ASSESSING THE EFFECTS OF LAND USE ON WATER QUALITY AND BIOTIC INTEGRITY IN THE SAW KILL (RED HOOK, NY) USING TWO MACROINVERTEBRATE INDICES AND CHEMICAL DATA

A Final Report of the Tibor T. Polgar Fellowship Program

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ABSTRACT

Chemical studies have been the focus for determining water quality, but biological considerations are also becoming a more integral part of assessing aquatic ecosystems. Here, two biotic indices were calculated and compared with chemical data and correlated to land use that occurs in the Saw Kill watershed. The two macroinvertebrate indices used were the New York State Department of Environmental Conservation's Biological Assessment Profile and the Ohio Environmental Protection Agency's Invertebrate Community Index. Chemical data (nitrates, phosphates, sulfates, and chlorides) were collected by personnel of the Hudson River National Estuarine Research Reserve (HRNERR) from June, 1991 to December, 1994. In summer of 1997, macroinvertebrate collections were taken at or near the same stations monitored by HRNERR, with the addition of two mainstem stations. In September 1997, surface waters at these sites were analyzed for nitrate, phosphate, sulfate, chloride, and seston. Chemical water tests and the indices did not significantly correlate, but there was correlation between the two indices. The macroinvertebrate indices suggested residential land use degraded water quality and biotic integrity more than any other land use. Comparison of the costs of the two biological methods suggested the New York State method to be most efficient and effective. The use of both chemical and biological methods and the analysis and comparison of these methods, to each other and land use, is recommended to serve as a model for assessing water quality in streams and rivers.

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INTRODUCTION

The Clean Water Act has brought about goals for national " ... restoration and protection of freshwater ecosystems..." (Davis and Simon 1995). Bode (1989) stated that the purpose of the Water Pollution Control Act, Section 101(a) is "...to restore and maintain physical, chemical, and biological integrity of the Nation's waters." Often it is assumed that aquatic ecosystems and thus biotic integrity, are protected when chemical contaminants are regulated or prevented from entering the system (Karr 1995). Yet, chemical monitoring cannot always detect all of the anthropogenic sources of pollution (Karr 1981). It has been suggested that biological monitoring of fresh water is a more comprehensive mechanism for measuring the integrity of a stream or river (Keller 1995). Simpson and Bode (1980) maintain that biological integrity cannot be sufficiently evaluated without accurate identification of the aquatic inhabitants. Since it has been suggested that measuring the integrity of a stream or river (Karr 1981) is more useful than simply using chemical tests, biological measurements are recommended in conjunction with chemical and physical monitoring (Rosenberg and Resh 1993). Physical, or habitat structure, and chemical conditions as well as measuring biotic integrity will often "....identify likely causes of recognizable perturbations of aquatic biological communities..." (Saylor and Ahlstedt 1990). The US Geological Survey's National Water-Quality Assessment Program incorporates this multidisciplinary approach of collecting biological, physical, and chemical data to measure water quality in a river basin (Cuffney et al. 1993).

Matthew defines biological monitoring in Rosenberg and Resh (1993): "...as the systematic use of biological responses to evaluate changes in the environment with the intent to use this information in a quality control program. The changes often are due to anthropogenic sources...". Biological monitoring began in Europe, in the beginning of the twentieth century, with the idea of "...saprobity (the degree of pollution) in rivers as a degree of contamination by organic matter (primarily sewage) and the resulting decrease in dissolved oxygen..." (Cairns and Pratt 1993). The earlier methods of biological monitoring or the "European Saprobien system" is being replaced by more quantitative methods requiring more sampling and detailed statistical analysis (Resh and Jackson). Since many of these methods are very labor intensive, rapid assessment approaches are also being used to study "long-term regional changes in water quality " (Resh and Jackson 1993, pg. 195). Resh and Jackson (1993) compared the use of rapid assessment approaches by a freshwater ecologist with that of a doctor using a thermometer to quickly assess the condition of his/her patient.

Macroinvertebrate indices of water quality or of biotic integrity were developed following the methods of the Index of Biotic Integrity (IBI) for fish created by Karr in 1981 (DeShon 1995, Davis 1995). The rationale for using macroinvertebrate communities and not solely upon chemical tests, as an indication of what is happening to a stream, is supported by many in the scientific community. Macroinvertebrates are important to survey, since they tend to live in or near the sediments of a streambed and have life cycles that can be almost immediately affected by adverse conditions (Cuffney et al. 1993). Since many macroinvertebrates are sensitive to environmental degradation, they can be a more reliable indicator of pollution than an occasional chemical test (Cuffney et al. 1993).

The Hudson River National Estuarine Research Reserve (HRNERR) conducted research (Nieder 1998) to analyze the chemical effects of land use practices within the watershed of the Saw Kill. The Saw Kill sampling was from March 10 to 16, 1992, which included a storm event on March 11. Six additional storm events were monitored from April 16 to October 18, 1993. Five subwatershed sites included one site in each of the following land use categories: forested, row crop, orchard, and residential. The other four sites were in the mainstream and included mixed land uses. The chemical data

demonstrated significant amounts of nitrates, phosphates and chlorides loading into the Saw Kill. The relationship between the concentrations of nitrates and the storm events indicated that they were from point sources, since the concentration was lower after a storm event and then rebounded. This would indicate that septic systems from residential areas were a source of nitrate loading. Statistical analysis indicated that the residential land use had the ".... greatest effect on water quality, more so than agricultural activities within the Saw Kill watershed" (Nieder 1998).

Creating biotic indices was appropriate for assessing water quality and biotic integrity as chemical data collection has been extensive in the Saw Kill, and this allows for comparison of biological data to current chemical data. Using two biotic indices created two discrete data sets to compare with the chemical data and allowed for the two methods to be compared. One of the two methods of forming biotic indices, using macroinvertebrates, was the New York State Department of Environmental Conservation's (NYS DEC) Biological Assessment Profile (BAP) (Bode et al. 1997, Bode et al 1993a, Bode et al. 1993b). This method was chosen, because it has been developed and used through out New York State (Bode et al. 1997). The other method was the Ohio Environmental Protection Agency's (Ohio EPA) Invertebrate Community Index (ICI) (Ohio EPA 1989). This method is similar to NYS DEC's method, as similar species are found in both states and can be used without ecoregional modifications as the ecology, climate, and macroinvertebrate taxonomy are similar (per conversation with Dr. Robert Schmidt 1996).

Even though the BAP was created for New York State rivers and streams, the Ohio ICI also was sensitive to ecological interaction within the stream. The ICI is a "...measure of the overall macroinvertebrate community condition..." (Ohio EPA 1989). It evaluates biological integrity in the "...designation of aquatic life uses, or the determination of evaluation of aquatic life use attainment..." (Ohio EPA 1989). In contrast, the NYSDEC BAP method measures water quality. It is a method that integrates chemical and physical water quality tests (Cuffney et al. 1993). The BAP assesses water quality to determine the major factors that affect the water-quality conditions and trends. It determines the source of pollution and type of pollution (Bode et al. 1996).

The significance in creating indices from the data collected at each of the stations studied by Nieder (1998) was to study the biotic integrity and water quality of these same stations in which Nieder's data indicated that the residential land use was adding the most sulfates, nitrates, chlorides, and phosphates. The additional stations at Linden Acres and South Tivoli Bay detect were meant to detect the biotic integrity and water quality of the stream, after it flowed through the entire residential and urban area, and just prior to it flowing into Tivoli South Bay and the Hudson River.

METHODS

STUDY SITE

The Saw Kill is located in northwestern Dutchess County, New York, on the east side of the Hudson River about 62 km north of New York City (Fig. 1). Its watershed encompasses the townships of Milan and Red Hook. The mouth, which is tidally influenced, is in Tivoli South Bay near the Bard College Field Station and is part of the HRNERR. The watershed of the Saw Kill is 6886 hectares (Reichheld and Barton 1991, Pitt and Barten 1994).

Stations were set up at or near the same nine stations that Nieder (1995) established (Fig. 1). Two main stream stations were added, a tenth station on the west end of Linden Acres, near Kelly Road, and an eleventh station near the mouth of the river, in South Tivoli Bay, just above the tidal influence. At stations that were not located at Nieder's (1998) original sites, land uses and watershed areas were estimated from existing literature (Pitt and Barton 1994, Riechheld and Barten 1991, Wagner 1981).

Subwatershed 1 (S1) - Forest: This station is located about 30 meters below a culvert that goes under Milan Hill Road and is approximately 0.2 km (0.12 miles) west of the intersection of Willow Glen Road. It includes an area of 68.25 hectares (0.265 sq. mi.) that is 95% forested or wetland. Five percent is hayfield (Pitt and Barton 1994).

Subwatershed 2 (S2)- Landfill: This was originally to be S2, but due to the drought and not enough water to make a macroinvertebrate collection, this station was not used.

Subwatershed 3 (S3) - Mixed Agriculture: This station was moved approximately 1 km to Cokertown at the intersection between Hapeman Hill Road and the road to Spring Lakes because Nieder's (1995) original station was dry. The land use is approximately 36% forested, 57% agriculture, and 7% residential (Pitt and Barten 1994). The watershed encompasses approximately 370 ha (1.43 sq. mi..) (Pitt and Barten 1994).

Subwatershed 4 (S4) - Orchards: The original site was on Echo Valley Road, south of the intersection with Fraleighs Road. It was dry, so the station was moved to a mainstream station west of Route 9 (approximately one mile southwest of Nieder's site). The land uses are 47% orchard, 17% hayfield, 28% forest and 8% wetland (Pitt and Barton 1994). The watershed encompasses approximately 4662 ha (18 sq. mi.).

Subwatershed 5 (S5) - Residential: This station is located north of the Village of Red Hook, on Aspinwall Road, west of Route 79. The sampling was done on the north side of the Red Hook Department of Public Works' pond. The watershed encompasses 49 ha (0.19 sq. mi.) and the land uses are 20% forest, 5% agricultural, and 75% residential (Pitt and Barton 1994).

Main stream 1 (M1) - Primarily Forest: This is located in Rock City, off of Route 199, below the old mill dam. A diesel fuel truck overturned on June 6, 1997 and dumped 7,000 gallons of fuel onto the road and into a subcatchment of the Saw Kill (Poughkeepsie Journal; June 7, 1997). The site is 20 meters above the subcatchment tributary that was

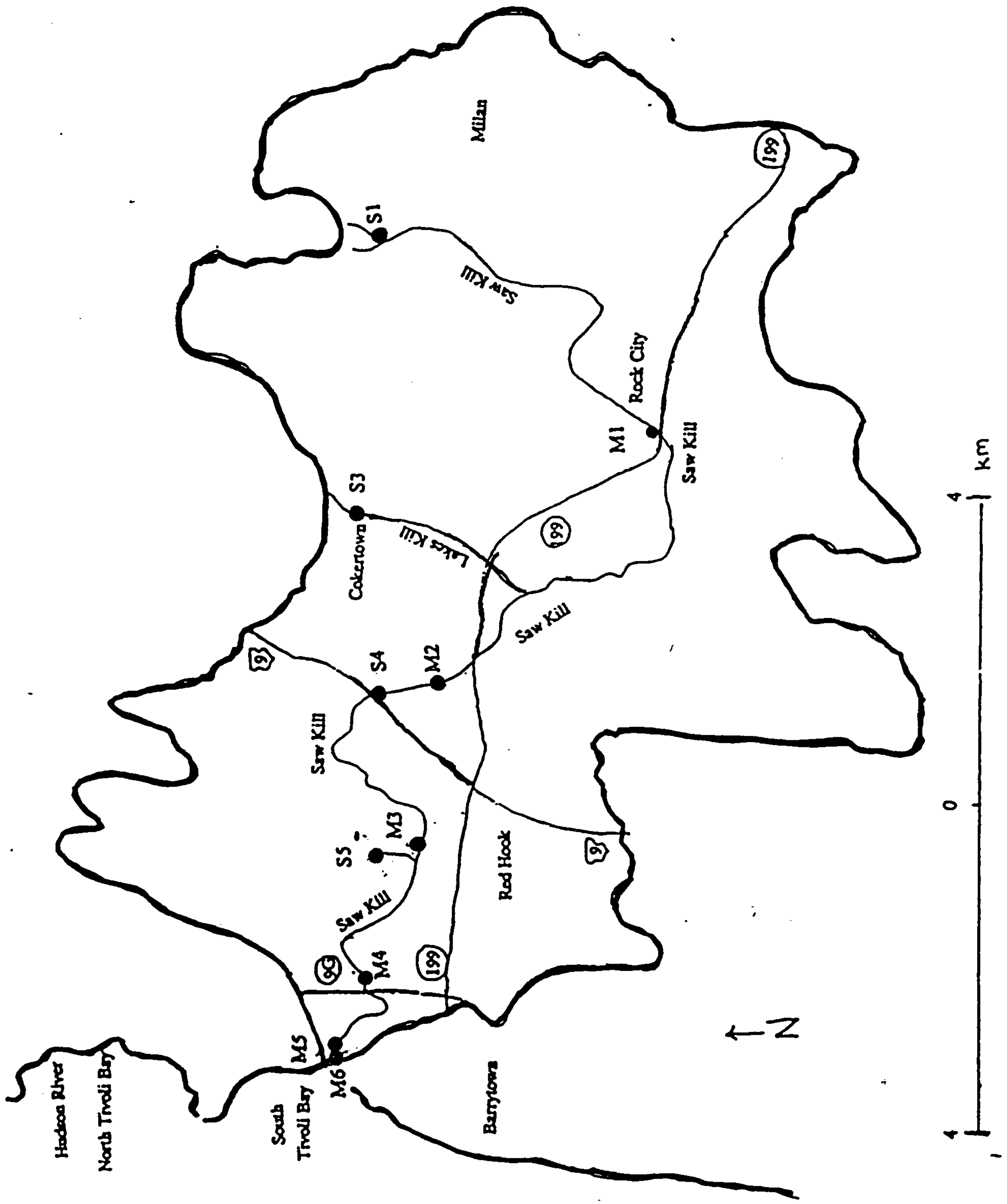

Figure 1. This delineates the Saw Kill watershed and shows were the 10 station are located.

contaminated by the diesel fuel. The land use is over 90% forested. The watershed encompasses 1634 has (6.31 sq. mi.) (Wagner 1981).

Main stream 2 (M2) - Primarily Forest and Agriculture: This is located on Echo Valley Road about one mile north of Route 199. The land uses are approximately 70% agriculture and 30% forest. The estimated watershed area is 3786 ha (14.62 sq. mi.).

Main stream 3 (M3)- Primarily Urban and Residential: This station is about 0.5 miles north of Linden Avenue Middle School on Linden Avenue. The Red Hook Department of Public Works' storm pipe effluent discharges in the Saw Kill above this station. The land uses are approximately 90% residential. The watershed encompasses 5413 ha (20.9 sq. mi.) (Wagner 1981).

Main stream 4 (M4) - Primarily Residential: This is an additional station located on the Saw Kill after it flows through more recent residential development as well as Linden Acres. It is located on Kelly Road near Route 9G. The land use is approximately 90% residential. The watershed encompasses approximately 5853 ha (22.6 sq. mi.).

Main stream 5 (M5)- Tivoli South Bay: This was the same station as Nieder's (1995) site and is located on the road to the Bard College Field Station. This site is above the falls and the effluent pipe from the Bard College sewage treatment plant. At this point in the river the land use includes most of the watershed and the totals are 55% forested, 27% agriculture and 18% residential (Riechheld and Barton 1991). The watershed encompasses approximately 6475 ha (25 sq. mi.).

Main stream 6 (M6)- Tivoli South Bay: This station includes the entire watershed. This is an additional station that is below the falls and above the tidal influence. This is the last station before the Saw Kill flows into the Hudson. It is also located just off the road that goes to the Bard College Field Station. The Bard College sewage effluent enters the stream at this station. The land use is considered the same as

M5, as they are within a few hundred feet of each other (Riechheld and Barton 1991). The watershed encompasses 6886 ha (26.59 sq. mi.) (Pitt and Barton 1994).

THE TWO MACROINVERTEBRATES INDICES

One of the two methods used was the Ohio Invertebrate Community Index Hester-Dendy multiple-plate artificial substrate sampler in conjunction with qualitative dip net sampling developed in 1987 (DeShon 1995). The other method was New York State Department of Environmental Conservation's Biological Assessment Profile that used the rapid assessment traveling kick sample that formed the following indices: Species Richness (SPP), the Hilsenhoff Biotic Index (HBI), the EPT (Ephemeroptera, Plecoptera, and Trichoptera), a Percent Model Affinity, (PMA) and an Impact Source Determination index (ISD).

THE OHIO ENVIRONMENTAL PROTECTION AGENCY'S INVERTEBRATE COMMUNITY INDEX (ICI)

FIELD METHODS: A total of 64 Hester-Dendy multiple-plate artificial substrate samplers were placed at the ten stations. Each station had six Hester-Dendy samplers, except for S1, which had only four since the low water level did not allow for six. They were made of 1/8 inch tempered hardboard cut into eight pieces, each three square inches. One inch square spacers of the same material were allowed for three spaces, three double spaces, and one triple space between the plates. This was held together by a 1/4 inch eyebolt and creates an artificial substrate area of 135.6 square inches (Ohio EPA 1989). Two multiple plate samplers were bolted to a patio block. These samplers were placed in the water during the third week of June and retrieved the first week of August.

At retrieval time, while the samplers were submerged, they were unbolted from the block and the plates were placed into labeled containers inverted onto the river bank and

fixed in less than 10% formalin and preserved in 70% ethanol. At retrieval time, a qualitative sampling of macroinvertebrates in the natural substrate was done by using a triangular D-frame 20- mesh dip net. Rocks and debris was scraped and hand picked above the net. All segments of the stream (runs, riffles, margins, and pools), and for no less that 30 minutes, were sampled until no new taxa were retrieved. After the macroinvertebrates were collected, they were fixed in less than 10% formalin and preserved in 70% ethanol (Ohio EPA 1989, per conversation with Jeff DeShon 1997).

LABORATORY METHODS: For both the Hester-Dendy and dip net sampling, all of the sample from each station was sorted and identified, except from stations M2 and S5. These stations were quarter-sampled as the immensity of their populations prohibited sorting and identifying the entire sample. The quarter sampling was done by pouring the sample into a pan and a fourth of the sample was removed and sampled. The counts were then multiplied by four. At the time of collection of the Hester-Dendy plate, a dip net sampling of the natural strata was taken. For both the dip net sampling and the Hester-Dendy multiple plate samplers, all specimens were identified to the recommended Ohio EPA taxonomic level. The specimens from the Hester-Dendy collection were preserved in 24 mL bottles containing 70% isopropyl alcohol.

DATA ANALYSIS: The Ohio ICI is comprised of ten compositional and structural community metrics (DeShon 1995). Each metric scores either 6, 4, 2, or 0 points, based on a comparison with a set of ecoregional reference sites (DeShon 1995). Six points constitutes values comparable to an undisturbed, clean stream, four points are given if a metric value reflects a good community (Ohio EPA 1988), two points are given to a metric if it slightly deviated from the expected range of good values (Ohio EPA 1988), and a score of 0 indicates that the metric values strongly deviated from the expected range of good values (Ohio EPA 1988). The summation of the scores results in the ICI. See Table 1 for the description of the results for each metric.

Table 1. Ohio ICI metrics are described below (Ohio EPA 1988).

METRIC	DESCRIPTION
1	Total taxa: If the score is high, then the biological conditions are stable indicated by high species richness and diversity.
2	The total number of mayfly taxa: Mayflies are intolerant to pollution and the greater the number of taxa, the greater the score, as greater mayfly taxa indicates high biotic integrity.
3	The total number of caddisfly taxa: As with mayflies, abundant caddisfly taxa indicates better biotic integrity. This metric depends on drainage area size, If the drainage area is less than 155,400 ha (600 sq. mi.) the total score will be more dependent upon this metric.
4	The number of dipteran taxa: Dipteran display the greatest range of pollution tolerance and are often the major component of invertebrate collections. The greater the number of taxa, the higher the score.
5	Percent Mayflies: Even if only a few mayflies are present, the station will score at least a 2 in this metric.
6	Percent caddis flies: As in metric 3, this metric depends on drainage area size, If the drainage area is less than 155,400 ha (600 sq. mi.) the total score will be more dependent upon this metric.
7	Percent Tanytarsini midges: This taxa is pollution sensitive and the higher the percentage, the greater the score.
8	Percent other dipteran and non-insects: This is a negative metric, as the greater the percent the more tolerant pollution organisms there are, thus indicating poor biotic integrity.
9	Percent tolerant organisms: This differs from metric 8 as the organisms will predominate under extremely polluted conditions. It, too, is a negative metric as the greater the percent, the lower the score.
10	EPT of natural substrata: When the Hester-Dendy samplers are collected, the total number of Ephemeropter, Plecoptera, and Trichoptera taxa are collected in the riffle, runs, margins, and pools and counted. The greater the taxa number, the better the score.

THE NEW YORK STATE DEPARTMENT OF ENVIRONMENTAL CONSERVATION'S BIOLOGICAL ASSESSMENT PROFILE

FIELD METHODS: In August, macroinvertebrate collections were made using the traveling kick method. This was done by positioning a D-frame aquatic net 10 in. x 12 in.

with a mesh opening of 0.8 mm x 0.9 mm about 0.5 m downstream from the collector. The stream bed was disturbed by the collector kicking and dislodging organisms that were captured by the net. This macroinvertebrate shuffle was performed for 5 minutes for a distance of 5 meters. The direction of sampling was taken in a diagonal transect of the stream. The contents of the net were emptied into a pan of stream water and major groups of organisms were noted. Larger debris was removed after the organisms had been extracted and the contents of the pan was sieved with a US no. 30 standard sieve. This material retained by the sieve was transferred to a plastic quart jar containing 70% alcohol. The jar was labeled and ready for identification. Prior to performing another sampling, the net was thoroughly rinsed in the stream (Bode et al. 1996).

LABORATORY METHODS: The samples were drained through a US no. 30 sieve to remove the alcohol and transferred to an enamel pan. A small amount of the sample was randomly removed and placed in a petri dish. This was examined under a stereomicroscope. Organisms were sorted into major groups, counted, and identified. The identification was completed when 100 organisms had been removed. The specimens were identified to recommended NYS DEC taxonomic levels, labeled, and preserved in 24 mL vials containing 70% isopropyl alcohol (Bode et al. 1996).

DATA ANALYSIS - To calculate the BAP, 100 organisms were identified from each station. The Species Richness (SSP) was the total number of taxa found in a sample, higher SSP values indicate cleaner water (Bode et al. 1996). The EPT was calculated by totaling the number of mayflies (Ephemeroptera), stoneflies (Plecoptera), and caddisflies (Trichoptera) and indicates mostly clean-water organisms (Bode et al. 1996). The Hilsenhoff Biotic Index (HBI) was calculated by multiplying the number of the individuals of each species by an assigned tolerance value for each species that ranges from 0 to 10, 0 being intolerant and 10 being tolerant to pollution. High HBI values indicate organic pollution and low values indicate clean-water conditions (Bode et al. 1996). The Percent Model Affinity (PMA) is a measure of similarity to a model non-impacted community based on percent abundance in 7 major groups (Bode et al. 1996). This was based upon the percent abundance of 40% Ephemeroptera, 5% Plecoptera, 10% Trichoptera, 10% Coleoptera, 10% Chironomidae, 5% Oligochaeta, and 10% other. The taxa identifications and percentages of each station were compared to the Impact Source Determination (ISD) community types. If the station community exhibited a similarity of greater than 50% to the ISD community type, then it was classified as that ISD community type. The community types are as follows: 1. Natural, 2. Nutrient Additions, Non-point sources, and 3. Toxic (Bode et al. 1996). If the samples indicated Nutrient Additions, Non-point sources or Toxic, then these communities were matched to ISD communities that have been identified to have a definite source for the pollution. These are listed as Sewage Effluent, Animal Wastes, Municipal/Industrial, Siltation, and Impoundment.

CHEMICAL WATER TESTS: For the purpose of obtaining more direct correlation between chemical tests and biotic indices, water samples were collected in clean polyethylene bottles on September 23, 1997 and sent to the Institute of Ecosystem Studies to be analyzed for levels of phosphates, nitrates, sulfates, and chlorides using ion chromatography or Alpkem autoanalyzer. Seston, alkalinity, and pH tests was determined in the HRNERR lab at the Bard College Field Station.

Nieder's 1993 chemical data collected April 15-20, October 12-18, and November 1-5 were rank for stations M1, S3, M2, M3, S4, and M5, because these were located in the same station as the chemical and biological data gathered for this research (Table 2).

CORRELATIONS: To obtain correlation for the ICI, BAP, and the water chemical index for statistical analysis, all three indices were normalized by ranking the scores and a ten-point scale. For the biotic indices, the lowest score ranked a one and the highest score ranked a ten. Similarly, for each chemical test, the highest concentrations ranked a 1 and the lowest ranked a 10. Ranks between one and ten were calculated by subtracting the lowest score or chemical reading from the highest and dividing by nine. This figure was added to the lowest score or chemical reading until the tenth rank was

reached. Finally, each station was ranked according to the scale for each biotic index and the water chemical index.

Station S1 is an outlying data point throughout the results, so I made correlations both with and without this station. When the Hester-Dendy substrata were set out, only four substrata were set out as there wasn't enough water for six, as in the other stations As the summer progressed, S1 became a standing pool. This resulted in the lowest scores for both the Ohio ICI and the NYS DEC BAP. S1 was located what should have been a pristine site, as it was located in the headwaters of the forest.

RESULTS

Chemical test results from this research and Nieder's (1993) research can be found in tables 2 and 3. The Ohio ICI results can be found in table 4 and the NYS DEC BAP can be found in tables 5 and 6. The total number of individuals captured in the Ohio ICI was 3,020 with a total of 83 taxa. The total number of individuals captured in the NYS DEC BAP method was 927 with a total of 151 taxa. Refer to Appendices 1 and 2 for the species lists for both the Ohio Hester-Dendy artificial substrata and the NYS DEC's traveling-kick method.

Table 2. Seston, pH, nitrate, sulfate, chloride, and phosphate (mg/L) results from water samples of the Saw Kill that were taken on September 23, 1997.

	Stations									
	S1	M1	S3	M2	S4	M3	S5	M4	M5	M6
seston	3.00	0.00	2.00	0.70	0.30	2.40	1.50	89.0	0.30	0.40
pH	7.20	7.44	8.46	7.98	8.17	7.65	7.97	7.85	7.98	8.13
nitrates	0.29	0.35	3.71	3.49	3.60	6.87	7.28	7.27	5.79	6.20
sulfates	19.51	13.56	14.18	18.84	19.07	23.02	32.54	26.36	25.69	26.60
chlorides	91.13	21.28	22.89	22.79	23.92	30.04	62.29	37.22	37.04	39.04
phosphates	0.017	0.005	0.074	0.0125	0.011	0.008	0.006	0.006	0.017	0.086

Table 3. Nitrate, sulfate, chloride, and phosphate (mg/L) mean chemical data from Nieder (1993). They were collected on April 15-20, Oct. 12-18, and Nov. 1-5, 1993.

	M1	S3	M2	M3	S5	M5
nitrates	0.93	1.20	1.80	2.70	9.55	2.59
sulfates	19.99	23.04	30.71	30.54	39.94	31.71
chlorides	16.88	18.54	15.47	16.18	36.86	18.42
phosphates	0.007	0.007	0.007	0.008	0.014	0.008

There was no significant correlation between the Ohio ICI and either of the water chemistry indices (Figure 2) , nor the NYS DEC and either of the water chemistry indices (Figure 3). Figure 4 does demonstrate a weak, significant correlation between the two biological indices.

Figure 5 represents the three categories of land uses found in the Saw Kill, what percentage of land use occurs at each station, and the biotic integrity, or the rank of the

Table 4. Numbers of individuals and taxa captured at each station, from the Saw Kill, using the Ohio ICI method from June 16 through July 27, 1997. The resulting ICI score for each station is also listed.

	Stations									
Totals	S1	M1	S3	M2	S4	M3	S5	M4	M5	M6
Individuals	98	112	466	352	346	248	454	151	389	404
Taxa	7	12	23	19	27	16	15	16	20	16
ICI score	6	26	36	30	36	20	8	28	36	34

Ohio ICI, of each station. M1 is in the forested land use and demonstrates good biotic integrity, as would be expected. S1 does not fit the model of good biotic integrity that would be found in a forested region, due to the conditions of the stream, as previously discussed. The agricultural land use is not deteriorating the biotic integrity of the Saw Kill in stations M2, S3, and S4 as much as the residential land use of S5, M3, and M4. Stations S5, M3, and M4 are predominantly residential and score some of the lowest

Table 5. Numbers of individuals and taxa captured at each station using the NYS DEC BAP method, on the Saw Kill, from July 22 and 23, 1997. The HBI, EPT, PMA calculations are also included for each station.

	Stations									
Totals	S1	M1	S3	M2	S4	M3	S5	M4	M5	M6
individuals	27	100	100	100	100	100	100	100	100	100
SSP	2	13	9	23	16	18	13	21	18	18
HBI	8.25	5.02	2.44	3.45	3.99	3.97	7.46	4.27	4.30	3.61
EPT	0	3	3	11	6	5	3	7	8	10
PMA	21	41	38	74	35	39	41	62	53	33

Table 6. The NYS DEC BAP total scores for the SSP, HBI, EPT, and PMA and mean for each of the ten stations.

	Stations									
totals	S1	M1	S3	M2	S4	M3	S5	M4	M5	M6
SSP	0.00	3.38	2.20	6.47	4.20	4.85	3.38	5.88	4.85	4.85
HBI	3.00	6.85	9.40	8.60	8.10	8.03	3.80	7.73	7.70	8.39
EPT	0.00	3.61	3.61	8.00	5.40	4.72	3.61	5.91	6.36	7.27
PMA	0.10	3.63	3.20	8.46	2.85	3.31	3.63	7.10	5.65	7.24
MEAN	0.78	4.37	4.60	7.88	5.14	5.23	3.61	6.65	6.14	5.69

ranks. This suggests that residential land use is respectively affecting the biotic community of the station more than agriculture and forested land uses. Stations M5 and M6, at the mouth of the Saw Kill , score the same, highest rank and exhibit a recovery from the deteriorating conditions that occur at the three previous stations (S5, M3, and M4). At M5 and M6, it can be estimated that the land use returns to be more forested than residential and this change in land use allows the biotic integrity of the Saw Kill to improve prior to it reaching the Hudson River.

Figure 6 also represent where the stations fit into the three land use categories and how the type of water quality that occurs, or the rank of the NYS DEC BAP.

When S1 is not included in the data, a slight negative correlation occurs between

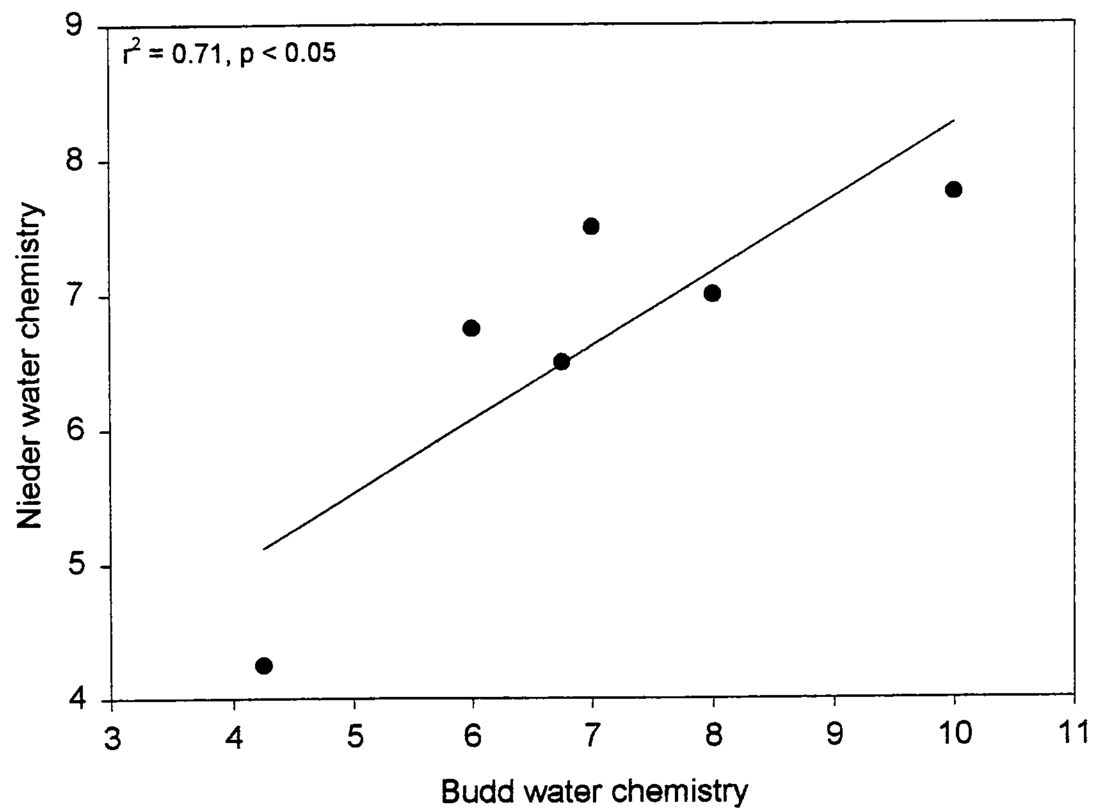

Figure 2. Regression line and correlation coefficient (one tailed test) between water chemistry data collected for this research (Sept. 23, 1997) and Nieder's (1993) chemical data.

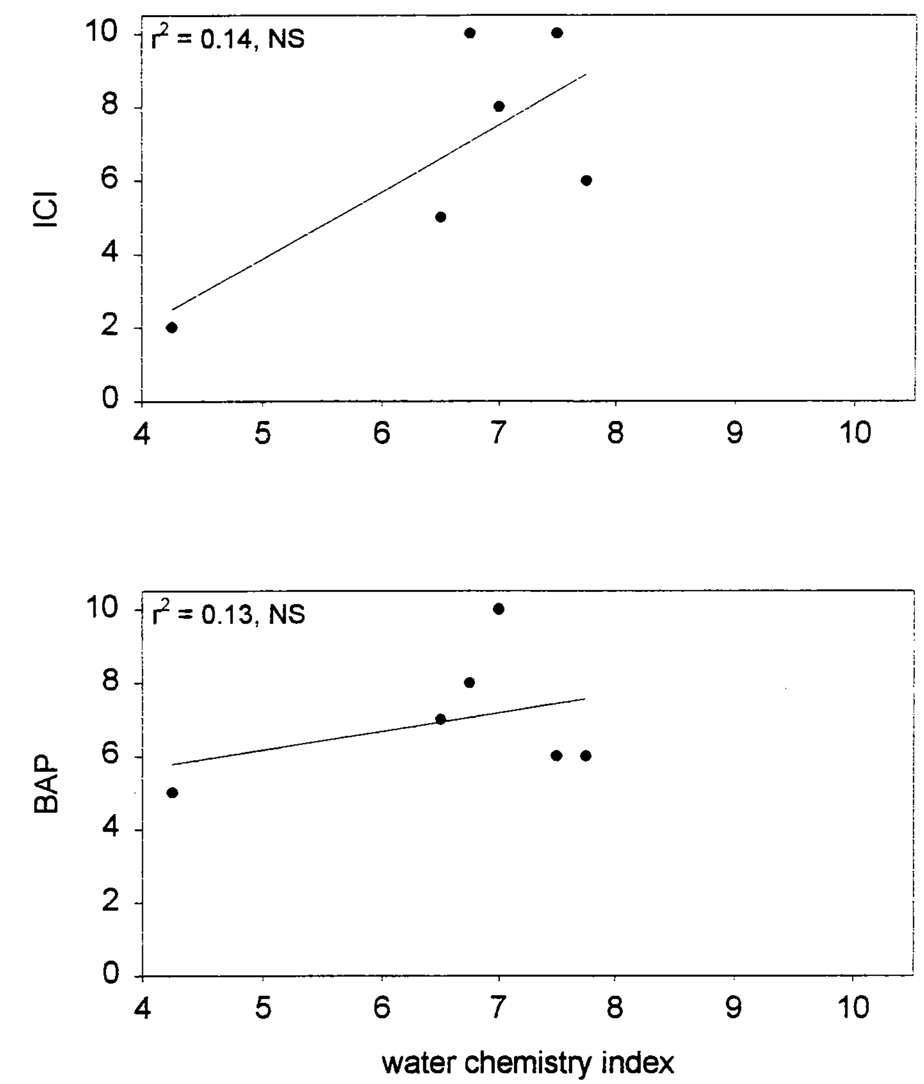

Figure 3. Regression lines and correlation coefficients (using one tailed tests) between the water index generated from this research and the ICI (upper graph) and the BAP (lower graph) Sept. 23, 1997

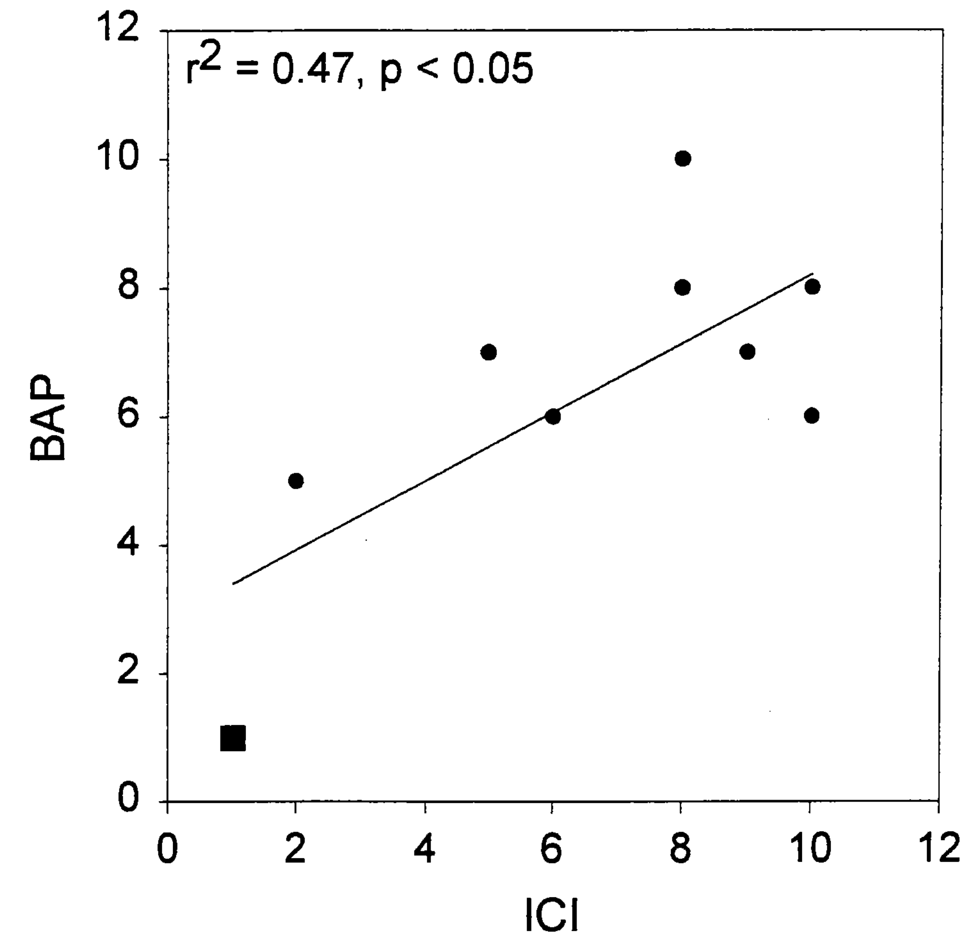

Figure 4. Regression line and correlation coefficient between the ICI and the BAP.

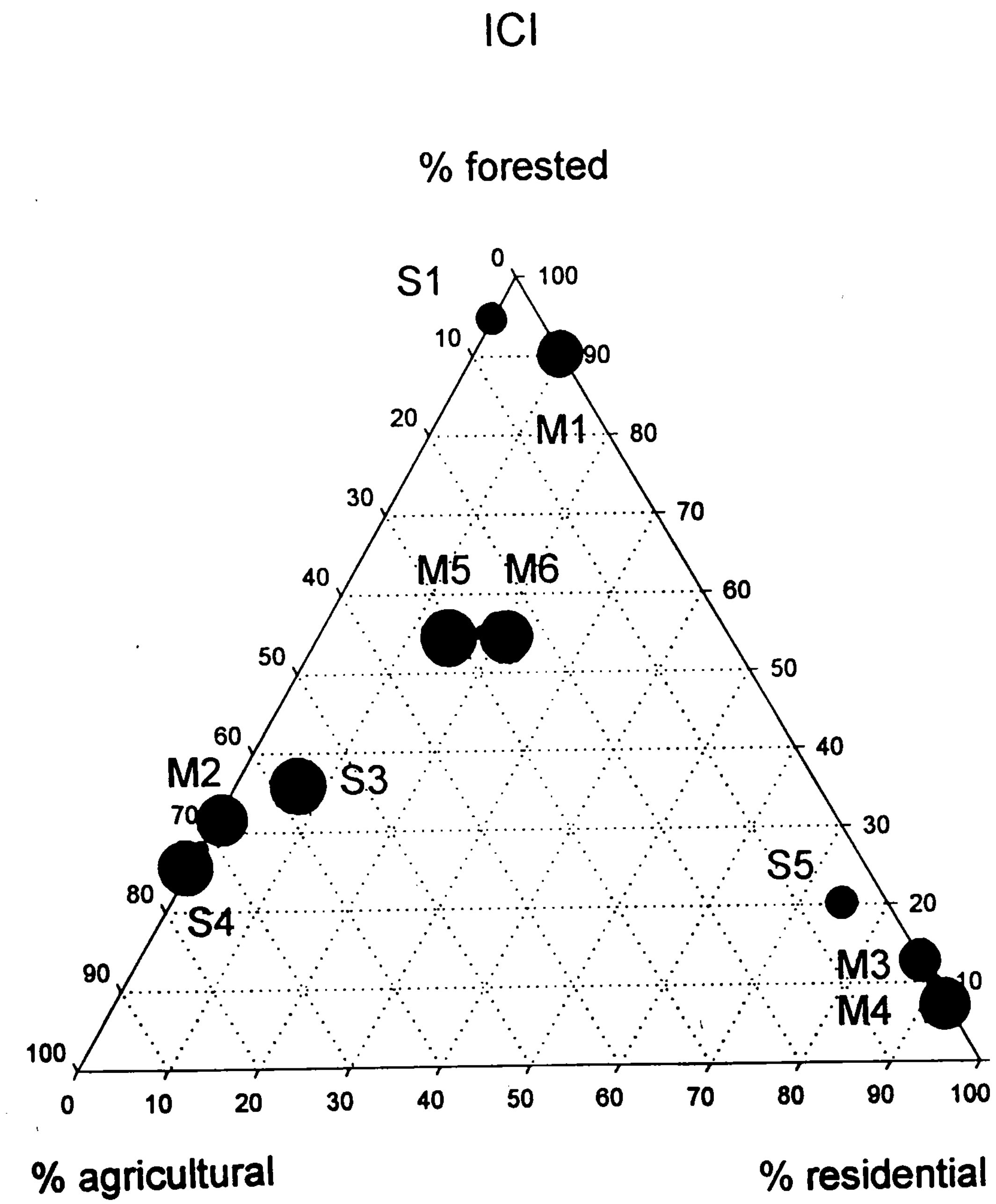

Figure 5: The three predominant land uses of the Saw Kill and the ICI are illustrated here. The smaller the circle, the worse the biotic integrity of the station. S indicates a substream station and the primary land use is as follows: S1 is forested, S3 and S4 are agricultural, S5 is residential. M indicates the main stream of the Saw Kill and the primary land use for each station is as follows: M1 is forested, M2 is agricultural, M3 and M4 are residential, and M5 and M6 return to forest.

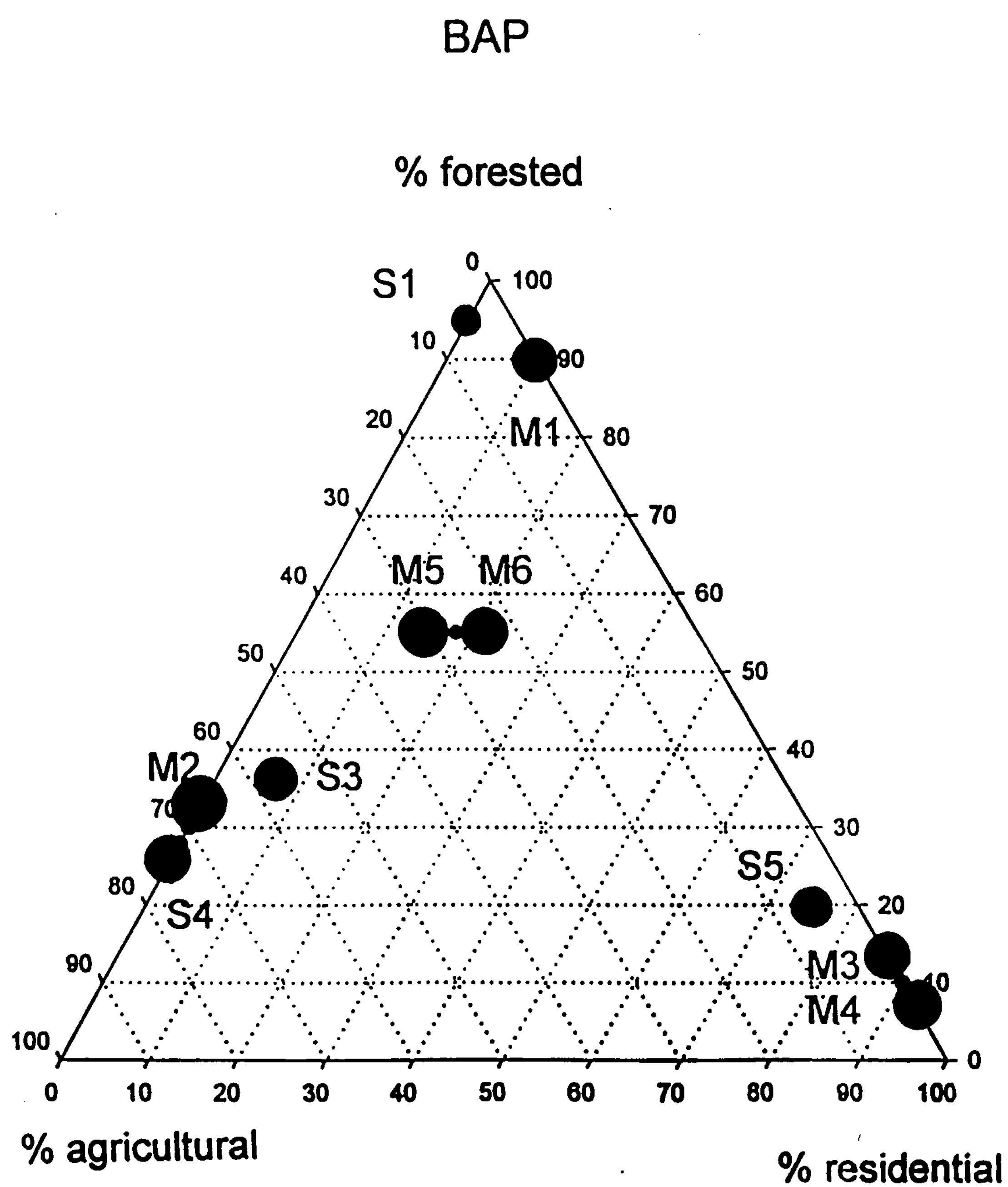

Figure 6: The three predominant land uses of the Saw Kill and the BAP are illustrated here. The smaller the circle, the worse the biotic integrity of the station. S indicates a substream station and the primary land use is as follows: S1 is forested, S3 and S4 are agricultural, S5 is residential. M indicates the main stream of the Saw Kill and the primary land use for each station is as follows: M1 is forested, M2 is agricultural, M3 and M4 are residential, and M5 and M6 return to forest.

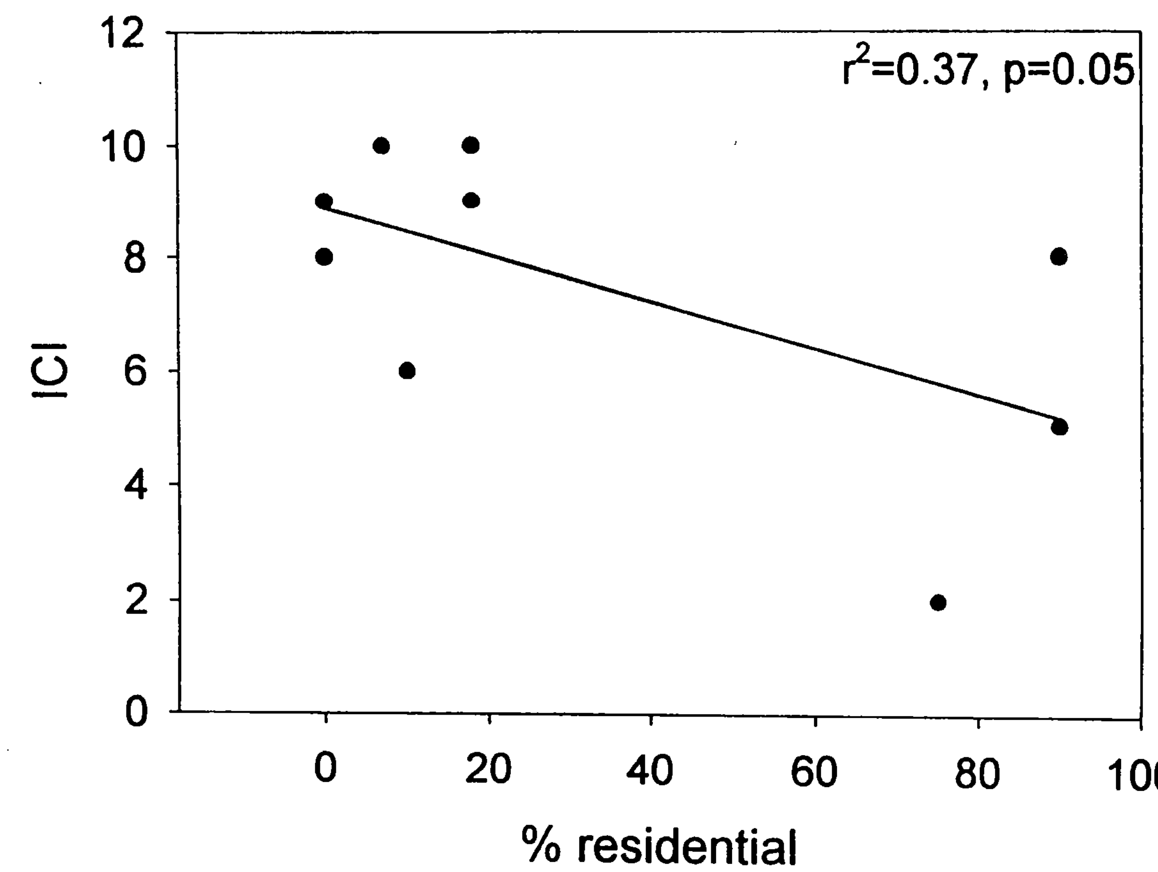

Figure 7. This demonstrates a slight negative correlation between the ICI and residential land use. S1 was excluded from the analysis.

Table 7: Cost comparison of the two methods. Labor cost is set at $20.00 per hour.

	Ohio ICI	NYS DEC BAP
1 pair of feather weight waders & boots	$ 299.23	$ 299.23
2 D-frame aquatic dip nets	179.00	179.00
36 1L sample jars	105.66	105.66
2 qts. isopropyl alcohol/method	1.80	1.80
Hester-Dendy substrata materials	160.00	0.00
24 mL specimen vials	71.82	63.42
Total cost	$ 817.51	$ 649.11

residential land use and the ICI or biotic integrity of the Saw Kill as shown in Figure 7. This does not occur when S1 is included with the ICI or the BAP results.

For both methods, expenses were recorded for a cost comparison (Table 7). If the labor was taken into account, for each of the sampling methods, the cost comparison differs substantially. The Ohio ICI took over 64 hours to assemble and set out the substrata. The NY BAP method did not required approximately one fourth of the time and effort to obtain samples. The time spent on identification for each method were more similar. Approximately 42 hours for the Ohio ICI method and 36 hours for the NY BAP method.

DISCUSSION

Chemical data from this research and Nieder's (1993) chemical tests had a significant correlation. Yet, neither of the chemical tests correlated with the biotic indices.

The two biological collections were made at different times and the conditions varied. The summer was dry, especially during the biotic collections. There had been more rain prior to the September collection of the water samples. This indicates that chemical tests results can diverge from the biotic results in a relatively short period of

time. These results support the idea that chemical tests, alone, may not reflect the water quality and biotic integrity of the macroinvertebrate community.

For most of the stations, this would indicate that to some extent, the two indices resulted in similar scores of biotic integrity, in the Ohio ICI, and water quality, in the NYS DEC BAP. The weakness of the correlation may be a result of the collections taking place at different times. Also, the two methods differ in where the collections are made in the river. The ICI is collected in a run of a river where there is greater depth to ensure that the Hester-Dendy substrata are covered with water. The BAP is collected in riffles where shallower water occurs. The fact that they do correlate, yet are two different methods of collecting, does indicate that similar communities, thus water quality and biotic integrity, do exist in most of the stations.

The water quality of M1 appears to be similar to the biotic integrity (of the ICI) and S1 again scores poorly. The water quality of M2 is not as good as the biotic integrity, yet S4 and S3 exhibit better water quality than biotic integrity. S3, M2, and S4 again show better water quality than the residential stations S5, M3, and M4. S5 does appear to have better water quality than biotic integrity. This may be due to the difference in collecting methods. For example, leeches and snails (responsible for lower scores) may not be as easily collected in a dip net as they are on artificial substrata. The collection, at S5, from the BAP methods, did not have the number of leeches and snails as the ICI method did. The water quality at M3 does rank higher than the biotic integrity, but at M4, the water quality is the same as the biotic integrity. M5 and M6 do not rank the same, as they did for the ICI, though the water quality of M6 is only one rank lower than the biotic integrity of the ICI. This, again, demonstrates a recovery of water quality conditions prior to the Saw Kill entering the Hudson River and further supports the buffering capacity of a forested region to allow for upgrading of a river water conditions prior to it entering a major body of water.

A slight, but significant correlation exists between residential land use and the ICI or biotic integrity of the Saw Kill as shown in Figure 7. This indicates that residential land use does adversely affect the biotic integrity of the Saw Kill more than any other land use. This coincides with Nieder's (1995) data that residential land use causes more pollution:

> "Regression analyses indicate that residential land use has the greatest effect on water quality, more so than agricultural activities within the Saw Kill watershed. Surface water concentrations of all constituents (nitrates, phosphates, sulfates, and chlorides) increased with an increase in residential area ($p<0.01$). None of these nutrients exhibited a positive correlation with increases in agricultural land use during this study, in fact nitrate loading appeared to decrease as area coverage of agriculture increased" (Nieder 1995).

This research supports chemical test results, through the Ohio ICI indices, that biotic integrity is most adversely affected by residential land use than any other land use on the Saw Kill.

The NYS DEC BAP method cost less than half as much as the Ohio ICI (see Table 7). Yet, the BAP method resulted in 68 more taxa than the ICI method and have broadly similar results (Figure 4). Much more time and effort in collecting is needed for the ICI, yet the substrata appear to capture fewer species than the taxa assessment method of the BAP. It would appear that the NYS DEC BAP is much more efficient and economical.

CONCLUSION

Water chemical tests, both generated from this research and Nieder's (1993) water sampling did not display significant correlation with Ohio ICI nor the NYS DEC BAP. The ICI and the BAP were correlated, indicating that the biotic integrity, detected by the ICI, and the water quality, detected by the BAP, were somewhat similar. This indicates concurrence between the two biological methods and supports the idea that the effects of the environmental conditions of the Saw Kill are being detected by the type of macroinvertebrate communities that exist in the Saw Kill.

Correlations between land use and the two macroinvertebrate indices indicate that the residential land use is deteriorating the biotic integrity of the Saw Kill more than any other land use. This is in agreement with Nieder's (1995) water chemical results.

Even though there is biotic integrity degradation on the Saw Kill in the residential area, recovery occurs in the forested area that exists at the mouth of the river. The buffer zone that this forested region provides allows for the environment of the Saw Kill to improve prior to it entering the Hudson River.

The NYS DEC BAP method is recommended as a index to use as the BAP proved to be more effective and less expensive.

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APPENDIX 1: **Macroinvertebrates collected using the Ohio EPA Hester-Dendy artificial substrata. Collections occurred June 15 to August 22, 1997.**

TAXA	S1	M1	S3	M2	S4	M3	S5	M4	M5	M6
	SITES									
ECTOPROCTA										
Phylactolemata sp.	-	-	-	-	-	-	130	-	-	-
COELENTERATA sp.	-	-	5	-	1	2	-	-	1	-
PELECYPODA sp.	-	-	-	-	1	-	-	-	-	-
GASTROPODA										
Physidae:										
Aplexa elongata	-	-	-	-	-	-	-	-	-	-
Physella sp.	15	-	15	-	-	-	44	-	4	-
Planorbidae:										
Planorbella companulata	-	-	-	-	-	-	24	-	2	-
PLATYHELMINTHES										
Turbellaria:										
Planariidae sp.	-	-	-	-	5	-	12	-	-	-
ANNELIDA										
Oligochaeta:	-	-	1	-	1	-	-	1	-	-
HIRUDINEA:										
Glossiphoniidae										
Batracobdella sp.	-	-	1	-	-	-	-	-	-	-
Helobdella stagnalis	-	-	3	-	-	-	32	-	-	-
H. fusca	-	-	1	-	-	-	32	-	-	-
Glossiphonia complanata	-	-	-	-	-	-	20	-	-	-
Pisciolcola sp.	-	-	-	-	-	-	20	-	-	-
CRUSTACEA										
Decapoda sp.	-	-	-	4	-	-	-	-	-	-
Asellidae:										
Caecidota sp.	-	-	59	4	1	-	-	-	-	-
Lirceus sp.	-	-	-	-	-	-	24	-	-	-
Gammaridae:										
Gammarus sp.	-	-	4	-	-	-	-	-	-	-
Talitridae:										
Hyalella azteca	-	-	-	-	-	3	44	-	2	-
HYDRACARINA:										
sp.	-	-	4	-	-	-	-	3	-	-

APPENDIX 1 (continued): Macroinvertebrates collected using the Ohio EPA Hester-Dendy artificial substrata to create the ICI. Collections occurred June 15 to August 22, 1997.

TAXA	S1	M1	S3	M2	S4	M3	S5	M4	M5	M6
	SITES									
EPHEMEROPTERA										
Siphlonuridae:										
Siphlonurus sp.	-	-.	2	-	10	-	-	1	-	1
Ameletus sp.	-	-	7	-	-	-	-	-	-	-
Baetidae:										
Acentrella sp.	-	-	-	-	14	-	-	-	-	-
Diphetor sp.	-	-	-	-	10	-	-	-	2	1
Oligoneuriidae:										
Isonychia	-	-	-	4	8	-	-	5	44	19
Heptageniidae:										
Undeterminec sp.	-	-	-	-	2	-	-	-	-	-
Stenacron sp.	-	-	-	-	-	3	-	-	-	-
Stenonema femoratum	-	6	-	-	3	1	-	-	-	-
S. modestum	-	-	-	4	3	-	-	-	3	1
S. pulchellum	-	-	2	-	-	-	-	-	-	-
S. smithae	-	16	3	48	31	6	-	6	20	2
S. terminaturm	-	9	-	-	-	-	-	-	-	-
Leptophlebiidae:										
Leptophlebia sp.	-	-	11	4	-	-	-	-	-	-
Ephemerellidae:										
Serratella sp.	-	-	-	-	-	1	-	-	-	-
Tricorythidae:										
Tricorythodes sp.	-	-	-	4	1	2	-	-	-	-
Caenidae:										
Caenis sp.	-	-	-	-	-	-	8	-	-	-
ODONATA										
sp.	-	-	-	-	-	-	8	-	-	-
Aeschnidae:										
Anax junicus	-	-	-	4	-	-	44	-	-	-
PLECOPTERA										
Pteronarcyidae:										
Pteronarcys sp.	-	-	-	-	-	-	-	6	8	22
Capniidae:										
Allocapnia granulata sp.	-	-	53	52	1	-	-	-	-	-
Perlidae:										
Agnetina sp.	-	-	-	4	-	-	-	-	-	-
Paragnetina sp.	-	-	-	-	20	-	-	-	-	-
Perlodidae:										
Isoperla sp.	-	-	1	-	-	-	-	-	-	-
COLEOPTERA										
Elmidae:										
Macronychus glabratus	-	-	-	8	-	-	-	-	-	-
Optioservus sp.	2	-	3	-	-	-	-	-	-	-
Stenelmis sp.	-	-	-	-	3	13	-	4	10	15

APPENDIX 1 (continued): Macroinvertebrates collected using the Ohio EPA Hester-Dendy artificial substrata to create the ICI. Collections occurred June 15 to August 22, 1997.

TAXA	SITES S1	M1	S3	M2	S4	M3	S5	M4	M5	M6
MEGALOPTERA										
Sialidae:										
Sialis sp.	-	-	-	-	1	-	-	-	-	-
Corydalidae:										
Nigronia serricornis	-	-	-	4	-	-	-	15	13	4
TRICHOPTERA										
Philopotamidae:										
Chimarra sp.	-	-	-	-	5	-	-	-	3	24
Polycentropodidae:										
Polycentropus sp.	-	-	-	-	-	24	-	1	-	-
Neureclipsis sp.	-	-	-	-	-	-	-	-	6	-
Hydropsychidae:										
Cheumatopsyche sp.	-	-	-	-	-	14	-	23	13	1
Hydropsyche sp.	-	-	-	92	130	-	-	-	128	266
Parapsyche sp.	-	-	-	-	-	-	-	-	-	17
Rhyacophilidae:										
Rhyacophila sp.	-	-	-	-	8	-	-	-	2	-
Hydroptilidae:										
Hydroptila sp.	-	-	-	-	-	-	-	22	-	-
Limnephilidae:										
sp.	-	1	-	-	-	6	-	-	-	-
Anabolia bimaculata	-	-	-	4	-	-	-	-	-	1
Asperophylax sp.	-	-	1	-	-	-	-	-	-	-
Grensia sp.	-	-	6	-	-	-	-	-	-	-
Glyphopsyce sp.	1	-	-	-	-	-	-	-	-	-
Hesperophylax sp.	-	-	-	-	-	-	-	-	-	-
Hydatophylax argus	-	-	-	8	1	10	-	-	-	-
Lepidostomatidae:										
Lepidostoma sp.	-	-	268	-	-	-	-	-	-	-
DIPTERA										
Simuliidae:										
Simulium sp.	-	-	-	-	2	-	-	-	-	1
Empididae:										
sp.	-	-	-	-	-	-	-	-	2	-
Hemerodromia sp.	-	-	-	-	2	-	-	5	-	-
Oreogeton sp.	-	-	-	-	-	-	-	4	-	-
Tipulidae:										
Antocha sp.	-	-	-	-	1	-	-	-	-	-
Tipula abdominalis	-	-	-	4	-	-	-	-	-	-
Chironomidae:										
Tanypodinae:										
Pentaneura sp.	6	-	-	-	-	-	-	-	-	-
Procladius sblettei	-	-	-	4	-	-	-	-	-	-
Thienemannimyia gr. spp.	-	14	-	20	22	-	-	16	17	-

APPENDIX 1. (continued): Macroinvertebrates collected using the Ohio EPA Hester-Dendy artificial substrata to create the ICI. Collections occurred June 15 to August 22, 1997.

TAXA	SITES S1	M1	S3	M2	S4	M3	S5	M4	M5	M6
DIPTERA										
Orthocladinae:										
Brillia flavifrons	-	-	-	-	-	-	-	-	-	25
Heterotrissocladius marcidus gr.	-	-	10	-	-	-	4	-	-	-
Parametriocenemus lundbecki	-	21	-	-	-	3	-	-	-	-
Chironominae:										
Chironomini:										
Chironomus decorus gr.	38	-	-	-	-	-	-	-	-	-
Chironomus sp.	-	-	-	56	-	-	-	-	-	-
Microtendipes sp.	18	-	-	-	-	80	-	-	-	4
Polypedilum sp.	-	31	-	20	59	80	8	25	50	-
Tanytarsini:										
Zaverelia sp.	18	14	5	-	-	-	-	14	59	-
TOTALS	98	112	466	352	346	248	454	151	389	404

TOTAL NUMBER = 3020 **TOTAL NUMBER OF TAXA = 83**

APPENDIX 2 - Macroinvertebrates collected using the New York State DEC Traveling - Kick method. Collections occurred on August 14, 1997.

TAXA	**SITES** S1	M1	S3	M2	S4	M3	S5	M4	M5	M6
ANNELIDA										
Oligochaeta:	-	1	-	-	1	-	7	-	-	4
Hirudinea:										
Glossiphoniidae sp.	-	-	-	-	-	-	8	-	-	-
GASTROPODA										
Physidae:										
Aplexa elongata	-	-	-	-	-	-	2	-	-	-
Physella sp.	-	1	-	-	-	-	-	-	-	-
P. heterostropha	-	-	-	-	-	-	-	-	-	1
P. magnalacustris	-	-	-	-	-	-	-	-	2	-
Planorbidae:										
Planorbella campanulata	-	1	-	-	-	-	-	-	-	-
Helisoma anceps	-	-	-	-	-	-	2	-	-	-
CRUSTACEA										
Decapoda sp.	-	-	-	-	-	1	-	-	-	-
Asellidae:										
Caecidota sp.	-	-	15	-	-	-	4	-	-	-
Talitridae:										
Hyalella azteca	-	1	-	-	-	1	42	-	-	-
HYDRACARINA:										
sp.	-	1	-	1	-	-	1	-	-	-
EPHEMEROPTERA										
Siphlonuridae:										
Siphlonurus sp.	-	-.	2	1	-	-	2	-	-	-
Ameletus sp.	-	-	7	-	-	-	-	-	3	-
Baetidae:										
Uknown sp.	-	-	-	2	-	-	-	-	-	-
Baetis sp.	-	-	-	-	-	-	-	-	1	7
Callibaetis sp.	-	-	-	-	3	-	-	-	3	-
Centroptilum sp.	-	1	-	-	-	-	-	-	-	-
Olgoneuriidae:										
Isonychia sp.	-	-	-	-	-	-	-	-	-	2
Ephemeridae										
Hexagenia sp.	-	-	-	-	-	-	-	1	-	-
Heptageniidae:										
Unknown sp.	-	-	-	-	2	-	-	-	-	-
Anepeorinae sp.	-	-	-	-	-	-	-	-	-	-
Macdunnea sp.	-	-	-	4	-	-	-	-	-	-
Stenocron sp.	-	-	-	-	-	-	-	-	-	-
Stenonema femoratum	-	-	-	-	-	-	-	-	-	-
S. mediopunctatum	-	-	-	-	-	-	-	-	1	-
S. modestum	-	-	-	-	-	-	-	7	-	-
S. pulchellum	-	-	-	13	-	-	-	-	-	-

APPENDIX 2 (continued): Macroinvertebrates collected using the New York State DEC Traveling - Kick method to create the BAP. Collections occurred on August 14, 1997.

TAXA	**SITES** S1	M1	S3	M2	S4	M3	S5	M4	M5	M6
EPHEMEROPTERA										
Stenonema smithae	-	-	-	-	-	8	-	3	-	1
Unknown sp.	-	-	-	-	2	-	-	-	-	-
Caenidae:										
Caenis sp.	-	-	-	1	-	-	3	1	-	-
ODONATA										
Gomphidae:										
Lanthus sp.	-	-	-	-	-	1	-	1	-	1
Stylogomphus sp.	-	-	-	-	-	-	-	2	1	-
Aeshnidae:										
Anax junicus	-	-	-	1	-	-	-	-	-	-
Macromiidae:										
Macromia sp.	-	-	-	-	-	-	4	-	-	-
Coenagrionidae:										
Enallagma sp.	-	-	-	-	-	-	1	-	-	-
PLECOPTERA										
Chloroperlidae:										
Utaperla sp.	-	-	27	16	-	-	-	-	-	-
Pteronarcyidae:										
Pteronarcys sp.	-	-	-	-	1	-	-	-	-	-
Capniidae:										
Allocapnia granulata	-	-	-	-	10	1	-	-	-	-
Perlidae:										
Acroneuria ruralis	-	-	-	2	-	-	-	-	-	-
COLEOPTERA										
Psphenidae:										
Ectopria sp.	-	1	-	3	-	1	-	-	-	1
Elmidae:										
Dubiraphia bivittata	-	-	-	-	2	2	-	-	-	-
Macronychus sp.	-	-	-	-	-	-	-	4	-	-
Olimnius sp.	-	-	3	6	16	22	-	-	-	-
O. latiusculus	-	-	-	-	-	-	-	-	-	4
Optioservus sp.	-	-	30	-	-	20	-	12	2	-
O. trivittatus	-	-	-	-	-	-	-	-	-	3
Promoresia tardellae	-	2	-	-	-	-	-	1	-	-
P. elegans	-	-	-	5	-	-	-	-	-	-
P. sp.	-	-	-	-	3	-	-	-	-	-
Stenelmis mirabilis	-	1	-	-	-	-	-	-	-	-
S. sp.	1	-	11	4	11	-	-	1	-	-
Sciritidae:										
Unknown sp.	-	-	-	-	1	-	-	-	-	-

APPENDIX 2 (continued): Macroinvertebrates collected using the New York State DEC Traveling - Kick method to create the BAP. Collections occurred on August 14, 1997.

TAXA	S1	M1	S3	M2	S4	M3	S5	M4	M5	M6
					SITES					
MEGALOPTERA										
Corydalidae:										
Nigronia serricornis	-	-	-	4	-	5	-	23	6	11
NEUROPTERA										
Unknown sp.	-	-	-	-	-	-	-	1	-	-
TRICHOPTERA										
Philopotamidae:										
Chimarra sp.	-	-	-	1	3	10	-	-	5	14
Polycentropodidae:										
Neureclipsis sp.	-	-	-	1	-	-	-	3	2	3
Hydropsychidae:										
Cheumatopsyche sp.	-	3	-	-	-	-	-	6	1	-
Diplectrona sp.	-	-	4	-	-	-	1	-	-	-
Hydropsyche sp.	-	-	-	-	37	17	-	-	47	28
H. slossona	-	61	-	7	-	-	-	-	-	-
Potamyia sp.	-	-	-	-	-	2	-	-	-	9
Rhyacophilidae:										
Rhyacophila sp.	-	-	-	-	-	-	-	-	4	-
R. fuscula	-	-	-	1	4	-	-	-	-	9
Hydroptilidae:										
Stactobiella sp.	-	-	-	-	-	-	-	1	1	-
Limnephilidae:										
Hydatophylax sp.	-	-	-	1	-	-	-	-	-	-
Unknown sp.	-	-	-	-	-	-	-	-	-	1
Lepidostomatidae:										
Lepidostoma sp.	-	-	-	-	-	-	-	-	-	1
DIPTERA										
Athericidae:										
Atherix sp.	-	-	-	1	-	-	-	-	-	-
Ceratopogonidae:										
Unknown sp.	-	-	-	-	-	1	-	-	-	-
Simuliidae:										
Simulium sp.	-	1	-	-	-	-	-	-	-	-
Empididae:										
Uknown sp.	-	-	-	-	1	3	-	2	1	-
Scathophagidae:										
Uknown sp.	-	-	-	-	-	2	-	-	-	-
Tanpanidae:										
Unknown sp.	-	-	-	-	-	-	-	1	-	-
Tipulidae:										
Unknown sp.	-	-	1	-	-	1	-	-	-	-
Antocha sp.	-	-	-	1	-	-	-	-	-	-

APPENDIX 2 (continued): Macroinvertebrates collected using the New York State DEC Traveling - Kick method to create the BAP. Collections occurred on August 14, 1997.

TAXA	S1	M1	S3	M2	S4	M3	S5	M4	M5	M6
					SITES					
DIPTERA										
Chironomidae:										
Tanypodinae:										
Ablabesmyia sp.	-	-	-	-	-	-	23	27	-	-
Natarsia sp.	-	25	-	-	-	-	-	-	-	-
Procladius subletti	26	-	-	-	-	-	-	-	-	-
Thienemannimyia gr. spp.	-	-	-	-	1	2	-	1	10	-
Polypedilum fallax gr.	-	-	-	-	2	-	-	-	-	-
P. illinoense	-	-	-	24	-	-	-	1	-	-
Paratendipes sp.	-	-	-	-	-	-	-	-	3	-
Tanytarsini:										
Zaverelia	-	-	-	-	-	-	-	1	7	-
TOTAL	27	100	100	100	100	100	100	100	100	100
TOTAL NUMBER = 927	**TOTAL TAXA = 84**									