COMPARISON OF REFERENCE QUALITY AND RANDOMLY CHOSEN STREAMS IN THE NORTHEASTERN MORAINAL NATURAL DIVISION OF ILLINOIS

Prepared for

Marvin Hubbell, Manager
Conservation 2000 Ecosystem Division
Illinois Department of Natural Resources
Office of Realty and Environmental Planning
524 South 2nd Street
Springfield IL 62701-1787

and

David Wahtel
Chicago Wilderness C2000 Partnership
8 S Michigan Ave., #900
Chicago IL 60603

Submitted by

Dr. R. Edward DeWalt
Aquatic Entomologists for the Critical Trends Assessment Program
Illinois Natural History Survey
Center for Biodiversity
607 E Peabody Dr.
Champaign IL 61820

CBD Technical Report 2002(10)

28 June 2002

Abstract: Illinois streams are highly disturbed with few remaining "pristine" conditions from which to infer presettlement, reference conditions. What is left throughout the state may be termed "least-impacted." Ten such stream reaches were identified for the Northeastern Morainal Natural Division of Illinois. Characterization of these streams took place from 1999-2001 using Illinois Critical Trends Assessment Program (CTAP) stream protocols. Significant differences occurred between 10 regional reference and 10 randomly chosen streams in EPT (Ephemeroptera, Plecoptera, and Trichoptera) taxa richness and in a habitat quality scores. Guidelines were established for rating random streams using reference stream characterizations. A multimetric index of condition, fashioned from EPT, Hilsenhoff Biotic Index values, and habitat quality scores suggests that up to 80% of streams in the region should be rated as fair-to-poor in condition, while only 20% should be rated as good. Suggestions for maintenance of good streams and improvement of fair ones is provided.

INTRODUCTION

The greater Chicago area is home to a high concentration of rare community types that are of national and global significance, yet these communities are becoming increasingly isolated and are rapidly degrading (Sullivan 1997). The Chicago Wilderness (www.chiwild.org), an organization of institutions, local experts, and concerned citizens, is dedicated to the protection, restoration, and stewardship of these natural communities.

A major goal of the Chicago Wilderness *Biodiversity Recovery Plan* (Chicago Wilderness 1999) is to "Improve the scientific basis of ecological management". This goal includes development of reliable indicators, gathering of baseline information, and setting of targets against which to evaluate the effectiveness of restoration and management of these communities. This type of work is expensive, time consuming, and requires the expertise of many individuals. Currently, there is no single entity that will undertake this process, but there are many institutions and individuals who can contribute information and expertise.

The Critical Trends Assessment Program (CTAP) of the Illinois Department of Natural Resources (IDNR), in conjuction with scientists at the Illinois Natural History Survey (INHS), has been assessing the condition of randomly chosen wetlands, forests, grasslands, and streams in Illinois streams since 1997. More about the CTAP program, including its citizen scientists, educational programs, and regional support functions for Conservation 2000's Ecosystem Partnership program can be found at http://dnr.state.il.us/orep/inrin/ctap/. Additionally, the recently published *Critical Trends in Illinois Ecosystems* (Illinois Department of Natural Resources 2001) provides a preliminary interpretation of the results of the first three years of professional scientist and up to five years of the citizen scientist data. This document is available in PDF format at the URL given above.

CTAP samples 150 sites in each of the four ecosystems in five-year cycles, with sampling repeated in the sixth year. The program interprets spatial and temporal trends in biological condition across the entire state. For this purpose, a probablistic design (randomly chosen sites) provides a more accurate assessment of area-wide condition than would a targeted design (sites of special, local interest, e.g. determining compliance with permit restrictions for release of effluent to streams) (Barbour et al. 1999). Data derived from sampling these sites are useful in defining several baselines including an appraisal of current conditions for each site, regional conditions, and statewide averages of condition. After resampling of sites, temporal changes may also be assessed. A proportional number of sites fall within the area defined by the Chicago Wilderness.

However, randomly chosen sites do not often coincide with high quality habitat, especially in the modern Illinois landscape where such habitat is rare. This shortcoming provides little opportunity to compare the random locations to reference quality sites. Ultimately, it is important to characterize an appropriate number of these remaining high quality areas, using the same rigorous methodology, to provide a context in which to place the condition of the randomly chosen sites. Currently, it is difficult to state with confidence how each site compares to the best regional examples of its community.

Most often, it is advisable to characterize multiple reference sites within a defined geographical, physiographic, or ecological region (ecoregion) to subsume enough variation to be meaningful, while minimizing variation that should be assigned to neighboring regions (Barbour et al. 1999, Hughes et al. 1994). Unfortunately, most Illinois biological monitoring currently lacks such reference data (Illinois Environmental Protection Agency 1996), including the CTAP professional and citizen scientist monitoring efforts. Recently, the IEPA has attempted to developed such reference characterizations for stream fish communities from archived data (Illinois Environmental Protection Agency 2000). Simultaneously, they have tailored the fish Index of Biotic Integrity (Karr et al. 1986) by evaluating the performance of individual metrics that compose the index against a range of archived habitat and chemical degradation data.

CTAP is aware of the shortcomings posed by its lack of regional reference data. Its streams assessment is furthest along in development of useful ecological indicators and has the greatest body of literature supporting such efforts (see Barbour et al. 1999 for discussion and references therein). Most Illinois stream community types stratify on stream size and current velocity. They require less stratification to produce meaningful characterizations than do terrestrial ecosystems sampled by CTAP. Additionally, the Chicago Wilderness has developed stream biodiversity recovery priorities in the region which provide an initial assessment and prioritization for protection and restoration activities in streams (Chicago Wilderness 1999). The latter provides guidance for chosing reference streams in the region.

The goal of the current project is to provide empirically derived biological and habitat quality criteria, benchmarks against which to measure progress in protection and restoration, for streams in the Chicago Wilderness region. These criteria will be developed using CTAP professional stream monitoring protocols using the environmentally sensitive aquatic insect orders Ephemeroptera (mayflies), Plecoptera (stoneflies), and Trichoptera (caddisflies) (a.k.a. EPT taxa). These criteria will be developed for “wadeable” streams whose EPT assemblage and local habitat quality are least-impacted. Streams used in this study will be limited to the Northeastern Morainal Division (NEMD) as defined by Schwegman et al. (1973), which provides a convenient and biologically meaningful delimitation.

METHODOLOGY

Chosing Reference Locations: Schweggman et al. (1973) defined the NEMD as containing the area east of the Rock River to Lake Michigan and south through Kane County in to Will County, and north of an east-west line above Peotone. The Chicago Wilderness (1999) presents a list of streams prioritized for protection and restoration. Additionally, IEPA water quality reports indicate the best streams using their criteria (www.epa.state.il.us/water/water-quality/).

Additionally, Page et al. (1991) provides a list of "Biologically Significant Streams". These sources provided a preliminary list of potential stream reaches to investigate.

Several criteria were used to select least-impaired streams within the region. Foremost is the lack of major municipal or industrial discharges into the watershed. This was ascertained by consulting USGS 7.5 minute topographic maps of the area and by visually inspecting stream locations during reconnaissance visits. The presence of thick biofilms (sludge) and scent of sewage negated sites from consideration. Another high priority was the presence of an adjacent riparian forest. A third criterion was that streams exhibited a sinuous course, thus providing a variety of depths, habitats, and current speeds for aquatic macroinvertebrates. Streams that had heavily silted bottoms or coarse substrates that were clogged with fine sediment were also avoided for use in this study.

Assemblages Sampled and Ecological Indicators Used: CTAP professional stream biologists use three orders of aquatic insects as indicators of condition: the Ephemeroptera (mayflies), Plecoptera (stoneflies), and Trichoptera (caddisflies) (collectively, EPT taxa). These often contribute the major proportion of the abundance and species richness to the aquatic macroinvertebrate assemblage found in streams. The history and usefulness of EPT taxa was summarized by Lenat and Penrose (1996). Lenat (1988) found that quality ratings based on the EPT index varied predictably across Mountain, Piedmont, and Coastal Plain Ecoregions in North Carolina. Wallace et al. (1996) reported that EPT richness correlated well with several measures of stream ecosystem function (e.g., nutrient processing) and demonstrated that it could assess habitat-specific impact. Barbour et al. (1992) stated that EPT taxonomic richness varied much less than total invertebrate richness, density, or biomass estimates. They concluded that the EPT index was relatively easy to obtain, and that it was one of the simplest indices for non-biologists to use and understand. Additionally, numerical disturbance/pollution tolerance values, indicating relative sensitivities, exist for many EPT taxa resident in the upper Midwest (Hilsenhoff 1987, Barbour et al. 1999).

The INHS has had a long and distinguished history of research on the systematics and ecology of EPT species. State identification manuals exist for all three orders (Burks 1953 for mayflies, Frison 1935 for stoneflies, and Ross 1944 for caddisflies). Most specimens associated with these statewide treatments still reside in the insect collections of the INHS. This allows confirmation of specimens by direct comparison to type or authoritatively identified specimens. Data capture of 710,000 EPT specimens has been completed, permitting a rapid comparison of present data with that collected before the worst degradation of Illinois streams took place. These databases have increased the efficiency of evaluating losses in EPT species across the state (DeWalt et al. 2001, DeWalt et al. 2002). The mayfly and stonefly databases are available at www.inhs.uiuc.edu/cbd/EPT/index.html.

The Hilsenhoff Biotic Index (1987) is a weighted average of the pollution and disturbance tolerance of stream dwelling aquatic insects. It was originally developed for Wisconsin streams, and may be applied in Illinois. The index is as follows:

$$HBI = \sum T_i N_i / N_{i-j}$$

Where T_i is the tolerance value of taxon i, N_i is the abundance of taxon i in the sample, and $N_{i\text{-}j}$ is the sample unit abundance. Taxon tolerances range 0-10, with 10 being the most tolerant. Samples with higher HBI values usually indicate poorer stream quality.

Habitat destruction currently does the most damage to aquatic systems (Karr et al. 1986). Measurements of habitat quality are important in estimating the potential to support healthy aquatic communities in streams. The USEPA (Barbour et al. 1999) designed a standardized stream habitat assessment form for use over a wide area of the country. CTAP has modified this form and scoring criteria for use in Illinois. The current form utilizes a 12 point quality scoring scheme to rate such attributes as riparian cover and zone width, degree of channelization, sedimentation, bank structure, channel sinuosity, and others. Each reference stream reach was evaluated with this standard form, and an overall habitat quality score was developed.

Snapshot values of several water chemistry and physical attributes were collected at each site using a Solomat 520-C multiparameter meter. These included water temperature, dissolved oxygen, pH, and conductivity. Calibration of the meter occurred daily. Parameters were measured in quiet, but flowing, water.

EPT Sampling Methods: Burks (1953), Frison (1935), Ross (1944) and INHS insect collection databases were consulted for information on the phenology of EPT species in the NEMD. Late spring and early summer was accepted as the period to provide the greatest diversity of EPT species. The immature specimens (the object of sampling efforts) would be largely guaranteed to still inhabit streams across Illinois within this time frame.

EPT were sampled using a standardized, semi-quantitative, multi-habitat approach. This approach yields a large proportion of the EPT species richness found in these wadeable streams, while also weighing time spent at each site and resources available for processing of samples. In Illinois streams, the greatest proportion of EPT species inhabit two general habitats: high energy (where water tumbles over substrates) riffles and wood debris dams and low energy (flat water, but with some perceptible current) undercut banks, pools, stands of aquatic vegetation, and smooth water runs. Wood and coarse mineral substrates support similar EPT species, and were viewed as interchangeable. The low energy habitats usually support a subset of the riffle assemblage, dependent upon current speed, but also harbor other EPT fauna, contributing greatly to the overall species richness of the sample reach. Undercut banks provide the bulk of these additional taxa and are the preferred low energy habitat for CTAP EPT sampling. Hence, in most streams, mineral riffles or snags and undercut banks were sampled. Streams lacking these habitats were not considered for characterization.

Two sample units were collected from each habitat class using a heavy-duty, rectangular frame dipnet with dimensions of 34 cm x 45 cm x 0.5 mm mesh size. In order to encompass the variation inherent at each reach, replicate sample units were collected from non-adjacent habitats of the same class. Sampling effort was standardized in high energy habitats by sampling in the the fastest current available. An upstream area encompassing the dimesions of the net was sampled in mineral substrates. Rocks were disturbed and washed into the net. Large rocks were closely inspected for attached caddisflies not dislodged by routine washing. These were removed directly to a sample bottle. Wood riffles were standardized by chosing large wood pieces, 2-10 cm in diameter, with an accumulated length approaching 3 m. Leaf packs associated with wood were not partitioned. The net was used to trap any drifting EPT as wood was being gathered. Wood was inspected by hand to remove all small and/or delicate taxa to a sample bottle. Larger debris were washed and discarded until a relatively small volume remained in the net.

Two bank samples were collected in perceptible current, where the exposed roots of trees or grasses protruded. The dipnet was thrust from the bottom of the bank, up to the water line, in a vigorous fashion. A sample unit consisted of approximately 10 such thrusts. Aquatic vegetation samples consisted of submerged or emergent vascular plants in flowing water pulled from a 34 cm x 45 cm area. Vegetation was stored in the net for latter inspection. Kicking of sediment in the sample area dislodged burrowing EPT.

Sample processing, identification, and vouchering of specimens: Sample units from all habitats were field picked alive and specimens stored in 80% EtOH for preservation. All EPT specimens were identified to species where possible, stored in separate vials, and labeled with the appropriate location data. These were deposited in the INHS insect collection and included in the EPT database.

Statistical Analysis: A single, composite sample was computer generated from all habitats sampled. This provided a wholistic look at the taxa present at a site. EPT richness and HBI score were developed and paired with habitat quality and physico-chemical variables. These reference data were directly compared to NEMD CTAP data from random sites.

Due to some problems with normality, a Wilcoxon 2-sample test, employing a normal approximation (Z score) with a continuity correction of 0.5, was used to assess differences between reference and random sites. (SAS 1985). A Spearman Rank correlation analysis was conducted to evaluate relationships among several variables in the data matrix including latitude, longitude, and several taxonomic richness measures.

RESULTS

The 10 reference quality sample reaches used during the study are presented in Table 1 and displayed geographically in Fig. 1. Streams were nearly equally distributed among the Des Plaines, Fox, and Rock rivers. They occurred within five of the nine counties found in the NEMD. Most streams were less than 5 m across, but two, the Kishwaukee River at Morengo and the South Branch of the Kishwaukee near Cherry Valley, were > 10 m across. Ten randomly chosen CTAP stream sites existed in the region. They were also distributed across the same five counties as the reference locations. Small stream were predominant, but one site occurred on the Fox River at East Dundee. One randomly chosen site, Ferson Creek was of reference quality and was removed from the random list and added to the reference list for this analysis.

Table 1. Reference and random stream locations in the NE Morainal Natural Division of Illinois. Site identification codes are provided for random sites.

Stream	County	Location	Drainage	Latitude	Longitude
Reference Sites					
Kishwaukee River #1	McHenry	1.5 km NW Crystal Vista	Rock	42.2503	-88.3842
Kishwaukee River #2	McHenry	1.5 km N Morengo	Rock	42.2650	-88.6080
S Banch Kishwaukee River	Winnebago	6 km S Cherry Valley	Rock	42.1802	-88.9503
S Kinnikinnick Creek	Winnebago	5.2 km E Roscoe	Rock	42.4121	-88.9476
Ferson Creek	Kane	3 km NE Rainbow Hills	Fox	41.9333	-88.3401
Jackson Creek	Will	3 Km WNW Elwood	Des Plaines	41.4117	-88.1425
Plum Creek #1	Will	5 km SE Crete	Des Plaines	41.4069	-87.5963
Plum Creek #2	Will	6.5 km E Crete	Des Plaines	41.4504	-87.5544
Trib. Brewster Creek	Du Page	2.5 km NE Valley View	Fox	41.9790	-88.2687
Tyler Creek	Kane	5 km WNW Elgin	Fox	42.0567	-88.3389

Table 1. Continued.

Stream	County	Location	Drainage	Latitude	Longitude
Random Sites					
006802S Kishwaukee River	McHenry	6.2 km SE Woodstock	Rock	42.2718	-88.3993
001401S Sequoit Creek	Lake	1.2 km SW Antioch	Fox	42.4817	-88.1050
023001S Long Run	Will	3 km S Lemont	Des Plaines	41.6428	-87.9984
018401S Blackberry Creek	Kane	9 KM S Elburn	Fox	41.8135	-88.4739
011403S Fox River	Kane	East Dundee	Fox	42.0978	-88.2756
015601S Willow Creek	Cook	Rosemont	Des Plaines	41.9901	-87.8613
006401S Bull Creek	Lake	Libertyville	Des Plaines	42.3065	-87.9689
028102S Butterfield Creek	Cook	Olympia Fields	Des Plaines	41.5119	-87.6958
031103S N Br. Rock Creek	Will	3 km SSW Monee	Kankakee	41.3929	-87.7579
027901S Plum Creek	Cook	3 km E Sauk Village	Des Plaines	41.4848	-87.5293

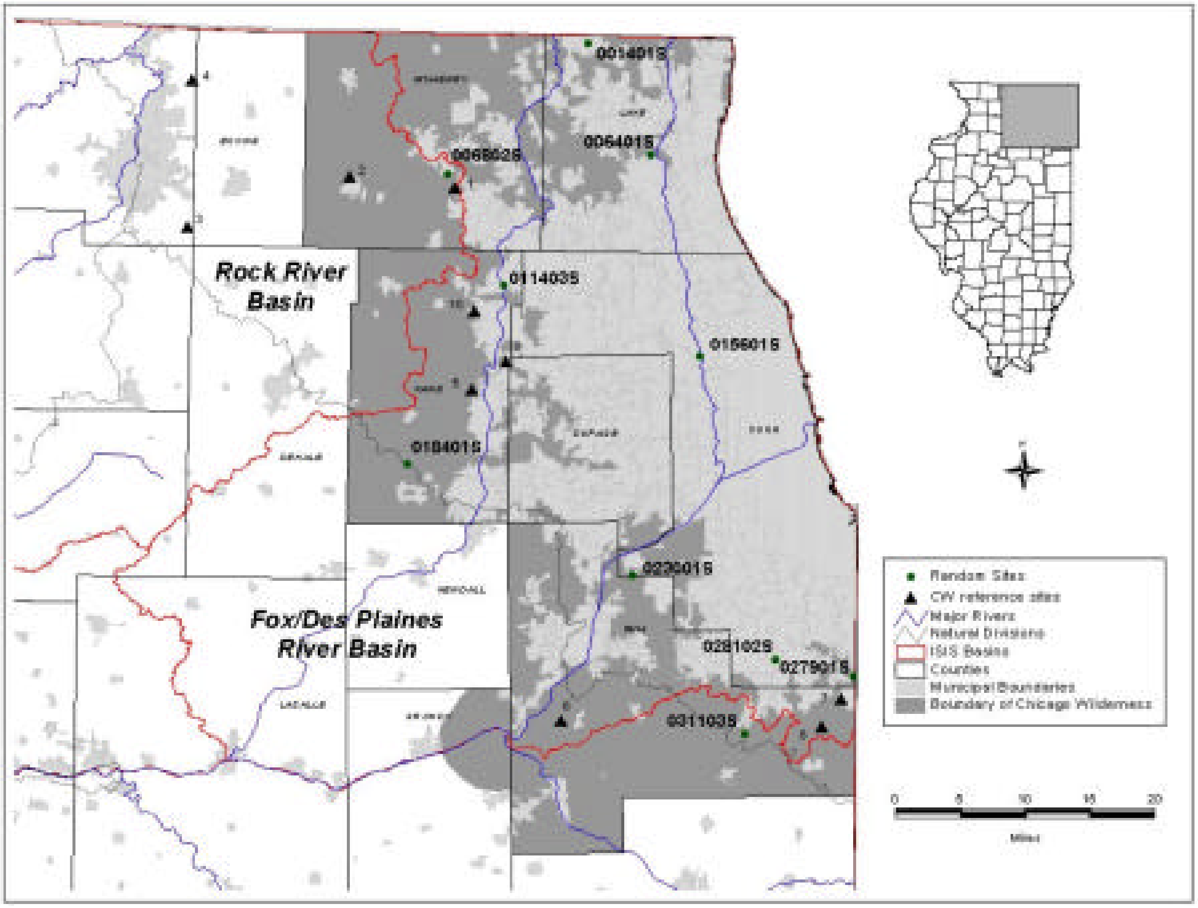

Fig. 1. Reference and random stream locations in Northeastern Morainal Natural Division of Illinois.

Water Temperature and Chemistry: It was impossible to standardize stream temperature readings by time of day, hence much of the variation in this parameter is likely attributable to that factor alone. There were no differences in temperature between reference and random sites (Z=-0.64, p=0.52). Nearly all stream were classified as "warm-water" (Table 2). However, the South Branch of Kinnikinnick Creek demonstrated marked departure from the temperatures of all other streams. It is probably best characterized as a "cool-water" stream.

Dissolved oxygen concentration varied greatly across both reference and random streams and was not found to be significantly different across stream types (Z=0.22, p=0.82). Most streams were not fully saturated with oxygen (Table 2). Plum Creek #1 provided the lowest percentage saturation, 58.8%, for a reference stream. The source of this relative hypoxia is not known, but an upstream beaver pond may have trapped enough locally-derived organic matter to drive oxygen concentrations downward. Conversely, the Brewster Creek tributary and the upstream-most segment of the Kishwaukee River exhibited supersaturated conditions. The riparian zone was most open at these reference locations, facilitating photosynthesis. Butterfield Creek, at 54.2% saturation, had the lowest value for a randomly chosen stream site. The Fox River was highly supersaturated due to physical aeration below a low-head dam in East Dundee.

pH was always basic in NEMD streams (Table 2). Significantly higher pH values were found in random streams (Z=2.04, p=0.04). Reference streams were more heavily forested than random ones, which leads to less photosynthesis, a physiological process that elevates pH. Conductivity was significantly higher in randomly chosen streams (Z=3.42, p=0.0006). These sites were much more heavily influenced by human disturbance that leads to conductivities elevated above regional background levels (Table 2).

Table 2. Comparison of in-situ water parameters measured at 10 reference quality and 10 randomly chosen streams in the NE Morainal Natural Division of Illinois. Blank cells indicate missing data points, due to equipment failure.

Stream	**Temp (C)**	**DO_2**	**% Sat DO2**	**pH**	**Cond (µS/cm)**
Reference Sites					
Kishwaukee River #1	12.0	11.7	108.1	7.24	705.0
Kishwaukee River #2	21.0	6.9	76.6	7.50	757.2
S Branch Kishwaukee River	24.1	7.9	92.5	7.82	590.5
S Kinnikinnick Creek	11.2	7.9	70.9	7.46	471.0
Ferson Creek	15.2	8.2	81.4	7.38	685.5
Jackson Creek	19.3	7.9	83.9	7.43	568.4
Plum Creek #1	18.6	5.6	58.8	7.26	605.5
Plum Creek #2	23.1	6.7	77.0	7.44	681.9
Trib. Brewster Creek	21.9	10.2	116.3	7.48	740.4
Tyler Creek	19.7	8.3	89.4	7.02	560.1
Averages	18.51	8.15	85.49	7.41	628.79
Random Sites					
006802S Kishwaukee River	21.4	.	.	.	.
001401S Sequoit Creek	23.3	.	.	.	.
023001S Long Run	15.8	7.7	77	7.31	747
018401S Blackberry Creek	14.3	9.7	93.3	7.75	759
011403S Fox River	19.2	12.4	131.9	8.48	765
Stream	**Temp (C)**	**DO_2**	**% Sat DO2**	**pH**	**Cond (µS/cm)**
015501S Willow Creek	13.4	8.98	85.5	7.45	1111.4
006401S Bull Creek	15.7	7.36	72.9	7.48	1150.2
028102S Butterfield Creek	17.2	5.26	54.2	7.67	1317.3
031103S N Br. Rock Creek	19.1	9.96	106	7.88	1122.3
027901S Plum Creek	17.8	7.58	79.8	7.85	1051.6
Averages	17.72	8.62	88.58	7.73	1002.98

In-Stream and Riparian Habitat Quality: Significant differences in habitat quality existed between reference and random stream reaches (Figs. 2 and 3, Z=-2.80, p=0.0051). The mean value (± standard deviation) for reference streams was 131.3 ± 17.6 units out of a possible 180. Randomly selected streams scored only 95.9 ± 28.4 units. Differences between the two resulted from loss or narrowing of a treed riparian zone, channelization of the stream (6 of 10 random sites were channelized), and erosion of banks.

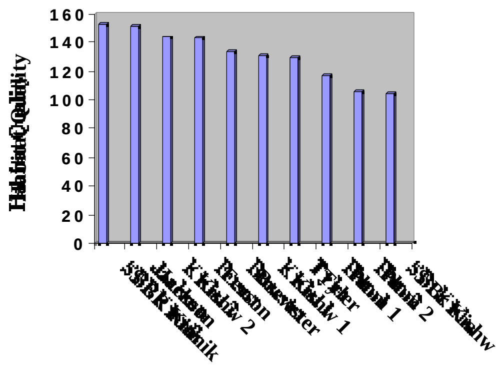

Fig. 2 Habitat quality scores for reference streams in the NE Morainal Division of Illinois.

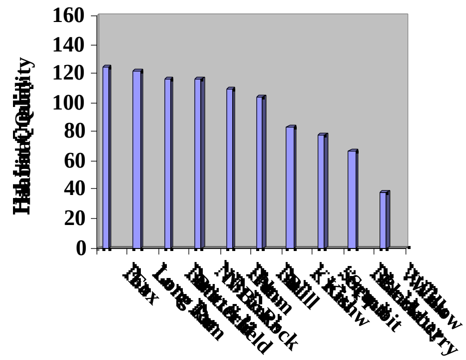

Fig. 3 Habitat quality scores for CTAP randomly chosen streams in the NE Morainal Division of Illinois.

<u>EPT and HBI Scores:</u> A total of 7,720 EPT specimens, comprising 55 species across 18 families occurred in reference stream samples (Appendix 1). EPT richness was significantly greater in reference streams than in CTAP randon streams (Figs. 4 and 5, Z=-3.23, p=0.001). Reference streams averaged 15.5 ± 5.23 taxa, while random streams averaged only 7.1 ± 3.90 taxa. Most of this difference was due to addition of mayfly and caddisfly taxa, both found to be significantly greater in reference streams (Z=-2.32 to -2.90, p=0.02 to 0.004, respectively). Stonefly taxa constituted a minor component of the EPT index and no significant differences between classes were detected (Z=-1.81, p=0.07). Reference streams with the greatest EPT richness were the South Branch of the Kishwaukee River near Cherry Valley and Ferson Creek near Rainbow Hills (Fig. 4). Plum Creek of the random grouping had the highest EPT, while Willow Creek at Rosemont supported no EPT whatsoever.

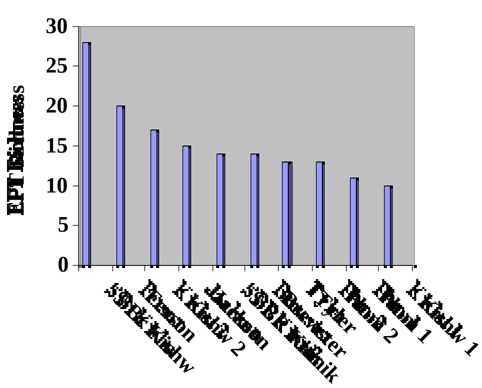

Fig. 4. EPT richness for reference streams in the NE Morainal Division of Illinois.

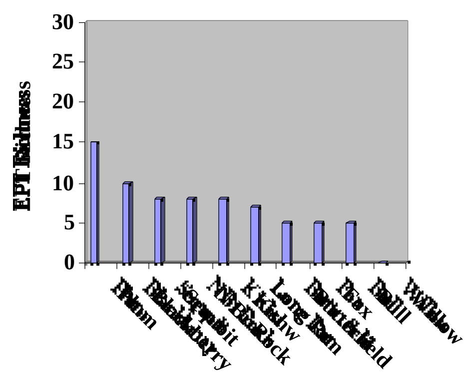

Fig. 5 EPT richness for CTAP randomly chosen streams in the NE Morainal Division of Illinois.

Stream size appeared to be a significant predictor of EPT richness in reference streams (Fig. 6). No such relationship existed for randomly selected streams (R=-0.35, p=0.32).

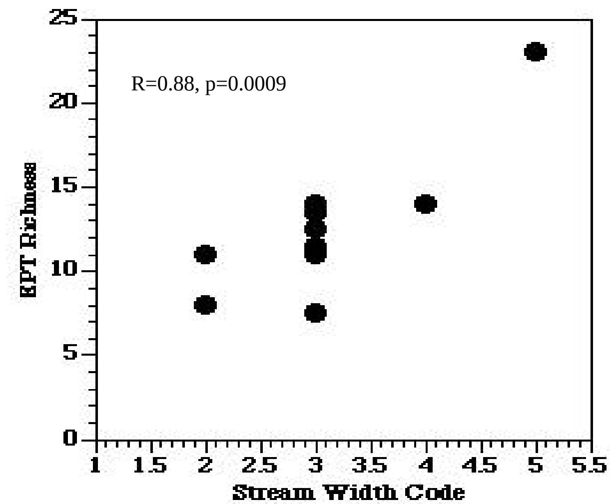

Fig. 6. EPT richness versus stream width code for refence streams in the NEMD of Illinois.

HBI values averaged much lower for reference streams (4.87 ± 0.67 units) than for random streams (5.50 ± 0.78 units), indicating that reference streams were less disturbed, or impacted, than random ones (Figs. 7 and 8). However, no significant differences were detected to high variance within classes (Z=1.67, p=0.09).

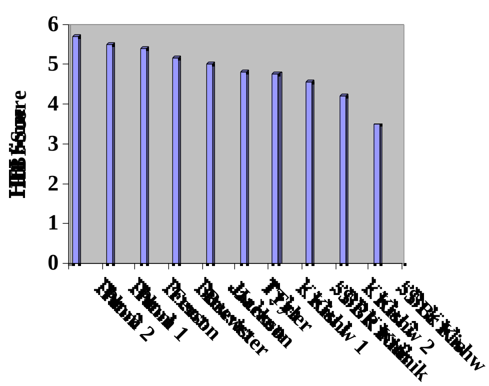

Fig. 7. I for reference streams in the NE Morainal Division of Illinois.

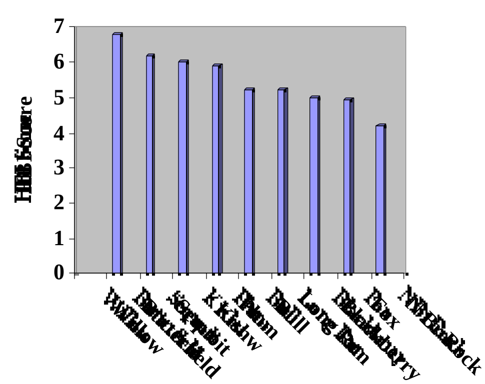

Fig. 8. HBI for CTAP randomly chosen streams in the NE Morainal Division of Illinois.

A Spearman Rank Correlation using reference data suggested that HBI was heavily influenced by proximity to metropolitan areas. Figs. 9 and 10 demonstrated a strong correlation with both latitude and longitude. No such correlation existed for HBI versus latitude (R=0.31, p=0.4, n=9) and longitude(R=-0.22, p=0.58) from random sites.

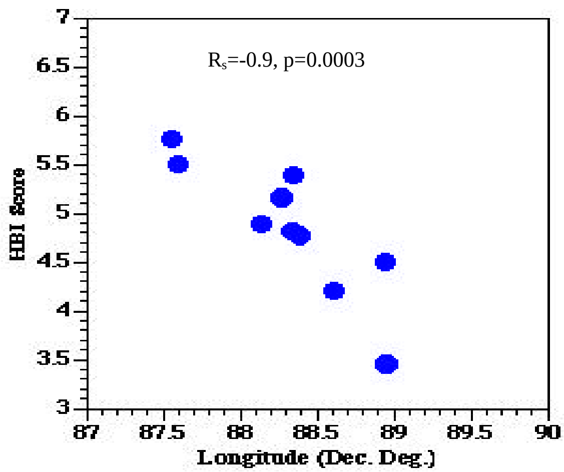

Fig. 9. Scatterplot of HBI scores with longitude for 10 reference streams in the NE Morainal Natural Division of Illinois. Coefficients of determination and probabilities are provided.

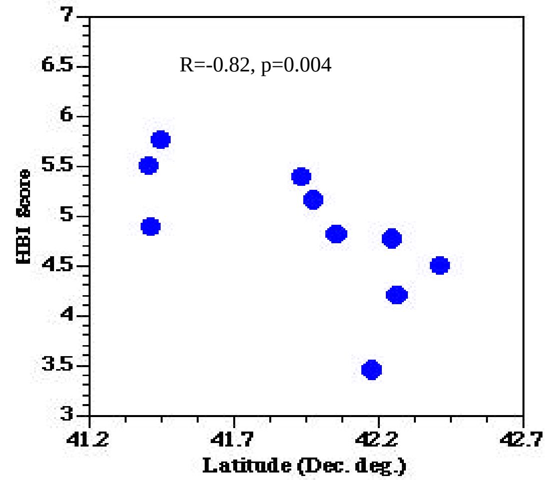

Fig. 10. Scatterplot of HBI scores with latitude for 10 reference streams in the NE Morainal Natural Division of Illinois. Coefficients of determination and probabilities are provided.

Stream size was negatively correlated with HBI score for reference streams (Fig. 11)—HBI decreased as streams became larger. No such relationship existed for randomly selected streams (R=-0.14, p=0.73).

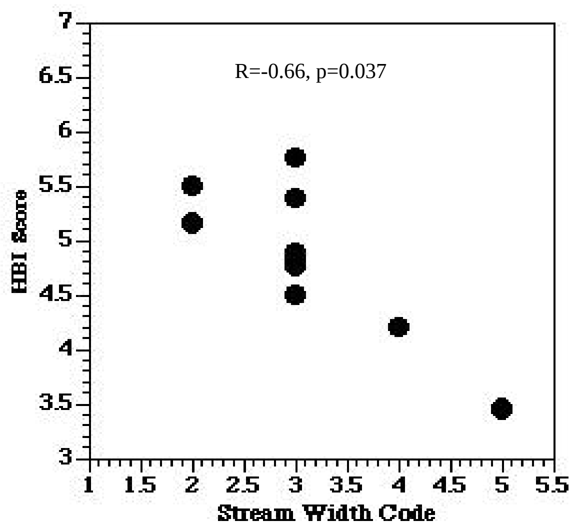

Fig. 11. HBI score versus stream width code for reference streams in the NEMD of Illinois.

DISCUSSION

Reference stream characteristics in the NEMD were different from randomly chosen sites. EPT and HBI were correlated with physical and geographic factors; relationships not found for randomly chosen streams. One assumption is that, due to greater overall degradation, normal factors controlling EPT communities no longer preside.

Reference stream characteristics help to put randomly chosen streams into the context of a stream quality classification system. Additionally, relationships of EPT and HBI to stream size necessitate some stratification of the data upon which this classification is built. Streams were rated on the basis of three parameters, EPT, HBI, and habitat quality. These were folded into a multimetric index, with some weighting criteria, for establishing an overall quality rating for randomly selected streams in the region.

EPT Rating: Reference stream data for this parameter were stratified by stream size. Those with width code ≥4 (>10 m across) were considered large streams, while the rest were considered small streams. A scale was developed using the mean as the cutoff point for excellent EPT richness and one to three standard deviation units less than the mean to accommodate good, fair, and poor categories (Fig. 12). According to this scale, >75% of randomly chosen small streams supported fair-to-poor EPT assemblages. The lone large, random stream, Fox River at East Dundee, scored well below the average for large streams in the region and should be rated as poor.

HBI Rating: Although no significant differences occurred between random and reference sites with this parameter, mean differences were great. A rating scale is presented, but caution is suggested in its use. Less weight should be given to this parameter in producing an overall quality score. HBI was stratified by stream size—small and large streams. This score increases with degradation, and the direction of the scale for assigning quality ratings follows suit (Fig. 13). HBI appears to be less sensitive than the EPT index in that approximately 50% of all random locations scored in the fair and poor quality ranges. Fully 25% of all sites scored in the excellent category.

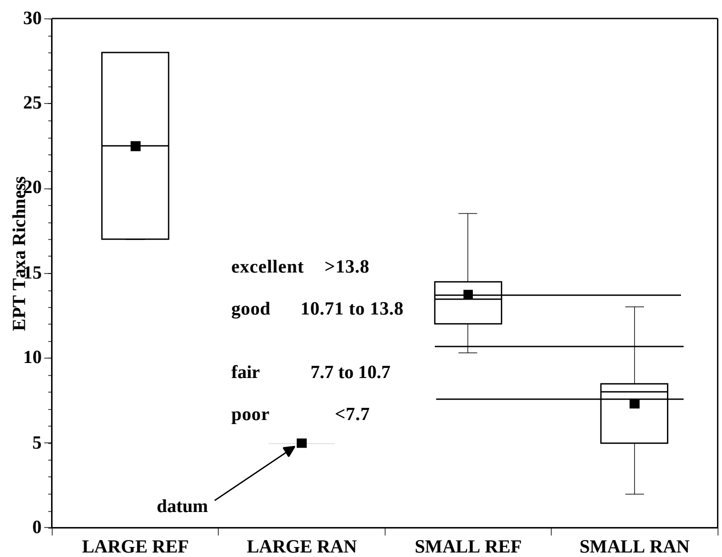

Fig. 12. EPT richness for reference and random sites within the NEMD in Illinois. Box plots indicate 90th, 75th, 50th, 25th, and 10th percentiles along with the mean (solid square). Horizontal bars indicate suggested qualitative ratings cutoffs calculated using the mean and above as excellent and lower quality classes as one, two, and three standard deviations less than the mean.

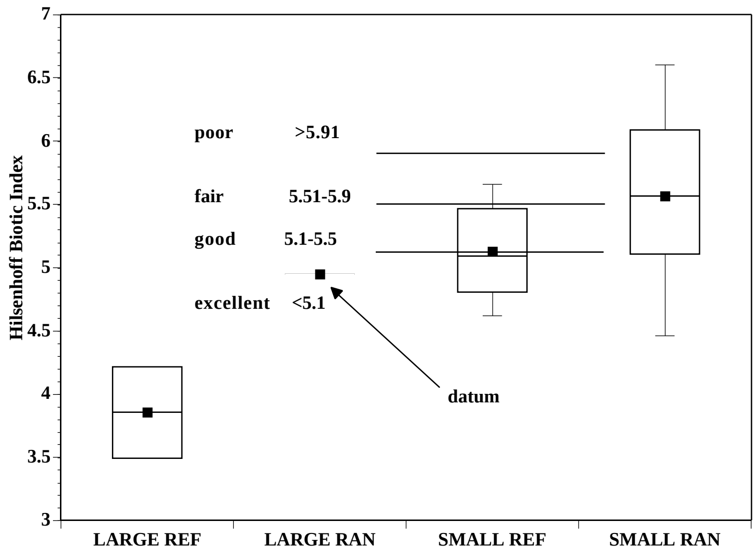

Fig. 13. HBI score for reference and random sites within the NEMD in Illinois. Note that value of this index increases with increase disturbance of watersheds. Box plots indicate 90th, 75th, 50th, 25th, and 10th percentiles along with the mean (solid square). Horizontal bars indicate suggested qualitative ratings cutoffs calculated using the mean and below as excellent and lower quality classes as one, two, and three standard deviations above the mean.

Habitat Quality: This parameter displayed no relationship to stream size; hence, no stratification is necessary. Approximately 60% of all randomly chosen stream sites scored in the fair and poor quality ranges (Fig. 14). None displayed excellent habitat quality. Habitat quality appears equilivent to EPT in its sensitivity for rating stream quality.

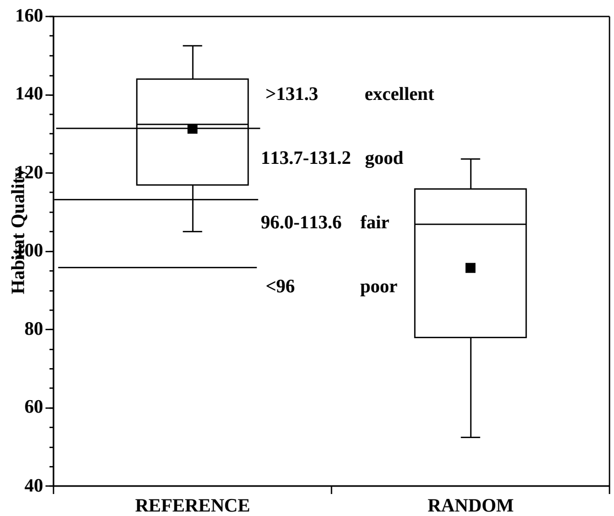

Fig. 14. Habitat quality for reference and random sites within the NEMD in Illinois. Box plots indicate 90th, 75th, 50th, 25th, and 10th percentiles along with the mean (solid square). Horizontal bars indicate suggested qualitative ratings cutoffs calculated using the mean and above as excellent and lower quality classes as one, two, and three standard deviations less than the mean.

A Multimetric Index: Quality ratings now exist for each site based on three parameters, when a single multimetric measure that can be converted to a quality rating is desirable. Development of an overall rating was accomplished for each site by assigning an integer value for each parameter such that Excellent = 1, Good = 2, Fair = 3, Poor = 4. Since EPT and habitat seemed to be more sensitive indicators of disturbance than did HBI score, they were weighted more heavily: EPT and habitat at 0.4 and HBI at 0.2. These weights were used to calculate an average overall quality score ranging from one and four (Table 3). Conversion back to a qualitative rating was accomplished using the scale shown in Fig. 15. Hence, every random site in the NEMD was given an overall quality rating. Percentages of streams falling into each category could then be calculated (Fig. 16). Overall, 80% of randomly chosen streams in the region were found to be of either fair or poor condition, while only 20% were of good quality.

Fig. 15. Overall rating scale for conversion of numerical multimetric index into a quality category for streams in the NEMD of Illinois.

Table 3. Calculation of multimetric index and overall quality rating for randomly chosen streams in NEMD of Illinois.

Stream	**EPT(0.4)**	**HBI(0.2)**	**Habitat(0.4)**	**Overall**	**Rating**
Blackberry	3	1	4	3	Fair
Bull	4	2	3	3.2	Fair
Butterfield	4	4	2	3.2	Fair
Fox	4	2	2	2.8	Fair
Kishwaukee	3	4	4	3.6	Poor
Long Run	4	2	2	2.8	Fair
N Br. Rock	3	1	2	2.2	Good
Plum	1	3	3	2.2	Good
Sequoit	3	4	4	3.6	Poor
Willow	4	4	4	4	Poor

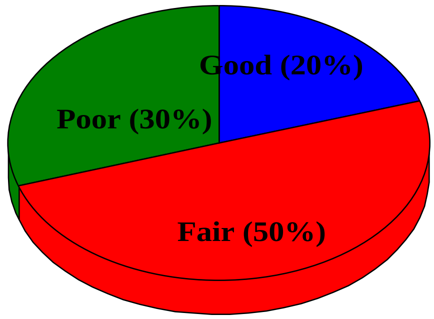

Figure 16. Distribution of overall quality ratings for randomly chosen stream sites in the NEMD of Illinois.

CONCLUSIONS

Reference quality streams still exist in the NEMD as isolated small streams and a few larger water courses. The condition of these streams appears to improve with distance from metropolitan areas and with an increase in size. Specifically, reference streams to the west and north of the greater Chicago area were of better condition as evidenced by lower HBI scores. It appears that no streams within metropolitan areas remain as suitable for characterizing reference condition.

It was apparent that even these reference streams had experienced degradation, but that they had perhaps recovered from previous insults or had not experienced degradation to the same extent as the random locations. Very few truly sensitive EPT taxa were found during the entire study. With the exception of perhaps the South Branch of the Kishwaukee River, high EPT richness was the result of widespread species establishing local populations. HBI values were relatively high even when EPT richness was high. This was especially so in smaller streams. Historically abundant taxa like *Neoperla* and *Acroneuria*, two genera of perlid stoneflies, no longer existent in this region. It may take a long time for these taxa to recolonize streams in the region because source streams are separated from rehabilitated streams by a veritable desert of uninhabitable streams. Zwick (1992) discusses these fragmented aquatic systems as major impediments to recolonization of rehabilitated streams.

The reference data now allow for interpretation of any small stream reach sampled by CTAP methods within the NEMD. Randomly chosen streams in the region were mostly of fair to poor quality based on EPT, HBI, and habitat quality. Two “good” streams, Plum Creek in Cook County and the North Branch of Rock Creek in Will County, were found either in or near public lands and should be protected in hopes that their quality can be maintained. Blackberry Creek (remeander, widen buffer and plant some trees), Bull Creek (reduce urban runoff), and Long Run (reduce sedimentation and urban runoff) could be better protected and their quality improved. Bull Creek had a unique fauna composed chiefly of *Rhyacophila*, a predaceous caddisfly. Reaches below this area provide good habitat, but urban runoff from Libertyville may be degrading the sampled reach. Large, reference quality streams still cannot be adequately characterized as only two sites were sampled. It is suggested that portions of the upper Des Plaines River at the Wisconsin border, a branch of the Du Page River, and possibly an additional site on the lower Kishwaukee River might provide reference conditions. I will attempt sampling of these locations at a future date to improve CTAP's ability to rate streams in the region.

The proportion of streams in poor condition in the region is disturbing. A random sampling design for CTAP was adopted in order to derive inference about the condition of habitats not sampled. This sampling program adequately assesses streams on a broad scale; therefore, it is assumed that most streams in the region are in fair-to-poor condition.

ACKNOWLEDGEMENTS

This work was sponsored by the Conservation 2000 program of the Illinois Department of Natural Resources in conjunction with Chicago Wilderness. Thanks to Brenda Molano-Flores and Greg Spyreas, both of the Critical Trends Assessment Program professional monitoring group at the INHS, for reviewing an earlier draft of this document. Thanks are due to Cassie Connor and Vanessa Block for help with fieldwork.

LITERATURE CITED

Barbour, M. T., J. Gerritsen, B. D. Snyder and J. B. Stribling. 1999. Rapid Bioassessment Protocols for Use in Streams and Wadeable Rivers: Periphyton, Benthic Macroinvertebrates and Fish, Second Edition. EPA 841-B-99-002. U. S. Environmental Protections Agency; Office of Water; Washington, D. C.

Barbour, M. T., J. L. Plafkin, B. P. Bradley, C. G. Graves, and R. W. Wisseman. 1992. Evaluation of the EPA's rapid bioassessment benthic metrics: Metric redundancy and variability among reference stream sites. Environmental Toxicology and Chemistry 11: 437-449.

Burks, B. D. 1953. The mayflies, or Ephemeroptera, of Illinois. Illinois Natural History Survey Bulletin 26: 1-216.

Chicago Wilderness. 1999. Biodiversity Recovery Plan. Chicago Wilderness. 190 pp.

DeWalt, R. E., D. W. Webb, and A. M. Soli. 2002. The *Neoperla clymene* (Newman) complex (Plecoptera: Perlidae) in Illinois, new state records, distributions, and an identification key. Proceedings Entomological Society of Washington 104:

DeWalt, R. E., D. W. Webb, and T. N. Kompare. 2001. The *Perlesta placida* (Hagen) complex (Plecoptera: Perlidae) in Illinois, new state records, distributions, and an identification key. Proceedings Entomological Society of Washington 103: 207-216.

Frison, T. H. 1935. The stoneflies, or Plecoptera, of Illinois. Illinois Natural History Survey Bulletin 20: 281-467.

Hilsenhoff, W. L. 1987. An improved biotic index of organic stream pollution. Great Lakes Entomologist 20: 31-39.

Hughes, R. M., S. A. Heiskary, W. J. Matthews, and C. O. Yoder. 1994. Use of ecoregions in biological monitoring, pp. 125-151. In: Biological Monitoring of Aquatic Systems, S. L. Loeb, and A. Spacie, eds. Lewis Publishers, Boca Raton. 381 pp.

Illinois Environmental Protection Agency. 2000. Illinois Water Quality Report. IEPA/BOW/00-005, Springfield, Illinois.

Illinois Environmental Protection Agency. 1996. Surface Water Monitoring Strategy. IEPA/BOW/96-062, Springfield, Illinois.

Illinois Department of Natural Resources. 2001. Critical Trends in Illinois. IDNR, Office of Realty and Environmental Planning and Office Scientific Research, Division Illinois Natural History Survey.

Karr, J. R., K. d. Fausch, P. L. Angermeier, P. R. Yant, and I. J. Schlosser. 1986. Assessing biological integrity in running waters: a method and its rationale. Illinois Natural History Survey Special Publication 5. 28 p.

Lenat, D. R. 1988. Water quality assessment of streams using a qualitative collection method for benthic macroinvertebrates. Journal North American Benthological Society 7: 222-233.

Lenat, D. R., D. L. Penrose. 1996. History of the EPT taxa richness metric. Bulletin North American Benthological Society 13: 305-307.

Page, L. M, K. S. Cummings, C. A. Mayer, S. L. Post, and M. E. Retzer. 1992. Biologically Significant Illinois Streams: An Evaluation of the Streams of Illinois Based on Aquatic Biodiversity. Technical Report No. 1992(1), Illinois Natural History Survey, Champaign, Illinois. 485 pp.

Ross, H. H. 1944. The caddis flies, or Trichoptera, of Illinois. Illinois Natural History Survey Bulletin 23: 1-326.

Statistical Analysis System. 1985. SAS User's Guide: Statistics, ver. 5. SAS Institute, Inc., Cary, North Carolina. 597 pp.

Schwegman, J. E., Fell, G. B., M. Hutchinson, W. M. Shepherd, G. Paulson, J. White. 1973. Comprehensive Plan for the Illinois Nature Preserves System, Part 2, the Natural Divisions of Illinois. Illinois Nature Preserves Commission.

Sullivan, J. 1997. Chicago Wilderness: An Atlas of Biodiversity. Chicago Region Biodiversity Council. 64 pp.

Wallace, J. B., J. W. Grubaugh, and M. R. Whiles. 1996. Biotic indices and stream ecosystem processes: results from an experimental study. Ecological Applications 6: 140-151.

Zwick, P. 1992. Stream habitat fragmentation – a threat to biodiversity. Biodiversity and Conservation 1: 80-97.