Article 21

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Habitat and Biological Impairment In Delaware Headwater Streams

As part of a comprehensive watershed management demonstration study, John Maxted and his colleagues at Delaware's Department of Natural Resources and Environmental Control (DNREC) examined the effects of urban stormwater runoff on non-tidal headwater streams in Delaware's Coastal Plain and Piedmont ecoregions using a variety of biological and physical habitat assessments. Maxted and his colleagues selected headwater streams for three primary reasons. First, headwater streams are arguably the narrowest window receiving urban stormwater runoff and are not usually exposed to impacts from other sources (i.e., industrial or sewage treatment plant discharges). Second, the biological and physical habitat characteristics of headwater streams are reasonably well understood and amply documented in the literature. Third, most non-tidal waterway systems are made up of headwater streams. So targeted protection and restoration of these sensitive water resources will, by default, provide a level of protection to downstream and watershed resources.

Biological and habitat monitoring methods were selected over more traditional chemical monitoring due to the intermittent and varied nature of stormwater runoff. Unlike steady-state flows, used in the analysis of point-source discharges, stormwater events range in frequency, duration, and magnitude and produce varied, and often statistically random, responses of pollutant concentrations. Furthermore, although the states and U.S. EPA have developed pollutant concentration criteria for many pollutants, there are no criteria for many of the most common stormwater pollutants. Therefore, chemical constituent monitoring may yield results of little practical use due to the absence of a standard. In fact, Delaware's 1994 305(b) Report indicated that 87% of the State's non-tidal streams supported the designated life uses based on chemical measures (primarily dissolved oxygen exceedance criteria); whereas if biological and habitat assessments were included, just the opposite was true, and only 13% of the state's non-tidal waters supported designated life uses. This same phenomena was observed by Ohio EPA in 1991 where approximately 50% of that State's waters were identified as impaired when using biological assessments versus approximately 3% when using chemical monitoring alone (Rankin, 1991).

Biological monitoring was conducted using macroinvertebrates as indicators of stream system quality at 42 Coastal Plain sites and 38 Piedmont sites. Macroinvertebrates have varying life stages from a few months to several years, are relatively immobile, and are therefore good tools for assessing both long term and short term impacts in streams. The following three biological measurements were conducted to quantify

Table 1: Macroinvertebrate Community Measurements Used by Delaware Dept of Natural Resource and Environmental Control (Shaver *et al.*, 1995)

Metric Name	Description	Type
Taxa richness	Total # of unique taxa	Richness
EPT richness*	Total # of EPT taxa	Richness/tolerance
% EPT abundance	% of sample that are EPTs	Tolerance/composition
% dominant taxon	Largest % of a single taxon	Composition
%Chironomidae**	% of sample from this group	Tolerance
Biotic index	Composite tolerance by taxon	Tolerance

* EPT consists of the orders ephemeroptera (mayflies), plecoptera (stoneflies), and trichoptera (caddisflies) (considered among the most pollutant sensitive macroinvertebrate species)

** Chironomidae consists of the family of midges (considered among the most pollutant tolerant macroinvertebrate species)

Table 2: Results of Biological Assessment using Selected Macroinvertebrate Data from the Coastal Plain and Piedmont Ecoregions (Shaver *et al.*, 1995)
Sensitivity of Biological Metrics by Condition and Ecoregion (mean values at genus level)

Ecoregion/ Condition	# of Sites	TR	EPT	%EPT	%Midge	%DT
Coastal Plain						
Good	22	29	8	36.5	24.6	21.9
Fair	17	25	4	16.1	29.1	25.1
Poor	3	20	2	3.0	79.9	30.4
Piedmont						
Good	13	23	10	67.8	9.1	32.2
Fair	19	21	5	322.2	20.5	24.6
Poor	6	17	3	15.1	32.8	35.9

TR = Taxonomic richness; EPT = EPT richness; %EPT = Percent EPT abundance; %Midge = Percent chironomidai;
% DT = Percent dominant taxon

the condition of the macroinvertebrate communities based on the principals of EPA's Rapid Bioassessment Protocols (Plafkin, 1989):

- Species richness or diversity measures in terms of total number and redundancy of unique taxa
- Community tolerance measures in terms of which organisms are indicators of polluted conditions versus high quality and stable conditions
- Composition measurements in terms of the structural makeup of the community

The measurements used to evaluate the macroinvertebrate community are identified in Table 1. Table 2 illustrates the results of the biological monitoring conducted in the Coastal Plain and Piedmont. The data revealed that sites rated as biologically "poor" had reduced total diversity, reduced diversity and abundance of sensitive species, increased abundance of organisms considered pollutant tolerant, and reduced community composition.

Physical habitat measurements were also conducted for both the Coastal Plain and Piedmont ecoregions using various parameters. These measures included assessments in the following four broad areas: general characteristics, instream measures, stream bank measures, and riparian zone measures. The specific type of measures are shown in Table 3. Physical habitat scores designating "poor" habitat conditions were those that lacked stable submerged habitats, had eroded and unvegetated banks, and had impacted floodplains or riparian zones.

Maxted's team also conducted a paired analysis of biological and habitat conditions. Macroinvertebrates and habitat data were collected at 40 sites in the highly urbanized, Northern Piedmont ecoregion of Delaware. The results, as illustrated in Figure 1, support a direct correlation between habitat quality and biological quality and indicate that the majority of non-tidal streams studied are biologically degraded. The results further suggest that the leading contributor to habitat degradation is urban runoff.

The final element of the monitoring study supports the now well documented assertion that, as the level of watershed imperviousness exceeds certain thresholds, biological community degradation occurs. A preliminary analysis of 19 sites (again in the Delaware Northern Piedmont) showed biological quality impairments occurring between eight and 15% imperviousness. The results also suggest that additional research is needed to examine whether or not the use of stormwater treatment practices can push this degradation threshold to a point where healthy biological communities can be supported with higher levels of imperviousness (see Figure 2). Obviously, this important question is one that needs to be answered to help assess the success of stormwater management programs.

Maxted's approach is clearly an adaptable, cost effective application of a biologically based monitoring effort which assesses levels of aquatic degradation, and helps identify the causes and sources of these impacts. This same protocol, or other similar methods can be repeated in other regions and climates with only minor adaptations.

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Table 3: Measures Used to Assess Habitat Quality (Shaver *et al.*, 1995)			
Northern Piedmont Ecoregion	**Area of Assessment**	**Coastal Plain Ecoregion**	**Area of Assessment**
Channel modification	General	Channel modification	General
Instream habitat	Instream	Instream habitat	Instream
Bank stability	Streambank	Bank stability	Streambank
Bank vegetative type	Streambank	Bank vegetative type	Streambank
Shading	Riparian	Shading	Riparian
Riparian zone width	Riparian	Riparian zone width	Riparian
Velocity/depth ratio	General	Pools	Instream
Sediment deposition	Instream		
Embeddedness	Instream		
Riffle quality	Instream		
Riffle quantity	Instream		

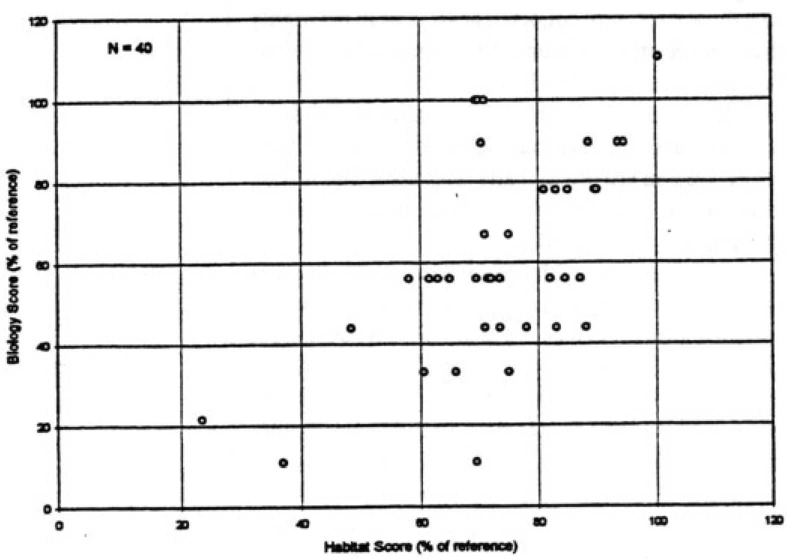

Figure 1: Relationship Between Habitat and Biological Quality in Delaware's Piedmont Ecoregion

References

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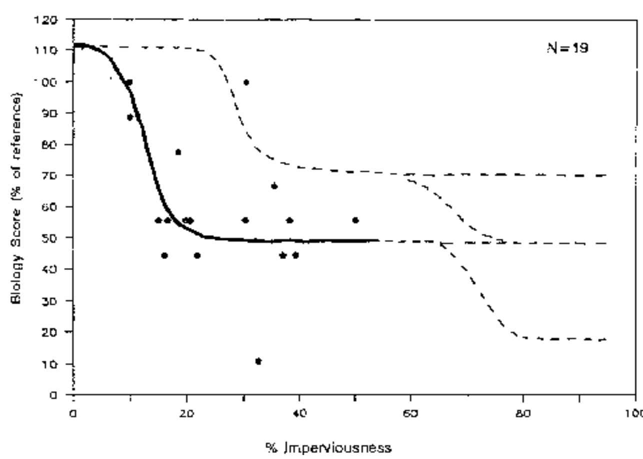

Dashed line shows potential curve shift using stormwater practices and assuming stream protection measures.

Figure 2: Effect of Watershed Imperviousness on Biologic Integrity Within the Northern Piedmont Ecoregion of Delaware, 1993 (Shaver *et al.*, 1995)