic expectations are needed. This report describes, assesses, and applies a methodology to predict Benthic invertebrate Index of Biotic Integrity (BIBI) scores for individual stream reaches based on the Impervious Surface Cover (ISC) in the watershed. Predicted BIBI scores were compared against observed BIBI scores calculated from monitoring data in Montgomery County, MD streams. Differences were analyzed in order to identify if aspects of stormwater best management practices or the proximity to potential donor-rescue reaches improved ecological condition.

Model predictions corresponded closely to the observed BIBI scores for the Montgomery County DEP reference streams, which represent the set of most ecologically intact streams in the county. The 99.5th percentile density distribution of predicted BIBI scores provided the maximum amount of overlap with the actual monitoring data and suggests that the model predictions realistically represent what is ecologically possible. There was little if any bias in predictions when examined across the ISC gradient, again suggesting a realistic representation of ecological potential.

Based on the predictions' correspondence with the reference streams, I used the predicted 95th percentile density distribution as the standard against which to compare observed BIBI scores from the monitoring data. In cases where more than one monitoring sample existed for a reach, only the highest observed BIBI score was used. Reach performance was calculated by subtracting the predicted BIBI score from the observed BIBI score. Reaches meeting expectations had a BIBI score within +/- 0.5 of the predicted 95th percentile score. Reaches with an observed BIBI exceeding 0.5 of predicted were classified as over-performing, whereas those with a BIBI more than 0.5 below the predicted were under-performing, and those greater than 1.5 below the predicted BIBI were poor performing.

While some restored reaches met model predictions, most underperformed. Seven reaches met expectations where observed BIBI scores were within +/- 0.5 of the predicted 95th percentile BIBI scores. The remaining 19 underperformed with three of these being poor performers. Most restored reaches did not even attain the 50th percentile of predicted, and almost half attained less than the 30th percentile of what was predicted.

The AUC that maximized overlap between restored reaches and predictions was the 65th percentile density distribution, suggesting that restored reaches can be expected to attain the 65th percentile of predicted. However, most reaches (76%) did not even achieve the 60th percentile, and so the 65th percentile is probably optimistic. A more likely and realistic expectation is for a restored reach to attain its 30th percentile of predicted as this corresponds most closely with the frequency of attainment.

There was no evidence that reaches with lower predicted potential had lower attainment than those with higher predicted potential, nor did reaches in higher ISC watersheds have lower attainment relative to their predicted BIBI scores.

Restored reaches tended to have both lower predicted ecological potential as well as lower attainment compared to the non-restored reaches in the Montgomery County monitoring data. Thus, those reaches that were restored were in greater need of intervention, but their performance lagged.

Unfortunately, I was not able to identify why some restorations met predicted expectations and why most underperformed. While watershed ISC was significantly related to BIBI scores, it was not related to how well a restoration performed compared to its predicted state. The lack of a significant relationship

between ISC and reach performance suggests that the predictions behave similarly across the ISC gradient and are not biased, and I view this as a positive feature. Nonetheless, restored reaches in proximity to other reaches with lower ISC tended to perform better and also have higher observed BIBI scores than reaches with fewer potential donor streams. Although I think most of the relationship is more of a proxy for where reaches are located than due to donor-rescue effects, the trend cannot be ignored because reach performance also tended to be higher in donor-rich areas. Other attributes, such as watershed area, land uses, or the various components of stormwater best management practices were not found to be influential in restoration performance. Stream restorations continue to appear to be idiosyncratic and have no clear reasons for why some meet expectations while others fall short.

INTRODUCTION

Stream restorations are a widely used approach to mitigate for human and natural degradation to streams and their watersheds because the restorative abilities of flowing water can be substantial. Specific projects span a continuum ranging from simple to highly complicated depending on the nature and extent of the degradation and the techniques employed. For less degraded streams, the potential for recovery can be high with minor intervention as in the case of fencing out livestock to stabilize stream banks and lower water temperature (Roni et al. 2008). Even ecologically dead streams can be almost completely restored when the effective treatment is chemical mitigation as in acid leachate neutralization (McClurg et al. 2007), providing the chemical treatment continues *ad infinitum*. However, some forms of degradation have proven to be less tractable and more difficult to recover ecological pattern or process despite tremendous intervention and expense.

Urban stream restorations are perhaps the most intensive and invasive of stream restoration projects. Many are destructive in their own right with complete relocations of stream channels in order to repair the damages done by years of erosion and altered hydrologic conditions. The practice has become so pervasive that billions of dollars were spent within the United States over a decade ago (Bernhardt et al. 2005), and project numbers and investments continue to increase. The logic supporting current urban stream restorations is that providing stable habitats in restored channels will allow for the fish and benthic macroinvertebrates to re-establish. Unfortunately, there is little evidence that the ecological structure has been restored for the benthic macroinvertebrates (Violin et al. 2011; Stranko et al. 2012). The lack of success is not for lack of trying as many restorations target habitat conditions thought to benefit the biota. However, restorations focus on the channel and floodplain while ignoring the watershed. Many of the causes for the degradation are due to watershed conditions, and failure to address them ignores the problem while substantial money is spent on addressing the symptoms. The process traps us in a very expensive Sisyphus Complex (*sensu* Hilderbrand et al. 2005), where restoration costs can exceed $2 million/mile of stream that doesn't recover ecologically and remains subject to the initial stressors causing the degradation.

Because of limited ecological responses, more realistic expectations need to be defined. While geomorphic stability is relatively easy to design and achieve given hydraulic relationships, ecological responses can be quite complicated. The proximity of donor-source reaches for recolonization may limit recovery (Sundermann et al. 2011) as may the more complex interactions associated with community assembly, the existence of competitors and predators, and an effective population size large enough to avoid genetic, stochastic, and demographic extirpation risks. However, prior to any biotic interactions, each taxon must have suitable site conditions within their physiological and stress-tolerance limits. The best physical habitat available is useless if an organism cannot survive due to conditions outside of its physiological tolerances. Evidence is accumulating than many fish (Utz et al. 2010) and benthic macroinvertebrates (Utz et al. 2009) disappear above taxon-specific levels of human land uses. While the exact reasons for extirpation may be specific to each taxon, broad categories such as urbanization or impervious surface cover (ISC) can be good surrogates, and the pattern becomes clear when examined across large samples and spatial scales. These patterns can be used to inform more realistic restoration expectations that are based on the distributions of taxa under specific land use settings.

Existing information can be used to identify taxa limits based on surrogate information, and from this, predictions of restoration potential. Thus, realism can be incorporated into restoration expectations given the landscape setting of any stream reach. Surrogates for human activities can be used as a landscape filter (Stranko et al. 2005; Chessman 2006), and landscape factors are identified that strongly relate to species occupancy. Watershed ISC is a very strong predictor of stream health and of species occupancy for sensitive taxa (Utz et al. 2009; Utz et al. 2010; King et al. 2011). ISC is also easily calculated from spatial datasets and allows for spatially explicit estimates for any watershed in question. Once the set of taxa capable of existing within a specific watershed with given ISC is estimated, the taxa list can be used to establish the best expected ecological results should a restoration provide adequate habitat and geomorphic stability. The results can also be used to estimate the highest ecological condition achievable based on the predicted taxa list.

Within the state of Maryland, and many other states, a Benthic Macroinvertebrate Index of Biotic Integrity (BIBI) is used for assessing stream ecological condition, or stream "health" (Southerland et al. 2007). The BIBI is legal biocriteria within Maryland and thus is an important tool for evaluating stream health and responses to activities such as stream restoration. Because of its importance for assessments, predicting the BIBI score should be a good benchmark for evaluating the best possible ecological outcome for any proposed urban stream restoration given the watershed condition. Such a tool can provide for pre-restoration screening where planners, regulators, and funders can evaluate the possibility of ecological success at any site. In addition, comparing observed BIBI scores to the predicted BIBI scores allows an assessment of how well restorations perform relative to a site's potential. This research has three main objectives:

1. Predict the best realistically achievable BIBI scores for 1286 stream reaches around Montgomery County Maryland, USA.
2. Compare predictions against actual BIBI scores generated from monitoring data.
3. Identify the extent to which stormwater best management practices (BMPs) and nearby potential source/donor streams explain why some sites outperform predictions.

METHODS

Spatial datasets

All land use and land cover data were extracted from products created by the SHEDS (Spatial Hydro-Ecological Decision Support) project of the Conte-Ecology group of the USGS (http://conte-ecology.github.io/shedsGisData/). The data are based on the 2006 NLCD 2011 Edition and the National Hydrography Dataset High Resolution Delineation Version 2 (NHDHRVD2) stream layer. For each stream reach within the study area, I extracted the percent of catchment upstream of the pour point in urbanized land covers and ISC. These land cover data were used to both estimate the upper values beyond which a taxon was no longer present and to predict the suite of taxa capable of existing within a catchment given the existing land cover.

Potential nearby dispersal donor streams for recolonization were identified using two distinct forms: "as the insect flys" and "as the fish swims". For each method from the pour-point of every stream reach, the total number of other stream reaches and the total stream length of nearby streams within a specified search distance and level of ISC in the upstream catchment (Table 1) was calculated. For "as the fish swims", the distances were constrained to be along the connected linear stream network, whereas streams for "as the insect flys" were determined using a search radius regardless of whether a nearby stream was within the connected network.

Spatially explicit data for stormwater facilities (BMPs) were obtained from the Montgomery County Department of Environmental Protection. These data are used for their annual stormwater reporting requirements. For each site physically sampled for benthic macroinvertebrates, all stormwater projects within the catchment upstream were extracted for statistical analyses. Stormwater BMP attributes extracted for each watershed included the total number of BMPs within different treatment types and the amount of ISC treated by each specific BMP as well as the total number and total amount of ISC treated across all stormwater BMPs within a catchment (Table 2).

Table 1. Attributes defining categories of potential donor streams in proximity to a stream reach. All combinations of the attributes were calculated.

Search Method	Aerial radius: As the insect flys Network: As the fish swims
Search Distance (km)	1, 2, 3 ,4 ,5 ,7.5, 10, 15, 20, 25
ISC classes	<1%, <3%, <5%, <7%, <10%, <15%, <20%, <25%
Metric	Total number of reaches Total length of reaches

Table 2. Attributes of stormwater BMP projects used as independent variables to explain stream reach performance.

BMP Type Code	BMP Type
	Alternative Surfaces (A)
AGRE	Green Roof – Extensive
AGRI	Green Roof – Intensive
APRP	Permeable Pavements
ARTF	Reinforced Turf
	Nonstructural Techniques (N)
NDRR	Disconnection of Rooftop Runoff
NDNR	Disconnection of Non-Rooftop Runoff
NSCA	Sheetflow to Conservation Areas
	Micro-Scale Practices (M)
MRWH	Rainwater Harvesting
MSGW	Submerged Gravel Wetlands
MILS	Landscape Infiltration
MIBR	Infiltration Berms
MIDW	Dry Wells
MMBR	Micro-Bioretention
MRNG	Rain Gardens
MSWG	Grass Swale
MSWW	Wet Swale
MSWB	Bio-Swale
MENF	Enhanced Filters
	Ponds (P)
PWED	Extended Detention Structure, Wet
PWET	Retention Pond (Wet Pond)
PMPS	Multiple Pond System
PPKT	Pocket Pond
PMED	Micropool Extended Detention Pond
	Wetlands (W)
WSHW	Shallow Marsh
WEDW	Extended Detention – Wetland
WPWS	Wet Pond – Wetland
WPKT	Pocket Wetland
	Infiltration (I)
IBAS	Infiltration Basin
ITRN	Infiltration Trench
	Filtering Systems (F)
FBIO	Bioretention
FSND	Sand Filter
FUND	Underground Filter
FPER	Perimeter (Sand) Filter
FORG	Organic Filter (Peat Filter)
FBIO	Bioretention
	Open Channels (O)
ODSW	Dry Swale
OWSW	Wet Swale
	Other Practices (X)
XDPD	Detention Structure (Dry Pond)
XDED	Extended Detention Structure, Dry
XFLD	Flood Management Area
XOGS	Oil Grit Separator
XOTH	Other

Benthic macroinvertebrate datasets

Two independent benthic macroinvertebrate datasets were used for predictions and analyses and were derived from three sources: Maryland Biological Stream Survey (MBSS), Montgomery County Department of Environmental Protection, and UMCES Appalachian Laboratory (UMCESAL). However, all of the samples were collected using the same sampling and enumeration techniques regardless of the organization collecting the samples. Benthic macroinvertebrate samples comprising the datasets were collected between 2007 and 2018. In all cases, benthic macroinvertebrates were collected between March 1 and April 30 in a given year and followed MBSS protocols (Stranko et al. 2019). Briefly, a D-frame net was used to sample 20ft^2 of habitat in relative proportions to that occurring at each site. Samples were stored in ethanol and later processed in the laboratory. Each sample was randomly sorted using the EPA standard grid system and continued until the random grid containing the 100th individual was fully picked or when the entire sample was picked if there were fewer than 100 individuals. While often referred to as a 100 individual count, there were frequently more than 100 individuals in any given sample. All individuals were identified to genus or lowest practical taxon.

Benthic macroinvertebrate samples from both MBSS and MCDEP were a mixture of random samples and targeted samples. The targeted samples generally focused on sites of exceptional value or sites that had undergone stream restoration. All of the UMCESAL samples targeted stream restorations in Montgomery County.

Data Analysis and Modeling

Thresholds of watershed ISC and urbanization above which taxa no longer occur on the landscape were identified using the MBSS benthic macroinvertebrate dataset. Across 513 samples collected from the surrounding geographic area, the ISC and urbanization associated with the specific stream reach from which the sample was collected was used to calculate the 99th percentile of the taxon's distribution for all of the taxa found. I chose the 99th percentile in order to both avoid the most extreme outliers as well as to ensure that nearly every site that could possibly contain a taxon was included in the predictions. For taxa that responded positively to increasing ISC in Utz et al. (2009), no upper threshold was set. The complete set of ISC and urbanization thresholds are found in Appendix A.

The realistically best achievable condition for any given stream reach was predicted using a multi-step process of applying environmental filters for taxa sorting followed by resampling those potentially occurring taxa to generate an overall reach condition score. The ultimate endpoint for comparisons was Maryland's Benthic Index of Biotic Integrity (BIBI; Southerland et al. 2005). The BIBI is an integrative index that summarizes the ecological condition of a site based on the attributes of the benthic macroinvertebrate community. BIBI scores range from 1-5 with a 1 representing a site in very poor ecological condition and a 5 indicating a site having very high ecological condition. Because the overall BIBI is calculated from component metrics such as the total taxonomic richness or the percentage of pollution intolerant organisms present in a sample, sites may have the same score for different reasons. While a potential source of variation, this type of substitution also embraces the variation and acknowledges that similar endpoints can be achieved by different pathways.

Each of the 1286 stream reaches in the study received 10,000 iterations of the resampling approach in order to bootstrap a distribution of BIBI scores for later analysis. The existing ISC for each stream reach's catchment was used to identify the suite of taxa potentially capable of occurring based on their calculated thresholds. From this suite of potentially occurring taxa, several taxa were selected at random. Both the total number of taxa selected and the numbers of individuals within each taxon corresponded to the distributions of all taxa found in regionally occurring urban streams within the MBSS dataset. Each of the 10,000 iterations randomly selected the taxon richness/individual count distributions profile of one of the 109 urban streams. Using this profile, the suite of potential taxa was randomly selected to generate a "sample" from which the BIBI was calculated.

The endpoint for each reach was a probability distribution of predicted BIBI scores for use in restoration planning and data analyses. The distributions of predicted BIBI scores at each stream reach were constructed from the 10,000 resamplings to allow comparison of different probability levels to distributions from actual benthic macroinvertebrate collections. This approach allowed exploration of several questions related to stream condition, restoration performance, and any influences of nearby recolonization sources and stormwater BMP activities.

Predictions were compared against actual BIBI scores calculated from physical collections of benthic macroinvertebrates by MCDEP and UMCESAL at 474 stations from 286 reaches. Several reaches were sampled in more than one year, with one outlier reach sampled 39 times at various stations across the 12 year time span. However the median number of samples for these reaches was two, and the upper quartile was four. A subset of 99 samples specifically targeted stream restorations at 56 stations along 38 stream reaches. The distribution of observed BIBI scores in restored streams was compared to a suite of different probability percentile curves for predicted BIBI scores for these same reaches in order to identify the extent to which restored streams can approach the predicted maxima given catchment land cover. The probability percentile curve most closely matching the observed BIBI score curve represents the level of reach condition that can be realistically achieved using current restoration practices. I used a similar approach to explore the degree to which streams with different levels of ISC within the larger dataset compare to what might be expected under best case conditions.

Some sites in any system are found to be outliers and perform substantially better than predicted, whereas others rate much lower than expected. Reach performance was evaluated by taking the difference between the observed BIBI score and the 95th percentile of the predicted BIBI score for each reach. Overperforming reaches had observed BIBI scores at least 0.5 greater than predicted. Equal performance reaches had an observed BIBI score +/- 0.5 of the predicted BIBI. Underperforming reaches were divided into two categories because the differences were so large. Poor performing reaches had observed BIBI scores at least 1.5 lower than predicted, whereas underperforming reaches had BIBI scores 0.5-1.5 under predicted. Thus, four end-member reach performance categories (Poor, Underperforming, Equal, and Overperforming) were constructed for analysis.

I used Discriminant Analysis of Principal Components (DAPC) in the adegenet package for R (Jombart 2008; Jombart and Ahmed 2011) to predict reach performance and identify predictive attributes. DAPC is used widely in population genetics research where thousands of single nucleotide polymorphisms (SNPs) are examined for associations with targeted sample groups. I use an analogous approach here to examine the many potential, and inter-related, combinations of predictor variables in Tables 1 and 2 that might associate with reach performance. DAPC initially performs a principal components analysis on the suite of predictor variables to identify those predictors accounting for most of the variation. These principal components become inputs to a linear discriminant analysis that predicts, in this case, the reach performance category. DAPC is an effective approach to analyze many variables as well as those that might be highly correlated. Enough principal components were retained to account for 95% of the variation in predictor variables. Within the Discriminant Analysis portion, all available axes were retained to predict the four reach performance groups. Attributes important to predicting reach performance were considered to be those with component loadings exceeding 0.02.

In addition to DAPC end-member modeling, I used ANOVA and ANCOVA to explore relationships in the difference of observed and predicted BIBI scores in relation to the same set predictor variables used in the DAPC analysis. These included the various stormwater BMP attributes and nearest neighbor counts and lengths of potential donor streams.

Finally, the probability percentiles for the predicted BIBI scores were linked to a stream layer for Montgomery County in a GIS in order to produce display maps as well as a product deliverable. The shapefile of the streams and their predicted BIBI scores for each probability percentile are included with the submission of this report.

RESULTS

Validation of the prediction model and rationale for using the P95 as the comparison standard

Montgomery County's Reference streams represent the set of the remaining streams in the best ecological condition and serve as a good test for the prediction model. Comparing the density distribution of observed BIBI scores from those streams to their predicted BIBI density distributions shows that the 99.5th percentile of predicted maximizes the Area Under the Curve (AUC) overlap (**Fig. 1**). This suggests that the prediction model adequately captures the behavior of the BIBI in the most ecologically intact streams. While it is possible for a stream to have a BIBI score above the predicted value, it is unlikely, and the model predictions seem reasonable.

Although the maximum AUC overlap occurs at the predicted 99.5th percentile of the BIBI, I chose the 95th percentile set as the standard for prediction. I did this for several reasons. The 99.5th percentile is an extremely high standard and is unrealistic to expect all reaches to perform at this level. It essentially sets up most stream reaches for failure. In contrast, the top 5% of any distribution is widely recognized as exemplary whether it be IQ, physical abilities, or stream condition. In addition, setting the standard at the 95th percentile allows for some variation due to sampling errors in benthic collections, identifications, sorting, or the underlying land use data. This is still a reasonably high standard, but it is specific to each stream reach and is determined by the stream reach's watershed setting. A stream reach achieving its predicted 95th percentile is not too high of a standard, especially when considering that reach performance is not penalized unless it is 0.5 BIBI units below the prediction for that specific reach. Thus, there is a substantial amount of conservatism built in to allow for a further degree of non-attainment.

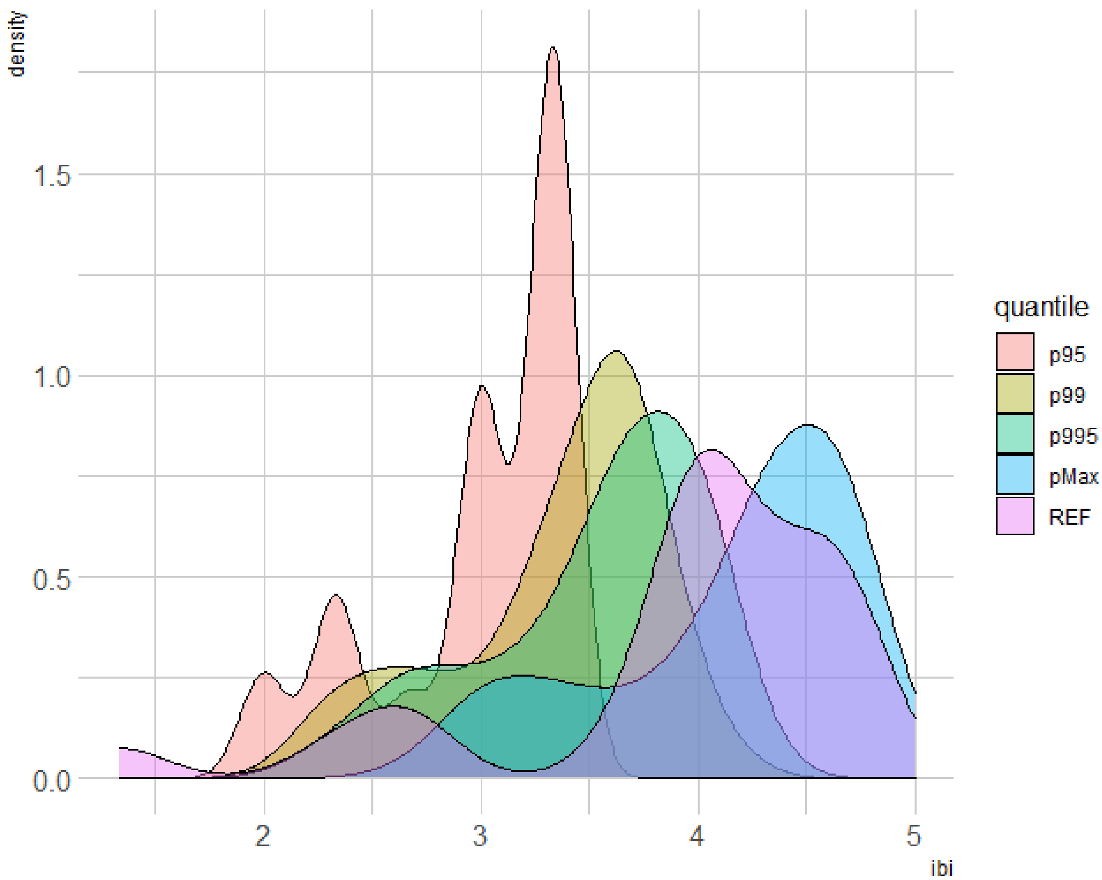

Figure 1. Density curve of observed BIBI scores at Montgomery County Reference reaches (REF; curve in pink) in relation to the density distributions of the predicted 95th, 99th, 99.5th and maximum BIBI scores from those same reaches. The maximum AUC overlap occurred between the Reference reaches and the 99.5th percentile.

Realistic restoration expectations are not clear cut

The AUC maximizing overlap between the highest observed BIBI score in each restored reach and the predicted BIBI scores suggests that there are two populations of restored streams in Montgomery County. This complicates a clean interpretation of what is realistic for a restoration to achieve and requires some explanation. One group of restorations centers on achieving the 30th percentile of predicted BIBI, while the other group centers on the 65th percentile (**Fig. 2, Panel A**). The sharp drop in AUC between the 40th to 50th percentiles marks a separation between groups in contrast to a single group that would produce a smoother, unimodal AUC curve. When each reach was paired with its predicted BIBI percentile closest to the observed BIBI, the frequency histogram shows two or even three groups of restored streams (**Fig. 2, Panel B**). Nearly half (10) of the 21 restored reaches cluster in the 3rd to 10th percentile of predicted and performed extremely poorly. Four reaches achieved 30th to 40th percentile of predicted, while the remaining seven reaches achieved the 60th percentile or better. Thus, over half of the reaches did not even achieve their predicted 50th percentile, and 76% did not achieve the 60th percentile. While many reaches only achieved the 10th percentile of predicted, some of these reaches had such a low 95th percentile predicted BIBI that the difference between observed and predicted did not meet the criterion of being considered Poor performance because they could not drop any lower on the observed BIBI.

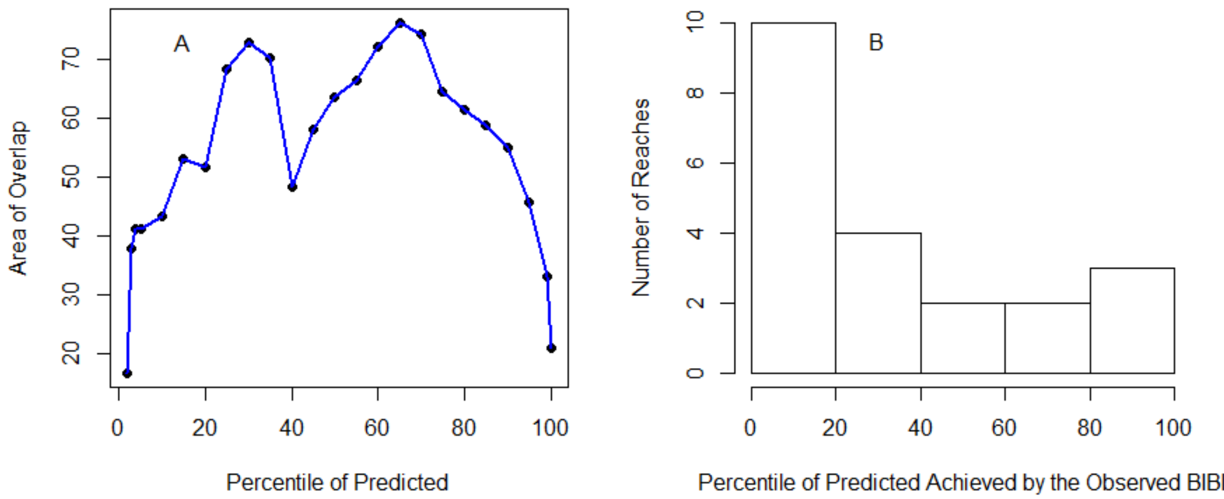

Figure 2. Plot of the Area Under the Curve (AUC) total comparing the various prediction percentiles overlapping with the observed BIBI scores (Panel A) and a frequency histogram (Panel B) of the predicted percentile BIBI closest to the observed BIBI.

The presence of multiple distinct groups is due to at least two reasons that were somewhat difficult to disentangle. Many restored reaches underperformed their predicted potential. This resulted in the large peak of sites with very low BIBI scores seen in **Fig. 3**. However, there are several sites that have BIBI scores meeting expectations as seen in the drawn out tail to the right for the restored reaches, and this tail far exceeds the predicted 30th percentile, but overlaps substantially with the predicted 65th. So, the first explanation is that the two groups are comprised of a group of underperforming streams and a set of better performing streams that could be considered successful restorations. In addition, the predicted 65th percentile (green curve in **Fig. 3)** has more than a single hump to the distribution, and this smaller hump lines up closely with the mode of the predicted 30th percentile. Thus, the predicted 65th percentile covers more width of the BIBI, and the secondary hump partially aligns with the lower performing streams. Under this explanation, the separation into two groups is due to there being differences in predicted potential due to watershed conditions rather than primarily the observed BIBI results. Thus, many restored streams have low potential to begin with due to watershed conditions, whereas the remaining restored streams have greater predicted potential.

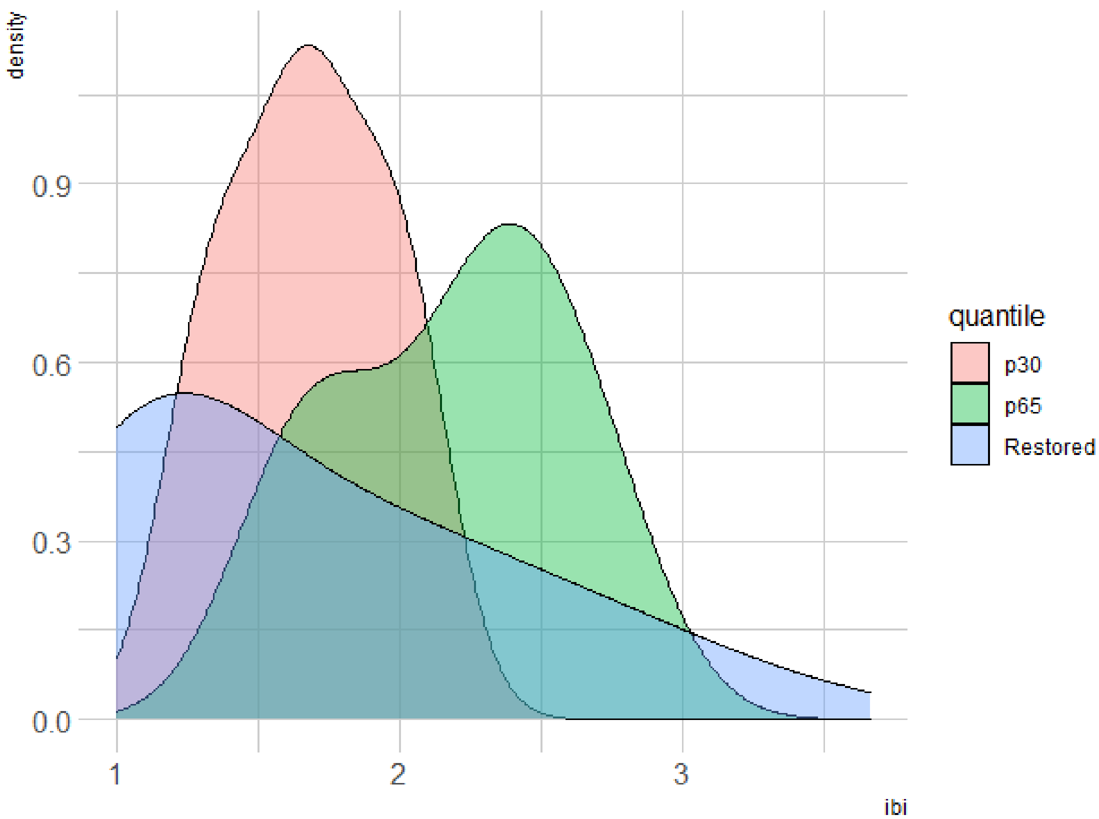

Figure 3. Density plots of observed BIBI scores in restored reaches and the 30th and 65th percentiles of predicted BIBI scores.

Panel A in **Fig. 4** shows that there are clear differences in the predicted expectations of what can be achieved in a restoration. The predicted 95th BIBI percentile shows that nearly half of the streams are not predicted to achieve above a BIBI of 2.4, which garners a BIBI narrative rating of “Poor” and is reasonably close to being rated as “Very Poor”. Thus, given the existing ISC in the watershed, these reaches were predicted to be in “Poor” condition even if the restoration were executed to the best of current technological approaches and the reach attained what was predicted. Only six restored reaches in Panel A are predicted to have a BIBI exceeding 3. In addition, Panel B shows the predicted maximum BIBI scores given the watershed ISC. Even here, most reaches can only merit a narrative rating of “Fair” if the restoration achieves the best outcome that can be expected. As a reminder, no restored reaches exceeded predictions.

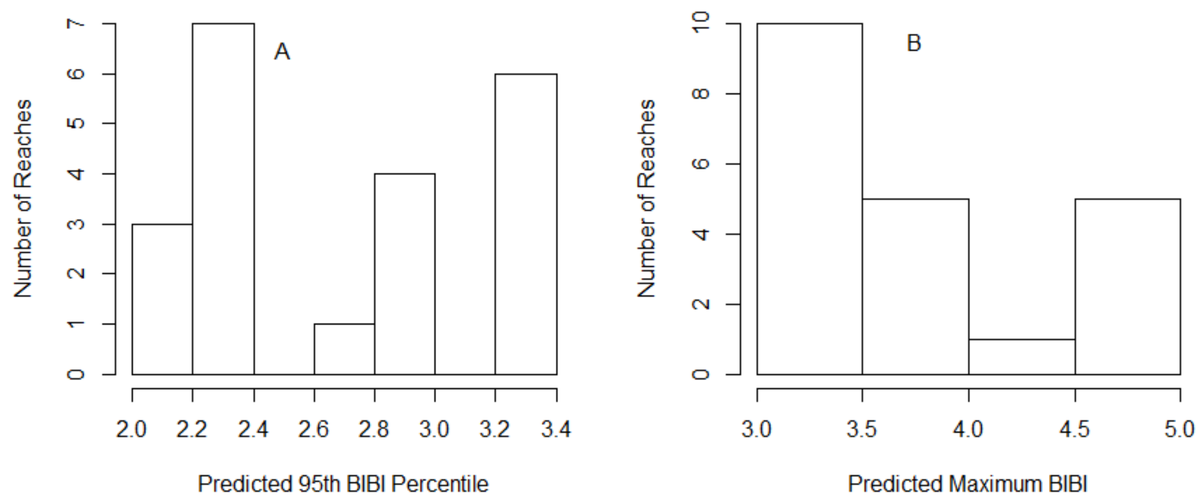

Figure 4. Frequency histograms of the predicted 95th percentile BIBI scores for restored reaches (Panel A) and the predicted maximum BIBI scores for those same reaches (Panel B).

There does not appear to be substantial bias across the ISC gradient regarding how well restored reaches did compared to the predictions. However, some slight tendency exists for observed BIBI scores in restored reaches in low ISC watersheds to be closer to predicted values than in high ISC watersheds (**Fig. 5, Panel A**). Plotting the same data, but color coded for the predicted 95th percentile BIBI (**Fig. 5, Panel B**) again shows a slight tendency for restored reaches in lower ISC watersheds to better achieve their predicted BIBI scores. The bias is very slight, and I do not think that it is enough to lessen confidence in the predictions. Similar patterns existed for the non-restored streams as well where slightly more reaches meeting or exceeding predictions (difference > 0) occurred on the lower end of the ISC gradient than the higher (**Fig. 5, Panels C and D**).

When the performance of restored reaches is examined from the perspective of what is predicted, there again appears to be little clear pattern (**Fig. 6**). The restored reaches with the lowest predicted potential more frequently under-performed their predictions (2 Equal and 8 Under), but did so in the same proportion to those reaches with the highest predicted potential (1 Equal and 4 Under or Poor). In fact, the only restored reaches that had Poor performance were in the group of restored reaches that had the highest predicted potential. Finally, when grouped into the reach performance categories, both Equal- and Under- performing reaches have the same relationship between the observed and expected BIBI (**Fig. 7**). The parallel lines indicate that there is no difference in the way restored reaches behaved based on their performance category.

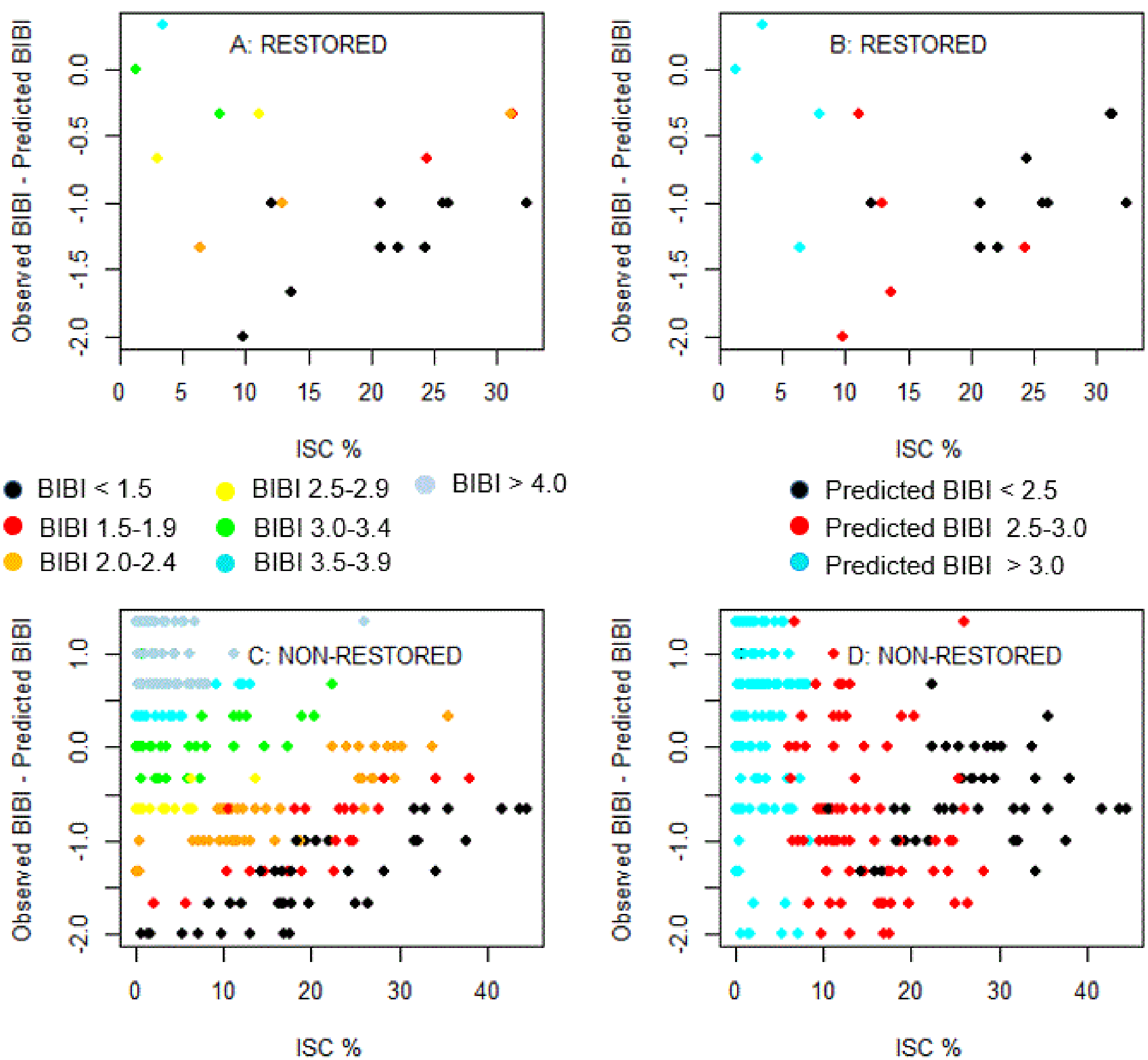

Figure 5. Relationship between the difference between observed and predicted BIBI scores with respect to ISC and color coded by the observed BIBI scores (Panel A), and the same relationship, but color coded by the predicted 95th percentile BIBI score (Panel B). The same plots are shown in Panels C and D for non-restored reaches.

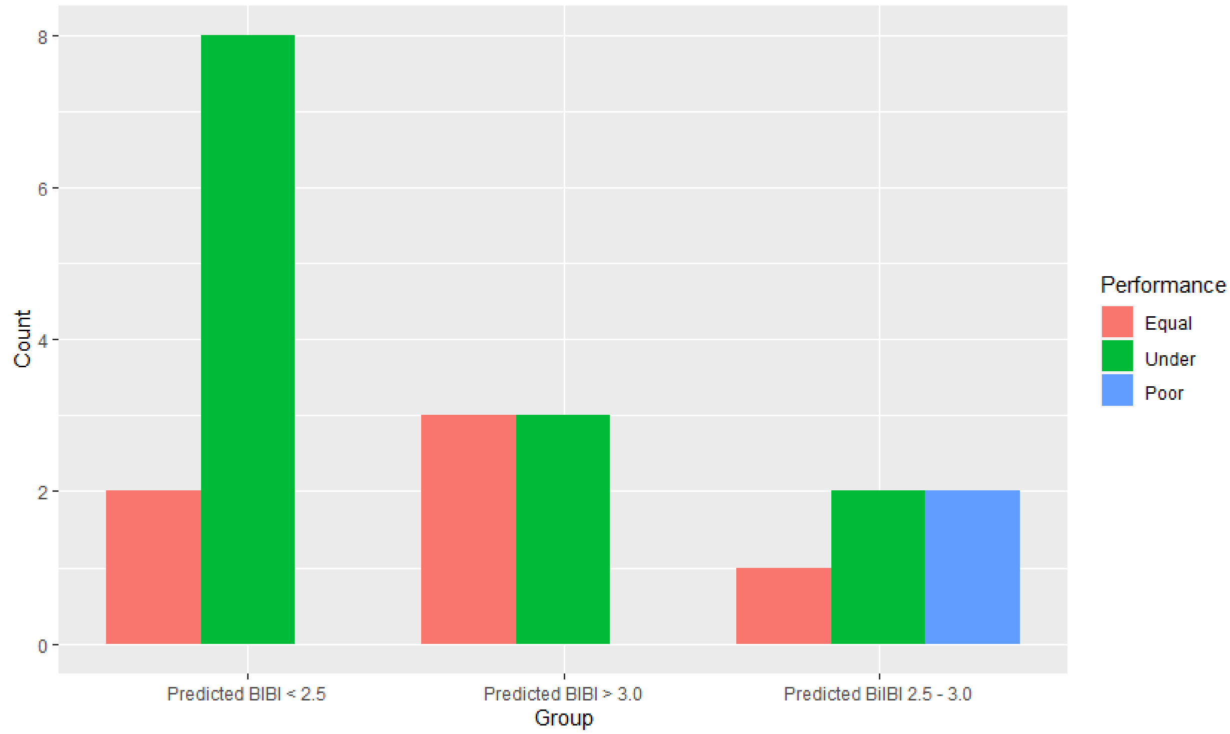

Figure 6. Plot of the frequencies of occurrence of the different reach performance grouped by their predicted 95th percentile BIBI.

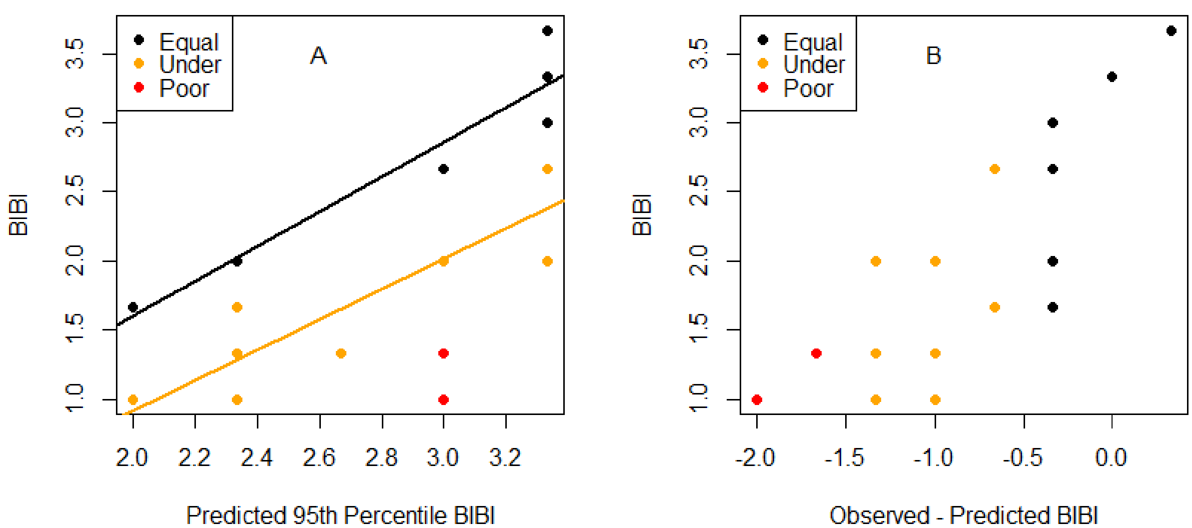

Figure 7. Plots of observed BIBI against the predicted BIBI (Panel A) and observed BIBI against the difference between observed and predicted (Panel B).

Summary realistic restoration expectations:
Given the predictions, data distributions, and actual reach responses, I believe that a defensible, realistic expectation for BIBI scores in an urban stream restoration is around 65% of its predicted BIBI. Obviously some reaches exceeded the 65th percentile, and that is great. However, most reaches (76%) did not even achieve the 60th percentile, and so the 65th percentile might be optimistic. Nonetheless, the maximum AUC overlap between the observed and percentile predictions occurs at the 65th percentile. There was no evidence that reaches with lower predicted potential had lower achievement than those with higher predicted potential, nor did reaches in higher ISC watersheds have lower achievement relative to their predicted BIBI scores. Unfortunately, I could not determine why half of the reaches performed so poorly compared to their predicted potential (analyzed more fully later).

A small number of reaches have relatively high potential for ecological success, and some have achieved it. In contrast, roughly half of the restorations have sufficient ISC in their watersheds that they were predicted to have low potential for ecological success, even with a well-executed restoration, and these reaches demonstrated low actual BIBI scores. No restored reaches outperformed predictions, and most underperformed to varying degrees. There was no pattern to determine if a restored reach would meet predictions; reaches with low predicted potential met expectations as often as those reaches with higher predicted potential. When half of the restored reach population is limited by watershed ISC, it should not be surprising that research projects and monitoring programs report most restored reaches as having low ecological condition when assessed by benthic macroinvertebrates; the watershed conditions likely do not allow for a more diverse benthic community that contains sensitive taxa.

Performance and potential of restored reaches lags unrestored reaches
None of the restored sites monitored by Montgomery County or my previous CBT-administered research outperformed the predicted BIBI scores. Of the 26 restored reaches with monitoring data, only seven (27%) met performance expectations. The remaining 19 (73%) reaches underperformed with three (12%) severely underperforming and the remaining 16 (62%) underperforming. In contrast, 58% of non-restored reaches met or exceeded expectations, with 84 (32%) exceeding expectations and 67 (26%) meeting expectations. Nonetheless, 108 (42%) of non-restored reaches did not meet expectations, with 22 (9%) severely underperforming and the remaining 86 (33%) simply underperforming. It is important to keep in mind that this comparison is not about how high the BIBI scores rate. Instead, the comparison is about how well a reach did relative to what was predicted given the watershed ISC. In this context, restored reaches as a group did not achieve what was expected of them given their landscape setting in the same proportions as non-restored reaches.

Increasing the sampling universe by incorporating multi-year sampling of restored reaches, rather than the highest recorded BIBI, and allowing for multiple samples on a single reach, the performance remains similar. Of the 92 total samples used in the analysis of 56 restored sites, only 15 samples (16%) performed equal to predictions of +/- 0.5 of the predicted BIBI. The remaining 77 samples fell below predictions, with 20 samples (22%) falling far below what could be achieved with an ideal restoration. For those restorations that had more than one sample, only two sites met predicted expectations more than once, and both of these sites had actual BIBI scores of “very poor” with BIBI<2 (**Table 3**). Despite these two outliers, restored sites that met predicted expectations had significantly greater observed BIBI scores than those not meeting expectations (Fig. 8).

Table 3. Performance of restored and non-restored reaches.

	Poor	Under	Equal	Over
Restored	3	16	7	0
Non-Restored	23	86	67	84
All	26	102	74	84

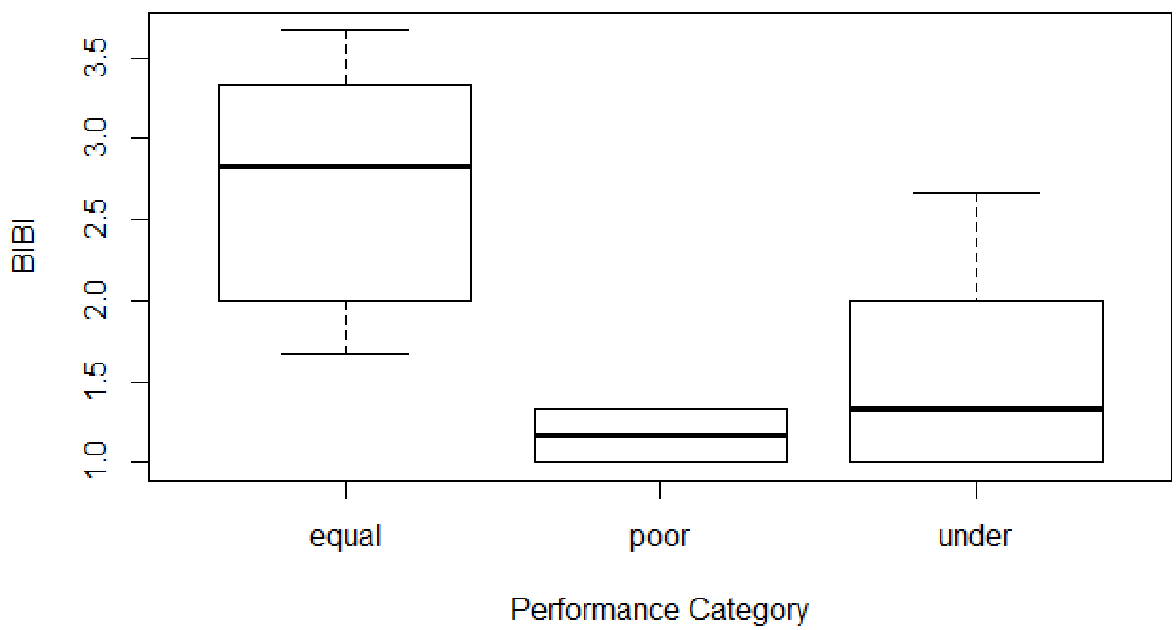

Figure 8. BIBI scores of restored reaches grouped into their performance categories.

As a group, restored reaches have both lower performance and lower potential than the non-restored reaches. For example, the density plot of reaches in the Montgomery County monitoring data (**Fig. 9**) show observed BIBI scores in restored reaches (RES; olive colored curve) to be lower than any of the other station types. Among these other types are special projects reaches that are closely monitored streams with point sources or other known activities that are degrading the streams. In comparison, the modes of the reference (REF; salmon colored curve) and special protected areas stations (SPA; blue-green colored curve) representing more intact and ecologically “heathy” reaches are distinctly separate from the restored reaches.

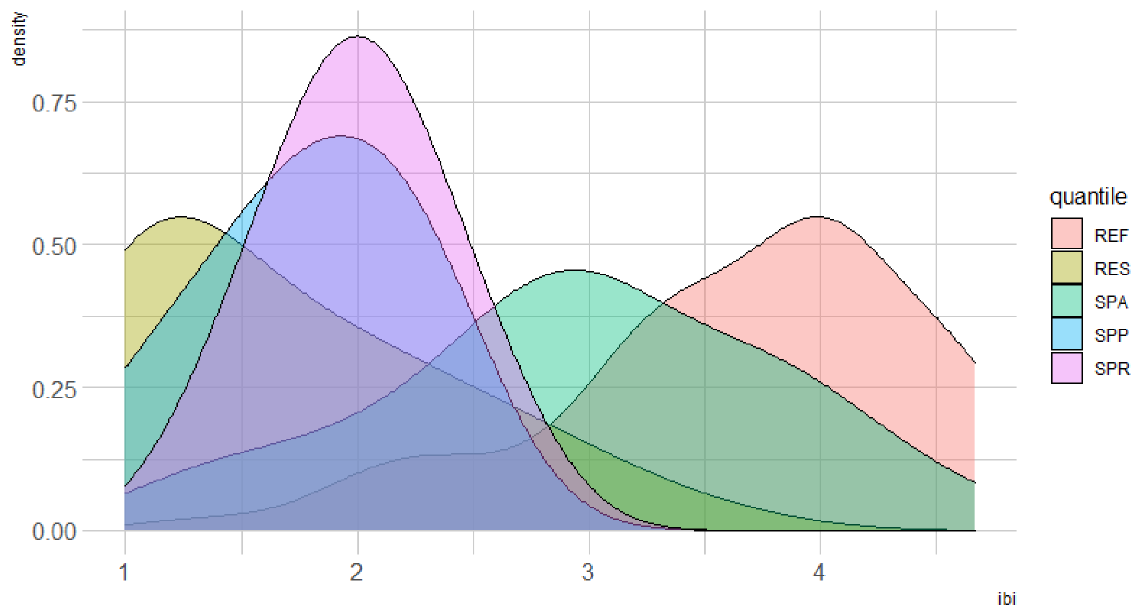

Figure 9. Density plots of the observed BIBI scores for reaches in the Montgomery County monitoring dataset grouped into their station types: REF=Reference sites; RES=Restored reaches; SPA=Special Protected Areas; SPP and SPR=Special Projects.

Restored reaches also have lower predicted potential than the other reaches. As seen in **Fig. 10**, the mode of the 50th percentile density distribution of restored reaches (restp50; blue colored curve) is to the left of that for the non-restored reaches (p50; salmon colored curve). However, the differences change depending on the probability percentile chosen. At low probability percentiles, restored reaches have small, but noticeably lower potential, whereas the difference disappears at the maximum predicted BIBI score.

The patterns in the probability percentiles suggest several things about urban stream restorations. A perfectly executed restoration that achieves the highest potential will bring the stream back to similar levels as the general population of reaches. However, a less than perfect restoration will likely result in a stream that performs below its peers. This statement stems from the prior observation that the maximum AUC overlap occurs at roughly the 30th and 65th percentiles of predicted BIBI scores, which represent two populations of restored reaches. Similarly, restored reaches typically drain catchments with higher ISC, which limits the predicted BIBI score for all but the highest probability percentiles. Therefore, the realistically likely potential in a restored reach will be lower than for the general population of reaches. Finally, the probability percentiles highlight that the reaches being restored are those most in need of attention given that their potential has already been greatly reduced.

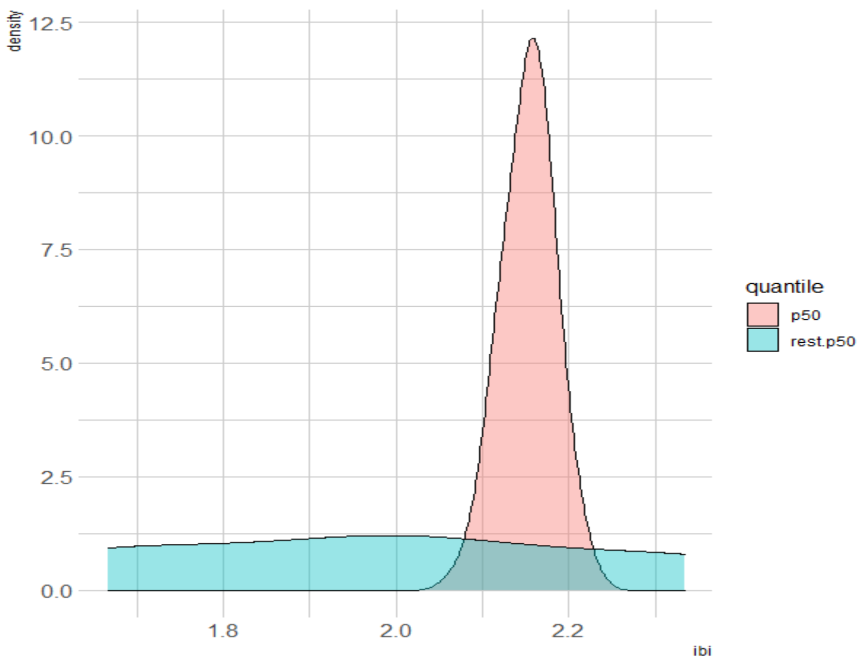

Figure 10. Density plots of the 50th percentile of restored reaches (blue) and non-restored reaches (salmon).

No restored reaches exceeded expectations: Few unexpected taxa were found

Most restored sites did not have taxa present that were not already predicted. However, 12 sites did have at least one unexpected taxon present. One site (URCB101C) had eight unexpected taxa observed. Several circumstances makes this sample a unique outlier. All of the unexpected taxa were represented by a single individual, except for the Chironomid, Tanytarsini, which had two individuals. In addition, *Isotomurus* is a terrestrial springtail and not in the MBSS database, while Philopotamidae is the parent family of an additional unexpected taxon, *Dolophilodes*, and is likely a duplicate. The sample collected from this site had a large percentage of Trichoptera, which in itself is impressive for a site with 33% ISC and 78% urban in the watershed. URBC101C was one of the seven reaches with performance equal to predicted, scoring only -0.33 below the predicted BIBI of 2.3.

Stormwater best management practices does not positively influence restoration success or the condition of non-restored reaches

Unfortunately, no relationship existed with stormwater BMP activities and measures of restoration success. Neither the total number of stormwater projects, the acres of ISC treated, or the percentage of the watershed treated by stormwater BMPs showed any relation to reach performance categories or the raw differences between observed and predicted BIBI scores (**Fig. 11, Panels A-C**). Similarly, observed BIBI scores were not related to any of these stormwater measures (**Fig. 12, Panels A-C**). However, both the observed BIBI scores and restoration performance declined significantly with increasing watershed ISC.

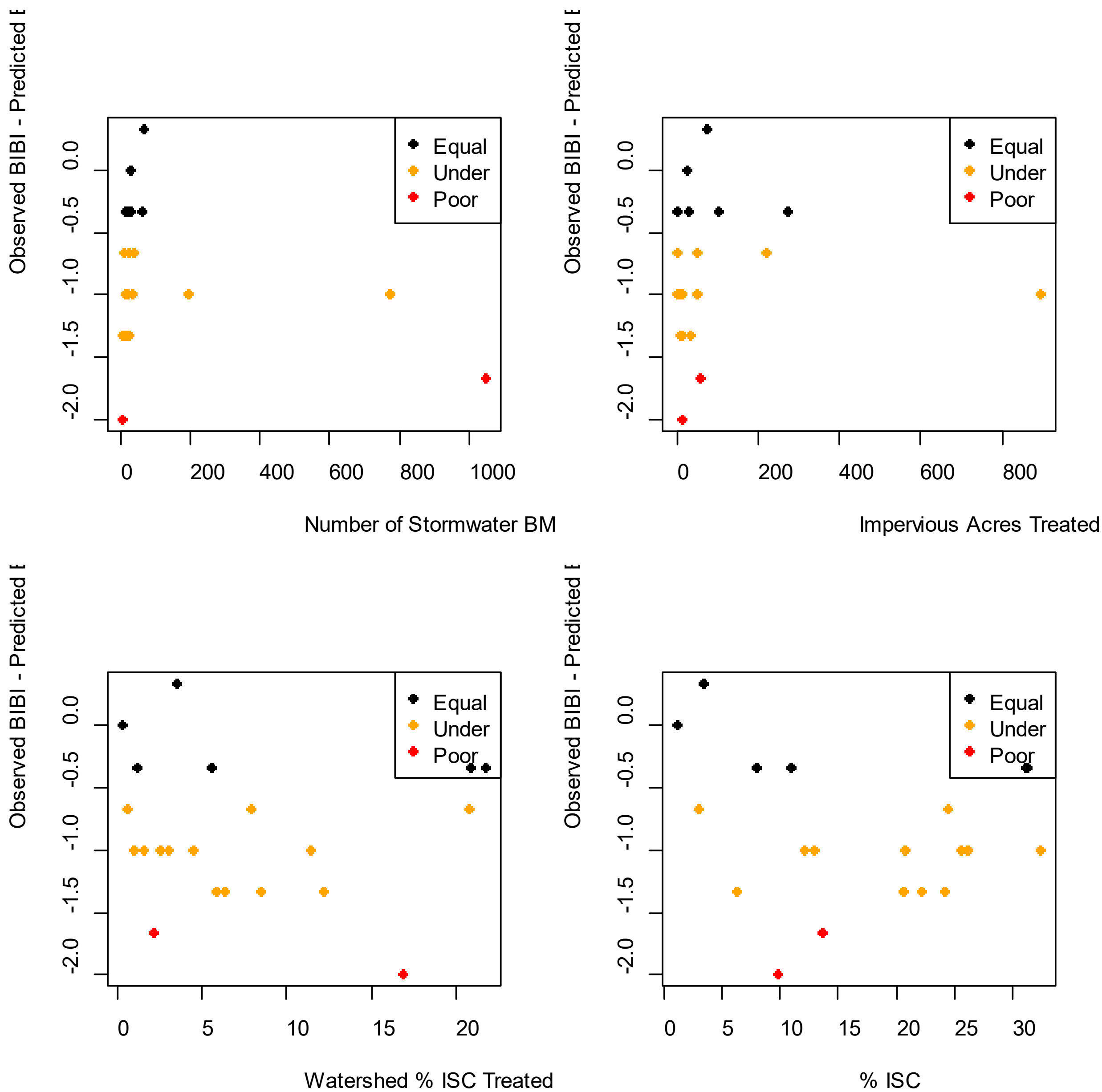

Figure 11. Relationship between different measures of stormwater activities within a watershed and the difference of Observed – Predicted BIBI scores of restored reaches. Points are color coded to represent their restoration performance with respect to their predicted BIBI.

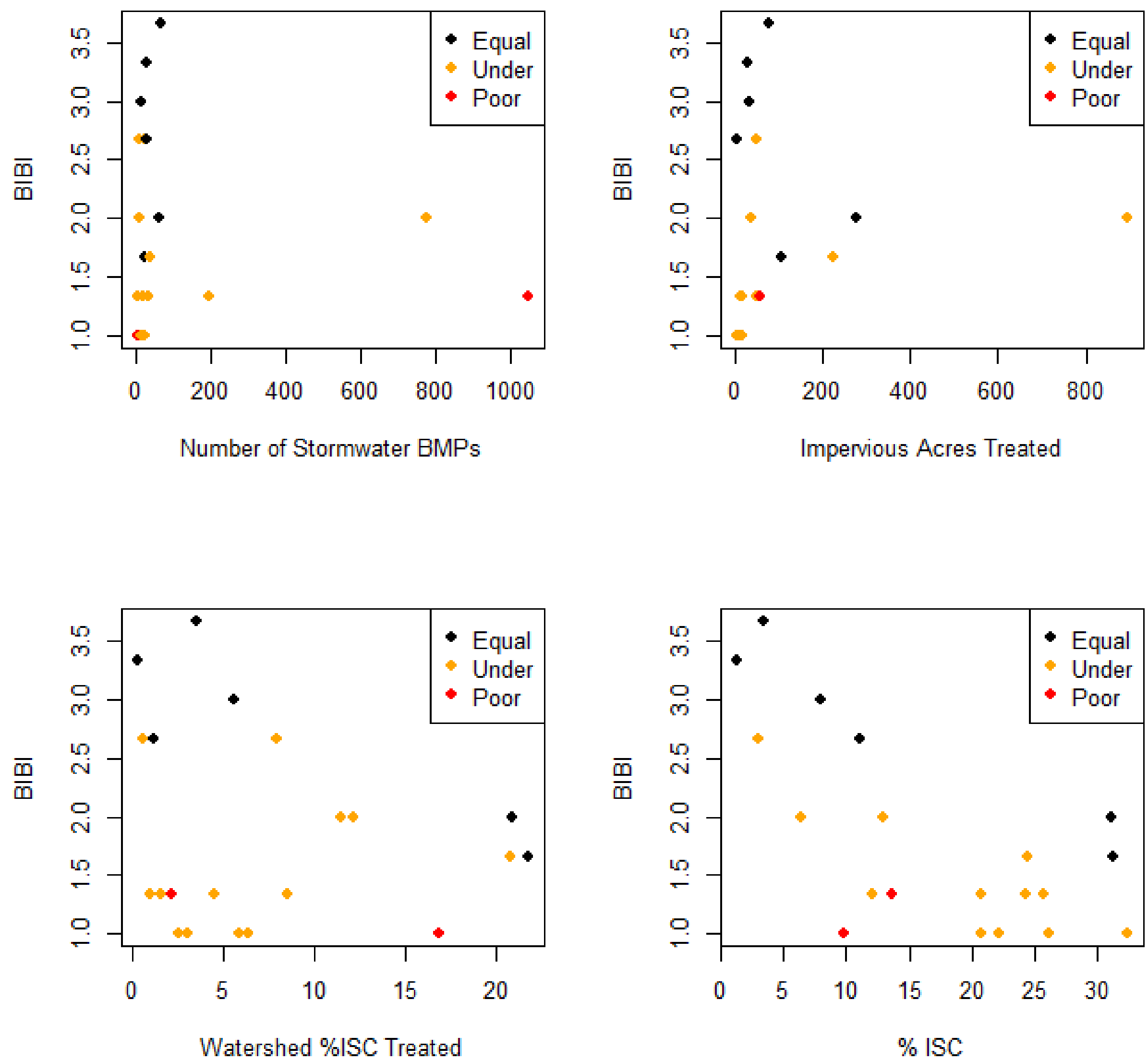

Figure 12. Relationship between different measures of stormwater activities within a watershed and the observed BIBI scores of restored reaches. Points are color coded to represent their restoration performance with respect to their predicted BIBI.

The remaining results border on a fishing expedition, but I wanted to present a full treatment of the analyses investigating the subcomponents of stormwater to determine if any specific type of BMP produced detectable results. As reported in **Appendix B**, no specific components of stormwater BMPs were associated with the observed BIBI scores in restored reaches.

Similar to BIBI scores, the performance category of restored reaches compared to predictions was not influenced by stormwater management BMPs. No stormwater-related variables were important to predicting performance of restored reaches in the DAPC analysis.

Within the non-restored reaches, similar patterns of non-positive response existed. Although the lines on the following two figures sometimes suggest a negative relationship (Figure stormwater performance nonrestored and Figure stormwater BIBI nonrestored), there was no significant relationship between stormwater BMP activities and either BIBI scores or the difference between the observed and predicted BIBI scores. However, a significant interaction occurred in both analyses where over-performing reaches showed significant negative decreases in observed BIBI scores as the amount of treated ISC increased, but the line extends far beyond the data is a severe extrapolation.

As with the restored reaches, I could find no relationships between reach performance (**Fig. 13**) or BIBI scores (**Fig. 14**) and the various components of stormwater BMPs. One could always assume that conditions might be worse without the BMPs, but the evidence suggests that a detectable positive effect does not exist.

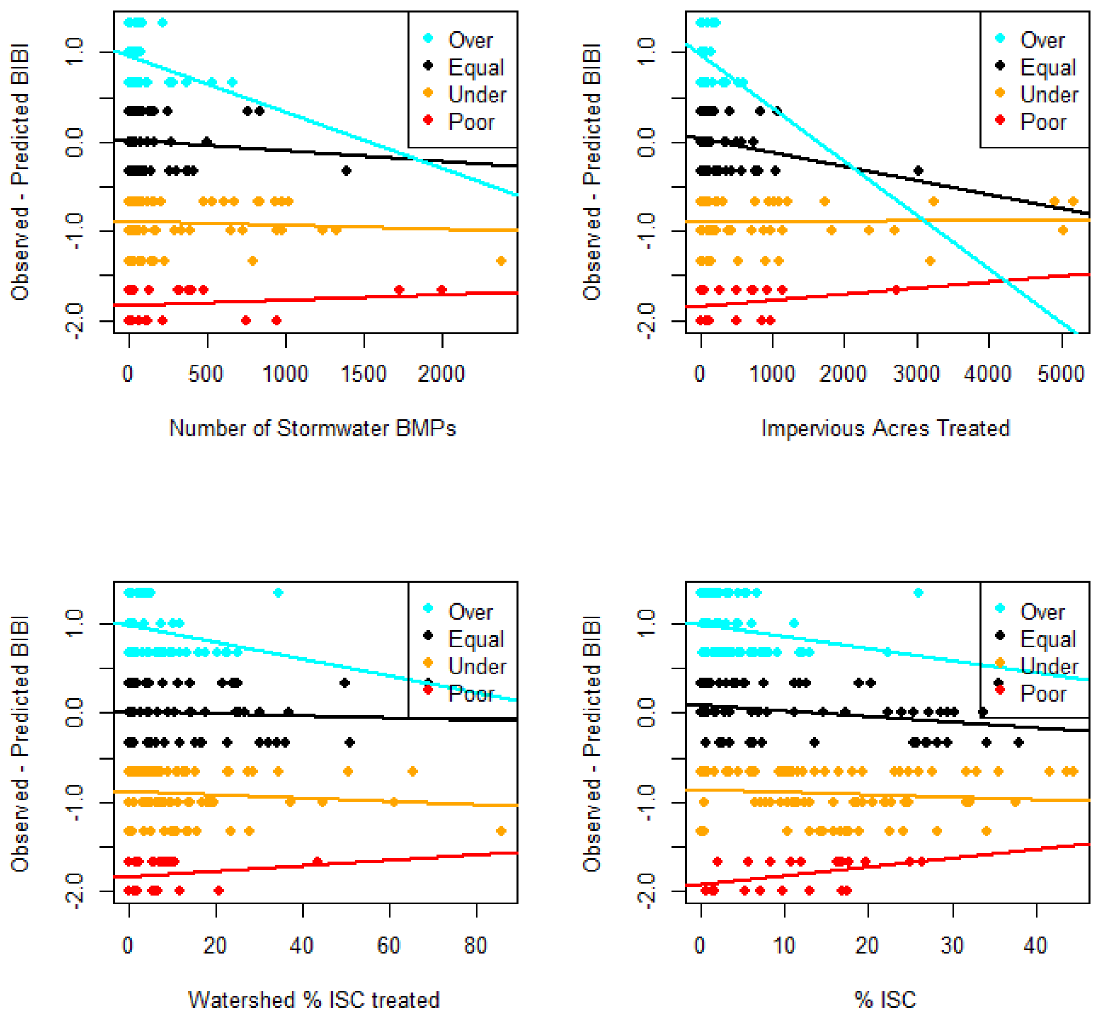

Figure 13. Relationship between different measures of stormwater activities within a watershed and the difference of Observed – Predicted BIBI scores of restored reaches. Points are color coded to represent their restoration performance with respect to their predicted BIBI.

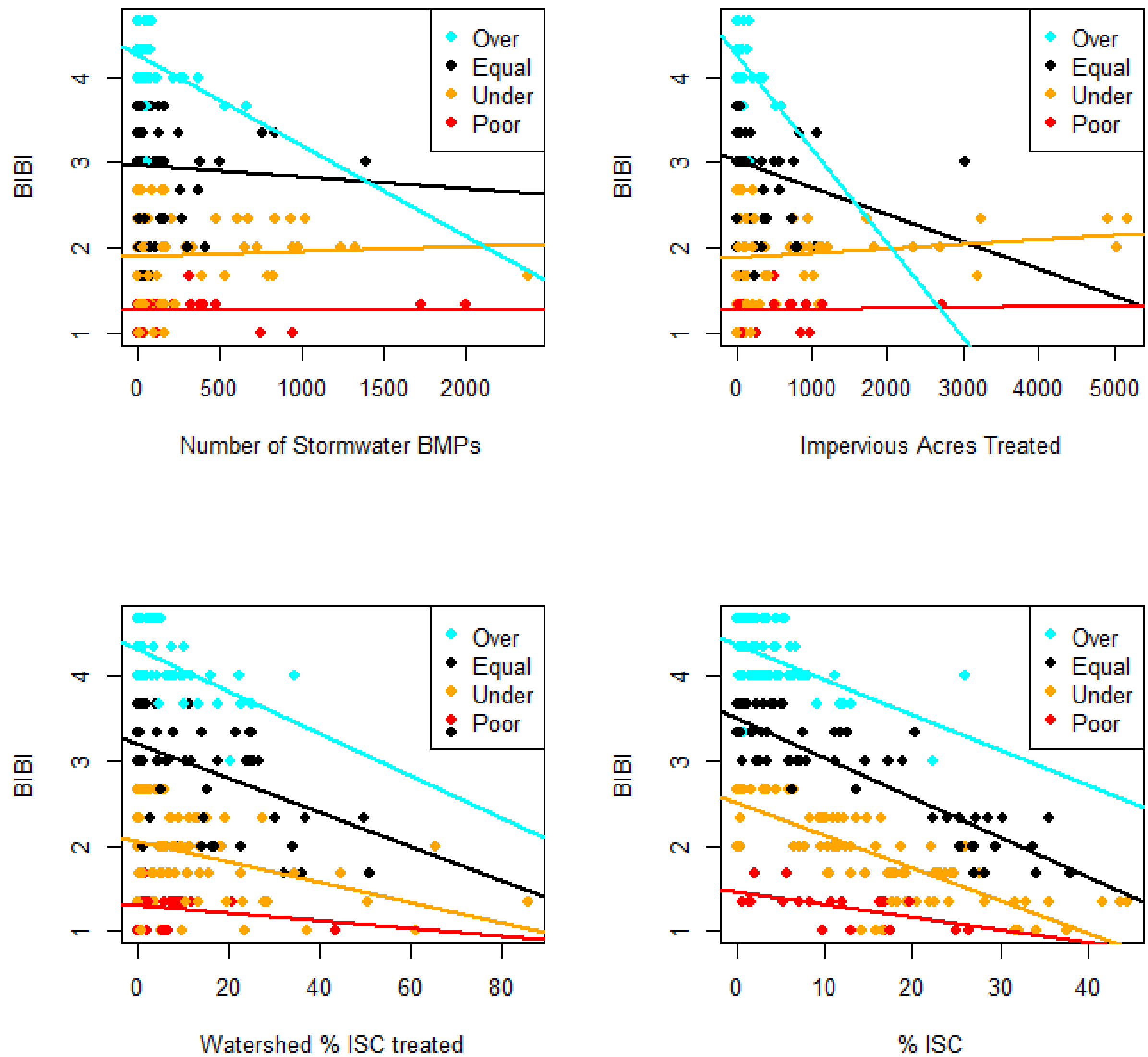

Figure 14. Relationship between different measures of stormwater activities within a watershed and the observed BIBI scores of restored reaches. Points are color coded to represent their restoration performance with respect to their predicted BIBI.

Stormwater Summary. There was no evidence that measures of stormwater BMP activities or its component approaches improved the BIBI or the performance of either restored or non-restored reaches. I cannot determine if the absence of stormwater activities would have made things worse. Some stormwater attributes were negatively correlated with performance and the BIBI, but this is almost certainly due to greater stormwater activities in the more developed watersheds.

The proximity of potential donor streams relates to higher observed BIBI scores and restoration performance

A substantial number of the variables used to describe proximity of potential high quality streams were significantly related to the observed BIBI scores and to the performance of restored reaches. **Appendix C** shows the full set of results. Because almost all of these variables are correlated with one another, I have selected the top performing variable in terms of its R^2 and its slope. However, we must realize that any one of the variables might be a more ecologically relevant measure of donor streams.

The frequency of streams within a 1km radius ‘as the insect flies’ and in catchments containing less than 7% ISC explained 81% of the variation in a restored reach’s observed BIBI score (**Fig. 15, Panel A**). The positive slope of 0.34 suggests that the BIBI score of a restored stream improves by 0.34 for every additional stream within 1km that drains a catchment having less than 7% ISC. The aerial distance (as the insect flies) was typically a better predictor than linear network distance (as the fish swims).

While the potential donor effect relationship is exciting, I believe it is an artefact and is probably a proxy for spatially clumped zones of low development. I believe this for multiple reasons. Firstly, there is a strong negative relationship between the watershed ISC for a reach and the number of potential donor reaches (**Fig. 15, Panel B**) that indicates a spatially clumped distribution. The strong relationship between BIBI scores the number of potential donor sites is also strongly tied to the ISC within each restored reach’s catchment (**Fig. 16**), and it is difficult to disentangle. The same pattern is seen for non-restored streams as well (**Fig. 17, Panel B**), which also indicates a spatial clumping of low ISC reaches. In addition, the spread of non-restored reaches meeting predicted expectations (Equal performance reaches) across the ISC gradient indicates that there is actually little effect of donor reaches, and most influence is related to the ISC within each watershed. Restored reaches in watersheds with low ISC are also in close proximity to other watersheds with low ISC, and an ‘as the insect flies’ search method should be a much stronger indicator than ‘as the fish swims’. Indeed, the lower importance of network distance compared to aerial distance suggests a spatial correlation that falls off with distance because network distances will almost always have lower numbers and lengths of potential donors than will aerial distances. Nonetheless, restored reaches with more potential donor streams nearby tended to perform better than those without donor streams (**Fig. 15, Panel A**), and so there remains the possibility of a donor-rescue effect.

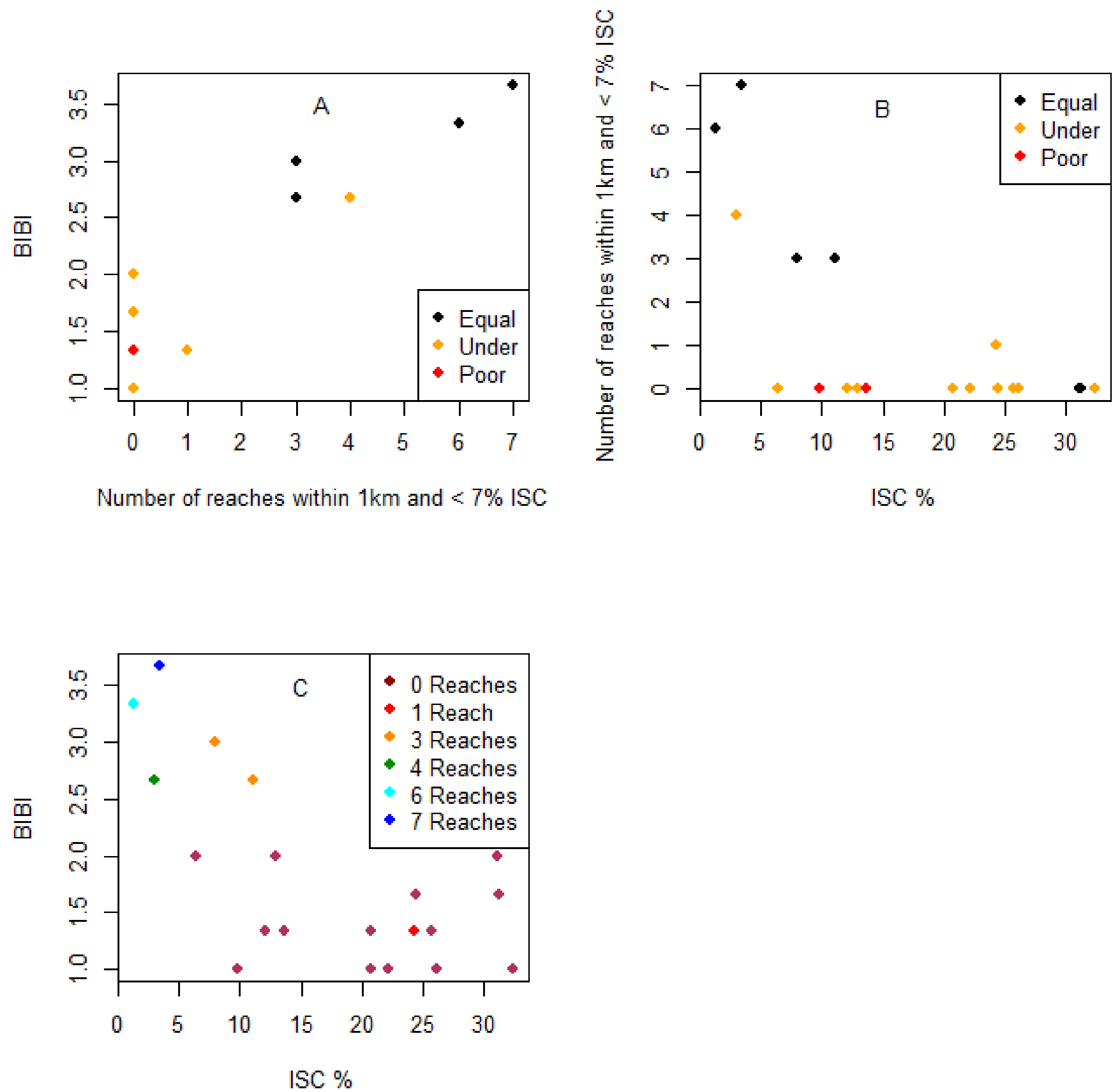

Figure 15. Relationships between a restored reach's BIBI score and the number of potential donor stream 'as the insect flies' (Panel A), between the number of potential donor streams and ISC (Panel B), and between BIBI and ISC with sites colored according to the number of potential donor reaches nearby (Panel C). Note that a single point may represent several reaches in Panel A.

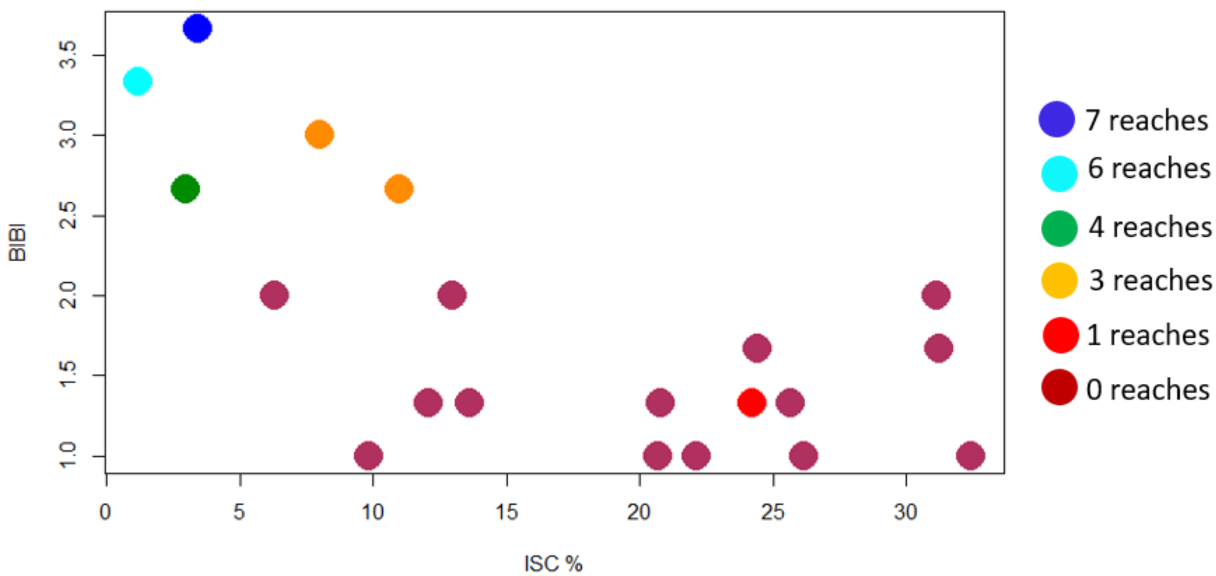

Figure 16. Relationship between a reach's BIBI score and its % ISC in the watershed in the context of the number of potential donor streams, coded by color.

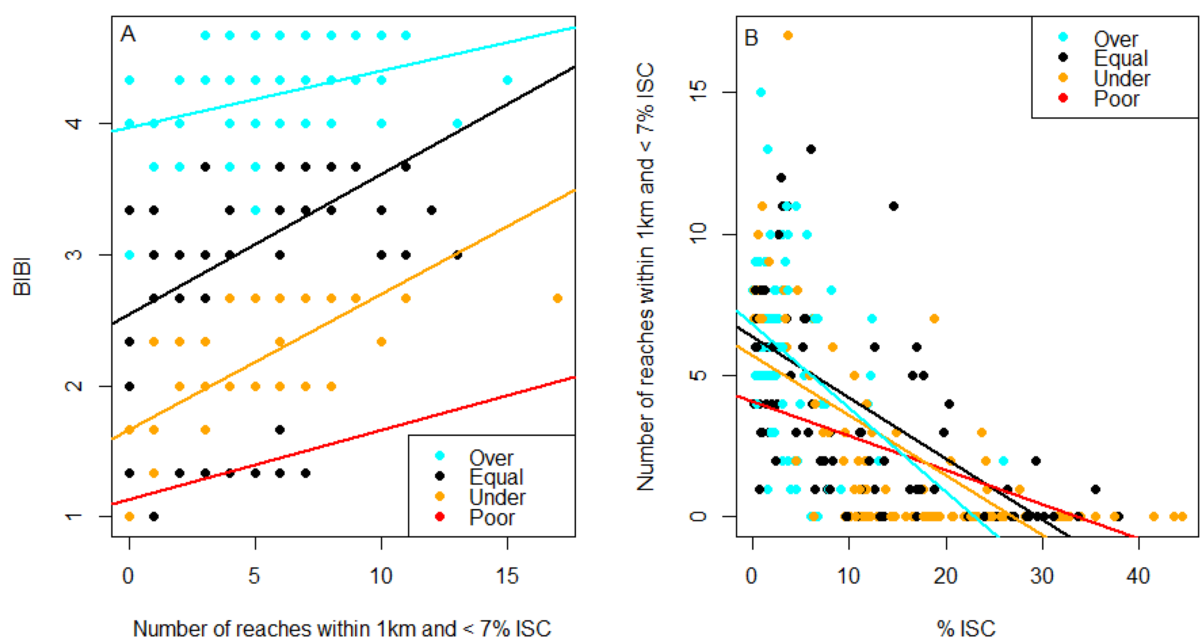

Figure 17. Relationship between observed BIBI scores and the number of potential donor reaches (Panel A) and the relationship between the number of potential donor sites and watershed % ISC (Panel B). Reaches are color coded for performance.

Discussion with relevance to the research questions and the broader restoration community

The research results demonstrate that restored reaches are capable of meeting predictions. Seven reaches met expectations where observed BIBI scores were within +/- 0.5 of the predicted 95th percentile BIBI scores. While this shows that some restored reaches are capable of meeting expectations, most reaches underperformed relative to what was predicted. This lack of performance translated into most sites not even attaining the 50th percentile of predicted, and almost half of the restored reaches attained less than 30% of what was predicted. Because many restored reaches reside in watersheds with high ISC, the predicted BIBI scores are not high to begin with, and so the observed BIBI scores were frequently in the Poor to Very Poor range. The wide range of performance responses resulted in large variation in what can be expected from a restoration because those few sites actually meeting expectations shifted the AUC curve (**Fig 2, Panel A**) much farther to the right than for the average restoration. Most restored reaches were sampled in more than one year, and I used only the highest scoring sample in order to best describe the observed potential. While there is variation in BIBI scores due to random effects in sampling and sorting, almost every reach maintained the same performance rating in multiple years. That is, a reach did not underperform in one sampling year and meet expectations in all of the other years.

The results imply that a realistic urban stream restoration expectation is for a reach to able to achieve the 65th percentile of what is predicted. However, since most streams achieved far below the 65th percentile, I suggest that a more realistic expectation is that most restored urban reaches will attain only the 30th percentile of predicted. I'm not claiming that restorations are not capable of achieving better results, but quality outcomes seem to be the exception rather than the norm. The few streams meeting expectations moved the AUC curve much farther right than the frequencies of good outcomes indicate. Therefore, I believe it is more honest to specify what will most likely occur rather than what might occur if everything aligns in ways that we still do not understand.

Unfortunately, I was not able to identify why some restorations met predicted expectations and why most underperformed. While watershed ISC was significantly related to BIBI scores, it was not related to how well a restoration performed compared to its predicted state. The lack of a significant relationship between ISC and reach performance suggests that the predictions behave similarly across the ISC gradient and are not biased, and I view this as a positive feature. Nonetheless, restored reaches in proximity to other reaches with lower ISC tended to perform better and also have higher observed BIBI scores than reaches with fewer potential donor streams (**Fig. 15, Panel A**). Although I think most of the relationship is more of a proxy for where reaches are located than due to donor-rescue effects, the trend cannot be ignored because reach performance also tended to be higher in donor-rich areas. Other attributes, such as watershed area, land uses, or the various components of stormwater management practices were not found to be influential in restoration performance. Stream restorations continue to appear to be idiosyncratic and have no clear reasons for why some meet expectations while others fall short.

My research is based on the assumption that the amount of ISC in a reach's watershed largely influences the pool of taxa capable of existing in that reach. ISC itself is probably not the proximal stressor that excludes taxa from a watershed. However, the changes in hydrology, stream power, water temperature, water chemistry, and a suite of other attributes are highly correlated with ISC when examined across the large dataset comprised of MBSS samples. Thus, the amount of ISC upstream of a reach can be a good proxy for the cumulative stressors that human activities exert on streams. In this context, the model predictions line up quite well with the BIBI scores from actual monitoring data from the set of reference streams in Montgomery County. These higher quality streams maximized overlap with model predictions at the 99.5th percentile of predicted, but not at the maximum predicted BIBI. I interpret this result as evidence that the predictions are realistic. The results are far from perfectly capturing reality; there is variation in sampling as well as variation in the data underlying the model itself. However, I believe the predictions are a good first approximation to allow the restoration community to start comparing what is observed against what is realistically possible given the landscape conditions. While not perfect, this approach allows us to begin more rigorous analyses and is a major advance.

Interjecting realism into expectations of ecological uplift in urban stream restorations

There are many good reasons to conduct urban stream restoration projects. Unfortunately, accumulating evidence (Violin et al. 2011; Stranko et al. 2012; Hilderbrand et al. 2019) and my current research suggest that ecological uplift is not one of them. Most stream restorations examined in this research project are achieving a small fraction of their predicted potential. I was not able to determine why most fall short, but the data are clear.

Until we have a better understanding of why half of the projects achieved less than the predicted 50th percentile, the restoration community needs to more critically examine when, where, and why to do urban stream restorations. The poor performance of the restorations examined in this report suggests that projects could actually degrade the existing ecological condition rather than improve it. If the main goal for the project is to protect infrastructure, reduce erosion, or stabilize the banks or channel, restoration may be a good choice. However, the effort and expense will not likely be a good return on investment if one of the main goals is to improve the ecological structure.

My research results can be used with targeted monitoring data to help identify *where* restorations may be a net benefit and *when* other locations may be a better choice. *Why* a restoration is conducted is up to the resource management and regulatory professionals. For example, the data suggest that a restoration is likely to achieve only the 50th percentile for most projects. New or existing monitoring results for a specific stream can be compared to the predictions for that reach. If the monitoring results exceed the 50th percentile of the predicted BIBI, then it is likely that a restoration will not provide a better ecological outcome. This does not guarantee that a restoration absolutely will not provide ecological uplift, but uplift is unlikely. The probability level for evaluation can also be altered to account for more cautious (lower predicted percentile) or optimistic (higher predicted percentile) expectations for assessing the potential risks and benefits of conducting a restoration. Using the science in this way could substantially inform decisions for which specific streams to invest in restoring as well as those streams unlikely to be ecologically improved. Another application of this research is to be able to compare two or more streams to identify which reaches have a higher predicted BIBI given their current landscape setting (**Figs. 18 and 19**). This would allow planners, resource managers, and regulators to better weight the potential for ecological improvement in a more quantitative and rigorous fashion.

Given the current ISC levels of most streams in Montgomery County, it is clear that achieving only the 50th percentile of predicted will be a disappointing result (**Fig. 18**). There are no streams in the county in which the 50th percentile exceeds a BIBI of 2.5, which ranks firmly in the “Poor” narrative rating. In a surprising number of streams, even the best-case outcome might be disappointing as some streams are predicted to never be able to rate higher than “Poor” on the BIBI (**Fig. 19**). While only the 50th and 99th percentile predictions maps are shown, similar maps can be constructed using the stream layer and predictions in a GIS application. The restoration community can use these data with other spatial data and planning scenarios to better understand and predict restoration opportunities. While the results are currently generated only for Montgomery County, the same method could be applied across the region.

Viewing the predictions in a GIS

As a project deliverable, a stream layer shapefile is included with the report. The stream layer comes from the SHEDS (Spatial Hydro-Ecological Decision Support) project of the Conte-Ecology group of the USGS (http://conte-ecology.github.io/shedsGisData/). Documentation for the stream layer and land use data can be obtained on their website. Every stream reach has unique FEATUREID identifier that links to any tables found on their site. Viewing the predicted BIBI scores for a given probability level can be accomplished by linking or joining the accompanying predictions data to the stream layer using the FEATUREID field common to both.

I believe this will be a very valuable tool for planning purposes as it will allow anyone to see the various predicted BIBI score percentiles for any stream reach. Although ecological uplift is not the sole reason for stream restorations, it is often cited as an important objective. The predictions that resulted from my research will allow for a more informed view of the ecological potential of each stream reach. I have no doubt that the results can be refined and improved, but I believe this is a good starting point to add some objective realism into what we can expect from ecological responses to stream restorations.

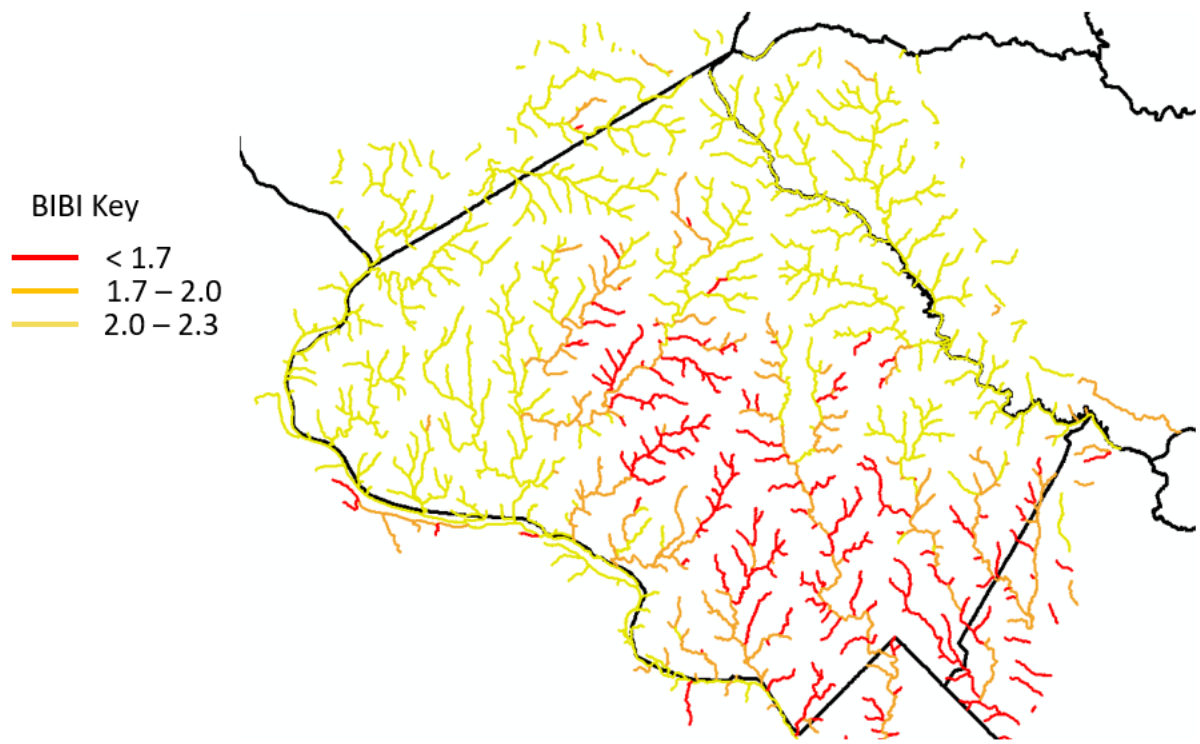

Figure 18. Predicted 50th percentile BIBI scores for Montgomery County stream reaches. Reaches are color coded according to their predicted BIBI score.

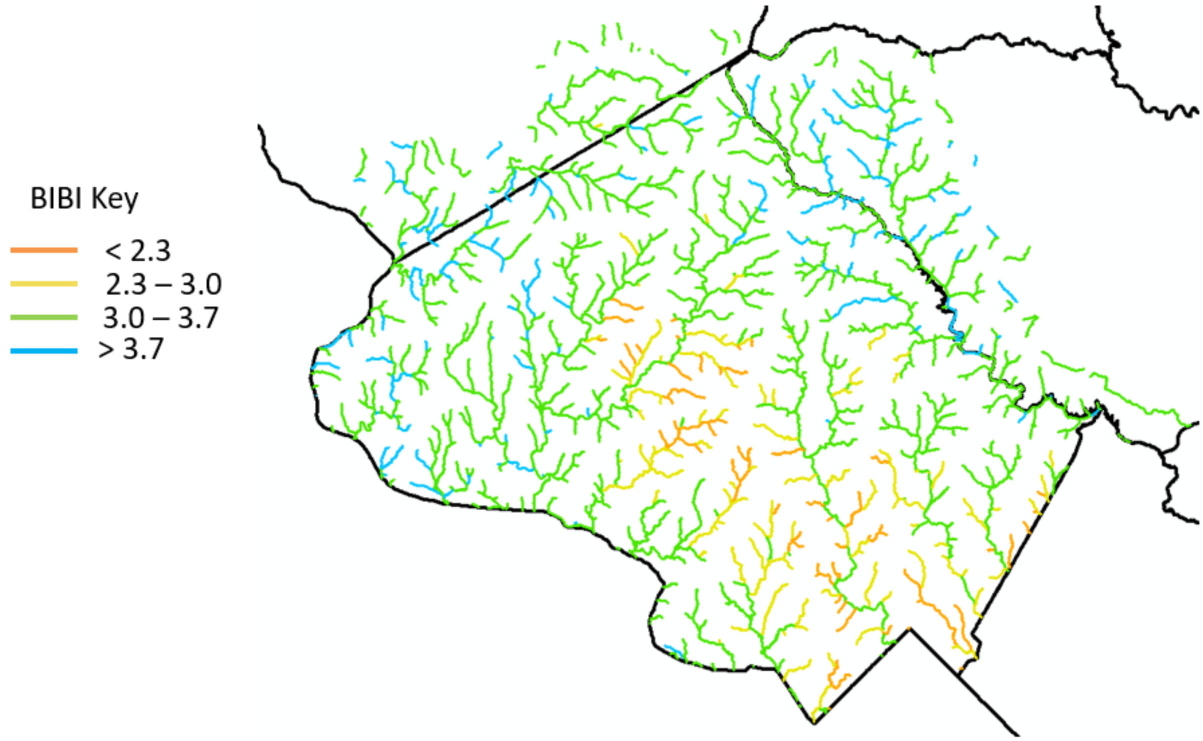

Figure 19. Predicted 99th percentile BIBI scores for Montgomery County stream reaches. Reaches are color coded according to their predicted BIBI score.

Acknowledgments

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Appendix A. Responses of benthic macroinvertebrates to watershed ISC and Urbanization and the thresholds beyond which the taxon is no longer found. ISC response = No indicates there is no significant relationship between a specific taxon and ISC. ISC response = Yes indicates there is a significant negative relationship between a taxon and ISC. The values under each percent (e.g., ISC 95%) indicate the ISC value beyond which a taxon is no longer found for 95%, 97%, and 99% of the taxon's distribution. Urban responses are interpreted in the same way.

TAXON	ISC response	Urban response	ISC 95%	Urban 95%	ISC 97%	Urban 97%	ISC 99%	Urban 99%
ABLABESMYIA	No	No	26.8	78.8	28.3	89.7	30.8	95.1
ACENTRELLA	Yes	Yes	17.2	68.4	23.2	70.7	30.9	73.8
ACERPENNA	Yes	Yes	6.4	30.6	8.2	36.1	9.6	41.9
ACRONEURIA	Yes	Yes	6.1	34.1	8.2	42.4	11.4	51.1
ALLOCAPNIA	Yes	Yes	8.2	28.5	11.1	34.9	13.0	44.7
AMELETUS	Yes	Yes	8.3	54.0	11.4	58.3	23.7	70.9
AMPHINEMURA	Yes	Yes	6.4	49.3	9.3	54.7	19.3	69.5
ANCHYTARSUS	Yes	No	10.7	56.1	11.9	60.4	19.1	75.5
ANCYRONYX	Yes	No	22.4	80.5	22.8	83.1	22.9	85.8
ANTOCHA	No	No	23.8	83.6	27.4	87.3	32.9	93.8
ARGIA	Yes	Yes	26.7	92.3	28.3	95.4	32.0	97.7
BAETIDAE	Yes	Yes	5.4	37.9	9.9	39.8	16.0	67.6
BAETIS	Yes	No	4.9	45.5	5.8	53.4	10.5	60.5
BEZZIA	Yes	Yes	10.1	49.8	14.1	54.0	18.0	58.2
BOYERIA	Yes	No	24.0	83.5	25.9	87.3	27.4	94.9
BRILLIA	No	No	26.8	82.1	31.4	86.0	40.2	89.9
CAECIDOTEA	No	No	23.4	85.0	24.6	86.3	29.8	90.8
CAENIS	Yes	Yes	20.1	73.2	27.7	74.4	31.5	79.8
CALOPTERYX	No	No	24.3	85.2	26.5	89.3	26.8	94.8
CAPNIIDAE	Yes	Yes	11.1	57.0	11.1	59.2	11.5	66.1
CARDIOCLADIUS	Yes	Yes	33.0	87.4	33.9	87.5	34.3	90.6
CENTROPTILUM	Yes	Yes	6.8	44.0	8.6	47.2	11.9	48.9
CERATOPOGON	Yes	Yes	10.4	65.7	11.9	75.4	17.6	81.4
CERATOPOGONIDAE	No	Yes	22.6	83.4	27.5	84.3	37.6	84.6
CERATOPSYCHE	Yes	No	24.9	75.6	27.9	82.6	30.9	89.5
CHAETOCLADIUS	No	No	20.5	74.8	24.8	76.7	27.6	81.5
CHELIFERA	Yes	Yes	9.0	50.3	11.2	52.7	16.8	62.0
CHEUMATOPSYCHE	No	No	23.4	81.4	27.8	86.9	33.0	92.8
CHIMARRA	No	No	20.2	71.8	20.3	74.7	29.0	81.4
CHIRONOMIDAE	No	No	8.0	61.3	9.8	63.1	13.5	66.7
CHIRONOMINAE	No	No	31.1	92.6	31.6	92.8	32.1	92.9
CHIRONOMINI	No	No	18.4	75.7	20.1	76.4	24.9	82.3
CHIRONOMUS	Yes	Yes	11.0	59.5	13.4	65.9	15.8	72.3
CHLOROPERLIDAE	Yes	Yes	6.2	28.5	9.0	29.4	10.1	35.7

CHRYSOPS	Yes	Yes	22.1	77.1	25.8	77.6	26.9	77.7
CLADOTANYTARSUS	Yes	Yes	20.0	65.5	20.0	68.6	20.1	71.7
CLINOCERA	No	No	19.8	71.6	22.0	76.3	27.9	84.0
COENAGRIONIDAE	Yes	Yes	17.8	79.0	20.6	83.0	26.3	83.9
CORBICULA	No	No	25.2	82.3	26.3	90.5	35.8	95.4
CORDULEGASTER	Yes	Yes	20.5	71.8	21.1	73.3	21.7	74.9
CORYDALUS	Yes	Yes	12.3	55.9	15.8	58.9	34.4	76.2
CORYNONEURA	Yes	No	20.0	70.9	24.0	76.1	28.1	87.2
CRANGONYX	No	No	32.5	88.2	38.7	93.0	41.6	96.6
CRICOTOPUS	No	Yes	29.3	87.9	32.4	92.4	39.1	94.2
CRYPTOCHIRONOMUS	Yes	Yes	13.3	61.7	13.5	68.9	19.0	75.6
DIAMESA	Yes	No	22.3	76.4	25.1	79.0	27.9	87.6
DIAMESINAE	No	Yes	24.8	77.7	26.1	78.0	27.4	84.8
DICRANOTA	Yes	Yes	13.5	61.7	19.6	70.8	24.3	74.6
DICROTENDIPES	No	Yes	30.4	92.5	31.0	94.4	36.5	96.2
DINEUTUS	Yes	Yes	2.5	17.9	2.5	18.1	2.5	18.2
DIPHETOR	Yes	Yes	3.7	27.6	5.0	28.4	6.2	29.2
DIPLECTRONA	No	No	20.1	70.3	22.2	75.5	38.7	88.0
DIPLOCLADIUS	No	Yes	22.5	74.5	23.6	75.6	26.2	76.5
DIPLOPERLA	Yes	Yes	2.3	43.4	2.4	47.6	2.4	51.8
DOLOPHILODES	Yes	No	15.1	67.8	17.0	74.0	18.9	76.5
DRUNELLA	Yes	Yes	2.2	18.4	2.3	20.0	2.4	22.9
DUBIRAPHIA	Yes	Yes	18.1	63.0	18.8	65.0	25.9	94.2
ECCOPTURA	Yes	Yes	11.8	55.2	11.8	59.9	19.5	64.0
ECTOPRIA	Yes	Yes	2.3	20.7	2.3	21.1	2.3	21.4
ELMIDAE	Yes	Yes	11.9	58.2	14.8	64.8	15.6	68.6
EMPIDIDAE	No	Yes	29.0	75.0	31.9	76.4	33.0	81.3
ENCHYTRAEIDAE	No	No	28.0	87.5	29.3	88.4	32.8	97.4
EPEORUS	Yes	Yes	3.9	28.1	5.8	33.4	8.2	47.4
EPHEMERELLA	Yes	Yes	8.0	53.6	13.9	61.4	24.1	75.2
EPHEMERELLIDAE	Yes	Yes	5.1	26.4	6.0	27.6	9.4	33.2
EUKIEFFERIELLA	No	No	22.3	76.8	26.2	85.7	32.4	87.9
EURYLOPHELLA	Yes	Yes	10.4	53.6	14.3	63.5	18.8	75.8
FERRISSIA	Yes	Yes	20.1	67.9	21.6	74.3	23.5	82.3
GAMMARUS	No	No	29.8	84.1	32.6	89.2	33.0	93.3
GIRARDIA	Yes	Yes	27.3	92.4	29.0	93.6	30.8	97.1
GLOSSOSOMA	No	Yes	18.1	61.5	19.8	69.6	21.0	71.6
GOMPHIDAE	Yes	Yes	6.8	45.2	8.0	45.8	10.8	53.4
GORDIIDAE	Yes	Yes	25.1	82.4	26.4	83.0	27.0	83.4
HAPLOPERLA	Yes	Yes	9.4	35.9	9.8	39.4	10.2	42.8
HELICHUS	Yes	Yes	11.3	59.8	15.5	69.1	18.9	74.8
HEMERODROMIA	No	No	26.4	87.2	29.4	92.5	31.8	95.4
HEPTAGENIIDAE	Yes	Yes	3.2	27.6	3.5	38.4	4.0	44.6

HETEROTRISSOCLADIUS	Yes	Yes	22.8	80.3	24.5	81.9	26.2	83.5
HEXATOMA	Yes	Yes	17.2	67.9	18.7	75.7	21.0	80.1
HYDROBAENUS	No	No	22.3	76.6	25.1	83.2	28.6	88.8
HYDROPSYCHE	No	No	24.2	84.0	27.9	87.1	33.0	93.0
HYDROPSYCHIDAE	No	Yes	16.8	60.3	22.3	75.0	26.7	85.7
HYDROPTILA	Yes	Yes	24.3	90.3	26.0	94.7	26.4	96.0
IRONOQUIA	Yes	Yes	16.1	76.2	18.1	76.5	20.2	76.6
ISONYCHIA	Yes	Yes	13.1	49.5	18.0	62.8	21.2	75.0
ISOPERLA	Yes	Yes	1.8	23.4	2.1	25.1	5.4	46.0
ISOTOMURUS	Yes	Yes	21.5	72.5	21.8	76.6	22.2	80.8
LEPIDOSTOMA	Yes	Yes	20.1	69.5	27.7	72.5	31.5	74.0
LEPTOPHLEBIA	Yes	Yes	2.7	23.9	2.9	24.1	3.2	24.2
LEPTOPHLEBIIDAE	Yes	Yes	6.7	43.4	8.8	45.0	14.0	49.7
LEPTOXIS	Yes	Yes	8.2	36.4	9.4	44.6	10.5	52.9
LEUCOTRICHIA	No	No	30.0	86.5	32.8	88.9	33.8	91.6
LEUCTRA	Yes	Yes	20.7	59.9	22.7	77.1	26.6	77.7
LEUCTRIDAE	Yes	Yes	6.8	47.3	8.8	54.7	10.0	61.7
LIMNEPHILIDAE	Yes	No	21.1	76.5	22.0	79.8	22.4	84.4
LIMNODRILUS	No	No	25.6	83.5	27.7	88.1	35.0	89.0
LIMNOPHYES	Yes	Yes	27.6	87.5	30.1	88.3	37.6	90.3
LIMONIA	Yes	Yes	21.3	85.2	22.1	85.5	22.8	85.8
LUMBRICULIDAE	No	No	30.1	87.7	32.7	91.8	39.1	93.4
LYPE	Yes	Yes	5.1	38.2	5.2	41.8	6.2	49.4
MACCAFFERTIUM	Yes	Yes	19.8	69.1	25.7	73.0	30.3	83.7
MACRONYCHUS	No	No	25.9	76.6	27.2	81.1	30.7	95.1
MENETUS	Yes	Yes	17.9	72.6	21.1	77.7	24.2	82.9
MICRASEMA	Yes	Yes	2.8	20.3	3.1	20.5	3.4	20.6
MICROCYLLOEPUS	Yes	Yes	24.4	90.5	25.9	94.2	26.3	95.8
MICROPSECTRA	Yes	Yes	18.5	70.6	19.9	75.5	22.6	83.8
MICROTENDIPES	Yes	Yes	18.0	64.2	20.0	73.3	22.5	83.8
MUSCULIUM	Yes	Yes	22.9	76.5	24.9	81.0	26.9	85.5
NAIDIDAE	No	No	23.4	77.5	25.8	82.5	28.5	86.3
NANOCLADIUS	Yes	Yes	21.3	75.8	25.2	77.6	28.6	88.9
NATARSIA	No	No	15.8	68.5	19.5	74.2	23.9	83.2
NEMOURIDAE	Yes	Yes	8.4	44.9	12.1	49.0	19.7	58.9
NEOPHYLAX	Yes	Yes	9.8	49.7	13.0	56.5	22.3	73.0
NEOPLASTA	Yes	No	13.3	61.7	14.8	67.2	16.3	72.7
NIGRONIA	Yes	Yes	9.7	46.5	10.1	48.1	11.7	58.7
OPTIOSERVUS	Yes	Yes	17.0	63.8	18.8	74.3	26.3	85.2
ORMOSIA	Yes	Yes	11.9	50.8	15.7	61.1	19.4	71.4
ORTHOCLADIINAE	No	No	26.5	84.9	29.0	86.9	38.6	91.6
ORTHOCLADIUS	No	No	26.2	84.9	28.5	87.2	34.3	92.6
OULIMNIUS	Yes	No	17.0	70.9	20.0	75.5	25.0	80.2

PARACLADOPELMA	Yes	Yes	13.8	55.0	16.3	57.1	18.8	59.2
PARAKIEFFERIELLA	Yes	Yes	4.0	38.3	4.6	48.6	12.5	66.2
PARALEPTOPHLEBIA	Yes	Yes	3.5	27.1	3.5	27.4	3.5	61.6
PARAMETRIOCNEMUS	Yes	No	20.2	75.8	23.1	81.4	32.4	87.7
PARAPHAENOCLADIUS	Yes	Yes	18.6	71.9	20.1	73.0	23.0	76.8
PARATANYTARSUS	No	No	26.5	87.5	30.4	90.0	33.1	92.6
PARATENDIPES	Yes	Yes	20.5	76.4	20.8	76.5	21.1	76.5
PERLESTA	Yes	Yes	33.0	74.6	33.0	74.6	33.0	74.6
PERLIDAE	Yes	Yes	5.2	44.6	8.7	53.9	29.0	73.0
PERLODIDAE	Yes	Yes	10.1	60.3	19.1	69.5	31.3	73.9
PHAENOPSECTRA	Yes	Yes	30.7	92.5	32.1	92.9	32.4	93.0
PHILOPOTAMIDAE	Yes	Yes	10.4	49.8	10.8	54.2	11.5	58.4
PHYSA	No	No	25.7	85.8	28.3	88.0	32.5	97.3
PISIDIIDAE	No	No	12.2	62.9	15.4	71.6	21.5	81.4
PISIDIUM	Yes	Yes	11.5	58.0	13.4	62.0	15.3	66.0
POLYCENTROPUS	Yes	Yes	13.4	53.5	18.1	63.3	25.8	93.7
POLYPEDILUM	No	No	22.1	76.7	26.6	83.2	29.7	87.4
POTTHASTIA	Yes	No	29.0	73.7	30.9	74.6	33.0	75.5
PROBEZZIA	Yes	Yes	10.2	52.0	11.1	69.3	16.9	80.9
PROCLADIUS	Yes	Yes	19.7	65.0	23.0	74.1	26.3	83.2
PROMORESIA	Yes	Yes	3.0	28.5	3.3	37.0	3.5	45.5
PROSIMULIUM	Yes	Yes	7.7	44.9	10.9	50.9	19.1	72.1
PROSTOIA	Yes	Yes	9.4	47.3	11.5	58.9	20.7	76.7
PROSTOMA	No	No	30.0	90.9	35.6	93.1	41.8	96.0
PSEPHENUS	No	Yes	20.0	71.8	23.1	76.1	25.3	91.3
PSEUDOLIMNOPHILA	Yes	No	6.7	45.6	9.0	55.1	10.9	70.3
PSEUDORTHOCLADIUS	Yes	Yes	12.1	58.6	12.7	63.0	13.4	67.4
PSILOTRETA	Yes	Yes	6.7	54.3	6.7	66.3	6.8	78.3
PSYCHOMYIA	Yes	Yes	9.5	41.1	13.6	54.2	13.9	58.5
PTERONARCYS	Yes	Yes	1.2	21.9	1.2	22.4	1.2	22.8
PYCNOPSYCHE	Yes	Yes	6.5	45.3	6.6	61.8	18.3	85.7
RHEOCRICOTOPUS	No	Yes	25.4	78.1	27.1	85.7	32.2	92.7
RHEOTANYTARSUS	No	No	20.2	73.8	22.4	76.0	30.9	81.4
RHYACOPHILA	Yes	Yes	8.7	49.0	10.5	55.1	20.2	71.4
ROBACKIA	Yes	Yes	8.9	48.9	10.8	50.8	12.6	52.7
SERRATELLA	Yes	Yes	3.2	34.3	6.1	38.6	8.3	54.0
SIALIS	Yes	Yes	8.1	41.6	11.7	45.1	12.1	55.3
SIMULIIDAE	Yes	Yes	14.7	72.0	18.2	82.6	22.2	84.9
SIMULIUM	No	No	24.4	77.3	27.5	81.5	31.1	87.4
SPHAERIUM	Yes	Yes	3.6	38.2	9.9	50.7	16.3	63.3
SPIROSPERMA	Yes	Yes	15.2	71.4	19.8	75.0	21.9	76.0
STAGNICOLA	Yes	Yes	27.7	93.3	28.0	94.6	28.2	96.0
STEGOPTERNA	Yes	Yes	12.8	53.4	15.5	61.8	22.2	77.0

STEMPELLINELLA	Yes	Yes	3.2	42.4	3.2	51.1	3.6	51.4
STENACRON	Yes	Yes	6.3	39.6	9.9	51.4	16.2	63.1
STENELMIS	No	No	22.5	80.7	25.4	84.6	28.5	87.3
STENONEMA	Yes	Yes	18.1	69.3	19.4	74.6	26.7	83.4
STICTOCHIRONOMUS	Yes	Yes	14.5	56.1	16.8	64.2	19.1	72.3
STILOCLADIUS	Yes	No	9.5	75.9	24.5	79.5	26.5	85.7
STROPHOPTERYX	Yes	Yes	7.1	30.4	8.2	34.2	12.7	53.7
STYGOBROMUS	Yes	Yes	22.9	83.1	25.9	94.2	26.3	95.8
STYLOGOMPHUS	Yes	Yes	9.1	63.2	13.2	70.9	17.9	74.6
SUBLETTEA	No	No	25.6	85.6	27.5	86.9	28.7	87.1
SWELTSA	Yes	Yes	5.8	27.4	5.9	27.4	5.9	27.5
SYMPOTTHASTIA	No	Yes	22.4	76.2	27.0	83.6	32.7	87.7
SYNORTHOCLADIUS	Yes	Yes	19.8	69.8	25.3	91.6	26.3	95.7
TAENIOPTERYX	No	Yes	20.6	77.7	21.4	79.1	22.1	80.6
TALLAPERLA	Yes	Yes	2.5	21.5	2.8	23.8	3.1	26.0
TANYPODINAE	No	No	26.2	85.0	29.1	87.6	41.6	91.6
TANYTARSINI	Yes	Yes	16.5	68.0	19.7	71.6	28.3	75.3
TANYTARSUS	No	No	20.6	76.5	25.2	84.8	29.1	90.5
TELOGANOPSIS	Yes	Yes	20.0	60.3	20.0	60.3	20.0	60.3
THIENEMANNIELLA	No	No	24.0	81.4	25.9	84.6	27.3	86.9
THIENEMANNIMYIA	No	No	6.2	40.6	6.4	42.1	6.5	43.6
TIPULA	No	No	26.3	84.6	29.1	87.1	38.7	89.8
TIPULIDAE	Yes	Yes	23.0	81.3	24.3	82.9	33.9	86.3
TRIBELOS	Yes	Yes	20.5	77.6	25.7	93.5	26.3	95.7
TRISSOPELOPIA	Yes	Yes	20.6	75.9	24.6	77.7	27.0	82.9
TUBIFICIDAE	No	No	28.3	87.7	30.9	91.6	39.3	95.2
TVETENIA	No	No	21.3	76.6	23.2	79.2	27.9	86.8
ZAVRELIMYIA	Yes	Yes	27.0	87.5	27.9	87.6	33.0	92.3

Appendix B. Results of regression analyses examining the various stormwater BMP components in terms of number of projects (_Count) and the acres of ISC treated (_Imp). Variable definitions can be found in Table 2.

Variable	intercept	slope	t-value	P-Value	R^2
AGRE_Count	1.91	-0.07	-0.55	0.59	0.02
AGRI_count	1.86	0.18	NA	NA	0.00
APRP_Count	1.96	-0.05	-1.07	0.30	0.06
ARTF_Count	1.86	0.18	NA	NA	0.00
FBIO_Count	1.82	0.01	0.53	0.60	0.01
FORG_Count	1.85	0.15	0.17	0.87	0.00
FSND_Count	1.74	0.03	1.37	0.19	0.09
FUND_Count	1.89	-0.01	-0.28	0.78	0.00
IBAS_Count	1.80	0.39	0.99	0.34	0.05
ITRN_Count	1.87	0.00	-0.11	0.91	0.00
MIBR_Count	1.86	0.18	NA	NA	0.00
MIDW_Count	1.90	0.00	-0.68	0.51	0.02
MILS_Count	1.87	-0.02	-0.25	0.80	0.00
MMBR_Count	1.93	-0.03	-0.80	0.44	0.03
MRNG_Count	1.83	0.04	0.39	0.70	0.01
MRWH_Count	1.86	-0.02	-0.05	0.96	0.00
MSGW_Count	1.85	0.15	0.17	0.87	0.00
MSWB_Count	1.88	-0.04	-0.26	0.80	0.00
MSWG_Count	1.85	0.00	0.16	0.87	0.00
ODSW_Count	1.78	1.55	1.93	0.07	0.16
OTH_Count	1.90	-0.01	-0.30	0.77	0.00
PWED_Count	1.59	0.37	2.06	0.05	0.18
PWET_Count	1.74	0.19	1.18	0.25	0.07
WEDW_Count	1.82	0.04	0.41	0.68	0.01
WPWS_Count	1.87	-0.20	-0.23	0.82	0.00
WSHW_Count	1.86	0.18	NA	NA	0.00
XDED_Count	1.85	0.01	0.15	0.88	0.00
XDPD_Count	1.80	0.02	0.79	0.44	0.03
XOGS_Count	1.86	0.00	0.01	0.99	0.00
XOTH_Count	1.86	0.18	NA	NA	0.00
AGRE_Imp	1.90	-0.50	-0.58	0.57	0.02
AGRI_Imp	1.86	0.18	NA	NA	0.00
APRP_Imp	1.97	-2.28	-1.22	0.24	0.07
ARTF_Imp	1.86	0.18	NA	NA	0.00
FBIO_Imp	1.74	0.05	1.09	0.29	0.06
FORG_Imp	1.85	0.29	0.17	0.87	0.00
FSND_Imp	1.80	0.01	0.82	0.42	0.03
FUND_Imp	1.88	0.00	-0.14	0.89	0.00

IBAS_Imp	1.85	0.00	0.21	0.83	0.00
ITRN_Imp	1.84	0.01	0.28	0.78	0.00
MIBR_Imp	1.86	0.18	NA	NA	0.00
MIDW_Imp	1.90	-0.04	-0.61	0.55	0.02
MILS_Imp	1.82	1.10	0.57	0.57	0.02
MMBR_Imp	1.93	-0.20	-0.87	0.39	0.04
MRNG_Imp	1.87	-1.70	-0.23	0.82	0.00
MRWH_Imp	1.90	-8.37	-0.77	0.45	0.03
MSGW_Imp	1.85	0.09	0.17	0.87	0.00
MSWB_Imp	1.88	-0.31	-0.37	0.71	0.01
MSWG_Imp	1.85	0.00	0.19	0.85	0.00
ODSW_Imp	1.78	9.57	1.93	0.07	0.16
OTH_Imp	1.88	0.00	-0.13	0.90	0.00
PWED_Imp	1.78	0.01	0.78	0.44	0.03
PWET_Imp	1.83	0.00	0.32	0.75	0.01
WEDW_Imp	1.84	0.00	0.18	0.86	0.00
WPWS_Imp	1.87	-0.07	-0.23	0.82	0.00
WSHW_Imp	1.86	0.18	NA	NA	0.00
XDED_Imp	1.85	0.00	0.14	0.89	0.00
XDPD_Imp	1.83	0.00	0.32	0.75	0.01
XOGS_Imp	1.86	0.00	-0.04	0.97	0.00
XOTH_Imp	1.86	0.18	NA	NA	0.00
Total BMP Count	1.89	0.00	-0.40	0.69	0.01
Acres ISC treated	1.83	0.00	0.33	0.74	0.01

Appendix C. Results of regression analyses examining the various combinations of search distance, type of search, and the maximum ISC % for each category. Frequency refers to the total number of donor reaches within the category, while length refers to the length of donor stream within the category. Results are sorted in descending order by R^2.

Variable	Method	Metric	ISC %	Search Distance (km)	Intercept	Slope	t - value	P- value	R^2
fly.7.f.1000	insect flys	frequency	7%	1	1.41	0.34	9.00	0.000	0.810
swim.7.f.3000	fish swims	frequency	7%	3	1.31	0.17	8.97	0.000	0.809
fly.15.f.7500	insect flys	frequency	15%	7.5	0.39	0.02	8.76	0.000	0.802
fly.10.l.7500	insect flys	length	10%	7.5	0.83	0.00	8.74	0.000	0.801
swim.7.f.4000	fish swims	frequency	7%	4	1.29	0.13	8.69	0.000	0.799
fly.15.l.7500	insect flys	length	15%	7.5	0.25	0.00	8.66	0.000	0.798
fly.10.f.7500	insect flys	frequency	10%	7.5	0.86	0.02	8.64	0.000	0.797
swim.7.f.2000	fish swims	frequency	7%	2	1.37	0.23	8.37	0.000	0.787
fly.20.f.7500	insect flys	frequency	20%	7.5	-0.31	0.02	8.34	0.000	0.786
swim.7.f.5000	fish swims	frequency	7%	5	1.30	0.10	8.27	0.000	0.782
swim.7.l.4000	fish swims	length	7%	4	1.33	0.10	8.24	0.000	0.781
swim.7.l.5000	fish swims	length	7%	5	1.33	0.08	8.21	0.000	0.780
fly.15.l.3000	insect flys	length	15%	3	0.81	0.00	8.17	0.000	0.778
swim.7.l.3000	fish swims	length	7%	3	1.35	0.13	8.15	0.000	0.778
swim.10.l.4000	fish swims	length	10%	4	1.17	0.11	8.04	0.000	0.773
swim.10.f.2000	fish swims	frequency	10%	2	1.25	0.23	8.02	0.000	0.772
swim.10.l.2000	fish swims	length	10%	2	1.34	0.16	7.94	0.000	0.768
swim.10.l.5000	fish swims	length	10%	5	1.18	0.08	7.88	0.000	0.766
fly.20.f.10000	insect flys	frequency	20%	10	-0.64	0.02	7.84	0.000	0.764
fly.15.l.10000	insect flys	length	15%	10	0.04	0.00	7.83	0.000	0.763
fly.15.f.10000	insect flys	frequency	15%	10	0.18	0.01	7.78	0.000	0.761
fly.10.l.3000	insect flys	length	10%	3	1.20	0.00	7.69	0.000	0.757
fly.10.f.10000	insect flys	frequency	10%	10	0.74	0.01	7.67	0.000	0.756
fly.10.l.10000	insect flys	length	10%	10	0.71	0.00	7.63	0.000	0.754
fly.10.l.4000	insect flys	length	10%	4	1.11	0.00	7.62	0.000	0.754
swim.7.l.7500	fish swims	length	7%	7.5	1.27	0.06	7.62	0.000	0.753
fly.10.l.2000	insect flys	length	10%	2	1.26	0.00	7.58	0.000	0.751
fly.7.l.2000	insect flys	length	7%	2	1.37	0.00	7.57	0.000	0.751
swim.10.l.3000	fish swims	length	10%	3	1.22	0.13	7.52	0.000	0.748
fly.7.l.3000	insect flys	length	7%	3	1.36	0.00	7.49	0.000	0.747
fly.20.l.7500	insect flys	length	20%	7.5	-0.85	0.00	7.41	0.000	0.743
fly.7.l.1000	insect flys	length	7%	1	1.47	0.00	7.39	0.000	0.742
fly.10.f.3000	insect flys	frequency	10%	3	1.18	0.07	7.33	0.000	0.739
fly.10.l.5000	insect flys	length	10%	5	1.04	0.00	7.31	0.000	0.738
fly.7.f.3000	insect flys	frequency	7%	3	1.35	0.07	7.22	0.000	0.733
fly.7.l.7500	insect flys	length	7%	7.5	1.08	0.00	7.20	0.000	0.732

fly.10.f.4000	insect flys	frequency	10%	4	1.09	0.05	7.18	0.000	0.731
fly.20.l.10000	insect flys	length	20%	10	-1.22	0.00	7.17	0.000	0.730
fly.7.f.7500	insect flys	frequency	7%	7.5	1.11	0.02	7.15	0.000	0.729
swim.10.l.7500	fish swims	length	10%	7.5	1.13	0.06	7.11	0.000	0.727
fly.10.l.1000	insect flys	length	10%	1	1.37	0.00	7.11	0.000	0.727
swim.10.f.4000	fish swims	frequency	10%	4	1.15	0.12	7.08	0.000	0.725
fly.7.f.2000	insect flys	frequency	7%	2	1.36	0.11	7.07	0.000	0.725
fly.7.l.4000	insect flys	length	7%	4	1.31	0.00	7.05	0.000	0.723
fly.15.f.3000	insect flys	frequency	15%	3	0.87	0.07	6.98	0.000	0.720
fly.7.f.10000	insect flys	frequency	7%	10	1.03	0.01	6.93	0.000	0.717
fly.10.f.5000	insect flys	frequency	10%	5	1.04	0.03	6.92	0.000	0.716
swim.7.l.2000	fish swims	length	7%	2	1.45	0.15	6.92	0.000	0.716
swim.7.f.7500	fish swims	frequency	7%	7.5	1.28	0.06	6.87	0.000	0.713
swim.10.f.5000	fish swims	frequency	10%	5	1.17	0.09	6.85	0.000	0.712
fly.15.l.5000	insect flys	length	15%	5	0.57	0.00	6.82	0.000	0.710
fly.7.l.10000	insect flys	length	7%	10	1.02	0.00	6.81	0.000	0.709
fly.15.f.5000	insect flys	frequency	15%	5	0.64	0.03	6.73	0.000	0.704
swim.10.f.3000	fish swims	frequency	10%	3	1.20	0.16	6.69	0.000	0.702
fly.20.f.5000	insect flys	frequency	20%	5	0.10	0.04	6.65	0.000	0.700
fly.10.f.1000	insect flys	frequency	10%	1	1.31	0.31	6.51	0.000	0.690
fly.7.l.5000	insect flys	length	7%	5	1.26	0.00	6.50	0.000	0.690
fly.7.f.4000	insect flys	frequency	7%	4	1.31	0.05	6.46	0.000	0.687
swim.10.f.7500	fish swims	frequency	10%	7.5	1.15	0.06	6.39	0.000	0.683
fly.10.f.2000	insect flys	frequency	10%	2	1.26	0.11	6.38	0.000	0.682
swim.15.l.2000	fish swims	length	15%	2	1.12	0.15	6.37	0.000	0.681
swim.15.f.2000	fish swims	frequency	15%	2	1.07	0.21	6.37	0.000	0.681
fly.15.l.4000	insect flys	length	15%	4	0.76	0.00	6.29	0.000	0.675
swim.7.l.10000	fish swims	length	7%	10	1.27	0.04	6.25	0.000	0.672
fly.20.l.5000	insect flys	length	20%	5	-0.18	0.00	6.22	0.000	0.671
fly.15.l.2000	insect flys	length	15%	2	0.93	0.00	6.22	0.000	0.671
fly.5.f.10000	insect flys	frequency	5%	10	1.25	0.01	6.17	0.000	0.667
swim.10.l.10000	fish swims	length	10%	10	1.14	0.04	6.17	0.000	0.667
fly.5.l.10000	insect flys	length	5%	10	1.25	0.00	6.11	0.000	0.663
fly.25.f.7500	insect flys	frequency	25%	7.5	-3.60	0.04	6.10	0.000	0.662
fly.15.f.4000	insect flys	frequency	15%	4	0.79	0.05	6.06	0.000	0.659
fly.7.f.5000	insect flys	frequency	7%	5	1.28	0.03	5.99	0.000	0.654
fly.5.l.7500	insect flys	length	5%	7.5	1.33	0.00	5.88	0.000	0.646
fly.5.f.7500	insect flys	frequency	5%	7.5	1.35	0.02	5.88	0.000	0.645
swim.10.f.10000	fish swims	frequency	10%	10	1.17	0.04	5.81	0.000	0.640
swim.15.l.5000	fish swims	length	15%	5	0.97	0.07	5.75	0.000	0.635
fly.15.l.1000	insect flys	length	15%	1	1.16	0.00	5.74	0.000	0.634
swim.7.f.10000	fish swims	frequency	7%	10	1.31	0.04	5.65	0.000	0.627
fly.5.f.15000	insect flys	frequency	5%	15	0.77	0.01	5.60	0.000	0.623

swim.15.l.4000	fish swims	length	15%	4	0.98	0.09	5.55	0.000	0.619
fly.3.l.10000	insect flys	length	3%	10	1.38	0.00	5.54	0.000	0.617
fly.20.f.3000	insect flys	frequency	20%	3	0.62	0.07	5.53	0.000	0.616
fly.7.f.15000	insect flys	frequency	7%	15	0.55	0.01	5.50	0.000	0.614
fly.3.f.10000	insect flys	frequency	3%	10	1.38	0.01	5.48	0.000	0.613
fly.5.l.15000	insect flys	length	5%	15	0.74	0.00	5.46	0.000	0.611
fly.3.f.15000	insect flys	frequency	3%	15	0.92	0.01	5.39	0.000	0.605
fly.7.l.15000	insect flys	length	7%	15	0.53	0.00	5.33	0.000	0.599
swim.5.l.5000	fish swims	length	5%	5	1.50	0.10	5.32	0.000	0.598
fly.20.f.4000	insect flys	frequency	20%	4	0.38	0.05	5.31	0.000	0.598
fly.20.l.3000	insect flys	length	20%	3	0.59	0.00	5.28	0.000	0.595
fly.25.f.10000	insect flys	frequency	25%	10	-3.80	0.02	5.28	0.000	0.595
swim.15.f.4000	fish swims	frequency	15%	4	1.01	0.09	5.27	0.000	0.594
fly.3.l.15000	insect flys	length	3%	15	0.91	0.00	5.19	0.000	0.586
swim.15.f.5000	fish swims	frequency	15%	5	1.03	0.07	5.17	0.000	0.585
fly.10.f.15000	insect flys	frequency	10%	15	0.30	0.01	5.16	0.000	0.583
fly.1.f.15000	insect flys	frequency	1%	15	1.31	0.02	5.15	0.000	0.583
fly.15.f.2000	insect flys	frequency	15%	2	1.05	0.10	5.15	0.000	0.582
fly.5.f.1000	insect flys	frequency	5%	1	1.57	0.32	5.13	0.000	0.580
swim.5.l.3000	fish swims	length	5%	3	1.54	0.14	5.11	0.000	0.579
swim.5.f.3000	fish swims	frequency	5%	3	1.53	0.18	5.10	0.000	0.578
swim.7.l.1000	fish swims	length	7%	1	1.49	0.43	5.03	0.000	0.571
swim.15.l.3000	fish swims	length	15%	3	1.08	0.11	5.02	0.000	0.570
swim.10.l.1000	fish swims	length	10%	1	1.37	0.43	4.99	0.000	0.567
fly.3.f.7500	insect flys	frequency	3%	7.5	1.47	0.02	4.97	0.000	0.565
fly.3.l.7500	insect flys	length	3%	7.5	1.45	0.00	4.97	0.000	0.565
swim.7.f.1000	fish swims	frequency	7%	1	1.45	0.57	4.97	0.000	0.565
swim.5.f.5000	fish swims	frequency	5%	5	1.48	0.12	4.95	0.000	0.564
fly.10.l.15000	insect flys	length	10%	15	0.27	0.00	4.89	0.000	0.558
fly.15.l.15000	insect flys	length	15%	15	-0.34	0.00	4.88	0.000	0.556
fly.1.f.20000	insect flys	frequency	1%	20	0.95	0.01	4.85	0.000	0.553
fly.5.l.1000	insect flys	length	5%	1	1.59	0.00	4.84	0.000	0.552
fly.15.f.15000	insect flys	frequency	15%	15	-0.20	0.01	4.84	0.000	0.552
swim.5.f.2000	fish swims	frequency	5%	2	1.55	0.24	4.82	0.000	0.550
fly.20.l.4000	insect flys	length	20%	4	0.31	0.00	4.77	0.000	0.545
fly.1.l.15000	insect flys	length	1%	15	1.36	0.00	4.76	0.000	0.544
swim.5.l.4000	fish swims	length	5%	4	1.55	0.11	4.73	0.000	0.541
fly.1.l.20000	insect flys	length	1%	20	1.00	0.00	4.67	0.000	0.535
swim.5.f.4000	fish swims	frequency	5%	4	1.52	0.14	4.67	0.000	0.534
swim.15.f.10000	fish swims	frequency	15%	10	0.99	0.03	4.66	0.000	0.533
fly.5.l.2000	insect flys	length	5%	2	1.54	0.00	4.65	0.000	0.533
swim.3.l.1000	fish swims	length	3%	1	1.57	0.69	4.63	0.000	0.530
fly.20.f.15000	insect flys	frequency	20%	15	-0.96	0.01	4.62	0.000	0.529

swim.15.f.3000	fish swims	frequency	15%	3	1.13	0.12	4.61	0.000	0.528
swim.15.f.7500	fish swims	frequency	15%	7.5	1.00	0.05	4.59	0.000	0.526
swim.5.l.2000	fish swims	length	5%	2	1.58	0.15	4.59	0.000	0.525
swim.5.l.7500	fish swims	length	5%	7.5	1.52	0.06	4.49	0.000	0.515
fly.5.f.2000	insect flys	frequency	5%	2	1.52	0.14	4.48	0.000	0.514
swim.3.f.1000	fish swims	frequency	3%	1	1.60	1.10	4.39	0.000	0.504
swim.15.l.7500	fish swims	length	15%	7.5	0.93	0.04	4.37	0.000	0.502
fly.15.f.1000	insect flys	frequency	15%	1	1.16	0.27	4.36	0.000	0.500
swim.20.l.2000	fish swims	length	20%	2	1.06	0.14	4.34	0.000	0.498
swim.15.l.10000	fish swims	length	15%	10	0.92	0.03	4.26	0.000	0.488
fly.3.f.20000	insect flys	frequency	3%	20	0.53	0.01	4.24	0.000	0.486
fly.5.f.20000	insect flys	frequency	5%	20	0.31	0.01	4.23	0.000	0.485
fly.5.l.5000	insect flys	length	5%	5	1.52	0.00	4.19	0.001	0.480
swim.20.f.2000	fish swims	frequency	20%	2	0.99	0.19	4.16	0.001	0.476
fly.5.l.4000	insect flys	length	5%	4	1.56	0.00	4.13	0.001	0.474
fly.20.l.15000	insect flys	length	20%	15	-1.19	0.00	4.12	0.001	0.472
fly.5.l.3000	insect flys	length	5%	3	1.58	0.00	4.11	0.001	0.471
fly.5.l.20000	insect flys	length	5%	20	0.32	0.00	4.11	0.001	0.471
fly.25.f.3000	insect flys	frequency	25%	3	-0.85	0.10	4.09	0.001	0.468
swim.20.f.5000	fish swims	frequency	20%	5	0.87	0.07	4.07	0.001	0.466
fly.7.f.20000	insect flys	frequency	7%	20	0.11	0.01	4.07	0.001	0.466
fly.10.f.20000	insect flys	frequency	10%	20	-0.11	0.00	4.03	0.001	0.460
fly.15.f.20000	insect flys	frequency	15%	20	-0.56	0.00	4.02	0.001	0.459
fly.5.f.5000	insect flys	frequency	5%	5	1.53	0.03	3.97	0.001	0.454
fly.7.l.20000	insect flys	length	7%	20	0.14	0.00	3.97	0.001	0.453
swim.5.l.1000	fish swims	length	5%	1	1.60	0.38	3.97	0.001	0.453
swim.3.l.2000	fish swims	length	3%	2	1.63	0.19	3.97	0.001	0.453
fly.15.l.20000	insect flys	length	15%	20	-0.61	0.00	3.96	0.001	0.453
fly.3.l.20000	insect flys	length	3%	20	0.56	0.00	3.96	0.001	0.453
fly.10.l.20000	insect flys	length	10%	20	-0.08	0.00	3.94	0.001	0.450
fly.25.f.5000	insect flys	frequency	25%	5	-1.61	0.05	3.93	0.001	0.448
fly.5.f.3000	insect flys	frequency	5%	3	1.58	0.07	3.92	0.001	0.447
swim.20.l.5000	fish swims	length	20%	5	0.91	0.06	3.90	0.001	0.444
fly.5.f.4000	insect flys	frequency	5%	4	1.57	0.05	3.87	0.001	0.440
fly.20.f.20000	insect flys	frequency	20%	20	-1.14	0.00	3.85	0.001	0.438
swim.5.f.7500	fish swims	frequency	5%	7.5	1.55	0.06	3.83	0.001	0.435
swim.10.f.1000	fish swims	frequency	10%	1	1.39	0.46	3.82	0.001	0.434
fly.25.f.15000	insect flys	frequency	25%	15	-4.29	0.01	3.80	0.001	0.432
swim.5.l.10000	fish swims	length	5%	10	1.54	0.04	3.79	0.001	0.430
swim.20.f.10000	fish swims	frequency	20%	10	0.79	0.04	3.78	0.001	0.429
swim.3.l.3000	fish swims	length	3%	3	1.63	0.17	3.76	0.001	0.426
swim.20.f.7500	fish swims	frequency	20%	7.5	0.81	0.05	3.69	0.002	0.418
fly.20.l.20000	insect flys	length	20%	20	-1.20	0.00	3.67	0.002	0.414

swim.20.f.4000	fish swims	frequency	20%	4	0.93	0.09	3.67	0.002	0.414
swim.10.l.15000	fish swims	length	10%	15	1.19	0.02	3.66	0.002	0.413
swim.10.f.15000	fish swims	frequency	10%	15	1.23	0.02	3.65	0.002	0.412
fly.10.f.25000	insect flys	frequency	10%	25	-0.42	0.00	3.62	0.002	0.409
fly.10.l.25000	insect flys	length	10%	25	-0.39	0.00	3.61	0.002	0.407
fly.7.f.25000	insect flys	frequency	7%	25	-0.21	0.00	3.59	0.002	0.404
swim.5.f.1000	fish swims	frequency	5%	1	1.62	0.49	3.59	0.002	0.404
fly.5.f.25000	insect flys	frequency	5%	25	-0.04	0.00	3.58	0.002	0.403
fly.7.l.25000	insect flys	length	7%	25	-0.15	0.00	3.58	0.002	0.403
swim.3.f.2000	fish swims	frequency	3%	2	1.66	0.32	3.57	0.002	0.401
fly.5.l.25000	insect flys	length	5%	25	0.00	0.00	3.51	0.002	0.393
fly.25.l.3000	insect flys	length	25%	3	-1.93	0.00	3.50	0.002	0.392
fly.20.l.2000	insect flys	length	20%	2	0.95	0.00	3.48	0.003	0.389
swim.7.l.15000	fish swims	length	7%	15	1.38	0.02	3.46	0.003	0.387
fly.15.f.25000	insect flys	frequency	15%	25	-0.76	0.00	3.44	0.003	0.384
fly.3.f.25000	insect flys	frequency	3%	25	0.23	0.00	3.44	0.003	0.384
fly.15.l.25000	insect flys	length	15%	25	-0.77	0.00	3.42	0.003	0.381
fly.20.f.2000	insect flys	frequency	20%	2	1.05	0.08	3.38	0.003	0.376
fly.1.f.10000	insect flys	frequency	1%	10	1.64	0.03	3.37	0.003	0.374
fly.3.l.25000	insect flys	length	3%	25	0.26	0.00	3.34	0.003	0.370
swim.15.l.1000	fish swims	length	15%	1	1.31	0.31	3.28	0.004	0.362
swim.7.f.15000	fish swims	frequency	7%	15	1.42	0.02	3.28	0.004	0.362
fly.20.l.25000	insect flys	length	20%	25	-1.20	0.00	3.27	0.004	0.361
fly.20.f.25000	insect flys	frequency	20%	25	-1.12	0.00	3.26	0.004	0.358
fly.3.l.5000	insect flys	length	3%	5	1.64	0.00	3.22	0.004	0.354
swim.20.f.3000	fish swims	frequency	20%	3	1.13	0.10	3.22	0.005	0.353
swim.5.f.10000	fish swims	frequency	5%	10	1.59	0.04	3.21	0.005	0.352
swim.3.l.4000	fish swims	length	3%	4	1.66	0.12	3.20	0.005	0.350
swim.20.l.3000	fish swims	length	20%	3	1.15	0.09	3.19	0.005	0.349
swim.15.f.15000	fish swims	frequency	15%	15	1.04	0.02	3.19	0.005	0.348
swim.3.l.5000	fish swims	length	3%	5	1.65	0.10	3.15	0.005	0.343
fly.1.f.25000	insect flys	frequency	1%	25	0.75	0.01	3.15	0.005	0.343
swim.20.l.4000	fish swims	length	20%	4	1.03	0.07	3.14	0.005	0.342
fly.25.f.4000	insect flys	frequency	25%	4	-1.08	0.07	3.14	0.005	0.342
fly.1.l.10000	insect flys	length	1%	10	1.66	0.00	3.14	0.005	0.341
fly.25.f.20000	insect flys	frequency	25%	20	-3.59	0.01	3.13	0.005	0.341
swim.20.l.7500	fish swims	length	20%	7.5	0.87	0.04	3.10	0.006	0.335
fly.1.l.25000	insect flys	length	1%	25	0.81	0.00	3.07	0.006	0.332
fly.3.l.1000	insect flys	frequency	3%	1	1.72	0.00	3.07	0.006	0.332
swim.3.f.3000	fish swims	frequency	3%	3	1.67	0.22	3.05	0.007	0.329
fly.1.f.7500	insect flys	frequency	1%	7.5	1.69	0.04	3.03	0.007	0.325
swim.20.l.10000	fish swims	length	20%	10	0.84	0.03	2.99	0.008	0.320
fly.3.l.4000	insect flys	length	3%	4	1.67	0.00	2.95	0.008	0.314

fly.3.f.5000	insect flys	frequency	3%	5	1.66	0.03	2.93	0.009	0.312
fly.3.l.2000	insect flys	length	3%	2	1.68	0.00	2.93	0.009	0.312
fly.3.f.1000	insect flys	length	3%	1	1.73	0.34	2.87	0.010	0.303
swim.10.f.20000	fish swims	frequency	10%	20	1.34	0.02	2.76	0.012	0.286
swim.3.l.7500	fish swims	length	3%	7.5	1.68	0.06	2.70	0.014	0.277
swim.10.l.20000	fish swims	length	10%	20	1.32	0.02	2.69	0.014	0.276
fly.1.l.7500	insect flys	length	1%	7.5	1.71	0.00	2.67	0.015	0.272
fly.3.l.3000	insect flys	length	3%	3	1.71	0.00	2.65	0.016	0.269
fly.25.l.20000	insect flys	length	25%	20	-4.26	0.00	2.64	0.016	0.269
swim.7.l.20000	fish swims	length	7%	20	1.46	0.02	2.64	0.016	0.268
swim.15.f.1000	fish swims	frequency	15%	1	1.38	0.32	2.63	0.017	0.267
swim.7.f.20000	fish swims	frequency	7%	20	1.49	0.02	2.61	0.017	0.263
fly.3.f.4000	insect flys	frequency	3%	4	1.70	0.04	2.57	0.019	0.258
fly.25.f.25000	insect flys	frequency	25%	25	-2.36	0.00	2.55	0.019	0.255
swim.5.l.15000	fish swims	length	5%	15	1.61	0.02	2.53	0.021	0.251
swim.15.l.15000	fish swims	length	15%	15	1.05	0.02	2.52	0.021	0.250
swim.3.f.4000	fish swims	frequency	3%	4	1.70	0.14	2.51	0.021	0.249
swim.3.l.10000	fish swims	length	3%	10	1.69	0.03	2.46	0.023	0.242
fly.25.l.15000	insect flys	length	25%	15	-5.06	0.00	2.45	0.024	0.240
fly.25.l.10000	insect flys	length	25%	10	-4.49	0.00	2.39	0.027	0.232
swim.20.f.15000	fish swims	frequency	20%	15	0.98	0.02	2.38	0.028	0.229
swim.15.f.20000	fish swims	frequency	15%	20	1.16	0.02	2.38	0.028	0.229
fly.3.f.3000	insect flys	frequency	3%	3	1.71	0.06	2.34	0.030	0.224
fly.3.f.2000	insect flys	frequency	3%	2	1.71	0.13	2.31	0.032	0.220
swim.20.l.1000	fish swims	length	20%	1	1.29	0.27	2.31	0.033	0.219
swim.3.f.5000	fish swims	frequency	3%	5	1.70	0.11	2.30	0.033	0.217
swim.5.f.15000	fish swims	frequency	5%	15	1.64	0.02	2.28	0.034	0.215
fly.1.l.5000	insect flys	length	1%	5	1.76	0.00	2.25	0.036	0.210
swim.25.l.2000	fish swims	length	25%	2	0.83	0.12	2.20	0.041	0.202
fly.1.f.5000	insect flys	frequency	1%	5	1.76	0.06	2.19	0.041	0.202
swim.10.f.25000	fish swims	frequency	10%	25	1.48	0.01	2.13	0.046	0.193
swim.3.f.7500	fish swims	frequency	3%	7.5	1.73	0.05	2.10	0.050	0.188
swim.7.f.25000	fish swims	frequency	7%	25	1.58	0.01	2.10	0.050	0.188
swim.7.l.25000	fish swims	length	7%	25	1.57	0.01	2.10	0.050	0.188
swim.10.l.25000	fish swims	length	10%	25	1.49	0.01	2.06	0.053	0.183
fly.1.l.4000	insect flys	length	1%	4	1.77	0.00	2.06	0.053	0.183
swim.5.l.20000	fish swims	length	5%	20	1.64	0.01	2.05	0.055	0.181
swim.3.f.10000	fish swims	frequency	3%	10	1.74	0.03	2.03	0.057	0.178
fly.1.f.4000	insect flys	frequency	1%	4	1.78	0.10	2.02	0.058	0.176
fly.25.l.7500	insect flys	length	25%	7.5	-3.61	0.00	2.00	0.060	0.174
fly.20.l.1000	insect flys	length	20%	1	1.41	0.00	2.00	0.060	0.174
swim.3.l.15000	fish swims	length	3%	15	1.72	0.02	1.99	0.062	0.172
fly.1.f.1000	insect flys	frequency	1%	1	1.78	1.55	1.93	0.068	0.165

fly.1.f.2000	insect flys	frequency	1%	2	1.78	0.39	1.93	0.068	0.165
fly.1.f.3000	insect flys	frequency	1%	3	1.78	0.22	1.93	0.068	0.165
fly.1.l.1000	insect flys	length	1%	1	1.78	0.00	1.93	0.068	0.165
fly.1.l.2000	insect flys	length	1%	2	1.78	0.00	1.93	0.068	0.165
fly.1.l.3000	insect flys	length	1%	3	1.78	0.00	1.93	0.068	0.165
swim.1.f.10000	fish swims	frequency	1%	10	1.78	0.06	1.93	0.068	0.165
swim.1.f.2000	fish swims	frequency	1%	2	1.78	1.55	1.93	0.068	0.165
swim.1.f.3000	fish swims	frequency	1%	3	1.78	0.78	1.93	0.068	0.165
swim.1.f.4000	fish swims	frequency	1%	4	1.78	0.78	1.93	0.068	0.165
swim.1.f.5000	fish swims	frequency	1%	5	1.78	0.39	1.93	0.068	0.165
swim.1.f.7500	fish swims	frequency	1%	7.5	1.78	0.11	1.93	0.068	0.165
swim.1.l.10000	fish swims	length	1%	10	1.78	0.09	1.93	0.068	0.165
swim.1.l.2000	fish swims	length	1%	2	1.78	0.63	1.93	0.068	0.165
swim.1.l.3000	fish swims	length	1%	3	1.78	0.53	1.93	0.068	0.165
swim.1.l.4000	fish swims	length	1%	4	1.78	0.53	1.93	0.068	0.165
swim.1.l.5000	fish swims	length	1%	5	1.78	0.29	1.93	0.068	0.165
swim.1.l.7500	fish swims	length	1%	7.5	1.78	0.15	1.93	0.068	0.165
swim.5.f.20000	fish swims	frequency	5%	20	1.66	0.01	1.93	0.069	0.164
swim.1.f.25000	fish swims	frequency	1%	25	1.78	0.02	1.90	0.072	0.160
swim.1.l.25000	fish swims	length	1%	25	1.78	0.02	1.89	0.074	0.159
swim.1.f.20000	fish swims	frequency	1%	20	1.78	0.03	1.89	0.075	0.158
swim.1.f.15000	fish swims	frequency	1%	15	1.78	0.04	1.87	0.078	0.155
swim.15.f.25000	fish swims	frequency	15%	25	1.36	0.01	1.86	0.078	0.154
swim.1.l.20000	fish swims	length	1%	20	1.78	0.04	1.85	0.079	0.153
swim.15.l.20000	fish swims	length	15%	20	1.18	0.01	1.85	0.080	0.152
swim.1.l.15000	fish swims	length	1%	15	1.78	0.05	1.81	0.086	0.147
swim.25.f.1000	fish swims	frequency	25%	1	2.59	-0.22	-1.81	0.086	0.147
swim.3.l.20000	fish swims	length	3%	20	1.73	0.01	1.79	0.089	0.145
swim.3.f.15000	fish swims	frequency	3%	15	1.75	0.02	1.79	0.090	0.144
swim.5.l.25000	fish swims	length	5%	25	1.68	0.01	1.74	0.098	0.137
swim.25.f.5000	fish swims	frequency	25%	5	0.86	0.05	1.73	0.100	0.136
swim.25.f.4000	fish swims	frequency	25%	4	0.90	0.06	1.71	0.103	0.134
swim.3.l.25000	fish swims	length	3%	25	1.74	0.01	1.70	0.105	0.132
swim.3.f.20000	fish swims	frequency	3%	20	1.75	0.01	1.69	0.108	0.130
fly.20.f.1000	insect flys	frequency	20%	1	1.40	0.13	1.68	0.109	0.129
swim.3.f.25000	fish swims	frequency	3%	25	1.76	0.01	1.68	0.110	0.129
swim.5.f.25000	fish swims	frequency	5%	25	1.70	0.01	1.67	0.111	0.128
swim.15.l.25000	fish swims	length	15%	25	1.37	0.01	1.59	0.129	0.117
swim.25.f.10000	fish swims	frequency	25%	10	0.87	0.02	1.59	0.129	0.117
fly.25.f.2000	insect flys	frequency	25%	2	0.80	0.07	1.57	0.132	0.115
swim.25.f.7500	fish swims	frequency	25%	7.5	0.85	0.03	1.49	0.154	0.104
fly.25.l.5000	insect flys	length	25%	5	-0.90	0.00	1.48	0.155	0.104
swim.20.l.15000	fish swims	length	20%	15	1.19	0.01	1.48	0.155	0.104

swim.20.f.20000	fish swims	frequency	20%	20	1.27	0.01	1.46	0.160	0.101
swim.25.f.2000	fish swims	frequency	25%	2	1.16	0.10	1.32	0.201	0.084
swim.25.f.3000	fish swims	frequency	25%	3	1.24	0.06	1.28	0.216	0.079
swim.25.l.20000	fish swims	length	25%	20	2.64	-0.01	-1.27	0.218	0.079
swim.25.l.3000	fish swims	length	25%	3	1.27	0.05	1.27	0.220	0.078
swim.25.l.5000	fish swims	length	25%	5	1.13	0.03	1.25	0.228	0.076
swim.25.l.4000	fish swims	length	25%	4	1.24	0.04	1.18	0.254	0.068
swim.20.f.25000	fish swims	frequency	20%	25	1.46	0.01	1.13	0.274	0.063
swim.20.f.1000	fish swims	frequency	20%	1	1.53	0.17	1.12	0.279	0.061
swim.25.l.25000	fish swims	length	25%	25	2.43	-0.01	-1.00	0.328	0.050
swim.25.l.15000	fish swims	length	25%	15	2.50	-0.01	-0.97	0.344	0.047
swim.20.l.20000	fish swims	length	20%	20	1.55	0.00	0.65	0.524	0.022
fly.25.l.4000	insect flys	length	25%	4	0.83	0.00	0.61	0.551	0.019
fly.25.f.1000	insect flys	frequency	25%	1	2.13	-0.05	-0.60	0.555	0.019
swim.20.l.25000	fish swims	length	20%	25	1.63	0.00	0.58	0.567	0.018
swim.25.l.1000	fish swims	length	25%	1	2.08	-0.06	-0.54	0.595	0.015
swim.25.f.15000	fish swims	frequency	25%	15	1.52	0.01	0.52	0.607	0.014
swim.25.l.7500	fish swims	length	25%	7.5	1.58	0.01	0.35	0.730	0.006
fly.25.l.2000	insect flys	length	25%	2	1.63	0.00	0.27	0.787	0.004
swim.25.l.10000	fish swims	length	25%	10	1.72	0.00	0.19	0.854	0.002
fly.25.l.1000	insect flys	length	25%	1	1.80	0.00	0.12	0.903	0.001
swim.25.f.25000	fish swims	frequency	25%	25	1.89	0.00	-0.07	0.943	0.000
swim.25.f.20000	fish swims	frequency	25%	20	1.86	0.00	0.00	1.000	0.000
swim.1.f.1000	fish swims	frequency	1%	1	1.86	0.18	NA	NA	0.000
swim.1.l.1000	fish swims	length	1%	1	1.86	0.18	NA	NA	0.000