Focusing Conservation Efforts for Freshwater Biodiversity

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Abstract

Priority watersheds for protecting freshwater species at risk in Canada were identified by creating a conservation hot spot index based on the biodiversity of fishes and mussels and the threats to these taxa. The watersheds of Carolinian Canada were identified as the 'conservation hot spots' for freshwater biodiversity in Canada. Here, in this most southerly region of the country, overall fish and mussel richness peaks at the watershed level. Carolinian watersheds also support the highest diversity of species at risk, including several globally rare fishes and mussels. Such diverse aquatic communities in this region are primarily attributed to moderate climatic conditions and biogeographic history. Unfortunately, this region of high biodiversity occurs in the Great Lakes basin where threats from human impacts and aquatic invasive species are most severe. To ensure the preservation of aquatic biodiversity in priority watersheds of the Carolinian zone, an aquatic ecosystem approach to recovery planning is underway.

Keywords: *freshwater fish, species at risk, priority watersheds, conservation, hot spot index, Great Lakes*

Introduction

North American freshwater fauna are disproportionately imperiled compared to terrestrial biota yet are often neglected by conservation practitioners. In the United States, 67% of freshwater mussels, 37% of fishes, 51% of crayfishes, and 40% of amphibians are vulnerable to extinction, as compared with only about 15% for birds and mammals (Master *et al.* 1998). Over the past 100 years, at least 123 freshwater fishes, molluscs, crayfishes,

and amphibians have already gone extinct in North America (Ricciardi and Rasmussen, 1999). Using an exponential decay model, Ricciardi and Rasmussen (1999) derived recent and future extinction rates for North American freshwater fauna that are five times higher than those for terrestrial fauna. Clearly, immediate and effective conservation action is required to protect and recover fragile freshwater ecosystems. With limited resources available, the identification of "conservation hot spots" provides a tool to help direct conservation actions to watersheds of highest priority and help prevent the trend in freshwater species extinctions.

In Canada, the Committee on the Status of Endangered Wildlife in Canada (COSEWIC) is responsible for assigning status designations for species at risk (SAR). The Committee has been evaluating freshwater fishes since 1978 but has only recently begun to evaluate the status of freshwater molluscs; other freshwater taxa have yet to be considered. Our analysis will focus on fishes and freshwater mussels – two of Canada's most imperiled freshwater taxa. The objective of this study is to identify priority watersheds for the conservation of freshwater biodiversity with particular emphasis on fish and freshwater mussel SAR and their threat factors.

Methods

In terms of fishes and freshwater mussels, the Great Lakes drainage basin supports the richest freshwater communities in Canada. Of some 229 species of native and introduced fishes found nationally, 142 species are known from the Great Lakes proper (Cudmore-Vokey and Crossman, 2000). Similarly, of 55 species of freshwater mussels found in Canada, 40 species are known from the lower Great Lakes drainage basin (Metcalfe-Smith *et al.,* 1998). Consequently, the current analysis and mapping was conducted on the tertiary watersheds of the Great Lakes basin using ArcView GIS version 3.2a.

'Conservation hot spots' were identified using a priority ranking score applied to tertiary watersheds (established by the Water Survey of Canada) across the Great Lakes basin. This index is the sum of the equally weighted biodiversity, SAR diversity and SAR threat factors as follows:

> Priority Rank = Biodiversity [fishes + freshwater mussels] + SAR diversity [fishes + freshwater mussels] + SAR threats [human stress + invasive species]

The index thus gives a double weighting to SAR which include species of highest conservation concern nationally. The components of the priority rank are described below.

Biodiversity and Species at Risk

Fishes

Distribution data for fishes were obtained from an extensive national database containing data from more than 30 government agencies and museums from across North America (N.E. Mandrak, unpublished data). This database currently has 378,901 fully geo-referenced records for 229 freshwater fish species.

Freshwater Mussels

Distribution data for freshwater mussels occurring in the lower Canadian Great Lakes drainage basin were taken from Metcalfe-Smith *et al.* (1998). Distribution data on the eight mussel SAR occurring in Ontario were taken from their conservation status reports prepared for COSEWIC.

Species at Risk Threats

In a recent analysis, Dextrase and Mandrak (in press) identified habitat loss and degradation (due to human stresses) as the predominant threat factor contributing to the endangerment of freshwater fishes and molluscs in Canada. Invasive species were identified as the second most prevalent threat for fishes and a lesser primary threat for freshwater mussels. Human stress and invasive species were both integrated into the index as threats to SAR.

Human Stress

Human impact on the freshwater environment can be summarized by a human stress index developed by Chu *et al.* (2003) in their regional analysis of factors impacting freshwater fish biodiversity in Canada. This overall stress index is based on the average of agriculture, industrial and population stress values for each watershed.

Invasive Species

As of 2001, 162 aquatic invasive species were established in the Great Lakes basin (Ricciardi, 2001) and over 180 species are now known to be established (B. Cudmore, pers. comm.). The watersheds of southwestern Ontario are thus subject to the greatest number of invasive species in the country. Although these invasive species include plants, algae and invertebrates, readily available and complete datasets are only available for fishes (from the national database). The impacts of aquatic invasive species were summarized as the total number of introduced fish species by watershed.

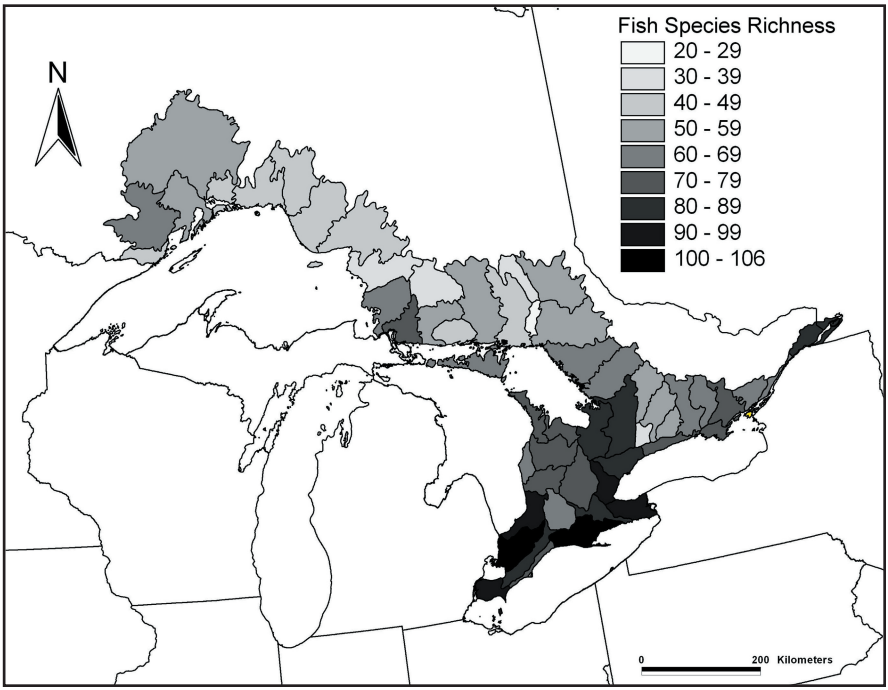
Results and Discussion

The tertiary watersheds of southwestern Ontario have the highest richness of fishes and freshwater mussels in the country. Up to 102 fishes are known from individual watersheds (Figure 1) within the Carolinian region. Similarly, 34 species of freshwater mussels are known from the Sydenham River watershed – making it the richest basin for mussels in Canada. Such high aquatic diversity in southwestern Ontario can be attributed primarily to the following reasons:

- many species are at the northern limit of their range;
- this region enjoys some of the mildest climate in Canada;
- biogeography, this region is closest to the Mississippian refugium which had the highest species richness – 77 fishes and 35 mussel species colonized Ontario from this glacial refugium (Mandrak and Crossman, 1992; Clarke, 1981).

The pattern of SAR distribution mirrors that of overall diversity with the majority of SAR occurring in the watersheds of southwestern Ontario. Of twelve freshwater mussels currently listed by COSEWIC in Canada, eight species occur solely in this region with all eight species known from the Sydenham River (Figure 2). Other watersheds with high SAR mussel rich-

Figure 1. Fish species richness in tertiary watersheds of the Great Lakes.



ness include the Grand, Thames and Ausable Rivers. As many as 13 fish SAR are known from these and other watersheds in southwestern Ontario. Many of these SAR are at the northern limit of their range and are sometimes more common in the United States; however, several fishes and mussels are globally rare, including the northern riffleshell (*Epioblasma torulosa rangiana*), rayed bean (*Villosa fabalis*), northern madtom (*Noturus stigmosus*) and pugnose shiner (*Notropis anogenus*). All four of these species are listed as "Endangered" by COSEWIC. Such species tend to have a unique subset of life history and ecological characteristics which make them particularly vulnerable to environmental degradation.

Unfortunately, threats to SAR are most severe in the watersheds of southwestern Ontario. Human impact on freshwaters in this region was identified as the highest in Canada as indicated by the human stress index (Chu *et al.,* 2003). High stress values in the Carolinian region are due to the combined effects of agriculture, industry and overall high population density. These factors also contribute indirectly to the high invasive fish species richness observed in these watersheds. Here, invasive fish species richness reaches a maximum of 15 (Figure 3). These include species such as common carp (*Cyprinus carpio*) and round goby (*Neogobius melanostomus*), which are known to be very disruptive to native aquatic communities.

Figure 2. Freshwater mussel SAR richness in tertiary watersheds of the Great Lakes basin.

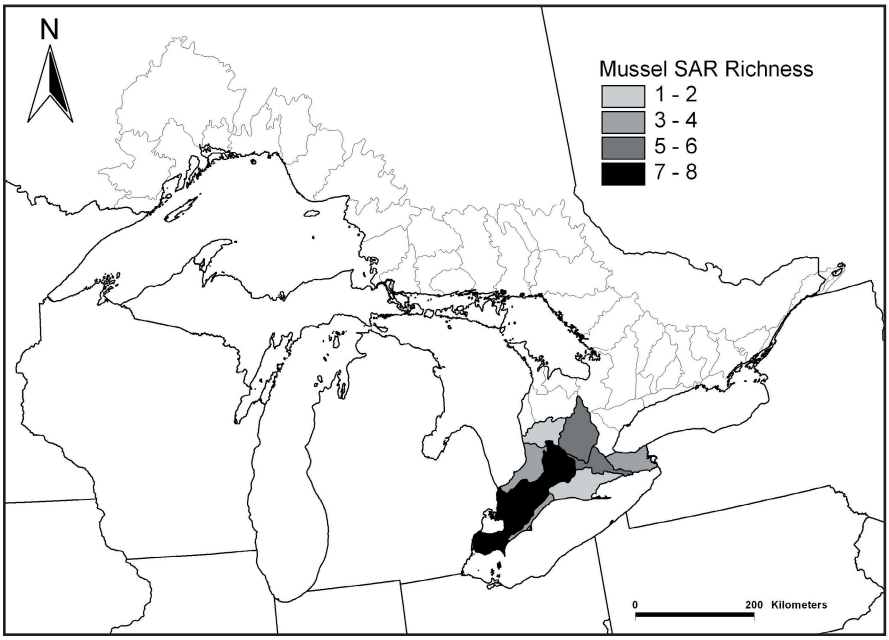
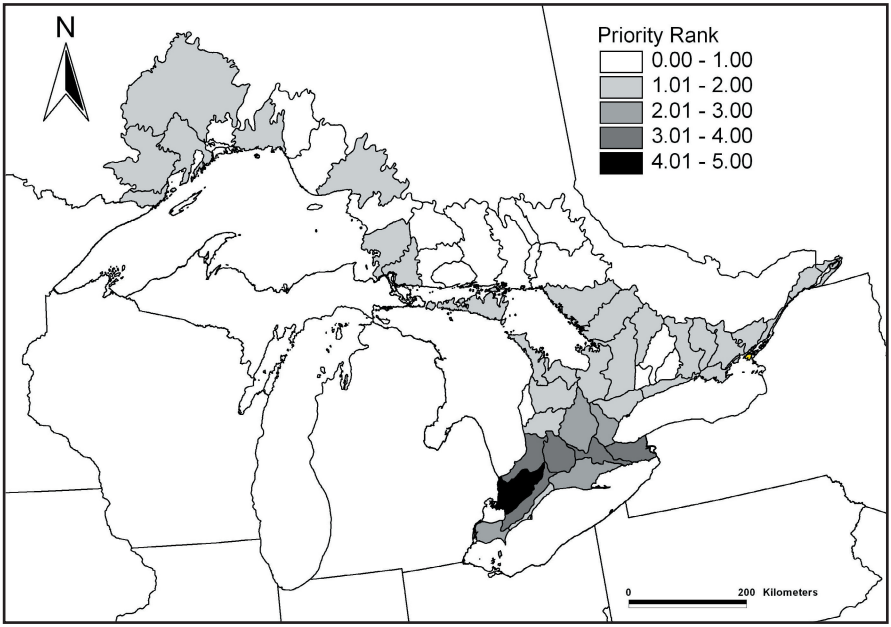


Figure 3. Invasive fish species richness in tertiary watersheds of the Great Lakes basin.



The results of the priority ranking score, which is a composite of biodiversity, SAR diversity and SAR threat factors, are illustrated in Figure 4. Tertiary watersheds with the highest priority ranking represent the highest conservation priority in terms of biodiversity under stress. Not surprisingly, these 'conservation hot spots' are located in the Carolinian region of southwestern Ontario and include the Thames, Sydenham, Ausable and Grand Rivers. Directing conservation efforts to these high priority watersheds will help ensure the survival of some of Canada's most imperiled freshwater species.

SAR recovery planning efforts are already well underway in the identified conservation hot spots. The Sydenham River was first to attract attention as one of the richest watersheds in all of Canada for aquatic species at risk and is a globally significant freshwater ecosystem (Staton *et al.,* 2003). The Sydenham River Recovery Team was also the first in the country to adopt an aquatic ecosystem approach to recovery planning for species at risk (fishes, mussels, and reptiles). The recently approved recovery strategy (Dextrase *et al.,* 2003) is being used as a model for other diverse watersheds within the Lake Erie-Lake St. Clair region of southwestern Ontario. These recent recovery planning initiatives include the Ausable, Thames and Grand Rivers as well as the Essex-Erie region (Figure 5). The protection and recovery of

Figure 4. Conservation hot spots – priority watersheds for conservation in the Great Lakes basin.

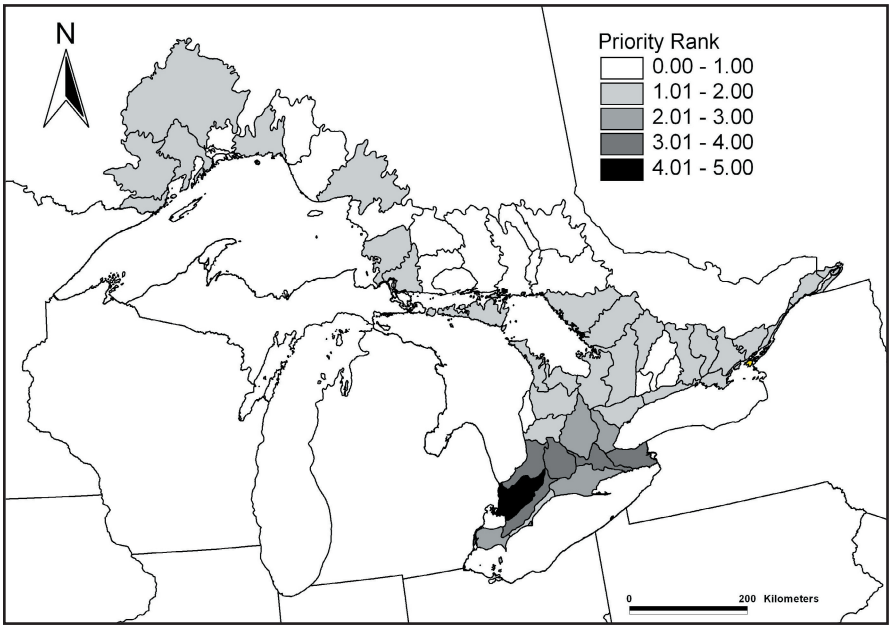
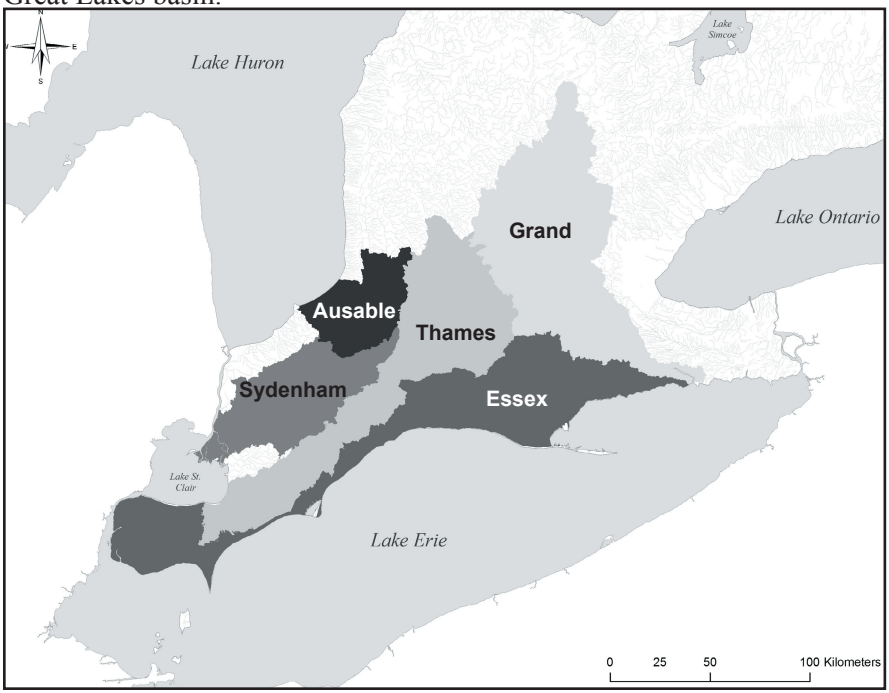


Figure 5. Aquatic ecosystem-based recovery planning initiatives in the Great Lakes basin.



these watersheds of high conservation priority is essential to the preservation of aquatic biodiversity in Canada.

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