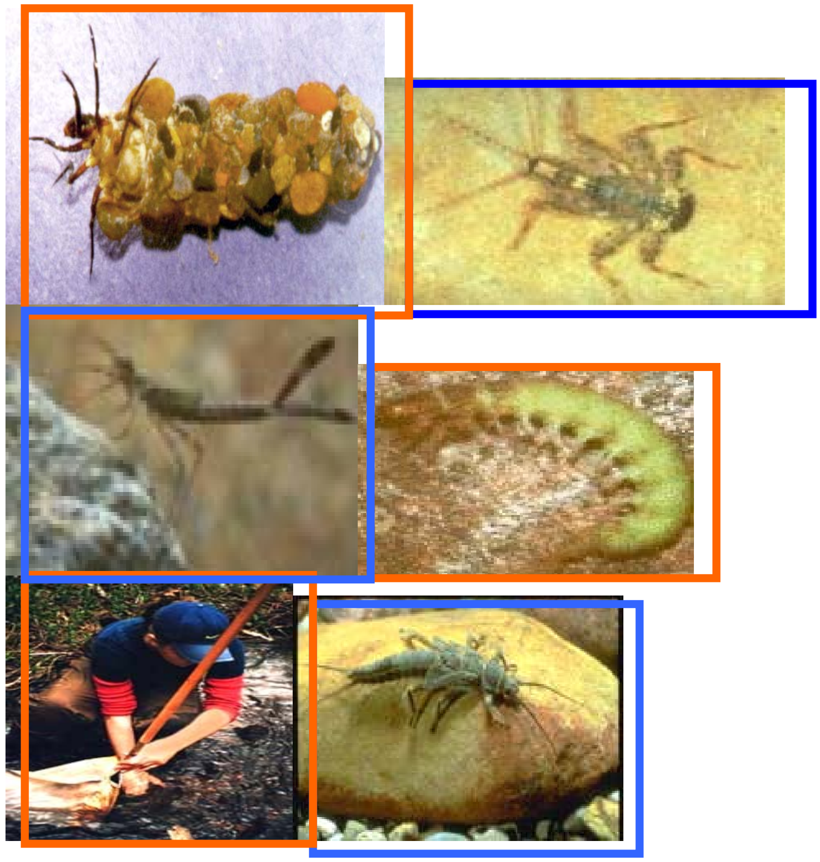
Watershed Science Institute
Watershed Condition Series
Technical Note 3
The EPT Index



Contents

Benthic macroinvertebrates[1], or aquatic insects can be used as an indicator of water quality in a stream, river or lake. Once macroinvertebrate samples are collected and analyzed, the data can be assembled into indices for comparison between sites. Four common indices are *Beck's Biotic Index* (Terrell and Perfetti, 1996), the *Benthic Index of Biotic Integrity* (Fore et al., 1998), *Hilsenhoff's Biotic Index* (Hilsenhoff, 1981), and the EPT Index (Lenat, 1988). The EPT Index uses three orders of aquatic insects that are easily sorted and identified and is commonly used as an indicator of water quality. Although the EPT Index is not a standard method within NRCS, it is useful for agency staff to be familiar with its principles because this technique has direct application in conducting rapid resource assessments. This technical note provides an overview of the EPT Index and shows how EPT Index is used to monitor water quality and prioritize resource management actions.

[1] Words in italics are defined in the glossary.

Introduction

Benthic macroinvertebrates[2] are small stream-inhabiting creatures that are large enough to be seen with the naked eye and spend all or part of their life cycle in or on the stream bottom. The name benthic macroinvertebrate means bottom-dwelling (benthic) and small organisms without backbones (invertebrate). Benthic macroinvertebrates have adapted to life in a stream, utilizing all habitat niches. For example, some are adapted to higher velocity portions of the stream, some live below the bottom of the stream, some crawl for food, while others let the food come to them. Healthy streams can have several hundred different kinds of benthic macroinvertebrates with total numbers ranging in the thousands.

The EPT Index is named for three orders of aquatic insects that are common in the benthic macroinvertebrate community: Ephemeroptera (mayflies), Plecoptera (stoneflies), and Trichoptera (caddisflies). The EPT Index is based on the premise that high-quality streams usually have the greatest species *richness*. Many aquatic insect species are intolerant of pollutants and will not be found in polluted waters. The greater the pollution, the lower the species richness expected, as only a few species are pollutant tolerant. Some basic identification features of stoneflies, mayflies, and caddisflies are shown in Figures1a, 1b, and 1c respectively.

2 A compendium of macroinvertebrates is located at http://www.epa.gtov/ceis/…atlas/bioindicators

Figure 1a. **Common stonefly Plecoptera group**. The common stonefly measures less than 1 inch in length (without tail), and has two wings, two sets of branched gills between the underside of the body, and yellow to brown color. The stonefly is not tolerant to low levels of dissolved oxygen and therefore prefers cold, swift-moving streams. Stoneflies are an important source of food for trout. The streamlined, flat body of stonefly nymphs enables them to move about the streambed in rapid currents.

Figure 1b. Common mayfly, Ephemeroptera group. The common mayfly is up to 1 inch in length (without tail), and has three distinct fuzzy or threadlike tails, and green, brown, gray, but usually black color. Mayflies have variable tolerance to pollution, but are usually considered to inhabit cleaner waters.

Figure 1c. **Caddisfly, Trichoptera group**. The caddisfly (which resembles a caterpillar) has a soft, wormlike body, a hard covering on the head, and yellow or brown but usually green color. Larvae build hollow cases that either carry or attach to rocks. Cases are built from sand, twigs, small stones, crushed shells, or rolled leaves, and are used for protection and pupation. Caddisflies have a large range of tolerance to pollution.

Features of an EPT Index

The EPT Index method uses a rapid sampling technique for determining between-site differences in water quality or watershed studies with a large number of sites, and "emergency" sampling where it is desirable to rapidly assess the effects of spills and unusual discharges. The EPT Index should not be used in areas that naturally are known to have low EPT species *richness* (either inherent or human-induced) or in areas where more pollution-tolerant groups are of interest. The EPT Index is a versatile index because of certain characteristics of benthic macroinvertebrates. Benthic macroinvertebrates are sensitive to stress, both natural and human-induced. When human actions affect their environment, the population will change, leading to an impaired or imbalanced community. Much like the "canary in the coal mine," the response of aquatic insects gives an early warning of possible harm to a waterbody. Because many aquatic insects spend their entire lives within aquatic systems, they show the effects of physical habitat alteration, point and non-point contaminants, and cumulative pollutants over their life cycle. Other important features of aquatic insects are that they -

- Are found in all aquatic environments
- exhibit diversity and are sensitive to pollution
- display a wide range of responses to pollution
- are less mobile than many other groups of organisms (ie., fish)
- are often of easily collectible size

Like all biotic indices, the EPT Index can be used when chemical and physical measurements for a complex mixture of pollutants are not feasible. Moreover, these aquatic insects show responses to a wide array of potential pollutants and are sensitive to both short-term and long-term conditions affecting water quality.

Collecting samples to construct an EPT Index

Benthic macroinvertebrates are collected using a variety of methods.[3] The suite of sample collection techniques, described below, consists of the kick net sample (called kick), sweep-net sample (called sweep), leaf pack sample, and visual collections (USEPA, 1999). These techniques are aimed at sampling the favorite habitats and food sources of the aquatic insects. Stream food resources are larger organic matter particles in leaf litter and large woody debris; smaller organic matter particles in suspended materials and sediments; *diatoms* or algae and other materials growing on rocks, wood, and plants; and prey (Hauer and Lamberti, 1996). Each macroinvertebrate occupies a certain niche according to its feeding group: shredders, collector-gathers, scrapers, filterers, or predators (Fig. 2). Shredders prefer to feed on larger particles of organic matter such as leaves and twigs, in turn churning these into smaller organic matter that can be fed upon by collector-gatherers. Collector-gathers feed on small particles of organic matter in or on the bottom of the stream. Scrapers feed on diatoms and algae that are attached to underwater surfaces. Filterers feed by straining small organic matter particles out of the water. Filters can be fanlike appendages on the insect's body or built externally by the insect to resemble little underwater nets.

[3] More information on aquatic insect sampling techniques is located at http://www.epa.govowowwtr1/monitoring

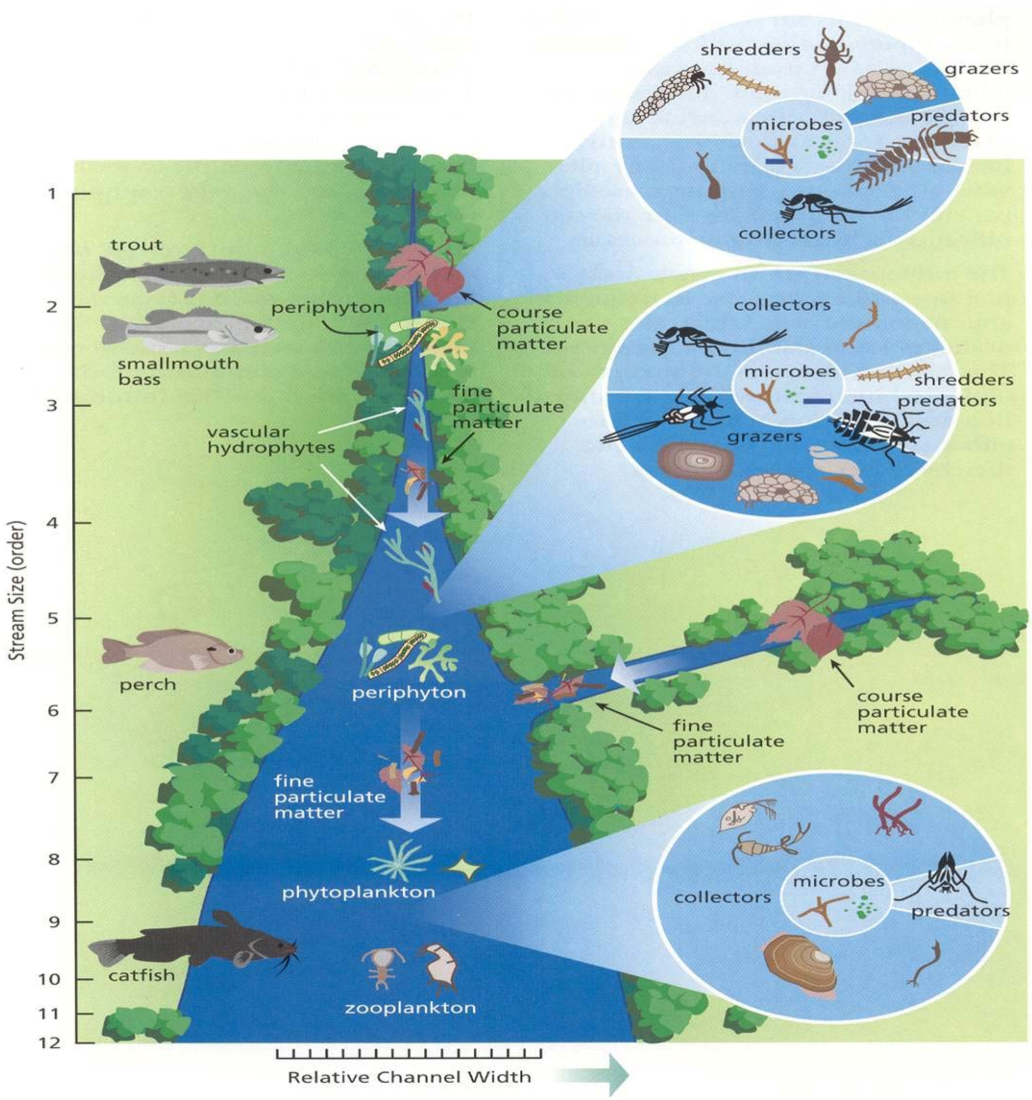


Figure 2. "The River Continuum Concept. " Each aquatic insect species occupies a certain stream niche (from Vannote et al., 1980).

Predators feed on other macroinvertebrates. In healthy streams, all feeding groups should be present. Stream impairment may be indicated when one or more feeding groups are missing from a stream.

In general, stoneflies are predators, mayflies are scrapers or collectors, and caddisflies are scrappers, collectors, or shredders. The ratio and number of these macroinvertebrates change with the stream food resources and human impacts and therefore can be used as a tool for assessing the ecological status of the biotic community and water quality. The kick sample is conducted using a rectangular section of window screening attached between two poles (Figure 3). The net is positioned on the

Figure 3. Sampling macroinvertebrates with a kick net.

stream floor, downstream of the sampler. One person holds onto the net. The other person disturbs the stream bottom upstream of the net and ‘kicks’ the invertebrates present into the net. Invertebrates collected on the net are washed into a bucket for collection at the end of the sampling procedure. A long-handled triangular net is also used to disrupt and sweep areas under banks, root masses, and mud banks (Figure 4). Netted invertebrates are washed into a bucket. This procedure collects mayflies and caddisflies which prefer low-current environments in the stream. Leaf packs in the stream, snags, sticks, and small logs are examined and macroinvertebrates separated into a bucket. In general, shredders such as the caddisflies prefer these environments. A final visual search of upturned rocks, cobbles, and logs is conducted, to collect adhering macroinvertebrates. For example, rocks in low current areas harbor stoneflies. Macroinvertebrates are separated or picked from the bucket samples with forceps and placed in vials containing ethanol.

Figure 4. Collecting macroinvertebrates with a dipnet.

Figure 5. Student empties macroinvertebrate sample from net during sampling of Smith Creek, Oregon.

Macroinvertebrates usually require identification in the laboratory by a trained biologist. However, community watch group volunteers, teachers, and students (Figure 5) can be successfully trained to make basic identifications of the three groups used in the EPT Index. In fact, school monitoring programs often collect macroinvertebrates in targeted watersheds for government agencies and use these data as part of the school's science curriculum (SWRP, 1996). The NRCS Stream Visual Assessment Protocol (SVAP) also uses aquatic insects to assess stream condition.[4]

[4] USDA-NRCS 1999.

EPT Index score development

The EPT Index is the total number of distinct *taxa* within the groups, Trichoptera, Ephemeroptera, and Plecoptera. For example, if five species of Ephemeroptera (mayflies), five Plecoptera (stoneflies), and two Trichoptera (caddisflies) are found at a site, the total number of EPT taxa and Index would equal 12. In this case, the EPT Index would equal 12. The EPT Index is then compared to values on an EPT rating chart. Many state water quality departments are a good source of information on how to develop a rating chart for a particular ecoregion. The EPT Index increases with improving water quality i.e.; there should be a greater number of EPT insect taxa in cleaner water. Ratings are tailored to account for differences in species pollution tolerance between regions. Table 1 shows an example of EPT criteria developed for the Southern Piedmont of North Carolina. In this example, a site with an EPT Index of 12 would have a rating of fair.

Table 1. Example of EPT index ranges and their corresponding water quality ratings. (modified from NCDENR, 1997).

Rating	Excellent	Good	Good-fair	Fair	Poor
EPT	>27	21-27	14-20	7-13	0-6

Exploring the value of the EPT Index to NRCS

The EPT Index can be used to directly assess the cumulative effects of all activities in the watershed. These results allow establishment of baseline or reference conditions for watersheds to characterize their overall condition, identify potential nonpoint and point source pollutants, target resource efforts in impaired watersheds, and evaluate the effectiveness of pollution control measures. In the following discussion three examples of EPT Index use are presented. The first example is from the Capisic Watershed in Portland, Maine. This project is of interest because it shows how the EPT Index can be used to establish expected ranges of aquatic condition within a given stream classification, and also to assess the response of aquatic biota and subsequent water quality deterioration resulting from urban nonpoint impacts. The second example is from Clayton County, Iowa. Here the EPT Index is used to assess the effecitveness of conservation practice implementation. The third is from North Carolina. It demonstrates the direct influence of dominant land use on water quality and aquatic biota.

Example 1.

Using biomonitoring to develop aquatic attainment classes for the State of Maine

(from http://janus.state.me.us/dep/blwq/docmonitoring/biological/biorep2000.htm)

In 1994, Maine's Biomonitoring Program and Division of Watershed Management initiated a project, which focused on smaller lower order streams where nonpoint sources (NPS) predominate as the cause of water quality threat or impairment. Biological monitoring and habitat assessment of NPS-impacted streams is being used to accelerate the project by identifying waters that are threatened or impaired by NPS pollution and to facilitate prioritization of water resource efforts. Biological monitoring and habitat assessment techniques are also used as tools to evaluate the effectiveness of practices implemented to improve water quality or stream habitat.

The assessment of NPS impacts on streams is conducted in a three-level approach. The first uses percent watershed imperviousness and a Watershed Pollution Potential Index (WPPI) based on population, road, and land cover data. The level one assessment provides a ranking of the streams based on potential impact from nonpoint source pollution. Level two assessment is a rapid bioassessment of streams (based on method described in Lenat (1988) identified in level one. The third level is also a biological assessment, but uses rock-filled bags (Figure 6) to sample aquatic insects in small streams. Data from three

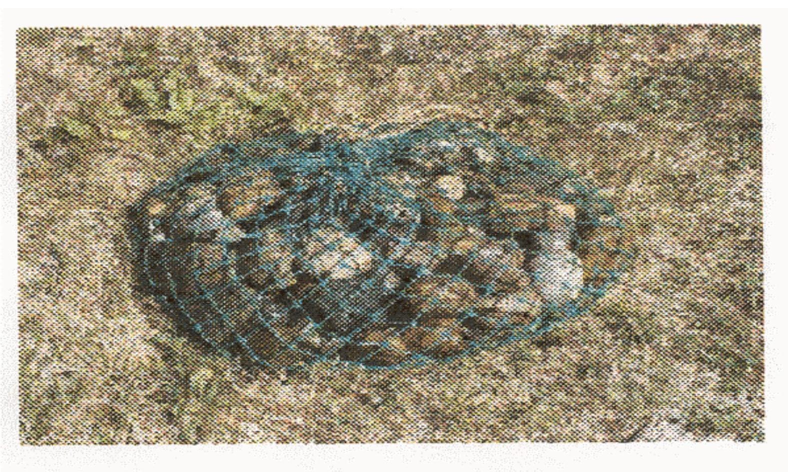


Figure 6. The Maine Biological Monitoring Program uses rock-filled bags to sample benthic macroinvertebrates in streams less than 5 inches deep.

assessments are then used to assign a Classification Attainment[5] (Table 2) for each stream reach. A database of biological values (i.e., EPT Index ranges) by Classification Attainment is maintained as a reference of expected biological standards for Maine streams and rivers. Figure 7 shows an example of how biological standards are used to assess Classification Attainment of two stream monitoring stations. In this example, one stream (Dudley) was outside the expected range of its assigned classification attainment group, and as a result was given priority by the State of Maine for restoration.

Since 1996, a total of 62 stations have been monitored for NPS impacts using these techniques. Twelve of these stations are not meeting their assigned Classification Attainment. Stations in urbanized areas or highly disturbed watersheds were found to be the most significantly impacted of all streams monitored.

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[5] Attainment classes A, B, and C were developed to represent levels of aquatic biota and water quality. Each class has a certain biological standard.

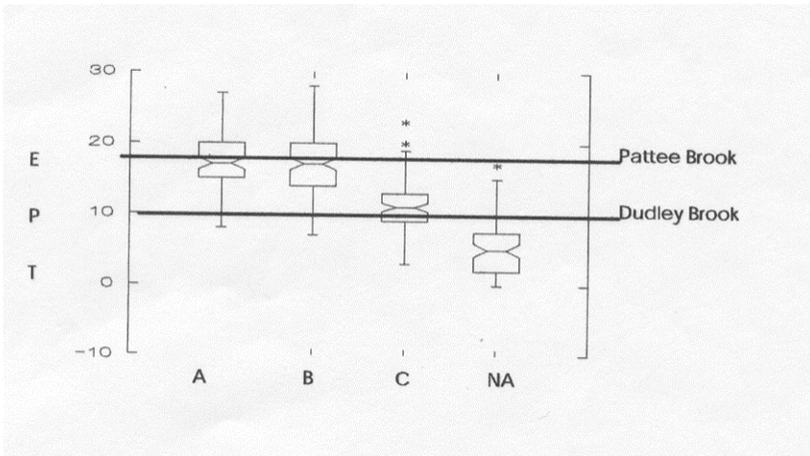


Figure 7. Box plots showing EPT Index values for the Pattee and Dudley Brook class B monitoring stations compared to the distribution of all EPT Index values for all sites within a given attainment class (A, B, C, N/A). Dudley Brook did not meet its classification attainment and as a result was given priority for restoration.

Assessment of urban nonpoint impacts, Capisic Brook Watershed

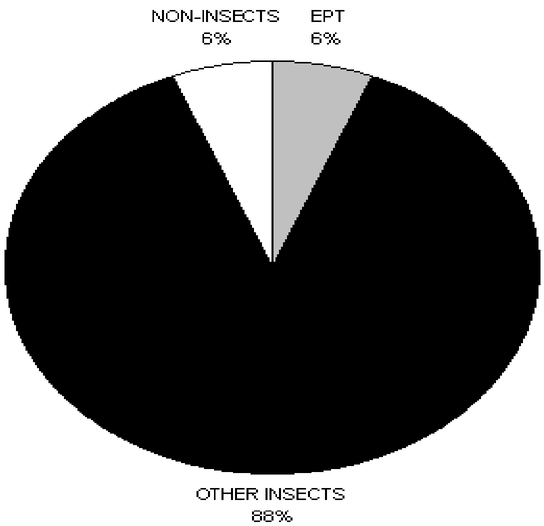
An example of a watershed that has been severely impacted by urban NPS pollution is the Capisic Brook Watershed. Capisic Brook is a small first and second order stream; it originates in a spring or wetland near Westbrook College, Portland, Maine. Several stream monitoring sites were selected to evaluate urban nonpoint impacts in the Capisic Brook Watershed. The control or reference site, Evergreen Cemetery, was a relatively undisturbed forested area upstream of dense residential and industrial development. The Evergreen Cemetery monitoring site served as the best attainable modern condition for the watershed. Other stream sites were located within and below areas of urban development.

CLASS	MANAGEMENT	BIOLOGICAL STANDARD
AA	High quality water for recreation and ecological interests. No discharges or impoundments permitted.	Habitat shall be characterized as natural and free flowing. Aquatic life shall be as naturally occurs.
A	High quality water with limited human interference. Discharges limited to noncontact process water or highly treated wastewater of quality equal to or better than the receiving water. Impoundments allowed.	Habitat shall be characterized as natural. Aquatic life shall be as naturally occurs
B	Good quality water. Discharge of well treated effluent with ample dilution permitted.	Habitat shall be characterized as unimpaired. Discharges shall not cause adverse impacts to aquatic life. Receiving water shall be of sufficient quality to support all aquatic species indigenous to the receiving water without detrimental changes in the resident biological community.
C	Lowest water quality. Maintains the interim goals of the Federal Water Quality Act (fishable/swimmable). Discharge of well treated effluent permitted.	Habitat for fish and other aquatic life. Discharges may cause some changes to aquatic life, provided that the receiving waters shall be of sufficient quality to support all species of fish indigenous to the receiving water and maintain the structure and function of the resident biological community.
Impoundments	Riverine impoundments classified as Great Ponds and managed for hydropower generation	Support all species of fish indigenous to those waters and maintain the structure and function of the resident biological community.

Table 2. Maine's aquatic attainment classes and corresponding biological standard narrative.

Aesthetic appearance of the brook and several key water quality parameters changed dramatically between the reference and the urbanized locations. In particular, water temperature, conductivity, total phosphorus, and total dissolved solids reflected the impacts of urbanization. Dissolved oxygen was higher downstream due to increased algal biomass, caused by nutrient enrichment. The EPT Index followed this decline (Figure 8). Pollution-sensitive aquatic insects, mayflies, stoneflies, and caddisflies were present in low numbers. In addition, the percentage of pollution-tolerant aquatic insects, worms and leeches increased downstream. A combination of causes probably led to the drastic change in aquatic insect composition. These were runoff from residential and industrial sites, temperature elevation due to increased impervious surfaces and reduction in canopy cover along the stream, combined with sewage overflow within the urban sector of the brook.

CAPASIC BROOK ABOVE THE URBANIZED SECTOR



CAPASIC BROOK BELOW THE URBANIZED SECTOR

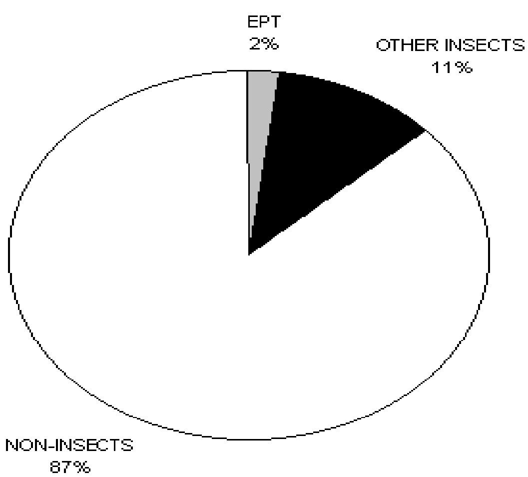


Figure 8. The percentage of EPT Index aquatic insects decreased in response to urban nonpoint impacts. Pollution tolerant non-insects, such as worms and leeches increased downstream of the urban sector.

In summary, biological monitoring has proven useful in Maine's nonpoint source impact program. Reference sites are critically important in trying to establish the magnitude of decline in aquatic biota or relative success of restoration efforts. The State of Maine has recognized the importance of biological monitoring by developing attainment classes or expected reference ranges for aquatic condition of its streams. These attainment classes were useful for prioritizing resources, gauging the impacts of NPS pollution, and evaluating the success of restoration projects.

Example 2.

Assessment of water quality from implementation of Best Management Practices-Sny Magill and Bloody Run Watersheds, Clayton County, Iowa
(modified from http://www.igsb.uiwoa.edu).

The Sny Magill Watershed in Clayton County, Iowa is the location of the Sny Magill Creek Non-point Source Pollution Monitoring Project and is part of the USEPA's National Monitoring Program (Figure 9a). The Sny Magill Watershed is about 35.6 mi^2 and is primarily forested pasture, forest, row crop, cover crop, and pasture. Initiated in 1991, the project was designed to monitor and assess improvements in water quality from the implementation of best management practices in the watershed. BMPs were intended to reduce sediment, fertilizer, and pesticide inputs relative to a control watershed, the Bloody Run. BMP effectiveness was assessed by observing biological habitat improvement of the stream corridor and monitoring of benthic macroinvertebrates and fish populations. Macroinvertebrate monitoring proved to be the most sensitive measure of watershed condition change in the early stages of the project. As of December 1997, there were improvements in mcaroinvertebrate populations (as measured by the EPT Index, Figure 9b) and pesticide concentration. However, fish populations, habitat indices, and nitrates and sediment remained unchanged.

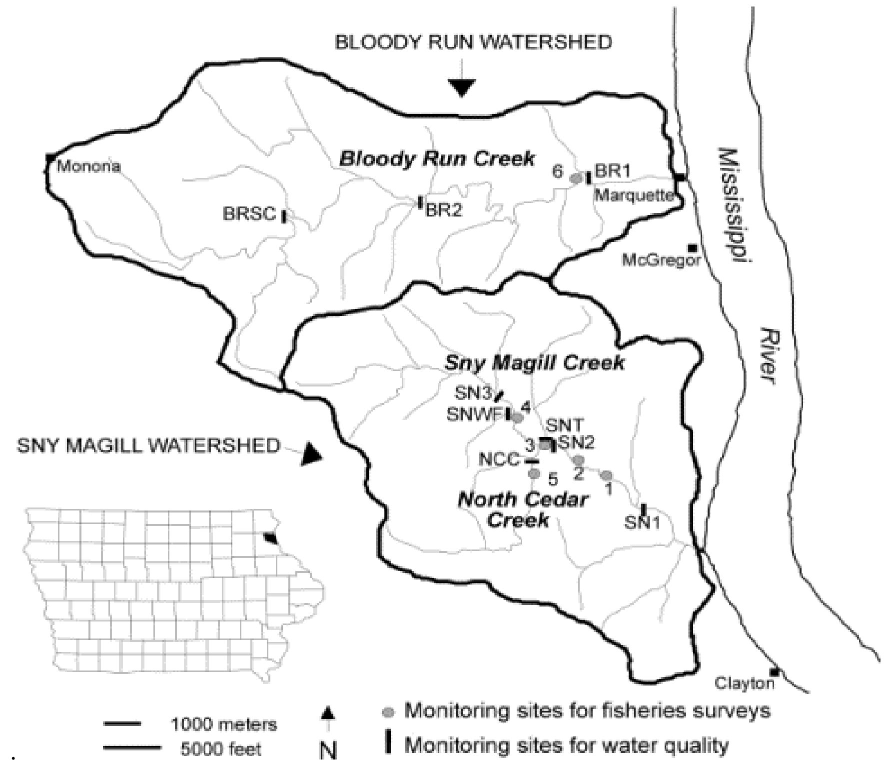


Figure 9a. Location of Sny Magill and Bloody Run Watersheds, Clayton County, Iowa.

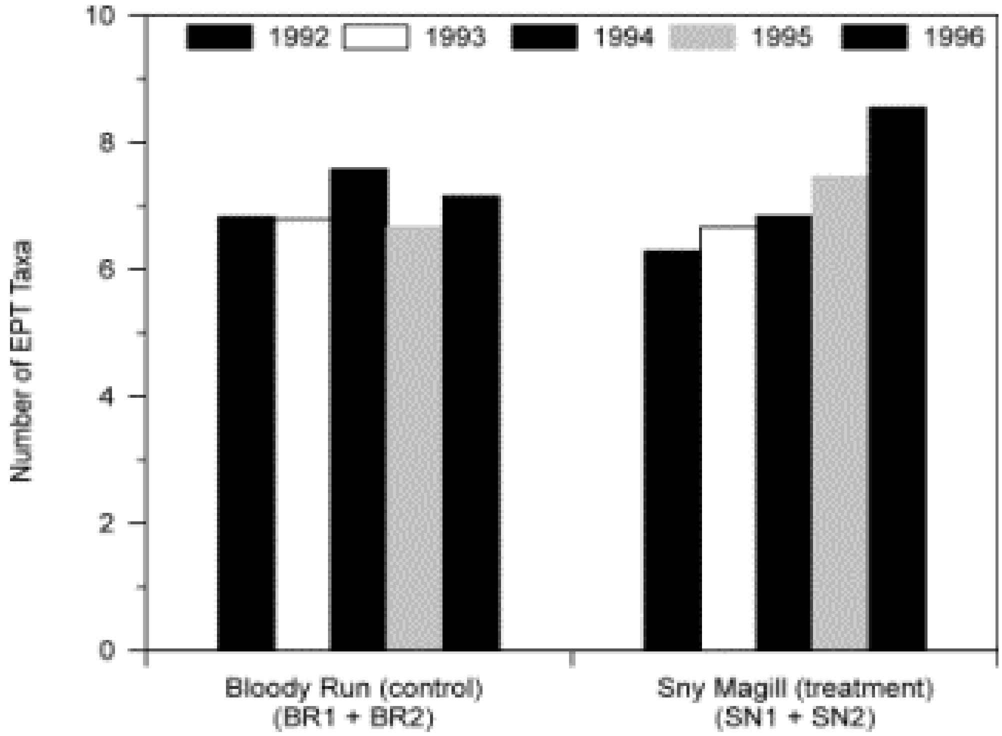


Figure 9b. Sny Magill and Bloody Run Creek watersheds were part of a 5-year study to assess Best Management Practice effectiveness. EPT Index Scores improved from 1992 (BMP implementation) through 1996 in the Sny Magill Watershed. The study also noted synonymous improvements in biotic habitat and pesticide concentrations in this watershed.

In summary, biological monitoring was proven to be the most sensitive measure of watershed condition change in the early stages of the Sny Magill Watershed BMP project. Chemical or habitat measures of BMP effectiveness were less sensitive to change than biological indicators (EPT Index) and remained unchanged in the early project stages.

Example 3

Effects of land use on aquatic biota –
Southern piedmont ecoregion, North Carolina
(modified from Lenat and Crawford, 1994)

Three streams in the southern Piedmont ecoregion of North Carolina were studied to evaluate the effect of land use (forested, agricultural, urban) on water quality and aquatic biota. Three watersheds were selected where the primary difference was dominant land use. The three watersheds and their land use characteristics were

- Smith Creek – 3,700 acres of forested land
- Devil's Creek – 2,700 acres of agricultural lands
- Marsh Creek – 3,400 acres of urban land

Further breakdowns of the land cover types for each watershed are shown in Table 3.

Table 3. EPT Index scores and other watershed measurements at three southern Piedmont streams.

Measurement	Smith Creek	Devil's Creek	Marsh Creek
Row crops %	12	48	3
Pasture %	10	5	3
Urban %	2	12	70
Forests %	75	31	24
EPT index score	29	14	4.5
EPT rating	Good	Fair	Poor

The agricultural watershed (Devil's Creek) had few best management practices in place. Some narrow field borders were present, but few grassed waterways were present. The urban watershed (Marsh Creek) had substantial ongoing development.

Results of the study showed that land use appeared to strongly influence the aquatic condition of the watershed. The benthic macroinvertebrtes (EPT Index scores) indicated moderate stress (fair rating) at the agricultural watershed and severe stress (poor rating) at the urban watershed. The forested watershed (Smith Creek) had a significantly higher EPT Index (good rating) than either the urban or agricultural watersheds.

Summary

The EPT Index uses three orders of aquatic insects that are easily collected, sorted and identified; it is commonly used as an indicator of water quality. Although identification of some aquatic insects may require a trained biologist, for the most part the EPT Index can be easily applied with little training to make cursory evaluations of water quality. The EPT Index is a reliable tool to evaluate watershed condition and could be useful to NRCS for

- ✓ **establishing reference conditions**
- ✓ **setting protection and restoration goals**
- ✓ **identifying disturbances**
- ✓ **choosing control measures**
- ✓ **evaluating the effectiveness of BMP improvement measures**
- ✓ **monitoring watershed condition change in the early stages of a project**

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Glossary

Beck's Biotic Index. A system developed in Florida by Beck used to indicate environmental stress. The index is calculated from 2 times the summation of the number of class I species (sensitive or intolerant to pollution) added to the number of class II (can live under varying pollution conditions) species of benthic macroinvertebrates in a water body.

Benthic Index of Biotic Integrity. A system developed by Karr in Washington used to indicate the condition of the aquatic organisms and infer water quality. A suite of metrics (number of taxa, number of pollution-intolerant species, and trophic group, etc. of benthic macroinvertebrates) is used to determine a numerical index which describes condition of the streams.

Benthic macroinvertebrates. Organisms that inhabitat the bottom substrates of freshwater habitats, for at least one part of their life cycle.

Biotic indicator Organisms such as benthic macroinvertebrates used to evaluate the change in environmental condition.

Biomass. The total weight of the biotic community of interest, such as fish or benthic macroinvertebrates in a sample.

Diatom. A class of small unicellular plankton or algae with silicified skeletons

Hilsenhoff's Biotic Index. A system using benthic macroinvertebrates, developed in Wisconsin by Hilsenhoff and used to detect organic pollution based on the indicator organism approach to water quality; values are on a scale of 0 to 10, with the higher values indicating more polluted conditions.

Index of Biotic Integrity. A system develop by Karr in Washington used to indicate the condition of the aquatic organisms and infer water quality. A suite of metrics (number of taxa, number of pollution-intolerant species, and trophic group, etc. of fish community) is used to determine a numerical index which describes condition of the streams.

Indices (plural of index). A numerical value used to summarize environmental condition.

Species richness. Total number of individual species of a certain biotic community, such as fish or benthic macroinvertebrates in a sample. An increase in the number of species generally denotes better water quality.

Subtrates. Habitats and food sources for the macroinvertebrates such as sediments, debris, logs, macrophytes, and filamentous algae at the bottom of freshwater streams

Taxa (plural of taxon). A group of organisms systematically classified according to their natural relationship, such as a group of macroinvertebrates, which is used to represent the diversity within a sample; a taxonomic group or entity. Taxa are used as a key metric in some biotic condition indices, for example, the Index of Biotic Integrity