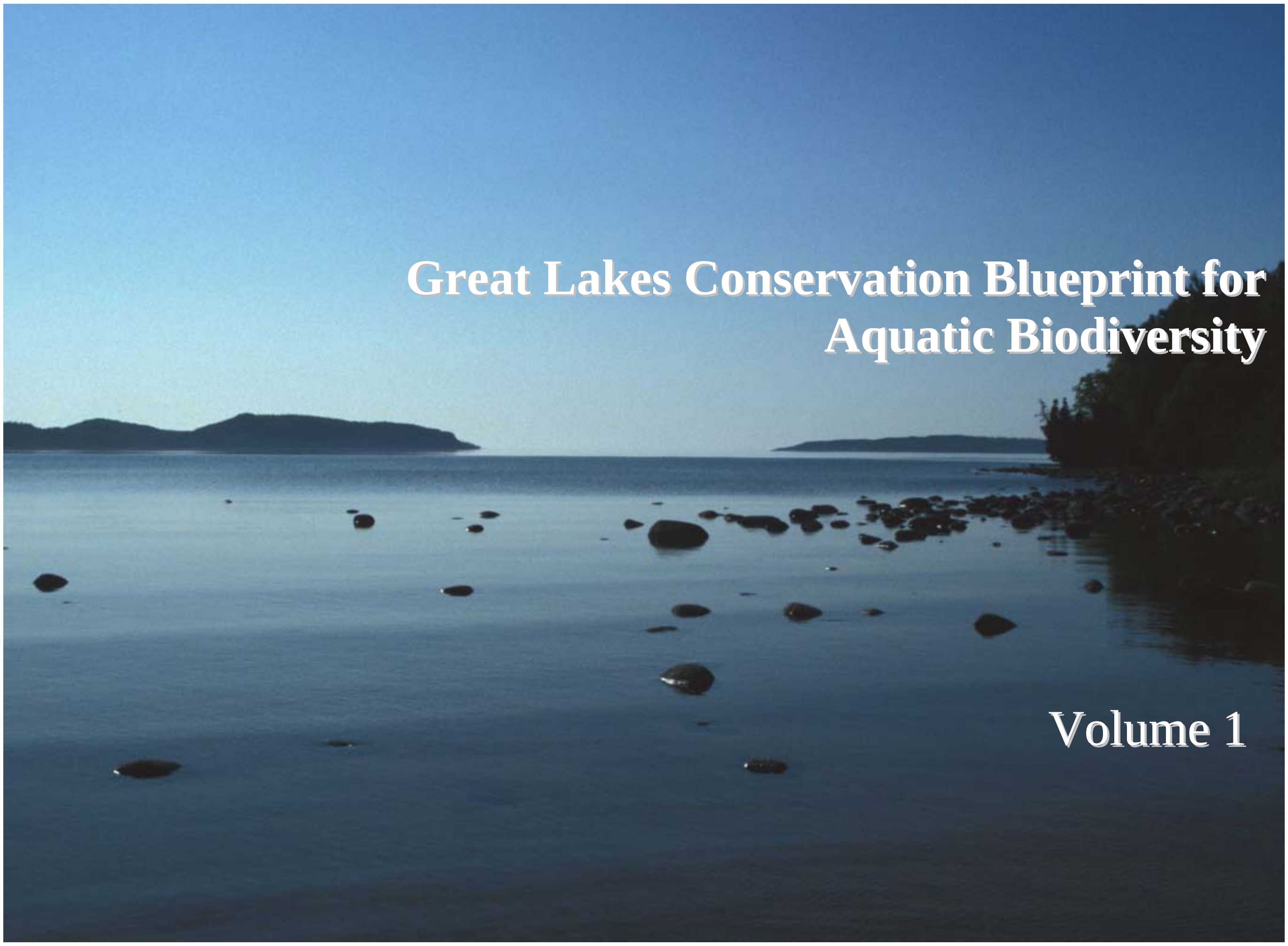

Great Lakes Conservation Blueprint for Aquatic Biodiversity

Volume 1

G.A. Wichert, K.E. Brodribb, B.L. Henson and C. Phair




2005

Nature Conservancy Canada
Natural Heritage Information Centre
Ontario

The Great Lakes Conservation Blueprint for Aquatic Biodiversity was completed with the generous funding support of

The Charles Stewart Mott Foundation

Ontario Ministry of Natural Resources

Ontario Parks

Living Legacy Trust

The W. Garfield Weston Foundation

Environment Canada

Great Lakes Conservation Blueprint for Aquatic Biodiversity

Volume 1

G.A. Wichert, K.E. Brodribb, B.L. Henson and C. Phair

2005

Nature Conservancy Canada
Natural Heritage Information Centre
Ontario

The Great Lakes Conservation Blueprint for Aquatic Biodiversity was completed as a partnership project between the Nature Conservancy of Canada and the Ontario Ministry of Natural Resources

Produced by the Nature Conservancy of Canada under Licence with the Ontario Ministry of Natural Resources © Queen's Printer for Ontario, 2005.

Canadian Cataloguing in Publication Data:

ISBN 0-9695980-3-3

1. Conservation plan – Great Lakes region
I. Nature Conservancy of Canada.
II. Title.
Includes bibliographic references.

The maps presented in this report are for illustrative purposes only. These maps are not intended as a precise indication of routes, locations of features, or as a guide to navigation.

Cover photos: Shesheeb Bay, Black Bay Peninsula, Lake Superior (looking south); Northern Wiry Sedge Shore Fen *(W.D. Bakowsky, NHIC Archives)*; Lake Erie Watersnake (*Nerodia sipedon insularum*), Eastern Prairie Fringed-orchid (*Platanthera leucophaea*), Wood Turtle (*Glyptemys insculpta*) (*M.J. Oldham, NHIC Archives*).

For further information contact the Nature Conservancy of Canada at 1-877-343-3532 or the Natural Heritage Information Centre at 1-705-755-2159.

The Nature Conservancy of Canada is a non-profit, non-advocacy organization that takes a business-like approach to land conservation and the preservation of Canada's biodiversity. Its plan of action involves partnerships and creative conservation solutions with individuals, corporations, community groups, conservation organizations and government agencies that share its passion. Since 1962, NCC and its supporters have protected more than 725,000 hectares (1.8 million acres) of ecologically significant land across Canada – mountains and valleys, coasts and lakes and rivers, prairies, forests, wetlands and tundra – and all the species and ecosystems that those landscapes support.

The Natural Heritage Information Centre was established in 1993, as a partnership between the Ontario Ministry of Natural Resources, the Nature Conservancy of Canada, the Natural Heritage League and The Nature Conservancy. The NHIC maintains a central database of Ontario's natural areas, and species and communities of conservation concern, and works with partners on a wide-range of conservation initiatives. Science-based information is made available to organizations and individuals involved in the conservation of biodiversity. The NHIC also represents Ontario's interests in many national and international biodiversity and conservation matters through the NatureServe network.

Table of Contents

Volume 2 of this report includes summaries, tables and maps of each tertiary watershed in the Great Lakes region.

i. Acknowledgements

The Great Lakes Conservation Blueprint Project team would like to acknowledge the generous contributions of The C.S. Mott Foundation, Ontario Natural Heritage Information Centre (Ontario Ministry of Natural Resources), Ontario Parks (OMNR), Living Legacy Trust, The W. Garfield Weston Foundation and Environment Canada to this project. In particular, the early involvement and support of Lois DeBacker of the C.S. Mott Foundation, Michele DePhilip (The Nature Conservancy), Ron Desjardine of the Fisheries Section (OMNR), Ted Harvey of Science and Information Division (OMNR), and Jim Mackenzie of the Natural Heritage Information Centre (NHIC) was critical. The partnership between Nature Conservancy of Canada (NCC) and OMNR to conduct this project was established through a memorandum of agreement on support for and service by the NHIC, supported by OMNR, Ontario Nature, Bird Studies Canada and NCC.

The Conservation Blueprint's Steering Committee provided project guidance and institutional context for the project. The Committee included James Duncan (NCC), Barton Feilders (OMNR), Pat Freistatter (OMNR), Edward Harvey (OMNR), Joe Kapron (OMNR), Dan Kraus (NCC), Cheryl Lewis (OMNR), Jim Mackenzie (OMNR), Dave Maraldo (OMNR), Dan Maringh (OMNR), John Riley (NCC), Al Sippel (OMNR) and Robert Taylor (OMNR).

The project's Core Science Team provided general project guidance and ensured the exchange of information among agencies and programs. These members also reviewed and contributed to the methodology. We would like to thank Wasyl Bakowsky (OMNR), Bill Crins (OMNR), Michele DePhilip (TNC), Jack Imhof (Trout Unlimited Canada), Don Jackson (University of Toronto), Colin Jones (OMNR), Wendy Leger (Environment Canada), Jim Mackenzie (OMNR), Nick Mandrak (Fisheries and Oceans Canada), Rob McLaughlin (University of Guelph), Mike McMurtry (OMNR), Debbie Ming (Fisheries and Oceans Canada), Michael Oldham (OMNR), John Riley (NCC), Les Stanfield (OMNR), and Chris Wilson (OMNR).

The Provincial Geomatic Service Centre (PGSC) staff was instrumental in the development and implementation of the extensive GIS analysis. We would like to thank Marcin Haladaj, Jason Henson, Kevin Jarbeau, Derek Johnston-Main, Randal Kuyvenhoven, Selena Mann, Zoë Morrison, Paul Staples and Mark Woolley. We would also like to thank the PGSC, particularly Greg Sikma, for the work on the variety of cartographic products.

We would also like to thank Gary Allen (OMNR), Bill Crins (OMNR), Michele DePhilip (TNC), Greg Deyne (OMNR), Glen Hooper (OMNR), Jack Imhof (Trout Unlimited Canada), Keiko Lui (OMNR), Tom MacDougall (OMNR), Nick Mandrak (Fisheries and Oceans Canada), Rob McLaughlin (University of Guelph), Mike McMurtry (OMNR), Robert Metcalfe (OMNR), Brian O'Donoghue (OMNR), Brian Potter (OMNR), Phil Ryan (OMNR), Les Stanfield (OMNR), Tom Stewart (OMNR), Nick Stow (OMNR), Shaun Thompson (OMNR), and Chris Wilson (OMNR) for their comments on the aquatic ecosystem classification.

We are also thankful to Jarmo Jalava and Fenella Hood for their comments and thoughtful review of these reports.

Data for this project were provided by the Natural Heritage Information Centre, Ontario Parks, Ontario Ministry of Northern Development and Mines, Bird Studies Canada, Department of Fisheries and Oceans, the Royal Ontario Museum, Parks Canada, Environment Canada, Ontario Federation of Anglers and Hunters, the Conservation Authorities of Ontario, and the Nature Conservancy of Canada.

ii. Executive Summary

The Nature Conservancy of Canada (NCC) partnered with the Ontario Ministry of Natural Resources (OMNR) to produce the aquatic and terrestrial Conservation Blueprints for the Ontario portion of the Great Lakes ecoregion. This report summarizes the analysis of aquatic biodiversity for the Canadian side of the Great Lakes ecoregion, excluding the Great Lakes themselves. The Great Lakes Conservation Blueprint for Terrestrial Biodiversity is a complementary study (Henson *et al.*, 2005 and Henson and Brodribb, 2005). The Great Lakes Conservation Blueprint represents a significant conservation planning investment across the ecoregion that will identify or re-validate best representative areas across the Great Lakes, regardless of land tenure, to be shared among conservation partners.

Analytical concepts that were applied for the Great Lakes Conservation Blueprint were consistent with those used by the Ministry of Natural Resources and Ontario Parks to identify Areas of Natural and Scientific Interest and Ontario Living Legacy sites. The approach is also consistent with the approach used by The Nature Conservancy (US) to identify sites for conservation in the US portion of the Great Lakes watershed (Harkness *et al.*, 1999). The application of consistent approaches throughout the entire Great Lakes watershed suggests that results from these related initiatives will be comparable and will represent a system of priority areas for conservation of aquatic biodiversity.

The aquatic Conservation Blueprint for the Great Lakes watershed includes about 6,769,591 hectares (ha), or about 24.2% of the total area of the watershed. Approximately 12.3% of the study area consists of protected areas and conservation lands. An additional 11.9% of the watershed's total area is required to achieve conservation goals for under-represented freshwater ecological systems, species and vegetation community targets in Ontario's Great Lakes basin.

The generation of the aquatic Conservation Blueprint, including coarse- and fine-filter biodiversity analyses, was an approach to evaluate the representation of biodiversity targets in existing conservation lands and to identify additional locales to capture under-represented conservation targets.

The Great Lakes Conservation Blueprint identified under-representation of stream system, inland lake, wetland and Great Lakes shoreline habitats in existing protected areas and conservation lands, and improved their representation with a portfolio of sites for future conservation action. The process also identified and filled gaps in under-represented species and vegetation community targets. The final Conservation Blueprint portfolio includes all known, viable occurrences for some fine-filter targets and a substantial proportion of known occurrences for others.

The top three examples of each stream, lake and coastal ecosystem and the top six examples of wetlands were identified within each tertiary watershed across the Ontario portion of the Great Lakes basin. Stream systems dominated the Conservation Blueprint portfolio in terms of area contribution; Great Lakes shoreline and wetlands contributed the least area to the portfolio.

The spatial distribution of existing conservation lands is more concentrated along the Great Lakes coast than in inland areas. When existing conservation lands and coarse-filter portfolio sites were combined, a more balanced distribution of conservation sites within the upper watershed and lower reaches throughout the watershed was achieved.

Numerous occurrences of fine-filter biodiversity targets did not fall within existing protected areas and conservation lands. If implemented, the Conservation Blueprint portfolio can enhance the effectiveness of the existing conservation lands for protecting rare species and vegetation communities.

1.0 Introduction

The Great Lakes Conservation Blueprint for Aquatic Biodiversity is the product of a partnership between the Nature Conservancy of Canada and the Ontario Ministry of Natural Resources (Natural Heritage Information Centre and Ontario Parks). This project developed as a response to the need to better understand the types and distribution of freshwater biodiversity in the Ontario portion of the Great Lakes basin, to describe what features and functions were already represented in Ontario's protected areas system, and to identify additional priority sites for conservation action.

The Great Lakes basin spans about 1,200 km from west to east and lies within eight states and two provinces. Approximately 40 million people live in the basin or use water extracted from it (IJC, 2000). Various land use activities including residential, industrial, agricultural, recreational, and water uses including consumption, power generation and cooling, transportation cleaning and other industrial processes occur within the basin. These activities influence physical habitat and water quality for the diverse aquatic biota living in the basin.

A relatively young ecosystem, the present Great Lakes appeared about 8,000 years ago after the retreat of the Wisconsinan Glacier (Cudmore-Vokey and Crossman, 2000). Fishes from Mississippi and Atlantic Drainage refugia formed the nucleus of the present association of fishes in the Great Lakes and their tributaries (Underhill, 1986). As the glacier receded, inlets and outlets to the basin changed allowing movement of fish in and out of the Great Lakes basin from adjacent refugia during various periods. Presumably freshwater mussels and crayfishes in the Great Lakes came from the same glacial refugia as the fishes, but descriptive accounts for the post-glacial distribution of these taxa are not available.

The Great Lakes show relatively low species richness and endemism for aquatic species compared to other parts of North America. The most recent glacier, the Wisconsinan, receded 10,000 to 15,000 years before present. The relatively short period since then has not allowed a high degree of speciation and endemism to occur (Abell *et al.*, 2000).

The Great Lakes have undergone profound transformations since permanent European settlements were established in the mid-19th Century (Sly, 1991; Regier and Kay, 1996; Kay and Regier, 1999). Early documented changes include extirpation of native species such as Atlantic Salmon (*Salmo salar*) and local degradation of near shore areas, deforestation, and habitat fragmentation due to dam construction for mill works and flood control.

Efforts to identify aquatic features in need of conservation and protection have been hampered by a lack of knowledge on the variety and distribution of aquatic species, communities and systems on a watershed basis. The study of aquatic resources has focused largely on fish population dynamics, sustainable levels of exploitation, community ecology and the effects of a range of stressors operating on aquatic systems. Biodiversity conservation is, however, becoming an increasingly important theme in aquatic resource management (Allan and Flecker, 1993; Master *et al.*, 1998; Weitzell *et al.*, 2003; Martens and Dumont, 2004). Comprehensive taxonomic treatments of the major groups of freshwater plants and animals have been available for some time, but the geography of freshwater biodiversity, at the species, community and system scale, is poorly known. We do know that there are many threats to freshwater biodiversity, including over-exploitation (Post *et al.*, 2002); habitat destruction (Snell, 1989); invasion by and deliberate introduction of non-native species (Zaret and Paine, 1973; Nalepa, 1994; Catling and Porebski, 1995); excess nutrients (Evans *et al*., 1996) and contaminants transported by air and water (Glooschenko *et al*., 1992; Young *et al*., 2004). The selection of areas for protection in Ontario has been largely based on terrestrial features and has not included representative examples of aquatic systems.

The purpose of this study was to delineate, classify and characterize aquatic ecosystems in the Ontario portion of the Great Lakes basin and to prioritize systems and sites for the conservation of aquatic biodiversity. The extent to which the existing system of parks and protected areas sustain the range of biodiversity was assessed for each tertiary watershed within the study area. The study considers stream, lake, wetland and coastal systems, but excludes the Great Lakes themselves. The results of this analysis are intended to be a first approximation at identifying a portfolio of sites across Ontario's Great Lakes basin that are important for the conservation of aquatic biodiversity. The results can provide a basis for resource management decisions, a guide to which sites may be important for conservation actions, and a basis for further discussion and refinement. The approach adopted was strongly influenced by methodology developed by The Nature Conservancy (U.S.) (Groves *et al*., 2000) and the methods used to assess candidate life science areas for the Ontario Areas of Natural and Scientific Interest (ANSI) and protected areas programs (Riley *et al*., 1996; Crins and Kor, 2000).

A suitable system for classifying ecological systems based on landform and vegetation types was available to be used as a framework for the terrestrial Conservation Blueprint (Henson *et al*., 2005). There was no equivalent classification method available for freshwater systems in Ontario until recently (Wichert *et al.*, 2004). Classification systems for lake and stream ecosystems have been based on hydrology, temperature regime, fauna and nutrient regime, but there has not been a framework that combines physical and ecological attributes in one overall classification system. Poor spatial correspondence between terrestrial and fish faunal region classifications (Mandrak, 1998) suggests that protection of aquatic biota and aquatic ecosystems is not being well addressed in Ontario using terrestrially derived frameworks to identify protected areas. Wichert *et al.* (2004) developed a classification framework for aquatic ecosystems for the purpose of the Conservation Blueprint project that relies on data available at a landscape scale in Ontario. This methodology and the resulting classification form a foundation to the present report.

2.0 An Approach to Conservation Planning

A systematic approach to the analysis and a defensible set of criteria were essential in order to identify a portfolio of sites that represents the full range of biodiversity in the Great Lakes watershed. The coarse- and fine-filter approach to biodiversity analysis as described by Groves *et al.* (2000) was adopted for the aquatic Conservation Blueprint project.

Most conservation planning approaches specify that biodiversity assessment and conservation should apply to several geographic scales and levels of biological organization (Poiani *et al.*, 2000; Groves *et al.*, 2002; Silk and Ciruna, 2004; Higgins *et al.*, 2005). Coarse-filter analysis considers targets at community, ecosystem, and landscape levels of organization and ensures representation of the range of habitat and ecosystem types. Coarse-filter approaches aim to conserve not only species and immediate habitat but also ecosystem linkages and processes (Pickett *et al.*, 1996; Schwartz, 1999). Coarse-filter conservation can also protect resources preemptively before they become imperiled. Despite the logical reasons for coarse-filter conservation, implementation of the approach can be difficult. Numerous attributes of ecosystems may be considered for coarse-filter conservation. The relative value of ecosystems can be judged in terms of 1) rarity of ecosystem type, 2) regional hotspots of biodiversity, 3) representation among habitat types, and 4) critical ecosystem functions. No *a priori* basis has been articulated to prioritize one set of attributes against another; rather the relative values are usually assigned using expert judgment (Margules and Pressey, 2000; Groves *et al.*, 2002). The key criteria used to guide the aquatic Conservation Blueprint portfolio design were representation, irreplaceability, complementarity, efficiency, and viability/suitability. Practical issues such as data availability and weight of evidence based on a mix of ecological, ethical, social, economic and other considerations can be used to prioritize efforts to protect specific sites and provide the basis for measures of achievement.

Fine-filter analysis considers targets at gene, population and species levels of organization. The simplest rationale for fine-filter conservation is that "populations and species must be saved from extinction" (Schwartz, 1999). The simple objective of preventing extinction makes evaluation of conservation at that scale straightforward. Formal programs to document species at risk assist the identification of fine-filter conservation targets. Finally, fine-filter programs are supported by legislation such as Ontario's Endangered Species Act and the Federal Species at Risk Act.

Despite the advantages associated with fine-filter conservation, its implementation is flawed because the problem of conserving biodiversity species by species is too large (Rohlf, 1991; Walker, 1992). Since its inception in the US in 1973, the Endangered Species Act has resulted in the recovery and de-listing of five species (USFWS, 1996). These recoveries have resulted from two measures: alleviating predation, and reducing pollutants causing reproductive failure. Reversing habitat degradation, fragmentation and loss, the limiting resources for most endangered species, are more difficult to address (Noss *et al.*, 1997; Schwartz, 1999).

Both coarse- and fine-filter biodiversity analyses were used to identify sites with high conservation values within each tertiary watershed (Figure 1). Conservation values were assigned by assessing condition, ecological functions, diversity, and special features associated with each Aquatic Ecological Unit (AEU). These same criteria have been used to identify protected areas including Provincial Parks, Conservation Reserves, Areas of Natural and Scientific Interest, and Ontario Living Legacy lands (Crins and Kor, 2000; Riley and Brodribb, 2003).

Data representing multiple levels of biological organization were utilized to ensure that habitat configurations and processes supporting life history requirements for most aquatic biota were considered in the assessment. This approach made optimal use of available data relating to physical representation of aquatic habitat and of supplementary data records for aquatic biota indicating conservation values and locales with high ecosystem integrity (Groves *et al.*, 2002).

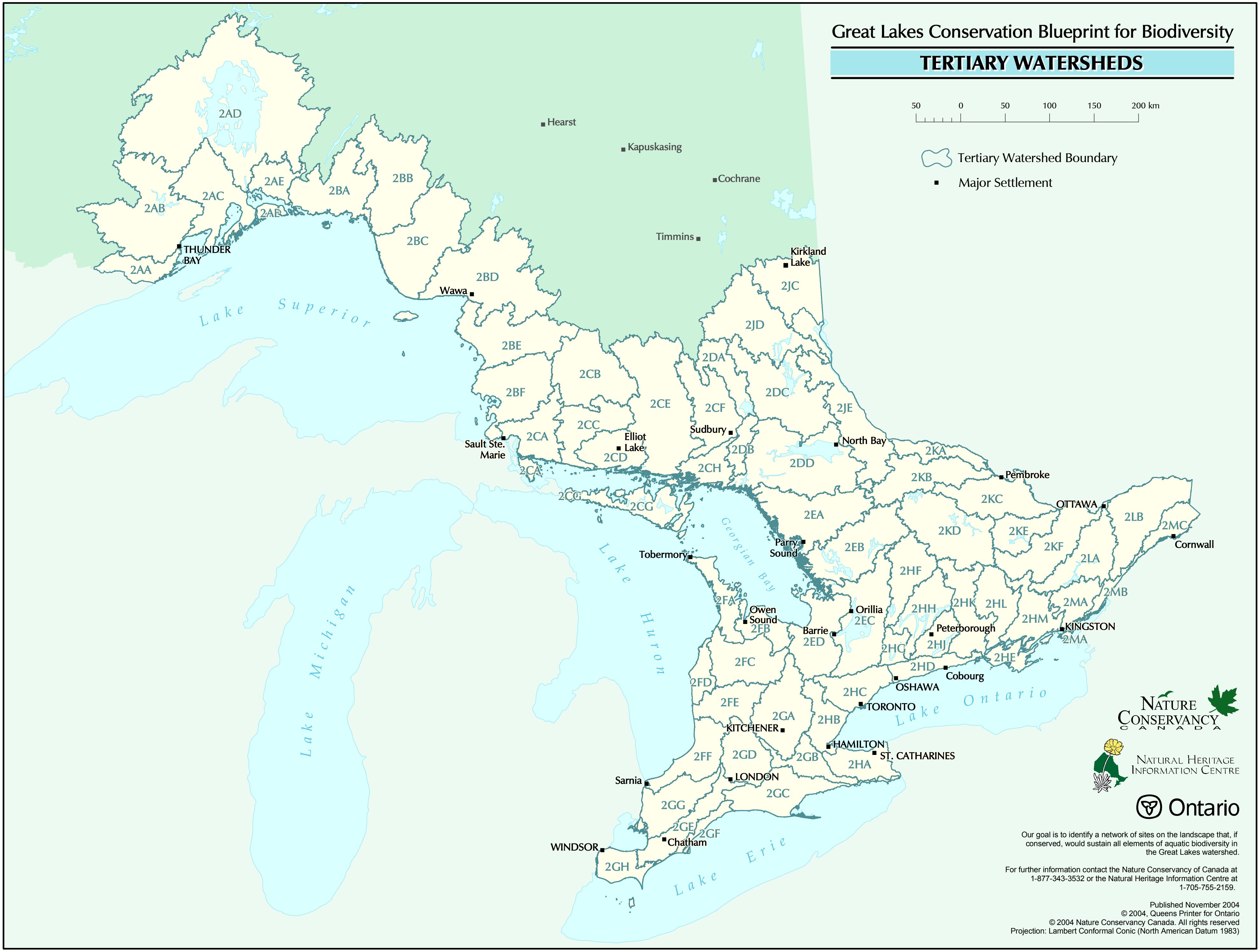

Figure 1. Tertiary watersheds in the Ontario portion of the Great Lakes watershed.

Coarse- and fine-filter targets not represented within the existing protected area system were identified and sites that sustain these aquatic habitats and species were added to the Conservation Blueprint portfolio. Candidate locales to supplement the existing protected area system were judged according to irreplaceability, efficiency, complementarity, and viability/suitability to ensure the creation of an efficient portfolio.

3.0 Characterizing Aquatic Ecosystems

3.1 Aquatic Landscape Inventory System and the Aquatic Ecosystem Classification

Landscape conditions have a considerable influence on the biophysical properties of aquatic systems (Maxwell *et al.*, 1995; Seelbach, 1997; Higgins *et al*., 1998). The creation of a digital dataset to delineate, characterize and classify valley segments into a landscape context was essential. A GIS-based Aquatic Landscape Inventory System (ALIS) was developed initially to delineate water flow in the Lake Huron basin (Kilgour and Stanfield, 2001). ALIS was then adapted to characterize aquatic habitats according to physical criteria for each tertiary watershed within the Great Lakes watershed for use in the Great Lakes Conservation Blueprint for Aquatic Biodiversity (Stanfield and Kuyvenhoven, 2002). This was accomplished by adding processes to characterize water polygons and the Great Lakes coast. ALIS performs aquatic habitat delineation and characterization that can support numerous applications including aquatic ecosystem classification (Wichert *et al.*, 2004).

ALIS was used to delineate and characterize Great Lakes coastal areas, streams, wetlands, and inland lakes in the Ontario portion of the Great Lakes basin based on physical criteria such as size, watershed position, geology and climate. Each of these aquatic ecological units was characterized in terms of estimates of landscape and site characteristics (*e.g.*, drainage area, stream order, underlying geology, land cover). With this information a hierarchical Aquatic Ecosystem Classification (AEC) was developed (Wichert *et al.*, 2004). Five hierarchical levels are represented in the AEC (Table 1). The Great Lakes basin and individual Great Lake watersheds were the largest spatial units considered. These units respond to disturbance processes such as plate tectonics and glacial cycles. Approximate time for change is greater than 10,000 years and biotic processes observed at this scale are speciation and extinction (Maxwell *et al.*, 1995). Ecological Drainage Units are aggregations of tertiary watersheds that respond in similar ways to local uplift, faulting and folding, and flood cycles (Figure 2). They are delineated based on hydrology, geology and climate and form an intermediate level in the hierarchical aquatic classification framework in Table 1. Biotic processes include genetic variation and time for change is 1,000 to 10,000 years (Maxwell *et al.*, 1995).

Table 1. Comparison between Ontario's terrestrial Ecological Land Classification framework (Lee *et al.*, 1998) and proposed Aquatic Ecosystem Classification units.

Terrestrial units	**Aquatic units**	**Spatial scale**	**Classification factors for aquatic units**
Eco-zone	Entire Great Lakes basin	10,000s to 100,000s km^2	Continental-scale climate; plate tectonics; glaciation pattern
Eco-province	Individual Great Lake watersheds	1,000s to 10,000s km^2	Regional climate; post-glacial dynamics
Eco-region	Ecological Drainage Units	1,000s to 10,000s km^2	Consistent AEU response to hydrologic and climatic influence
Eco-district	Tertiary watersheds	100s to 1,000s km^2	Drainage based; scale appropriate for management and planning
Eco-site	Aquatic Ecological Units (AEU)	10s to 100s km^2	Relative uniformity within AEUs with respect to hydrological properties, mappable units

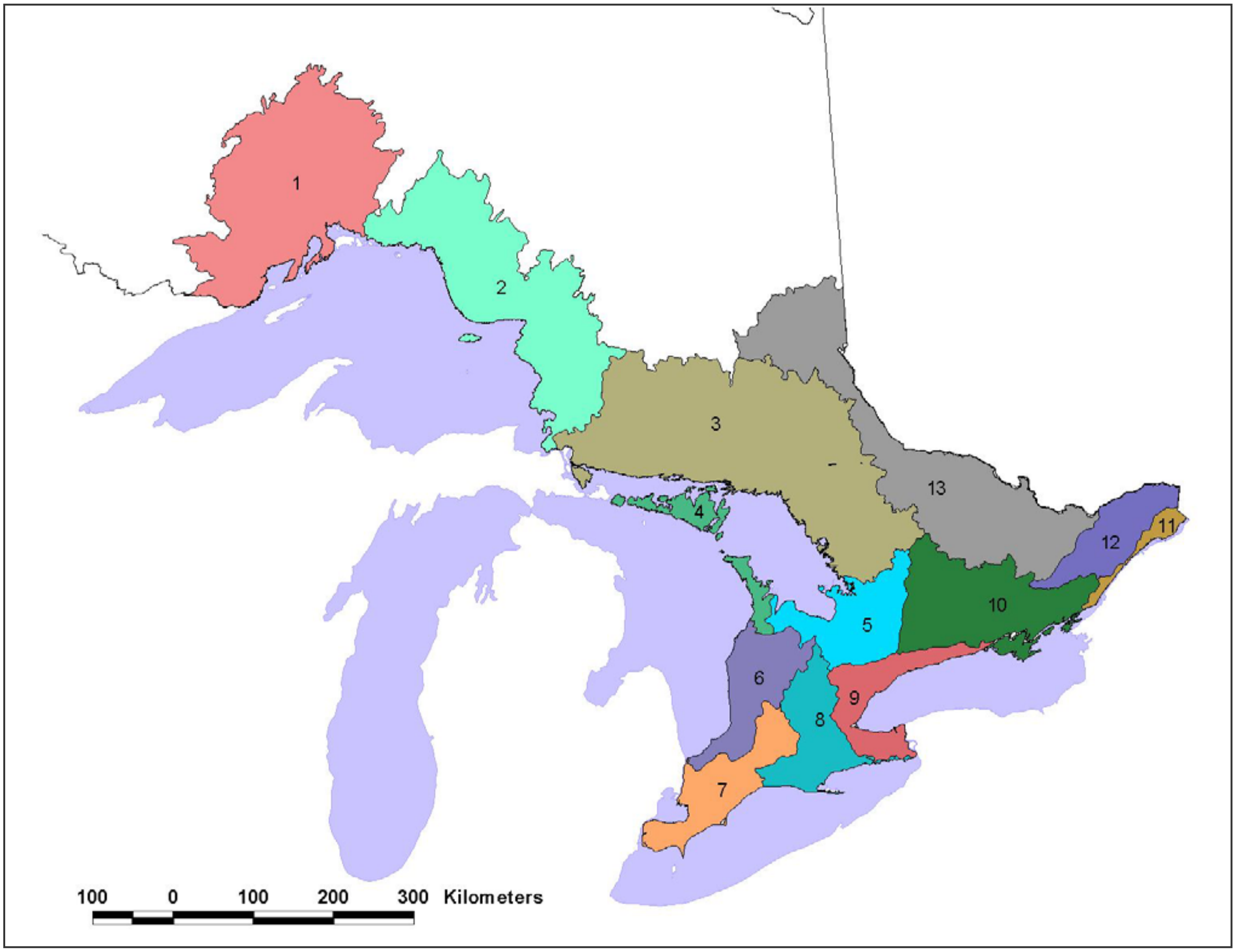

Figure 2. Ecological Drainage Units (EDUs) for the Ontario Great Lakes watershed.

3.2 Aquatic Ecological Units

The Aquatic Ecosystem Classification (AEC) was used to classify and map Aquatic Ecological Units (AEU). These AEUs formed the foundation for analysis of representation of the aquatic features upon which prioritization of areas for conservation was based (Wichert *et al.*, 2004). The types of AEUs applied throughout the Great Lakes watershed for the Conservation Blueprint included the Great Lakes shoreline and coastal areas, stream systems, wetlands and inland lakes that exhibited similar physical characteristics.

Tertiary watersheds represent units that are convenient for watershed management and planning, and integrate ecological processes related to water quality, nutrients and movement of aquatic species. Aquatic Ecological Units are the smallest units that were defined in the AEC. These units represent polygons for individual Great Lakes coastal areas, inland lakes or wetlands, or aggregations of adjacent stream segments within common watershed position, gradient, permeability and water storage potential (Figure 3). Disturbance processes for AEUs include geomorphology and local climate regimes. Similar AEU types are expected to show similar population demographics. Approximate time for changes in the configuration of AEUs is 100 to 1,000 years (Maxwell *et al.*, 1995).

Figure 3. Examples of aquatic ecological units (AEUs) that form the basis for the coarse-filter assessment. Shades of grey depict Great Lakes coastal areas, green polygons depict wetlands, blue polygons represent inland lakes, and brown and yellow polygons represent stream systems.

Class intervals were defined using ecological information when justification for those decisions was supported in the literature. When there was no literature to support ecological class intervals, class intervals were defined by information that related to abiotic processes.

Inland lakes and wetlands are considered in two ways in the AEC. The proportion of the lake and wetland area to the total drainage of a stream system unit is an emergent property of these features and characterizes water storage potential. In addition, individual inland lakes and wetlands are classified based on size, shoreline complexity, geological context and connectivity. Lake depth is a key variable for lake classification; however, this information is available for only a small set of lakes within the study area and was not used as a classification variable.

In its first iteration, ALIS delineated and characterized only the water flow. Rivers and streams were broken into 'segments' (*sensu* Seelbach *et al.*, 1997) based on six ecological criteria according to changes in hydrology:

- where a water course flowed into or out from an inland lake
- where a water course flowed into or out from a wetland
- where a stream drained into a Great Lake
- at a confluence where stream order changed
- at a water flow barrier (*e.g.*, dam or waterfall and changes in geology)
- where water flow crossed from one to another of 32 geological classes defined on provincial surficial geology maps.

These segments were characterized in terms of drainage area, area of lakes and wetlands within the catchment, geology, gradient, and number of dams in the catchment. The initial delineation process also identified water polygons (wetlands and inland lakes) connected to the water flow but did not characterize these features. Functions were incorporated that characterized all lakes and wetlands (both those connected to and those isolated from the water flow) with respect to geology, size, shape, and number of inflows and outflows.

The Great Lakes shoreline was considered as two distinct habitat types: coastal areas with defined surface water flow and those without surface water flow. The shoreline ecotone was characterized with respect to geomorphology and water flow patterns where streams intersected the shoreline. The coastal area with no defined surface flow was further characterized with respect to size and geological permeability (Wichert *et al.*, 2004).

Criteria for classifying Great Lakes shoreline and coastal areas are elaborated in Table 2 and 3. Adjacent stream segments with similar watershed position, geologic permeability, water storage potential, and gradient were aggregated into AEUs according to the classification criteria in Table 4. Wetlands were classified by type, size and connectivity to water flow according to the criteria in Table 5. Inland lakes were classified according to size, shape, geologic permeability, and connectivity according to the criteria in Table 6.

Table 2. Aquatic Ecosystem Classification categories and classes for the Great Lakes coastal areas with defined drainage (Wichert *et al.*, 2004).

Category	Class	Comment
Shoreline	Gently sloping shoreline gradient	High or low bluffs with beach; sandy beach/dunes; coarse beach dunes/bay mouth-barrier beach; bedrock
	Abrupt shoreline gradient	High or low bluff without beach; sandy/silty banks; clay banks; bedrock; composite
	Low riverine coastal plain	Connecting channels and river mouths
	Open shoreline wetlands	Subject to wave action
	Semi-protected wetlands	Not subject to wave action
	Artificial or unclassified	
Drainage pattern	$\leq$3rd order stream (small streams)	Concentration of key life cycle processes where lake and river ecosystems meet (Stephenson, 1990; Regier and Kay, 1996; Willis and Magnuson, 2000)
	$\geq$3rd order stream (large streams)	
	Mixed – large and small streams	
	None	

Table 3. Aquatic Ecosystem Classification categories and classes for the Great Lakes coastal polygons with undefined surface flow (Wichert *et al.*, 2004).

Category	Class	Interval	Rationale
Permeability	High	>2.34	Geological permeability values range from 1 to 3 on a continuous scale. Observed cold water species distribution
	Intermediate	>1.67 to $\leq$2.34	
	Low	$\leq$1.67	

Table 4. Aquatic Ecosystem Classification categories, classes and class intervals for Great Lakes rivers and streams (Wichert *et al.*, 2004).

Category	Class	Interval	Rationale
Permeability	High	>2.34	Geological permeability values range from 1 to 3 on a continuous scale. Observed cold water species distribution
	Intermediate	>1.67 to $\leq$2.34	
	Low	$\leq$1.67	
Gradient	Low	$\leq$0.20%	Substrate size composition (Gordon *et al.*, 1992)
	Medium	>0.20 to $\leq$2.0%	
	High	>2.0%	
Water storage potential: lake and wetland area in catchment	High	$\leq$ 10% of catchment	Water quality and peak flow thresholds (Detenbeck *et al.*, 2003)
	Low	>10 % of catchment	
Watershed position	Headwater	$\leq$100 upstream 1st order streams	Relate to differences in species richness (Osborne and Wiley, 1992) Energy and nutrient dynamics (Vannote *et al.*, 1980)
	Medium	>100-1000 upstream 1st order streams	
	Main channel	>1000 upstream 1st order streams	

Table 5. Wetland types, classes and class intervals identified within the Great Lakes watershed (Wichert *et al.*, 2004).

Type	Class	Interval	Rationale
Marsh	Small	≤100 ha	10-100 ha support species such as Black Tern, Forster's Tern, Short-eared Owl; >100 ha support Least Bittern and King Rail (Environment Canada *et al.*, 1998)
	Large	>100 ha	
For marshes, swamps, fens, bogs and muskeg	Unconnected	0 inflows or outflows	Presence and absence of connections relates to island biogeography theory and habitat isolation (Magnuson *et al.*, 1998)
	Connected	>0 inflows or outflows	

Table 6. Aquatic Ecosystem Classification categories, classes and class intervals for inland lakes in the Great Lakes watershed (Wichert *et al.*, 2004).

Category	Class	Interval	Rationale
Connectivity	Unconnected	0	Presence and absence of connections to the water flow relates to island biogeography theory and habitat isolation (Magnuson *et al.*, 1998)
	Connected	>1	
Size	Small	≤200 ha	Piscivores and small-bodied fish do not co-exist (Jackson *et al.*, 2001)
	Medium	200 to ≤1000 ha	Cool and warm water fish associations dominate (Johnson *et al.*, 1977; Marshall and Ryan, 1987); low concentration of major ions, susceptible to acidic deposition (Quinlan *et al.*, 2003)
	Large	>1000 ha	Transition from cool to cold water communities (Johnson *et al.*, 1977; Marshall and Ryan, 1987); high concentration of major ions, less susceptible to acidic deposition (Quinlan *et al.*, 2003)
Shape	Round	0.97 to 1.5	Shape index likely relates to extent of littoral zone and thus influences aquatic species abundance (Hinch *et al.*, 1991) and species richness (Eadie and Keast, 1984); 1.5 is the median for EDU 5
	Irregular	>1.5	
Permeability	High	>2.34	Geological permeability values range from 1 to 3 on a continuous scale. Observed lake trout distribution in EDU 5
	Intermediate	>1.67 to ≤2.34	
	Low	≤1.67	

4.0 Analytical Units for an Aquatic Conservation Blueprint Portfolio

The main goal of this study was to identify a portfolio of sites that would efficiently include the range of aquatic biodiversity in the Ontario portion of the Great Lakes watershed. The analysis does not include the Great Lakes themselves. An early step in the process was to assess what elements of aquatic biodiversity already exist in the protected area system. Candidate locales were identified that would supplement under-represented aquatic species, communities and ecosystems in the existing network of conservation lands. A site identification process was used and was based on the same criteria used by the Ontario Ministry of Natural Resources and Ontario Parks to identify Areas of Natural and Scientific Interest (ANSIs) and Ontario Living Legacy sites (Crins and Kor, 2000): representation, condition, ecological functions, diversity, and special features.

Representation analysis is used to determine the extent to which all conservation targets are included in the portfolio of aquatic Conservation Blueprint sites. Condition, ecological functions, diversity and special features indicate conservation values associated with each AEU (coarse-filter targets). These conservation values are used to prioritize coarse-filter targets for the aquatic conservation portfolio and to prioritize inclusion of sites containing fine-filter targets not captured during the coarse-filter evaluation.

4.1 Ecological Systems (coarse-filter targets)

Aquatic coarse-filter biodiversity targets were selected from the set of AEUs identified through the aquatic ecosystem classification process described above. A total of 129 possible types of AEUs were identified (24 Great Lakes shoreline, 3 Great Lakes coastal areas, 54 stream, 12 wetland, and 36 inland lake types) of which 120 were targets for representation in the aquatic Conservation Blueprint portfolio. The remaining nine ecological system types were not targeted due to insufficient amount of information to appropriately classify them. The list of all AEU types and coarse-filter targets for Ontario’s Great Lakes basin is included in Appendix 1.

4.2 Coarse-filter Conservation Goals

A consideration of distribution and replication are implicit in coarse- and fine-filter conservation goals. Large conservation planning areas should be subdivided and conservation goals should be specified for sub-units to ensure that areas identified for conservation are distributed geographically throughout the planning area (Groves *et al.*, 2000). Conservation goals were defined for tertiary watersheds for the Great Lakes Conservation Blueprint for aquatic biodiversity. For stream, lake and coastal systems, the three best scoring examples of each on a tertiary watershed basis were selected. Six of the best scoring examples of each wetland system were also incorporated into the Conservation Blueprint portfolio. Very little scientific information is available to support these conservation goals, but Margules and Pressey (2000) argue that a practical value associated with setting these types of goals is to measure achievement. Three (or six for wetlands) examples of each aquatic ecosystem within each tertiary watershed were identified to help ensure that the elements of biodiversity associated with these aquatic habitats will be conserved.

4.3 Rare Species and Habitats (fine-filter targets)

Fine-filter biodiversity targets include aquatic species and vegetation communities that are of conservation concern (Table 7). The following targets were identified based on conservation ranking and ecological criteria:

- Globally Imperiled Species (G1-G3G4)
- Species at Risk
- Endemic Species
- Declining Species
- Disjunct Species
- Rare Aquatic Vegetation Communities

These targets were compiled in the spring of 2004 and may not include species or vegetation communities that have met the above criteria since this date. The rankings associated with these target species and vegetation communities are current as of spring 2005. Species and vegetation community rankings are reviewed regularly, and the NHIC should be periodically consulted for the most recent rankings. Records of fine-filter biodiversity targets were obtained from the NHIC Element Occurrence Database and the Royal Ontario Museum Fish Distribution Database. Occurrences of fine-filter species targets are mapped in Figure 4. For a complete list of fine-filter targets see Appendices 2 and 3.

Table 7. Summary of Great Lakes ecoregion fine-filter biodiversity targets and conservation goals.

	Total	**Fish**	**Birds**	**Reptiles**	**Amphibians**	**Insects**	**Molluscs**	**Vascular Plants**
Species Targets	**121**	**28**	**9**	**7**	**5**	**30**	**13**	**29**
Primary Targets	**66**	**7**	**2**	**1**	**0**	**28**	**13**	**15**
Goal to obtain all viable occurrences	30					17	6	7
Goal to obtain 2, 3 or 4 occurrences	36	7	2	1		11	7	8
Globally rare (G1 to G3G4)	61	6	2	1		28	12	12
Provincially rare (S1 to S3)	41	7	2	1		8	9	14
Endangered (COSEWIC)	14	3	1	1			5	4
Threatened (COSEWIC)	3	2						1
Special Concern (COSEWIC)	4	2						2
Endangered – Regulated (OMNR)	5		2	1				2
Endangered (OMNR)	10	3					5	2
Threatened (OMNR)	4	2						2
Special Concern (OMNR)	1	1						
Peripheral in basin	20	1	1			6	5	7
Widespread in basin	6	2	1				1	2
Endemic in basin	10	3		1		1	4	1
Disjunct in basin	3							3
Limited in basin	12	1				6	3	2
Unknown in basin	15					15		

Table 7. Summary of Great Lakes ecoregion fine-filter biodiversity targets and conservation goals continued.

	Total	**Fish**	**Birds**	**Reptiles**	**Amphibians**	**Insects**	**Molluscs**	**Vascular Plants**
Secondary Targets	**55**	**21**	**7**	**6**	**5**	**2**	**0**	**14**
Globally rare (G1 to G3G4)	2					2		
Provincially rare (S1 to S3)	46	15	5	6	4	2		14
Endangered (COSEWIC)	12		2	1	2			7
Threatened (COSEWIC)	14	5	1	3	2			3
Special Concern (COSEWIC)	21	13	2	2				4
Endangered – Regulated (OMNR)	8		3		2			3
Endangered (OMNR)	5			1				4
Threatened (OMNR)	18	8	1	3	3			3
Special Concern (OMNR)	21	12	3	2				4
Peripheral in basin	41	12	4	6	5			14
Widespread in basin	7	2	3			2		
Limited in basin	0							
Community Targets	**32**							
Goal to obtain all viable occurrences	13							
Goal to obtain 3 occurrences	6							
Globally rare (G1 to G3G4)	13							
Provincially rare (S1 to S3)	16							
Secondary targets	13							

*For details on conservation goals of species and vegetation community targets, see section 4.4
**Targets can be included in more than one category, as categories are not mutually exclusive.

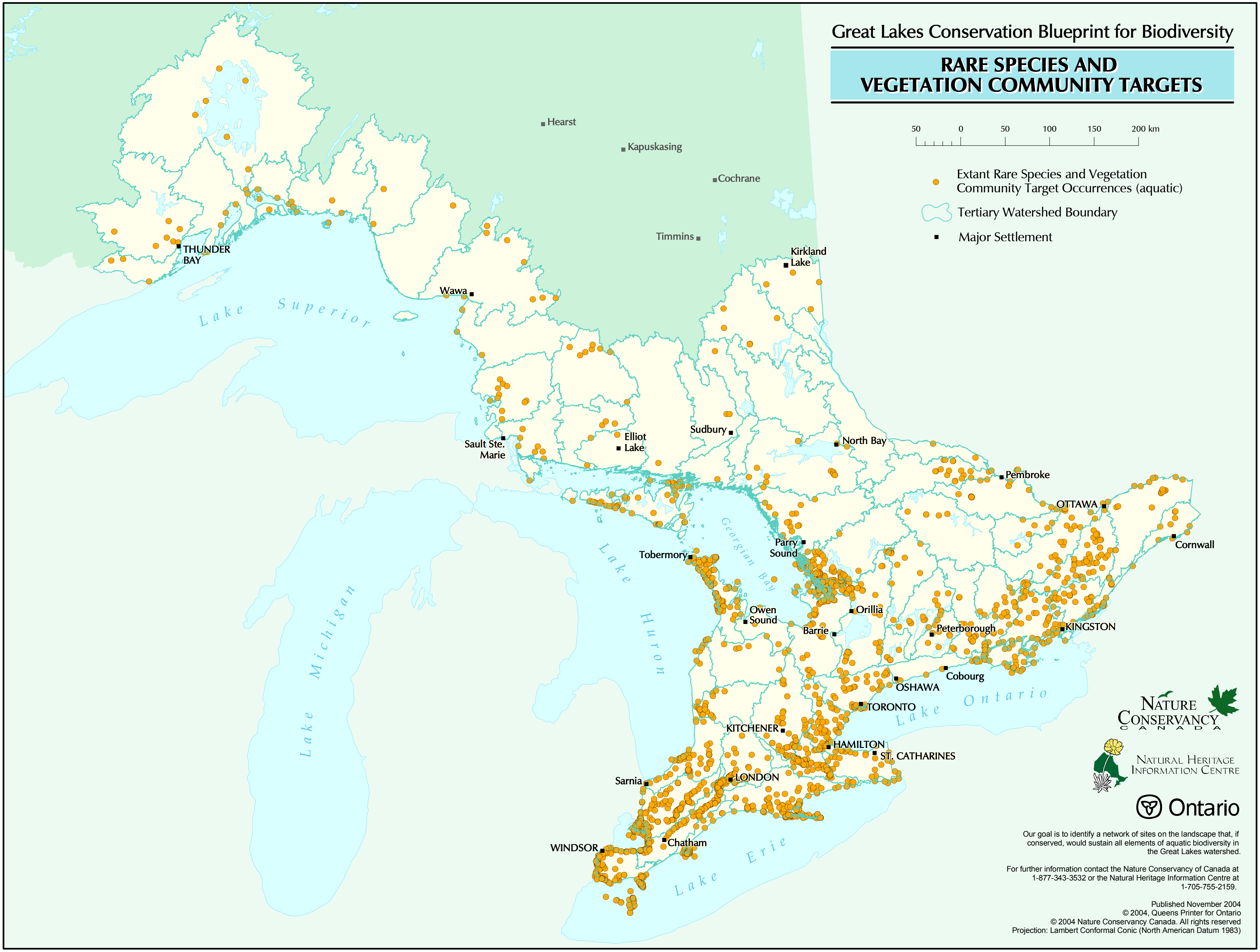

Figure 4. Occurrences of species and vegetation community targets in the Great Lakes basin of Ontario.

4.4 Fine-filter Conservation Goals

Fine-filter conservation goals were defined based on two considerations: sub-national and global conservation status of species and communities, and species distribution within Ontario's Great Lakes basin (Table 8 and Table 9). In general, the goals were more inclusive for globally rare species, and species with limited geographic distribution in North America.

Table 8. Conservation goals for species targets.

	G1	G2	G3	G4 - G5
Widespread	All viable occurrences	All viable occurrences	2 per tertiary watershed	secondary target
Peripheral	All viable occurrences	All viable occurrences	2 per tertiary watershed	secondary target
Limited	All viable occurrences	All viable occurrences	4 per tertiary watershed	secondary target
Disjunct	All viable occurrences	All viable occurrences	4 per tertiary watershed	3 per tertiary watershed
Endemic	All viable occurrences	All viable occurrences	4 per tertiary watershed	4 per tertiary watershed
Wide-ranging	All viable occurrences	All viable occurrences	1 per tertiary watershed	1 per tertiary watershed

Table 9. Conservation goals for occurrences of vegetation community targets.

	G?	G1	G2	G3	G4 - G5
S1	3 per tertiary watershed	All viable occurrences	All viable occurrences	All viable occurrences	3 per tertiary watershed
S2	3 per tertiary watershed		All viable occurrences	All viable occurrences	3 per tertiary watershed
S3	3 per tertiary watershed			All viable occurrences	3 per tertiary watershed
S4 – S5	Secondary target				secondary target

5.0 Creating an Aquatic Conservation Blueprint Portfolio

The goal of the Conservation Blueprint for aquatic biodiversity is to identify a network of sites on the landscape that, if conserved, would sustain all elements of aquatic biodiversity in the Great Lakes watershed. A key component of the analysis was to assess representation, condition, ecosystem function, and special features within each tertiary watershed of the Great Lakes watershed. These criteria have been used extensively in Ontario to identify Areas of Natural and Scientific Interest (ANSIs) for at least 20 years (Riley and Brodribb, 2003). These criteria are also applied to select parks and protected areas (Crins and Kor, 2000). Concepts of representation and persistence, through the assessment of condition, biodiversity, and ecosystem function, are converging in systematic conservation planning as conceived by Noss *et al.* (1997), Margules and Pressey (2000), and Groves *et al.* (2002) and implemented by The Nature Conservancy (Groves *et al.*, 2000) and the Ontario Ministry of Natural Resources (Crins and Kor, 2000).

The aquatic Conservation Blueprint portfolio was created by performing the following steps in each tertiary watershed (key steps are summarized in Figure 5).

1. Delineate coarse- and fine-filter targets and rank coarse-filter targets by type according to conservation value. Conservation values were assigned using a GIS-based model for assessing condition, ecological functions, habitat diversity, and special features (Table 10).

2. Use these conservation values to identify the ‘top three’ examples of each targeted stream, lake and coastal AEU for inclusion in the Conservation Blueprint. The six highest scoring examples of each wetland type were also incorporated into the portfolio.

3. Identify all conservation lands and protected areas in the watershed and include them in the Conservation Blueprint.

4. Where fine-filter goals were not met within the existing protected area system or sites identified during the coarse-filter process, identify a set of sites with high conservation values containing fine-filter targets for potential inclusion in the aquatic Conservation Blueprint portfolio.

5. Where options existed for selecting sites to fulfill conservation targets, prioritize selections by applying concepts of irreplaceability, complementarity, efficiency and viability/suitability (Table 11).

Final selection of portfolio sites was guided by the following principles:

- Account for the biodiversity targets sustained by existing protected areas in Ontario by focusing on sites with viable occurrences of under-represented conservation targets.

- Give high priority to sites identified as having high “irreplaceability”, such as a site that supports extremely globally imperiled species.

- Consider only viable targets in order to select sites that support features with a high probability of sustainability.

- Weight sites that contain multiple conservation targets to generate an efficient portfolio.

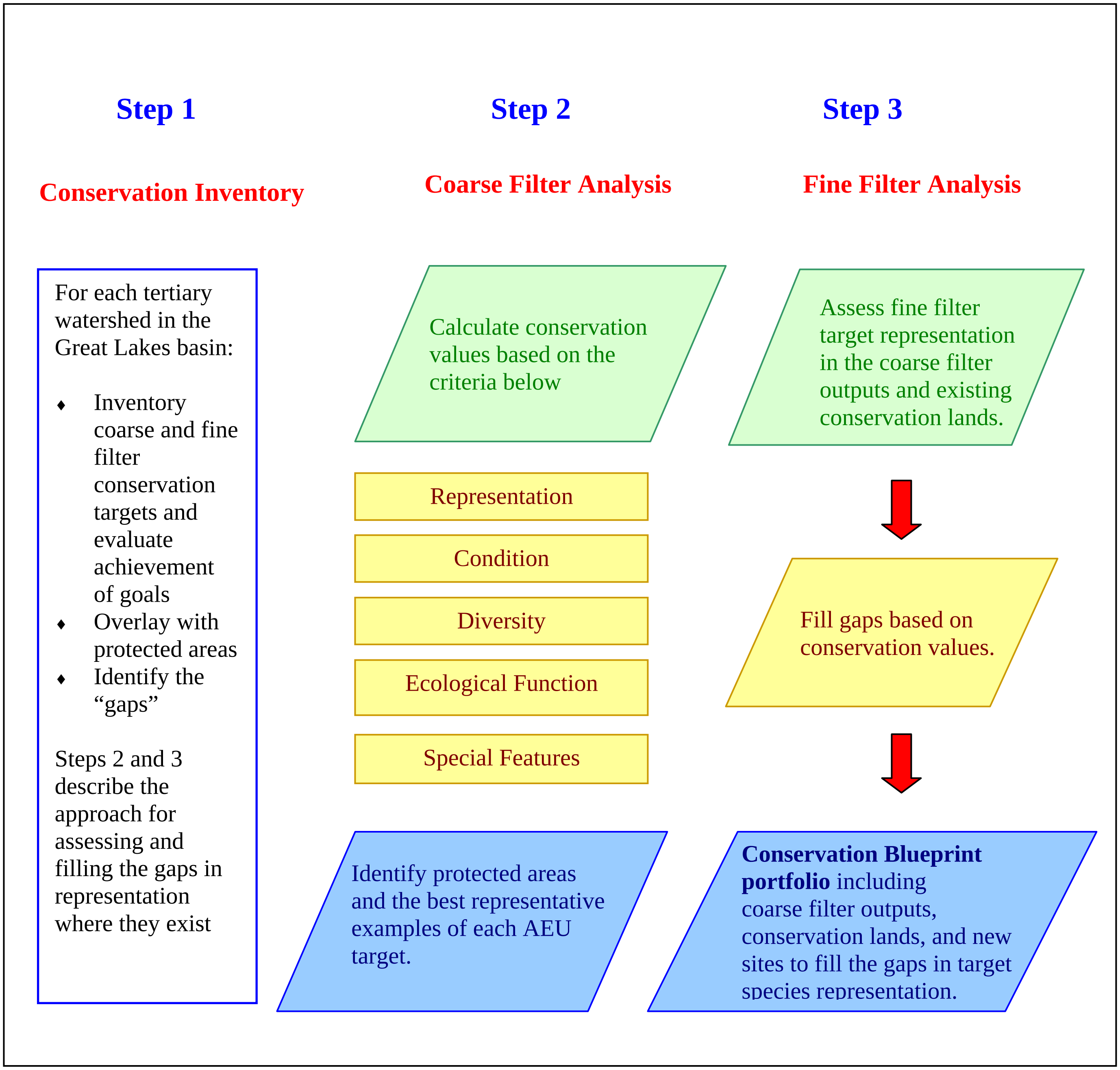

Figure 5. The key steps used to generate the aquatic Conservation Blueprint portfolio of sites (adapted from Brodribb and Phair, 2004).

Table 10. Descriptions of criteria to identify and rank coarse-filter targets in terms of conservation value. Scores for calculating conservation values by which targets are ranked are provided in Appendix 4.

Criteria	Description
Representation	Assess presence of conservation targets in the existing protected area system and identify under-represented targets to include in the aquatic conservation portfolio of aquatic conservation sites. The final portfolio includes examples of each coarse-filter target with high conservation values within each tertiary watershed. Where several options for completing the portfolio exist, other criteria were applied.
Condition	Calculation of the conservation value for each AEU was based on: ♦ Amount of natural area within each AEU ♦ Estimate of the influence from roads, urban areas, and cropland within each AEU ♦ Estimate of the influence from active pits, quarries or mine sites ♦ Presence of indicator and invasive species
Diversity	Estimate of conservation value based on the number of aquatic habitats (AEU types) within the adjacent landscape
Ecological Functions	Calculation of the conservation value for each AEU was based on: ♦ Presence of riparian areas ♦ Size ♦ Distance from dams ♦ Coincidence with existing conservation lands ♦ Proximity to existing protected areas
Special Features	Calculation of the conservation value for each AEU was based on: ♦ Count of Element Occurrence data for species targets ♦ Count of occurrences of other rare species targets ♦ Count of occurrences of target aquatic vegetation communities

Table 11. Factors determining the selection of sites for the aquatic Conservation Blueprint portfolio.

Factor	Description
Irreplaceability	Sites containing the only or best example of a conservation target
Complementarity	Sites that supplement conservation targets already known to occur within existing conservation lands
Efficiency	Sites containing multiple examples of conservation targets
Viability/suitability	Sites having persistent ecological processes and landscape patterns required to support target species and communities

By following the process and applying the principles listed above, the aquatic Conservation Blueprint portfolio represents a set of locales that efficiently supplements the existing protected area system with sites to meet all of the conservation goals specified in this study. Detailed methods for assembling the GIS layers and processing of the coarse- and fine-filter biodiversity analysis are described in Brodribb and Phair (2004).

5.1 Calculating Conservation Values Scores in the Coarse-filter Biodiversity Analysis

The conservation value scores used in the coarse-filter biodiversity analysis were calculated from derived data layers. Values for each layer were totaled to create a layer with cumulative conservation value scores that indicates the relative conservation value of all aquatic habitats across the landscape. This layer was used to select the "top three" scoring examples of each AEU that were included in the Conservation Blueprint (or the "top six" for wetland systems). These cost/value layers represent GIS-derived surrogates for assessing the diversity, condition, ecological functions and special features criteria outlined earlier.

Each 25 m^2 pixel on each GIS layer was assigned a score. Cumulative scores for layers within each sub-group (condition, diversity, ecological functions, special features) were summed to calculate a sub-group total score. The pixel values within each AEU were averaged to generate a single score for that unit. Sub-group scores were adjusted to convey the relative importance of that particular criterion against other criteria. For example, the condition criterion was adjusted to reflect 35% of the total score. The scores for each of the four sub-groups were combined to calculate a final conservation value score for each AEU. High-scoring aquatic ecological system types were identified to fill in the representation gaps.

The following sections describe each GIS layer that was used to calculate conservation value scores, a summary of the input, output, and ecological rationale for each layer. The layers were created to allow flexibility in assigning score values. All scores are defined in Appendix 4. These GIS layers cover the entire Great Lakes Conservation Blueprint study area in Ontario and are available as digital data layers through the Ontario Geospatial Data Exchange. For further technical details on these layers, consult Brodribb and Phair (2004).

5.1.1 CONDITION CRITERIA

The condition of a site was scored based on the percent of natural cover in the AEU, the distance from cropland, distance from urban and settled areas, presence of pits and quarries, hydro corridors, railways and roadlessness. The overall condition score was adjusted to 35% of the total score.

Percent Natural Cover

Examples of aquatic ecological units (AEUs) that contain a large amount of natural cover were given priority in the Conservation Blueprint over sites that are in non-natural settings. It is generally recognized that the ecological integrity of aquatic ecosystems is linked to that of terrestrial habitats within the catchment. The amount of land in a natural state within each aquatic ecological unit was calculated and represented as a percentage of the AEU. The score of the AEU increased with the amount of natural land cover within the polygon.

The percent natural cover layer was created using the provincial land cover map, which is in raster format (25 metre resolution). All of the areas that were considered non-natural (cropland, urban areas, *etc*.) were reclassified to a value of 0 and all areas that were considered natural were reclassified to a value of 1. Because the amount of natural cover *within* each AEU was scored, all lakes and wetlands were automatically assigned a natural cover value of 100%. The percentage of natural cover for each stream and coastal AEU was then calculated.

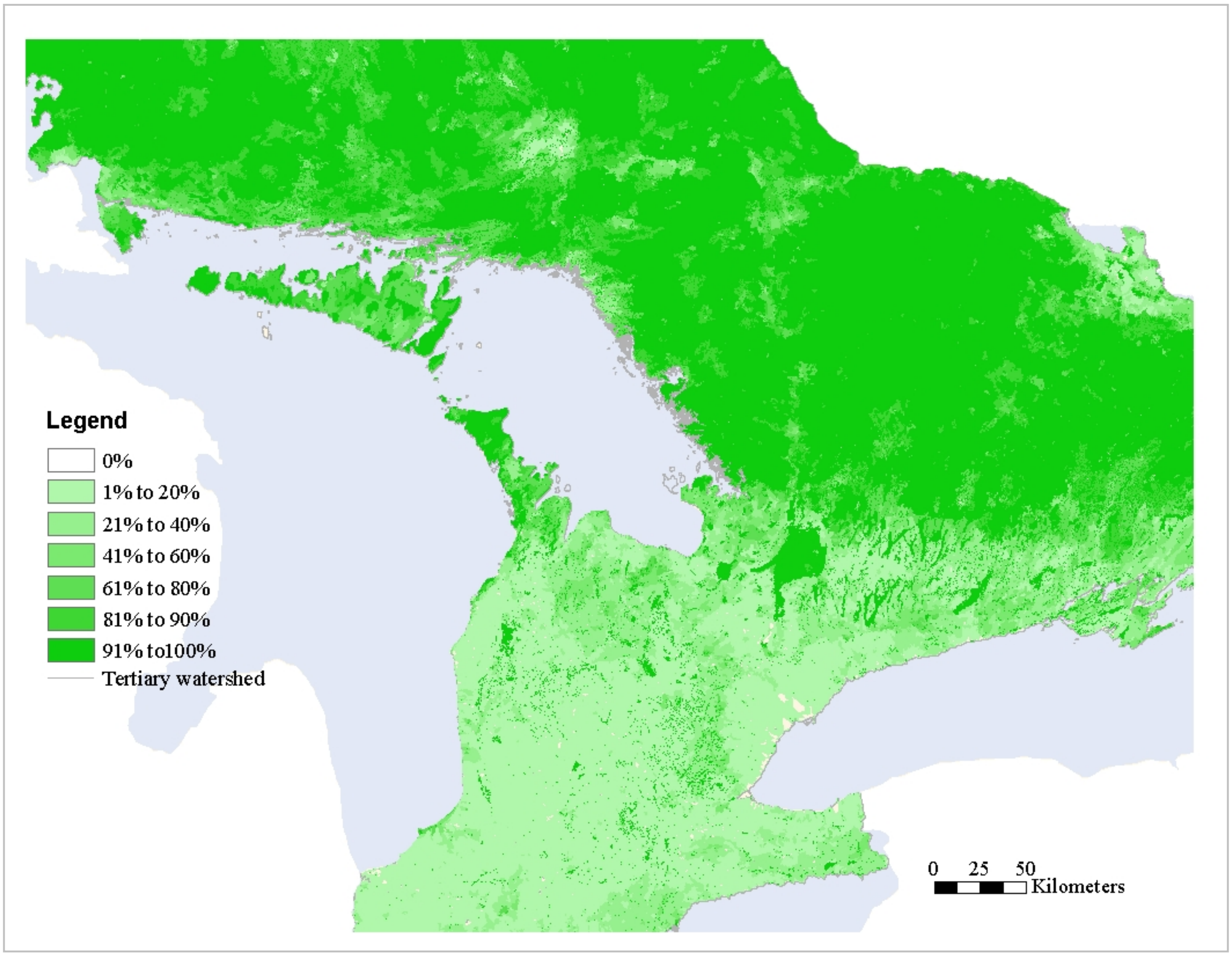

Figure 6. Percent natural cover within each Aquatic Ecological Unit (AEU).

Distance from Cropland and Urban Areas

Areas further away from developed agricultural land were valued higher than those sites coincident with or adjacent to agricultural fields. Agricultural and urban lands can adversely impact the physical, chemical and biological integrity of freshwater habitats. Sites were assigned progressively higher scores with increasing distance away from cropland. Similarly, aquatic habitats further away from urban or settled areas were assigned progressively higher scores.

The urban and cropland layers were created from the provincial land cover data set for Ontario. Each of these themes was extracted from the dataset to generate new "urban" and "cropland" layers. Each layer was buffered to create a theme with different values for 50 m, 100 m, 200 m, 300 m and greater than 300 m away from the cropland or urban areas.

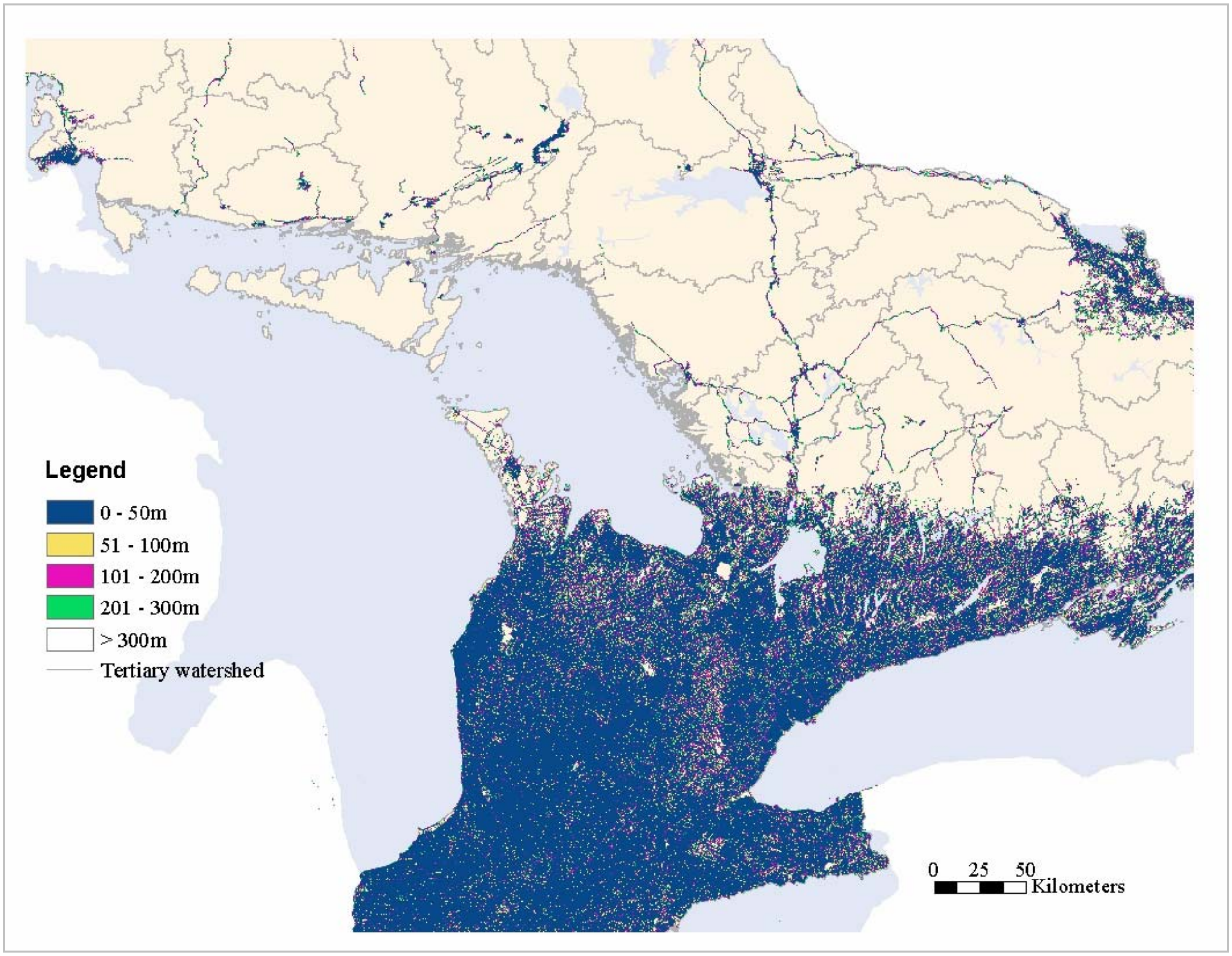

Figure 7. Distance from cropland and urban areas.

Pit, Quarry and Mine Sites

Aquatic ecological units were assigned negative scores if they contained or were adjacent to pits, quarries or mines. The data for pit, quarry and mine sites was taken from the Natural Resources Values and Information System (NRVIS) data for Ontario. These features were buffered to distances of 50 m, 100 m, 200 m, 300 m and greater than 300m. Assigned negative scores decreased with distance away from the pit, quarry or mine. If sites did not coincide with the buffered zone they were not scored.

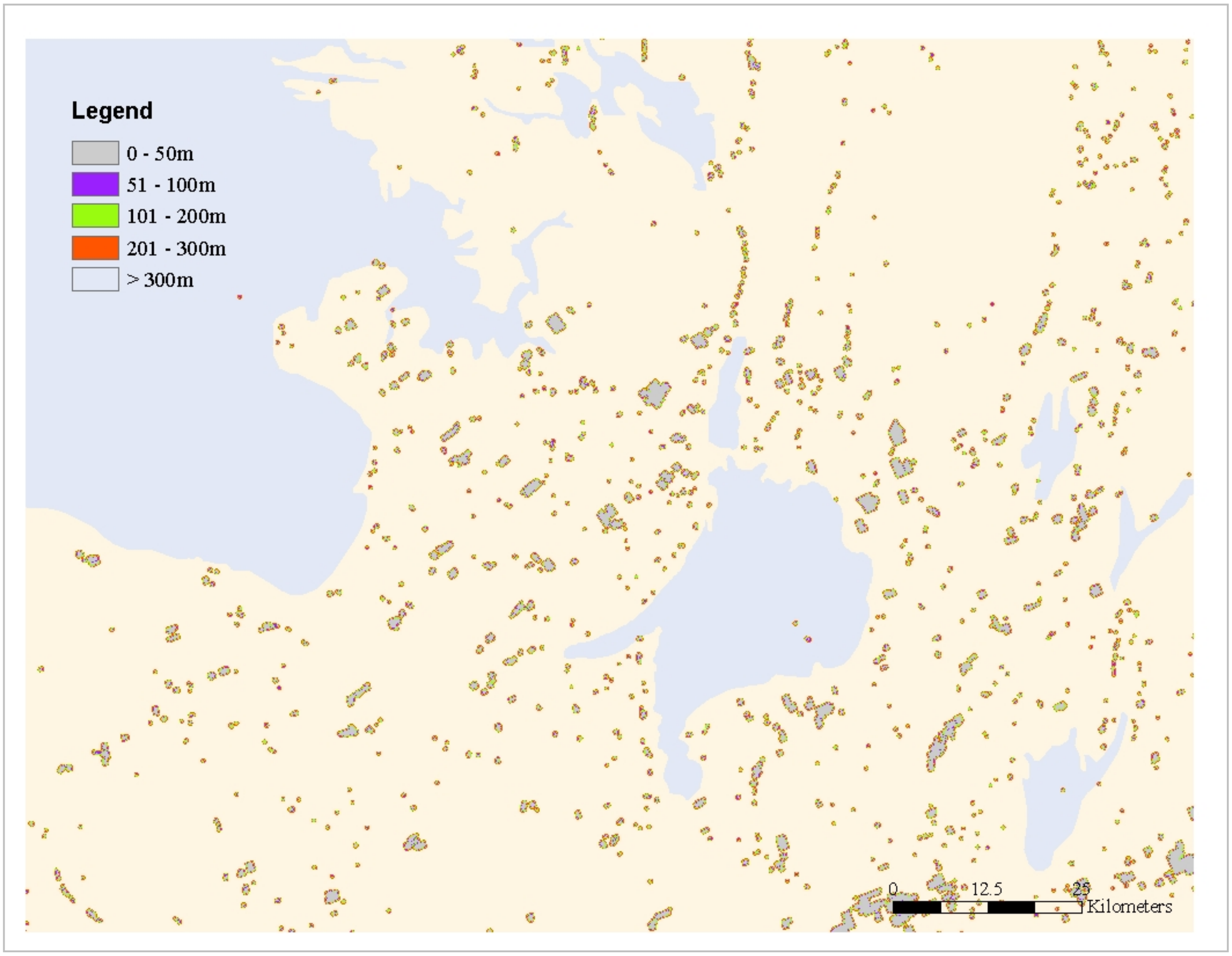

Figure 8. Proximity to gravel pits, quarries and mine sites.

Intakes and Outflows

The coverage of water intakes and outflows from Environment Canada was obtained through the Great Lakes Heritage Coast Project. These data represent point sources where water is removed or discharged into the Great Lakes for a variety of purposes. The point data were buffered at increments of 50 m, 100 m, 200 m, 300 m; areas within 300 m of an intake or outflow were assigned negative scores. Areas outside the 300 m buffer were not scored.

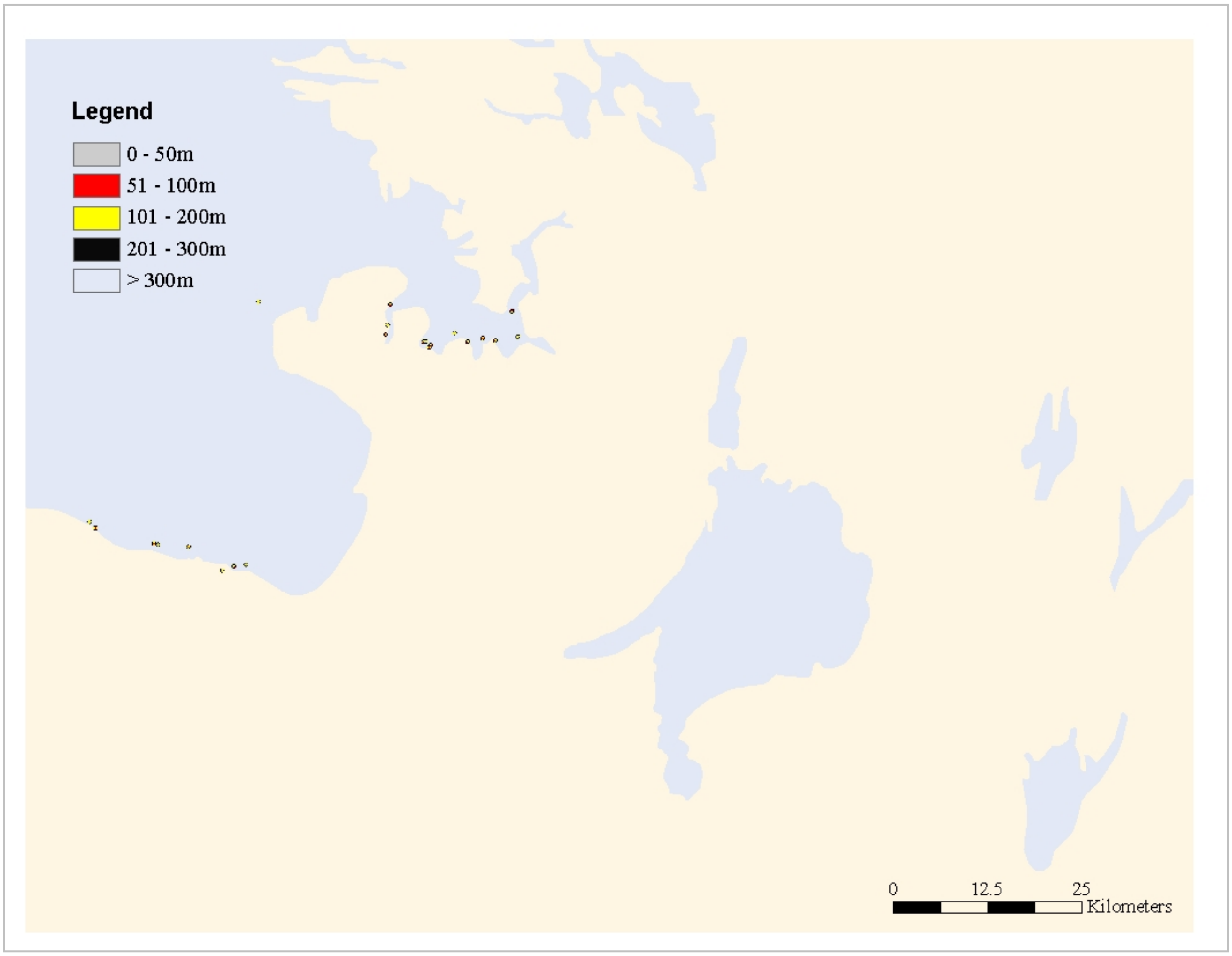

Figure 9. Proximity to water intakes and outflows along the Great Lakes coast.

Roadlessness

The roads coverage (NRVIS, 1:10,000) was separated into primary, secondary and tertiary roads. Each of these three themes was buffered to distances of 100 m, 200 m, and 400 m. Sites that are less fragmented by roads were given a higher priority in the design of the Conservation Blueprint. Areas closer to primary roads were assigned a lower score than areas closer to secondary or tertiary roads.

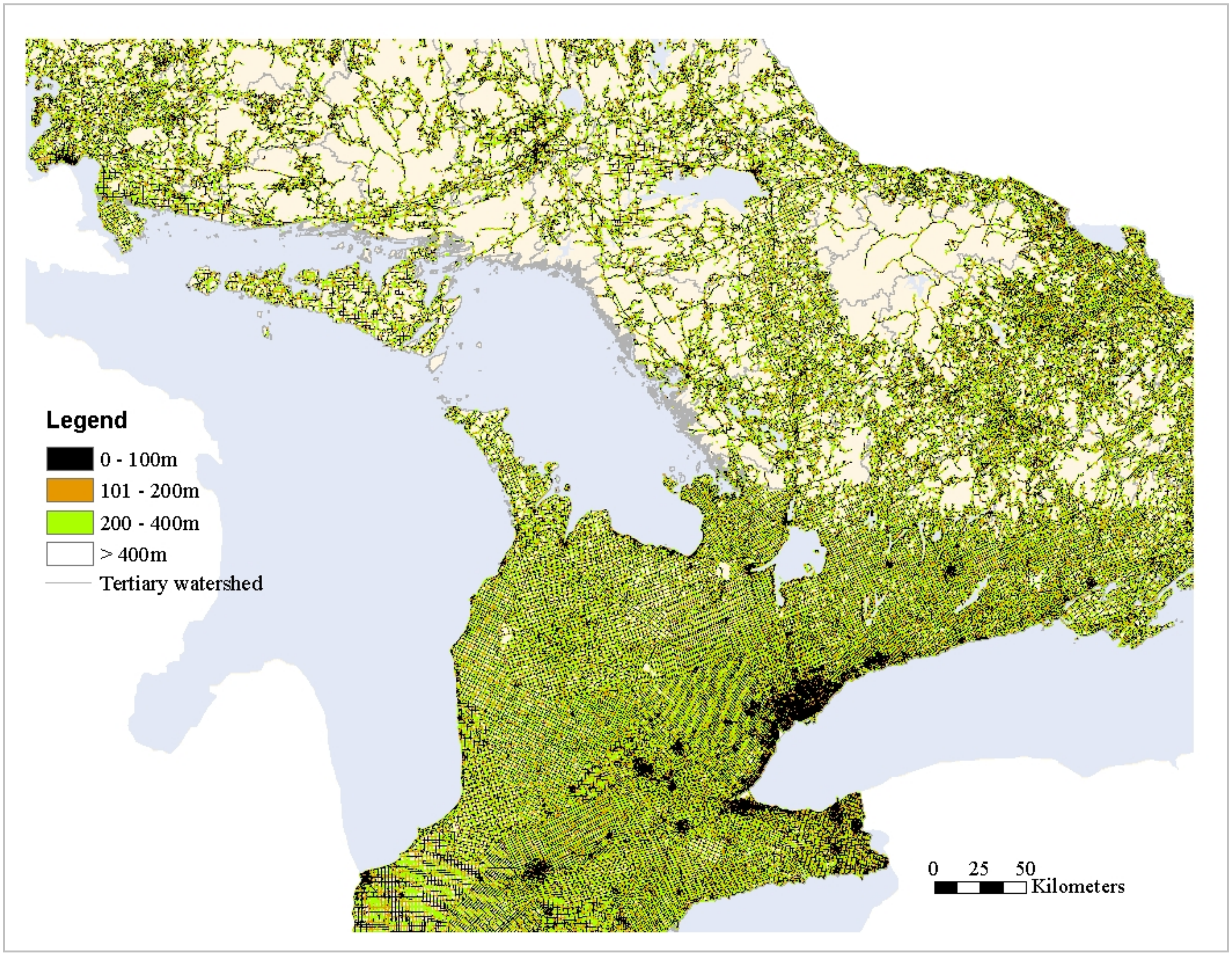

Figure 10. Distance from roads.

Road crossings

Areas with a high road density have a greater degrading influence on the surrounding waterways than areas with low road densities. The frequency of road crossings in each AEU is indicated in the figure below.

The road crossing layer was created with water flow data from the Water Resources Information Project (WRIP, 1:10,000 scale) overlaid with the NRVIS roads layer (1:10,000 scale). A process was developed to create a geographic point file of locales where roads intersected with the water flow arcs. The number of road crossings per AEU was summarized. Aquatic ecological units with large numbers of road crossings were assigned negative scores. Areas with few (0-25) road crossings were not scored.

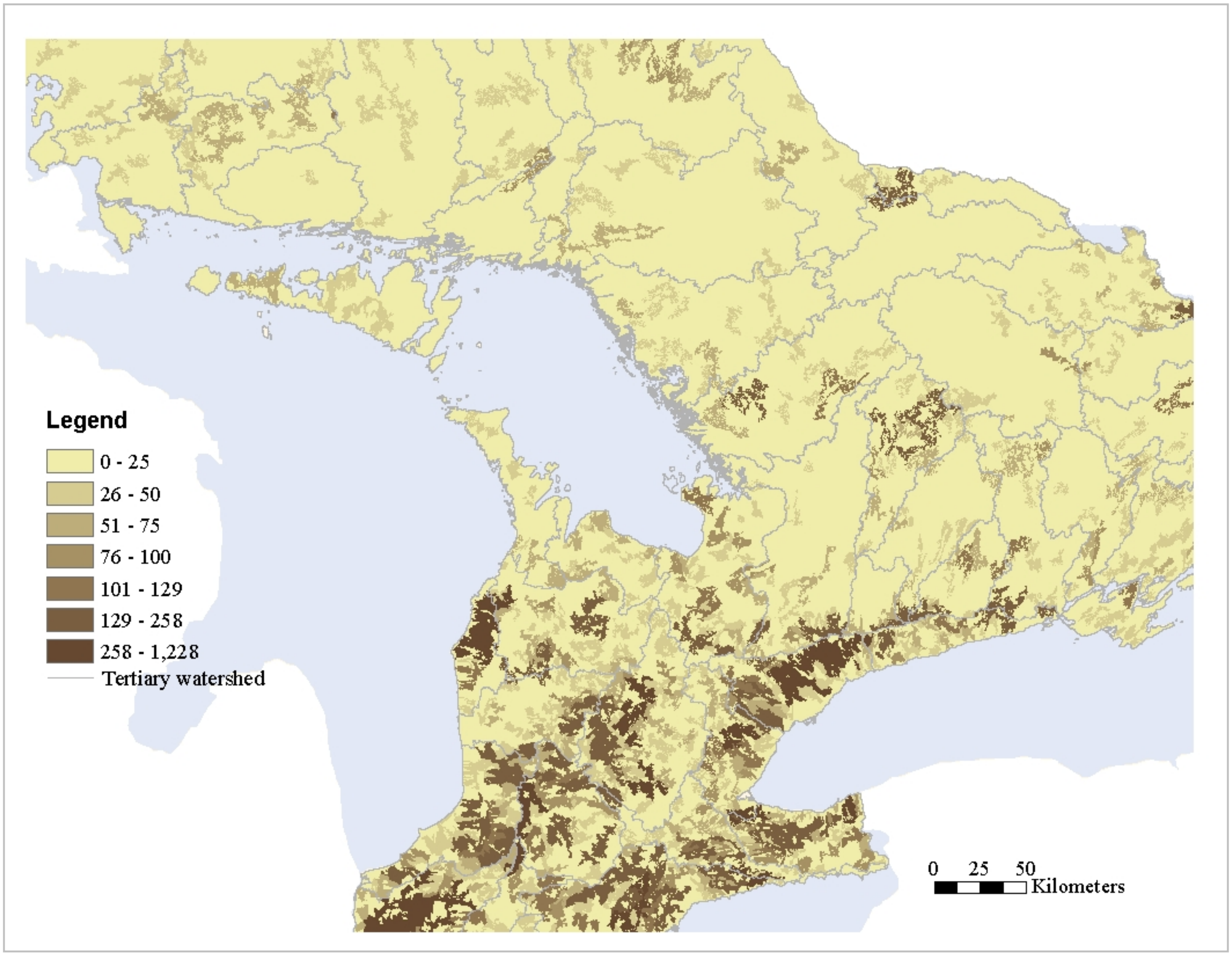

Figure 11. Number of roads that cross streams, lakes or wetlands.

Invasive and Non-native Species

The presence of invasive and non-native species in aquatic ecosystems can adversely impact native species and can cause environmental and economic harm. The invasive and non-native species data set was included in this analysis to identify areas that are inundated with invasive species. Wherever possible, sites with few or no invasive species were selected in the design of the Conservation Blueprint.

The data set for invasive and non-native species was received from three different sources: Non-native fish species records were extracted from the Ontario Fish Information System (OFIS) of OMNR. Additional records for fish were queried from the Ontario Fish Distribution Database (OFDD) from the Royal Ontario Museum. Invasive species data were also received from the Ontario Federation of Anglers and Hunters (OFAH). Other invasive and non-native species, such as Spiny Water Flea (*Bythotrephes cederstroemi*), Quagga Mussel (*Dreissena bugensis)*, Rusty Crayfish (*Orconectes rusticus*), Purple Loosestrife (*Lythrum salicaria*), European Common Reed (*Phragmites australis*) and Eurasian Water-milfoil (*Myriophyllum spicatum*) were not included in the analysis due to the lack of available digital data.

Available invasive and non-native species data were received in database or tabular format listing coordinates of the invasive fish and Zebra Mussel observations. The coordinate data were imported into a geographic point data layer and the total number of invasive species was compiled for each AEU (each species was counted once, not each

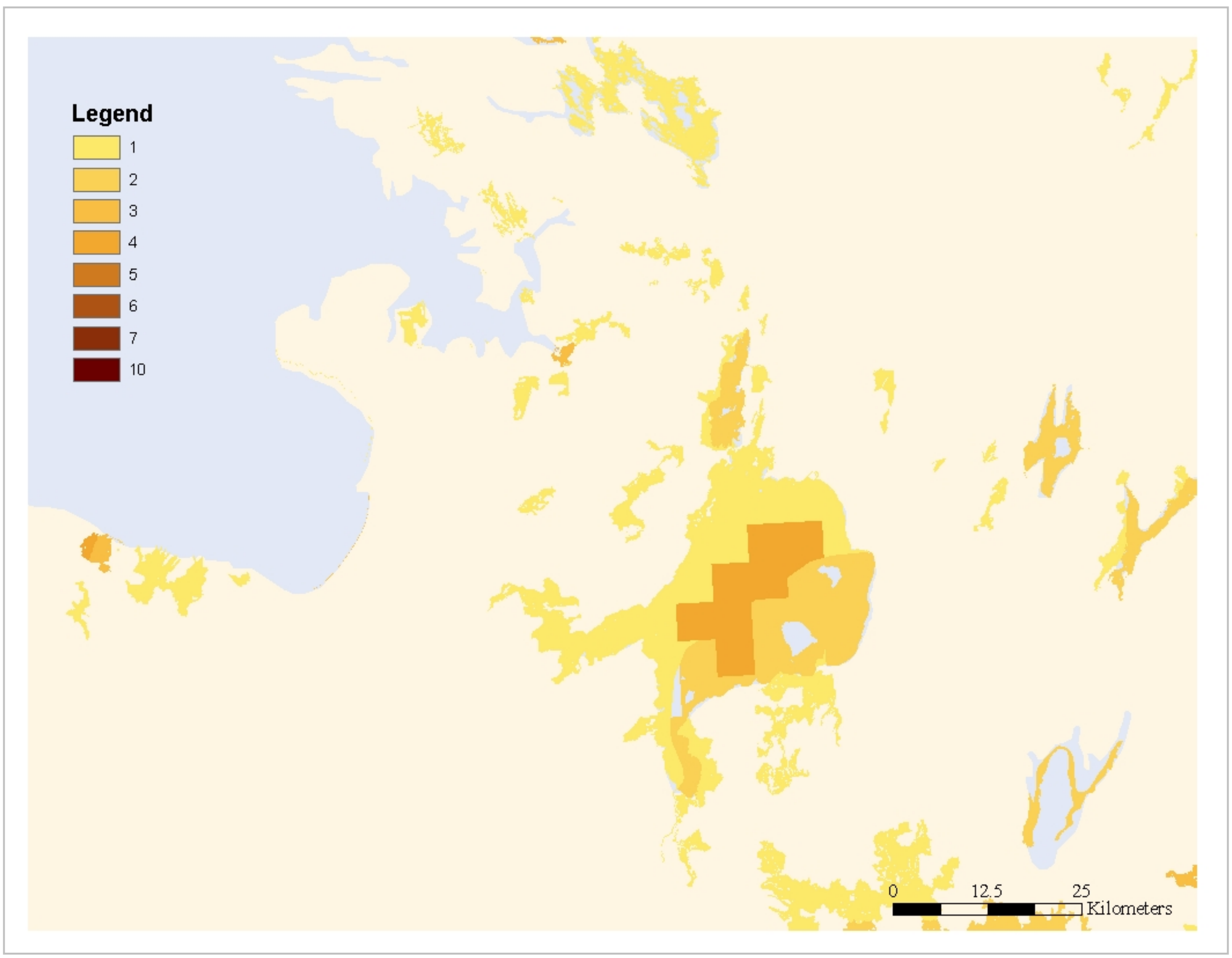

Figure 12. Concentration of invasive and non-native species within each Aquatic Ecological Unit.

individual species occurrence). Some fish species were considered invasive only in parts of the study area.

Fish species considered invasive in certain aquatic systems were compiled by the Core and Science Teams to include: Alewife (*Alosa pseudoharengus*), American Shad (*Alosa sapidissima),* Arctic Grayling (*Thymallus arcticus)*, Atlantic Salmon (*Salmo salar*), Brown Trout (*Salmo trutta*), Bullhead (*Ictalurus nebulosus*), Chinook Salmon (*Oncorhynchus tshawytscha*), Coho Salmon (*Oncorhynchus kisutch*), Common Carp (*Cyprinus carpio*), European Flounder (*Platichthys flesus*), Fourspine Stickleback (Apeltes quadracus), Freshwater Drum (*Aplodinotus grunniens*), Ghost Shiner (*Notropis buchanani*), Gizzard Shad (*Dorosoma cepedianum*), Goldfish (*Carassius auratus*), Grass Carp (*Ctenopharyngodon idella*), Pink Salmon (*Oncorhynchus gorbuscha*), Rainbow Smelt (*Osmerus mordax*), Rainbow Trout (*Oncorhynchus mykiss*), Red Oscar (*Astronotus ocellatus*), Round Goby (*Neogobius melanostomus*), Round Whitefish (*Prosopium cylindraceum*), Rudd (*Scardinius erythrophthalmus*), Ruffe (*Gymnocephalus cernuus*), Sea Lamprey (*Petromyzon marinus*), Shad (*Alosa sapidissima*), Sockeye Salmon (*Oncorhynchus nerka*), Threespine Stickleback (*Gasterosteus aculeatus*), Tubernose Goby (*Proterorhinus marmoratus*) and White Perch (*Morone americana*).

Indicator Species

Indicator species were selected to assess the condition of aquatic ecological units in the Great Lakes watershed. Their preferences range from offshore pelagic habitat in lakes to upstream reaches. These species occur either throughout the Great Lakes watershed, or have regionally restricted distributions. They are usually found in areas with relatively high water quality, from warm to cold waterbodies, and are indicators of areas with minimal human disturbances. An attempt was made to capture the representation of integrative indicator species across the study area. The list of selected indicator species was assembled with input from the Core and Science Teams and included Lake Sturgeon (*Acipenser fulvescens)*, Longnose Gar *(Lepisosteus osseus*), Brook Trout (*Salvelinus fontinalis fontinalis*), Lake Trout (*Salvelinus namaycush*), Cisco or Lake Herring (*Coregonus artedi*), Northern Pike (*Esox lucius*), Muskellunge (*Esox masquinongy*), Central Mudminnow (*Umbra limi*), Golden Shiner (*Notemigonus crysoleucas*), Emerald Shiner (*Notropis atherinoides*), Sand Shiner (*Notropis stramineus*), Largemouth Bass (*Micropterus salmoides*), Yellow Perch (*Perca flavescens*), Walleye (*Stizostedion vitreum vitreum*), Rainbow Darter (*Etheostoma caeruleum*) and Iowa Darter (*Etheostoma exile*).

The data set for indicator species was compiled based on information in the Ontario Fish Distribution Database obtained from the Royal Ontario Museum. The data were in a database format and coordinates of fish species locations were imported into geographic point data. Individual species were counted once per AEU and a total count of different indicator species was assigned to each AEU in the final grid.

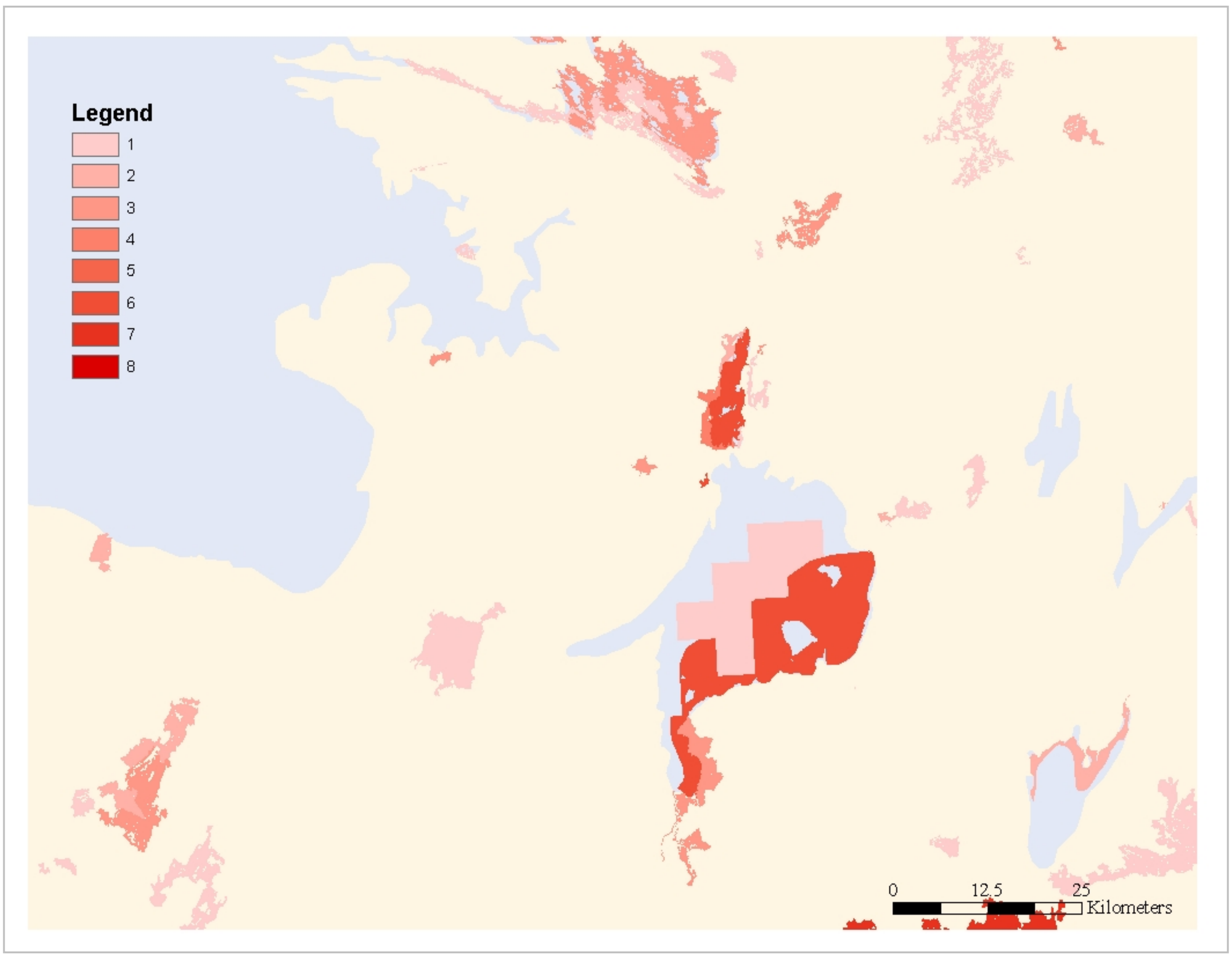

Figure 13. Number of indicator species within each Aquatic Ecological Unit (AEU).

5.1.2 DIVERSITY CRITERIA

A value was calculated for each cell in the diversity grid based on how many different AEU types were surrounding it within a 100 m^2 window (a 9 x 9 cell grid was used). Areas that were more diverse in a small geographical area were assigned higher scores. A "diversity" score was calculated for each AEU based on the heterogeneity of surrounding habitats. The diversity score was adjusted to 5% of the total score.

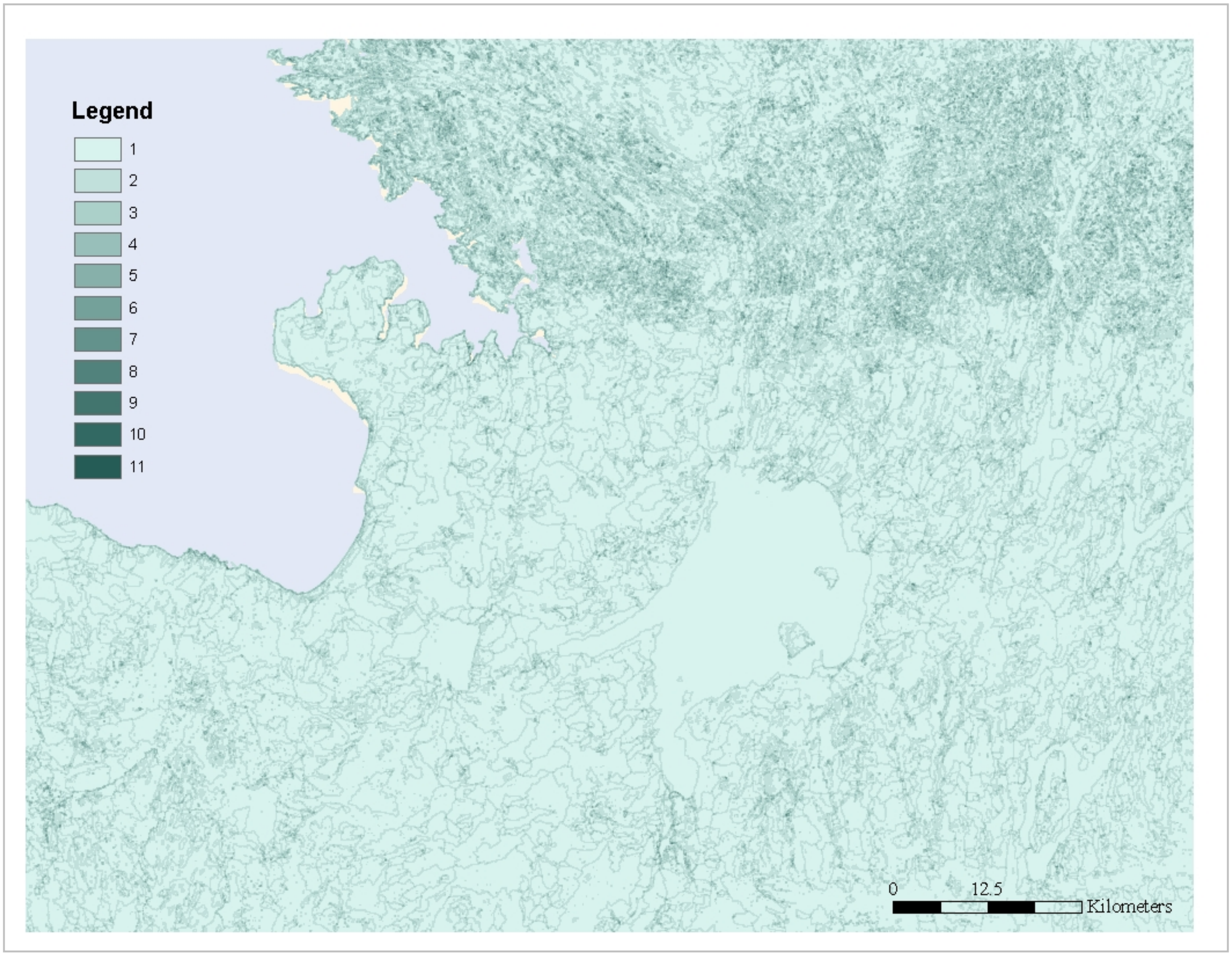

Figure 14. Diversity of Aquatic Ecological Unit (AEU) types.

5.1.3 ECOLOGICAL FUNCTIONS CRITERIA

The ecological functions of a site were assessed based on proximity to existing protected areas, coincidence with existing conservation lands, size of wetlands, distance from dams and coincidence with riparian areas. The total ecological functions score was adjusted to 40% of the cumulative conservation value score.

Size of Wetlands

In general, larger wetlands sustain more biodiversity than smaller and fragmented wetlands. The wetland systems were extracted from the AEU layer and transformed into their own grid layer. This wetland layer was processed through a grouping function that identified wetlands of the same system type that were adjacent to one another, therefore giving them a greater value because of their larger size. The aggregate wetland layer was reclassified into six size classes (0-25 ha, 26-50 ha, 51-100 ha, 101-200 ha, 201-500 ha, > 500 ha). Higher scores were assigned to larger wetlands.

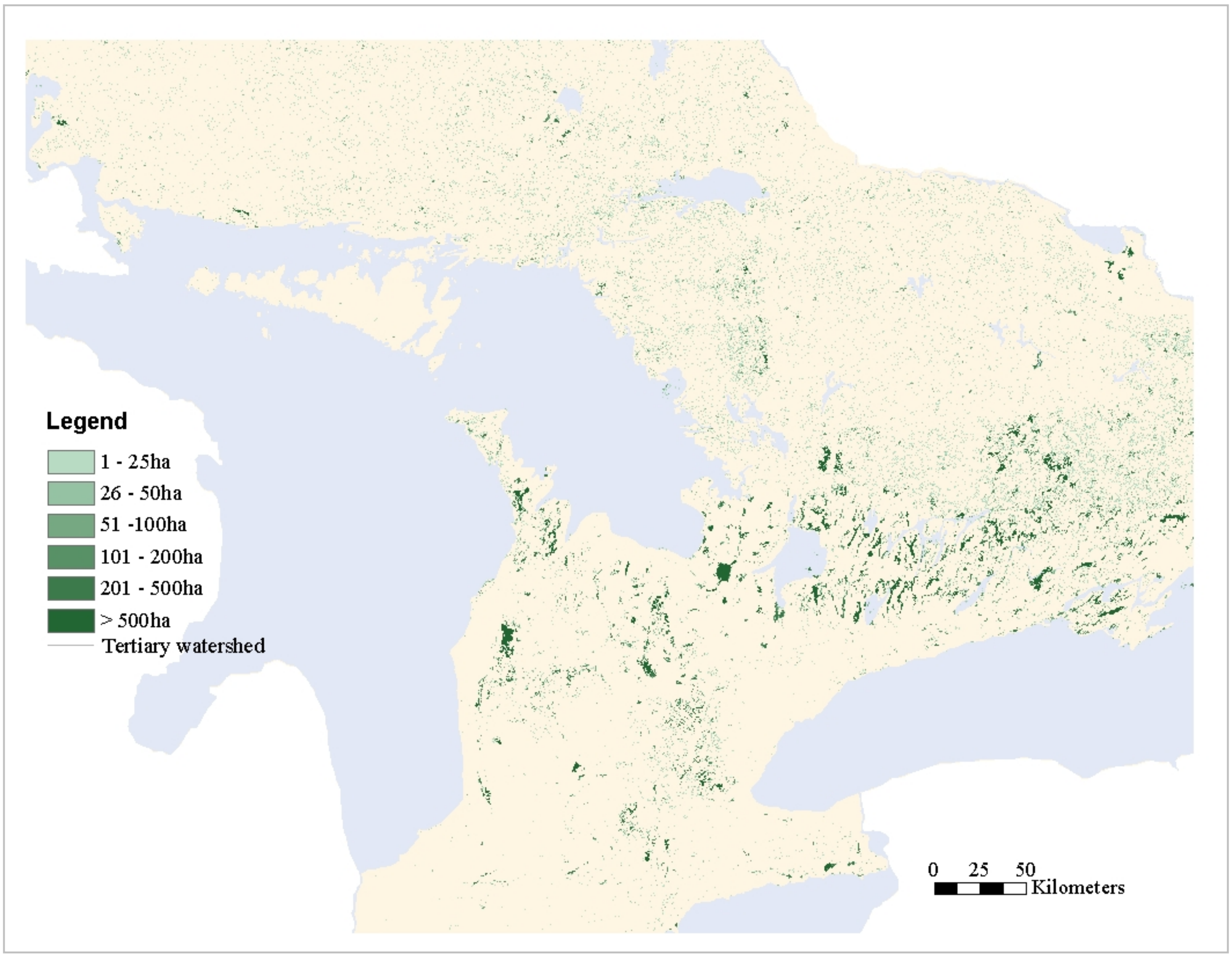

Figure 15. Wetlands classified by total area.

Distance from Dams

Dams have a negative impact on aquatic biodiversity. The data set for dams was obtained from the Water Resources Information Project (WRIP). The dam points were buffered to 50 m, 100 m, 200 m and 300 m. Areas immediately surrounding the dams were assigned negative scores, attenuating with distance from the feature.

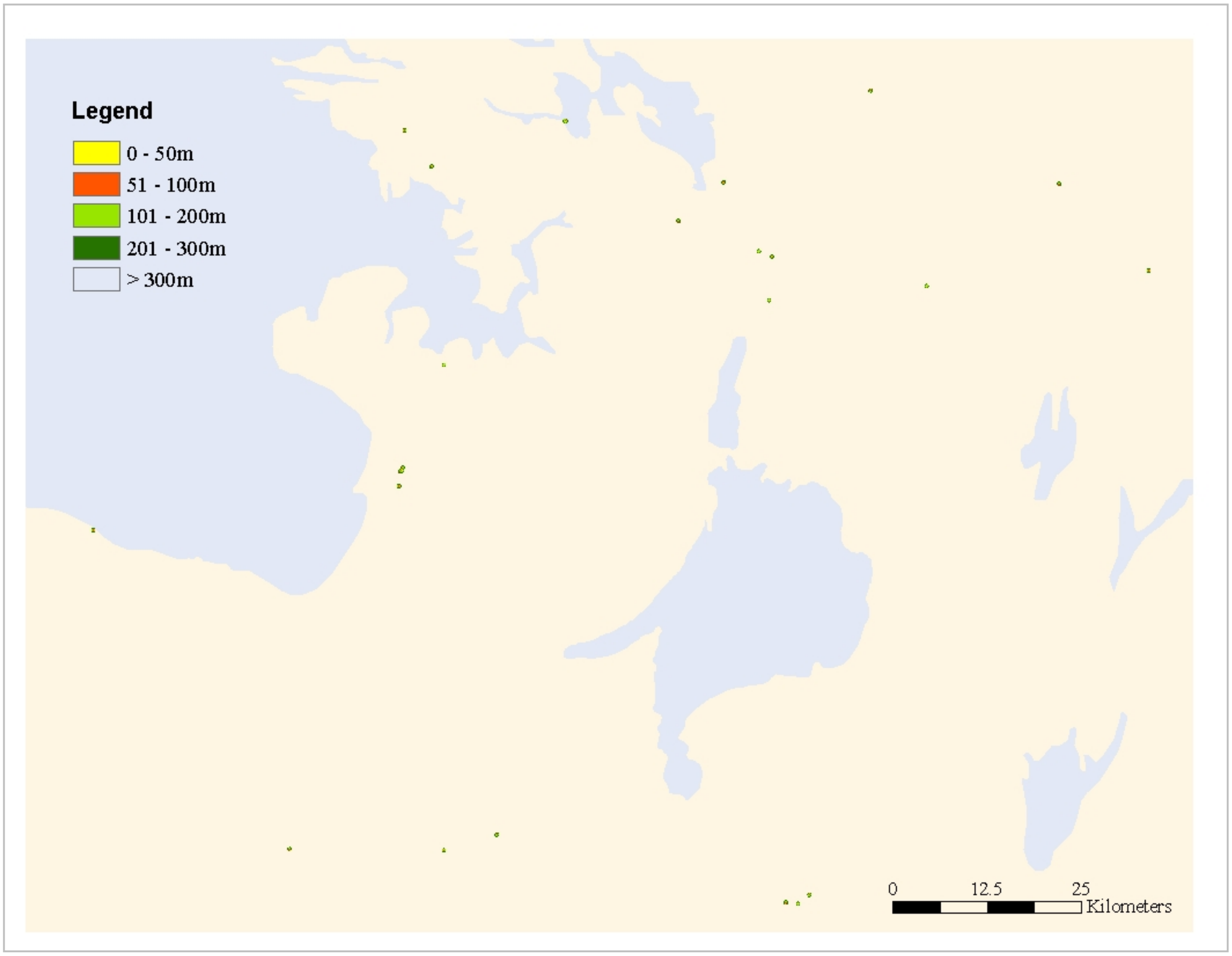

Figure 16. Proximity to dams.

Coincidence with Conservation Lands

Pixels in the study area overlapping with conservation lands were assigned higher scores in the analysis. Conservation lands included life science ANSIs (with provincially significant ANSIs scoring higher than regionally significant ones), provincially significant wetlands, Conservation Authority lands, Nature Conservancy of Canada properties, regulated forest reserves, and Important Bird Areas.

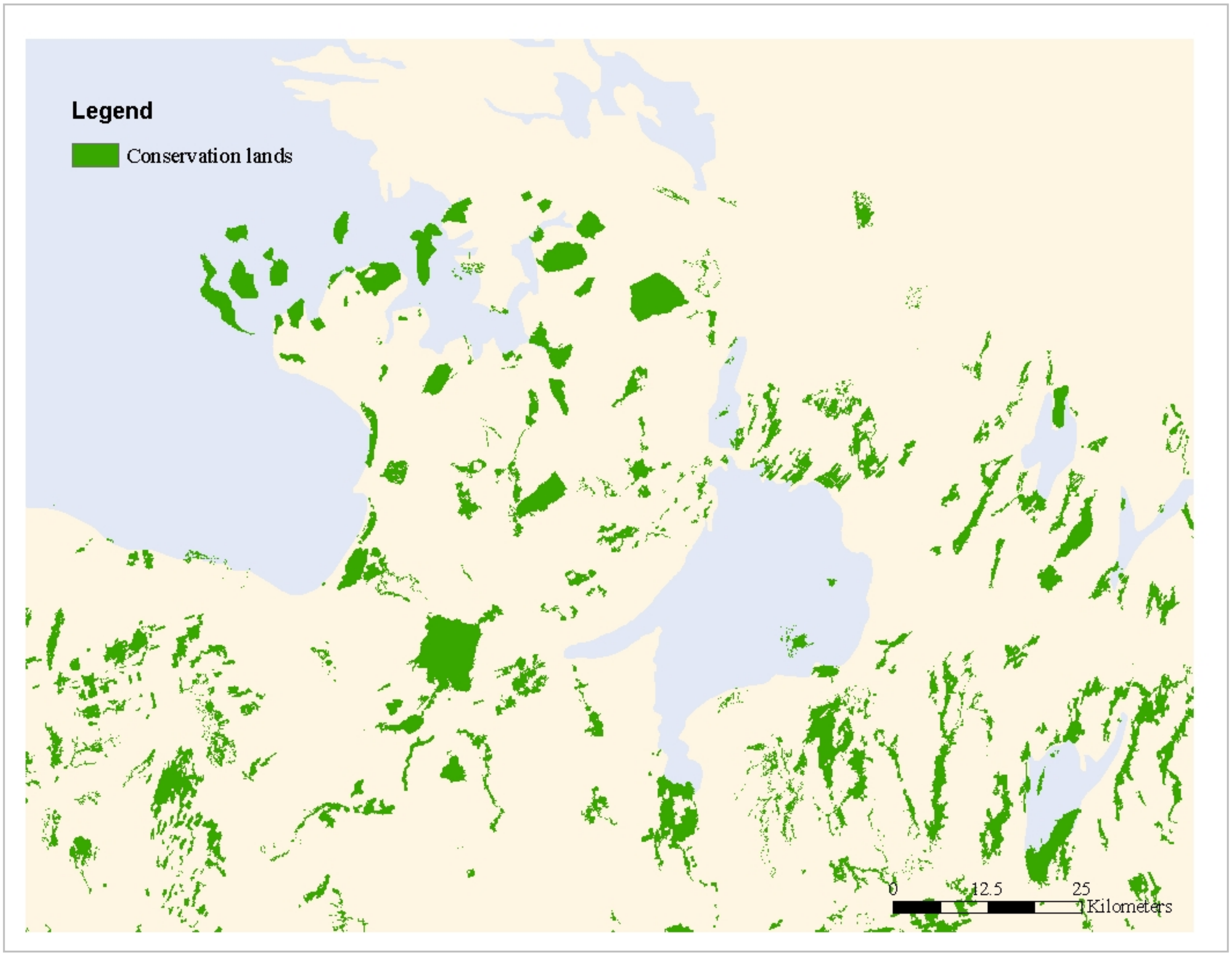

Figure 17. Coincidence with conservation lands.

Proximity to Protected Areas

Sites closer to existing protected areas were assigned higher scores than more distant ones. The protected areas layers include regulated National Parks, National Wildlife Areas, Migratory Bird Sanctuaries, National Marine Conservation Areas, regulated Provincial Parks, Conservation Reserves, and unregulated Provincial Parks and Conservation Reserves identified from Ontario Living Legacy program. These lands were buffered by 50 m, 100 m, 200 m and 300 m. Areas further than 300 m from a protected area were not assigned scores.

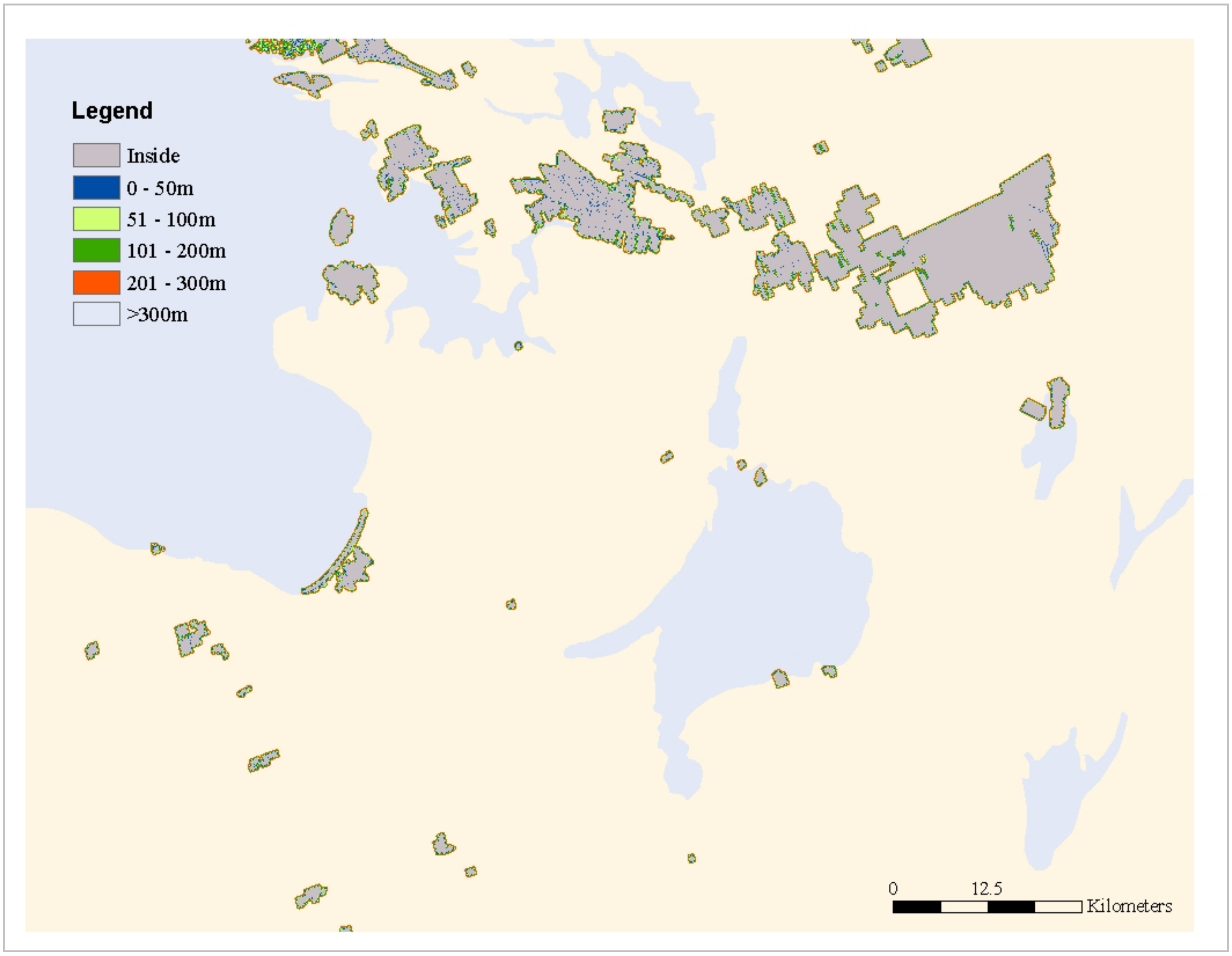

Figure 18. Proximity to protected areas.

Riparian Areas Associated with Streams

Riparian areas are important to the survival of many aquatic plant and animal species, providing food and shelter. They also provide numerous benefits to the land-water ecotone because they can filter and absorb storm water, thereby improving water quality. Provincial water flow stream data from the Water Resources Information Project (all stream orders including small and ephemeral streams were identified) were used to create this digital layer. Natural ecological systems were selected if they were within 300 m of a stream or river.

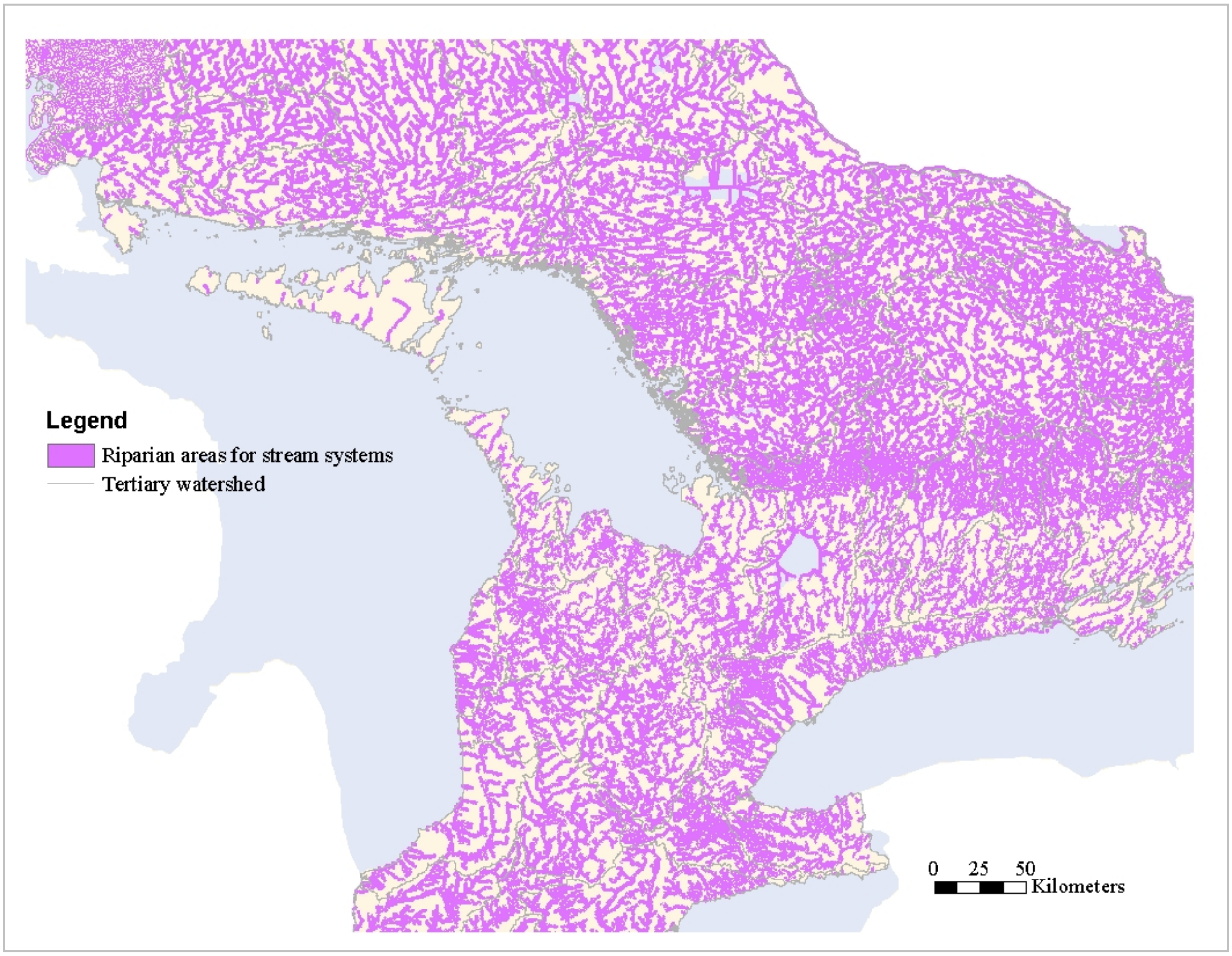

Figure 19. Riparian areas associated with streams and rivers.

Great Lakes Shoreline

The Provincial Land cover mapping was used to identify Great Lakes shoreline areas. Riparian areas were defined as natural ecological systems adjacent to and extending inland up to 1 km from the Great Lakes shoreline.

Figure 20. Great Lakes shoreline.

Riparian Area of Inland Lakes

Inland lake data were obtained from the Water Resources Information Project. Riparian areas were identified as natural cover adjacent to a lake and extending up to 300 m inland.

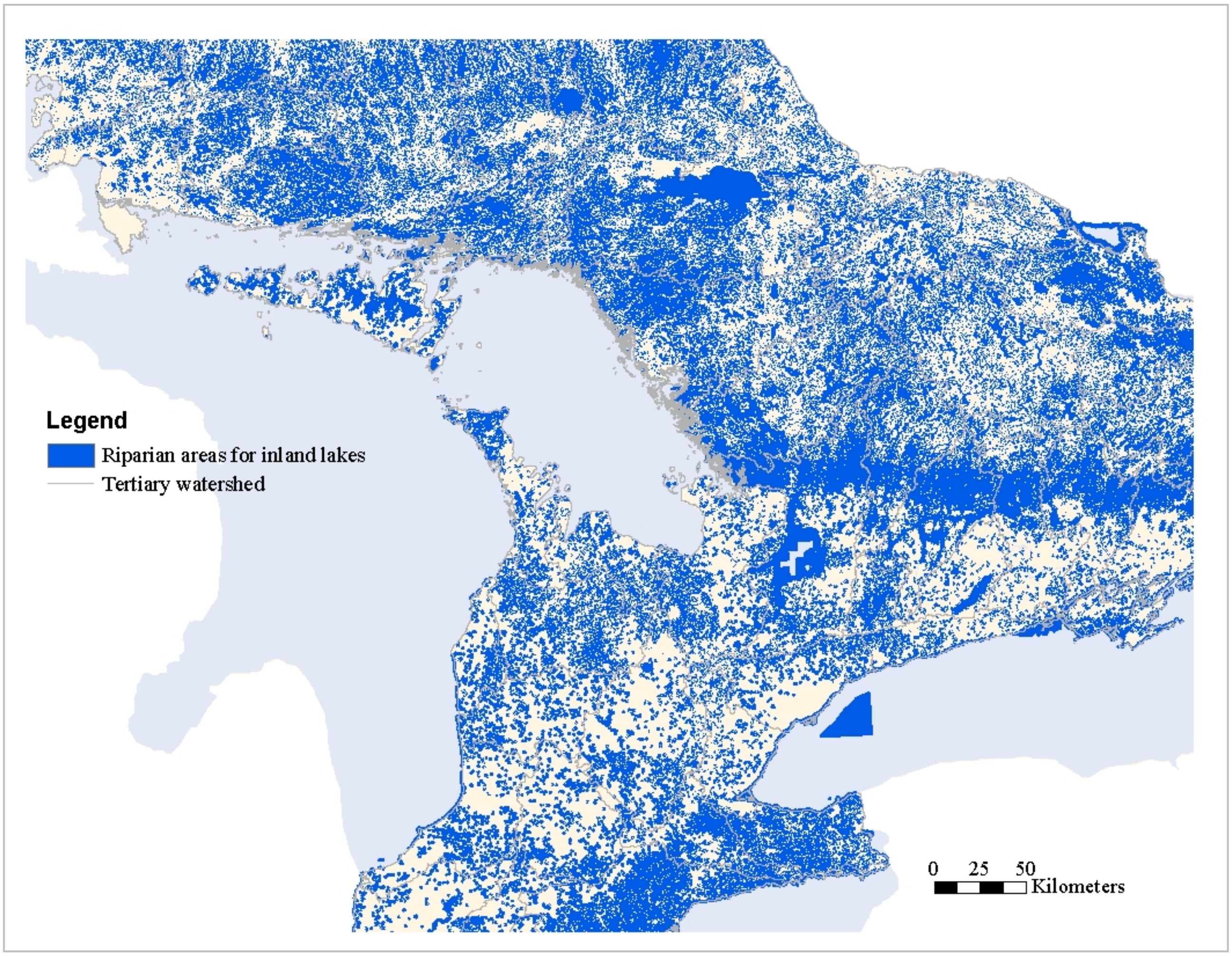

Figure 21. Riparian areas associated with inland lakes.

5.1.4 SPECIAL FEATURES CRITERIA

Sites that support occurrences of species targets, other provincially rare species and vegetation community element occurrences were scored accordingly. The source data for these layers was the NHIC Element Occurrence database for species and vegetation communities. Extant records were used in the analysis; no historic element occurrences were used (last observation more than 20 years ago). The total special features score was adjusted to 20% of the total conservation values score.

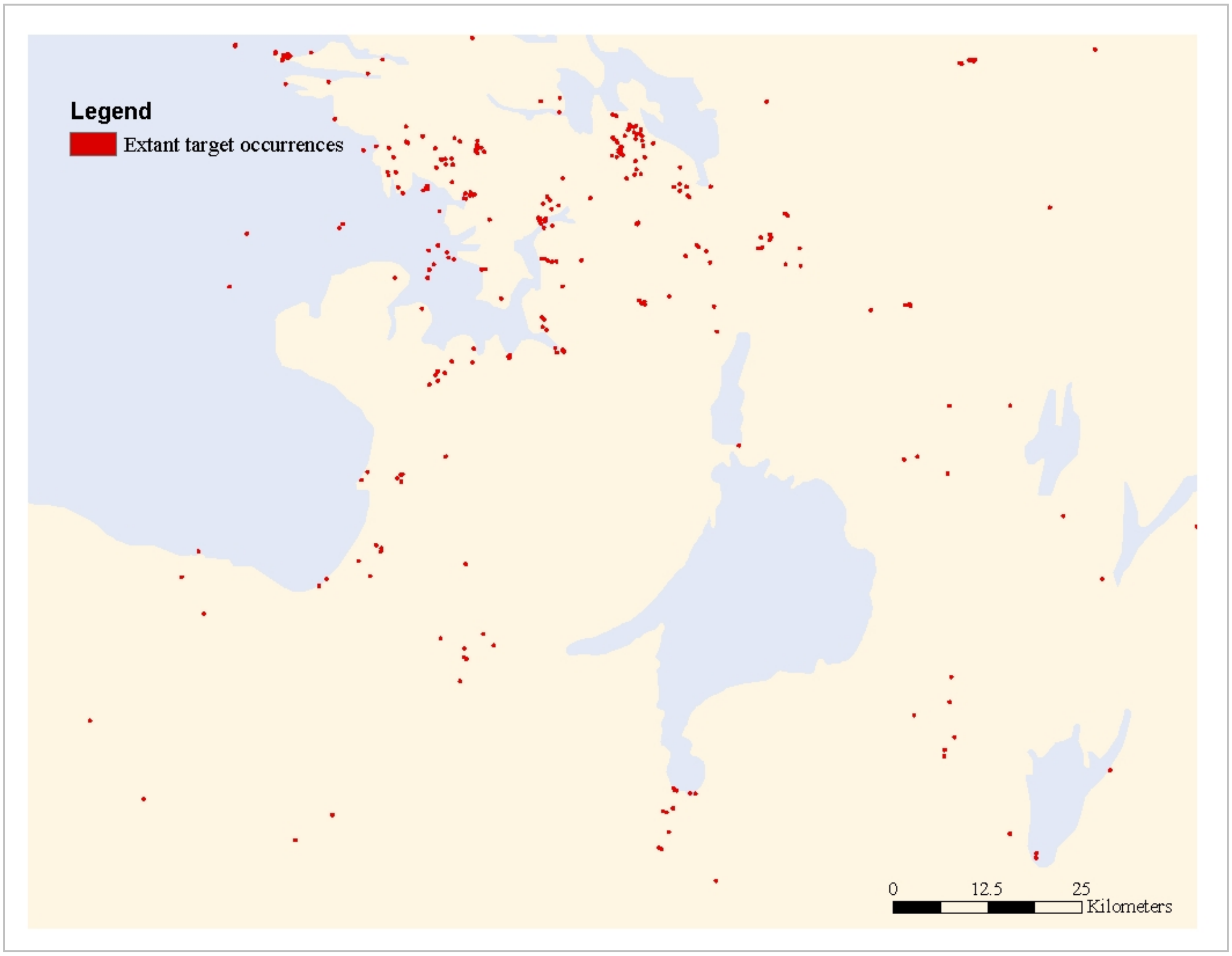

Figure 22. Occurrences of target species and vegetation communities.

5.2 Coarse-filter Biodiversity Analysis

Scores associated with the conservation value layers described above (scores listed in Appendix 4) were summed together to produce four subtotals – one for each assessment variable of condition, ecological functions, diversity, and special features. Subtotal scores for each assessment variable were adjusted according to the proportion each criterion contributed to the final output (Figure 23 or Appendix 4). These four weighted subtotal scores layers were combined to create a cumulative conservation value layer containing the final score for each AEU on the landscape. This layer enabled the three top-ranking examples of each type of coarse-filter target for streams, coastal areas and inland lakes to be selected for inclusion in the aquatic Conservation Blueprint portfolio. For targeted wetland systems, the six highest ranking examples of each target wetland ecological system were selected for inclusion in the Conservation Blueprint portfolio.

A GIS coverage of these high conservation value AEUs was created to identify all sites that were selected through the coarse-filter analysis. This coverage was combined with all protected areas and conservation lands.

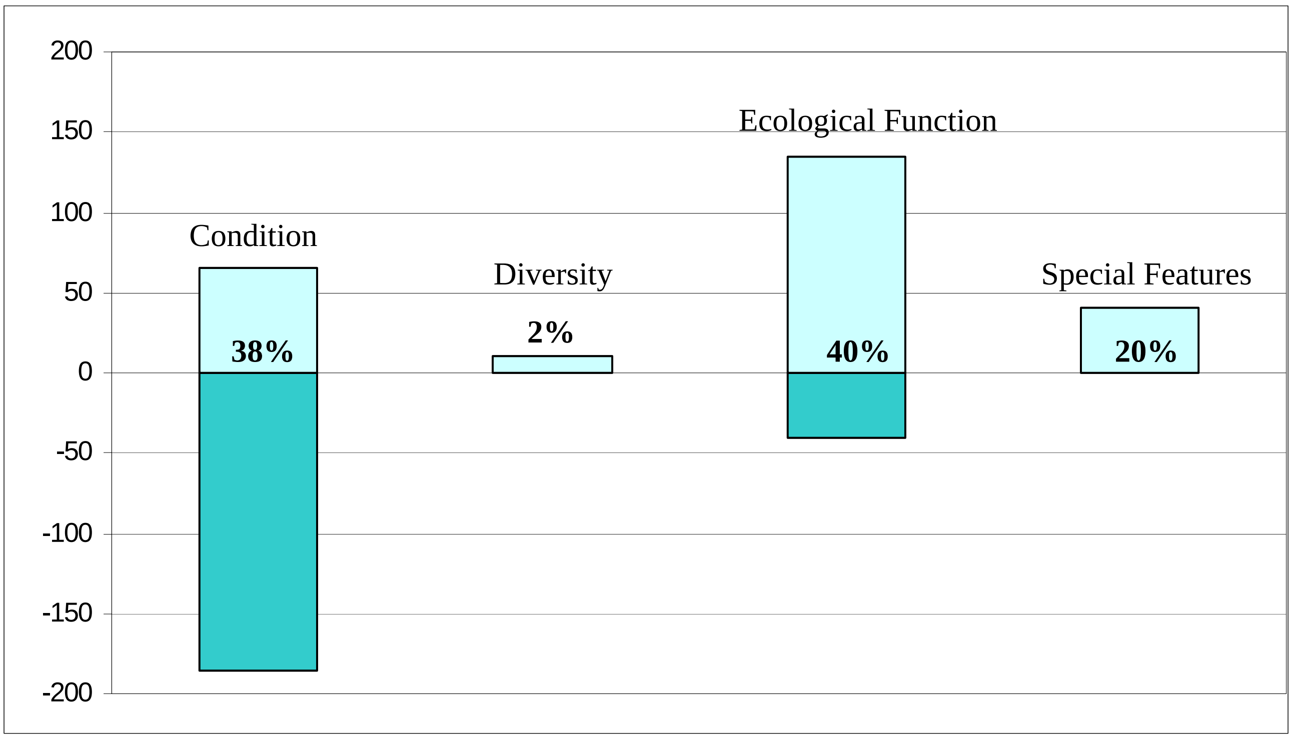

Figure 23. Range of scores in the coarse filter biodiversity analysis.

5.3 Fine-filter Biodiversity Analysis

The decision support software C-Plan was used to determine the minimum number of polygons required to fulfill conservation goals for the fine-filter biodiversity targets. An overlay of viable species target occurrences within the coarse-filter outputs, protected areas and conservation lands was performed in order to identify under-represented fine-filter targets. Conservation goals were defined for each target (Table 8). When fewer occurrences of a target were observed in the combined coverage of conservation lands, protected areas and coarse-filter outputs than the goal for that target specified, that target was considered under-represented. For example, a target species endemic to the Great Lakes would have a goal of four occurrences per tertiary watershed in the portfolio. If two of these occurrences were within a protected area, a gap of two occurrences would be identified. In this case C-Plan would attempt to fill gaps for species and community targets simultaneously by using irreplaceability scores to optimize the areas where multiple conservation targets occur.

Some occurrences of fine-filter targets fell outside protected areas and did not coincide with top-ranking conservation targets identified during the coarse-filter analysis. In these cases, the conservation scores assigned to the AEUs during the coarse-filter analysis in which those fine-filter targets occurred were applied to weight the decision process. In this way, C-Plan selected target occurrences that coincided with the locales with the highest conservation value and generated an efficient portfolio for biodiversity conservation.

C-Plan required a polygon coverage of sites that were automatically included in the Conservation Blueprint portfolio. This layer was comprised of the following:

- National Parks
- National Wildlife Areas
- Migratory Bird Sanctuaries
- Provincial Parks
- Conservation Reserves
- Ontario Living Legacy sites
- Provincially Significant Life Science ANSIs
- Provincially Significant Wetlands
- Conservation Authority Lands
- Nature Conservancy of Canada properties
- Sites identified through the coarse-filter analysis (top scoring examples of each aquatic ecosystem)

A data set including all extant element occurrence data with reasonable spatial accuracy (accurate to within 10 km) was created for all fine-filter targets. Element occurrences (EOs) that had ranks of F (failed to find), X (extirpated) or H (historical) were not included.

The following list of rules demonstrates how the features were selected in C-Plan:

1. Select polygons with an individual features irreplaceability greater than 0%.
2. From this set, select the subset of polygons with the highest summed feature irreplaceability. This selection emphasized efficiency by preferentially identifying locales containing multiple species targets.
3. Select the sites with the highest conservation scores that were calculated from the coarse-filter analysis.
4. Select the polygons where features are present and required to meet their conservation goals.
5. Select the sites in descending priority sequence until the requirements specified above are met.

Sites identified through this process were included in the aquatic Conservation Blueprint portfolio.

6.0 Results of the Conservation Blueprint

The portfolio of sites for the Great Lakes Conservation Blueprint for aquatic biodiversity is illustrated in Figure 25. The Conservation Blueprint includes all conservation lands and protected areas, as well as sites identified through the coarse and fine-filter biodiversity analyses. In order to identify watersheds that remain largely in natural cover, all "non-natural" lands were removed from one version of the Conservation Blueprint. This enabled the results to be portrayed as the portions of the watersheds that remain in natural cover.

The following sections report on the representation of freshwater biodiversity targets in the Conservation Blueprint. Volume 2 of this report further details the biodiversity targets and the Conservation Blueprint for each tertiary watershed. Each tertiary watershed report contains a summary of the natural heritage features within the watershed, protected areas and conservation lands, and within the Conservation Blueprint (Phair *et al.*, 2005). Volume 2 also includes maps of ecological systems and the Conservation Blueprint for each tertiary watershed.

6.1 Protected Areas and Conservation Lands

Ontario's federal and provincial public lands account for about 87% of the provincial landbase and include a variety of regulated protected areas (Figure 24). Municipal and private lands account for about 13% of the provincial landbase, some of which are conservation lands or have natural heritage designations (Paleczny *et al.*, 2000). For the Conservation Blueprint, GIS coverages were assembled for 11 classes of protected areas and conservation lands (Figure 26). These protected areas fall into various World Conservation Union (IUCN) categories to characterize conservation management (Table 12). National Wildlife Areas, Migratory Bird Sanctuaries, Provincial Parks and Conservation Reserves fit the widest range of IUCN-defined protected area management categories; National Parks and Nature Conservancy of Canada lands appear subject to the most restricted range of management categories (Table 13).

Many of the coarse-filter biodiversity targets and some of the fine-filter targets identified in this study occurred within existing conservation lands and protected areas.

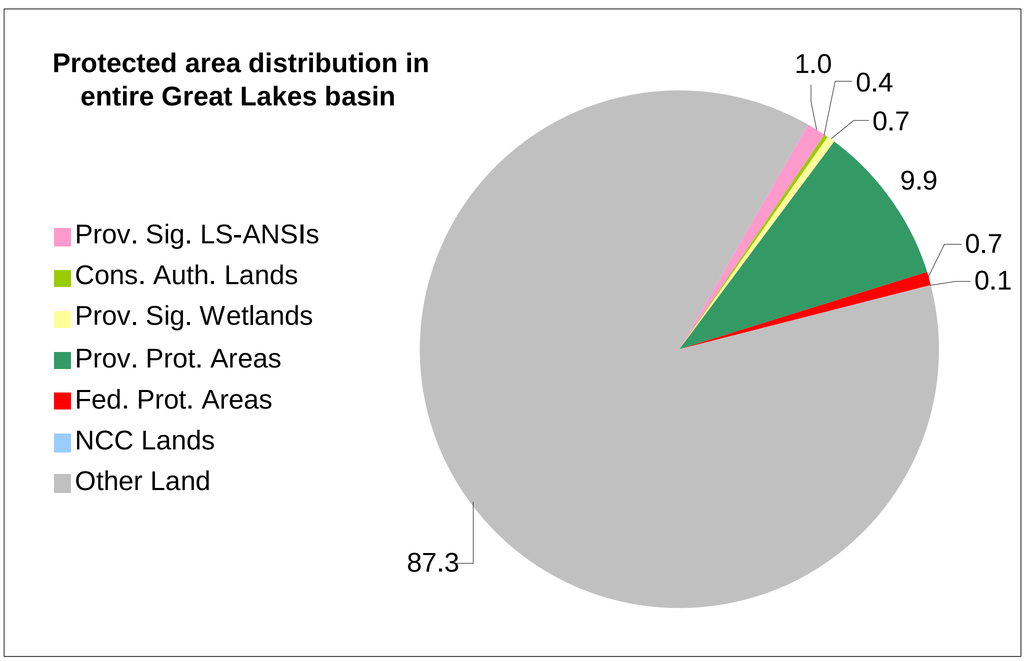

Figure 24. Breakdown of protected areas and conservation lands as a percentage of the total area of the Great Lakes watershed.

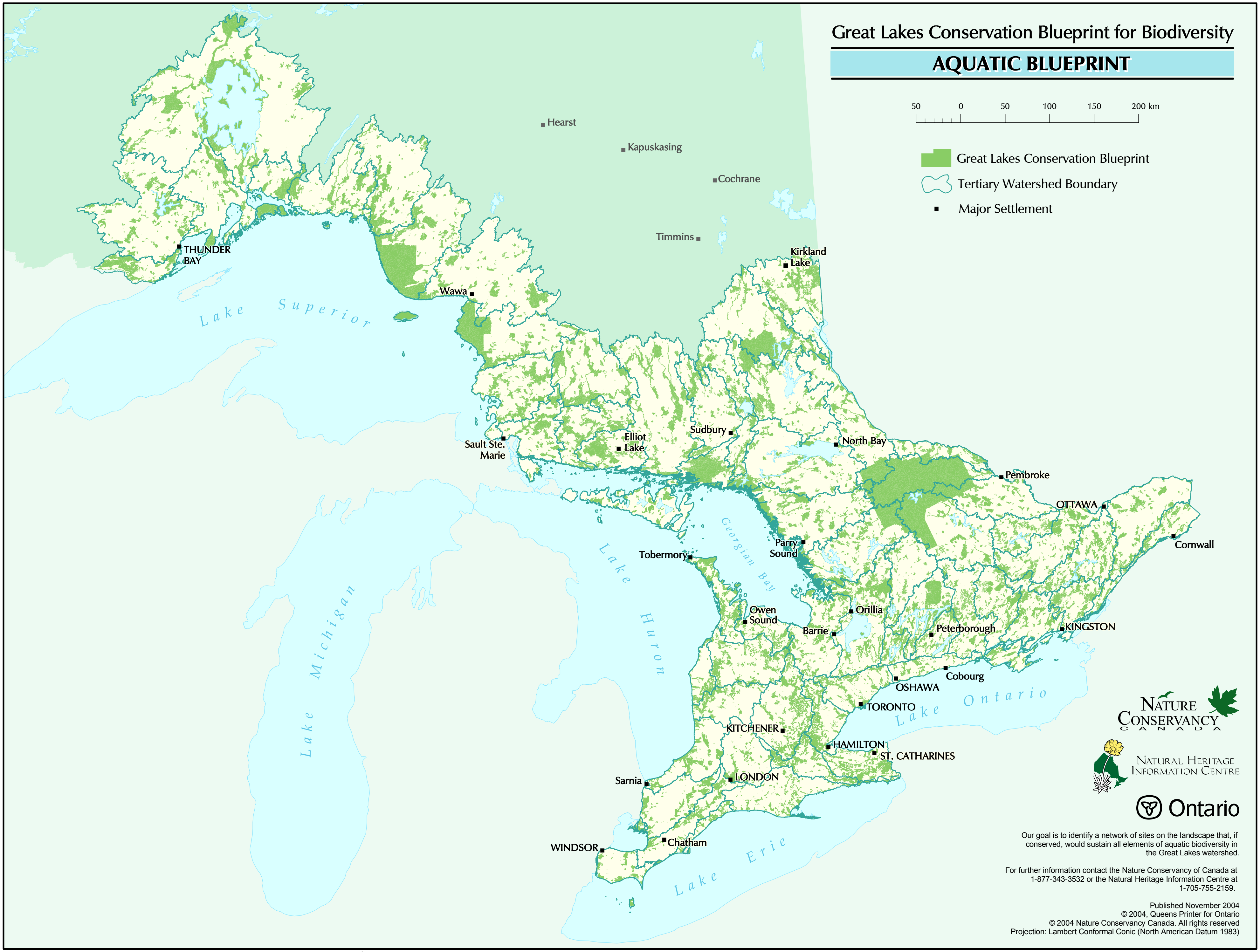

Figure 25. Great Lakes Conservation Blueprint for aquatic biodiversity.

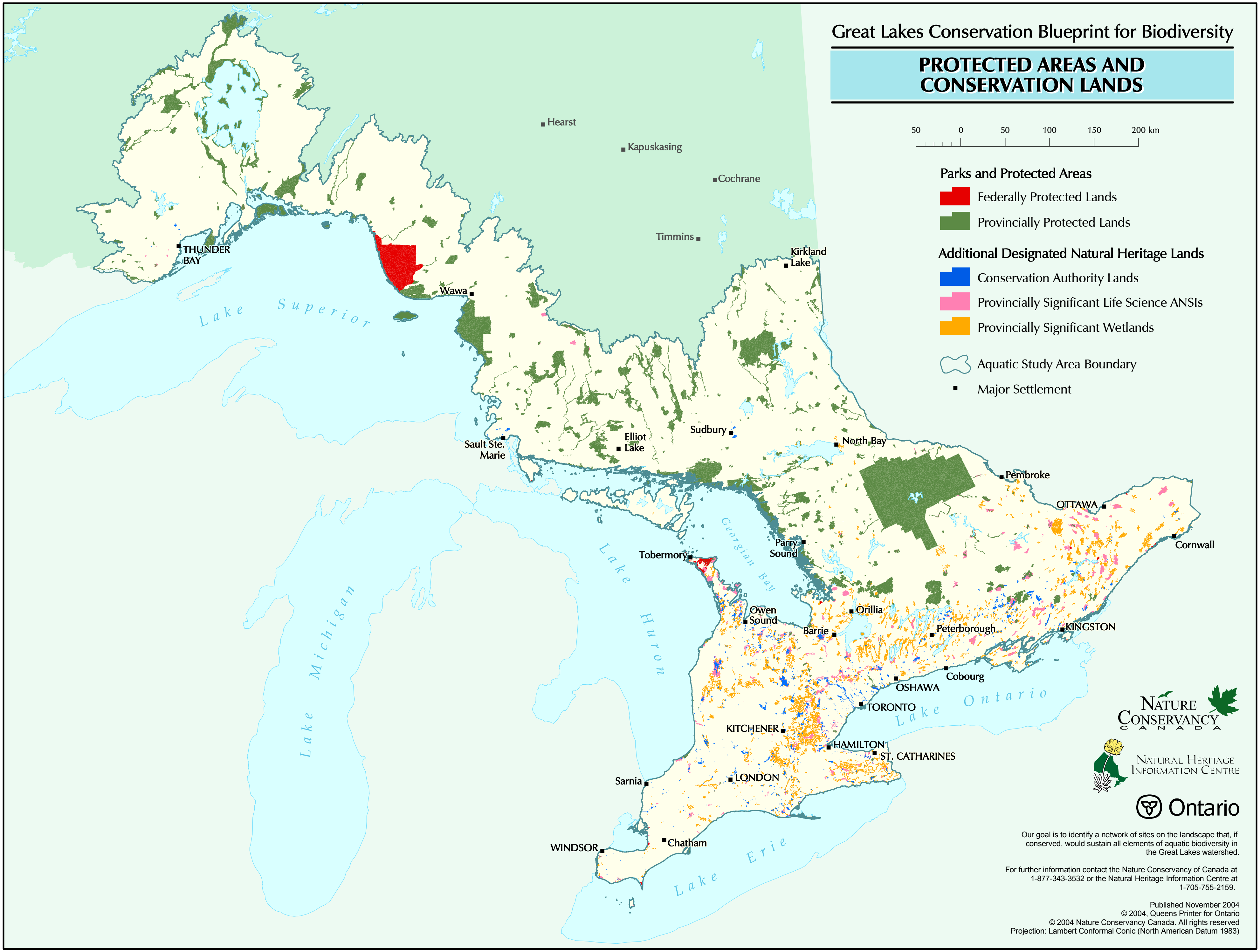

Figure 26. Protected areas and conservation lands in the Great Lakes watershed.

Table 12. IUCN protected area management categories (IUCN, 1994).

Category	**Description**
Ia: Strict Nature Reserve	Protected area managed mainly for science
Ib: Wilderness Area	Protected area managed mainly for wilderness protection
II: National Park	Protected area managed mainly for ecosystem protection and recreation
III: National Monument	Protected area managed mainly for conservation of specific natural features
IV: Habitat/Species Management Areas	Protected area managed mainly for conservation through management intervention
V: Protected Landscape/Seascape	Protected area managed mainly for landscape/seascape conservation and recreation
VI: Managed Resource Protected Area	Protected area managed mainly for the sustainable use of natural ecosystems

Table 13. Characterization of protected area types in the Great Lakes (adapted from Paleczny *et al.*, 2000). 'X' is an area classification by IUCN categories, and may vary on a case-by-case basis. 'I' are conservation lands that were included in the Conservation Blueprint portfolio. 'N' are conservation lands that were included depending on conservation value for the locale.

Type of area	Degree of Protection	IUCN Protected Area Category							No Category	Blueprint status
		Ia	Ib	II	III	IV	V	VI		
Important Bird Area	Full, Partial, None									N
National Park	Full		X	X						I
National Marine Conservation Area	Full		X	X						I
National Wildlife Areas	Full	X	X	X	X	X				I
Migratory Bird Sanctuaries	Full and partial	X		X	X	X			X	I
Provincial Parks	Full	X	X	X	X					I
Conservation Reserves	Full	X	X	X	X					I
Ontario Living Legacy Sites	Full	X	X	X	X					I
Provincially Significant Wetlands	Full and partial								X	I
Provincially Significant Areas of Natural and Scientific Interest	Partial and none	X		X		X			X	I
Regionally Significant Areas of Natural and Scientific Interest	Partial and none	X		X		X			X	N
Conservation Authority Lands	Full and partial			X	X	X			X	I
Nature Conservancy of Canada lands	Full	X								I

6.2 Coarse -filter Biodiversity Analysis

The Ontario portion of the Great Lakes basin is largely composed of unprotected lands. Of the nearly 15% of the basin that is protected or designated as conservation lands, the majority is regulated as provincial protected areas (Figure 25). There are very few federally protected areas in the Great Lakes watershed (Table 14). The largest federal protected area is Pukaskwa National Park on the shore of Lake Superior. Provincial protected areas in the southern reaches of the Great Lakes basin tend to be small, with more extensive provincial parks and conservation reserves occurring on the Canadian Shield. Provincially significant life science Areas of Natural and Scientific Interest (ANSIs) and provincially significant wetlands comprise the bulk of conservation lands in southern Ontario.

The aquatic Conservation Blueprint analysis included all protected areas and conservation lands within the Great Lakes basin. This resulted in a portfolio of sites where protected areas and conservation lands constitute over half of the total area of the Conservation Blueprint (Figure 27). The bulk of the protected areas and conservation lands within the Conservation Blueprint are provincial protected areas.

Table 14. Percentage of the total area that is within protected areas, conservation lands and the Conservation Blueprint.

	Federally Protected	Prov. Protected	Cons. Authority Lands	Prov. Sig. Life Science ANSIs	All Protected Areas and Conservation Lands	Conservation Blueprint	Conservation Blueprint (natural cover only)
Lake Superior	2.2 %	11.0 %	0.1 %	0.1 %	13.3 %	22.7 %	22.6 %
Lake Huron	0.1 %	9.1 %	0.4 %	1.1 %	11.3 %	24.9 %	23.2 %
Lake Erie	0.1 %	0.1 %	0.5 %	0.9 %	4.2 %	19.1 %	7.1 %
Lake Ontario	0.0 %	2.2 %	1.2 %	1.8 %	6.8 %	16.8 %	13.5 %
St. Lawrence River	0.1 %	17.2 %	0.1 %	1.4 %	19.8 %	30.9 %	29.9 %

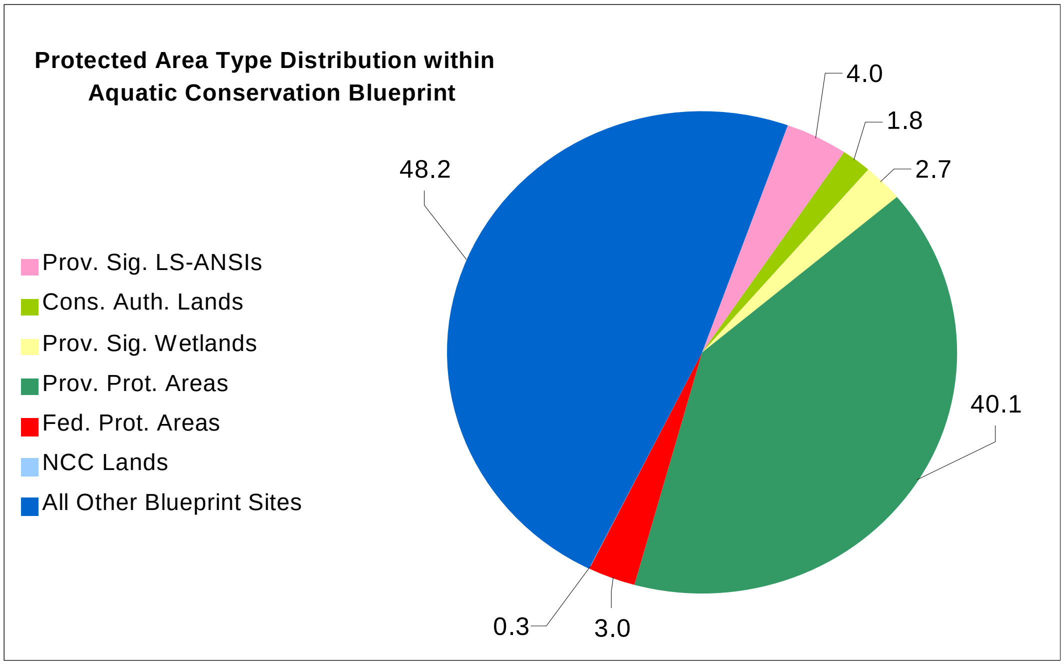

Figure 27. Percentages of the total area of the Aquatic Conservation Blueprint that are within various classes of protected areas or conservation lands.

The aquatic Conservation Blueprint covers 6.8 million ha, of which nearly 6.3 million ha are in a state of natural cover (Table 15). The natural cover component of the Conservation Blueprint includes over 22% of the total area of the Great Lakes basin in Ontario.

Table 15. Aquatic ecological systems in the aquatic Conservation Blueprint portfolio.

	Coastal Systems	Stream Systems	Lakes	Wetlands	All Systems
Lake Superior catchment (ha)	118,894	6,805,861	920,672	386,779	8,232,206
Lake Superior Conservation Blueprint (ha)	57,612	1,538,040	181,207	55,652	1,832,511
% of the Total Area of the Lake Superior Conservation Blueprint	48.5	22.6	19.7	14.4	22.3
Lake Huron catchment (ha)	222,144	7,451,091	802,227	590,936	9,066,398
Lake Huron Conservation Blueprint (ha)	65,603	1,600,633	403,691	176,392	2,246,319
% of the Total Area of the Lake Huron Conservation Blueprint	29.5	21.5	50.3	29.8	24.8
Lake Erie catchment (ha)	40,308	2,147,603	6,532	79,185	2,273,628
Lake Erie Blueprint (ha)	10,385	324,280	2,825	62,069	399,559
% of the Total Area of the Lake Erie Conservation Blueprint	25.8	15.1	43.2	78.4	17.6
Lake Ontario catchment (ha)	60,819	2,316,338	130,349	316,726	2,824,232
Lake Ontario Conservation Blueprint (ha)	12,211	418,221	76,985	131,022	638,439
% of the Total Area of the Lake Ontario Conservation Blueprint	20.1	18.1	59.1	41.4	22.6
St. Lawrence River catchment (ha)	16,268	4,537,483	301,013	497,634	5,352,398
St. Lawrence River Conservation Blueprint (ha)	2,586	1,318,077	158,752	173,348	1,652,763
% of the Total Area of the St. Lawrence River Conservation Blueprint	15.9	29.0	52.7	34.8	30.9
Total Area in the Great Lakes basin (ha)	458,433	23,258,377	2,160,793	1,871,230	27,993,563
Total area in the Conservation Blueprint (ha)	**148,397**	**5,199,251**	**823,460**	**598,484**	**6,873,882**
% of the Total Area of the Feature in the Conservation Blueprint relative to the Great Lakes Basin	**32.37**	**22.35**	**38.11**	**31.98**	**24.56**
Total area in the Conservation Blueprint - Natural cover (ha)	**133,416**	**4,635,752**	**823,460**	**598,484**	**6,294,444**
% of the Total Area of the Feature in the Conservation Blueprint (natural cover) relative to the Great Lakes Basin	**29.10**	**19.93**	**38.11**	**31.98**	**22.49**

*The term “Great Lakes Basin” used here refers only to the Ontario portion of the basin.

The protected areas and conservation lands within the Great Lakes basin can be further analyzed to determine the portion of the landbase within each conservation land type that contains top scoring systems identified in the Conservation Blueprint coarse-filter biodiversity analysis. Throughout the entire Great Lakes basin in Ontario, the majority of the conservation land types contain at least one-quarter of their landbase as top-scoring aquatic ecological systems (Figure 28a).

The drainage basin for each Great Lake can also be analyzed to determine the amount of landbase that contains top scoring systems (Figures 28b-f). Appendix 5 lists tertiary watersheds by Great Lake drainage basin. The results show that, although most protected areas and conservation lands in Ontario were designed based on terrestrial biodiversity values, several of these conservation lands coincide with high quality freshwater habitats.

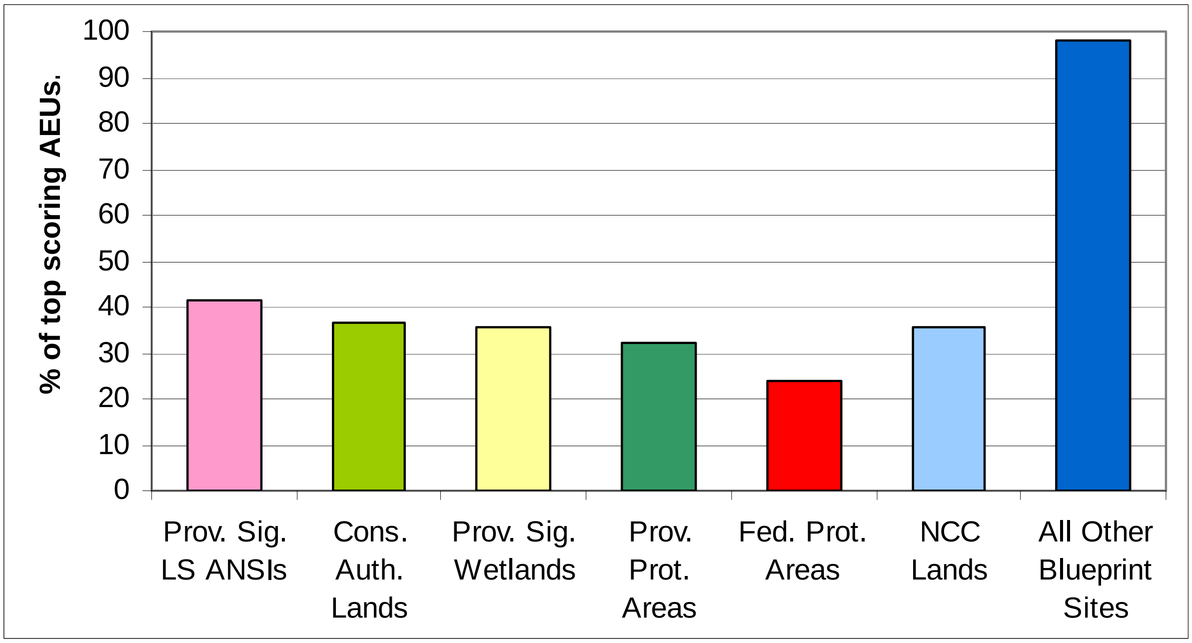

Figure 28a. Percentage of the total area of protected areas and conservation lands that are top scoring aquatic ecological systems within the Great Lakes basin in Ontario.

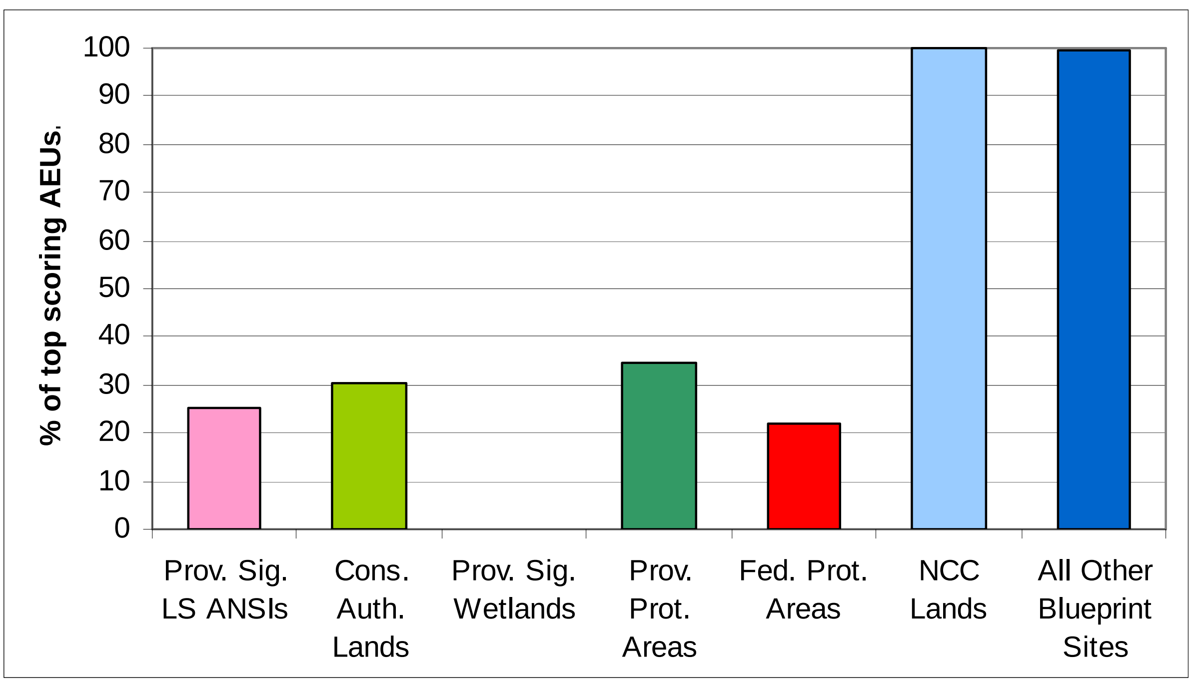

Figure 28b. Percentage of the total area of protected areas and conservation lands that are top scoring aquatic ecological systems within the Lake Superior drainage basin in Ontario.

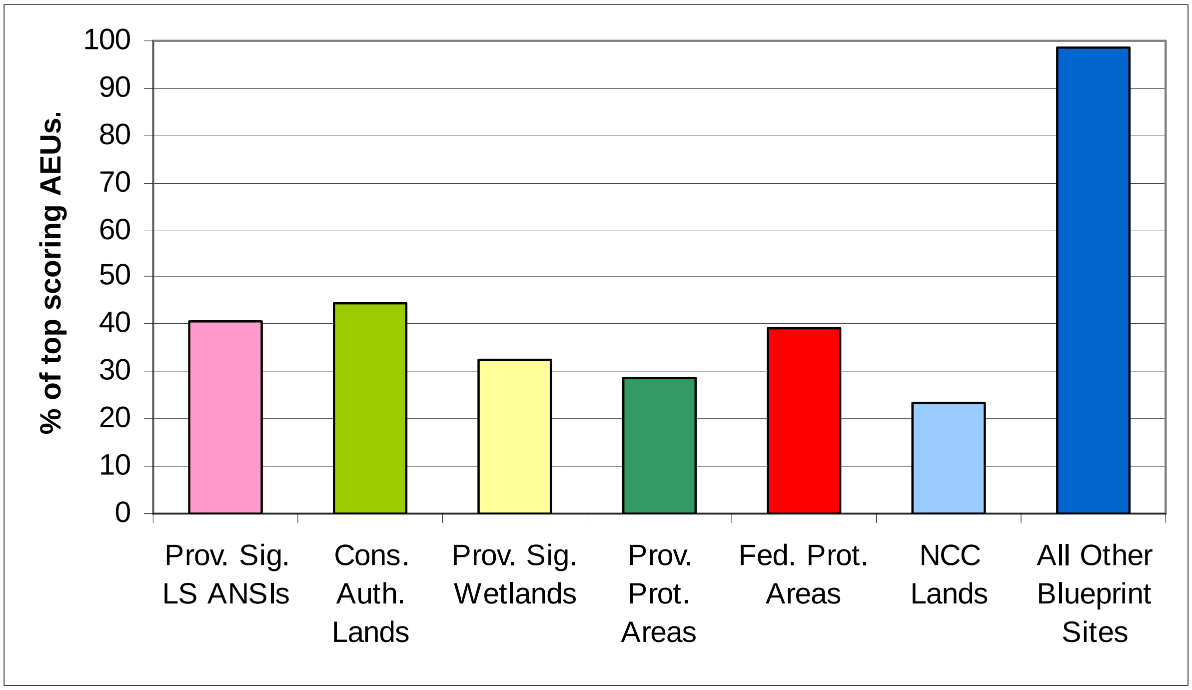

Figure 28c. Percentage of the total area of protected areas and conservation lands that are top scoring aquatic ecological systems within the Lake Huron drainage basin in Ontario.

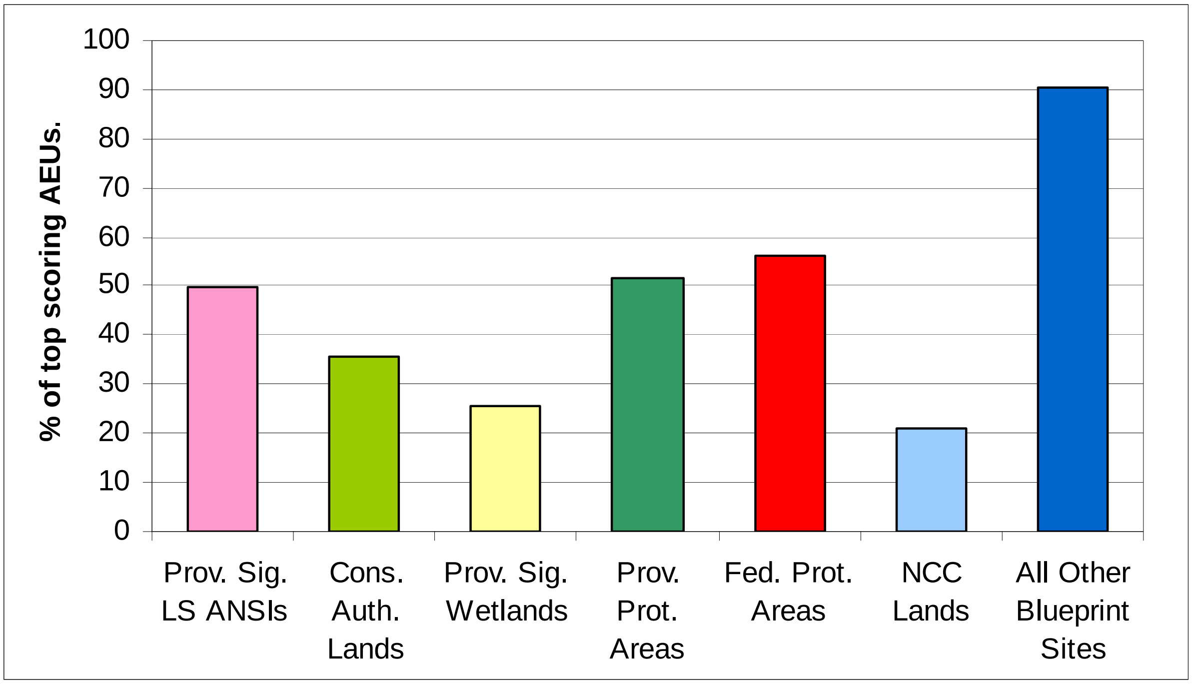

Figure 28d. Percentage of the total area of protected areas and conservation lands that are top scoring aquatic ecological systems within the Lake Erie drainage basin in Ontario.

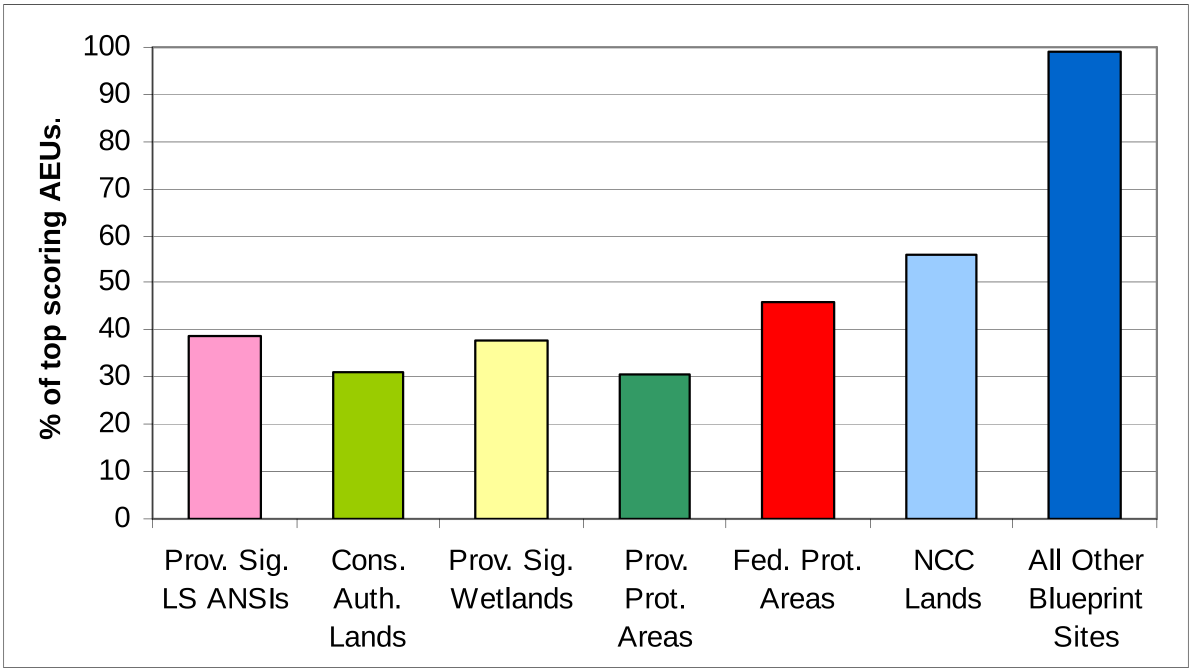

Figure 28e. Percentage of the total area of protected areas and conservation lands that are top scoring ecological systems within the Lake Ontario drainage basin in Ontario.

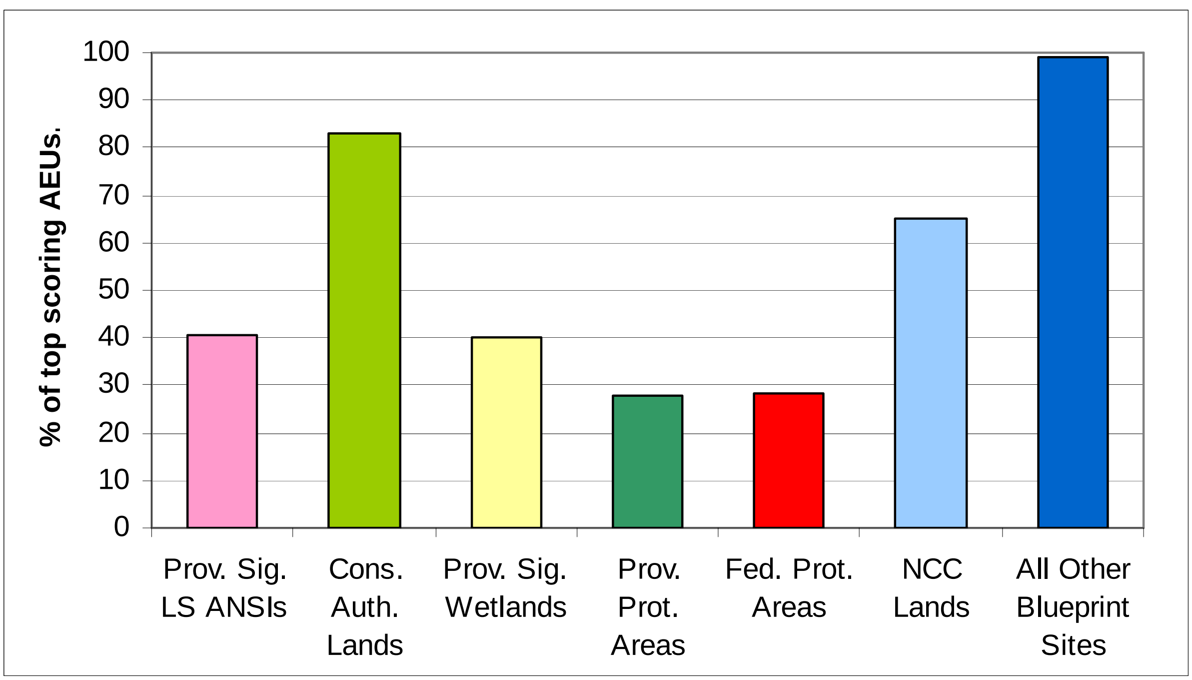

Figure 28f. Percentage of the total area of protected areas and conservation lands that are top scoring aquatic ecological systems in the drainage basin of the St. Lawrence River in Ontario.

6.2.1 TARGET ECOLOGICAL SYSTEMS

Great Lakes Shoreline

There are 27 Great Lakes shoreline types in the aquatic ecosystem classification system. Of these, 23 were targets for representation in the coarse-filter biodiversity analysis (Appendices 1A and 1B). In general, coastal systems were fairly well represented in existing protected areas in Lake Huron and Lake Superior (Tables 16 and 17). Coastal habitats were poorly represented in Lake Erie, Lake Ontario and the St. Lawrence River watersheds (Tables 18, 19 and 20). The Conservation Blueprint made substantial gains in the representation of shoreline and coastal features in these three watersheds. Overall, implementing the Conservation Blueprint would represent a 12% increase in the total amount of shoreline that is currently within existing protected areas or conservation lands.

Stream Systems

There are 54 possible stream types, all of which were targeted for representation in the coarse-filter biodiversity analysis (Appendix 1C). In general, these systems were not adequately represented by existing protected areas, particularly in southern parts of the Great Lakes basin. The Conservation Blueprint represents a gain of 112% in the total area of stream systems over the current network of protected areas and conservation lands. Stream systems account for approximately 77% of the total area of the Conservation Blueprint.

Wetlands

There were 12 possible wetland types; of these, 10 were targeted for representation in the coarse-filter biodiversity analysis (Appendix 1D). The addition of wetlands to satisfy aquatic Conservation Blueprint conservation goals represents a 14% gain in wetland area over what occurs in existing conservation lands. These relatively small gains suggest that many wetlands with high conservation values were already included in existing conservation lands, particularly in the southern portion of the study area.

Inland Lakes

There are 32 types of inland lakes in the aquatic ecosystem classification, all of which were targeted for representation in the Conservation Blueprint (Appendix 1E). The Conservation Blueprint increased the amount of inland lakes by 132% over the current area of inland lakes in protected areas and conservation lands. Most types of inland lakes were not well-represented in existing conservation lands.

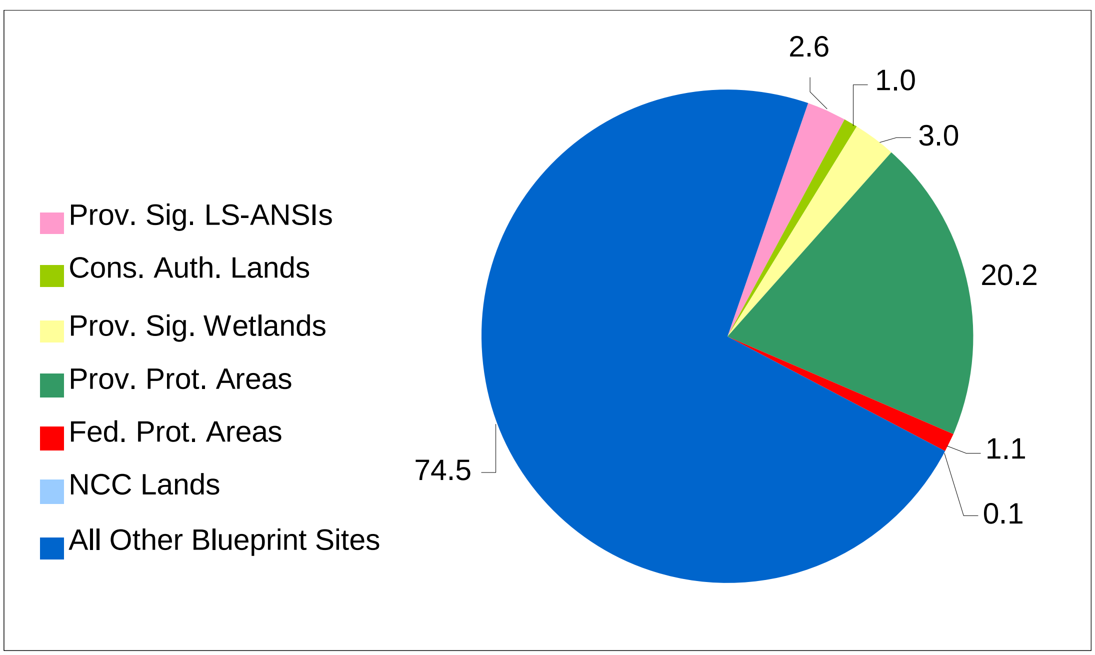

Figure 29. Distribution of top scoring Aquatic Ecological Units (AEUs) within protected areas, conservation lands and other sites in the Conservation Blueprint. Values are expressed as the percentage of the total area of the Great Lakes basin.

Approximately 26% of the top aquatic systems identified through the coarse-filter analysis coincide with conservation lands, primarily within provincial protected areas. Top scoring systems are also present throughout the entire suite of conservation lands. This shows that all conservation land initiatives in Ontario contribute in some degree to maintaining the best quality examples of aquatic ecological systems in the Canadian portion of the Great Lakes basin. Figures 29 to 34 outline the degree to which conservation lands contribute to capturing best quality examples of aquatic ecological systems in the various drainage areas for the entire Canadian portion of the Great Lakes basin, and for each of the Canadian Great Lakes.

Lake Superior Basin

Over 27% of the top scoring aquatic ecological systems coincided with provincially protected areas in the Lake Superior basin (Figure 30). Coastal and shoreline habitats were fairly well represented in existing protected areas and conservation lands (Table 15). The Conservation Blueprint considerably increased the number of lake, wetland and stream habitats in order to satisfy the representation goals of high quality habitat targets. Nearly 70% of the best representative freshwater habitats are outside of the existing network of protected areas and conservation lands.

Table 16. Proportion of aquatic ecosystems in the Lake Superior watershed that are in conservation lands and the Conservation Blueprint.

	Total Area (ha)	Area in Prot. Areas and Cons. Lands (ha)	% in Prot. Areas and Cons. Lands	Area Conservation Blueprint (ha)	% of Feature in Conservation Blueprint
Coastal systems	118,894	50,046	42.1	57,612	48.5
Stream systems	6,805,861	826,241	12.1	1,538,040	22.6
Lakes	920,672	119,233	13.0	181,207	19.7
Wetlands	386,779	38,184	9.9	55,652	14.4

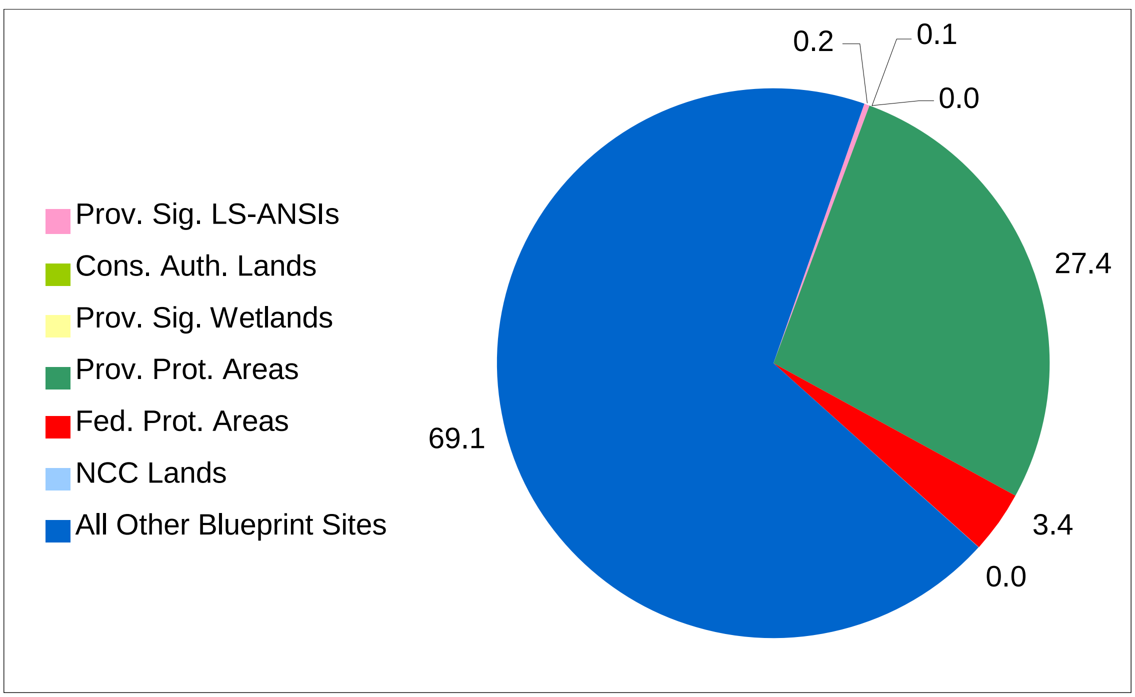

Figure 30. Distribution of top scoring Aquatic Ecological Units (AEUs) within protected areas, conservation lands and other sites in the Conservation Blueprint in the Lake Superior basin.

Lake Huron Basin

Over 16% of the top scoring aquatic ecological systems coincided with provincially protected areas in the Lake Huron basin (Figure 31). Wetland habitats were fairly well represented in existing protected areas and conservation lands (Table 17). The Conservation Blueprint considerably increased the number of lake and stream habitats in order to satisfy the representation goals of high quality habitat targets. Eighty percent of the best representative freshwater habitats are outside of the existing network of protected areas and conservation lands.

Table 17. Proportion of aquatic ecosystems in the Lake Huron watershed that are in conservation lands and the Conservation Blueprint.

	Total Area (ha)	Area in Prot. Areas and Cons. Lands (ha)	% in Prot. Areas and Cons. Lands	Area Conservation Blueprint (ha)	% of Feature in Conservation Blueprint
Coastal systems	222,144	47,878	21.6	65,603	29.5
Stream systems	7,451,091	665,745	8.9	1,600,633	21.5
Lakes	802,227	126,370	15.8	403,691	50.3
Wetlands	590,936	162,234	27.5	176,392	29.8

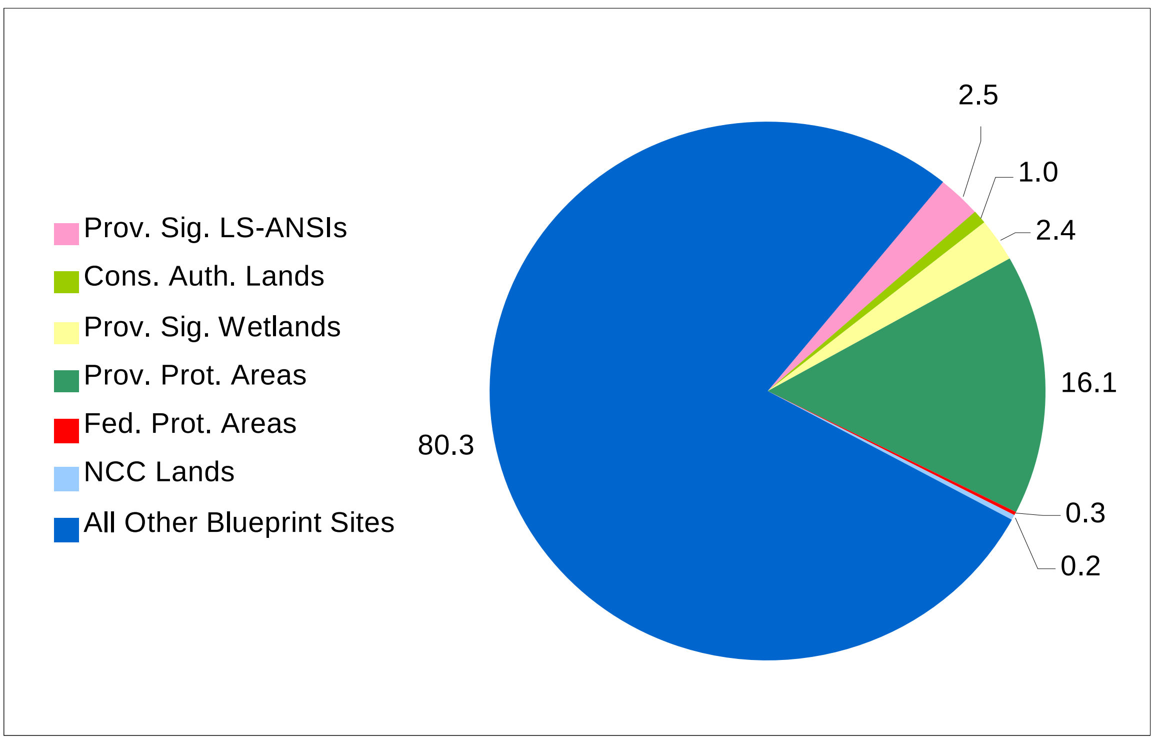

Figure 31. Distribution of top scoring Aquatic Ecological Units (AEUs) within protected areas, conservation lands and other sites in the Conservation Blueprint in the Lake Huron basin.

Only 11% of the top scoring aquatic ecological systems coincided with provincially significant life science ANSIs, provincially significant wetlands or Conservation Authority lands in the Lake Erie basin (Figure 32). Wetland habitats were well represented in existing protected areas and conservation lands (Table 18). The Conservation Blueprint considerably increased the number of coastal and stream habitats in order to satisfy the representation goals of high quality habitat targets. More than ninety percent of the best representative freshwater habitats are outside of the existing network of protected areas and conservation lands.

Table 18. Proportion of aquatic ecosystems in the Lake Erie watershed that are in conservation lands and the Conservation Blueprint.

	Total Area (ha)	Area in Prot. Areas and Cons. Lands (ha)	% in Prot. Areas and Cons. Lands	Area Conservation Blueprint (ha)	% of Feature in Conservation Blueprint
Coastal systems	40,308	2,731	6.8	10,385	25.8
Stream systems	2,147,603	32,941	1.5	324,280	15.1
Lakes	6,532	2,060	31.5	2,825	43.2
Wetlands	79,185	55,855	70.5	62,069	78.4

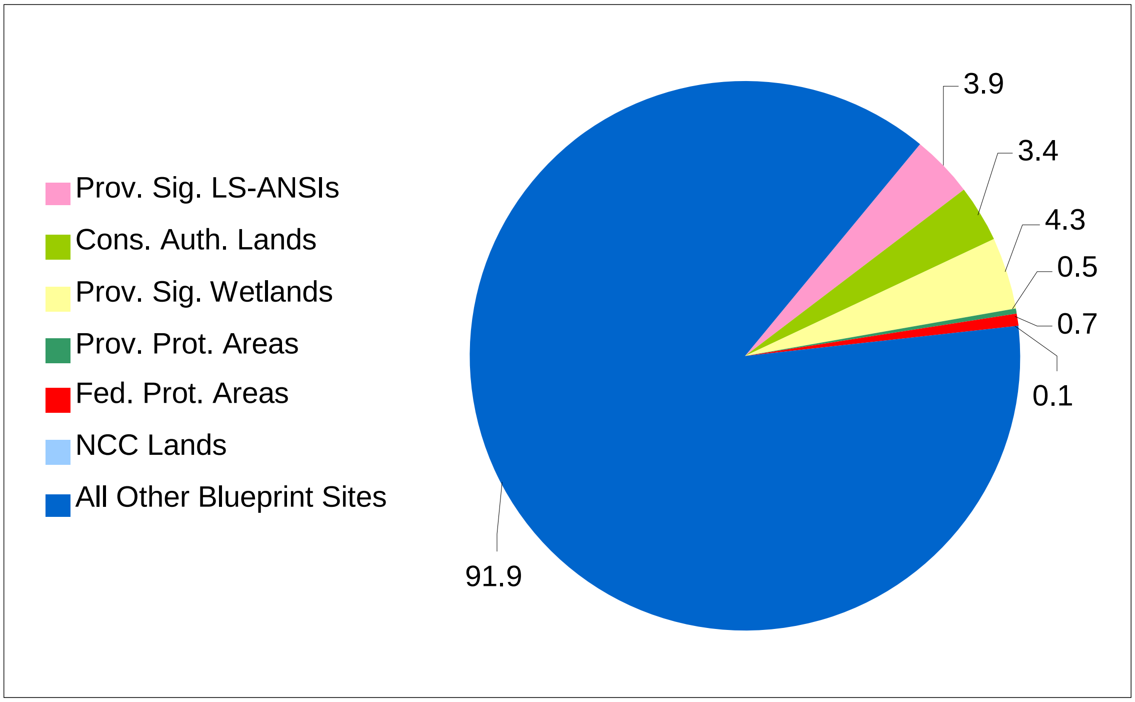

Figure 32. Distribution of top scoring Aquatic Ecological Units (AEUs) within protected areas, conservation lands and other sites in the Conservation Blueprint in the Lake Erie basin.

Nearly 20% of the top scoring aquatic ecological systems coincided with provincially significant life science ANSIs, provincially significant wetlands or provincially protected areas in the Lake Ontario basin (Figure 33). Wetland habitats were fairly well represented in existing protected areas and conservation lands (Table 19). The Conservation Blueprint considerably increased the number of coastal, lake and stream habitats in order to satisfy the representation goals of high quality habitat targets. More than 80% of the best representative freshwater habitats are outside of the existing network of protected areas and conservation lands.

Table 19. Proportion of aquatic ecosystems in the Lake Ontario watershed that are in conservation lands and the Conservation Blueprint.

	Total Area (ha)	Area in Prot. Areas and Cons. Lands (ha)	% in Prot. Areas and Cons. Lands	Area Conservation Blueprint (ha)	% of Feature in Conservation Blueprint
Coastal systems	60,819	2,741	4.5	12,211	20.1
Stream systems	2,316,338	125,403	5.4	418,221	18.1
Lakes	130,349	12,871	9.9	76,985	59.1
Wetlands	316,726	113,491	35.8	131,022	41.4

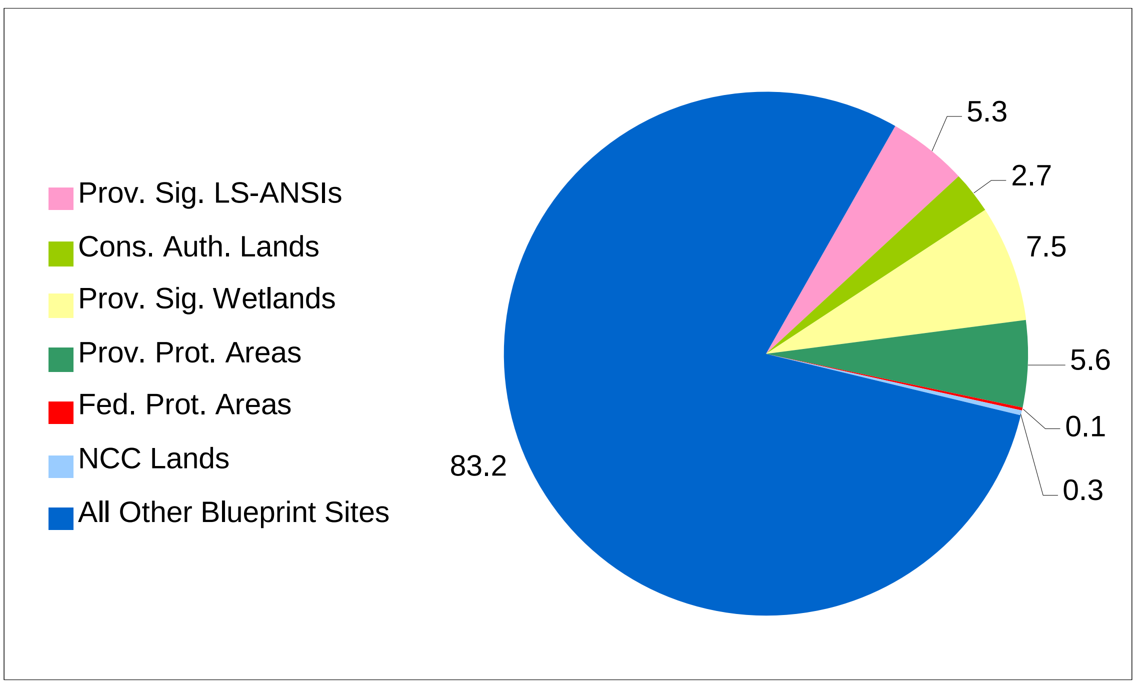

Figure 33. Distribution of top scoring Aquatic Ecological Units (AEUs) within protected areas, conservation lands and other sites in the Conservation Blueprint in the Lake Ontario basin.

More than 28% of the top scoring aquatic ecological systems coincided with provincially protected areas in the St. Lawrence River watershed (Figure 34). Wetland habitats were fairly well represented in existing protected areas and conservation lands (Table 20). The Conservation Blueprint considerably increased the number of coastal, lake and stream habitats in order to satisfy the representation goals of high quality habitat targets. More than 65% of the best representative freshwater habitats are outside of the existing network of protected areas and conservation lands.

Table 20. Proportion of aquatic ecosystems in the St. Lawrence River watershed that are in conservation lands and the Conservation Blueprint.

	Total Area (ha)	Area in Prot. Areas and Cons. Lands (ha)	% in Prot. Areas and Cons. Lands	Area Conservation Blueprint (ha)	% of Feature in Conservation Blueprint
Coastal systems	16,268	1,324	8.1	2,586	15.9
Stream systems	4,537,483	807,051	17.8	1,318,077	29.0
Lakes	301,013	93,997	31.2	158,752	52.7
Wetlands	497,634	154,220	31.0	173,348	34.8

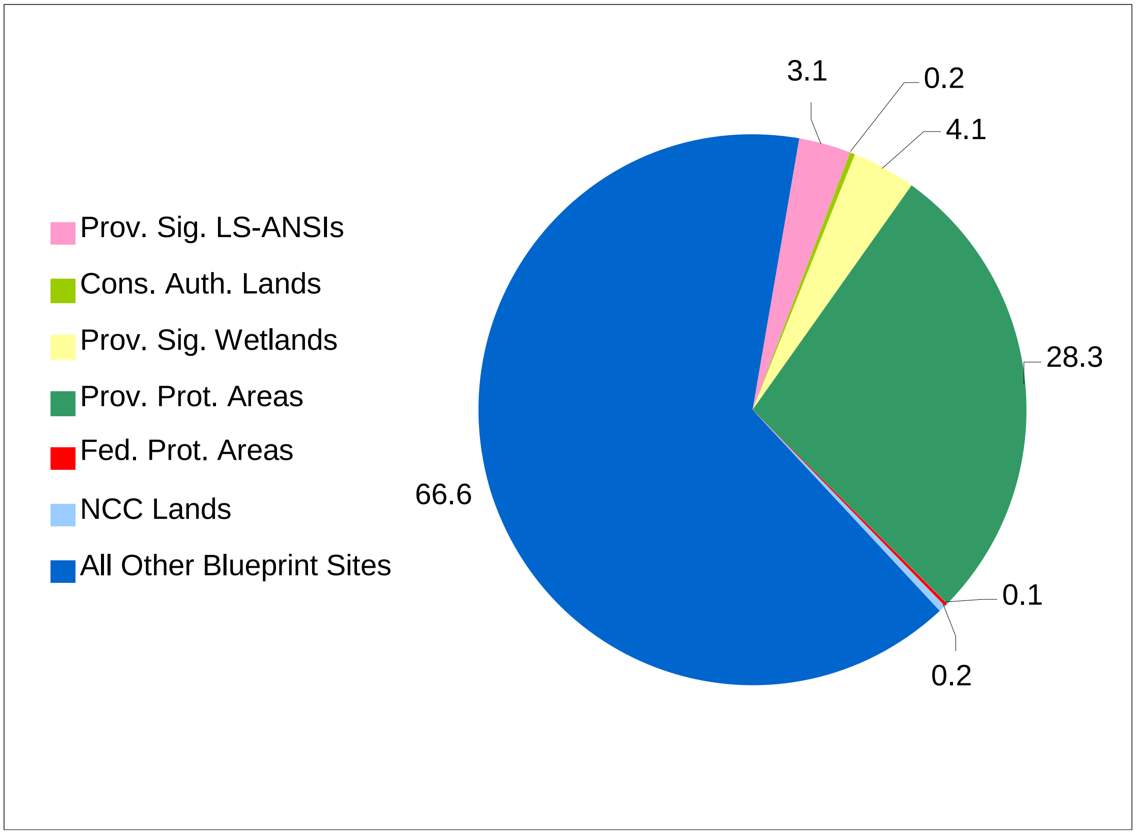

Figure 34. Distribution of top scoring Aquatic Ecological Units (AEUs) within protected areas, conservation lands and other sites in the Conservation Blueprint in the St. Lawrence River watershed in Ontario.

6.3 Fine-filter Biodiversity Analysis

A total of 121 species and 32 vegetation community types were targeted for representation in the fine-filter biodiversity analysis of the aquatic Conservation Blueprint (Table 7). More than one-third of the element occurrence records of fine-filter biodiversity targets within the aquatic Conservation Blueprint are reptiles, followed by birds and vascular plants. Targeted aquatic vegetation communities account for 16% of all the element occurrences in the Conservation Blueprint (Figure 35). The aquatic Conservation Blueprint includes all known species and vegetation community occurrences that were available for primary fine-filter biodiversity targets, as well as all secondary community targets. The Conservation Blueprint also includes the majority of element occurrence records for secondary species targets (Figure 36).

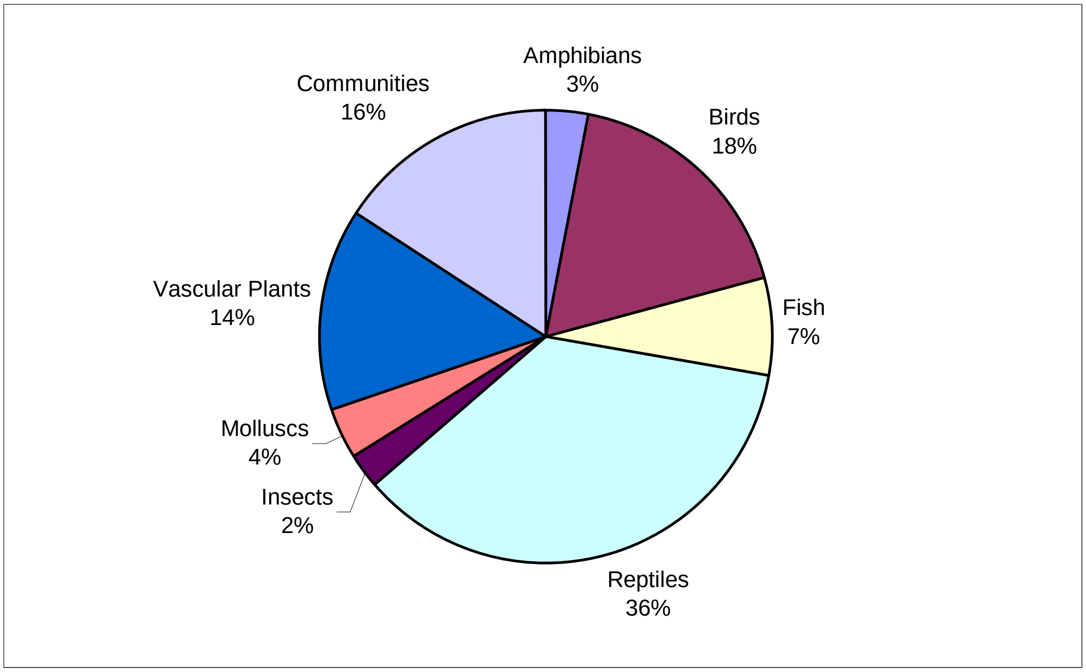

Figure 35. Element occurrence records of fine-filter biodiversity targets in the Conservation Blueprint, grouped by taxa.

.

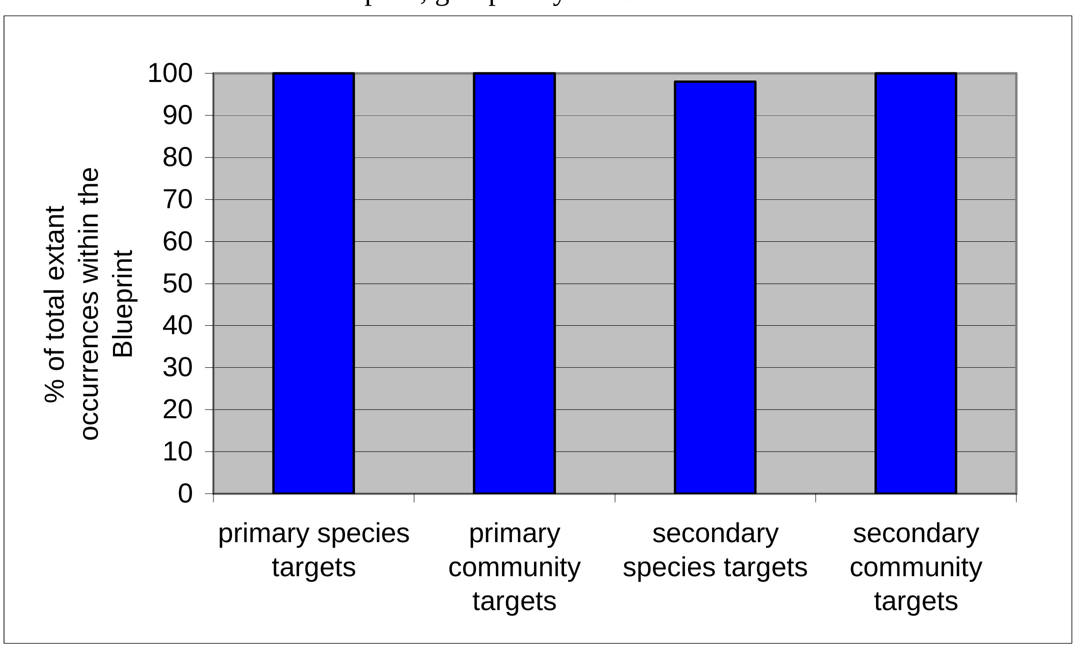

Figure 36. Total number of element occurrence records in the Conservation Blueprint for primary and secondary fine-filter biodiversity targets.

Although the Conservation Blueprint analysis efficiently included target species and vegetation community occurrences, the analysis was only capable of including species and community occurrence for which there was occurrence data available. The number of target species and vegetation communities represented in the Conservation Blueprint is a function of the conservation goals that were used for the analysis. It was not possible to represent species targets for which element occurrence data were lacking. For example, in Figure 37 many of the primary insect targets lacked occurrence information and consequently, it was not possible to incorporate them into the Conservation Blueprint portfolio. This illustrates the importance of continuing to create and update element occurrence data for groups of taxa that may have insufficient data, particularly for freshwater invertebrates.

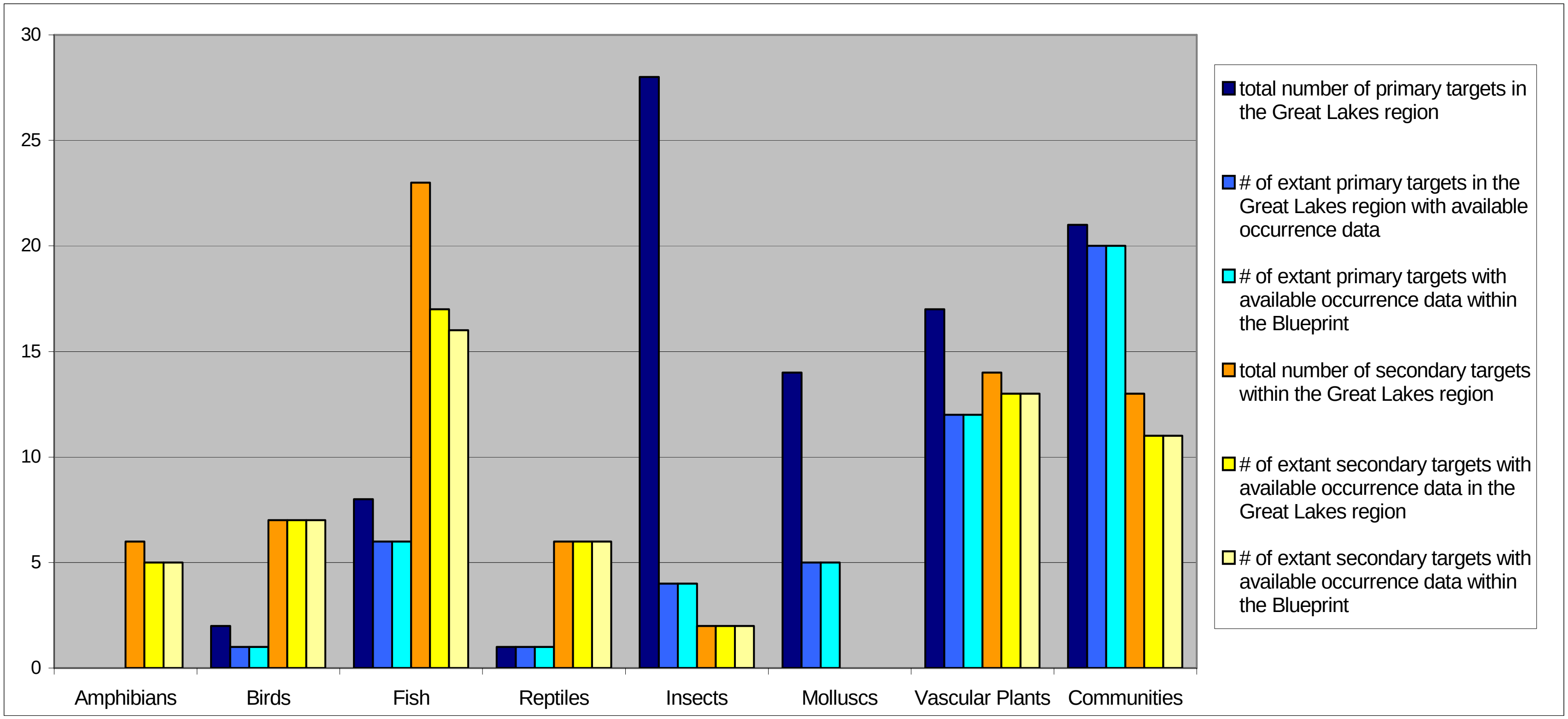

Figure 37. Number of fine- filter targets within the Great Lakes region and the Conservation Blueprint by taxa.

The majority of element occurrence records for primary species targets were concentrated in the southern portion of the study area (Figure 4). In general, these species and vegetation communities are not well represented in existing conservation lands. Areas of Natural and Scientific Interest (ANSIs) and provincially significant wetlands contained more habitats for fine-filter biodiversity targets compared to provincially and federally protected areas. The Conservation Blueprint delineates sites that are critical to the conservation of rare species and ecological communities in the Great Lakes watershed, the majority of which occur outside of existing protected areas.

Figures 38 to 43 illustrate the number of occurrences of species and vegetation community targets that are included in the Conservation Blueprint for the entire Canadian portion of the Great Lakes watershed and each drainage basin. The numbers are reported for protected areas, conservation lands, and other Conservation Blueprint sites.

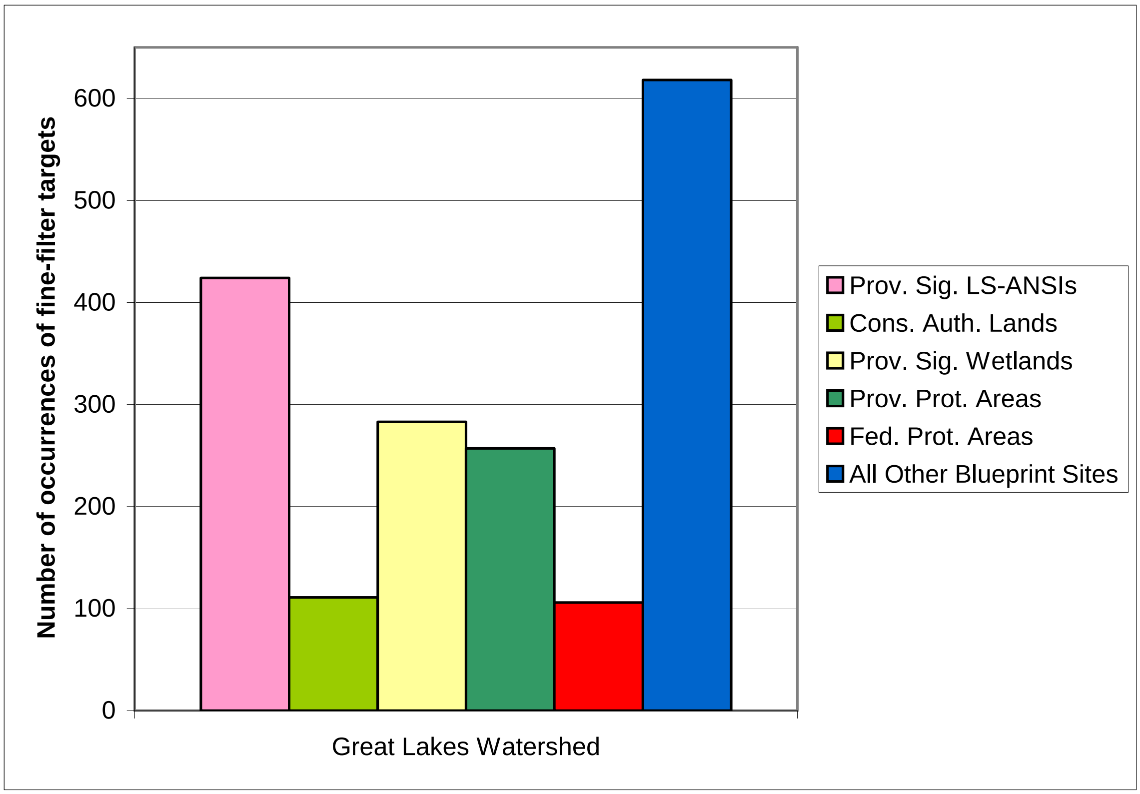

Figure 38. Number of element occurrences of species and vegetation community targets in the Great Lakes watershed.

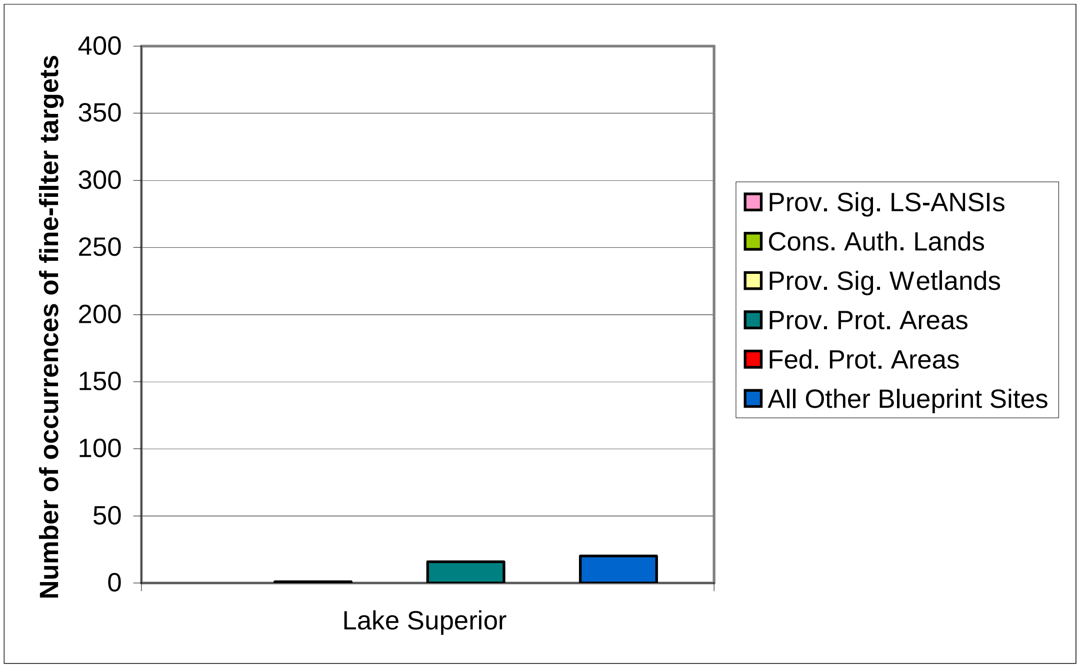

Figure 39. Number of element occurrences of species and vegetation community targets in the Lake Superior watershed.

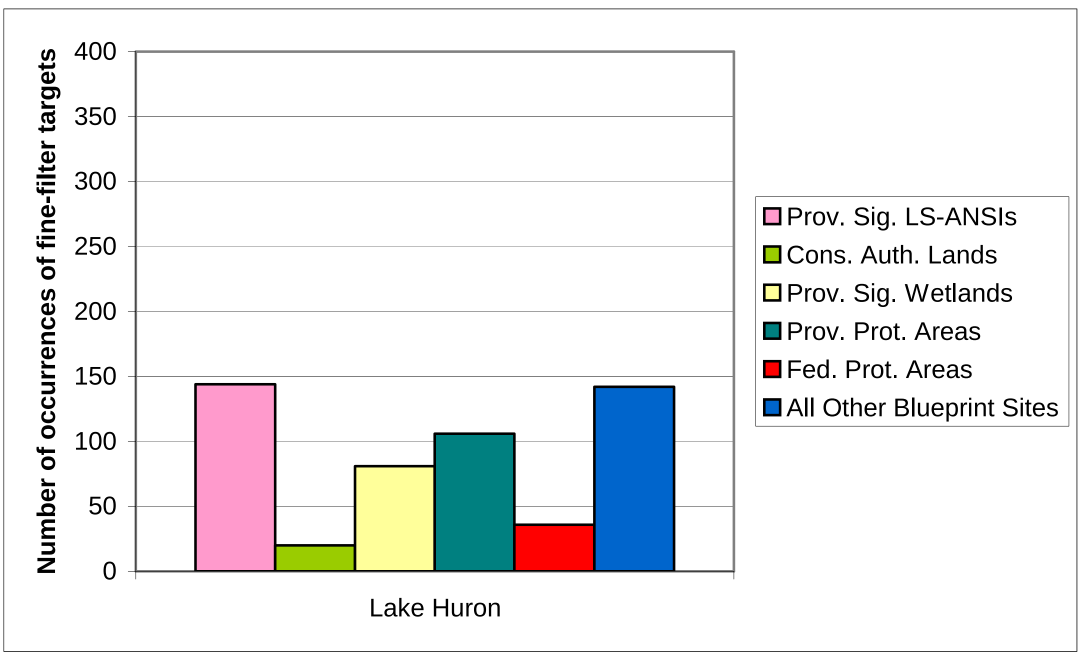

Figure 40. Number of element occurrences of species and vegetation community targets in the Lake Huron watershed.

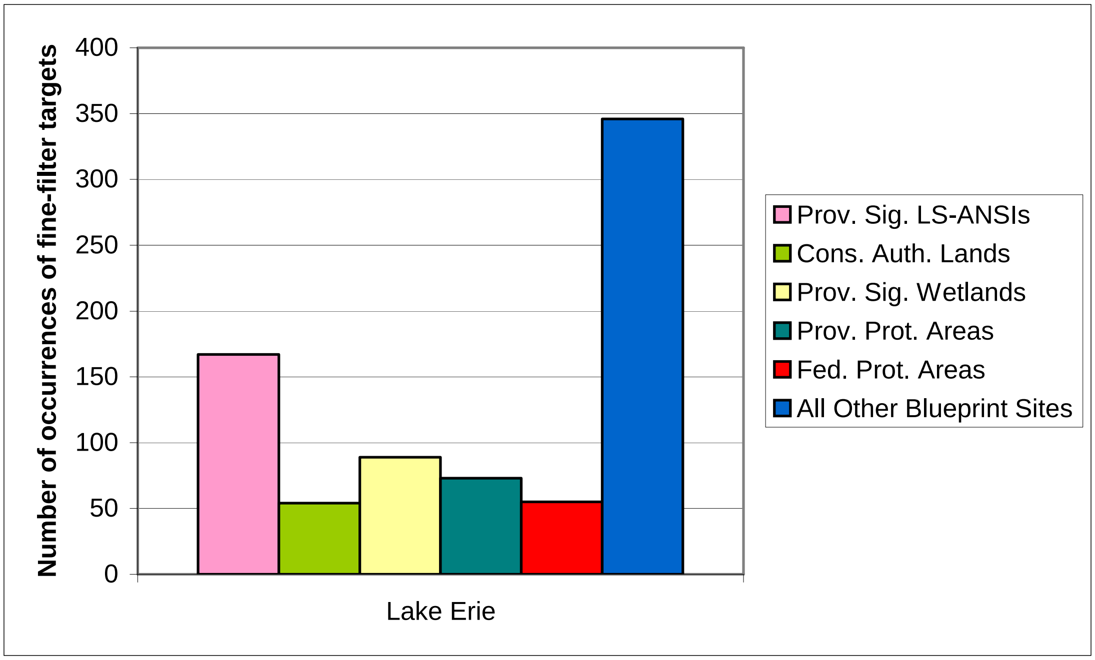

Figure 41. Number of element occurrences of species and vegetation community targets in the Lake Erie watershed.

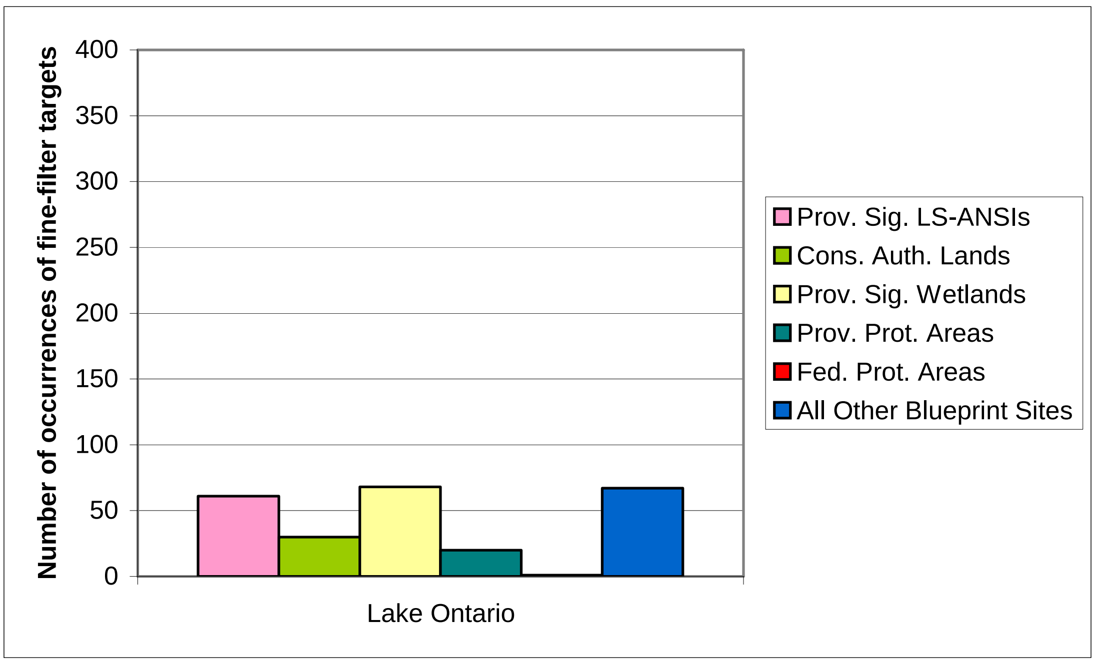

Figure 42. Number of element occurrences of species and vegetation community targets in the Lake Ontario watershed.

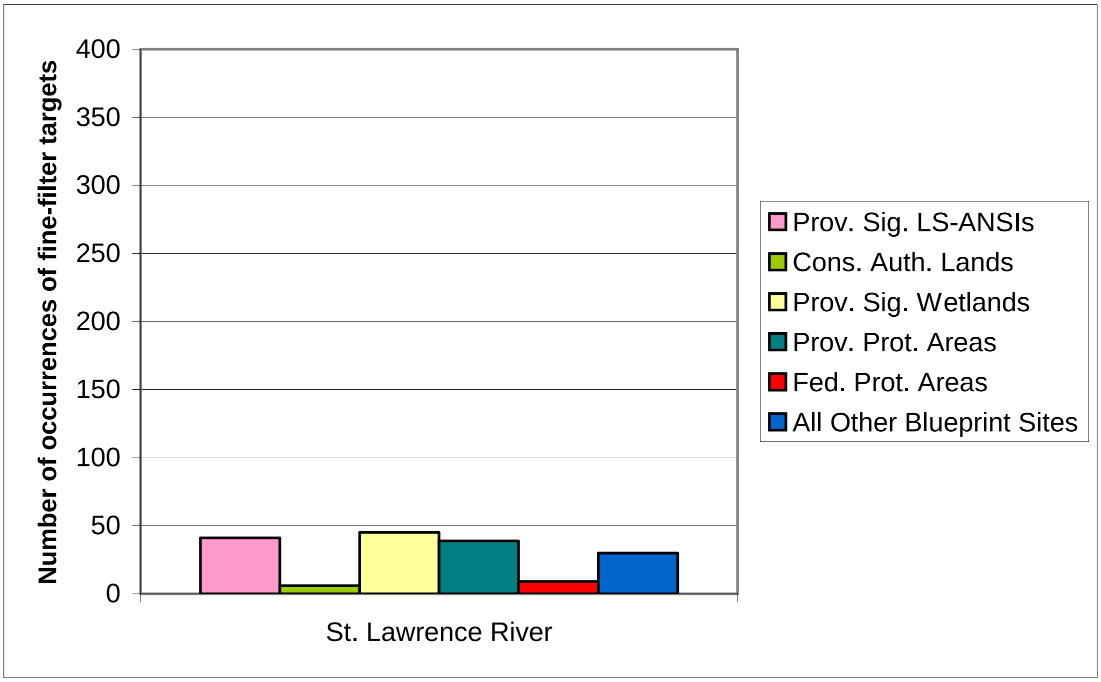

Figure 43. Number of element occurrences of species and vegetation community targets in the St. Lawrence River catchment.

7.0 Conclusion

Strengths and Innovations

A number of factors contributed to the success of this project. The Core Science Team members were chosen for their expertise, relationships with other conservation professionals in the study area, and the conservation mission of their respective organization. The team's involvement was instrumental in the creation of the aquatic ecological classification for the Great Lakes basin. Discussion and consensus-building between team members was also critical in the development of strategies to guide methodological decisions when there was insufficient scientific information (*e.g.*, setting conservation goals).

At the beginning of the project a formal project charter was developed with the Nature Conservancy of Canada and the Ontario Ministry of Natural Resources (including the Ontario Natural Heritage Information Centre and Ontario Parks) as signatories. This document was helpful in obtaining support from provincial government biologists and in gaining access to key GIS layers and other natural heritage databases that are maintained by the Government of Ontario.

Aligning the methodology for assessing condition, viability and landscape context to Ontario's assessment framework (representation, condition, diversity, ecological functions and special features) enabled the project team to portray the design of the Conservation Blueprint in familiar terms to conservation planners across the study area.

Throughout the project a number of valuable data layers were created including the aquatic ecological systems layer and the assembly of protected areas and conservation lands spatial data. A considerable amount of data on natural heritage features, threats, condition, *etc.* has been archived, and can be used by NCC, NHIC and other conservation partners.

The Great Lakes Conservation Blueprint is based on fine scale data (25 m pixel resolution). Maintaining the analysis at this fine level of resolution enables the results of the portfolio to not only be communicated at the scale of individual sites, but also synthesized to deliver a larger landscape scale context. Throughout the analysis, a series of attributes on the GIS files were maintained in order to ensure that the portfolio can be queried for the underlying biodiversity values and the rationale for why these areas were included in the portfolio.

The level of detail and transparency of the methodology will facilitate sharing the Conservation Blueprint with other conservation partners. The portfolio selection algorithm has also been automated to allow the analysis to be re-run if scores are changed or digital layers are added or removed. This enables the model to be flexible and adaptive for further iterations of the Great Lakes ecoregional analysis or adapted for use in other geographic areas.

Data Needs and Gaps

Major progress has been made in gathering natural heritage information in the Great Lakes ecoregion, but significant information gaps remain, particularly with aquatic ecological systems.

Much of the focus of natural heritage inventories has traditionally been on terrestrial landscapes in southern Ontario. Documentation of the biodiversity of terrestrial sites on the Canadian Shield and aquatic habitats throughout the ecoregion has generally been sparse and unevenly gathered.

As development pressures increase, the need for consistent and current inventories is critical. Life science surveys of existing protected areas provide the information needed to determine vegetation community and species representation, and contribute to assessments of species viability. Protected area inventories also provide baseline data for the long-term monitoring of population trends, threats, impacts of particular management activities, and many other ecological variables. Threats to biodiversity are often greatest on private lands, particularly in southern Ontario because of the intensity of land uses and development, yet permission to survey such lands is often difficult to obtain. Digital data gaps also exist for certain types of conservation lands, including county forests and land trusts.

Maintaining information on the current status and distribution of species of conservation concern and economically important species continues to be challenging despite the substantial improvements made with the creation of the NHIC in 1993. The inability to efficiently update information on known populations resulted in some occurrences being no longer considered extant, and therefore removed from the Conservation Blueprint analysis. A lack of sufficient element occurrence data for many of the aquatic species targets is also a data gap, particularly for invertebrates.

Although Ontario excels in digital landscape data compared to other jurisdictions, current digital data for natural heritage analysis is out-of-date or lacking altogether in some areas of the province.

Further discussion is needed to build support for a standardized aquatic ecological classification and further identification of these ecological systems remains a requirement to adequately identify rare and representative communities across the entire ecoregion. The aquatic ecological classification developed through the Conservation Blueprint is a foundation for further assessment, testing and ground-truthing.

It is important to continue to advocate for the NHIC as a central repository of rare species, vegetation community and natural areas information in Ontario. Centralized information is integral to the efficiency of analyses conducted at regional and landscape scales, such as the Conservation Blueprint.

The availability of more detailed scientific information on aquatic species and ecological systems will help to further refine the conservation goals of the targets for the project. Digital data layers continue to improve, element occurrence databases continue to be populated, knowledge of ecological processes and species' biological needs continues to be enhanced, and technological tools for assessing and analyzing the landscape continue to be developed. Such improvements will make it possible in the future to strengthen and refine the selection of representative sites that require conservation and protection.

Lessons Learned

In future projects such as this, it is recommended that a data-sharing policy with key partners be established early to allow response to data inquiries in a timely and consistent manner.

The importance of maintaining strong communication between the members of the project team cannot be emphasized enough, as it ensures concerns are addressed effectively and methodological consensus is achieved in a timely manner.

Ecoregional planners should have adequate GIS expertise to manage large-scale GIS-based projects such as this. Inconsistent digital data layers for the study area, a lack of seamless data across the ecoregion, and the extensive GIS processing and interpretation required creative thinking and management to deal with unforeseen technical limitations and obstacles. Geomatics work should be clearly defined and scoped properly in order to remain within acceptable time and cost projections.

Designing the aquatic conservation blueprint required the conceptualization and development of a map-based aquatic ecosystem classification system prior to assessing watersheds with respect to biodiversity targets. When undertaking projects with the detail and scope represented by this particular project, and using untested processes, a pilot approach to develop and implement an ecosystem characterization and subsequent methods for conservation assessment in one or several representative watersheds is advised. A subset of essential processes and features supporting the relevant findings can be identified in the pilot study for implementation across the entire study area, thus facilitating efficient project delivery.

Outreach and Next Steps

A Great Lakes Ecoregion Conservation Strategy:
Identifying and conserving the most valuable and vulnerable natural areas will not be enough to ensure the protection of the biodiversity in the Great Lakes ecoregion. However, it is a critical ingredient in strategies to deal with the broader environmental sustainability of the region.

The essential goal of the Great Lakes Conservation Blueprint was to enable policy-makers, natural resource managers, landowners and other stakeholders to improve decision-making and to take the necessary steps to conserve biodiversity in the Great Lakes basin.

The Great Lakes Conservation Blueprint as a Conservation Tool:
This project is the first region-wide identification of the most important areas for conserving native biodiversity across the Canadian portion of the Great Lakes ecoregion. Its results inform us on how successful existing conservation efforts have been in achieving conservation goals for specific, mapped biodiversity targets. Its results also inform us about the location of other important potential conservation lands which, in concert with the results of the terrestrial Conservation Blueprint as well as field testing and local knowledge, may be priorities for consideration in future land-use planning, resource management and land securement.

The Conservation Blueprint provides a regional perspective for the wide spectrum of interested parties, and helps balance discussions relating to biodiversity protection and development issues in the Great Lakes region. The Conservation Blueprint's regional perspective may also assist stakeholders in identifying priority conservation actions, agree on common goals for conservation, and developing indicators and monitoring standards to measure their conservation achievements over time.

It is important to acknowledge that the Conservation Blueprint portfolio should not be considered a final, inflexible display of existing and potential conservation sites. It is an analysis based on the best available biodiversity data available at the time of the project. The Conservation Blueprint includes not only the current protected areas and potential conservation sites, but also highlights the naturally vegetated areas that surround them.

Data Management Strategy:
The digital data layers compiled over the course of the project, including the Aquatic Ecological Classification, have been documented and catalogued. These layers will be made available by various means to conservation practitioners. GIS layers used in the Conservation Blueprint that are held by other custodians and digital layers that contain sensitive or proprietary information will not be re-distributed.

Implementation Strategy:
Results from the Conservation Blueprint will inform a number of activities of the Nature Conservancy of Canada (NCC) and the Ministry of Natural Resources. An important application for the NCC is to provide strategic direction for setting land protection priorities. Approximately 55% of the lands in the Great Lakes basin are privately owned, and these lands have traditionally been the focus of NCC's land protection programs. NCC is also working with colleagues at The (U.S.) Nature Conservancy to align the U.S. and Canadian conservation plans in order to harmonize and improve the efficiency of biodiversity conservation activities across the entire Great Lakes basin.

The Conservation Blueprint will inform such OMNR activities as land-use planning, forest management planning, protected areas identification, monitoring and stewardship. A better understanding of the geography of biodiversity in Ontario provided by the Conservation Blueprint should benefit a broad range of conservation actions at a variety of scales.

Communication Strategy:
Biodiversity conservation depends on the cooperation and participation of many stakeholders. The results of the Conservation Blueprint will be shared as widely as possible among conservation practitioners and decision-makers, with the goal of promoting cooperative approaches to the conservation of the biodiversity of the Great Lakes ecoregion.

A number of communication products are planned to convey key messages, issues, data products, timelines, budgets and measures of success. These communication products will be shared with a wide array of conservation practitioners throughout Ontario and the Great Lakes region.

Merging Terrestrial and Aquatic Portfolios:
The results from the aquatic Conservation Blueprint will be integrated with the results from the parallel terrestrial Conservation Blueprint. A similar framework was employed in these two components and the results can be merged, contrasted and compared, further helping to inform, focus and prioritize conservation activities on the landscapes and waterscapes of the Great Lakes basin.

8.0 Literature Cited

Abell, R.A., D.M. Olson, E. Dinerstein and P.T. Hurley. 2000. Freshwater ecoregions of North America: a conservation assessment. Island Press, Washington, D.C.

Allan, J.D. and A.S. Flecker. 1993. Biodiversity conservation in running waters. BioScience 43:32-43.

Brodribb, K.E. and C. Phair. 2004. Great Lakes Conservation Blueprint Project for Aquatic Biodiversity: Technical Methodology. The Nature Conservancy of Canada. Toronto, Ontario. 41pp.

Catling, P.M. and Z.S. Porebski. 1995. The status and current distribution of European Frogbit, *Hydrocharis morsus-ranae* L., in North America. Canadian Field-Naturalist 109(2): 236-241.

Crins, W.J. and P.S.G. Kor. 2000. Natural heritage gap analysis methodologies used by the Ontario Ministry of Natural Resources (Draft 6 January 2000). Open File Natural Heritage Technical Report 2000-1. Ontario Ministry of Natural Resources, Lands and Natural Heritage Branch, Natural Heritage Section, Peterborough, Ontario. 31pp.

Cudmore-Vokey, B. and E.J. Crossman. 2000. Checklists of the fish fauna of the Laurentian Great Lakes and their connecting channels. Canadian Manuscript report of Fisheries and Aquatic Sciences 2250:v+39p.

Detenbeck, N.E., C.M. Elonen, D.L. Taylor, L.E. Anderson, T.M. Jicha and S.L. Batterman. 2003. Effects of hydrogeomorphic region, catchment storage and mature forest on baseflow and snowmelt stream water quality in second-order Lake Superior Basin tributaries. Freshwater Biology 48:912-927.

Eadie, J.M. and A. Keast. 1984. Resource heterogeneity and fish species diversity in lakes. Canadian Journal of Zoology 62:1689-1695.

Environment Canada, Ontario Ministry of Natural Resources, and Ontario Ministry of Environment. 1998. A framework for guiding habitat rehabilitation in Great Lakes Areas of Concern. Canada-Ontario Remedial Action Plan Steering Committee. 75pp.

Evans, D.O. K.H. Nicholls, Y.C. Allen and M.J. McMurtry. 1996. Historical land use, phosphorus loading, and loss of fish habitat in Lake Simcoe, Canada. Canadian Journal of Fisheries and Aquatic Sciences 53(Supplement 1): 194-218.

Glooschenko, V., W.F. Weller, P.G.R. Smith, R. Alvo and J.H.G. Archibold. 1992. Amphibian distribution with respect to pond water chemistry near Sudbury, Ontario. Canadian Journal of Fisheries and Aquatic Sciences. 49:114-121.

Gordon, N.D., T.A. McMahon and B.L. Finlayson. 1992. Stream hydrology: an introduction for ecologists. Chichester, UK: John Wiley & Sons. 526pp.

Groves, C.R., D.B. Jemsen, L.L. Valutis, K.H. Redford, M.L. Shaffer, J.M. Scott, J.V. Baumgartner, J.V. Higgins, M.W. Beck and M.G. Anderson. 2002. Planning for biodiversity conservation: putting conservation science into practice. BioScience 52: 499-512.

Groves, C., L. Valutis, D. Vosick, B. Neely, K. Wheaton, J. Touval and B. Runnels. 2000. Designing a geography of hope: a practitioner's handbook for ecoregional conservation planning. The Nature Conservancy. 457pp.

Harkness, M., H. Potter and H. Taylor. 1999. Great Lakes Ecoregional Plan. The Nature Conservancy. Great Lakes Program, Chicago, IL. 57pp + maps + appendices.

Henson, B.L., K.E. Brodribb and J.L. Riley. 2005. Great Lakes Conservation Blueprint for Terrestrial Biodiversity. Volume 1. Nature Conservancy of Canada. 157pp.

Henson, B.L. and K.E. Brodribb. 2005. Great Lakes Conservation Blueprint for Terrestrial Biodiversity. Volume 2. Ecodistrict Summaries. Nature Conservancy of Canada. 344pp.

Higgins, J.V., M.T. Bryer, M.L. Khoury and T.W. Fitzhugh. 2005. A Freshwater Classification Approach for Biodiversity Conservation Planning. Conservation Biology 19(2): 432-445.

Higgins, J., M. Lammert, M. Bryer, M. DePhilip and D. Grossman. 1998. Freshwater conservation in the Great Lakes Basin: development and application of an aquatic community classification network. The Nature Conservancy, Chicago.

Hinch, S.G., N.C. Collins and H.H. Harvey. 1991. Relative abundance of littoral zone fishes: biotic interactions, abiotic factors, and postglacial colonization. Ecology 72:1314-1324.

IJC. 2000. Protection of the Waters of the Great Lakes. Final Report to the Governments of Canada and the United States. 58 pp.

IUCN. 1994. Guidelines for Protected Areas Management Categories. IUCN, Cambridge, U.K. and Gland, Switzerland. 261pp.

Jackson, D.A., P.R. Peres-Neto and J.D. Olden. 2001. What controls who is where in freshwater fish communities – the roles of biotic, abiotic, and spatial factors. Canadian Journal of Fisheries and Aquatic Sciences 58:157-170.

Johnson, M.G., J.H. Leach, C.K. Minns and C.H. Olver. 1977. Limnological characteristics of Ontario lakes in relation to associations of Walleye (*Stizostedion vitreum vitreum*), Northern pike (*Esox lucius*), Lake trout (*Salvelinus namaycush*), and Smallmouth bass (*Micropterus dolomieui*). Journal of the Fisheries Research Board of Canada 34:1592-1601.

Kay, J.J., and H.A. Regier. 1999. An ecosystemic two-phase attractor approach to Lake Erie's ecology. In M. Munawar, T. Edsall, and I.F. Munawar, editors. The State of Lake Erie (SOLE) – Past, Present and Future. A tribute to Drs. Joe Leach and Henry Regier. Backhuys Academic Publishers, Netherlands. pp. 511-533.

Kilgour, B. and L.W. Stanfield 2001. Protocols for delineating, characterizing and classifying valley segments, joint Publication of Regional Municipality of Ottawa-Carlton and Ontario Ministry of Natural Resources, Glenora. 51pp.

Lee, H., W. Bakowsky, J. Riley, J. Bowles, M. Puddister, P. Uhlig and S. McMurray. 1998. Ecological Land Classification for Southern Ontario: First Approximation and its Application. Ontario Ministry of Natural Resources, Southcentral Sciences Section, Science Development and Transfer Branch, SCSS Field Guide FG-02. 225pp.

Magnuson, J.J., W.M. Tonn, A. Banerjee, J. Toivonen, O. Sanchez and M. Rask. 1998. Isolation vs. extinction in the assembly of fishes in small northern lakes. Ecology 79:2941-2956.

Mandrak, N.E. 1998. An assessment of the suitability of using a terrestrial ecoregion classification to protect aquatic biodiversity in Ontario. Trent University, Peterborough, Ontario.

Margules, C.R. and R.L. Pressey. 2000. Systematic conservation planning. Nature 405:243-253.

Marshall, T.R. and P.A. Ryan. 1987. Abundance patterns and community attributes of fishes relative to environmental gradients. Canadian Journal of Fisheries and Aquatic Sciences 44 (Supplement 2):198-215.

Martens, K. and H.J. Dumont, Editors. 2004. Aquatic biodiversity: a celebrity volume in honour of Henri J. Dumont. Springer. 356pp.

Master, L.L., S.R. Flack and B.A. Stein, Editors. 1998. Rivers of life: critical watersheds for protecting freshwater biodiversity. The Nature Conservancy, Arlington, Virginia. 71pp.

Maxwell, J.R., C.J. Edwards, M.E. Jensen, S.J. Paustian, H. Parrot and D.M. Hill. 1995. A hierarchical framework of aquatic ecological units in North America (Near Arctic zone). North Central Forest Experiment Station, Forest Service – U.S. Department of Agriculture, St. Paul, Minnesota. 78pp.

Nalepa, T.F. 1994. Decline of native unionid bivalves in Lake St. Clair after infestation by the zebra mussel, *Dreissena polymorpha*. Canadian Journal of Fisheries and Aquatic Sciences 51: 2227-2233.

Noss, R.F., M.A. O'Connell and D.D. Murphy. 1997. The science of conservation planning: habitat conservation under the Endangered Species Act. Island Press, Washington, D.C. xvii + 246pp.

Osborne, L.L. and M.J. Wiley. 1992. Influence of tributary spatial position on the structure of warmwater fish communities. Canadian Journal of Fisheries and Aquatic Sciences 49: 671-681.

Paleczny, D.R., P.A. Gray, T.J. Beechey, R.J. Davidson and J.V. Jalava. 2000. Ontario's protected areas: an examination of protection standards with a provisional application of IUCN's protected area management categories. Pages 850-862 *In* S. Bondrup-Nielsen, N.W.P. Munro, G. Nelson, J.H.M. Willison, T.B. Herman, and P. Eagles. Managing Protected Areas in a Changing World: proceedings of the fourth international conference on science management of protected areas. 14-19 May 2000, Wolfville, Nova Scotia.

Phair, C., B.L. Henson and K.E. Brodribb. 2005. Great Lakes Conservation Blueprint for Aquatic Biodiversity. Volume 2: Tertiary Watershed Summaries. Nature Conservancy of Canada. 454pp.

Pickett, S.T.A., R.S. Ostfeld, M. Shachak and G.E. Likens. 1997. The ecological basis of conservation: heterogeneity, ecosystems and biodiversity. Chapman & Hall, New York. 466pp.

Poiani, K.A., B.D. Richter, M.G. Anderson and H.E. Richter. 2000. Biodiversity conservation at multiple scales: functional sites, landscapes, and networks. BioScience 50:133-146.

Post, J.R., M. Sullivan, S. Cox, N.P. Lester, C.J. Walters, E.A. Parkinson, A.J. Paul, L. Jackson and B.J. Shuter. 2002. Canada's recreational fisheries: the invisible collapse? Fisheries 27(1): 6-17.

Quinlan, R., A.M. Paterson, R.I. Hall, P.J. Dillon, A.N.

Wilkinson, B.F. Cumming and M.V. Douglas. 2003. A landscape approach to examining spatial patterns of limnological variables and long-term environmental change in a southern Canadian lake district. Freshwater Biology 48:1676-1697.

Regier, H.A. and J.J. Kay. 1996. An heuristic model of transformations of the aquatic ecosystems of the Great Lakes-St. Lawrence River basin. Journal of Aquatic Ecosystem Health 5:3-21.

Riley, J.L. and K.E. Brodribb. 2003. Great Lakes Conservation Blueprint Methods and Past Ontario Studies of Significant Life Science Natural Areas. The Nature Conservancy of Canada, Toronto. 15pp.

Riley, J.L., J.V. Jalava and S. Varga. 1996. Ecological survey of the Niagara Escarpment Bioshere Reserve, Volume 1. Ontario Ministry of Natural Resources, Southcentral Region, Peterborough, Ontario. 629pp.

Rohlf, D.J., 1991. Six Biological Reasons Why the Endangered Species Act Doesn't Work-and What to Do About it. Conservation Biology 5(3): 181-200.

Seelbach, P.W., M.J. Wiley, J.C. Kotanchik and M.E. Baker. 1997. A landscape-based ecological classification system for river valley segments in lower Michigan (MI-VSEC Version 1.0). Michigan Department of Natural Resources, Fisheries Division Research Report No. 2036.

Schwartz, M.W. 1999. Choosing the appropriate scale of reserves for conservation. Annual Review of Ecology and Systematics 30:83-108.

Silk, N. and K. Ciruna, editors, 2004. A Practitioner's Guide to Freshwater Biodiversity Conservation. Arlington, Virginia. The Nature Conservancy.

Sly, P.G. 1991. The effects of land use and cultural development on the Lake Ontario ecosystem since 1750. Hydrobiologia 213:1–75.

Snell, E.A. 1989. Recent wetland loss trends in southern Ontario. Pp. 183-197 *In* Bardecki, M.J. and N. Patterson (editors.) Wetlands: inertia or momentum. Proceedings of a conference held in Toronto, Ontario October 21-22, 1988.

Stanfield, L. and R. Kuyvenhoven. 2002 Protocol for application used in the aquatic landscape inventory software application for delineating, characterizing and classifying valley segments within the Great Lakes basin. Ontario Ministry of Natural Resources, Glenora, Ontario. 21pp.

Stephenson, T.D. 1990. Fish reproductive utilization of coastal marshes of Lake Ontario near Toronto. Journal of Great Lakes Research 16:71-81.

Underhill, J.C. 1986. The fish fauna of the Laurentian Great Lakes, the St. Lawrence Lowlands, Newfoundland, and Labrador. Pages 105-136 in C.H. Hocutt and E.O. Wiley, editors. The zoogeography of North American freshwater fishes. John Wiley & Sons, Inc., New York.

U.S. Fish and Wildlife Service. 1996. Endangered and threatened wildlife and plants. 50 CFR 17.11 and 17.12. Washington, DC: USGPO.

Vannote, R.L., G.W. Minshall, K.W. Cummins, J.R. Sedell and C.E. Cushing. 1980. The river continuum concept. Canadian Journal of Fisheries and Aquatic Sciences 37:130-137.

Walker, B.H. 1992. Biodiversity and ecological redundancy. Conservation Biology 6:18-23.

Weitzell, R., M.L. Khoury, P. Gagnon, B. Schreurs, D. Grossman and J. Higgins. 2003. Conservation Priorities for Freshwater Biodiversity in the Upper Mississippi River Basin. NatureServe and The Nature Conservancy. 101pp + 299 pp appendices.

Wichert, G.A., J. MacKenzie and P. Staples. 2004. Aquatic ecosystem classification for the Great Lakes basin. Ontario Ministry of Natural Resources. Peterborough, Ontario. 78pp.

Willis, T.V. and J.J. Maguson. 2000. Patterns in fish species composition across the interface between streams and lakes. Canadian Journal of Fisheries and Aquatic Sciences 57:1042-1052.

Young, B.E., S.N. Stuart, J.S. Chanson, H.A. Cox and T.M. Boucher. 2004. Disappearing jewels: the status of New World amphibians. NatureServe. Arlington, Virginia. 53pp.

Zaret, T.M. and R.T. Paine. 1973. Species introduction in a tropical lake. Science 182:449-455.

9.0 Appendices

Appendix 1: List of Aquatic Ecological Units and Conservation Targets

Table 1A. Types of Great Lakes shoreline aquatic ecological units; 20 of 24 possible types are conservation targets.

Name	Target
Abrupt shoreline gradient intersected by small streams	Yes
Abrupt shoreline gradient intersected by large streams	Yes
Abrupt shoreline gradient intersected by large and small streams	Yes
Abrupt shoreline gradient intersected by no streams	Yes
Gently sloping shoreline gradient intersected by small streams	Yes
Gently sloping shoreline gradient intersected by large streams	Yes
Gently sloping shoreline gradient intersected by large and small streams	Yes
Gently sloping shoreline gradient intersected by no streams	Yes
Low riverine coastal plain intersected by small streams	Yes
Low riverine coastal plain intersected by large streams	Yes
Low riverine coastal plain intersected by large and small streams	Yes
Low riverine coastal plain intersected by no streams	Yes
Open shoreline wetlands intersected by small streams	Yes
Open shoreline wetlands intersected by large streams	Yes
Open shoreline wetlands intersected by large and small streams	Yes
Open shoreline wetlands intersected by no streams	Yes
Semi-protected wetlands intersected by small streams	Yes
Semi-protected wetlands intersected by large streams	Yes
Semi-protected wetlands intersected by large and small streams	Yes
Semi-protected wetlands intersected by no streams	Yes
Artificial or unclassified intersected by small streams	No
Artificial or unclassified intersected by large streams	No
Artificial or unclassified intersected by large and small streams	No
Artificial or unclassified intersected by no streams	No

Table 1B. Types of Great Lakes coastal area aquatic ecological units; 3 of 3 possible types are conservation targets.

Name	Target
High permeability coastal area	Yes
Intermediate permeability coastal area	Yes
Low permeability coastal area	Yes

Table 1C. Types of stream system aquatic ecological units; 54 of 54 possible types are conservation targets.

Name	Target
Headwaters with high permeability, steep gradient and high water storage potential	Yes
Headwaters with high permeability, steep gradient and low water storage potential	Yes
Headwaters with high permeability, medium gradient and high water storage potential	Yes
Headwaters with medium permeability, steep gradient and high water storage potential	Yes
Headwaters with high permeability, gentle gradient and high water storage potential	Yes
Headwaters with high permeability, medium gradient and low water storage potential	Yes
Headwaters with medium permeability, steep gradient and low water storage potential	Yes
Headwaters with medium permeability, medium gradient and high water storage potential	Yes
Headwaters with low permeability, steep gradient and high water storage potential	Yes
Headwaters with medium permeability, medium gradient and low water storage potential	Yes
Headwaters with medium permeability, gentle gradient and high water storage potential	Yes
Headwaters with low permeability, steep gradient and low water storage potential	Yes
Headwaters with low permeability, medium gradient and high water storage potential	Yes
Headwaters with low permeability, gentle gradient and high water storage potential	Yes
Headwaters with high permeability, gentle gradient and low water storage potential	Yes
Headwaters with medium permeability, gentle gradient and low water storage potential	Yes
Headwaters with low permeability, medium gradient and low water storage potential	Yes
Headwaters with low permeability, gentle gradient and low water storage potential	Yes
Middle tributary with low permeability, gentle gradient and low water storage potential	Yes
Middle tributary with low permeability, medium gradient and low water storage potential	Yes
Middle tributary with low permeability, gentle gradient and high water storage potential	Yes
Middle tributary with medium permeability, gentle gradient and low water storage potential	Yes
Middle tributary with low permeability, steep gradient and low water storage potential	Yes
Middle tributary with high permeability, gentle gradient and low water storage potential	Yes
Middle tributary with medium permeability, medium gradient and low water storage potential	Yes
Middle tributary with medium permeability, gentle gradient and high water storage potential	Yes
Middle tributary with low permeability, medium gradient and high water storage potential	Yes
Middle tributary with low permeability, steep gradient and high water storage potential	Yes
Middle tributary with medium permeability, steep gradient and low water storage potential	Yes
Middle tributary with high permeability, medium gradient and low water storage potential	Yes
Middle tributary with high permeability, gentle gradient and high water storage potential	Yes
Middle tributary with high permeability, steep gradient and low water storage potential	Yes
Middle tributary with medium permeability, medium gradient and high water storage potential	Yes
Middle tributary with medium permeability, steep gradient and high water storage potential	Yes
Middle tributary with high permeability, medium gradient and high water storage potential	Yes
Middle tributary with high permeability, steep gradient and high water storage potential	Yes
Mainstem with high permeability, steep gradient and high water storage potential	Yes
Mainstem with high permeability, medium gradient and high water storage potential	Yes
Mainstem with high permeability, steep gradient and low water storage potential	Yes
Mainstem with medium permeability, steep gradient and high water storage potential	Yes
Mainstem with high permeability, gentle gradient and high water storage potential	Yes
Mainstem with low permeability, steep gradient and high water storage potential	Yes
Mainstem with high permeability, medium gradient and low water storage potential	Yes
Mainstem with medium permeability, medium gradient and high water storage potential	Yes
Mainstem with medium permeability, steep gradient and low water storage potential	Yes
Mainstem with high permeability, gentle gradient and low water storage potential	Yes
Mainstem with medium permeability, gentle gradient and high water storage potential	Yes
Mainstem with low permeability, medium gradient and high water storage potential	Yes

Name	Target
Mainstem with low permeability, steep gradient and low water storage potential	Yes
Mainstem with low permeability, gentle gradient and high water storage potential	Yes
Mainstem with medium permeability, medium gradient and low water storage potential	Yes
Mainstem with medium permeability, gentle gradient and low water storage potential	Yes
Mainstem with low permeability, medium gradient and low water storage potential	Yes
Mainstem with low permeability, gentle gradient and low water storage potential	Yes

Table 1D. Types of wetland aquatic ecological units; 10 of 12 possible types are conservation targets.

Name	Target
Small, unconnected marsh	Yes
Small, connected marsh	Yes
Large, unconnected marsh	Yes
Large, connected marsh	Yes
Unconnected swamp	Yes
Connected swamp	Yes
Unconnected fen	Yes
Connected fen	Yes
Unconnected bog	Yes
Connected bog	Yes
Large unconnected muskeg	No
Large connected muskeg	No

Table 1E. Types of inland lake aquatic ecological units; 36 of 36 possible types are conservation targets.

Name	Target
Large, unconnected, irregular shape, with high permeability	Yes
Large, connected, irregular shape, with high permeability	Yes
Large, unconnected, irregular shape, with medium permeability	Yes
Large, unconnected, round shape, with high permeability	Yes
Large, unconnected, irregular shape, with low permeability	Yes
Large, connected, irregular shape, with medium permeability	Yes
Large, connected, round shape, with high permeability	Yes
Large, unconnected, round shape, with medium permeability	Yes
Large, connected, irregular shape, with low permeability	Yes
Large, unconnected, round shape, with low permeability	Yes
Large, connected, round shape, with medium permeability	Yes
Large, connected, round shape, with low permeability	Yes
Medium size, connected, round shape, with low permeability	Yes
Medium size, connected, round shape, with medium permeability	Yes
Medium size, connected, irregular shape, with low permeability	Yes
Medium size, unconnected, round shape, with low permeability	Yes
Medium size, connected, irregular shape, with medium permeability	Yes
Medium size, unconnected, round shape, with medium permeability	Yes
Medium size, connected, round shape, with high permeability	Yes
Medium size, unconnected, irregular shape, with low permeability	Yes
Medium size, unconnected, irregular shape, with medium permeability	Yes

Name	Target
Medium size, connected, irregular shape, with high permeability	Yes
Medium size, unconnected, round shape, with high permeability	Yes
Medium size, unconnected, irregular shape, with high permeability	Yes
Small, unconnected, irregular shape, with high permeability	Yes
Small, connected, irregular shape, with high permeability	Yes
Small, unconnected, irregular shape, with medium permeability	Yes
Small, unconnected, round shape, with high permeability	Yes
Small, unconnected, irregular shape, with low permeability	Yes
Small, connected, irregular shape, with medium permeability	Yes
Small, connected, round shape, with high permeability	Yes
Small, unconnected, round shape, with medium permeability	Yes
Small, connected, irregular shape, with low permeability	Yes
Small, unconnected, round shape, with low permeability	Yes
Small, connected, round shape, with medium permeability	Yes
Small, connected, round shape, with low permeability	Yes

Appendix 2: List of Fine-filter Vegetation Community Targets

Common Name	GRank	SRank	Distribution	Conservation Goal	Justification
Atlantic Coastal Plain Shallow Marsh Type	G2?	S3	peripheral	all viable occurrences	GRank
Black Spruce - Tamarack - Leatherleaf Patterned Fen Type	G4	S5	limited	secondary target	high quality
Black Spruce Coniferous Organic Swamp Type	G5	S5	limited	secondary target	high quality
Boreal Open Seepage Fen Type	G2Q	S2S3	limited	all viable occurrences	GRank
Bulrush - Stiff Arrowhead - Pondweed Shallow Marsh Type	G4G5	S4	limited	secondary target	high quality
Buttonbush - Sweet Gale Mineral Thicket Swamp Type	G?	S2S3?	limited	3 per tertiary watershed	SRank
Buttonbush Mineral Thicket Swamp Type	G4	S3	limited	3 per tertiary watershed	SRank
Buttonbush Organic Thicket Swamp Type	G4	S3	limited	3 per tertiary watershed	SRank
Cattail Organic Shallow Marsh Type	G5	S5	widespread	secondary target	high quality
Cotton-grass Graminoid Bog Type	G3G4	S5	widespread	all viable occurrences	GRank
Few-seeded Sedge Graminoid Bog Type	G3G4	S5	widespread	all viable occurrences	GRank
Graminoid Coastal Meadow Marsh Type	G2?	S2	endemic	all viable occurrences	GRank
Graminoid Open Poor Fen Type	G3G4	S5	widespread	all viable occurrences	GRank
Gray Birch Treed Fen Type	G4?	S2S3	peripheral	3 per tertiary watershed	SRank
Leatherleaf - Chain fern / St. John's-wort Shrub Fen	G3G4	S3	limited	all viable occurrences	GRank
Leatherleaf - Forb Shrub Fen Type	G5	S5	widespread	secondary target	high quality
Mountain Holly Organic Thicket Swamp Type	G?	S3S4	limited	3 per tertiary watershed	SRank
Mountain Holly Shrub Fen Type	G3G4	S3S4	limited	all viable occurrences	GRank
Pondweed Submerged - Floating-leaved Shallow Aquatic Type	G5Q	S5	widespread	secondary target	high quality
Shrubby Cinquefoil Coastal Meadow Marsh Type	G2?	S1	endemic	all viable occurrences	GRank
Shrubby Cinquefoil Limestone Beach Type	G3G4	S2	endemic	all viable occurrences	GRank
Silver / Red Maple Mineral Deciduous Swamp Type	G4?	S5	limited	secondary target	high quality
Slender Sedge Graminoid Fen Type	G4G5	S5	widespread	secondary target	high quality
Sweet Gale Shrub Fen Type	G?	S5	widespread	secondary target	high quality
Tamarack Coniferous Organic Swamp Type	G4	S5	widespread	secondary target	high quality
Tamarack Treed Fen Type	G4?	S5	limited	secondary target	high quality
Virginia Chain Fern Open Bog Type	G3G4	S3	peripheral	all viable occurrences	GRank
Water Lily - Bullhead Lily Floating-leaved Shallow Aquatic Type	G5	S5	widespread	secondary target	high quality
White Cedar - Hemlock Coniferous Organic Swamp Type	G?	S3S4	limited	3 per tertiary watershed	SRank
White Pine - White Birch Mineral Mixed Swamp Type	G3G4	S3	limited	all viable occurrences	GRank
Wild-rice Mineral Shallow Marsh Type	G?	S5	widespread	secondary target	high quality
Winterberry Organic Thicket Swamp Type	G3G4Q	S3S4	limited	all viable occurrences	GRank

Appendix 3: List of Fine-filter Species Targets

Scientific Name	Common Name	GRank	SRank	COSEWIC	OMNR	Conservation Goal	Great Lakes Range	Justification
Amphibians								
Ambystoma jeffersonianum	Jefferson Salamander	G4	S2	THR	THR	secondary target	peripheral	SAR
Ambystoma texanum	Small-mouthed Salamander	G5	S1	END	THR	secondary target	peripheral	SAR
Desmognathus fuscus	Northern Dusky Salamander	G5	S1	NAR	END-R	secondary target	peripheral	SAR
Bufo fowleri	Fowler's Toad	G5	S2	THR	THR	secondary target	peripheral	SAR
Acris crepitans	Northern Cricket Frog	G5	SH	END	END-R	secondary target	peripheral	SAR
Birds								
Pelecanus erythrorhynchos	American White Pelican	G3	S2B,SZN	NAR	END-R	2 per tertiary watershed	peripheral	GRank SAR
Ixobrychus exilis	Least Bittern	G5	S3B,SZN	THR	THR	secondary target	widespread	SAR
Haliaeetus leucocephalus	Bald Eagle	G4	S4B,SZN	NAR	END-R	secondary target	widespread	SAR
Coturnicops noveboracensis	Yellow Rail	G4	S4B,SZN	SC	SC	secondary target	peripheral	SAR
Rallus elegans	King Rail	G4G5	S2B,SZN	END	END-R	secondary target	peripheral	SAR
Charadrius melodus	Piping Plover	G3	S1B,SZN	END	END-R	2 per tertiary watershed	widespread	GRank SAR
Chlidonias niger	Black Tern	G4	S3B,SZN	NAR	SC	secondary target	widespread	SAR
Protonotaria citrea	Prothonotary Warbler	G5	S1S2B,SZN	END	END-R	secondary target	peripheral	SAR
Seiurus motacilla	Louisiana Waterthrush	G5	S3B,SZN	SC	SC	secondary target	peripheral	SAR
Fish								
Ichthyomyzon fossor	Northern Brook Lamprey	G4	S3	SC	SC	secondary target	widespread	SAR
Myoxocephalus thompsoni	Deepwater Sculpin	G5	S4	THR	THR	secondary target	widespread	SAR
Acipenser fluvescens	Lake Sturgeon	G3G4	S3	SC	NAR	2 per tertiary watershed	widespread	GRank SAR
Lepisosteus oculatus	Spotted Gar	G5	S2	THR	THR	secondary target	peripheral	SAR
Anguilla rostrata	American Eel	G5	S5			secondary target	peripheral	declining
Coregonus clupeaformis pop 1	Lake Simcoe Lake Whitefish	G5T?	S?	DD	THR	secondary target	limited	SAR
Coregonus kiyi	Kiyi	G3	S3?	SC	SC	4 per tertiary watershed	endemic	GRank SAR endemic
Coregonus zenithicus	Shortjaw Cisco	G3	S2	THR	THR	2 per tertiary watershed	widespread	GRank SAR
Salvelinus fontinalis timagamiensis	Aurora Trout	G5T?	S1	END	END	4 per tertiary watershed	endemic	SAR endemic

Scientific Name	Common Name	GRank	SRank	COSEWIC	OMNR	Conservation Goal	Great Lakes Range	Justification
Fish continued								
Clinostomus elongates	Redside Dace	G4	S3	SC	THR	secondary target	limited	SAR
Exoglossum maxillingua	Cutlips Minnow	G5	S1S2	NAR	THR	secondary target	peripheral	SAR
Notropis anogenus	Pugnose Shiner	G3	S2	END	END	4 per tertiary watershed	endemic	GRank SAR endemic
Notropis bifrenatus	Bridle Shiner	G5	S2	SC	SC	secondary target	peripheral	SAR
Notropis photogenis	Silver Shiner	G5	S2S3	SC	SC	secondary target	peripheral	SAR
Macrhybopsis storeriana	Silver Chub	G5	S2	SC	SC	secondary target	peripheral	SAR
Opsopoeodus emiliae	Pugnose Minnow	G5	S2	SC	SC	secondary target	peripheral	SAR
Erimyzon sucetta	Lake Chubsucker	G5	S2	THR	THR	secondary target	limited	SAR
Ictiobus cyprinellus	Bigmouth Buffalo	G5	SU	SC	SC	secondary target	peripheral	SAR
Ictiobus niger	Black Buffalo	G5	SU	SC	SC	secondary target	limited	SAR
Minytrema melanops	Spotted Sucker	G5	S2	SC	SC	secondary target	peripheral	SAR
Moxostoma carinatum	River Redhorse	G4	S2	SC	SC	secondary target	peripheral	SAR
Moxostoma duquesnei	Black Redhorse	G5	S2	THR	THR	secondary target	limited	SAR
Noturus stigmosus	Northern Madtom	G3	S1S2	END	END	4 per tertiary watershed	limited	GRank SAR
Fundulus notatus	Blackstripe Topminnow	G5	S2	SC	SC	secondary target	peripheral	SAR
Lepomis gulosus	Warmouth	G5	S1	SC	SC	secondary target	peripheral	SAR
Ammocrypta pellucida	Eastern Sand Darter	G3	S2	THR	THR	2 per tertiary watershed	peripheral	GRank SAR
Etheostoma blennioides	Greenside Darter	G5	S4	SC	SC	secondary target	limited	SAR
Percina copelandi	Channel Darter	G4	S2	THR	THR	secondary target	limited	SAR
Reptiles								
Clemmys guttata	Spotted Turtle	G5	S3	END	SC	secondary target	peripheral	SAR
Glyptemys insculpta	Wood Turtle	G4	S2	SC	END	secondary target	peripheral	SAR
Graptemys geographica	Northern Map Turtle	G5	S3	SC	SC	secondary target	peripheral	SAR
Sternotherus odoratus	Stinkpot	G5	S3	THR	THR	secondary target	peripheral	SAR
Apalone spinifera	Spiny Softshell	G5	S3	THR	THR	secondary target	peripheral	SAR
Regina septemvittata	Queen Snake	G5	S2	THR	THR	secondary target	peripheral	SAR
Nerodia sipedon insularum	Lake Erie Watersnake	G5T2	S2	END	END-R	4 per tertiary watershed	endemic	GRank SAR endemic

Scientific Name	Common Name	GRank	SRank	COSEWIC	OMNR	Conservation Goal	Great Lakes Range	Justification
Insects								
Hygrotus sylvanus	Sylvan Hygrotus Diving Beetle	G1	SH			all viable occurrences	limited	GRank
Dubiraphia sp 1	Dubiraphian Riffle Beetle	G1G3Q	S?			all viable occurrences	limited	GRank
Brychius hungerfordi	Hungerford's Crawling Water Beetle	G1	S1			all viable occurrences	endemic	GRank endemic
Ameletus walleye	A Mayfly	G1	SH			all viable occurrences	unknown	GRank
Siphlonurus securifer	A Mayfly	G2	S?			all viable occurrences	unknown	GRank
Siphlonurus marshalli	A Mayfly	G3	S?			2 per tertiary watershed	unknown	GRank
Baetis hudsonicus	A Mayfly	G1	S?			all viable occurrences	peripheral	GRank
Baetis rusticans	A Mayfly	G2	S?			all viable occurrences	unknown	GRank
Eurylophella bartoni	A Mayfly	G1	S?			all viable occurrences	unknown	GRank
Centroptilum semirufum	A Mayfly	G2	S?			all viable occurrences	unknown	GRank
Centroptilum victoriae	A Mayfly	G3	S?			2 per tertiary watershed	unknown	GRank
Centroptilum minor	A Mayfly	G2	S?			all viable occurrences	unknown	GRank
Epeorus punctatus	A Mayfly	G3	S?			2 per tertiary watershed	unknown	GRank
Epeorus suffuses	A Mayfly	G1Q	S?			all viable occurrences	unknown	GRank
Nixe horrida	A Mayfly	G2	S?			all viable occurrences	unknown	GRank
Procloeon mendax	A Mayfly	G2	S?			all viable occurrences	unknown	GRank
Procloeon ozburni	A Mayfly	G2	S?			all viable occurrences	unknown	GRank
Procloeon simile	A Mayfly	G2	S?			all viable occurrences	unknown	GRank
Procloeon simplex	A Mayfly	G2	S?			all viable occurrences	unknown	GRank
Gomphus ventricosus	Skillet Clubtail	G3	S1			2 per tertiary watershed	peripheral	GRank
Gomphus quadricolor	Rapids Clubtail	G3G4	S1			2 per tertiary watershed	peripheral	GRank
Gomphus viridifrons	Green-faced Clubtail	G3	S1			2 per tertiary watershed	peripheral	GRank
Ophiogomphus anomalus	Extra-striped Snaketail	G3	S2			4 per tertiary watershed	limited	GRank
Aeshna mutata	Spatterdock Darner	G3G4	S1			2 per tertiary watershed	peripheral	GRank
Williamsonia fletcheri	Ebony Boghaunter	G3G4	S2			secondary target	widespread	GRank
Stylurus notatus	Elusive Clubtail	G3	S2			secondary target	widespread	GRank
Allocapnia illinoensis	A Stonefly	G3	S1			4 per tertiary watershed	limited	GRank

Scientific Name	Common Name	GRank	SRank	COSEWIC	OMNR	Conservation Goal	Great Lakes Range	Justification
Insects continued								
Alloperla idei	A Stonefly	G3	S?			2 per tertiary watershed	peripheral	GRank
Neoperla mainensis	A Stonefly	G2G3	S1S2			all viable occurrences	limited	GRank
Isogenoides olivaceus	A Perlid Stonefly	G3	S?			4 per tertiary watershed	limited	GRank
Molluscs								
Epioblasma torulosa rangiana	Northern Riffleshell	G2T2	S1	END	END	all viable occurrences	endemic	GRank SAR endemic
Epioblasma triquetra	Snuffbox	G3	S1	END	END	2 per tertiary watershed	peripheral	GRank SAR
Lampsilis fasciola	Wavy-rayed Lampmussel	G4	S1	END	END	2 per tertiary watershed	peripheral	SAR
Simpsonaias ambigua	Salamander Mussel	G3	S1	END	END	2 per tertiary watershed	peripheral	GRank SAR
Villosa fabalis	Rayed Bean	G1G2	S1	END	END	all viable occurrences	peripheral	GRank SAR
Valvata lewisi	Fringed Valvata	G3	S?			2 per tertiary watershed	widespread	GRank
Valvata perdepressa	Purplecap Valvata	G3	S1			2 per tertiary watershed	endemic	GRank endemic
Lyogyrus walkeri	Canadian Duskysnail	G2G3	S3S4			all viable occurrences	limited	GRank
Birgella subglobosus	Globe Siltsnail	G3G4	S2			2 per tertiary watershed	endemic	GRank
Acella haldemani	Spindle Lymnaea	G3	S1			2 per tertiary watershed	limited	GRank
Stagnicola woodruffi	Coldwater Pondsnail	G1G3	S?			all viable occurrences	endemic	GRank endemic
Planorbella corpulenta corpulenta	Capacious Manitoba Rams-horn	G2T2	SH			all viable occurrences	peripheral	GRank
Planorbella corpulenta whiteavesi	Whiteave's Capacious Rams-horn	G2T1	SH			all viable occurrences	limited	GRank
Vascular Plants								
Justicia americana	American Water-willow	G5	S1	THR	THR	secondary target	peripheral	SAR
Symphyotrichum praealtum	Willowleaf Aster	G5	S2	THR	THR	secondary target	peripheral	SAR
Solidago houghtonii	Houghton's Goldenrod	G3	S2	SC		4 per tertiary watershed	endemic	GRank SAR endemic
Solidago riddellii	Riddell's Goldenrod	G5	S3	SC	SC	secondary target	peripheral	SAR
Quercus shumardii	Shumard Oak	G5	S3	SC	SC	secondary target	peripheral	SAR
Bartonia paniculata ssp. paniculata	Branched Bartonia	G5T5	S1	THR	THR	3 per tertiary watershed	disjunct	SAR disjunct
Ammannia robusta	Scarlet Ammannia	G5	S1	END	END	secondary target	peripheral	SAR
Rotala ramosior	Toothcup	G5	S1	END	END	secondary target	peripheral	SAR

Scientific Name	Common Name	GRank	SRank	COSEWIC	OMNR	Conservation Goal	Great Lakes Range	Justification
Vascular Plants continued								
Hibiscus moscheutos	Swamp Rose-mallow	G5	S3	SC	SC	secondary target	peripheral	SAR
Plantago cordata	Heart-leaved Plantain	G4	S1	END	END-R	secondary target	peripheral	SAR
Agalinis gattingeri	Gattinger's Agalinis	G4	S2	END	END	secondary target	peripheral	SAR
Agalinis skinneriana	Skinner's Agalinis	G3	S1	END	END-R	2 per tertiary watershed	peripheral	GRank SAR
Arisaema dracontium	Green Dragon	G5	S3	SC	SC	secondary target	peripheral	SAR
Carex lupuliformis	False Hop Sedge	G4	S1	END	END-R	secondary target	peripheral	SAR
Carex schweinitzii	Schweinitz's Sedge	G3	S3			all viable occurrences	peripheral	GRank
Carex wiegandii	Wiegand's Sedge	G3	S1			all viable occurrences	peripheral	GRank
Eleocharis equisetoides	Horsetail Spike-rush	G4	S1	END	END-R	4 per tertiary watershed	disjunct	SAR disjunct
Eleocharis nitida	Slender Spike-rush	G3G4	S2			2 per tertiary watershed	peripheral	GRank
Lipocarpha micrantha	Small-flowered Lipocarpha	G4	S1	END	END	secondary target	peripheral	SAR
Juncus subtilis	Creeping Rush	G3	S3			all viable occurrences	widespread	GRank
Camassia scilloides	Wild Hyacinth	G4G5	S2	THR	THR	secondary target	peripheral	SAR
Cypripedium arietinum	Ram's-head Lady's-slipper	G3	S3			all viable occurrences	widespread	GRank
Cypripedium candidum	Small White Lady's-slipper	G4	S1	END	END-R	secondary target	peripheral	SAR
Listera auriculata	Auricled Twayblade	G3	S3			all viable occurrences	peripheral	GRank
Platanthera leucophaea	Eastern Prairie Fringed-orchid	G2	S2	END	END	all viable occurrences	peripheral	GRank SAR
Potamogeton hillii	Hill's Pondweed	G3	S2	SC	THR	4 per tertiary watershed	limited	GRank SAR
Potamogeton ogdenii	Ogden's Pondweed	G1	SH			all viable occurrences	limited	GRank
Isoetes engelmannii	Engelmann's Quillwort	G4	S1	END	END	4 per tertiary watershed	disjunct	SAR disjunct

Appendix 4: Conservation Values Scores

Criteria	Value Layer	Scale	Scores
Condition (adjusted to 38% of the total score)	% natural cover within the aquatic ecological unit	Each Aquatic Ecological Unit	0% : 0 1% - 20% : 5 21% - 40% : 10 41% - 60% : 25 61% - 80% : 35 80% - 90% : 45 91% - 100% : 50
	Distance from cropland	Each Pixel	0-50 m: -20 51-100 m: -15 101-200 m: -10 201-300 m: -5 > 300 m: 0
	Distance from urban and settlement areas	Each Pixel	0-50 m: -20 51-100 m: -15 101-200 m: -10 201-300 m: -5 > 300 m: 0
	Proximity to mines	Each Pixel	0-50 m: -25 51-100 m: -20 101-200 m: -15 201-300 m: -10 > 300 m: 0
	Proximity to pits and quarries	Each Pixel	0-50 m: -25 51-100 m: -20 101-200 m: -15 201-300 m: -10 > 300 m: 0
	Intakes	Each Pixel	0-50 m: -20 51-100 m: -15 101-200 m: -10 201-300 m: -5 > 300 m: 0
	Outflows	Each Pixel	0-50 m: -20 51-100 m: -15 101-200 m: -10 201-300 m: -5 > 300 m: 0
	Roadlessness	Each Pixel	*0-100m* *101-200m* *>201-400m* *>400m* Primary -30 -20 -10 0 Secondary -20 -10 -5 0 Tertiary -10 -5 -3 0
	Number of Road Crossings	Aquatic Ecological Unit	0-25 : 0 26-50 : -1 51-75 : -2 76-100 : -3 101-129 : -4 129-258 : -8 258-1228 : -15

Criteria	Value Layer	Scale	Scores
Condition continued *(adjusted to 38% of the total score)*	Presence of Indicator Species	Aquatic Ecological Unit	0:0 1:2 2:4 3:6 4:8 5:10 6:12 7:14 8:16
	Presence of Invasive Species	Aquatic Ecological Unit	0: 0 1:-1 2:-2 3:-3 4:-4 5:-5 6:-6 7:-7 8:-8 9:-9 10:-10
Diversity (adjusted to 2% of the total score)	Diversity of aquatic habitats within a certain radius	Each Pixel	0:0 1:1 2:2 3:3 4:4 5:5 6:6 7:7 8:8 9:9 10:10 11:11
Ecological Functions (adjusted to 40% of the total score)	System Size	Aquatic Ecological Unit	0-100ha : -50 101-200ha : -10 > 200 : 0
	Wetland Size	Aquatic Ecological Unit	0-25ha : -20 26-50ha : 2 51-100ha: 6 101-200ha : 15 201: 500ha : 30 > 500 : 40
	Distance from Dams	Each Pixel	0-50 m: -20 51-100 m: -15 101-200 m: -10 201-300 m: -5 300 m: 0

Criteria	Value Layer	Scale	Scores
Ecological Functions continued *(adjusted to 40% of the total score)*	Coincidence with conservation lands • ANSIs (LS) • PSW • CAA • NCC • Important Bird Areas • Rouge Park	Each Pixel	**Life Science ANSI** Provincially significant : 5 Regionally significant : 3 Outside : 0 **Provincially Significant Wetland** Inside : 5 outside : 0 **Conservation Authority Areas** inside : 5 outside : 0 **NCC Properties** inside : 5 outside : 0 **Important Bird Areas** inside : 5 outside : 0 **Rouge Park** inside : 5 outside : 0
	Proximity to protected areas • Provincial Parks • National Parks • Conservation Reserves • OLL sites • Lake Superior National Marine CA • National Wildlife Areas • Migratory Bird Sanctuaries	Each Pixel	Inside: 10 0-50 m: 8 51-100 m: 6 101-200 m: 4 201-300 m: 2 > 300 m: 0
	Riparian areas - Great Lakes Lakeshore - Stream riparian areas - Inland lake riparian areas	Each Pixel	**Great Lakes shoreline** positive : 25 negative : 0 **Riparian area (streams)** positive : 15 negative : 0 **Riparian area (inland lake)** positive : 15 negative : 0
Special Features (adjusted to 20% of the total score)	Aquatic Vegetation Community Targets	Each Pixel	Count *5
	Target Species	Each Pixel	Count *5
	Presence of other rare species	Each Pixel	Count*2

Appendix 5: Lake Drainage Basins and Their Associated Tertiary Watersheds

Drainage Basin	Tertiary Watershed (TWS)	
LAKE SUPERIOR	2AA 2AB 2AC 2AD 2AE	2BA 2BB 2BC 2BD 2BE 2BF
LAKE HURON	2CA 2CB 2CC 2CD 2CE 2CF 2CG 2CH 2DA 2DB 2DC 2DD	2EA 2EB 2EC 2ED 2FA 2FB 2FC 2FD 2FE 2FF
LAKE ERIE	2GA 2GB 2GD 2GE	2GF 2GG 2GH
LAKE ONTARIO	2HA 2HB 2HC 2HD 2HE 2HF	2HG 2HH 2HJ 2HK 2HL 2HM
ST. LAWRENCE RIVER	2JC 2JD 2JE 2KA 2KB 2KC 2KD 2KE 2KF	2LA 2LB 2MA 2MB 2MC

Appendix 6: Glossary of Terms

ANSI, Area of Natural and Scientific Interest: an area of land and water containing natural landscapes or features that have been identified as having life science or earth science values related to protection, scientific study or education under the Provincial Policy Statement (1996). These areas can be identified as having provincial or regional significance and can be situated on crown or private land. The Ontario Ministry of Natural Resources administers the ANSI program.

Biodiversity: the word "biodiversity" is a contraction of "biological diversity" and is commonly used to describe the number, variety and variability of living organisms. Biodiversity is commonly defined in terms of the variability of genes, species and ecosystems, corresponding to these three fundamental and hierarchically related levels of biological organization.

Biodiversity Target: an element of biodiversity selected as a focus for conservation planning or action. The three principle types of targets are species, ecological communities and ecological systems.

Biome: a regional ecosystem characterized by distinct types of vegetation, animals, and microbes that have developed under specific soil and climatic conditions.

Coarse-filter: an approach to assess and conserve species diversity by providing adequate representation (distribution and abundance) of ecological systems. The coarse-filter approach scores, compares and selects from among equivalent land units, terrestrial ecological systems in this case, and is often followed by and combined with a fine-filter approach.

Condition: measures the degree of which anthropogenic disturbances have occurred at a site. Currently, the condition of a site can only be accurately determined through field inspection.

Conservation Goal: the number and spatial distribution of occurrences of targeted species, vegetation communities and/or ecological systems considered necessary to adequately conserve the target in an ecodistrict, physiographic region or tertiary watershed.

Conservation Lands: natural areas that are managed or regulated (*e.g.*, through land-use policy) for the long-term protection of their significant natural heritage values. The conservation lands identified in the Great Lakes Conservation Blueprint include protected areas (National Parks, Migratory Bird Sanctuaries, National Wildlife Areas, Provincial Parks, Conservation Reserves), as well as Provincially Significant Life Science Areas of Natural and Scientific Interest (ANSIs), Provincially Significant Wetlands, Conservation Authority lands, and Nature Conservancy of Canada properties.

Conservation Reserves: complement Provincial Parks in protecting representative natural areas and special landscapes and are regulated under the Public Lands Act. Most non-industrial resources uses (*e.g.*, fur harvesting, commercial fishing and bait harvesting) are permitted if they are compatible with the values of individual reserves. Most recreational and non-commercial activities can continue in the area provided they pose little threat to the natural ecosystems and features protected by the conservation reserve.

COSEWIC, Committee on the Status of Endangered Wildlife in Canada: is a national committee of experts that assesses and designates which wild species are in danger of disappearing from Canada. COSEWIC assigns the following status to species:

Status	**Description**
EXT, Extinct	A species that no longer exists
EXP, Extirpated	A species no longer existing in the wild in Canada, but occurs elsewhere

END, Endangered	A species facing imminent extirpation or extinction
THR, Threatened	A species likely to become endangered if limiting factors are not reversed
SC, Special Concern	A wildlife species that may become a threatened or an endangered species because of a combination of biological characteristics and identified threats
NAR, Not At Risk	A species that has been evaluated and found to be not at risk of extinction given the current circumstances
DD, Data Deficient	A species for which there is inadequate information to make a direct, or indirect, assessment of its risk of extinction

COSSARO, Committee on the Status of Species at Risk in Ontario: a provincial group of experts whose mandate is to evaluate and recommend a provincial status to candidate species and re-evaluate current species at risk for the Ontario Ministry of Natural Resources. COSSARO employs a uniform, scientifically-based, defensible approach to status evaluations. The committee evaluates species by considering factors such as population size, trends and distribution, habitat trends and known threats. Based on its evaluation, COSSARO recommends the appropriate provincial status category for each candidate species. Once designated by the OMNR, assessed species are maintained on the OMNR's SARO List.

Declining Species: exhibit significant, long-term declines in habitat and/or abundance, are subject to a high degree of threat, or may have unique habitat or behavioural requirements that expose them to a great risk.

Disjunct Species: have populations that are geographically isolated from each other by at least one ecoregion.

Diversity: the variety of living organisms considered at all levels of organization including the genetic, species, and higher taxonomic levels. Biological diversity includes the variety of habitats, ecosystems and natural processes occurring within them.

Ecodistrict: a subdivision of an ecoregion characterized by distinctive assemblages of relief, geology, landforms and soils, vegetation, water, fauna, and land use.

Ecological Functions: means, in general, the natural processes, products or services that living and non-living environments provide or perform within or between species, ecosystems and landscapes. These may include biological, physical and socio-economic interactions.

Ecological System: dynamic spatial assemblages of ecological communities characterized by both biotic and abiotic components that 1) occur together on the landscape; 2) are tied together by similar ecological processes (*e.g.,* fire, hydrology), underlying environmental features (*e.g.,* soils, geology) or environmental gradients (*e.g.,* elevation, hydrologically-related zones); and 3) form a robust, cohesive, and distinguishable unit on the ground.

Element: refers to an element of biodiversity, a term used by CDCs and NatureServe to refer to the forms of biodiversity upon which CDCs and NatureServe compile information: species (including sub-species, varieties and hybrids) and natural communities.

Element Occurrence (EO): an area of land and/or water in which a species or natural community is, or was, present. An EO should have practical conservation value for the element (species or vegetation community) as evidenced by potential continued (or historical) presence and/or regular recurrence at a given location. For species, the EO often corresponds with the local population, but when appropriate may be a portion of a population (*e.g.,* long-distance dispersers) or a group of nearby populations (*e.g.,* metapopulation). For vegetation communities, the EO may represent a stand or patch of a natural community, or a cluster of stands or patches of a natural community. The Natural Heritage Information Centre is the central repository for Element Occurrence records.

Endemic: a species or ecological system that is restricted to a region, such as the Great Lakes ecoregion. Many endemic species and systems are generally considered more vulnerable to extinction due to their dependence on a single area for their survival.

Fine-filter: an approach to assess and conserve species diversity, in conjunction with a coarse-filter approach, for viable native species and ecological communities that cannot be reliably conserved through a coarse-filter and may require individual attention. Fine-filter targets include globally imperiled species (G1 to G3G4), species at risk, endemic species, declining species, disjunct species, wide-ranging species and rare vegetation communities.

Globally Imperiled Species: have been assigned a global rank of G1 or G2 by NatureServe (www.natureserve.org).

GRank (Global Rank): the overall status of a species or ecological community is regarded as its "global" status; this range-wide assessment of condition is referred to as its global conservation status rank (GRank). Global conservation status assessments are generally carried out by NatureServe scientists with input from relevant natural heritage member programs (such as the NHIC in Ontario) and experts on particular taxonomic groups, and are based on a combination of quantitative and qualitative information. The factors considered in assessing conservation status include the total number and condition of occurrences; population size; range extent and area of occupancy; short- and long-term trends in these previous factors; scope, severity, and immediacy of threats, number of protected and managed occurrences, intrinsic vulnerability and environmental specificity.

Ranking	**Definition**
G1, Critically Imperiled	At very high risk of extinction due to extreme rarity (often 5 or fewer populations), very steep declines, or other factors
G2, Imperiled	At high risk of extinction due to a very restricted range, very few populations (often 20 or fewer), steep declines, or other factors
G3, Vulnerable	At moderate risk of extinction due to a restricted range, relatively few populations (often 80 or fewer), recent and widespread declines, or other factors
G4, Apparently Secure	Uncommon but not rare; some cause for long-term concern due to declines or other factors
G5, Secure	Common; widespread and abundant
GH	Possibly extinct (species)- missing; known from only historical occurrences but still some hope of rediscovery or Presumed Eliminated (historic, ecological communities)- Presumed eliminated throughout its range, with no or virtually no likelihood that it will be rediscovered but with the potential for restoration.
GX	Presumed extinct (species)- not located despite intensive searches and virtually no likelihood of rediscovery or Eliminated (ecological communities) - Eliminated throughout its range, with no restoration potential due to extinction of dominant or characteristic species
GU	Unrankable, currently unrankable due to lack of information or due to substantially conflicting information about status or trends. Whenever possible, the most likely range is assigned and the question mark qualifier is added (*e.g.*, G2?) to express uncertainty, or a range rank

	(*e.g.*, G2G3) is used to delineate the limits (range) or uncertainty.
?	Denotes inexact numeric rank (*i.e.*, G4?)
G?	Unranked, or, if following a ranking, rank tentatively assigned (*e.g.*, G3?)
Q	Questionable taxonomy- taxonomic distinctiveness of this entity at the current level is questionable
T	Denotes that the rank applies to a subspecies or variety

Limited Species: are nearly restricted to the Great Lakes ecoregion. These are species that are not "true" endemics because there may be populations outside the ecoregion. However, the core part of the species range is in the Great Lakes ecoregion.

Muskeg: this is the term used for peatlands (bogs and fens) by the Ontario Forest Resource Inventory, one of the digital mapping sources used in the analysis of the Conservation Blueprint.

NRVIS, Natural Resources and Values Information System: the Ontario governments Geographical Information System (GIS) platform for storing, maintaining and managing tabular and spatial geographic information according to province-wide standards.

Peripheral: species or ecological systems that are located closer to the outer boundaries of an ecoregion than to the centre and are not widespread throughout the ecoregion (*e.g.*, where the Great Lakes ecoregion is the extreme edge of the species' range).

Primary Target: an element of biodiversity selected as a focus for conservation planning or action. The three main types of targets are species, vegetation communities and ecological systems.

PSW, Provincially Significant Wetlands: wetlands evaluated using the Ontario Ministry of Natural Resources' Ontario Wetland Evaluation System (OWES) and determined to be of provincial significance. Provincially significant wetlands are afforded protection from development through the Provincial Policy Statement if they occur south and east of the Canadian Shield. Evaluated wetlands can occur on either Crown or private land.

Protected Areas: natural area designation that is regulated under legislation such as the National Parks Act, Provincial Parks Act or the Public Lands Act. Protected areas identified in the Great Lakes Conservation Blueprint include National Parks, National Wildlife Areas, Migratory Bird Sanctuaries, Provincial Parks and Conservation Reserves.

Rare Vegetation Communities: ecological communities that have been identified by the Natural Heritage Information Centre (NHIC) that have been ranked as provincially significant (S1, S2 or S3).

SAR, Species at Risk: species designated as Endangered, Threatened or Special Concern by either the Ontario Ministry of Natural Resources (OMNR) or the Committee on the Status of Endangered Wildlife in Canada (COSEWIC).

SARO, Species At Risk in Ontario List: list issued by the Ontario Ministry of Natural Resources' Species at Risk Section. These status designations apply to the provincial level, and are used in the application of Ontario's legislation and policy for the protection of species at risk and their habitat. Ontario status designations are the product of complementary review and assessment processes implemented at national and provincial levels. The provincial review process is implemented by the OMNR's Committee on the Status of Species at Risk in Ontario (COSSARO), which includes non-OMNR representation.

Status	Description
EXT, Extinct	A species that no longer exists anywhere
EXP, Extirpated	A species that no longer exists in the wild in Ontario but still occurs elsewhere
END-R, Endangered (Regulated)	A species facing imminent extinction or extirpation in Ontario which has been regulated under Ontario's Endangered Species Act (ESA)
END, Endangered (Not Regulated)	A species facing imminent extinction or extirpation in Ontario which is a candidate for regulation under Ontario's ESA
THR, Threatened	A species that is at risk of becoming endangered in Ontario if limiting factors are not reversed
SC, Special Concern	A species with characteristics that make it sensitive to human activities or natural events (formerly Vulnerable)
NAR, Not at Risk	A species that has been evaluated and found to be not at risk (formerly Not In Any Category)
DD, Data Deficient	A species for which there is insufficient information for a provincial status recommendation (formerly Indeterminate)

Secondary Target: an element of biodiversity (species or vegetation community) that is of some conservation concern in the Ontario portion of the Great Lakes. Occurrences of secondary biodiversity targets were included in the Conservation Blueprint portfolio where their occurrence coincided with either a primary target occurrence, a protected area or conservation land.

SRank (Provincial Rank): provincial (or Subnational) ranks are used by the Ontario Natural Heritage Information Centre to set conservation priorities for rare species and vegetation communities. These ranks are not legal designations. Provincial ranks are assigned in a manner similar to that described for global ranks, but consider only those factors within the political boundaries of Ontario. Comparison of global and provincial ranks gives an indication of the status and rarity of an element in Ontario in relation to its overall conservation status, therefore providing insight into the urgency of conservation action for it in the province. The NHIC evaluates provincial ranks on a continuous basis and produces updated lists annually.

Ranking	Description
S1	Extremely rare in Ontario; usually 5 or fewer occurrences in the province or very few remaining individuals; often especially vulnerable to extirpation
S2	Very rare in Ontario; usually between 6 and 20 occurrences in the province or with many individuals in fewer occurrences; often susceptible to extirpation
S3	Rare to uncommon in Ontario; usually between 21 and 100 occurrences in the province; may have fewer occurrences, but with a large number of individuals in some populations; may be susceptible to large-scale disturbances
S4	Common and apparently secure in Ontario; usually with more than 100 occurrences in the province
S5	Very common and demonstrably secure in Ontario
SH	Historically known from Ontario, but not verified recently (typically not recorded in the province in the last 20 years); however suitable habitat is thought to be still present in the province and there is reasonable expectation that the species may be rediscovered
C	Captive/Cultivated; existing in the province only in a cultivated state; introduced population not yet fully established and self-sustaining
S?	Not ranked yet, or if following a ranking, rank uncertain (*e.g.*, S3?). S? species have not had a numerical rank assigned

SA	Accidental; of accidental or casual occurrence in the province; far outside its normal range; some accidental species may occasionally breed in the province
SAB	Breeding accidental
SAN	Non-breeding accidental
SE	Exotic; not believed to be a native component of Ontario's flora or fauna
SR	Reported for Ontario, but without persuasive documentation which would provide a basis for either accepting or rejecting the report
SRF	Reported falsely from Ontario
SU	Unrankable, often because of low search effort or cryptic nature of the species, there is insufficient information available to assign a more accurate rank; more data is needed
SX	Apparently extirpated from Ontario, with little likelihood of rediscovery. Typically not seen in the province for many decades, despite searches at known historic sites
SZ	Not of practical conservation concern inasmuch as there are no clearly definable occurrences; applies to long distance migrants, winter vagrants, and eruptive species, which are too transitory and/or dispersed in their occurrence(s) to be reliably mapped; most such species are non-breeders, however, some may occasionally breed
SZB	Breeding migrants/vagrants
SZN	Non-breeding migrants/vagrants

Tertiary watershed: delineation of watersheds that are nesting within primary and secondary watersheds. Tertiary watersheds are convenient sizes for watershed management and planning, and are comparable to the scale of an ecodistrict.

Wide-ranging species: are highly mobile species that require large tracts of habitat for their survival. These include top-level predators, migratory mammals, birds and insects. The design of fully functioning networks of conservation sites needs to take into account the habitat requirements of such species, including factors such as linkages, natural corridors, interior habitats and roadless areas.

Widespread: species or ecological systems occurring naturally throughout the Great Lakes ecoregion and considerably beyond the ecoregion.

2005
ISBN 0-9695980-3-3

Printed on
Recycled Paper