INTERIM REPORT

Relationship of Benthic Macroinvertebrate Biodiversity to Recent and Past Ditching Practices in Hardwood Creek Near Hugo, Minnesota

by

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21 March 2005

Introduction

In this document the biodiversity of benthic macroinvertebrates is detailed in relation to recent and past ditching practices in Hardwood Creek. Data for this study were generated using a standard, rapid bioassessment field methodology. The method uses dip-nets (DN) employed in a consistent manner and is described in this document. Detailed explanations are also provided of metrics that are calculated from the DN samples. This report summarizes interim results for samples collected in June, 2004. Additional samples were collected in October, 2004. However, samples from the later month have not yet been fully analyzed. Consequently, the results provided in this interim report, although based on extensive data sets, should be considered as preliminary in scope. Raw data by sample site and sample date are included in appendix form.

Locations of Sample Sites

Table 1 provides the locations of eight sites that have been sampled with DN during this project. Four of the sites are located in downstream sections of Hardwood Creek that have not been ditched (H-2 & H-1.2) or were ditched very long ago (H-1.1 & H-1). Two of the sites in the upper part of the watershed are located on stretches of Hardwood Creek that were ditched during winter 2003-2004 (H-1.5U & H-1.4). Two additional sites, H-1.5D and H-1.3, are located on stretches that have been ditched more recently than H-1 and H1.1, but significantly longer ago than H-1.5U and H-1.4.

Table 1: Locations of sample sites on Hardwood Creek.

Sample Site	Latitude	Longitude	Elevation
Site H-2 (Never ditched)	**N 45° 12.0’**	**W 93° 2.4’**	**907 ft**
Site H-1.2 (Never ditched)	**N 45° 11.8’**	**W 93° 1.5’**	**918 ft**
Site H-1.1 (Ditched long ago)	**N 45° 11.8’**	**W 92° 59.9’**	**927 ft**
Site H-1 (Ditched long ago)	**N 45° 12.5’**	**W 92° 58.7’**	**931 ft**
Site 1.3 (More recently ditched)	**N 45° 12.2’**	**W 92° 57.4’**	**933 ft**
Site 1.4 (Ditched in 2004)	**N 45° 12.3’**	**W 92° 56.7’**	**934 ft**
Site 1.5D (More recently ditched)	**N 45° 11.0’**	**W 92° 57.3’**	**936 ft**
Site 1.5U (Ditched in 2004)	**N 45° 12.5’**	**W 92° 57.4’**	**938 ft**

Methods

Methodology for Collecting Dip-Net (DN) Samples

Dip-net sampling is a common method for collecting aquatic macroinvertebrates for water quality assessments (Barbour *et al*. 1999). Several different variations of field protocols exist, but a commonly accepted approach is to sample sites according to a standardized procedure consisting of a pre-determined number of dips or "jabs" into each microhabitat present in a reach of stream. The dips are composited into a single sample that is then evaluated. In this approach it is assumed that species from each microhabitat will be proportionally represented in the composited sample. Typical microhabitats that are sampled include riffles, pools, bedrock, undercut banks, wood substrates or snags. A given sample site may be lacking one or more of the microhabitats and, unfortunately, with this approach it is not possible to determine the affect that the lack of the microhabitat(s) has on the metrics that are calculated from the composited sample.

In this project we used a modified dip-net sampling protocol. Our field protocol stipulated that individual microhabitats be sampled, with each dip of the net into a given microhabitat resulting in a single sample. In this approach, it is necessary to perform a visual reconnaissance of each site before samples are collected in order to determine the microhabitats that are present. Each microhabitat is considered as a stratification unit for the site and is sampled three times. Any given site can therefore have from one to many stratification units.

Our approach is extremely well suited for Hardwood Creek. Ditching sections of stream dramatically alters the stream channel and stream bed sediment characteristics. In the lower portions of Hardwood Creek there is considerably greater microhabitat heterogeneity than in the upper portions of the creek. Consequently, we defined stratification units as (1) stream bottom, (2) stream bank, (3) riffle, and (4) wood substrates. The stream bottom stratification unit (SBSU) was located in the deeper portions of a reach, and at downstream sites consisted of deeper areas of pools. In the upper portion of the stream the SBSU sampled was the midpoint between banks of the ditched channel. *Although sites in the downstream potion of Hardwood Creek contain all four stratification units, virtually no riffle microhabitat occurs in ditched areas of the upper portion of Hardwood Creek, and very little wood substrates are present. Consequently, only stream bottom and stream bank microhabitats are present at all eight sample sites. The data for this interim report are derived from the three dip-net samples collected from the SBSU of each the eight sample sites, and data across sites are directly comparable.*

Metrics Calculated from DN Samples

The following seven metrics were calculated for each of the sample sites investigated in this project: (1) cumulative species richness (sum of all three DN samples) by sample site; (2) Brillouin's Diversity Index (based on cumulative totals of all samples per site); (3) biotic index values primarily based on species tolerances used for the Midwest (Ohio) or Upper Midwest (WI); (4) percent EPT, (5) percent leeches and mollusks, (6) percent Chironomidae, and (7) percent dominance. The taxonomic similarity for all pairs of sample sites was calculated using Jaccard's Coefficent of Community Similarity. Each of these metrics is explained in subsequent paragraphs of this section of the interim report.

Cumulative Species Richness- Cumulative species richness represents the total number of species present in all three DN samples for a given sample site. *This metric is sensitive to the seasonal changes in macroinvertebrate life cycles and could change when samples for October are included in the final data set.*

Species Diversity- Species diversity indices were calculated from the cumulative data available for each sample site. The indices were calculated using ECOMEAS© software developed by the Water Quality & Freshwater Ecology Program at the Kansas Biological Survey of the University of Kansas. This software calculates ten of the more commonly used diversity indices and, when appropriate, their associated Evenness and Equitability values. Copies of the print outs for each composited sample will be available on request.

Brillouin's Index of Diversity will be used in this interim report to document patterns of diversity among sites. This index is considered most appropriate to quantify the diversity content of samples when not all taxa in the sample area can be expected to be represented in random samples taken from the site (Magurran 1998). Results of the other commonly reported indices such as the Shannon Index or Margelef's Index are not discussed but can be provided for persons that are more familiar with, or prefer to use, these two other indices.

For purposes of interpretation, empirical results from numerous studies using DN collections (mostly in Kansas, and dealing primarily with organic loading in urban streams) have shown that index values of 2.000 nats or greater are typical for streams with excellent to very good water quality. Values of less than 1.000 nats generally occur only when very significant alterations of macroinvertebrate communities have occurred as a consequence of pollutant-related stresses. Values between 1.500 nats and 2.000 nats are cautiously interpreted as a sign of either response to pollutant stress or reduced habitat heterogeneity. Values between 1.000 nats and 1.500 nats are confidently interpreted as a response to pollutant stress, since reduced habitat heterogeneity alone generally does not result in index values this low. *We are not aware of any comprehensive empirical data sets from a wide array of streams near our sample sites that report species diversity values for multiple DN samples at several sites. Consequently the cut-off values used for streams in Kansas are used as reference levels for interpreting the diversity values provided in this report.*

Biotic Index- Individual species-level or genus-level tolerances are required to calculate biotic index values for collections of macroinvertebrates. Barbour *et al.* (1999) discuss the concepts and underlying assumptions related to calculating biotic indices, and provide lists of taxa and their associated tolerance values for organic enrichment that have been developed for several regions of the United States. Two regions, the Midwest Region and Upper Midwest Region, are close to our project area and values for taxa in these two regions can logically serve as estimates of tolerance that should be appropriate for our biota. The values for the Midwest were developed in Ohio and those for the Upper Midwest primarily derive from research by William Hilsenhoff working on streams and rivers in Wisconsin. On the basis of geographic proximity the values for the Upper Midwest would seem to be the most appropriate, however several of the taxa that occur in Hardwood Creek are considered as more tolerant of organic enrichment in the scheme developed by Hilsenhoff compared to the tolerance values provided for Ohio. *Because of this disparity in the two schemes, the biotic index values are calculated using the tabled species' tolerance values for the Midwest or for the Upper Midwest that seem most appropriate based on best professional judgment and two Biotic Index values are provided for each sample site.*

Hilsenhoff (1987) provided a table for interpreting biotic index values. According to his scheme, index values between 0.00 and 3.50 are considered to represent excellent water quality. Index values between 3.51 and 4.50 are considered to represent very good water quality, with possible slight organic enrichment. Index values between 4.51 and 5.50 are considered to represent good water quality, with some organic enrichment. Index values between 5.51 and 6.50 are considered to represent fair water quality, with fairly significant organic enrichment. Index values between 6.51 and 7.50 are considered to represent fairly poor water quality, with significant organic enrichment. Index values between 7.51 and 8.50 are considered to represent poor water quality, with very significant organic enrichment. Index values between 8.51 and 10.00 are considered to represent very poor water quality, with severe organic enrichment.

Percent EPT

The percentage of Ephemeroptera, Plecoptera and Trichoptera (EPT) in dip-net samples is a common metric computed from collections of aquatic macroinvertebrates taken during water quality assessments (Barbour *et al.* 1999). We calculated EPT as (1) the cumulative percent of taxa at each site and (2) the cumulative percent of specimens at each site. *Moderate to high values for the EPT metric are interpreted as representing better water quality/habitat quality and lower values as poorer quality.*

Percent Leeches and Mollusks

This metric is not commonly calculated for dip-net samples and is not often used in water quality determinations. *We have calculated this metric, however, because it captures a very strong signal within our data set, and variation in this metric appears to be closely correlated with ditching practices.*

Percent Chironomidae

The percentage of Chironomidae specimens in dip-net samples is a common metric computed from collections of aquatic macroinvertebrates taken during water quality assessments (Barbour *et al*. 1999). We calculated Percent Chironomidae as the cumulative percent of specimens at each site. *This metric generally is considered to be inversely related to water quality or habitat quality, with moderate to high values interpreted as representing poorer water quality/habitat quality and lower values as higher quality. There are, however, very common exceptions to this interpretation and it is better to interpret this metric at the subfamily or tribe level rather that at the family level. However, we have opted to include the metric based on family level determination in this report only because it is a more commonly reported metric and therefore provides better opportunity for comparisons to other projects.*

Percent Dominance

The percentage of the three most abundant species in dip-net samples is a common metric computed from collections of aquatic macroinvertebrates taken during water quality assessments (Barbour *et al*. 1999). We calculated Percent Dominance based on the cumulative specimens in all three dip-net samples at each individual site. *This metric generally is considered to be inversely related to water quality or habitat quality, with moderate to high values interpreted as representing poorer water quality/habitat quality and lower values as higher quality.*

Analysis of Faunal Similarities Among Sample Sites

A numerical analysis of the similarities of macroinvertebrate composition for all pairs of sample sites has been calculated using the Community Similarity option in the ECOMEAS© software developed by the Water Quality & Freshwater Ecology Program at the Kansas Biological Survey of the University of Kansas. The Community Similarity option in the software calculates 16 of the more commonly used coefficients of community similarity. Copies of the print outs for each pair of sample sites can be made available on request. Jaccard's Coefficient of Community Similarity will be used in this interim report to document patterns of similarity of macroinvertebrates of SBSU among pairs of sample sites. Jaccard's Coefficient is considered appropriate to quantify the similarity of two communities based on presence/absence data (Magurran 1998), and it is commonly reported in other studies (e. g., Blackwood *et al*. 1995). Results of other commonly reported coefficients such as the Sorensen's or Ochiai's Coefficient will not be discussed but the index values can be obtained by persons that are more familiar with, or prefer to use, these other coefficients.

Jaccard's Coefficient is calculated as the formula $a/(a + b + c)$ where a is the number of species in common among two sample sites, b is the number of species present only in the first of the two sample sites being compared and c is the number of species present only in the second of the two sample sites being compared. With 8 different sample sites the number of two-site comparisons is calculated as $N*(N-1)/2$ where N is the number of sample sites. Thus, in this study there are 28 unique comparisons of sample sites taken two at a time.

The values for Jaccard's Coefficient are used to evaluate similarities of site pairs, and to compare individual site pairs to predictions based upon the River Continuum Hypothesis (RCH). This hypothesis predicts that streams and rivers present a continuum of changing conditions that influence the community structure of aquatic macroinvertebrates, in a predictable manner. One prediction of the RCH is that the community structure of macroinvertebrates in SBSU at adjacent sites should be more similar to each other than sites that are situated more distantly along the stream being investigated, assuming no complicating factors such as human modification of channel structure and/or pollution-related effects.

To test the predictions of the RCH a null hypothesis is created that assumes the ranks of all pairs of sample sites are randomly assorted. Under the null hypothesis any pairs of sample sites can be highly similar, moderately similar or very dissimilar. The RCH forms the basis of the alternative hypothesis and, in Hardwood Creek, can be tested by comparing the rank similarities of adjacent sample sites.

Under the alternative hypothesis, sites that are adjacent to each other should be most similar and have ranks of 1 through 7 if the macroinvertebrate communities in SBSU of the stream sites conform to predictions of the RCH. However, if ditching is strongly influencing the macroinvertebrate community structure, then the most similar sites should be those sites that are in the downstream sections of stream that have no history of ditching (H-2 through H-1) and the sites in the upper portion of the stream that have been ditched (H-3 through H-1.5U). Comparisons of sites among these two groups should not have high coefficients of similarity.

Methods to test the similarities of sites are based on non-metric, sum of ranks tests. To test the RCH assumption of adjacent sites being most similar, it is necessary to determine the rank similarity of the adjacent sites. If adjacent site pairs are most similar their ranks should be 1, 2, 3, 4, 5, 6, and 7. The sums of ranks should equal 28. In theory, if the ranks of similarities of adjacent site pairs deviate strongly from predictions their sum of ranks will be much larger than 28. The maximum sum of ranks that can be obtained corresponds to a condition where adjacent sample site pairs are the least similar pairs in terms of macroinvertebrate community compositions, with ranks of 28, 27, 26, 25, 24, 23 and 22, summing to 175. To perform the test, the actual sum of ranks for similarities of adjacent sample site pairs is calculated and the probability of obtaining the rank sum is determined.

Results and Discussion

Highway 61 roughly bisects Hardwood Creek into equal lengths of stream that differ markedly in physical structure related to recent and past ditching activities. The downstream portions of Hardwood Creek (Site H-1 to Site H-2) appear to have never been ditched or were ditched long ago. At these sites the stream substrates consist predominantly of clean sands or sand/gravel areas in erosional zones. Channel meanders are present, especially from Site H-1.1 downstream to Site H-2, and pools have finer sediments overlying sands. By contrast, sites upstream of H-1 clearly show physical signs of more recent ditching. Soft, unconsolidated silts and mud substrate predominate, and the stream channel has minimal to no meandering, especially at sites H-1.3, H-1.4 and H-1.5U.

The average numbers of macroinvertebrates collected from the stream bottom stratification unit (SBSU) per site in June 2004 do not differ significantly for sites in the area upstream of H-1 relative to the sites from H-1 to H-2 (Table 3, next page). The two sites with highest numbers of macroinvertebrates in SBSU occur in different portions of the stream, as do the two sites with the lowest numbers of macroinvertebrates. *Consequently it does not appear that ditching has markedly reduced the abundance of macroinvertebrates in SBSU at sites that have been more recently modified by ditching relative to the sites in the lower portion of the stream.*

Table 3: Summary of metrics for DN collections.

Sample Site	**Numbers of Specimens Collected**	**Cumulative Species Richness**	**Brillouin's Diversity Index (nats)**	**Biotic Index Based on Tolerances to Organic Enrichment OH (WI)**
Site H-2 (Never ditched)	**206**	**14**	**1.325**	**6.071 (6.203)**
Site H-1.2 (Never ditched)	**152**	**11**	**1.363**	**5.912 (6.155)**
Site H-1.1 (Ditched long ago)	**155**	**14**	**1.660**	**5.767 (5.950)**
Site H-1 (Ditched long ago)	**699**	**18**	**1.422**	**6.279 (6.383)**
Site H-1.3 (More recently ditched)	**84**	**15**	**1.700**	**6.440 (6.487)**
Site H-1.4 (Ditched in 2004)	**308**	**17**	**1.183**	**6.843 (6.855)**
Site H-1.5D (More recently ditched)	**1578**	**28**	**1.234**	**7.627 (7.629)**
Site H-1.5U (Ditched in 2004)	**177**	**15**	**1.328**	**6.553 (6.553)**

The species richnesses of SBSU at sites in the lower portion of Hardwood Creek, with one exception, are lower than the species richnesses detected at sites in the upper portion where the modifications from ditching are more obvious. Site H-1.5D has the highest species richness with 28 taxa detected from SBSU, which is considerably higher than the next highest detected richness of 18 taxa at Site H-1 in the lower portion of the stream. *The higher richness values at sites in the upstream portion of Hardwood Creek largely result from the greater numbers of leeches and mollusks at these sites. For instance, only two species of leeches, Glossiphonia complanata and Helobdella stagnalis, were encountered in low adundances at sites in the downstream portion of Hardwood Creek. By contrast, six species of leeches occurred at sites in the upstream portion of Hardwood Creek, and Helobdella stagnalis was approximately 8 times as abundant at these sites than at sites in the downstream portion of the creek.*

The Brillouin's Diversity Index values for SBSU at sites in Hardwood Creek are low. No consistent patterns are evident with regard to sites in upstream versus downstream portions of the stream, and the sites with the two highest values of this metric are in the upstream (Site H-1.3) and downstream (Site H-1.1) portions, respectively. *It is likely that the consistently low values of this metric are related to our sampling approach that uses stratification units and single dips rather than multiple dips from an array of microhabitats that are combined into one large sample. As samples from other stratification units are processed for this project the resulting data can then be sequentially amalgamated into successively larger "composited samples" and the influence that stratification units and multiple dips have on this metric can be determined.*

The two sets of Biotic Index (BI) values show similar trends but slightly different magnitudes for the SBSU. BI values calculated with species tolerances developed for the Mid West (OH) range from 5.767 to 7.627 and are generally lower than the BI values obtained when tolerance values developed for the Upper Mid West (WI) are used (range = 5.950 to 7.629). The averages of both sets of BI values are lower for sites in the lower portion of the stream (OH= 6.007; WI= 6.170) than for sites in the upper portion of the stream (OH= 6.866; WI= 6.881). *The average BI for SBSU at sites in the lower portion of Hardwood Creek falls within the range listed by Hilsenhoff*

(1987) as indicating fair water quality. By contrast, the average BI for SBSU of sites in the upper portion of the stream falls in the range indicating fairly poor water quality.

The percentages of EPT, Leeches & Mollusks, Chironomidae and Dominance are provided in Table 4. EPT in SBSU are low at all sites in Hardwood Creek, however clear patterns in terms of both species and specimens are apparent when sites in the lower portion of Hardwood Creek are compared to sites in the upper portion of the stream. *The average percent taxonomic composition of EPT in SBSU at sites in the lower portion of the creek is 22% compared with 4.9% for sites in the upper portion. Similarly, percent composition based on specimens in SBSU at sites in the lower portion of the stream averages 5.9% compared to 0.7% for sites in the upper portion of Hardwood Creek.*

Table 4: Summary of metrics derived from taxonomic composition for DN samples.

Sample Site	**Percent EPT Species and (Specimens)**		**Number Leeches & Mollusks and (% Specimens)**		**Percent Chironomidae Specimens**	**Percent Dominance of Three Most Abundant Taxa**
Site H-2	**23.2%**	**(4.0%)**	**5**	**(6.7%)**	**56.5%**	**84.5%**
Site H-1.2	**14.3%**	**(8.9%)**	**2**	**(4.0%)**	**67.9%**	**84.9%**
Site H-1.1	**32.1%**	**(8.7%)**	**2**	**(9.2%)**	**46.6%**	**72.9%**
Site H-1	**18.6%**	**(2.2%)**	**4**	**(17.4%)**	**52.4%**	**86.8%**
Site H-1.3	**4.8%**	**(1.7%)**	**6**	**(18.2%)**	**40.1%**	**71.4%**
Site H-1.4	**6.4%**	**(0.7%)**	**7**	**(67.1%)**	**4.6%**	**89.6%**
Site H-1.5D	**8.3%**	**(0.3%)**	**15**	**(25.1%)**	**3.7%**	**84.0%**
Site H-1.5U	**0%**	**(0.0%)**	**6**	**(60.9%)**	**25.1%**	**87.0%**

The number of species of leeches and mollusks at sites in the lower portion of Hardwood Creek in SBSU is consistently lower than at sites in the upper portion of the stream. Similarly, the percentage of specimens of leeches and mollusks is elevated at sites in the upper portion of the creek. *The increases in percentages of specimens are particularly evident at the two sites most recently ditched, Site H-1.4 and Site H-1.5U, where leeches and mollusks comprise 67.1% and 60.9%, respectively, of all macroinvertebrates in SBSU.*

The percent of Chironomidae shows substantial differences at sites in the lower portion of the stream compared with sites in the upper portion. The patterns are similar to those observed for EPT, with Chironomidae averaging 52.8% of all specimens in SBSU for sites in the downstream portion of Hardwood Creek, but only 18.4% at sites in the upstream portion. *Normally decreases in percent Chironomidae are interpreted as indicating improvement in water or habitat quality. However, in Hardwood Creek the declines in percent composition of Chironomidae are paralleled by declines in percent EPT and increases in percent of macroinvertebrates that are leeches and mollusks. In this study the decline in percent Chironomidae must be interpreted as representing declining water and/or habitat quality.*

Percent Dominance of the three most abundant species per sample site does not show a consistent pattern among sample sites in Hardwood Creek. All sample sites have high dominance among macroinvertebrates in SBSU, ranging from a low value of 72.9% at Site H-1.1 to the highest value of 89.6% at Site H-1.4. The average percent dominance of macroinvertebrates in SBSU at sites in the lower portion of the stream is 82.3%, whereas the average for sites in the upper portion of the creek is only 0.7% at 83%. *Although no consistent pattern is apparent for the different portions of Hardwood Creek, it should be noted that the two highest values of percent dominance were calculated for SBSU at Site H-1.4 and Site H-1.5U, both of which are located in stretches of the stream that have been ditched most recently.*

In summary, the alterations of physical habitat associated with ditching are clearly indicated by declines in EPT, increases in leeches and mollusks and changes in percent Chironomidae. By contrast, species richness, Brillouin's Index of Diversity, biotic indices, and percent dominance are not as useful in determining responses of macroinvertebrates in SBSU at sites with differing histories of ditching in Hardwood Creek.

Results of the numerical analysis of the similarities of macroinvertebrate composition across all eight sample sites based on Jaccard's Coefficient are presented in Table 6. Values below the diagonal represent the raw coefficient scores. Numbers above the diagonal indicate the rank similarities among pairs of sample sites.

Table 6: Similarity of taxonomic composition among pairs of sample sites based on Jaccard's Coefficient of Similarity

Sample Sites	**Site H-2**	**Site H-1.2**	**Site H-1.1**	**Site H-1**	**Site H-1.3**	**Site H-1.4**	**Site H-1.5D**	**Site H-1.5U**
Site H-2	-----	3	2	4	11.5	17.5	23.5	28
Site H-1.2	0.320	-----	8	19	21	25	26	24
Site H-1.1	0.321	0.240	-----	1	11.5	17.5	23.5	28
Site H-1	0.281	0.172	0.344	-----	7	13.5	15	18
Site H-1.3	0.207	0.154	0.207	0.242	-----	10	9	13.5
Site H-1.4	0.194	0.107	0.194	0.200	0.219	-----	6	20
Site H-1.5D	0.143	0.105	0.143	0.196	0.232	0.244	-----	5
Site H-1.5U	0.103	0.115	0.103	0.182	0.200	0.156	0.256	-----

* Denotes tied ranks

Based on the River Continuum Hypothesis that moving-water systems represent a continuum of changing conditions from headwaters to downstream areas, it is logical to expect that adjacent sample sites would exhibit the greatest degrees of similarities in terms of invertebrate community composition if ditching activities were not substantially altering community structure of macroinvertebrates. Therefore, it can be predicted that sample sites closest to the diagonal should have the highest values of Jaccard's Coefficient unless other extraneous stresses associated with ditching are operating to shift community structure. The seven most similar pairs of sample sites should be sites: H-2 & H-1.2; H-1.2 & H-1.1; H-1.1 & H-1; H-1 & H-1.3; H-1.3 & H-1.4; H-1.4 & H-1.5D; and H-1.5 D & H-1.5U. Although it is not possible to predict which of these seven pairs of sites should be most similar, the sum of their rank similarities should be 28 (i.e., 1 + 2 + 3 + 4 + 5 + 6 + 7).

From Table 6 it can be seen that the most similar pair of sites is located on the diagonal, sites H-1 & H-1.1 (0.344). Four additional site pairs on the diagonal conform to expectations, with sites H-2 & H-1.2 ranking as the third most similar site pair (0.320), H-1.5D & H-1.5U ranking as the fifth most similar site pair (0.256), H-1.4 & H-1.5D ranking as the sixth most similar site pair (0.244), and H-1 & H-1.3 as the seventh most similar site pair (0.242). However, the two remaining pairs of sites along the diagonal do not conform to expectations, with ranks of 8 and 13. The sum of ranks for pairs of sites adjacent to the diagonal is 40. Although nearly significant, the ranks do not depart from a random assortment of similarities. *Consequently it can be concluded that the similarities among adjacent pairs of sample sites do not conform to predictions of the River Continuum Concept, and factors other than proximity of sample sites are influencing the similarities observed among pairs of sites.*

Based upon results shown in Table 6 it must be concluded that community structure of Chironomidae in Hardwood Creek does not conform to predictions of the River Continuum Hypothesis and the departure may be due to management practices. Thus, an alternative question that can be asked is if the similarities of sample sites in Hardwood Creek support a hypothesis of ditching as strongly influencing community structure. In order to examine this question the average similarities of all site pairs in the lower portion of the creek and the upper portion of the creek have been calculated. The average of similarities of site pairs in the lower portion of the creek is 0.280 and the average of similarities of site pairs in the upper portion of the creek is 0.218. By contrast, the average of similarities of site pairs between sites that are in the upper and lower portions of the stream, and represent comparisons of sites that have dramatically differing histories of ditching, are much lower at 0.162. *Based on these results it is logical to propose that ditching has had a substantial role in structuring the community composition of macroinvertebrates at sites along Hardwood Creek. Implications of this conclusion are that differing expectations of community structure for ditched versus non-ditched stretches of the creek appropriate for the stream, and the differences will persist if the current management practices are continued.*

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