Mixed-wood Plains Ecozone Status and Trends Report: Benthic Invertebrates

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Benthic invertebrates include insects, worms, crustaceans, molluscs, and mites that inhabit the bottom sediments of waterbodies for at least for a portion of their lives (Fig. 1). These animals are sensitive to disturbances in their environment, and a variety of collection and analytical methods have been developed to guide scientists in their use as biological indicators of ecosystem condition or health (e.g., Resh and McElravy 1993, Carter and Resh 2001, Jones et al. 2005).

Figure 1: Some benthic invertebrates (snail [top left], hydra [top right], mayfly [bottom]). Photo credit: Chris Jones, Ontario Ministry of Environment.

Because the abundances of taxa naturally vary from place to place, and from time to time, the first step in biological monitoring is to determine what constitutes normal community composition. Control- or reference-sites are often used for this purpose. Judging condition also requires community composition to be summarized numerically. Indices are typically used for this purpose. Many types of indices are available, including compositional indices (e.g., % EPT, the proportion of taxa counts made-up of sensitive Ephemeroptera [mayflies], Plecoptera [stoneflies] and Trichoptera [caddisflies]), and biotic indices (e.g., Hilsenhoff 1988), which combine information about the abundances and sensitivities of collected taxa.

Benthic invertebrates have been negatively affected by land-use changes that have accompanied human settlement of the Mixed-wood Plains Ecozone's watersheds. Different human land-uses lead to different stresses acting on invertebrate communities. For example, farms contribute pollutants such as phosphorus, nitrogen, and silt to waterbodies, and urban development increases run-off, erosion, siltation, and contributes its own pollutants. There is overlap among the expected biological effects of these stressors. According to Jones (2008a), "the three best-documented responses are: (1) the loss of taxa; (2) opportunistic (tolerant) species becoming more numerically dominant; and (3) a reduction in the body size of the numerically dominant taxa". Typically, these responses increase in severity with increasing exposure to stress.

Besides being indicator taxa, the hundreds of species of benthic invertebrates also make a substantial contribution to biodiversity. The mean number of families of benthic invertebrates collected at 58 minimally impacted reference sites (i.e., 14.3 [standard error 0.44; Fig. 2; Fig. 3]), describes the richness norm for streams in the Mixed-wood Plains Ecozone (Jones 2008b).

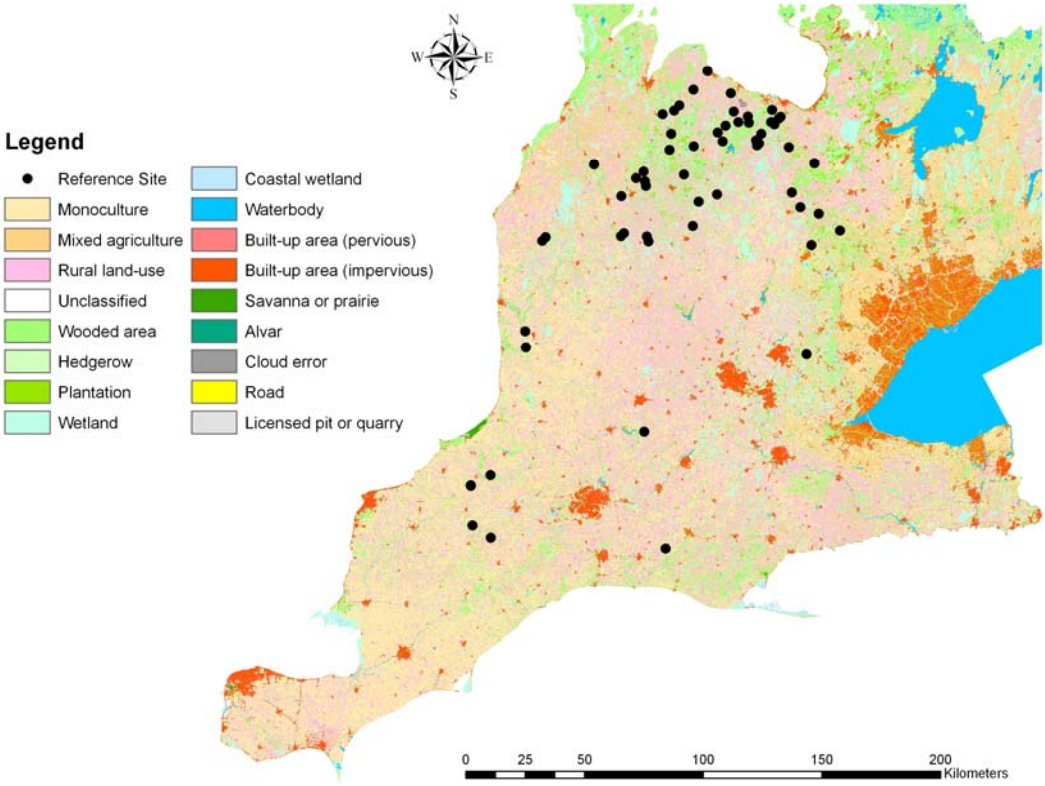

Figure 2: Reference-sites sampled in 2006 or 2007 to quantify the richness norm for the Mixed-wood Plains Ecozone (Jones 2008b).

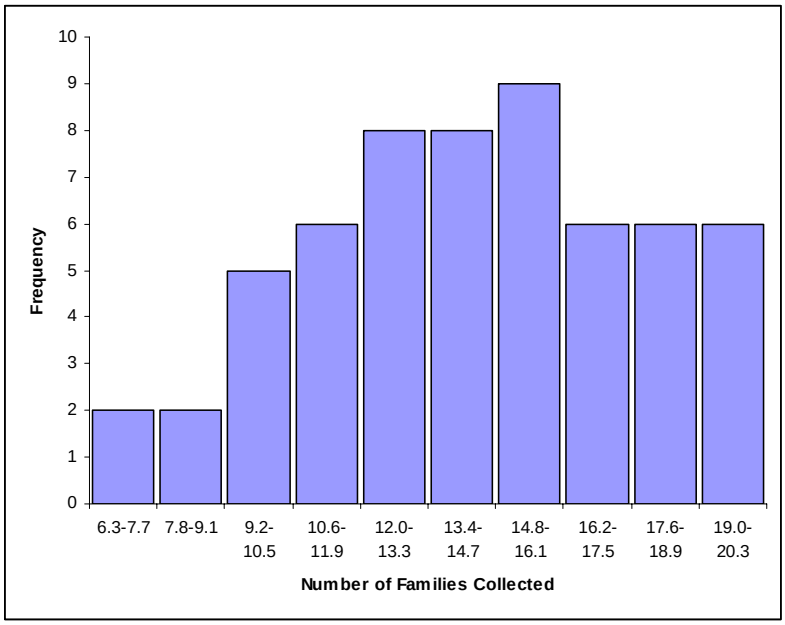

Figure 3: Frequency distribution showing the number of families of benthic invertebrates collected in 100-animal fixed-count samples collected at 58 minimally-impacted reference-sites in south-western Ontario (Jones 2008b).

In lieu of data from a comprehensive biological survey of Ecozone waterbodies, the following three case studies illustrate stressor-response relationships that exist in the Mixed-wood Plains Ecozone.

Case Study #1 and #2: Benthic invertebrates respond to land-cover and land-use patterns in the Saugeen and Nottawasaga Watersheds.

The Saugeen Valley Conservation Authority summarizes biomonitoring results every fifth year in Watershed Report Cards, and the Nottawasaga Valley Conservation Authority publishes biomonitoring results semi-annually as stream-health maps; recent editions of both show striking relationships between benthic-invertebrate-communities' health and land-use. In the Saugeen watershed, the condition of benthic-communities is poorest in catchments that are largely agricultural or have many towns, and is best in highly forested watersheds where human influence is minimal (Saugeen Valley Conservation Authority 2008; Table 1)

Table 1: Sub-watershed-specific water-quality scores assigned by Saugeen Valley Conservation Authority (Saugeen Valley Conservation Authority 2008).

Watershed	Mean % Agriculture	Mean % Forest	Mean % Urban	Benthic Invertebrate Score
Beatty Saugeen Sub-watershed North Saugeen Sub-watershed Upper Main Saugeen Sub-watershed	58	36	1	A
Rocky Saugeen Sub-watershed South Saugeen Sub-watershed Teeswater Sub-watershed Lower Main Saugeen Sub-watershed	66	28	1	B
Lake Fringe Sub-watershed Penetangore River Sub-watershed Pine River Sub-watershed	77	16	4	C

Similarly, headwater reaches of several tributaries that flow west-to-east into the Nottawasaga River are “below potential”. These streams arise in the agricultural zone on top of the Niagara Escarpment, and their biological condition improves in their sparsely populated, forested middle reaches. Their condition degrades once more, however, as they flow through the agricultural lands, villages, and towns (e.g., Alliston) of the Simcoe Lowlands. The poorest (i.e., “impaired”) stream condition occurs in areas of intensive agriculture (e.g., around Innisfil and Beeton), in cities and towns (e.g., Barrie and Alliston), and where stream habitat has been altered by dams (e.g., Hornings Mills) or ditching (e.g., several Wasaga Beach-area streams).

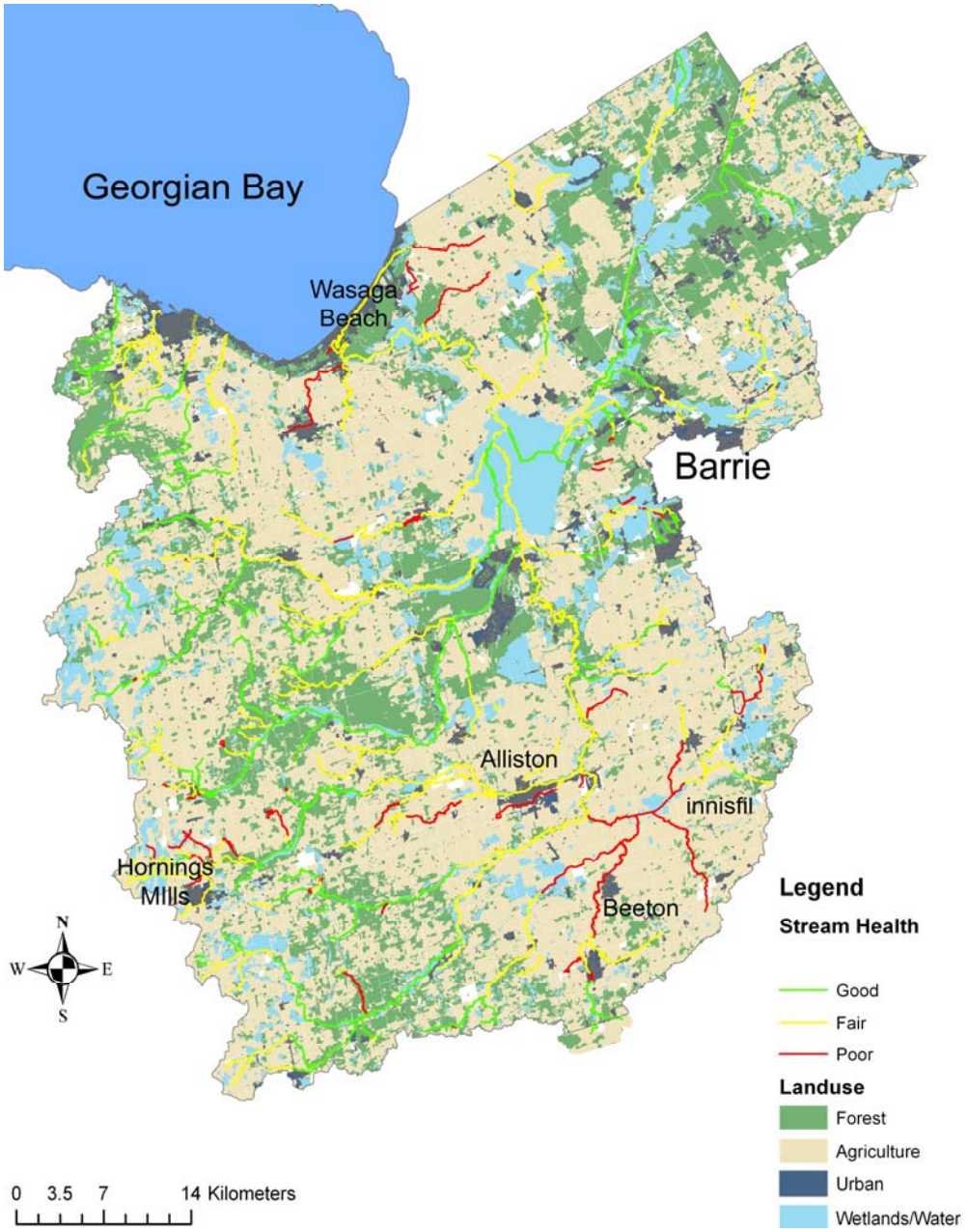

Figure 4: Stream health conditions and land-cover in the jurisdiction of the Nottawasaga Valley Conservation Authority (Nottawasaga Valley Conservation Authority 2008)

Case Study #3: Benthic-invertebrate richness, and the abundance of sensitive taxa, decline in response to urbanization in the Toronto area.

The Toronto Region Conservation Authority monitors benthic-invertebrate community structure at 38 sites along the Humber River (Fig. 5). Their sites occupy watershed positions influenced by either a low, medium, or high degree of urbanization. Between 2004 and 2007, both % EPT and the number of genera collected were lower at sites moderately or highly influenced by urban development than they were at sites that had little urbanization in their catchments (Table 2; Toronto Region Conservation Authority 2008).

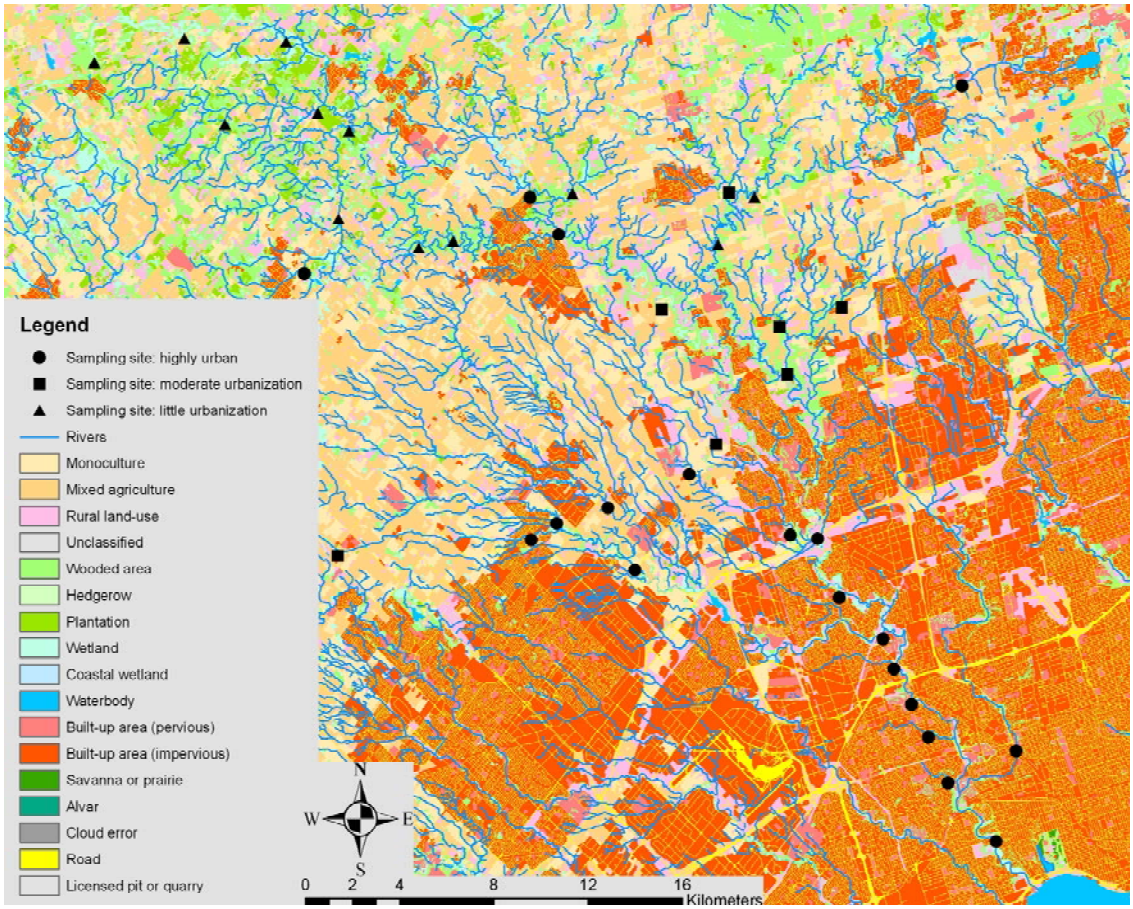

Figure 5: Benthic-invertebrate sampling locations and land-cover in the Humber River region (Toronto Region Conservation Authority 2008).

Table 2: The proportion of samples made-up of Ephemeroptera, Plecoptera, and Trichoptera (EPT) combined, and the number of genera collected at 38 Humber River benthic-invertebrate monitoring sites (Toronto Region Conservation Authority 2008; SE = standard error).

		Little Urbanization		Moderate Urbanization		High Urbanization	
		mean	SE	mean	SE	mean	SE
Proportion EPT	2004	36%	0.05	8%	0.03	28%	0.04
	2005	27%	0.05	14%	0.06	21%	0.04
	2006	20%	0.04	11%	0.03	24%	0.04
	2007	21%	0.06	8%	0.02	21%	0.04
Number of genera collected	2004	24	1.97	24	1.67	21	0.96
	2005	15	1.34	14	2.03	12	0.66
	2006	15	0.84	15	0.20	14	0.87
	2007	16	1.67	11	1.45	12	0.93

To summarize, no systematic biological survey of Mixed-wood Plains Ecozone waterbodies has been done. In lieu of such a survey, the case-study data described above characterizes the biodiversity norm for this area, and illustrates typical benthic-invertebrate responses to human activities. In general, the health of biological communities is best in natural watersheds, and worst in watersheds in which human uses of the land predominate. A more comprehensive assessment of the Mixed-wood Plains Ecozone is conditional upon our having additional reference-site data, and improved distribution of test-sites across the Ecozone. The Ontario Benthos Biomonitoring Network's Protocols (Jones et al. 2005) and Conservation Authorities' Watershed Reporting Standard (Conservation Ontario 2007) harmonize data collection, storage, and reporting. These standards will benefit future editions of this report if they are more widely adopted.

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