Great Lakes Conservation Blueprint for Terrestrial Biodiversity

Volume 1

B.L. Henson, K.E. Brodribb and J.L. Riley

2005

Nature Conservancy Canada

Natural Heritage Information Centre

Ontario

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

The Richard Ivey Foundation

Ontario Ministry of Natural Resources

Ontario Parks

The W. Garfield Weston Foundation

Environment Canada

Great Lakes Conservation Blueprint for Terrestrial Biodiversity

Volume 1

B.L. Henson, K.E. Brodribb, and J.L. Riley

2005

NATURE CONSERVANCY CANADA

NATURAL HERITAGE INFORMATION CENTRE

Ontario

The Great Lakes Conservation Blueprint for Terrestrial 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 0-9695980-5-X

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: Lake Superior, Sugar Maple Forest, Carden Alvar, Manitoulin Island, Black Oak Woodland *(W.D. Bakowsky, 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, 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, detailed tables and maps of each ecodistrict in the Great Lakes region.

i. Acknowledgements

The Great Lakes Conservation Blueprint Project team would like to acknowledge the generous contributions of The Richard Ivey Foundation, Ontario Parks (Ontario Ministry of Natural Resources, OMNR), the Natural Heritage Information Centre (OMNR), The W. Garfield Weston Foundation and Environment Canada (Ontario Region) to this project. In particular, the early involvement and support of Marvi Ricker of The Richard Ivey Foundation, Adair Ireland-Smith of Ontario Parks (OMNR), Ted Harvey of Science and Information Division (OMNR), and Jim Mackenzie of the Natural Heritage Information Centre (OMNR) 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 the following Ontario Ministry of Natural Resources (OMNR) staff: Barton Feilders (Ontario Parks, OMNR), Pat Freistatter (Lands and Waters Branch, OMNR), Joe Kapron (Science and Information Branch, OMNR), Jim Mackenzie (NHIC, OMNR), Dan Marinigh (Policy and Planning Coordination Branch, OMNR), Rob Taylor (Field Services Division, OMNR) as well as John Riley (NCC) and John Grant (NCC).

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 southern Ontario and Canadian Shield methodologies. We would like to thank Wasyl Bakowsky (NHIC, OMNR), Bill Crins (Ontario Parks, OMNR), Rob Davis (Ontario Parks, OMNR), Lyle Friesen (Canadian Wildlife Service), Mary Harkness (The U.S. Nature Conservancy - TNC), Steve Hounsell (Ontario Power Generation), Dan Kraus (NCC – Ontario Region), Mike McMurtry (NHIC, OMNR), Michael Oldham (NHIC, OMNR), Peter Sorrill (NHIC, OMNR) and Silvia Strobl (Ducks Unlimited Canada; OMNR).

The Provincial Geomatics Service Centre (PGSC) and Thunder Bay Geomatics Service Centre staff were instrumental in the development and implementation of the GIS analysis. We would like to thank Eric Beattie, Nancy Bookey, Lisa Casselman, Raymond Jahncke, Derek Johnston-Main, Thomas Krahn and Jennifer Neish-Ashfield. We would also like to thank the PGSC, particularly Greg Sikma, for the variety of cartographic products.

Among the many OMNR staff that provided useful advice, we would like to thank Frank Amtstaetter, Kim Armstrong, Bob Davidson, Gary Davies, Tricia Greer, Ron LeeKam, Greg Lucking, Rob MacKereth, Londa Mortson, Evan Simpson and Julie Sullivan for their contributions to the Canadian Shield methodology.

We would also like to thank the many additional individuals for technical support and assistance throughout the project: Michelle Albanese (NCC), Vivian Brownell, Jim Cameron (OMNR), Paul Catling (Agriculture Canada), Jasmine Chabot (OMNR), Wendy Cooper (Georgian Bay Land Trust), Dave Ewert (TNC), Rob Foster (Northern Bioscience), Sandy Gemmitti (OMNR), Michael Gluck (OMNR), Al Harris (Northern Bioscience), Jarmo Jalava, Colin Jones (OMNR), Rosita Jones (OMNR), Burke Korol (OMNR), Linda Ley, Catherine Lipsett-Moore (OMNR), Geoff Lipsett-Moore (OMNR), Kevin Loftus (OMNR), Kelly Ramster (OMNR), Tracy Sorrill (OMNR), Don Sutherland (OMNR), Steve Wilcox (Bird Studies Canada), Gord Wichert (OMNR) and Anthony Zammit (OMNR).

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, Parks Canada, Environment Canada, the Conservation Authorities of Ontario and the Nature Conservancy of Canada.

ii. Executive Summary

The Great Lakes ecoregion spans two countries and includes one province and eight states. It is the largest freshwater ecosystem in the world, supporting a growing human population and one of the largest industrial complexes in the world. It supports a population of more than 40 million, which is expected to grow by more than 4 million in Canada alone in the next 25 years. The Great Lakes basin contains more than 18% of the world's supply of surface fresh water, and the terrestrial portion of the Great Lakes watershed covers over 26,000,000 hectares (ha) or approximately one-half of Ontario's landbase. There are approximately 18,000 kilometres of shoreline along the entire Great Lakes coast, intermixed with over 35,000 islands including Manitoulin Island, the world's largest freshwater island.

This report outlines the methods and results of an ecoregional assessment of the terrestrial biodiversity of the Canadian portion of the Great Lakes ecoregion. It complements an earlier ecoregional assessment of the American portion of the Great Lakes ecoregion, done by The (U.S.) Nature Conservancy (TNC) (Harkness *et al.*, 1999). The Great Lakes Conservation Blueprint for Aquatic Biodiversity is a complementary study of freshwater biodiversity in the Ontario portion of the region (Wichert *et al*., 2005; Phair *et al*., 2005).

The Great Lakes ecoregion has the greatest diversity of species in Canada and is one of the most diverse ecoregions in North America in terms of ecological systems (Comer *et al.*, 2003). This remarkable biodiversity reflects the variations in climate, terrain and altitude of the region in southern Ontario and on the Canadian Shield. Internationally recognized habitats include rich southern coastal wetlands, subarctic coastal cliffshores, sand dunes, limestone alvars, rich southern deciduous forests, sparse boreal rock barrens and spruce woodlands. There is a sharper north-south gradient of environmental, climatic and biological change across the Canadian portion of the Great Lakes basin than across any other non-montane ecoregion in Canada. Biologically, it includes species representative of the Carolinian, boreal, Arctic, Atlantic and western montane areas, as well as some unique species and subspecies that have evolved as endemics on the shores of the Great Lakes.

The Great Lakes region has played an integral role in the history and development of Canada, and presently it sustains the core Canadian industrial economy. More than one-quarter of Canada’s population calls the region home. Nearly 25% of the total Canadian agricultural productivity and one of the world’s largest concentrations of energy production are found around the Great Lakes. The Canadian Shield portion of the ecoregion is primarily Crown or federal lands, with approximately 20% as patent lands, and with internationally important mining and forestry sectors. Southern Ontario, which lies south and east of the Canadian Shield, is dominated by private land, and by agricultural, urban and industrial land uses.

Many millions of people in Ontario and across Canada are dependent on the social, economic and ecological health of the Great Lakes region. There is therefore a compelling need to pursue a holistic approach to achieving the healthy ecosystem essential to the long-term sustainability of the area. The Great Lakes landscape has undergone enormous changes from its pre-settlement conditions. Most of the original woodlands in southern Ontario have been converted to human settlements or to agriculture. Wetlands that were once widely distributed throughout southern Ontario have also declined, particularly in the southwest. Prairie and savannah vegetation that was once widespread has virtually disappeared from the landscape. The predominant threats to the biodiversity in the Great Lakes ecoregion include habitat loss, incompatible recreational uses, exotic and invasive species, point and non-point pollution and, possibly, climate change. The Canadian government has committed to maintain this native biodiversity by signing the United Nations Convention on Biological Diversity, and this analysis contributes to Ontario's biodiversity strategy for the Great Lakes region.

The Great Lakes Conservation Blueprint

A Conservation Blueprint is an effort to assemble, catalogue, classify, map and analyze the available information on the biological diversity of a natural geographic region. Such an atlas of biodiversity data has many applications, including the assessment of the places across the Great Lakes ecoregion that, if appropriately conserved, would sustain the biodiversity of the region.

The Conservation Blueprint project is part of a history of such efforts across the Canadian portion of the Great Lakes basin. Precursors include NCC's science-based approach to conservation planning emphasizing scientific consensus and partnerships and the development of TNC's approach to conservation planning (Groves *et al.*, 2000). The Conservation Blueprint project recognizes the Ontario Ministry of Natural Resources' (OMNR) gap analysis and representation framework for the identification of provincial parks and protected areas, and Areas of Natural and Scientific Interest (ANSIs). The Conservation Blueprint project has deliberately developed an approach compatible with these frameworks, including the methods used to assess significant natural areas in Ontario over the past 20 years.

The OMNR partnered with NCC in terrestrial and aquatic Conservation Blueprints for the Ontario portion of the Great Lakes ecoregion. These projects are the first-ever computer-based landscape-level analyses for the region, and this report summarizes the analysis of terrestrial biodiversity. The Great Lakes Conservation Blueprint represents a significant conservation planning investment that will identify or re-validate the best representative areas, regardless of land tenure, across the ecoregion. Its results will be shared among partners developing their own conservation priorities.

The Geographic Information Systems (GIS)-based analysis of representation and gaps in existing protected areas provides a transparent, rule-based methodology that has used the best-available data and the scientific consensus of a team of core scientists to provide a basis for setting conservation priorities within a natural ecoregion. The analysis also sets the stage for subsequent re-analysis, update and measure of conservation achievements over time.

Analytical Approach to Conservation

One of the project needs was to compile digital data on the biodiversity in the Great Lakes ecoregion at different spatial scales. Another was to perform a gap analysis to assess how much of this biodiversity was within the existing protected areas. To this end, a suite of specific biodiversity targets was assessed and documented. The coarse-filter targets were ecological systems, expressed as unique combinations of landform and vegetation. On the Canadian Shield, the classification and mapping of ecological systems was based on fine-scale Forest Resource Inventory (FRI) data that was available for use as the primary source of vegetation information, resulting in an ability to specifically target those systems in the coarse-filter analysis. Fine-filter targets included species and vegetation communities of conservation concern for which specific geospatial data were available, and were assembled with the assistance of the Ontario Natural Heritage Information Centre (NHIC). The conservation goals for these biodiversity targets were determined by factors such as degree of rarity, distribution in the Great Lakes basin and information on natural disturbance regimes.

Because of the stark differences in the ecology, land use and condition between southern and central Ontario, the Great Lakes ecoregion was divided into two study areas: southern Ontario and the Canadian Shield. This permitted the use of data that were the best resolution for each sub-region, but not available or appropriate for both. However, the same five criteria - representation, diversity, ecological functions, condition and special features, were used for both study areas to organize and score digital data layers to select the best (highest-scoring) representative examples of each ecological system. In order to design an efficient portfolio of sites, the degree to which current protected areas in Ontario support these elements of biodiversity was also assessed. Other ecological factors considered in the portfolio design included irreplaceability, complementarity, and viability.

In technical terms, the coarse-filter biodiversity analysis assessed highest-scoring examples of ecological systems through the use of multiple data layers in a GIS environment. The layers were used to assign value/scores to specific areas, and allowed the analysis to be replicated several times with different weightings, to include additional datasets, and to vary the assessment of differing landscapes.

Conservation goals for species, vegetation communities and ecological systems were expressed and analyzed at the ecodistrict scale. Stratification rules were developed to select a pre-set number of replicate ecological systems for each ecodistrict and/or physiographic sub-district. Existing protected areas and conservation lands were added to these coarse-filter outputs to produce the suite of initial sites to be assessed against the fine-filter targets. It was then determined how many occurrences of those targets were already within protected areas and other conserved lands and how many additional occurrences needed inclusion in order to achieve the conservation goals set for individual species and vegetation-community targets.

The Conservation Blueprint portfolio should not be considered a final, inflexible display of existing and potential conservation sites, but as a modeled cartographic expression of the best data available to the project. The Conservation Blueprint also includes the landscape between existing and potential conservation lands. In southern Ontario, the Conservation Blueprint portfolio of sites is illustrated as embedded in the natural core and corridor areas identified by the Big Picture 2002 analysis (Riley *et al.*, 2003). On the Canadian Shield, the Conservation Blueprint portfolio is shown on a background of the total scores that the entire landscape received in the coarse-filter analysis.

Conservation Blueprint Results

A total of 58 ecological systems in southern Ontario and 250 ecological systems on the Canadian Shield were mapped as the foundation for the coarse-filter analysis. Of these systems, 48 natural ecological systems in southern Ontario and 182 on the Canadian Shield were targeted for inclusion in the Conservation Blueprint. In southern Ontario, approximately 87% of prairies and savannahs, 16% of targeted forest systems, and 63% of wetland systems are included in the Conservation Blueprint. The majority of the top-scoring ecological systems in southern Ontario occur outside of existing protected areas and conservation lands. Overall, the Conservation Blueprint identifies 10% of the landbase in southern Ontario, of which 7% is existing protected areas or conservation lands. These Conservation Blueprint areas are presented as core biodiversity conservation areas distributed within a network of core and corridor natural areas identified by the NCC/OMNR Big Picture project (35% of the landbase), essentially the same percent as the extent of natural cover that remains on the landbase of southern Ontario (34% of the landbase).

On the Canadian Shield, nearly 21% of the total area of targeted forest systems and 22% of the total area of wetland systems are identified in the Conservation Blueprint. Approximately 70% of the top-scoring ecological systems on the Canadian Shield occur outside of existing protected areas and conservation lands. Approximately 46% of the top-scoring ecological systems on the Canadian Shield occur on private lands, which have never before been assessed in terms of their representation potential (private lands comprise 21% of the Shield study area). Overall, the Conservation Blueprint identifies 23% of the landbase of the Canadian Shield portion of the Great Lakes basin in Ontario, of which 19% is existing protected areas or conservation lands. These Conservation Blueprint sites are presented as core biodiversity conservation areas distributed within a network of core and corridor natural areas identified as those lands having high conservation value scores in this analysis (6% of the landbase). These lands are, in turn, a further subset of the extent of natural cover that remains on the landbase of this part of the Canadian Shield (96% of the landbase).

The Conservation Blueprint for the entire Great Lakes ecoregion in Ontario identifies over 2,300,000 ha of targeted forest systems, 22,000 ha of alvars, 2,100 ha of prairies and savannahs and nearly 417,000 ha of wetlands. Overall, the terrestrial Conservation Blueprint identifies nearly 22% of the total area of all the targeted ecological systems in the ecoregion as necessary to represent the targeted ecological systems at the levels of representation (coarse-filter) and the thresholds of inclusion (fine-filter) set by the project.

Overall, a total of 428 species and 172 vegetation communities were identified as targets in the Great Lakes ecoregion, forming the basis for the fine-filter biodiversity analysis. Approximately 70% of all extant targets in the southern Ontario portfolio occur in existing protected areas and conservation lands, particularly in provincially significant life science ANSIs. On the Canadian Shield, approximately 68% of extant targets in the portfolio occur in existing protected areas and conservation lands, primarily in provincial parks and conservation reserves.

Existing protected areas and conservation lands occupy approximately 3,185,000 ha, or 14.3% of the landbase, of the Great Lakes ecoregion. They comprise about 81% of the total area of the Conservation Blueprint portfolio. In southern Ontario, one-third of the existing protected areas and conservation lands (nearly 630,000 ha) are provincially significant life science ANSIs. On the Canadian Shield, provincial parks and conservation reserves make up over 2,287,000 ha of the total 2,540,000 ha of protected areas and conservation lands.

The Great Lakes Conservation Blueprint project also assessed how its portfolio of sites might withstand natural disturbance regimes and support wide-ranging mammals.

The Great Lakes Conservation Blueprint as a Conservation Tool

This project is the first ecoregion-wide identification of the most important areas for conserving native biodiversity across the Canadian portion of the Great Lakes basin. The results provide a measure of how well past and existing conservation efforts have succeeded against specific conservation goals for specific (and mapped) biodiversity targets. In addition, the results inform us about the location of other important potential conservation lands, which, in concert with the results of the aquatic Conservation Blueprint, field testing and local knowledge, may be priorities for consideration in land-use planning, resource management and land securement. Biodiversity conservation depends on the cooperation and participation of many stakeholders with the ability to apply a variety of conservation tools. The results of the Conservation Blueprint will be shared as widely among conservation practitioners and decision-makers, with the goal of promoting cooperative approaches to the conservation of the biodiversity of the Great Lakes ecoregion.

Most organizations, planning agencies and individuals involved in conservation in the region pursue independent strategies in response to their local assessments of priorities. It is hoped that the Conservation Blueprint will provide a regional perspective on conservation needs and priorities in the Great Lakes basin, and to help balance discussions of protection and development. Finally, the Conservation Blueprint may provide a level of region-wide analysis that can help stakeholders identify priority conservation actions, agree on common goals for conservation, and develop indicators and monitoring standards to measure the effectiveness of conservation activities over the long term.

The identification and conservation of representative natural areas is vital to any attempt to conserve biodiversity in a region. The Great Lakes Conservation Blueprint portfolio provides a rule-based approach to establishing a network of conservation lands and protected areas that would secure the survival of existing native species, ecological systems and processes that are essential to the biodiversity of the Great Lakes ecoregion.

A Conservation Strategy for the Great Lakes Ecoregion

Identifying and conserving key natural areas will not be enough to protect 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. Future management within the ecoregion needs to maintain landscape-scale ecological functions and services, and restore and rehabilitate degraded systems.

It was the essential goal of the Great Lakes Conservation Blueprint 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 Ontario portion of the Great Lakes basin. With a long-term conservation vision, wise management and planning, it is possible to both conceive and realize the network of sites that will sustain all elements of terrestrial biodiversity while complimenting the Great Lakes region's social and economic development.

1.0 Introduction

The Great Lakes Conservation Blueprint for Terrestrial Biodiversity is a partnership between the Nature Conservancy of Canada (NCC) and the Ontario Ministry of Natural Resources (OMNR), particularly the Natural Heritage Information Centre (NHIC) and Ontario Parks. This project is the first-ever GIS-based landscape-level analysis of aquatic and terrestrial biodiversity in the Great Lakes ecoregion. The Conservation Blueprint represents a significant conservation-planning effort across the ecoregion, as it deals with lands of all tenure and identifies and re-validates the best representative natural areas across Ontario's Great Lakes basin. It is the project's goal to share this work with other conservation practitioners as they develop and refine their own strategies.

Some precursors to this project include the development of The (U.S.) Nature Conservancy (TNC) approach to ecoregional assessments described in *Designing a Geography of Hope* (Groves *et al.*, 2000), which stimulated detailed ecoregion planning or conservation blueprints, throughout U.S. ecoregions. The NCC is applying this approach across southern Canada in 14 ecoregions (Figure 1). The OMNR has developed a gap-analysis and representation framework for the selection of provincial parks, areas of natural and scientific interest (ANSIs) and conservation reserves (Crins and Kor, 2000, see discussion in Section 5.1). The Great Lakes Conservation Blueprint has made deliberate efforts to develop methods that are compatible with these approaches, including the representation framework used to assess significant natural areas in Ontario over the past 20 years (Riley and Brodribb, 2003).

The goal of the Conservation Blueprint project is to identify a network of sites on the landscape that, if properly conserved, has the ability to sustain all elements of terrestrial biodiversity in the Great Lakes basin. The project's GIS-based gap analysis applies a rule-based methodology designed to use the best-available data and scientific consensus from a team of core scientists. The methods were designed to provide a platform for selecting conservation priorities within ecoregional boundaries and to efficiently re-analyze, update and measure Ontario's conservation achievements.

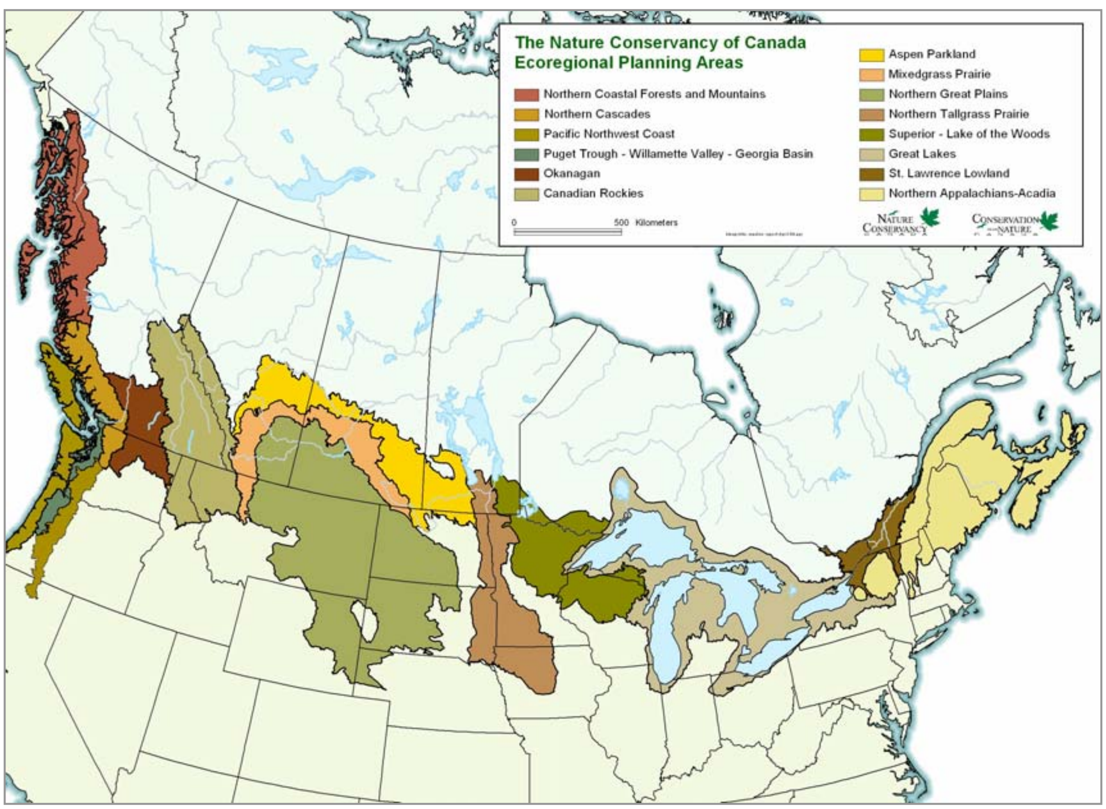


Figure 1. Nature Conservancy of Canada ecoregional planning areas.

2.0 Context of Conservation Planning in the Great Lakes Ecoregion

The Great Lakes ecoregion is located between 42° and 47° north latitude. It straddles two countries and includes portions of one province (Ontario) and eight states (Minnesota, Wisconsin, Illinois, Indiana, Michigan, Ohio, Pennsylvania and New York). The following section provides a general description of the Ontario portion of the Great Lakes ecoregion.

Previous work done on the Great Lakes ecoregion in the United States by The (U.S.) Nature Conservancy (TNC) defined the ecoregion as slightly smaller than the Great Lakes watershed and included portions of three ecological 'provinces' as defined by Bailey (2002) - the Laurentian Mixed Forest province, the Eastern Broadleaf Forest province and an unnamed subarctic taiga province. It straddled two different Canadian ecozones (ESWG, 1995) and therefore two independent analyses were undertaken using the same methodology.

Groves *et al.* (2000) can be consulted for additional information on the United States portion of the ecoregion and the associated Great Lakes ecoregional plan (Harkness *et al.*, 1999).

2.1 Geography

The Great Lakes are comprised of lakes Superior, Michigan, Huron, Ontario and Erie. This group of lakes is the world's largest freshwater ecosystem, extending more than 1,200 kilometres from west to east, containing about 2,300 cubic kilometres of water and covering a total of 244,000 square kilometres in surface area. The five Great Lakes contain roughly 18% of the world's supply of freshwater; only the polar ice caps contain more freshwater. The watershed that drains into the Great Lakes is just over 520,000 square kilometres. There are approximately 18,000 kilometres of shoreline along the Canadian and U.S. Great Lakes coast intermixed with over 35,000 islands. This includes the world's largest freshwater island - Manitoulin Island, which is part of the largest freshwater archipelago in northern Lake Huron and eastern Georgian Bay. The terrestrial portion of the Great Lakes watershed covers over 360,000 square kilometres, approximately one third of Ontario's landbase. Elevation ranges from 100 to nearly 700 metres (approximately 330 to 2,300 feet).

The Ontario portion of the watershed contains globally significant areas such as the St. Clair River Delta, the largest freshwater river delta, and among the most extensive concentrations of sand dunes of freshwater origin in the world. The southern Ontario portion of the watershed is also the most intensively populated part of Canada, illustrating the complexity of sustaining biodiversity within an economically and culturally important region.

2.2 Climate

The primary factors influencing weather in the Great Lakes basin are air masses entering the basin from other regions, the location of the Great Lakes on the North American continent, and the vast waters of the lakes themselves. The central position of the Great Lakes within the North American continent does not result in a strictly continental climate because of the location of Hudson Bay to the north. Hudson Bay depresses arctic air masses and the jet stream southward, resulting in cooler and moister regimes than would otherwise be the case. This depression of northern weather systems southward results in a steeper-than-normal gradient of climatic change across the Great Lakes region, from subarctic habitats on Lake Superior to temperate habitats on the north shore of Lake Erie. This climate includes distinctive and characteristic seasons due to the alternating flows of warm, humid air from the Gulf of Mexico and the cold, dry air from the Arctic. Average winter temperatures range from -2.5°C in the south to -20°C in the north. Average summer temperatures range from 22°C in the south to 17°C on the north shore of Lake Superior (Chapman and Thomas, 1968; Brown *et al.*, 1980; Environment Canada, 1982a, b).

Direct lake effects are significant around the Great Lakes. In the summer, heat is stored in the lakes and released during the fall and winter months. This moderates the climate near the shores of the lakes, particularly in southern Ontario. Cold, dry arctic air from the northwest also travels over the lakes in the winter and absorbs the moisture from the warmer lakes. When these air masses reach land, heavy snowfalls occur on the eastern, downwind sides of the lakes. These areas are often referred to as snowbelts, and pronounced snowbelts and other leeward effects occur east of lakes Erie, Huron and Superior. Another lake effect occurs around Lake Superior, the largest freshwater lake in the world. Its proximal effects include coastal fog zones in the summer, resulting in reduced sunlight, cool temperatures, and the presence of remnant coastal arctic ecosystems. Average snowfall varies between 700 mm in the northwest region of the ecoregion, to over 1,000 mm in the snowbelt areas.

Spring and fall seasons of the Great Lakes region see frequent cloud cover and occasional thunderstorms resulting from the alternating cold and warm air masses moving quickly through the region. In the spring, generally the land in the region warms more quickly than the water of the Great Lakes, which tends to allow the land adjacent to the lakes to have a longer period of cool conditions. This longer dormancy period promotes the survival of tender plants and plants characteristic of more southern and warmer climates by protecting them from late frosts. This is one of the reasons why orchards and vineyards thrive in the shadows of the lakes.

The climate of the Great Lakes has been dynamic during the postglacial Holocene epoch. It has included warmer periods such as the Hypsithermal, during which there was significant eastern and northern progression of species beyond their previous ranges. Prairie, savannah and, likely, alvar associations were established in southern Ontario during that period. Cooler periods have occurred since then, resulting in the southward contraction of tree-species ranges, such as Red Pine. Recently, the climate has warmed again dramatically, without evident impacts yet on natural vegetation but with extended growing seasons northward.

Other meteorological occurrences at medium scales include tornadoes, with a major track running west to east through central southern Ontario and storm-related down bursts, with impacts recently documented at Rondeau on Lake Erie. Finally, ice storms have had major impacts at landscape scales, such as in eastern Ontario in the 1990s. All of these meteorological impacts can be characterized as primarily setting back, but not significantly changing, natural succession at local and subregional scales.

Overall, the moisture gradient across the region varies from drier conditions in the northwest to more moist conditions in the south and east. Fire histories indicate more frequent and extensive fires in the north and west, especially on well-drained landforms with conifer (boreal) cover. In contrast, in mesic southern deciduous forests, fire is not a major agent of change, and natural disturbance regimes work at much finer scales, down to the scale of individual tree replacement and storm events (Larson *et al.*, 1999).

2.3 Geology and Landforms

Over four billion years ago, a fracture in the Earth running from Lake Superior to what is now Oklahoma created volcanic activity that nearly divided North America. Lava flowed intermittently from this fracture over the next 20 million years to form the igneous rocks of the Canadian Shield. Six hundred million years ago, central North America was covered by a shallow tropical sea. This sea deposited sand, salts, silts and calcium-rich bottom fauna, which were eventually compressed into limestone, sandstone, shale, halite and gypsum. Throughout the last two million years (the Pleistocene epoch), glaciers expanded and contracted out of the central

Laurentian basin of Hudson Bay and vicinity, with evidence of three major ice sheets occupying the Great Lakes region during that period (Thurston *et al.*, 1991-92).

The last of these glacial periods, the Late Wisconsinan, was primarily responsible for creating the current physiography of the Great Lakes region (Chapman and Putnam, 1984; Barnett, 1992). This glacier extended south of the Great Lakes during its glacial maximum about 20,000 years ago, and began deflating and exposing postglacial environments in southern Ontario about 14,000 years ago. The glaciers eroded highlands and enlarged and filled valleys and lowlands. Where they encountered more resistant bedrock in the north, such as volcanic deposits, only the overlying soil layers were removed. To the south, the softer sandstone and shale allowed the glaciers to dig out the large basins that make up the Great Lakes today.

The Late Wisconsinan glacier occupied the basins of the individual Great Lakes, which became the centres of particular ice-lobe movement patterns. On advance and deflation, and readvance and deflation, a pattern of major till plains and interlobate and end moraines were deposited across the region, largely defining the subsequent physiography. Major meltwaters were located under the glacier in some locations, and the movement of those waters, in some areas under pressure, resulted in exaggerated erosion in many parts of the central Great Lakes (Kor *et al.*, 1991). In addition, the glacial meltwaters occupied glacially depressed basins that extended as proglacial lakes and proto-Great Lakes over a much larger proportion of the landscape than is currently occupied by water (Dadswell, 1974; Barnett, 1992). Over a period of more rapid isostatic rebound of the land, these lake basins rose and their connecting channels and discharge channels to the Mississippi (first) and Atlantic (later) moved to gradually take up their modern positions. This landscape-wide water action reworked tills and moraines, and removed sediments from large areas of limestone plain and Canadian Shield, redepositing silts and sands in lowlands, proglacial lake basins and in progressively lower beach ridge systems.

The terrain in the northern portion of the Great Lakes ecoregion is dominated by granitic bedrock, referred to as the Canadian (or Laurentian) Shield, under a generally thin layer of acidic soils. In the southern portion of the Great Lakes, the glacier deposited sand, silt, clay and gravel in the forms of glacial drift or as glacial lake and river sediments. These glacial drift deposits include moraines, till plains, drumlins, and eskers. The Niagara Escarpment and the Oak Ridges Moraine illustrate the magnitude of glacial erosion and deposition, and the integral role that the glaciers played in the formation of the region's current landscape features.

The Holocene epoch of glacial deflation and meltwater accommodation was also the period during which vegetation re-occupied the landscape, with species moving northward into the basin from glacial-era refugia to the south, east and west of the region. Early arrivals were rapidly-colonizing tundra and boreal species. Pockets of the formerly widespread ice-front tundra vegetation persist now only in the low-competition, cold-climate shores of Lake Superior, having disappeared elsewhere by about 11,000 years ago. Boreal vegetation followed, and took up near-modern proportions and associations by about 11,000 years ago. Linked, vast shorelines of proglacial lakes and spillways provided connected open habitat, quite possibly the migratory routes by which Atlantic coastal species assemblages entered the Great Lakes basin (Jalava *et al.*, 2005) and by which western species occupied bare coastal limestone plains and alvars (Brownell and Riley, 2000).

Shoreline and alvar habitats have been extant long enough in the Great Lakes region to have given rise to a small group of endemic plant and animal species. Other alvar and shoreline species are peripheral in their distributions, with almost all of them also occurring in extraglacial areas south, west and east of the last regional glacier. Migration of species from the south into the region was a progressive movement of largely eastern North American species into, through and beyond the Great Lakes region. The pattern of first-arrival times has been documented from pollen records. Aquatic vascular plants and freshwater fishes probably followed similar routes into the Great Lakes region, with a major migration northward through the west Mississippi basin (see Species Migration and Eastern Species, in Riley, 2003).

Areas with milder climates, such as low-lying landforms (Brown *et al.,* 1980), and with nutrient-rich limestone bedrock, generally provided conditions that were more favourable for northward migration. Probably the most important route for species movement into northern Ontario was the limestone-based Michigan Peninsula, which was unglaciated and lake-free 3,000 years before much of southern and central Ontario. Other major pathways to the north were around the east and west ends of Lake Erie, the Ottawa Valley (Soper, 1962; Cody, 1982), Bruce Peninsula – Manitoulin Island, and along the lake-moderated coast at the east and west ends of Lake Superior (Chapman and Thomas, 1968). These routes provided receptive terrain northward past the barren shield landscapes east of Georgian Bay and on the Algonquin Precambrian dome. Evidence of such migration is provided by residual distribution patterns of certain species.

Throughout the basin, the Holocene has witnessed landscape drying, through uplift and draining of the land. At the same time, the landscape has paludified, as soils have developed and been moistened through humification and in-silting, and through the accumulation of organic matter (and peat) in anaerobic environments. This has given rise to a growing range of wetland and aquatic systems.

2.4 Landscape Patterns and Fragmentation

A variety of landscape patterns may be considered indicators of biological diversity, ecological integrity and resiliency of ecosystems. These include fragmentation and the reduction of habitat-patch size due to urban and suburban development, agricultural conversion, natural-resource extraction, roads, railways and utility corridors. There are also relationships between landscape patterns, anthropogenic activities and pressures on the land, and the abundance and variety of species that flourish in an area. Many land uses result in habitat loss and fragmentation, with adverse impacts on biodiversity. Landscape patterns can alter species and ecosystems in many different ways and at different geographic scales; therefore the magnitude of fragmentation and its context is also important. Landscape patterns are often summarized in the context of fragmentation as the two are often intertwined in settled landscapes.

In the Great Lakes ecoregion, the landscape has been altered to varying degrees from the historic and presettlement conditions. By 1920, approximately 90% of the original woodlands south and east of the Canadian Shield had been converted to non-forest uses such as urban settlements or agriculture. After a focused effort was made to conserve and replace upland woodlands since the 1920s, these woodlands still cover less than 20% of their original extent (Larson *et al*., 1999). Wetlands were widely distributed throughout southern Ontario before 1800, covering 2.38 million ha. By 1982, 0.93 million ha remained, a reduction of the original wetland area by 68% south of the Canadian Shield. The most severe decline has been in southwestern Ontario where over 90% of the original wetlands have been converted (Snell, 1987). Southern Ontario's prairies and savannahs are estimated to have covered 82,000 ha at the time of European settlement. Currently less than 3% of these prairies and savannahs remain. The three largest remnants at Grand Bend - Port Franks, Windsor and Walpole Island First Nation represent 2.6% of the estimated original extent in Ontario, while the remainders occur as small remnants. Agriculture, urbanization and the suppression of ground fires are the main causes of prairie and savannah loss (Bakowsky, 1993; Bakowsky, 1999).

The biological impacts of fragmentation across southern Ontario’s settled landscapes have been considered in additional detail elsewhere (Riley and Mohr, 1994; Larson *et al.*, 1999).

On the Canadian Shield portion of the study area, large tracts of forests of this area are allocated for forestry and timber management. The late 1800’s and early 1900’s resulted in intensive harvesting and clear-cuts particularly of pine stands. Large areas of mechanized logging have converted many aspen and birch forests in order to maintain a dominance of conifer species (Ricketts *et al.*, 1999). Habitat fragmentation has principally occurred as a result of forestry practices (harvesting and logging road creation), however large portions of the Canadian Shield still remain as intact habitats and habitat fragmentation exhibits relatively low impact on species. However, fewer patches of old-growth forests remain, which affects the sustainability of some species dependent on such habitat (OMNR, 1994). Fire suppression, mining development and road construction also contribute to fragmentation across the landscape on the Canadian Shield. The biological impacts of fragmentation have been considered in additional detail elsewhere (*e.g.*, Buse and Perera, 2002; Canadian Boreal Initiative, 2003; Jalava *et al.*, 2005).

2.5 Vegetation

When the first Europeans arrived in the Great Lakes ecoregion 400 years ago, they encountered extensive oak, maple and other hardwood forests dominating the southern portions, interspersed with drier-site prairies, sand barrens, woodlands and alvars, and wetter-site swamps, marshes and other wetlands. Conifer and mixedwood forests dominated the more central and northern regions, interspersed with rock barrens, open water, bogs and other wetlands. Although many of these ecosystems have been fragmented and others have been nearly eliminated, the Great Lakes ecoregion exhibits a high level of diversity in its natural environments. Examples range from internationally recognized coastal wetlands, to sand dunes and limestone alvars, to the species and habitats of the Carolinian Zone, to rocky shores of Lake Superior and Georgian Bay, to the mosaic of forest types of the Great Lakes - St. Lawrence forest region and the boreal forest region. The Great Lakes basin sustains Carolinian, boreal, Arctic, Atlantic coast and western montane species, as well as a number of endemic species and subspecies that have evolved along the shores of the Great Lakes.

Rowe (1972) maps and characterizes three distinctive forest regions dominating the Canadian portion of the Great Lakes basin. These are, from south to north:

a. *Deciduous Forest Region (the Carolinian Zone)*, more widespread southward in the U.S., and dominated by Sugar Maple, Beech, White Elm (formerly), Basswood, Red Ash, White Oak and Butternut, with range-limit species such as Tulip Tree, Cucumber Tree, Pawpaw, Red Mulberry, Black Gum, Blue Ash, Sassafras, and a variety of oaks and hickories;

b. *Great Lakes – St. Lawrence Forest Region*, mixed forest of White Pine, Red Pine, Eastern Hemlock and Yellow Birch, co-dominant with Sugar Maple, Red Maple, Red Oak, Basswood, and White Elm (formerly); and

c. *Boreal Forest Region*, with White Spruce, Black Spruce and Tamarack as characteristic species, admixed with White Birch, Trembling Aspen and Balsam Poplar, and Great Lakes species like White Pine, Red Pine, Yellow Birch, Black Ash and White Cedar.

Wetland types of the Deciduous Forest Region include inland, shoreline and Great Lakes marshes, mineral deciduous swamps and, very rarely, peatland swamps and bogs. Those of the Great Lakes – St. Lawrence Forest Region are predominantly deciduous and mixed swamps. South of the Canadian Shield, there are some inland, shoreline and Great Lakes marshes and, rarely, fens, bogs and swamps. On the Canadian Shield, there are a myriad of inland and coastal marshes and peatland edges, as well as numerous and widespread bogs, fens and swamps. Conifer and mixed swamps are frequent and deciduous swamps are rare. In the Boreal Forest Region in the study area, conifer swamps, thicket swamps and small bogs are frequent, with abundant, but small pockets of shoreline marsh.

3.0 Land Ownership and Management for Conservation in the Great Lakes

The following sections outline some of the different categories of land ownership, and the types of land designations and mechanisms for protection or conservation that are particularly relevant to an analysis of the conservation of the region's biological diversity.

3.1 International

Important Bird Areas (IBA) are sites identified as providing essential habitat for breeding or non-breeding birds according to their significance (based on specific bird population thresholds) as either globally, continentally, or nationally significant. These sites may contain threatened species, endemic species, or species representative of a biome or exceptional concentration of birds. The land can be comprised of a mixture of private, provincial and federal holdings. The IBA designation does not provide legislative protection but can be a catalyst for public awareness, stewardship and other conservation activities for these areas. The study area includes 51 identified IBAs.

Other internationally recognized conservation initiatives in the Great Lakes ecoregion include Ramsar Convention wetlands and UNESCO World Biosphere Reserves. The latter include the Niagara Escarpment, Long Point, Eastern Georgian Bay and Thousand Island – Frontenac Arch World Biosphere Reserves. These areas were not specifically included in the Conservation Blueprint but are well documented areas comprised of many other mapped features (such as ANSIs, provincially significant wetlands, provincial parks) that are included as protected areas and conservation lands in the Conservation Blueprint.

3.2 Federal

Approximately 2% of the lands of the Great Lakes region are under federal jurisdiction and about half of these are regulated as protected areas. About 0.27% of southern Ontario and 1.4% of the Canadian Shield portion of the study area are federally regulated for protection.

Of these federal protected areas, National Parks represent nationally significant examples of Canada's natural and cultural heritage. They are protected and managed under Parks Canada on behalf of the people of Canada. Parks Canada also manages national historic sites (recognizing significant places, persons and events), and National Marine Conservation Areas (marine areas managed for sustainable use and biodiversity protection). Parks Canada manages its lands in support of their ecological integrity. They are among the most strictly protected of Canadian lands.

Federal Migratory Bird Sanctuaries (MBSs) are managed by the Canadian Wildlife Service to prohibit the disturbance of migratory birds, their eggs and nests, and their habitats.

Federal National Wildlife Areas are also managed by the Canadian Wildlife Service to conserve essential habitats for migratory birds and other wildlife species, particularly endangered wildlife.

Other lands under federal jurisdiction but not included in this study are Department of National Defense properties, Atomic Energy of Canada Limited properties, First Nations lands, Canadian Heritage Rivers, National Capital Commission lands and other lands such as the Downsview park.

3.3 Provincial

Almost half (49%) of the Canadian Great Lakes region is public land in the form of provincial Crown land. This comprises 5% of the lands of southern Ontario and 77% of the land on the Canadian Shield. About 10.5% of the Canadian landbase of the Great Lakes region is protected as provincially regulated protected areas (provincial parks and conservation reserves) and, with a few exceptions, all of these occur on provincial public lands. About 0.5% of southern Ontario is provincially protected, and 17% of the Canadian Shield portion of the study area is provincially regulated as protected area.

Provincial parks are managed by Ontario Parks (OMNR) to ensure that their natural and cultural values are retained and enhanced for the benefit of present and future generations. Four key objectives of Ontario Parks are protection, recreation, heritage appreciation and tourism. Provincial parks are classified as six park types: wilderness, nature reserves, waterway, natural environment, historic and recreational parks. The extent of regulated parkland continues to grow, as the recommended parks from the Ontario Living Legacy Land Use Strategy (OMNR, 1999) continue to be regulated. The vast majority of these areas are strictly protected as natural environment, nature reserve or wilderness parks, with only minor recreational development zones, and without hydroelectric generation, mineral development or logging (except in parts of Algonquin Provincial Park) permitted.

Conservation reserves complement provincial parks to protect representative natural areas and special landscapes. Most recreational and non-commercial activities, such as fur harvesting, fishing and hunting, are permitted within conservation reserves if they are compatible with the values of the reserve and do not threaten their natural ecosystems and features. There is also ongoing regulation of candidate conservation reserves recommended during the Ontario Living Legacy Land Use Strategy.

The analysis in this report includes all regulated and candidate provincial parks and conservation reserves. Other lands that are identified provincially but are not acknowledged in this study are Wilderness Areas. These are parcels of Crown land regulated under the *Wilderness Areas Act*, which are often within provincial parks and protected areas. Forest reserves and enhanced management areas, identified in the Ontario Living Legacy Land Use Strategy, were also not incorporated into this study.

The remainder of Ontario's provincial Crown land is managed under a general use designation, with some areas identified or designated as wildlife management areas, Crown game preserves, fish sanctuaries, forest management areas and restricted access areas. These areas were not analyzed in this study. It is also worth noting that significant portions of the unregulated (unprotected) Crown landbase are set aside from harvesting through Forest Management Planning by the Province and forest license holders. These, and all other intervening lands, make significant contributions to the maintenance of regional biodiversity, particularly of wide-ranging species and characteristic ecosystems, and their sustainable management (and the management of wide-ranging, harvested species) is considered integral to the successful development of conservation strategies in support of the region's biodiversity.

3.4 Other Conservation Lands

The Canadian portion of the Great Lakes region has a variety of lands identified for conservation by means other than formal regulation. Such lands are nevertheless critical to the conservation of biological diversity. They are identified by consistent methods to recognize such areas' biodiversity, and have been incorporated into other legally mandated programs, such as land-use planning constraints and property tax reductions (see Section 5.1 for further detail).

Areas of Natural and Scientific Interest (ANSI) are areas of land and water containing natural landscapes or features that have been identified as having life science or earth sciences values related to protection, scientific study or education. ANSIs are afforded protection from development or site alteration under the Provincial Policy Statement, 2005. These areas can be identified as having provincial or regional significance and can be situated on Crown or private land. The OMNR administers the ANSI program. Approximately 2.5% of southern Ontario and 0.43% of the Canadian Shield is identified as provincially significant life science ANSIs, constituting approximately 1.2% of the Great Lakes region.

The OMNR is also responsible for wetland protection. Wetlands are evaluated through OMNR's Ontario Wetland Evaluation System. If wetlands are evaluated as provincially significant wetlands (PSWs), they are afforded protection from development and site alteration under the *Planning Act*, if they occur in OMNR ecoregions 5E, 6E and 7E, the southern two-thirds of Ontario's Great Lakes basin, or on any of the Great Lakes coast (PPS, 2005). Evaluated wetlands can occur on either Crown or private land. Approximately 4% of southern Ontario and 0.25% of the Canadian Shield has been identified as provincially significant wetlands, constituting approximately 1.7% of the Great Lakes region. Some of the highest-scoring of these PSWs are also ANSIs.

Ontario's network of 38 Conservation Authorities (CAs) manages and protects local ecosystems and water resources on a watershed basis. CAs maintain secure supplies of clean water, protect communities from flooding and contribute to the municipal planning process regarding water protection. These organizations acquire land for conservation and recreational purposes. Individual CAs define their own conservation areas, usually based on the importance of the land or shoreline to its watershed. These lands were secured using public and private funding in the period of 1945 to the present. These lands can only be sold by permission of the Minster of Natural Resources, and are eligible for property tax reduction under the *Conservation Land Act*. These lands cover over 111,000 ha and constitute the largest component of secured conservation lands in southern Ontario, parallel to the role of provincial parks on the Canadian Shield.

The Rouge Park, in the Rouge River watershed of Toronto, is a partnership between the Province of Ontario, Government of Canada, the Toronto Region Conservation Authority, municipal governments and other agencies. It is the largest park created within an urban area in North America (3,694 ha).

The Nature Conservancy of Canada acquires properties for conservation based on a variety of biodiversity criteria and other general criteria. The NCC also manages conservation easements in which a landowner agrees to restrictions on certain activities that might threaten the environmental value of their land in order to ensure the protection over time.

Lands that have been conserved by organizations and conservation groups that were not included in this study because of lack of comprehensive mapping include areas secured through the Eastern Habitat Joint Venture program, Federation of Ontario Naturalists (Ontario Nature), Bruce Trail Association, Ontario Heritage Foundation, Carolinian Canada, Ducks Unlimited Canada and regional land trusts.

Other lands that have conservation value managed at the municipal level but are also not included in the analysis include municipal parks and open spaces, agreement forests and Environmentally Sensitive Areas (for lack of comprehensive mapping across the region). Their absence from this analysis does not mean that they do not play an important role in the conservation of the region's biodiversity, but that their incorporation into similar types of analysis will deserve to be done through more local studies.

3.5 Private

Nearly half of the Canadian portion of the Great Lakes ecoregion in Ontario is privately owned, 93% of southern Ontario and 21% of the Canadian Shield (Figure 2). These private (or patent) lands are integral to the ecological and economic health of the province, and they similarly play a major role in maintaining regional biological diversity.

It has long been recognized in Ontario that the conservation of nature will succeed to the degree that private landowners are encouraged, thanked and supported in their stewardship of natural areas. This includes the predominant agricultural landownership of southern Ontario, and extends to the landowners of private woodlands and waterbodies, recreational lands, and industrial and infrastructure land assemblies.

Several non-government organizations, conservation groups and land trusts enter into conservation easements with landowners, whereby the landowner agrees to restrictions on certain activities that could interfere with specific environmental values of their land while ensuring the protection of the land from future development. Such easements are perpetual legal covenants attached to property deeds. Other formal and informal land-stewardship agreements are in place on many private lands, in support of wildlife-habitat projects, wetland-enhancement projects, nature trails, and other conservation-related goals.

4.0 Threats to Biodiversity

A 1999 survey found that 98% of Canadians agreed that nature in all its variety is essential to human survival and that Canadians spend an estimated 10 billion dollars a year on a number of nature-related activities (Canadian Wildlife Service, 2004). Current trends show that Canadians increasingly recognize the value of a holistic approach to promote healthy ecosystems as being essential to human health, sustainable development and the management of the natural environment (Taylor and Gowanlock, 2003). The Canadian government has also committed to maintain biological diversity by signing the United Nations Convention on Biological Diversity in 1992. However, despite these positive trends, portions of the Great Lakes ecoregion have continued to be altered to the detriment of overall biodiversity throughout the last century. The consequences of these changes have only recently become apparent. The predominant threats to biodiversity include habitat loss, land use and development, incompatible recreational uses, exotic and invasive species, point and non-point pollution and climate change. These threats are outlined in the following sections.

This suite of interacting, systemic and, in some cases, global threats, poses the serious question of how to design conservation strategies that can be sufficiently resistant, robust or viable to be self-sustaining over generations, or a century. It has been suggested that identifying and protecting supportive ecological systems throughout the geographic range of a species will allow the potential genetic and ecological variations of species to be conserved (Scott *et al.*, 2001). The approach taken in the design of the Conservation Blueprint portfolio is to identify, for each of the 39 ecodistricts comprising the region, the best examples of remaining ecological systems, and then include all already committed protected areas and conservation lands, and the specific known habitats of species and habitats at risk in sufficient numbers as to sustain them. By complementing the current protected-area system we can further enhance a network of protected areas to achieve more focused biodiversity conservation goals for the species and vegetation communities of the Great Lakes ecoregion.

This achieves well-distributed representation of conservation features, but leaves two challenges for further analysis:
(1) How much intervening or adjacent lands need to be added to these core biodiversity conservation areas (the portfolio sites) in order to sustain landscape-scale ecological functions and withstand the worst impacts of the threats to biodiversity?

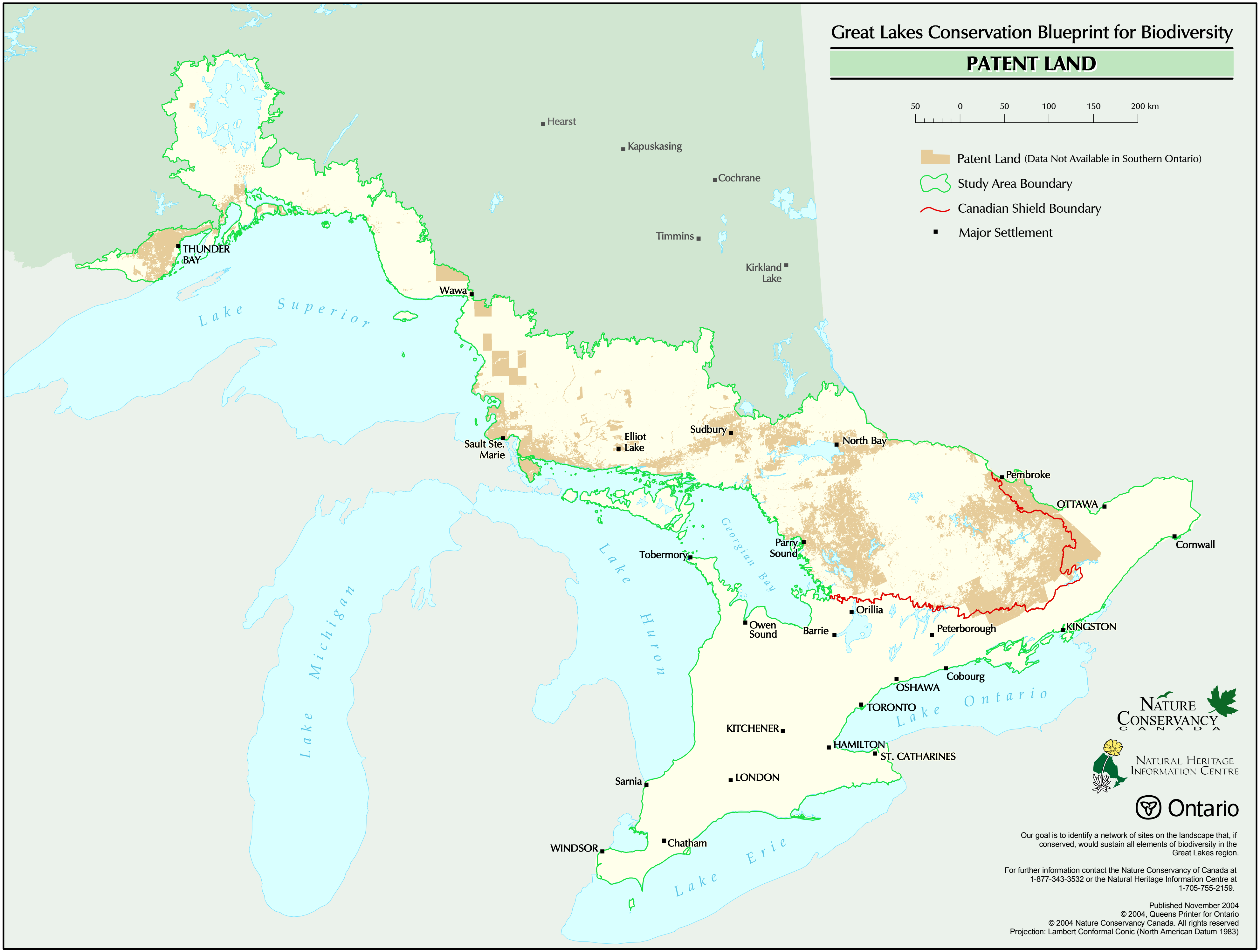


Figure 2. Patent land within the Great Lakes region. Data was not available for Southern Ontario.

(2) How is the portfolio sites identified here arrayed on the landscape in relation to the natural gradients of environmental change on those landscapes?

Both of these questions present the challenge of how to apply the assembled data to the design of priority conservation sites large enough (even if through restoration) and inclusive enough of environmental gradients (such as wet-to-dry, high-to-low elevation, southfacing-to-northfacing, coastal-to-interior, aquatic-to-terrestrial) to optimize their permanence as natural areas on the landscape.

4.1 Habitat Loss

Arrhenius first formalized the relationship between the number of species and the area of observation into an empirical law of ecology in 1921. This relationship is often used as the basis from which one of the many measures of diversity can be derived. The correlation between the size of an area and the number of species associated with that area is often the foundation to predict species loss following habitat loss (Brooks *et al.*, 2002). In general, the extent of habitat loss is a fairly good predictor of its number of threatened or extinct endemic species.

Habitat within the Great Lakes ecoregion has been significantly altered in the last 150 years. The majority of the remaining forests have been cut at least once and the soils that were suited to agriculture have since been altered from the pre-settlement forest, prairie or wetland conditions. Other portions of these ecosystems have been converted to urban and cottage development, transportation corridors and industrial areas.

Some of the habitats that have been lost are irreparable, making it difficult for the preservation and protection of wildlife species that require these habitats for part or all of their life cycle. Additionally, the existing food resources that once supported a higher population density now exhibit increased demand. If the remaining resources are insufficient to support all or part of the population, detrimental effects on the remaining species populations could continue to occur (Bender *et al.*, 1997; Norris, 2004). Some species in the Great Lakes ecoregion have become extinct as a result of these changes, and many others are being threatened.

In southern Ontario, where such data have been calculated, more than 70% of all pre-settlement wetlands have been converted (Snell, 1987); more than 99% of prairies and savannahs have been converted (Bakowsky and Riley, 1994); and about 94% of upland forest has been cleared and ploughed (Larson *et al.*, 1999).

On a largely converted working landscape such as southern Ontario, fragmentation has reduced most natural cover to polygon sizes less than the ‘landscape scale’. Both conservation and restoration are matters of concern and will require leadership for future conservation success. As a result, there remains a challenge to produce generalized and efficient coarse-scale mapping of coincident, contiguous, or neighbourhood aggregations of remnant ‘functional sites’ that could, given sufficient conservation attention, grow into ‘functional landscapes’ over time.

4.2 Land Use and Development

Intensive land development in the Great Lakes ecoregion, particularly in southern Ontario, has been extensive in the past 150 years (Figure 3). This includes conversion of natural areas to agriculture, urban development, and cottage development particularly on the shores of inland lakes and the Great Lakes coastlines (Thorp *et al.*, 1997). The boreal forest of the Canadian Shield has also experienced an increase in development of non-commercial forestry, exploration for oil, gas and minerals as well as hydroelectric power development. However, the boreal region still remains more ecologically intact than southern Ontario, allowing an opportunity to implement strategies to conserve it (Canadian Boreal Initiative, 2003).

Figure 3. Land use within the Great Lakes region.

Urban development is extensive in the Great Lakes ecoregion with only six metropolitan areas representing about 67% of the Great Lakes population. Ontario is a destination for more than 57% of immigrants to Canada, and two thirds of these new residents (100,000 a year) have been locating in the Greater Toronto Area (Allardice and Thorp, 1995). The north shore of Lake Ontario, dominated by the Greater Toronto Area, has experienced a 50% population increase since 1970, and is expecting 3.71 million new residents, 1.75 million new jobs and 1.69 million new housing units by 2031 (Hemsom, 2005). Urban sprawl has spread more than 100 km from central Toronto resulting in a substantial cumulative loss of productive agricultural land (approximately 5,000 ha per year). From 1981 to 1986, urban development in the GTA consumed nearly 21,000 ha (Allardice and Thorp, 1995).

Agricultural development has slightly decreased in recent years, but Ontario still accounts for more than a quarter of the total value of Canadian agricultural sales from approximately 68,000 farms. Total farmland amounts to 1.35 million acres, with 62% of it devoted to crop production (Allardice and Thorp, 1995).

Manufacturing and other industries in the Great Lakes ecoregion account for more than 50% of Canada's manufacturing activity, relying heavily on the abundant water supply from the Great Lakes, using 2 million gallons per day. Canada's four largest integrated mills are all in the ecoregion, and Ontario also has more than 80% of Canada's vehicle assembly work (Allardice and Thorp, 1995). Industry continues to expand in Ontario with the concentration in labour-intensive and resource-intensive industries such as paper, lumber, furniture and textiles.

The impacts of these land uses have been documented, and their effects on biodiversity have been varied. There is often a decrease in habitat quality, species richness and abundance and community composition with the effects varying over a distance gradient from the land use (Crosbie and Chow-Fraser, 1999; Crist *et al.*, 2000; Theobald, 2003; Houlahan and Findlay, 2003). For example, Houlahan and Findlay (2003) found that the effects of adjacent land use on wetland amphibians were strongest at 200 m from the wetlands and that the effects of the adjacent land use can extend over comparatively large distances. This suggests wetland conservation should extend into a regional landscape context of areas of wetlands and forests.

4.3 Exotic and Invasive Species

Invasive plants and animals are now considered one of the most serious threats to global biodiversity. Invasive aliens can have a number of impacts upon a natural area, and can contribute directly or indirectly to loss of native biodiversity (Havinga and OIPWG, 2000).

Exotic or alien plants may not always be invasive. Kaiser (1983) reported that approximately 700 species or 27% of the total flora growing in Ontario are exotic. The vast majority of exotic species consist of garden escapes, yard weeds, and garden seed mixture contaminants that do not pose a problem in natural areas because they are restricted to urban areas, agricultural fields, and other highly disturbed sites. Other alien species, such as the Common Dandelion (*Taraxacum officinale*) or the Helleborine Orchid (*Epipactis helleborine*), do grow in natural areas but they occur in small numbers and do not appear to displace or significantly compete with the native flora (White *et al.*, 1993). Finally, there are some alien species that have the ability not only to grow in natural areas, but also are able to thrive at the expense of the original native flora, including European Buckthorn (*Rhamnus cathartica*), Garlic Mustard (*Alliaria petiolata)*, and Eurasian Water-milfoil (*Myriophyllum spicatum*). It is these species that are a cause for concern as they can displace existing native plants once they become established, some of which may include rare native flora. Native plants support a complex suite of species that may also become displaced with their host plants. For example, muskrats cannot use Purple Loosestrife (*Lythrum salicaria*) for food, and many birds such as the grebes and terns do not nest in it (White *et al.*, 1993).

The most significant threat to the dominant forest ecosystems of northeastern North America continues to be the casual, deliberate and recurrent introduction of forest insect and fungal pathogens that prey with great specificity on the dominant forest species of the Great Lakes region:

- Chestnut (effectively extirpated by a Eurasian fungus introduced via Europe, likely on Asian Chestnuts brought to the Bronx Zoo in 1904);
- Native Elm species (effectively extirpated by a Eurasian fungus introduced via Europe, likely imported on fungal burls used in cabinetry; found Bronx Zoo in 1909);
- American Beech (being reduced throughout its range by a European fungus first found in Halifax in 1890, and transported by a European scale);
- Butternut (now designated an endangered species in the Canadian Great Lakes region, still being reduced by a Eurasian fungus, first identified on imported breeding stock at the University of Wisconsin in 1967);
- Flowering Dogwood (seriously compromised by the Asian anthracnose fungus, thought to arrive via Washington State in 1979, and now found in the Carolinian forest of southwestern Ontario);
- Native Ash species (all targeted by the Asian Emerald Ash Borer, considered to have been imported into Detroit around 1999 on wooden shipping pallets, and being defensively targeted for control in southwestern Ontario); and
- All deciduous tree species are targeted by the Asian Longhorn Beetle, introduced into Toronto in about 1998, likely on wooden shipping pallets, and being defensively targeted for control in northern Toronto.

To these we can add introduced pathogens that have caused major declines of other tree species: oaks (by Gypsy Moth, from Asia via France to Massachusetts, 1869); and White Pine (by Blister Rust, imported on European pines *ca.* 1900; by Pine Shoot Beetle, from Eurasia, first found Ohio 1992; and by Pine Shoot Moth, from Eurasia, first found Connecticut). These forest pathogens have already significantly diminished the forests of the Great Lakes region, and their rates of introduction do not appear to be slowing. The routes of ingress and their origins are known. Volumetrically, this is <u>the</u> major impact on both biomass and biodiversity in northeastern North American forests. Finally, the rate of introduction of non-native insects into North American ecosystems is accelerating, without well-understood implications. There are currently at least 400 species of exotic insects that have become naturalized on native and introduced woody plants in forests, parks, and urban landscapes in North America (Mattson *et al.*, 1994; Niemelä and Mattson, 1996).

4.4 Recreational Uses

Recreation in the Great Lakes ecoregion became an important economic and social activity in the 19th century when boating, fishing and canoeing became popular pastimes. The pleasure-boat industry has been thriving on the extensive lake and river systems. Niagara Falls attracted many travelers from great distances, which spurred the growth of a leisure-related economy for the region. As the industrial development continued, many people gained disposable incomes and shorter work weeks, and began spending time beyond the city limits. Land was acquired by the government and the parks system began to develop in order to protect not only valuable natural resources, but to also serve the recreational and relaxation needs of the growing population.

Opportunities for recreation currently range from pristine wilderness activities to the network of All-Terrain Vehicle (ATV) trails through forests and along waterways, to the intensive use of urban waterfront beaches. With the proximity to the international border and the accessibility to a major air transportation gateway, there are also significant numbers of international travelers in the ecoregion, with more than half of Canada's international visitors arriving in the country via southern Ontario (Allardice and Thorp, 1995).

Recreational development continues to intensify with some activities causing detrimental effects to the natural environment. For example, the extensive development of cottage areas, summer homes, beaches and marinas has resulted in the loss of wetland, dune and forested areas. The irreversible modifications to shorelines by developers and individual property owners have caused shoreline erosion, loss of fish habitat and alterations of the natural beach and wetland ecosystems and their associated species. Other uses, such as biking and hiking, may have severe localized impacts but fewer long-term effects if the activities were discontinued (Thurston and Reader, 2001).

However, it should also be recognized that although recreational uses are a threat to the quality of the Great Lakes ecosystem, they also provide a basis for protection by attracting and involving people who recognize the integrity of the ecosystem is essential to sustain the recreation that they value. Naturalists, anglers and cottagers are often among the first groups to bring environmental issues to the attention of the public.

4.5 Point and Non-Point Pollution

Toxic contaminants pose a threat to aquatic and terrestrial flora and wildlife species, as well as to human health. Humans depend on the natural environment to dispose of our waste products. Rivers, lakes and terrestrial lands have become repositories for industrial and residential waste. Some toxic substances biologically accumulate or are re-magnified as they move through the food chain and end up in the tissues of living organisms (Thompson-Roberts and Pick, 2000).

Long-term, low-level exposures are of concern because of subtle effects that toxic contaminants may have on reproduction, the immune system and development in young. Amphibians, for example, are key indicators of ecosystem health. Commonly used chemicals such as pesticides, herbicides and fertilizers have been found to be highly detrimental to frog populations. The reduced abundance and diversity of frog species are a warning signal about the impacts of pollution (Crump, 2001).

Sediments that were contaminated before pollutant discharges were regulated are another source of pollution. Even where it is possible to remove highly contaminated sediments, this removal can cause problems when sediments are placed in landfills that may later leak and contaminate wetlands and river systems (Brinson and Malvarez, 2002; De Simone Borma *et al.*, 2003).

Air pollution is another threat to the biodiversity, particularly for tolerant hardwoods. Air pollution and the acidification of soils increase the potential for nutrient deficiencies and imbalances, particularly on forest stands growing in shallow, poorly buffered soils. This results in a higher frequency and severity of decline (McLaughlin, 1998). A decline in these forests also results in impacts to the species dependent on these ecosystems, particularly bird species (Darveau *et al.*, 1997).

4.6 Climate Change

As industrialization and urbanization increase in the Great Lakes region, so do carbon dioxide and other greenhouse gas emissions. It is suggested that by the end of the century, temperatures in the Great Lakes ecoregion will have increased 3 to 7 degrees Celsius in the winter, and 3 to 10 degrees in the summer (Kling *et al.*, 2003). A warmer climate will allow for an increased level of evaporation at the surface of the lakes and evapo-transpiration from the surface of the surrounding land. This will increase the amount of precipitation returning to the atmosphere, and the resulting net basin supply of water will decrease by 23 to 50% (Government of Canada and the US EPA, 1995). The largest temperature increase is expected in northwestern and southern Ontario, with precipitation being predicted to decrease in these areas. However, an increase in precipitation is expected for northeastern Ontario (Colombo *et al.*, 1998).

Climate change may also result in a greater frequency of major insect and disease outbreaks in forests, directly influencing the age structure and composition of forest ecosystems. An increase in carbon dioxide levels will favour herbaceous plants over woody plants, allowing a shift in the competitive abilities of the dominant plant species in the ecoregion (Colombo *et al.*, 1998). It is predicted that throughout the next century, plant species will begin to migrate northward. For example, tolerant hardwood forests in central Ontario will advance to northeastern areas and the oak-hickory forests of the central United States may eventually advance into the Great Lakes - St. Lawrence forest region.

A warmer climate may also have a dramatic effect on the boreal forest and its associated fire regimes. Simulation studies have shown the potential for greatly reduced forest area in the boreal region and an increased level of fragmentation due to fire regimes that are highly sensitive to climate change. Fire response is directly associated with fuel moisture, which is affected by precipitation, relative humidity, air temperature and wind speed (Weber and Flannigan, 1997). With warmer, drier conditions the fire season will be extended, with concomitant increases in fire frequency, severity and the total area burnt.

Climate change may have direct impacts on wildlife as well. Long-distance migratory birds such as warblers and thrushes time their migration by day length rather than weather, possibly resulting in reduced food sources by the time they arrive in the region. Resident birds may begin their breeding earlier and raise more young per season which could further decrease the food availability for migratory songbirds, ultimately reducing the forest bird diversity in the region (Kling *et al.*, 2003).

If summer conditions become warmer and drier in continental regions and winters become milder and wetter, summer droughts could cause streams and wetlands to shrink, resulting in peat loss and bog contraction. This shrinkage combined with land use changes and habitat fragmentation may reduce the number and type of refugia for species, particularly those with limited dispersal capabilities. However, an excess of decomposition will lead to bogs becoming a carbon source - a positive feedback in global warming (Moore, 2002).

On the basis of such likely changes, how should conservation actions anticipate climate change? Theoretically, some conservation sites should be large enough and oriented well enough to cross and include the natural gradients of environmental change on the landscape, across which gradients climate change may force vegetation change. Such sites should incorporate gradients of altitude (low to high), moisture (wet to dry), aspect (south- to north-facing), substrate permeability (porous to impermeable), exposure (coastal to interior) and habitat (*e.g.*, mosaics). However, these kinds of design considerations are hypothetical at present. Suffice it to say that the available biodiversity data should be considered in terms of the design of priority conservation sites that are large enough (even if through restoration) and inclusive enough of environmental gradients to optimize their permanence as functioning natural areas.

5.0 The Great Lakes Conservation Blueprint Portfolio

A Conservation Blueprint is an attempt to assemble, catalogue, classify, map and analyze the available information on the biological diversity of a natural geographic region. Such an atlas of biodiversity data has many applications, and the particular application that NCC committed its resources to was *"the identification and assessment of the places across the Great Lakes ecoregion that, if appropriately conserved, would sustain the biodiversity of the region"*. This may or may not be achievable, but remains the challenge for conservation professionals.

The Conservation Blueprint project is part of a history of such efforts across the Canadian half of the Great Lakes basin. The Canadian basin lies entirely within the Province of Ontario, which has pursued protected area programs for more than a generation, and whose agencies were interested in partnering in this Conservation Blueprint.

The Great Lakes Conservation Blueprint Project is the first-ever GIS-based, landscape-level analysis of aquatic and terrestrial biodiversity in the ecoregion, and this report focuses on the terrestrial analysis. The Conservation Blueprint analyzes results regardless of administrative jurisdictions or land tenure, and identifies additional sites of conservation importance or re-validates existing protected areas and conservation areas.

Representation of all natural community types is central to the initiative. Identifying and conserving representative systems provides the means to preserve the widest variety of species in conditions that support them best. Some of these are widespread, 'matrix' community types. Other biodiversity targets include community, species, landforms or ecosystems that are rare throughout their global ranges and require appropriate scale of representation on the landscape.

In recent years, detailed information on species and habitats has been translated into computer-based, digital formats that now allow conservation planners to analyze and share this type of data in new ways. An array of approaches have been used to map and identify conservation areas for priority in a variety of landscapes (Poiani *et al.*, 2001; Bowker, 2000). With the recent innovation of being able to analyze multiple data layers in a GIS environment, it becomes possible for prioritization models to be more replicable and less prone to subjective bias. However, none of these approaches is a substitute for expert knowledge and in-field verification (Zhou and Narumalani, 2003).

In the first prospectus for the *"Great Lakes Terrestrial Conservation Blueprint"* (Nov. 1999), the challenge was stated as mapping *"all potential sites with biodiversity targets"*, analyzing their "*coincidence with existing protected areas and conservation lands"*, and designing "*an efficient and parsimonious portfolio of sites that together meet the targets and criteria*. The range of sites was described as including:

- small functional sites: conserving fine- and intermediate-scale biodiversity targets, with functionality in terms of the viability of target species or communities;
- large functional sites: conserving coarse-scale targets such as large matrix forest types, viable with respect to specific targets but not with respect to landscape-scale biodiversity;
- functional landscapes: conserving biodiversity at coarse, intermediate and fine scales, including common/matrix communities and species, with a high degree of intactness.

This was based on the experience of NCC in trying to work at appropriate site scales, and on the literature for ecoregional assessments. The first *Designing a Geography of Hope* (TNC, 1997) proposed the concept of "multiple-scale" sites, and subsequent discussions culminated in a framework inclusive of *functional sites, landscapes and networks* (Low *et al.*, undated; Poiani *et al.*, 2000; Groves *et al.*, 2000).

The consensus that biodiversity can be usefully characterized as a multiple-scale phenomenon (Noss, 1990) has been matched by an emerging consensus that conservation planning should also operate at multiple scales:

- functional sites (small/local-scale and large/intermediate-scale);
- functional landscapes (sub-regional/coarse-scale); and
- functional networks (regional/region-wide-scale) (Poiani *et al.*, 2000; *etc.*)

The Great Lakes Conservation Blueprint for Terrestrial Biodiversity, as presented here, identifies "functional sites", both small and large. Furthermore, it adopts the *"Big Picture"* approach (and its equivalent conservation value scores on the Canadian Shield) to characterize the "functional network" of remnant natural cover across the basin. It does not completely resolve the issue of the identification of "functional landscapes", which is especially problematic on highly fragmented and converted landscapes, where issues of restoration of intervening lands and waters become difficult challenges. However, the Conservation Blueprint provides the data necessary to that discussion, which it is hoped will become part of ongoing interpretation and refinement of the Conservation Blueprint.

5.1 Methods Context

Parks, Significant Natural Areas, ANSIs

The first Ontario effort to systematically inventory its natural areas was under the auspices of the International Biological Program (IBP) from 1969 to 1973. It was done by a small group of professionals with elite field skills, who collected original site data in a systematic format. This established a convention of naming and mapping natural areas in a standard way.

In 1975, Ontario Parks initiated a provincial survey of life and earth science natural areas to direct a growing park system, based on their objective "to protect provincially significant elements of the natural and cultural landscape of Ontario" (Ontario, 1978). Hence the concept of identifying 'provincially significant' features in a systematic way. The goal was to identify the suite of natural areas best representing the spectrum of natural landscapes, environments and biological communities in Ontario.

The concept of representation was central to distinguishing significant natural areas, as indicated in the same year by the Cabinet-endorsed goal of protecting "a system of features representative of Ontario's life science history and diversity". Areas so identified in the provincial park system became the nature reserve and wilderness classes (and zones) of provincial parks. Elsewhere, they were termed Areas of Natural and Scientific Interest (ANSIs).

Arising from the concept of representation was the question of the geographic context of that representation. Ontario scientists had earlier documented ecodistricts and ecoregions (site districts and regions) for use in natural resource planning and management (Hills, 1959 and 1961), revised in 1997 (see Jalava *et al.*, 1997; Riley *et al.*, 1997; Crins, 2000). As well, detailed mapping (1:250,000) of the physiography of southern Ontario was in wide use (Chapman and Putnam, 1973 and revised in 1984).

It was on the basis of this ecodistrict mapping and physiographic mapping that identification methods were developed. Evaluations of significant remnant natural areas were done for each of southern Ontario's ecodistricts (site regions 6E and 7E) by specialized field staff over the next 20 years (Riley *et al.*, 1997).

The first of these evaluations was released in 1976 for the Niagara Escarpment Planning Area (Cuddy *et al.*, 1976), and covered significant parts of ten ecodistricts. The sites were protected through a land-use planning designation – escarpment natural area – under the *Niagara Escarpment Planning and Development Act*. The standard method of these ecodistrict assessments is summarized in each report, and the general framework of comparative evaluations is outlined here to enable comparisons with the automated methods of the Conservation Blueprint.

The overall methods were conserved throughout the period of these studies even though they evolved over time to reflect new data and evolving scientific concepts. Available data included IBP data; museum and university collections; expert advice; agency files; historic, published and unpublished reports; landowner information; site visits; local natural-area studies; air photos and aerial surveys; topographic, geologic and soil maps. Over time, improved air photos and base maps at better scales were available, as were new data from atlases of rare vascular plants and breeding birds of Ontario. At the same time, other non-representation approaches using different geographic contexts (watersheds, regions and counties) were applied by conservation authorities and municipalities to document Environmentally Significant Areas (ESAs), or develop 'greenland' strategies, thus making available additional useful data. Another example of evolving methods was the new wetland classification systems that were adopted, so that representation targets moved away from wetlands in general to bog, fen, marsh, swamp and open water wetlands.

One of the key concepts was that all sites in an ecodistrict are evaluated. The studies reviewed all available biotic and abiotic mapping and all aerial photos of the ecodistrict, mapping results on 1:50,000 N.T.S. maps. This was complemented by airflights and field inspections, field mapping, reconnaissance species inventories, and vegetation-community documentation. Each site that was considered potentially significant was documented in a standard checksheet that identified the key features (biodiversity targets) of which the site was representative.

Representation was the key (coarse-filter) criterion. The overview of the natural features of the ecodistrict was summarized in tabular form, including the percent of each ecodistrict occupied by each physiographic region. An analysis was made of the dominant vegetation associated with each landform type, on the same table. The dominant vegetation-landform types (ecological systems) were classified, and these became the representation targets for selecting sites. The key secondary question then became how to determine the "best" representative natural areas. For this determination, four related criteria were applied:

♦ *Diversity*

Diversity was assessed as the number and range of vegetation-landform features at a site. The representation value of a site was often generally proportional to the diversity of habitats within the site, and to the size of a site.

♦ *Condition*

The degree of past disturbance of the main features of a site was assessed in terms of specific types of disturbance, recognizing that none of the sites in southern Ontario were pristine. In 2005, this remains a criterion that can only be determined through field inspection and, so, the fulfilment of this criterion remains a useful aspect of field verification of Conservation Blueprint results.

♦ *Ecological Functions*

Ecological considerations such as size, shape, buffering from adjacent land uses, watershed location, and connectivity to other natural cover were assessed. Larger sites were often more likely to sustain stable, diverse and viable natural communities. However, for some life-science features only small remnant sites were left, in such cases, sites that were close together or linked were ranked more highly. Headwater areas, and watershed units still with integrity, were also preferred.

♦ *Special Features*

Available information on the occurrence of rare and at-risk species, and those of phytogeographic interest, nesting sites for colonial birds, and concentration of breeding or migrating birds was considered. Because of the uneven state of such data at that time, this criterion was considered of secondary importance.

The dominant ecological systems of an ecodistrict were the primary focus of the representation analysis. The focus was on dominant themes because of the speed with which these studies were done. In retrospect, the shortcomings included insufficiently detailed classification systems and vulnerability-ranking systems for species and vegetation types.

The general rule-of-thumb for stratification of site selection was the one or two sites best representing the vegetation-landform themes of each physiographic region within each ecodistrict. These sites were termed "provincially significant" for policy purposes, and other sites that also ranked high on the basis of the selection criteria, but not judged the "best", were termed "regionally significant".

The analysis of best representative sites in an ecodistrict included an analysis of the representative features in existing *protected areas*, by which some ecological systems were considered adequately represented by some protected areas (based on the criteria above). Within provincial parks, these natural areas were considered candidate nature reserve zones for park management purposes.

In 1983, the OMNR released Land Use Guidelines for Ontario, which identified these significant natural areas as ANSIs. The most significant of these ANSIs were deemed provincially significant, and the Ministry made the commitment on public lands to "ensure that the land uses and activities, which occur, provide for the protection of identified values". On private lands, the commitment was that the Ministry would, "through cooperation with others, attempt to ensure that landowners are aware of significant features on their properties and seek the owners' cooperation in protecting such features". Collectively, this portfolio of sites was to provide "a focus for both the public and private sectors to contribute to the protection of Ontario's natural heritage" (Ontario, 1983a). Later, these sites became eligible for property-tax reductions under the Conservation Land Tax Incentive program.

Complementary Theme Studies

Over the same time, complementary studies were done on the best remaining natural areas *of particular ecological systems*. Most of these theme studies followed the same "representation framework" because it was the recognized vehicle for selecting "best representative" or "provincially significant" areas.

These theme studies complemented the coarse-filter, first-iteration approach of ANSI evaluations. Change-over-time analyses were done for particular ecological systems that were key to Ontario's biodiversity. For example, southern Ontario had lost 70% of its wetlands. Ninety-nine percent of Ontario's historic high-diversity prairies and savannahs were lost, and southern Ontario's upland forests had suffered a conversion rate of 94% over the period of historic settlement. As a result, it was clear that there were whole ecological systems "at risk" on southern Ontario's settled landscapes, and they deserved special conservation attention.

Some of the theme studies are mentioned below, particularly those that reached conclusions as to conservation significance of particular areas, and those that are mapped and tracked by the NHIC. These include both representation approaches and non-representation approaches. These results, as with ANSIs, became important data sources for the Great Lakes Conservation Blueprint.

<u>Representation Approaches</u>

Niagara Escarpment
This theme study for the Niagara Escarpment (Cuddy *et al*., 1976) focused on the particular ecological systems of the escarpment, and was a factor in the recognition of the Escarpment as an UNESCO World Biosphere Reserve. Twenty years later, a second ecological survey of the Niagara Escarpment was done (Riley *et al.*, 1995, 1996). It was the most detailed field inventory undertaken to that point on a regional scale, and it conformed to the earlier representation framework. It applied a more detailed assessment of i) vegetation-landform features ii) diversity, condition and ecological functions and iii) the conservation significance (rarity, vulnerability) of species and vegetation communities at global, national, provincial and regional scales.

Prairies and Savannahs
An inventory and evaluation of Ontario's remnant prairies and savannahs has been underway for ten years, and some of its interim results have been mapped and incorporated into local land-use planning. The methods parallel those used in the "representation framework" with a focus on prairie and savannah ecological systems (Bakowsky, 1993; Bakowsky and Riley, 1994).

Alvars
Great Lakes limestone plains and their unusual and characteristic flora and fauna were first documented as an ecological system in 1975 (Catling *et al*., 1975). Hence, they were generally overlooked in early ANSI ecodistrict reports. In 1996, private-sector foundations funded an International Alvar Conservation Initiative across the Great Lakes region, involving more than 50 scientists and stewardship professionals in original field studies. This culminated in a review of all Great Lake alvars (Reschke *et al.*, 1999), and a report on Ontario alvars (Brownell and Riley, 2000). In the latter, efforts were made to conform to the representation framework, using the same tabular analysis of representation and gap analysis.

Oak Ridges Moraine
An inventory of natural-heritage features on the Oak Ridges Moraine is being completed (Varga, in prep.). This is a second-iteration report on an earlier-studied ecodistrict but goes beyond the previous study in terms of detail and resolution. This report parallels the approach taken to the Niagara Escarpment but with much enhanced digital mapping. It will include tables summarizing its representation and gap analysis. The data on which it is based were the core data underpinning the protection of natural core areas and natural linkage areas through the *Oak Ridges Moraine Conservation Act*.

Eastern Georgian Bay Coast Project

The eastern Georgian Bay coast was the subject of two earlier ecodistrict reports, one south and the other north. Significant parts of the coast were regulated as provincial parks or conservation reserves through the Ontario Living Legacy program, and this led to a partnership between OMNR and NCC to complete an overall inventory of the area (Jalava *et al.*, 2005).

<u>Non-Representation Approaches</u>

Wetlands

A wetland-evaluation system and land-use policy were in place by 1992, and "provincially significant wetlands" and other wetlands have been identified, mapped and evaluated across most of southern Ontario. This work has involved several upgraded versions of the evaluation system, as well as significant investments in evaluation training, databases and mapping standards. Comparable evaluations are proceeding on the Canadian Shield.

Important Bird Areas

Non-government and agency researchers have pooled their resources to identify Important Bird Areas (IBAs) across Ontario. The "theme" of these studies was not an "ecological system" but a suite of species, in this case birds, for which particular areas of Ontario represent particularly significant percentages of their breeding, migratory or other habitat needs. The catalogue of IBAs resides with Bird Studies Canada.

Heritage Woodlands

A study of southern Ontario woodlands and their distribution, conversion and significance was completed in 1999 (Larson *et al.*, 1999). It tested evaluation approaches to older-growth woodlands.

Atlases, NHIC, and the Natural Area Database

Although not strictly comparable to theme studies, there is now a wide variety of other accessible data. Key elements of this are: Ontario's volunteer atlas projects (vascular plants, breeding birds, butterflies, mammals, odonates, herpetofauna); the expertise and capacity of the NHIC to act as a central repository for such data; and the establishment of a standard Natural Area Database within which to stockpile information on Ontario natural areas.

Conservation Lands and Land-Use Planning

April 1992 saw the first land-use policies for conservation under the Ontario *Planning Act*. This included special policies protecting provincially significant wetlands, and for supporting natural areas; "…*locally, regionally and provincially significant environmental features and areas and systems of natural areas be identified and protected from incompatible uses and development*."

In 1994, these policies were strengthened, and in 1996, and again in 2005, revisions were made to this Provincial Policy Statement (PPS) under the *Planning Act*. A number of different natural-heritage features became protected from incompatible land-use decisions regarding development and site alteration:

- natural heritage systems;
- significant habitat of endangered and threatened species;
- significant wetlands;
- significant coastal wetlands;
- significant woodlands south and east of the Canadian Shield;
- significant valleylands south and east of the Canadian Shield;
- significant wildlife habitat; and
- significant ANSIs

Some of these features were consistently mapped across the Great Lakes basin, and were thus important conservation lands to recognize in the development of a Conservation Blueprint.

This constraint on development was balanced by a program to support appropriate private landownership of such sites. In 1989, the *Conservation Land Act* enabled programs in support of the conservation of particular lands. This included the Conservation Land Tax Incentive Program, which provides significant property-tax relief to owners of provincially significant ANSIs, provincially significant wetlands, the critical habitats of threatened and endangered species, and lands designated Escarpment Natural on the Niagara Escarpment. These were the natural-heritage features for which there were standardized maps in place across most of the private landbase of the Great Lakes basin.

Natural Heritage Systems

Ontario municipalities, conservation authorities and others have developed, over the past 20 years, innovative approaches to natural-heritage planning and conservation, *viz.* greenbelt planning, greenway systems, *etc*. The motivation for such work was based on general public interest, supportive science (Riley and Mohr, 1994; Riley, 1999), and the 1992 provincial policy that "*locally, regionally and provincially significant environmental features and areas and systems of natural areas be identified and protected from incompatible uses and development*." Such "natural heritage systems" were identified and defined in 1994, and again in more detail in 2005, in the Provincial Policy Statement under the *Planning Act*.

In general, natural heritage systems are networks of conservation lands and waters linked, where possible, by natural or restored corridors. They include, but are not limited to, the categories of natural-heritage features cited above, as well as significant hydrological features. Their objectives are the conservation of biodiversity, ecological functions and viable populations of native species and ecosystems. Such systems also provide context for assessing the significance of some natural heritage features, and for assessing the effects of proposed developments.

These systems include high-value biodiversity areas and areas that buffer, connect and restore core biodiversity features. Their definition and mapping at municipal and watershed scales raised the challenge of whether such systems could be defined and mapped across all of southern Ontario, for example, and beyond. An important response to that challenge was the development of the "Big Picture" project.

The Big Picture Project

By the late 1990s, a number of the above noted features were digitally mapped to a standard format. However, they required further work to make the layers seamless and useful to landscape-scale planning:

- Provincial Land Cover (vegetation mapping);
- Protected Areas (parks, conservation reserves, wildlife management areas, *etc*.);
- Conservation Lands (ANSIs, provincially significant wetlands, tracked species element occurrences);
- Carolinian Canada Sites;
- Environmentally Significant Areas (but no provincial layer);
- Streams and lakes;
- Heritage (older-growth) woodlands;
- Areas of large forest interiors and high forest concentrations; and
- Alvars, prairies, savannahs, bogs, fens.

The possibility of mapping a natural heritage system for such a large area arose from the emergence of GIS technologies and the available digital data (Jalava *et al.*, 2001, 2002; Riley *et al.*, 2003). The motivations were i) to develop a GIS project in which a range of interested researchers could meet to reflect on how to develop best approaches ii) to explore the limits of the data and ensure they were seamless data layers iii) to test new hardware and software for such large data sets and iv) to motivate natural heritage planning.

The GIS method was based on the pixel-by-pixel approach used at a scale by the *Partnership for Public Lands* (Riley, 1998; Riley *et al.*, 1999), overlaying multiple spatial data layers for analysis using ArcInfo GIS software. The analytical goal was to identify a potential natural heritage system, based almost entirely on previous determinations of natural-heritage significance, and on the natural cover remaining on the landscape.

To develop "core" areas, all data layers were read through 25 metre pixels, with each pixel assigned positive conservation values based on cumulative pixel scores for measures of the following data:

- Natural cover
- Riparian areas and buffers
- ANSIs, wetlands
- Protected areas
- Older-growth woodlands
- Forest interiors >500 ha
- Forest-concentration areas
- Rare-species concentrations

This method adds no new knowledge of natural heritage values on the ground, but simply weights in favour of existing "natural" areas with some form of legislated protection or other digital documentation, such as areas with extensive forest cover, waterways, and concentrations of high-quality element occurrences (species populations or communities). Human-modified lands received negative or zero weighting in this. The resulting layer of pixel-by-pixel conservation values provides an intriguing 3-dimensional view of southern Ontario, and an arbitrary threshold value was established to pull out all the pixels scoring over that limit; these were termed core areas. The threshold was set carefully so as not to result in the elimination of key natural areas such as “provincially significant” conservation lands or already protected areas. No data on the distribution of Conservation Authority lands was available to this analysis.

A second challenge was whether natural links could be identified between core areas. To do this, a negative resistance or cost layer was calculated, based on digital coverages of urban areas and roads. Again, pixel-by-pixel scoring was done of these data layers, followed by a search for the “least-cost” links (or lowest pixel scores) between core areas, which tended to be areas of existing natural cover, especially riparian and streams. Where there was no natural cover between cores, the computer was asked to plot the shortest distance of least cost between cores, and assign a width of 200 m to that potential link. Finally, any natural cover (from the Provincial Land Cover layer) that was attached to core natural areas, or to existing or potential links between cores, was included as part of the final natural heritage system.

The final mapping is useful at fine scales because of its 25 metre-pixel base, and the accuracy of the underlying 1:10,000 Ontario Base Maps. However, it cannot be queried as to why particular sites are on the map, and it is not an analytical approach to questions related to fundamental principles; for example, the application of core selection criteria such as representation, diversity, condition, ecological functions or special features.

Lands for Life OMNR Gap Analysis

From 1997 to 2001, the Province of Ontario reviewed its land-use planning on public (Crown) lands (*Lands for Life*). Part of the program was to complete the parks and protected areas system in the area from the south end of the Canadian Shield north to *ca.* 50° north latitude. The conservation goal was to achieve representation of different age classes of each landform-vegetation type in each ecodistrict. Representation was the key criterion. Where they occurred in existing protected areas, the minimum size for sufficient representation was 50 ha or 1% of the areal extent of the type (whichever was greater), or the entire association if its areal extent within the ecodistrict was less than 50 ha (Crins and Kor, 2000).

The data used for landforms was the quaternary-geology layer for Ontario (1:1,000,000). The vegetation data was Provincial Land Cover data (generalized to 100 m pixels). The methods underlying this work were consistent with previous OMNR approaches, but focused on representation more than any other criteria (Crins and Kor, 2000).

The gap analysis for the *Lands for Life* planning initiative (later known as Ontario’s Living Legacy) resulted in the formal protection of many previously under-represented ecological systems in provincial parks and conservation reserves in central Ontario. These protected areas are included in the gap analysis of the Great Lakes Conservation Blueprint.

This was the first time in Ontario that life-science data were used in a GIS to develop a rule-based approach to gap analysis. The minimum size goal set for representation was conservative, and the resulting portfolio was considered by some to be less than necessary for the long-term maintenance of many biodiversity targets. It did not target species of conservation concern (or special features) except, in some cases, in the boundary delineation of sites.

Over the same period, the Partnership for Public Lands (Federation of Ontario Naturalists, World Wildlife Fund, Wildlands League and other NGOs) undertook a parallel exercise, based on some of the same mapped data (Riley *et al.*, 1999).

Room to Grow Projects

Following *Lands for Life*, the Province and the Partnership for Public Lands (PPL) acknowledged there remained gaps in the representation of central Ontario ecosystems (Blasutti *et al.*, 2001). The Ontario Forest Accord Advisory Board established a protocol to address Article 3 of the Accord: "*Support an increase to the existing representative parks and protected area system beyond the current 12%…through jointly acceptable processes.*" OMNR and PPL independently mapped coarse-filter targets that were under-represented. The two maps were merged into an 'overlapped gap map' that ranked areas by how much each target was represented (Blasutti *et al.*, 2001). The *Room to Grow* framework was an interim consensus that provided a way to implement on-the-ground conservation, but it did not aspire to being the next-iteration, science-based methodology.

Northern Boreal Initiative

The Northern Boreal Initiative was based on a Forest Accord commitment to develop and complete the protected area system north of 51° north latitude, as well as to determine the areas available for logging and mining as a result of First Nations' land-use planning (Lipsett-Moore *et al*., 2004). Recently Ontario Parks designed a framework for achieving representation of unique ecological systems (landform-vegetation types), stratified by age class, enduring features and focal species (Wolverine and Woodland Caribou) (Lipsett-Moore *et al*., 2004). This approach is similar to *Lands for Life* analyses in modeling the optimal network of areas to fill gaps of representation targets. C-Plan, a GIS-based decision support tool, is used to generate the most 'efficient' configuration of sites.

Conservation Blueprints

The U.S., Australia and Canada have made significant advances in conservation planning in the past two decades. The U.S. federal government sponsored State gap-analysis projects throughout the country. Australians have developed very useful software, and pioneered focal-species approaches. Each Canadian Province and Territory has its own protected-area strategy, based on unique analyses. The analysis of biodiversity 'hot-spots', both globally and locally, has been popular. Based on the data of Conservation Data Centres, and following a review of other approaches, The (U.S.) Nature Conservancy (TNC) developed an approach in *Designing a Geography of Hope* (Groves *et al.*, 2000) that has resulted in detailed biodiversity assessments of all U.S. ecoregions.

The Great Lakes Conservation Blueprint is one of these assessments, framed within the tradition of Ontario conservation planning. The similarities between the Great Lakes Conservation Blueprint, previous Ontario gap-analysis, and TNC ecoregional assessments are many, as noted in the following summary of methods. The approach taken here makes every effort to:

- Build on parallel past practices and develop consensus among scientific advisors;
- Generate accurate and replicable biodiversity targets and conservation goals at multiple scales (extending both to habitat classifications, ecological systems, and species occurrences);
- Be inclusive of existing protected areas and conservation lands;
- Share information widely; and
- Provide materials supportive of conservation strategies by a wide variety of conservation partners (Riley and Mohr, 1994; Riley, 2002).

5.2 Analytical Approach

The goal of the project was to identify the sites, landscapes and networks of sites that, if properly conserved, have the ability to sustain all elements of terrestrial biodiversity in the Great Lakes basin.

Our goal was achieved through a GIS-based analysis, by which a portfolio of core biodiversity conservation areas was identified across the region.

The methods used are explained in detail below. In general, they follow what is called a 'coarse-filter/fine-filter approach'.

1. Biodiversity targets were identified (species and habitat types at-risk, as were all representative ecological system types, which were assumed to provide the habitats required by not-at-risk species);

2. Conservation goals were set for target species, habitat types and ecological systems;

3. Conservation scores were calculated for every ecological system polygon, and the highest scoring polygons were selected based on stratified goals within each ecodistrict (the coarse-filter analysis);

4. Existing protected areas and conservation lands were included; and

5. Additional habitat polygons were added to ensure that species and habitats at risk were included at the levels established as conservation goals for those targets (the fine-filter analysis).

The analysis was done in a manner that permits reporting of biodiversity targets, conservation values, and protected areas and conservation land identities of any of the portfolio of sites. It also permitted the reporting of how many and which biodiversity targets were met by existing protected areas and conservation lands.

The terrestrial Conservation Blueprint study area was treated as two separate study areas as a result of their ecological distinctiveness. The geologies of the Precambrian Shield and the Paleozoic Lowlands are so distinct they are in different Canadian ecozones (ESWG, 1995), the Boreal Shield and the Mixed Wood Plains ecozones. Ecozones are the highest ecological classification level, reflecting areas of the Earth's surface representative of large and distinctive ecological patterns in abiotic and biotic features. The Canadian Shield supports relatively continuous natural vegetation cover, and natural-resource management, recreation and service industries are the dominant economic activities. On the Paleozoic lowlands to the south, natural vegetation has been largely converted for agricultural and urban land uses.

Splitting the ecoregion into two separate study areas also enabled use of more refined digital data that was seamless for one study area, but not necessarily for both. The southern Ontario study area consists of Ontario ecoregions 7E and 6E, and the Canadian Shield study area includes the ecodistricts of ecoregion 5E and ecodistricts 4E-3, 4E-1, 3E-4, 3W-5 and 4W-2 (Figure 2) (Crins, 2000; Jalava *et al.*, 1997).

The representation approach used in this analysis, and the selection criteria that were applied, were based on those used by the OMNR and Ontario Parks to identify provincial nature reserves, areas of natural and scientific interest (ANSIs) and Ontario Living Legacy sites (Crins and Kor, 2000). For each study area, some separate data layers, conservation criteria and methodologies were created. However, the common thread throughout the two methodologies was the application of the same five site selection criteria:

- Representation
- Diversity
- Ecological Functions
- Condition
- Special Features

Table 1 summarizes the GIS themes that were part of the decision-support model for the analysis, which are detailed in subsequent sections. See Brodribb and Jahncke (2003) and Johnston-Main *et al.* (2004a) for further details on the analysis for southern Ontario; and Henson and Brodribb (2004) and Johnston-Main *et al.* (2004b) for further details on the analysis of the Canadian Shield.

Figure 4. Great Lakes ecoregion and the associated ecodistricts.

Table 1. Gap analysis approach for ecological systems in the Great Lakes ecoregion.

Methodology	**Southern Ontario** (south and east of the Canadian Shield)	**Canadian Shield**
Representation	♦ Include representative examples of all ecological systems (combinations of landform/vegetation or l-v types). The goal was to select the highest scoring examples of the l-v types. These l-v units were the basis for the coarse-filter gap analysis. Where there were several equivalent options for filling the gaps, the other criteria were applied	♦ Include representative examples of all ecological systems (combinations of landform/vegetation or l-v types). The goal was to select the highest scoring examples of the l-v types. These l-v units were the basis for the coarse-filter gap analysis. Where there were several equivalent options for filling the gaps, the other criteria were applied
Condition	♦ Amount of natural area in adjacent landscape ♦ Distance from roads, urban areas and croplands	♦ Amount of natural area in adjacent landscapes ♦ Distance from roads, urban areas and croplands ♦ Not adjacent to or overlapping active pits and quarries ♦ Distance from railways and transmission lines
Diversity	♦ Wherever possible, when filling gaps select sites that contain multiple l-v combinations	♦ Wherever possible, when filling gaps select sites that contain multiple types of l-v combinations
Ecological Functions	♦ Size ♦ Amount of core area ♦ Hydrologic functions (riparian areas, river valleys, wetlands and Great Lakes shorelines) ♦ Coincidence with existing conservation lands ♦ Proximity to existing protected areas ♦ Overlap with Big Picture 2002 cores and linkage areas on the landscape	♦ Size ♦ Amount of core area ♦ Hydrologic functions (riparian areas, wetlands and Great Lakes shorelines) ♦ Coincidence with existing conservation lands ♦ Proximity to existing protected areas
Special Features	♦ NHIC element occurrence data for species targets and rare habitat targets ♦ Presence of other rare species	♦ NHIC element occurrence data for species targets and rare habitat targets ♦ Presence of other rare species

The degree to which the current system of protected areas (public) and conservation lands (public and private) supports these elements of biodiversity was also considered. Existing data suggest that publicly owned natural areas have a significantly greater number of globally and regionally rare species than privately owned natural areas, but both public and private areas complement each other in the conservation of rare species (Heagy, 1993; Lovett-Doust and Kuntz, 2002; Lovett-Doust *et al.*, 2003).

In general, the factors that were considered in designing the Conservation Blueprint were:

- Irreplaceability: Does a site contain the only or best example of a conservation target?
- Complementarity: Does a site add to or complement the conservation goals already met by existing protected areas or conservation lands?
- Efficiency: Does a site contain multiple biodiversity targets?
- Viability/Suitability: Are ecological processes and landscape functions in place to allow for their long-term persistence at a site?

5.2.1 Key Design and Selection Criteria

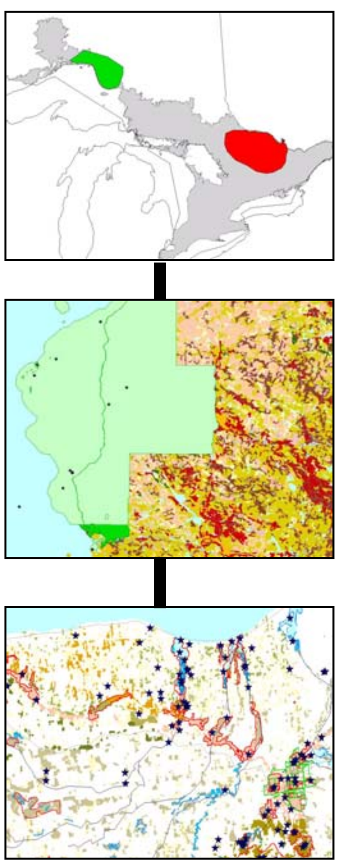
- It is important to account for the biodiversity targets being sustained by existing protected areas and conservation lands in Ontario. A gap analysis identifies the additional portfolio of sites that complement existing protected areas and conservation lands.

- Sites that are identified as having high “irreplaceability”, such as a site that supports a globally imperiled species, were given a high priority.

- Only populations of target species and rare habitats with high-predicted viability were considered in site selection. Viability was assessed based on information in the NHIC element occurrence database, and through GIS models of the landscape surrounding the target occurrence.

- Sites received additional scores when they contain multiple types of biodiversity targets, resulting in a more efficient portfolio.

- The Conservation Blueprint mapped biodiversity at several spatial scales to achieve a portfolio consisting of a network of sites at coarse, intermediate and fine scales (Figure 5).



Coarse Scale

- “Matrix” or dominant vegetation communities
- Habitat for wide-ranging species
- Large forested areas that accommodate infrequent but large-scale disturbances
- Important areas for sustaining bird biodiversity targets

Intermediate Scale

- Large patch vegetation communities
- Protected areas that accommodate most disturbance regimes
- Functional landscapes and networks

Fine Scale

- Small patch vegetation communities
- Rare species occurrences
- Core biodiversity conservation areas and functional sites

Figure 5. Achieving a Conservation Blueprint at multiple spatial scales.

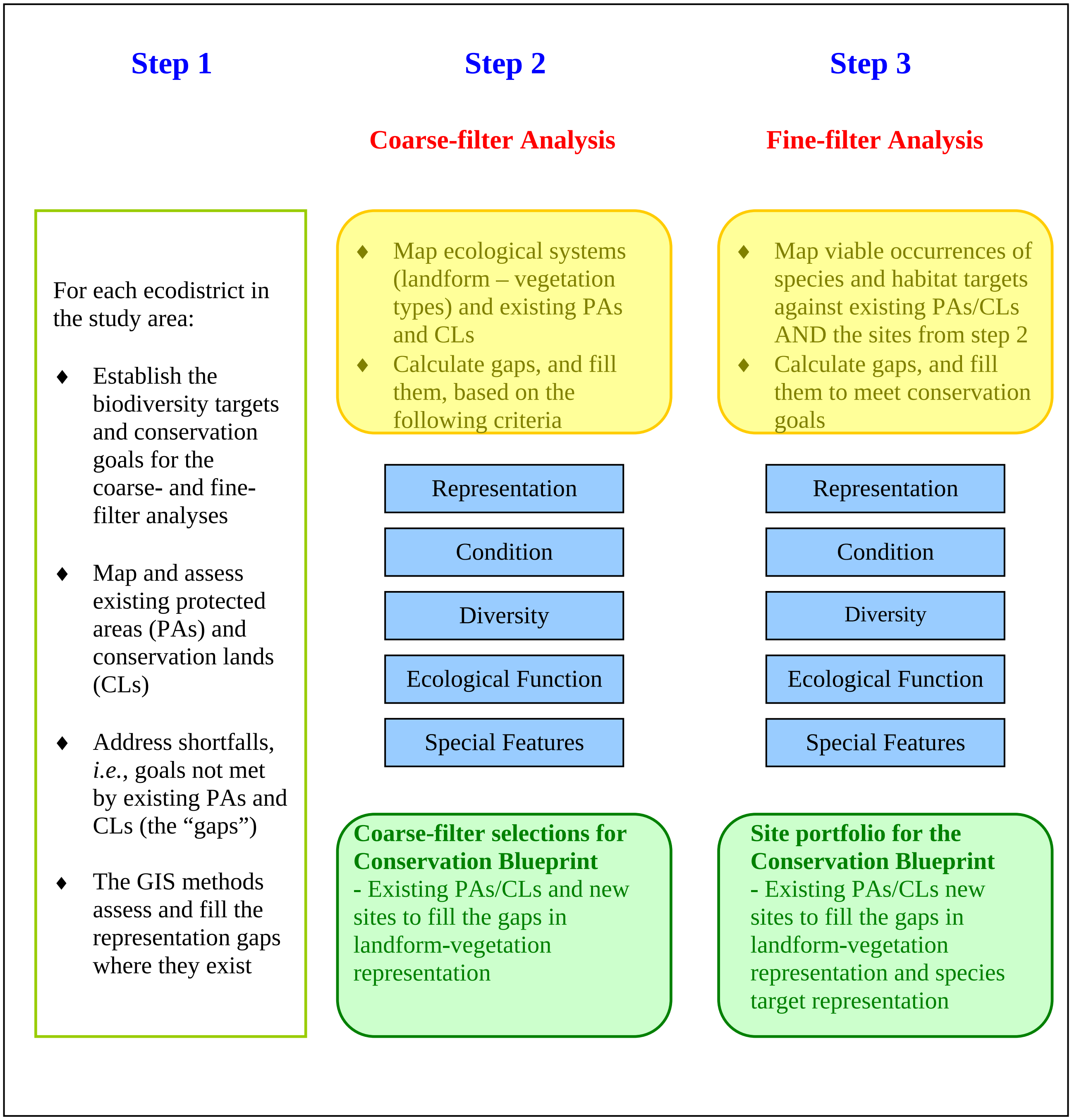


Figure 6. General methodology for the Conservation Blueprint gap analysis.

The general methodology for the gap analysis used for the coarse- and fine-filter targets is illustrated in Figure 6. This analysis was performed on an ecodistrict basis. Specific sets of GIS-derived variables were used to assess (and score) the condition, diversity, ecological functions and special features of target occurrences.

5.3 Biodiversity Targets

5.3.1 Ecological Systems (coarse-filter targets)

The coarse-filter analysis identifies sites representative of ecological systems and their component species. Representation based conservation strategies have been demonstrably more effective in identifying sites that support large-scale ecological processes and characteristic biodiversity than conservation strategies that focus on individual species or groups of species (Kintsch and Urban, 2002; Groves, 2003). In general, there is a predictable relationship between the size of a habitat and the number of species that an area can support, and as habitat area decreases over time, a loss of species occurs (Groves, 2003).

This study uses ecological system classification and mapping, derived by analysis of digital data, to compare sites with similar ecological systems and uses other digital data to select those systems best meeting the selected conservation criteria. This approach is also useful in identifying potential sites of rare species that prefer particular ecological systems, a feature especially useful for unsurveyed or highly fragmented landscapes (MacDougall and Loo, 2002).

Oliver and others (2004) corroborate that ecological (or land) systems can function as effective surrogates for biodiversity within an appropriate geographic distance or range for that system. Where some ecological system types are distributed farther apart on the landscape, biota of these ecological systems exhibited less similarity (Oliver *et al.*, 2004). For assessing representation, an ecological systems layer was considered to be the best surrogate for the characteristic biota of an area. The ecodistrict was the ecological land unit considered to be most suitable as the area within which vegetation-landform assemblages were similar enough for comparison. Ecological systems classification and mapping were completed *de novo* for this project; existing ecodistricts were used.

The ecological systems are unique combinations of landform and vegetation types, and were the basis for the coarse-filter analysis. The selection of representative landform-vegetation combinations in an area is the way to most predictably ensure that the elements of biodiversity associated with these features are selected. This approach is consistent with the approach that Ontario Parks and the OMNR use to identify candidate provincial parks and areas of natural and scientific interest (ANSIs). A variety of data sources were used to classify and map the ecological systems, or the landform-vegetation units for the southern Ontario and the Canadian Shield portions of the Conservation Blueprint (Table 2). Further detail on these layers is available in Section 5.5.1.1 of this report.

Table 2. Primary GIS layers used to identify the coarse-filter biodiversity targets.

GIS Layers	Southern Ontario	Canadian Shield
Primary landform and vegetation	♦ Physiography ♦ Provincial Land Cover mapping	♦ Quaternary geology ♦ Forest Resource Inventory (FRI) data
Other sources of vegetation information to refine the main data sources	♦ Community element occurrence data ♦ Prairie and savannah mapping ♦ Alvar mapping ♦ Heritage woodland mapping ♦ OMNR evaluated wetlands ♦ Great Lakes shoreline	♦ Provincial Land Cover mapping (where FRI mapping did not exist) ♦ Community element occurrence data ♦ Ontario Peatland Inventory ♦ OMNR evaluated wetlands ♦ Great Lakes shoreline ♦ FRI data on non-forest communities

5.3.2 Rare Species and Habitats (fine-filter targets)

Native species composition in most parts of the Great Lakes ecoregion has been dramatically impacted over the past two centuries, largely due to conversion of native, natural ecosystems to various human uses. Dramatic species declines have occurred and many wildlife species are now managed through hunting and fishing regulations. Other native wildlife species have been introduced or re-introduced, and various exotic wildlife species, which in some cases out-compete native species, have also been introduced. Some species are managed as nuisance wildlife species or high-risk rabies carriers. Currently, 114 species are federally listed as species at risk in the Ontario portion of the Great Lakes ecoregion, with the majority of these designations occurring as a result of habitat loss and human impacts.

Land conversion has isolated wildlife into remnant patches that frequently have insufficient resources for some species, such as interior-forest songbirds or wide-ranging mammals. These remnant habitat patches are also more accessible to hunting and predation, and to disturbance of sensitive species by roads, railways and other human activities.

The coarse-filter approach to conservation planning identifies sites that are representative of ecological systems and their component species, some of which are rare. However, this approach does not directly address documented occurrences of rare species or rare habitat types. The fine-filter approach ensures that many elements of biodiversity are included in the Conservation Blueprint. Fine-filter biodiversity targets were classified on the basis of rarity, population trend and distribution and include:

- Globally imperiled species (G1-G3G4)
- Designated species at risk
- Endemic species
- Declining species
- Disjunct species
- Wide-ranging species
- Rare vegetation communities

A total of 425 species and 172 vegetation communities were targeted for the terrestrial Conservation Blueprint. Table 3 outlines the variety of taxa and conservation status of these targets. A glossary of terms related to fine-filter targets is provided in Appendix 1. For further justification of why these targets were included in the Conservation Blueprint analysis, consult Appendices 2 and 3. 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. However, the rankings indicated in this report for the target species and vegetation communities were current as of spring 2005. Species and vegetation community ranks are reviewed regularly and the NHIC should be periodically consulted for the most recent rankings.

Figure 7 illustrates the extant element occurrences for the target species and vegetation communities. The framework for setting conservation goals for species targets took into consideration the species' global conservation status (global rank) and distribution within the Great Lakes ecoregion. The goals ranged from obtaining all viable occurrences of the primary target species within an ecodistrict to a species being a secondary target. Secondary species targets were not specifically targeted for inclusion in the Conservation Blueprint, but were included if the species occurrence coincided with that of a primary target species. The framework used for setting conservation goals for vegetation community targets considered the global conservation status (global rank) and the subnational conservation status (provincial rank) within the Great Lakes ecoregion.

Table 3. Summary of Great Lakes ecoregion targets by taxa.

	Total	Mammals	Birds	Reptiles	Amphibians	Insects	Vascular Plants	Mosses, Liverworts, Hornworts and Lichens
Species Targets	**425**	11	22	16	4	25	232	115
Primary Targets	**322**	1	3	3	0	23	178	114
Goal to obtain all viable occurrences	34		1			3	17	13
Goal to obtain 2, 3 or 4 occurrences	288	1	2	3		20	161	101
Globally rare (G1 to G3)	145	1	3	3		21	51	66
Provincially rare (S1 to S3)	244	1	2	3		20	116	102
Endangered (COSEWIC)	13		2	1			10	
Threatened (COSEWIC)	6			2			4	
Special Concern (COSEWIC)	3						2	1
Endangered-Regulated (OMNR)	9		3	1			5	
Endangered (OMNR)	5						5	
Threatened (OMNR)	6			2			4	
Special Concern (OMNR)	1					1		
Peripheral in basin	20		1			5	13	1
Widespread in basin	31	1	1			5	3	21
Endemic in basin	26		1	2		2	18	3
Declining in basin	2						2	
Disjunct in basin	217					7	126	84
Limited in basin	20			1			14	2
Secondary Targets	**103**	**10**	**19**	**13**	**4**	**2**	**54**	**1**
Globally rare (G1 to G3)	6		1			1	4	
Provincially rare (S1 to S3)	96	8	16	13	3	1	54	1
Endangered (COSEWIC)	39	1	7	2	2		27	
Threatened (COSEWIC)	27	2	3	6	2		14	
Special Concern (COSEWIC)	26	4	6	5		1	10	
Endangered-Regulated (OMNR)	26	1	7	1	1		16	

Table 3. Summary of Great Lakes ecoregion targets by taxa, *continued*.

	Total	**Mammals**	**Birds**	**Reptiles**	**Amphibians**	**Insects**	**Vascular Plants**	**Mosses, Liverworts, Hornworts and Lichens**
Secondary Targets continued								
Endangered (OMNR)	16	1	3	1			11	
Threatened (OMNR)	27	3	2	6	3		13	
Special Concern (OMNR)	27	3	7	5		1	11	
Peripheral in basin	80	3	10	12	4		51	
Widespread in basin	15	4	8			2		1
Declining in basin	1						1	
Limited in basin	5	1		1			3	
Other Species	**3**	**3**						
Wide-ranging mammals	3	3						
Community Targets	**172**							
Goal to obtain all viable occurrences	60							
Goal to obtain 3 occurrences	52							
Globally rare (G1 to G3)	59							
Provincially rare (S1 to S3)	104							
Secondary targets	60							

* For details on conservation goals of species and vegetation community targets, see Section 5.4.

** Targets can be included in more than one category, as categories are not necessarily mutually exclusive.

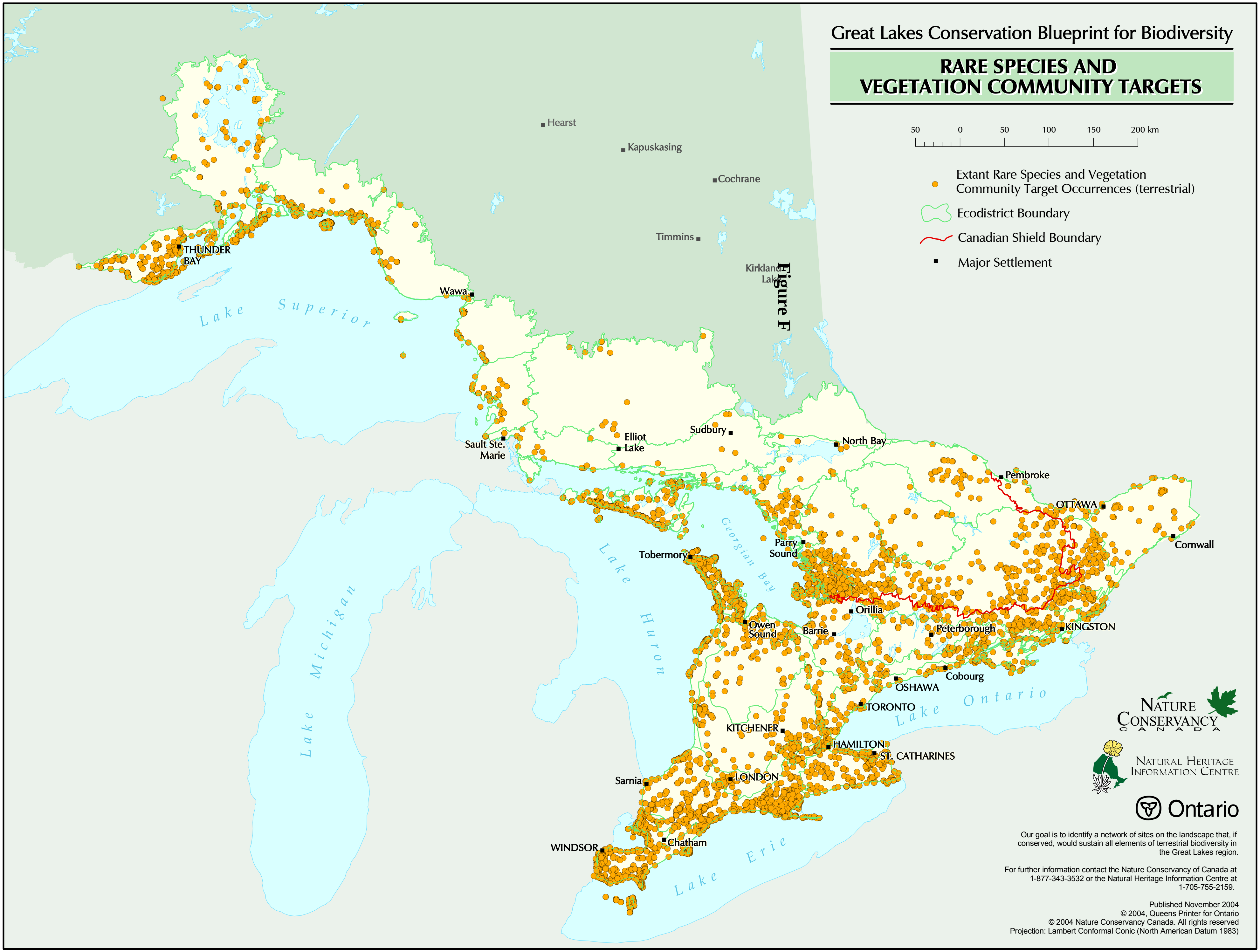


Figure 7. Occurrences of extant species and vegetation community targets in the Great Lakes ecoregion.

5.4 Conservation Goals (Identification and Stratification)

Stratification of Conservation Goals

Goals for how many or how much of a target species or habitat should be conserved are typically expressed as a certain number of occurrences across the target's distribution range. Conservation of multiple examples of a target across its geographic range better represents the variability of the target and its different environments. This replication requires a basis for stratifying site selection, to reflect those variations in landscape, climate and vegetation needed to increase the likelihood of persistence of a target throughout its range of variation. This entails standard application of ecological land units of homogeneous definition and scale.

The Canadian units that are standard in NCC work are Canadian ecoregions and ecodistricts of the Ecological Stratification Working Group (ESWG, 1995). An ecodistrict is an area of relatively homogeneous landform and physiography, within which vegetation, wildlife and ecological systems respond consistently. The majority of conservation goals in this analysis are stratified by ecodistrict (Figure 2). These ecodistricts, and their constituent physiographic regions in southern Ontario (Figure 8), represent environmental variability, standard ecological systems and their associated communities and species.

Quantitative, measurable goals for the targets set a benchmark for measuring conservation success at a given time. Such goals are approximations at best, and change with changing circumstances. Future ecoregional assessments will have refined goals, but will, even then, reflect uncertainty and risk (Comer, 2003).

Goals for Fine-filter Biodiversity Targets

Comer (2003) suggests that the conservation goals for species should be set so that "targeted species remain invulnerable to loss of viability within the ecoregion." This suggests the intention to maintain "minimum viable" populations, and to also attempt to address the specific vulnerabilities these species may have due to habitat loss, habitat conversion, or direct exploitation.

Table 4 outlines the Conservation Blueprint's approach to setting conservation goals for species targets throughout southern Ontario and the Canadian Shield. All obligate terrestrial species as well as species that spend a portion of their life cycle in a terrestrial landscape were identified as candidate species targets. The goals for representing fine-filter biodiversity targets in the Conservation Blueprint are based on two factors: the species' global conservation status (global rank) and the species' distribution within the Great Lakes region. See Appendix 1 for a glossary of these terms.

The targeted vegetation communities include those communities (and their occurrences) that have been identified by the NHIC as either rare in Ontario, or high quality examples of more common vegetation types. The NHIC defines "rare" in this circumstance as those communities ranked provincially rare (S1, S2 or S3). See Table 5 for the conservation goals that were applied to both the southern Ontario and the Canadian Shield regions.

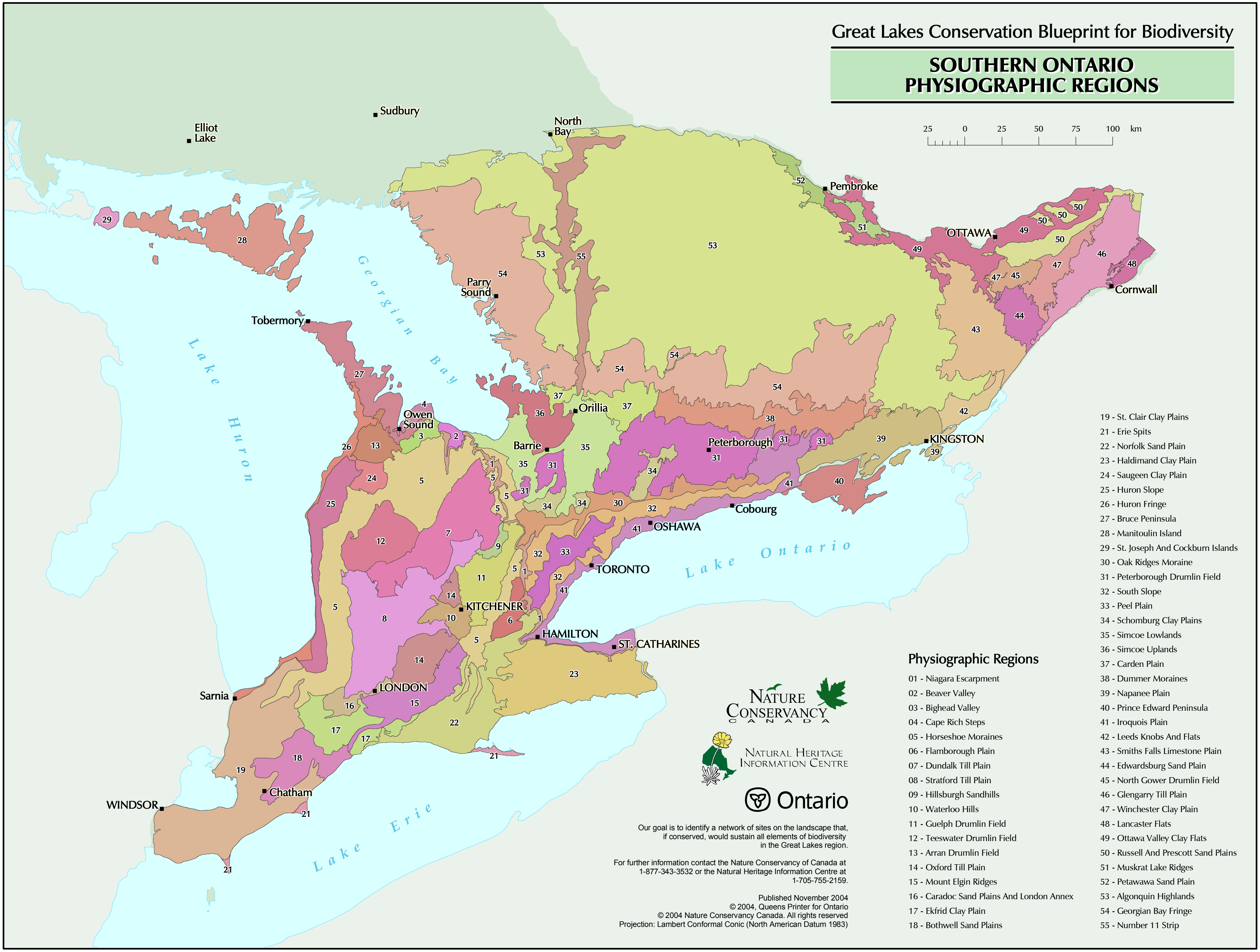


Figure 8. Physiographic regions of Southern Ontario based on Chapman and Putnam (1984).

Table 4. Framework for setting conservation goals for species targets.

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

Table 5. Framework for setting conservation goals for vegetation community targets.

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

Goals for Coarse-filter Biodiversity Targets

Conservation goals for fine-filter targets focus on the occurrence of individual species or vegetation communities within an ecosystem. In contrast, coarse-filter goals focus on the occurrence of representative ecosystems that can sustain ecological variability and integrity and provide secure, viable ecosystem services (*i.e.*, air, water, nutrients) in support of the wider range of non-target species (Comer, 2003).

A rule-based GIS can identify the 'top-scoring' ecological system areas (landform-vegetation types) on the landscape. The top-scoring systems are those worth ground-truthing and incorporating into conservation strategies. This analysis did not target a particular percentage of the landscape for each remaining system type, which could have been an alternative approach. The 'top-scoring' approach worked well for southern Ontario where the landscape is highly fragmented and there is a large degree of variance in the ecological integrity of the remaining natural areas.

For southern Ontario, the Core Science Team stratified the GIS search as follows:

1) The top-scoring example of each ecological system in each physiographic region in each ecodistrict was included in the portfolio.

2) The two top-scoring examples of each ecological system within each ecodistrict were also included in the portfolio.

This approach was also considered for the Canadian Shield portion of the analysis. Unfortunately the physiographic region data is only available for southern Ontario and therefore could not be applied to the Canadian Shield methodology. Few alternative data sets are available. One of the options is the Ontario Land Inventory (OLI) coverage. However, OLI units are mapped at a much more refined scale and were too numerous to be applied in the stratification framework for this study.

For the Canadian Shield portion of the analysis, the GIS search consisted of one step:

1) The three top-scoring examples of each ecological system within each ecodistrict were included in the portfolio.

5.5 Conservation Blueprint Methodology

The following section describes the methods used in the coarse-filter and fine-filter analyses of the southern Ontario and the Canadian Shield portions of the Great Lakes ecoregion. Where the scale of data permits, the methodological steps are accompanied by summary illustrations of the ecoregional data. Where the scale of data is too fine to be illustrated at ecoregional scales, more larger-scale screen captures of particular areas are used to illustrate the data used. (See Appendix 4 for details on data layers used.)

5.5.1 Coarse-filter Approach and Criteria

5.5.1.1 Ecological Systems Layers

The base data that the coarse-filter analysis was rooted on, was the ecological systems grid (map layer). This layer was established by integrating a biotic variable (vegetation) with an abiotic variable (physiography, landform).

Southern Ontario Ecological Systems

For southern Ontario, the ecological systems were initially generated from the overlay of the Provincial Land Cover mapping as the vegetation component (25 metre resolution) and physiography as the landform component (1:1,000,000 scale) (Figures 9 and 10). Lakes in the physiographic coverage were removed by setting their values to "no data". Since the surficial geology coverage did not align perfectly with the landcover mapping, data was extrapolated using the expand function to ensure complete overlap between the two coverages. Missing physiography data (primarily on Great Lakes islands) was digitized based on hard copy maps. All of the data for the coarse-filter analysis was projected into Lambert Conic Conformal, North American Datum 1983.

To this base, several other datasets were added to further refine the final ecological systems grid. These include:

- Gravel pit and quarry polygons (aggregate extraction) from the OMNR's Natural Resource Value Information System (NRVIS) were used to add detail to the "mine tailings, quarries and bedrock outcrop" theme in the Provincial Land Cover mapping. The remaining areas in the landcover class not identified as a pit or quarry were reclassified to "bedrock outcrop"
- Wetland polygons from OMNR evaluated wetlands digital mapping
- Prairie and savannah polygons digitized at the Ontario NHIC
- Alvar polygons from the International Alvar Conservation Initiative, digitized at the NHIC
- Significant older-growth woodland polygons from the Ontario Nature woodland study (Larson *et al.*, 1999), digitized at the NHIC

These updated vegetation types, combined with physiography, created a final ecological systems grid that could be classified based on the combinations of component data (*e.g.*, Fen Complex, or Kame Moraine Deciduous Forest Complex). These ecological system types were compared to the vegetation-landform themes used in past ANSI ecodistrict studies across southern Ontario to maintain consistency and compatibility. See Appendix 5 for the final ecological systems types.

Canadian Shield Ecological Systems

On the Canadian Shield, the ecological systems layer was generated from the overlay of Forest Resource Inventory (FRI) data for the vegetation component, and quaternary geology (1:1,000,000 scale) for the landform component (Figure 11).

All data for the coarse-filter analysis was projected into Lambert Conic Conformal, North American Datum 83.

Several preliminary grids needed to be created and merged in order to generate the final ecological systems map. Some of these grids were composed of refined datasets to improve the classification of the targeted ecological systems. For this reason, the preliminary grids were overlaid in a specific sequence in order to maintain the most refined boundaries and improve the accuracy of the systems mapping.

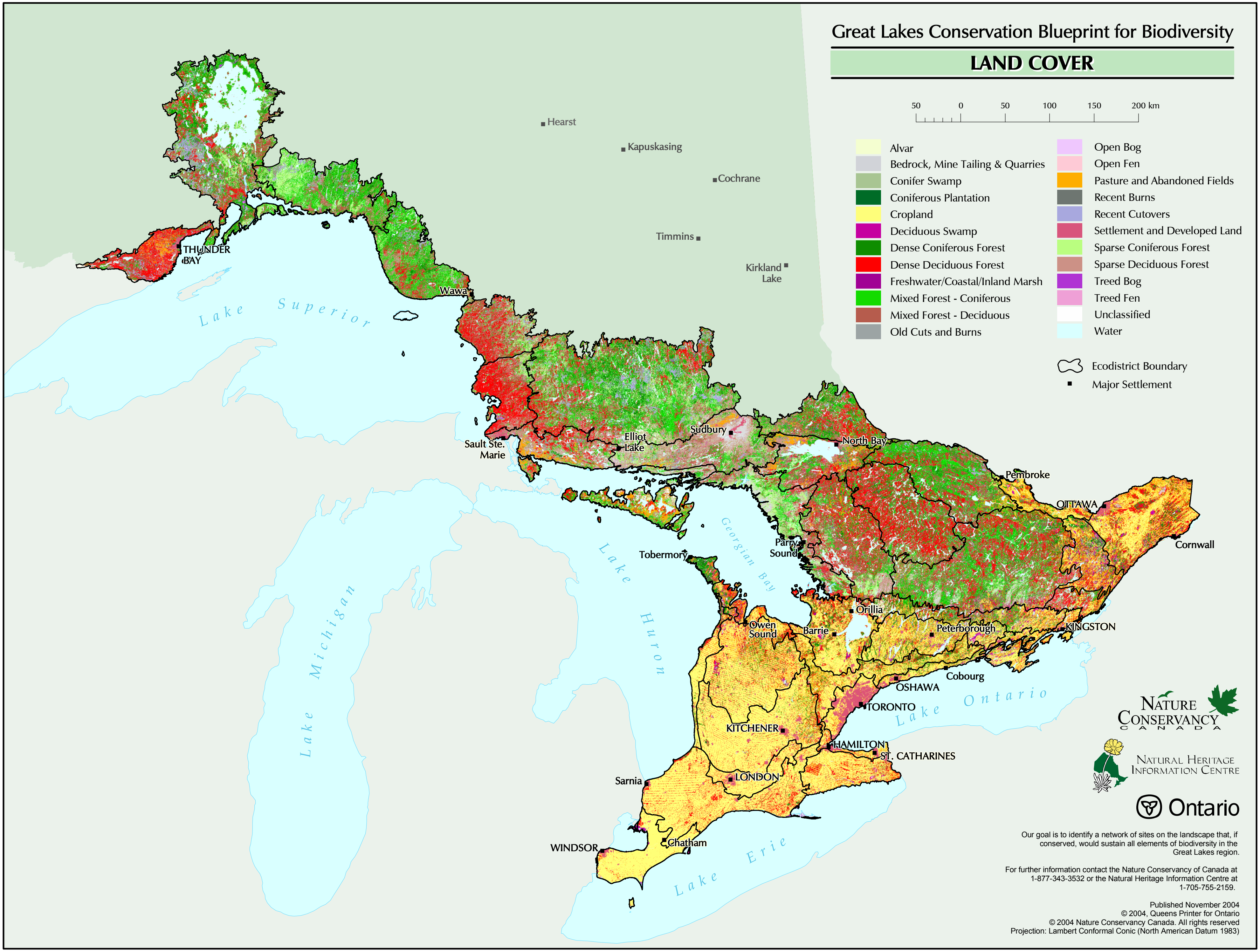


Figure 9. Land cover of the Great Lakes region.

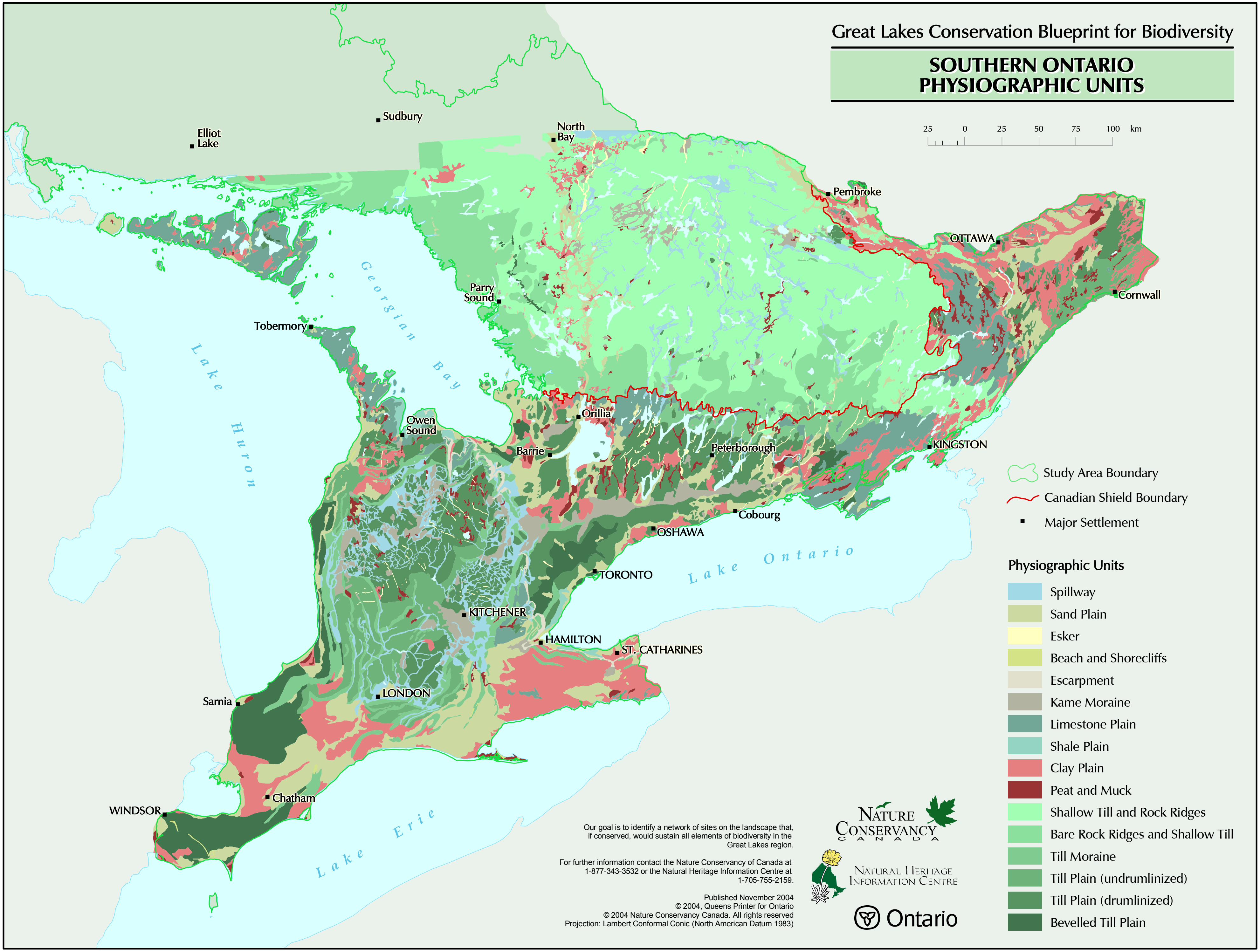


Figure 10. Physiographic units of Southern Ontario.

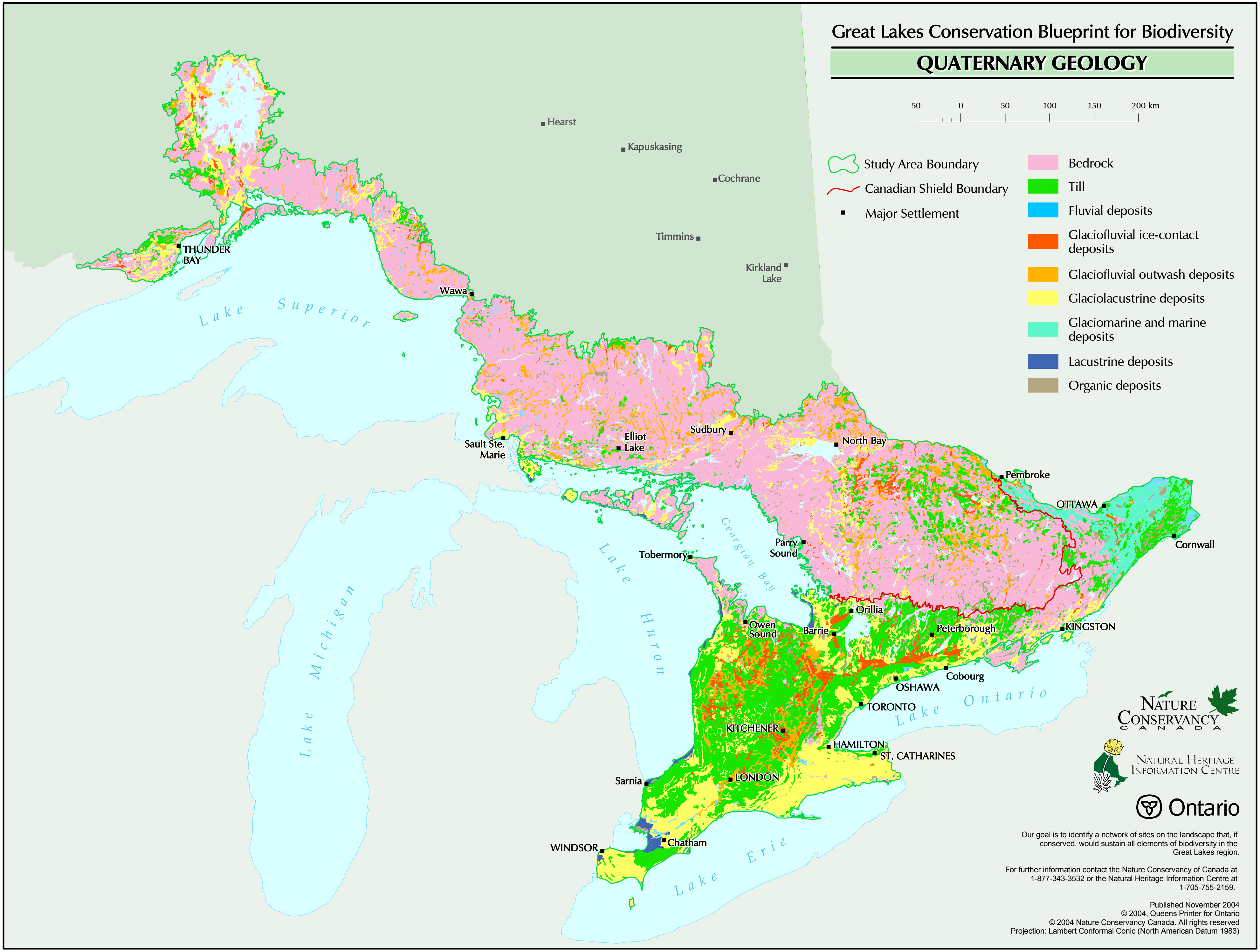


Figure 11. Quaternary geology of the Great Lakes region.

The preliminary grids included:

- **A non-forested ecosystem layer,** which included FRI barren and scattered stands, rock, developed agricultural lands, grass and meadow, brush and alder, settlement, water and unclassified/unsurveyed stand types.

- **A wetlands layer,** which included FRI attributed muskeg and 'brush and alder' stand types; Provincial Land Cover wetlands (25m resolution); and wetland types from the Ontario Peatland Inventory (Riley, 1994a, Riley, 1994b; Riley and Michaud 1994). Wetlands were classed as marsh, mixed swamp, deciduous swamp, coniferous swamp, open bog, treed bog, open fen, treed fen, open muskeg, treed muskeg, and 'brush and alder'. Due to the poor classification of wetlands in the FRI data, muskeg and 'brush and alder' types could not be classed as one of the four general wetland types (*i.e.*, swamp, marsh, fen, bog) but remain identified as muskeg and 'brush and alder'.

- **A forested ecosystems layer** was comprised of FRI forest stand types. The data set was processed through the Strategic Forest Management Model (SFMM) Tool to classify each forest stand as a standard forest unit for each of the OMNR administrative regions. For other forest communities not represented, further queries were conducted to identify and assign them appropriate forest units. The units were then combined within their administrative region to represent forested communities with similar ecological and conservation values (rather than forest management values). The combinations for each administrative region were then amalgamated into a smaller set of forest types standard across the Conservation Blueprint area. Table 6 outlines the forest-type classifications for the three OMNR administrative regions, and the final 15 Conservation Blueprint forest types used on the Canadian Shield.

- **A landform layer** was comprised of quaternary geology by the geological deposition and parent material description. This resulted in a suite of 13 standard landform types. See Appendix 6 for the landform descriptions.

These FRI-based forest vegetation types, with the addition of more refined vegetation types, were combined with standard landform types to create a final ecological systems grid that could be classified based on the combinations of component data (*e.g.*, Yellow Birch on till with undifferentiated, predominantly sandy silt to silt matrix, commonly rich in clasts, often high in total matrix carbonate content; or Conifer Swamp). See Appendix 7 for the resulting 250 ecological system types.

It is important to note that the FRI data layer had gaps in the coverage or was missing entirely for the following areas:

- Southern Ontario Forest Management Unit
- Georgian Bay Islands National Park
- Michipicoten Island
- Lake Superior Provincial Park
- The Superior Islands
- Pineland – Martel Forest Management Unit
- Pukaskwa National Park
- Canadian Forces Base: Petawawa
- National Forest Institute and Atomic Energy property near Algonquin Provincial Park

For these areas, Provincial Land Cover mapping was used to fill in these gaps and assign a forested vegetation description. However, this dataset is less refined than FRI and can only be mapped as mixed forest, sparse or dense coniferous forest, and sparse or dense deciduous forest.

Table 6. Combinations of standard forest units and the creation of Conservation Blueprint units.

Northwest Region Combinations	Northeast Region Combinations	Southern Region Combinations	Conservation Blueprint Combinations
	Red Pine	Red Pine	Red and White Pine Mixed
Red and White Pine	Mixed Red and White Pine mixed	White Pine and White Pine mixed	
Jack Pine Upland	Jack Pine Upland	Jack Pine	Jack Pine Upland
Lowland Conifer – Cedar and Larch	Lowland Conifer Mixed	Lowland Conifer Mixed	Lowland Conifer Mixed
Black Spruce Lowland	Black Spruce Lowland	Lowland Black Spruce	Lowland Black Spruce
Black Spruce Upland			Upland Black Spruce
	Black Spruce Mixed		Mixed Spruce/Pine
	Jack Pine Black Spruce mixed		
		Spruce and Pine Mixed	
		Hemlock	Hemlock
Poplar Upland	Poplar	Poplar Upland	Aspen
White Birch	White Birch		White Birch
		Yellow Birch	Yellow Birch
		Oak & Oak/Pine	Oak & Oak/Pine
Other Hardwood	Tolerant Hardwoods - upland & lowland		Tolerant Hardwoods
		Upland Hardwood	
		Lowland Hardwood	
		Midtolerant Hardwood	Midtolerant Hardwoods
Intolerant Hardwood Mix	Intolerant Hardwoods	Poplar and White Birch Upland	Intolerant Hardwoods
Conifer Mixedwood	Remaining Mixedwood (with Pine, Black Spruce)	Upland Mixedwood	Upland Hardwood & Conifer Mixed

5.5.1.2 Criteria and Scoring for Conservation Values Layers

Polygons of the same ecological system type were compared with each other by calculating for each polygon a specific numeric score. This score was based on 'values' assigned to each polygon to represent particular ecological criteria. Each of these scored 'values' was based on a specific mapped 'value grid'.

The value grids of the coarse-filter analysis were GIS-derived data layers, or map layers, which acted as surrogate values for assessing particular ecological criteria: diversity, condition, ecological functions and special features, as outlined earlier.

Each 25 metre pixel on the landscape was assigned a score from each grid. These grid scores were then numerically combined for each criterion, and the scores were calculated for each pixel to create a new layer of value scores representing each criterion. The pixel values within each intact ecological system polygon were averaged to generate a single score for each polygon, or patch. Scores were then adjusted to convey the relative importance of a particular criterion in relation to the other criteria. For example, in southern Ontario the 'condition' criterion was adjusted to

15% of the total score for each polygon (Figure 34; Appendix 8). All the criteria grids were combined to create a final value (positive) or cost (negative) for each ecological system polygon or patch. This final total score is termed the polygon's "conservation value", and those polygons with the highest scores were selected to represent core biodiversity conservation areas among the myriad of ecological systems.

The following section describes each value (or cost) grid, including the inputs, outputs, scores and ecological rationale for using that value as a surrogate for a particular ecological criterion. Appendices 8 and 9 list each layer and its associated scores. The GIS layers described in the following sections were used for both the southern Ontario and the Canadian Shield analyses, except where stated. These GIS data layers cover the entire Great Lakes Conservation Blueprint for southern Ontario and/or the Canadian Shield portions of the study area and are available through the Ontario Geospatial Data Exchange. For further details on these layers, consult Brodribb and Jahncke (2003) and Henson and Brodribb (2004).

CONDITION CRITERIA

In southern Ontario, the condition of each ecological system polygon was scored based on i) the percent of natural cover on the adjacent landscape, ii) the distance from cropland, iii) distance from urban or settled areas and iv) roadlessness. The overall condition score was adjusted to 15% of the total score.

On the Canadian Shield, the condition of each ecological system polygon was based on i) the percent of natural cover on the adjacent landscape, ii) the distance from cropland, iii) distance from urban or settled areas, iv) presence of gravel pits and quarries, hydro corridors, railways and v) roadlessness. The overall condition score was adjusted to 20% of the total score.

Degree of Natural Cover within a 2 km Radius

This measure of conservation value related directly to the degree of natural connectivity or isolation that a vegetation patch embodies. The amount of natural cover in an area influences many ecosystem processes, such as dispersal, in that more isolated patches are less likely to be recolonized after an extirpation event (MacArthur and Wilson, 1967; White *et al.*, 1996). It has also been suggested that interspersion, not necessarily dispersion, of patch types within a forested landscape results in higher forest values across the landscape (Bridge *et al.*, 2000).

In general, the connectedness and contiguity of natural vegetation, and particularly of forests and woodlands in the Great Lakes region, are important indicators of the abundance, movement and persistence of many forest birds. It is suggested that conservation work can benefit from recognizing the relative importance of 'within-patch' characteristics, patch size and overall landscape forest cover, regardless of the variable requirements of different bird species (Villard *et al.*, 1999; Lee *et al.*, 2002). Landscape context can also influence species richness and abundance (Riffell *et al.*, 2003); avian species abundance that was high for wet meadows adjacent to many natural patch types was even higher where wet meadows were located in overall natural contexts rather than in areas fragmented by development and roads.

The abundance of herpetofauna and mammals in wetlands is positively correlated to wetland area and to the amount of adjacent wetlands and forests on lands within two kilometres. However, incompatible adjacent land uses can have an affect on amphibian species richness and community composition as far removed as four kilometres from a wetland's edge (Findlay and Houlahan, 1997; Houlahan and Findlay, 2003).

The degree of natural cover layer was generated from the ecological systems layer. Sites that were adjacent to natural ecological systems were priorities for selection over sites that were adjacent to non-natural ecological systems. The amount of land in a natural state within a two-kilometre radius of each pixel was calculated. The higher the percent of natural cover in an area resulted in the area obtaining more points (Figure 12; Appendices 8 and 9).

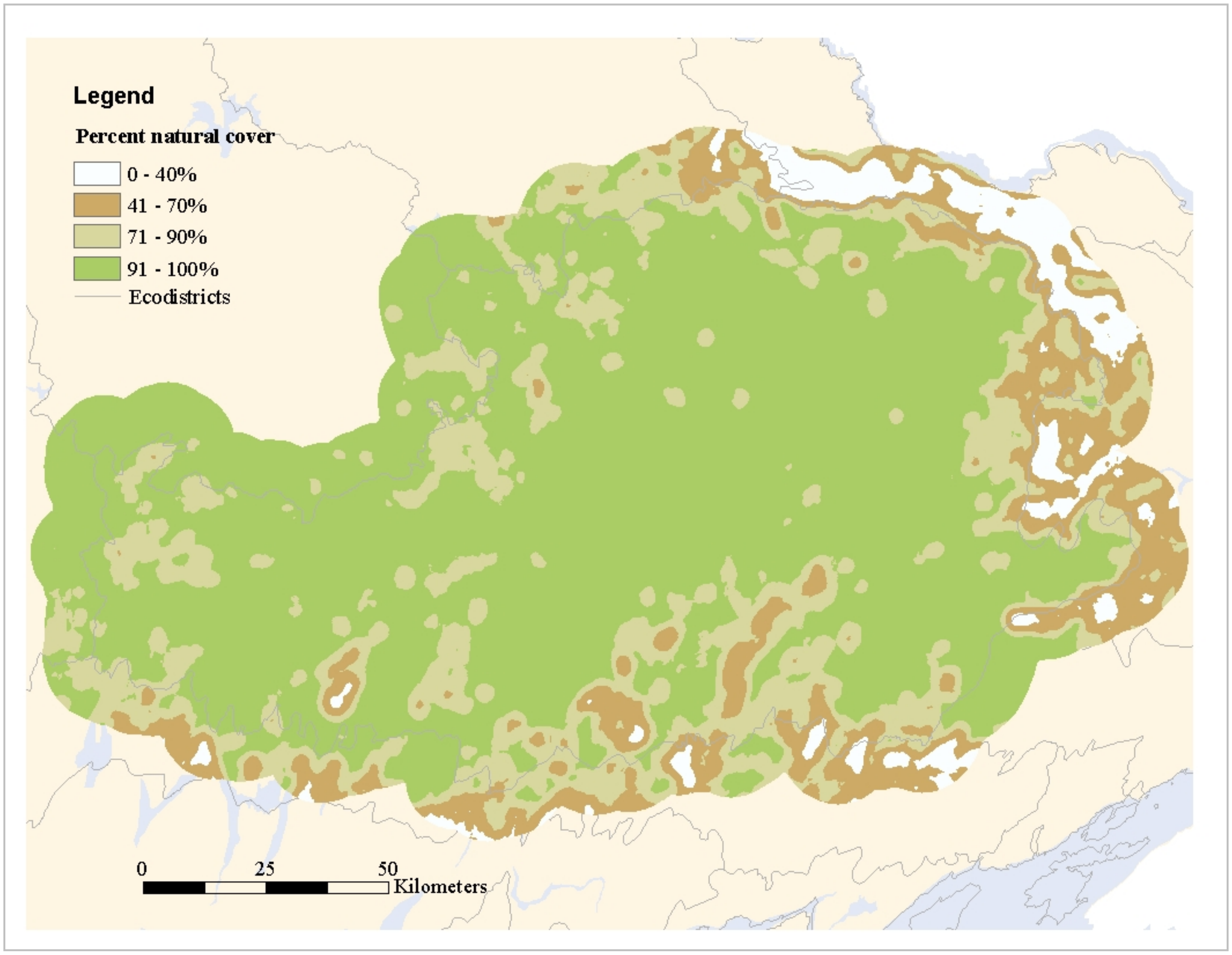


Figure 12. Percent natural cover within a 2 kilometre radius in ecodistrict 5E-11.

Distance from Cropland

Nearly 25% of Canada's total agricultural production is located in the Great Lakes basin (Government of Canada and US EPA, 1995). Past and ongoing conversions of land to agriculture resulted in massive changes in species and associated habitats. These impacts occur immediately, and they also occur on an ongoing basis in response to changing agricultural practices. For example, farmlands have exhibited a decline in bird species richness and total abundance over the last decade, primarily due to the replacement of the mosaic of pasture, hedgerows and winter grain fields by the larger fields, more intensive cultivation, and use of herbicides and chemical fertilizers associated with more intensive, modern agricultural practices (Freemark and Kirk, 2001; Benton *et al.*, 2002).

The quality of wetlands is significantly affected by the percent of agricultural lands in their watersheds, regardless of internal wetland stresses (Crosbie and Chow-Fraser, 1999). This suggests the need for retaining forested land or creating adequate buffer strips to mitigate agricultural runoff into adjacent natural habitats.

Agricultural land conversion has fragmented upland ecosystems in particular. In southern Ontario, 70% of wetlands were converted to agriculture (Snell, 1987), but 94% of upland forests were converted to agriculture (Larson *et al.*, 1999). Forest fragmentation increases as agricultural intensity increases (Belanger and Grenier, 2002). Fragmented forests are subjected to increased pressures from non-native plant

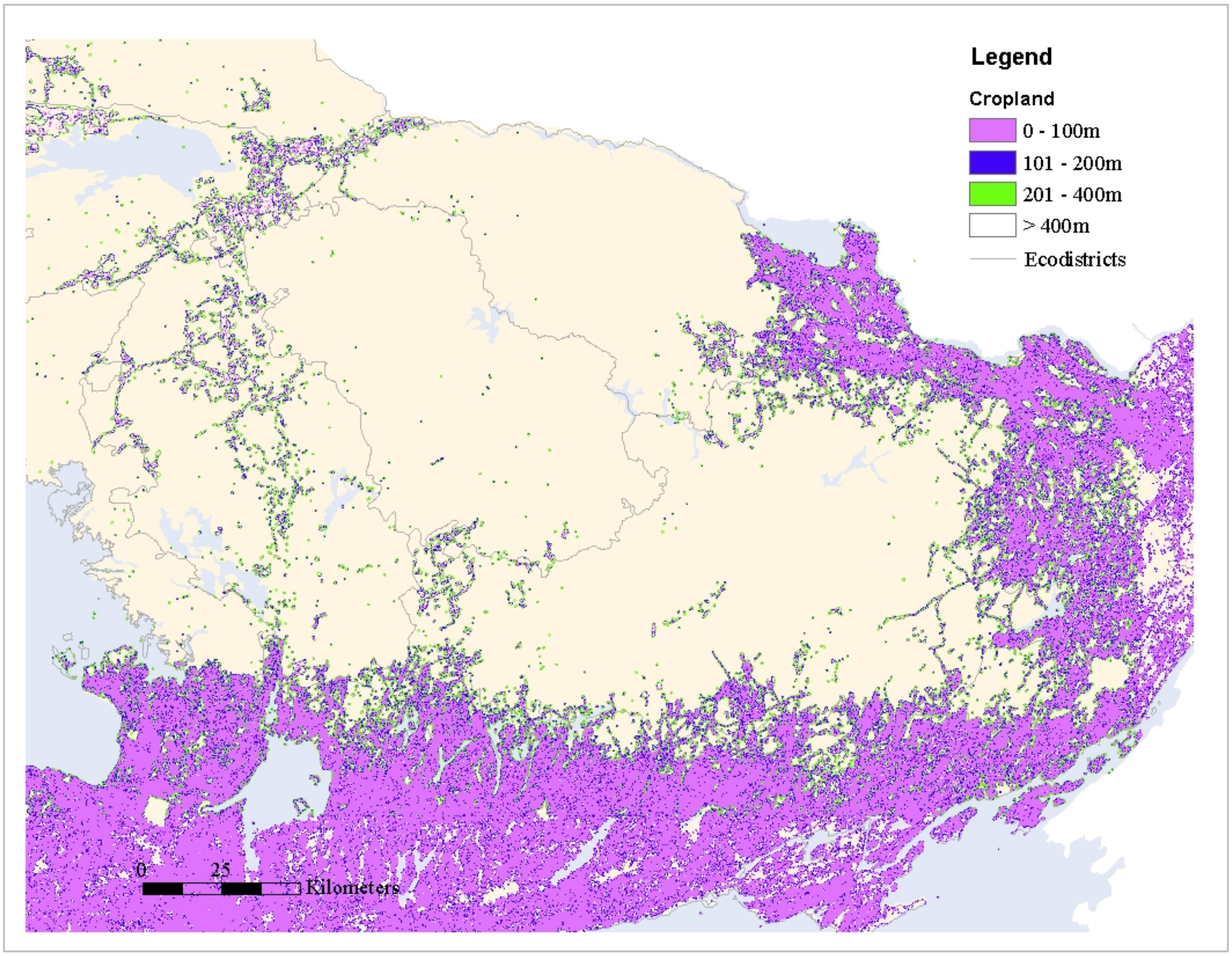


Figure 13. Proximity to cropland.

species, especially small remnant woodlots and woody hedgerows surrounded by intensive agricultural areas (Boutin and Jobin, 1998).

Plant species richness and composition varies substantially across agricultural landscapes, with areas dominated by row-crop monoculture having up to 30% weed species compared to much higher proportions of native species in areas of diverse crops and mixed crops (Freemark *et al.*, 2002).

Landscapes with a diversity of land uses are required to maintain habitat and species heterogeneity, and to protect the biodiversity of remnant natural areas as intervening agricultural practices intensify. Diversity, not only in natural areas but also in croplands, increases the landscape mosaic and decreases the risk of negative impacts to both the natural and agricultural landscapes (Paoletti *et al.*, 1992; Medley *et al.*, 1995).

The distance from cropland layer was generated from the Provincial Land Cover mapping for southern Ontario and a combination of landcover mapping and FRI mapping for the Canadian Shield. Natural areas that are farther away from developed agricultural land were given higher scores than those sites that were adjacent to agricultural fields. Sites were given progressively higher scores with their increasing distance from cropland (Figure 13; Appendices 8 and 9).

<u>Distance from Urban or Settlement Areas</u>

The Great Lakes basin is home to more than one-tenth of the population of the United States and one-quarter of the population of Canada, with some of the world's largest concentrations of industrial capacity (Government of Canada and US EPA, 1995). Socioeconomic indicators of risk to biodiversity, such as developed areas, are important in guiding conservation action.

Theobald (2003) measured the proportion of conservation lands affected by developed areas and the degree of fragmentation of patches (or conservation potential) caused by development. He considered areas that were highly fragmented, where natural patches were at least 15% developed, to be threatened or at risk.

The distribution and abundance of bird species are directly impacted by urban development (Cam *et al.*, 2000). Blair (1996) found that predominantly native bird species occur in less disturbed areas, and, moving gradually along a gradient of increased urbanization, more invasive and exotic species inhabited more highly urban areas. Friesen *et al.* (1995) studied bird populations in relation to woodlot size and the number of houses within 100m of woodlands, and reported that neo-tropical migrant songbirds consistently decreased in species diversity and abundance as development increased, regardless of woodland size.

The distance from settled or urban areas layer was generated from the Provincial Land Cover mapping and was created using the same process as the distance from cropland grid. Natural areas were given progressively higher scores with increasing distance from urban or settled areas (Figure 14; Appendices 8 and 9).

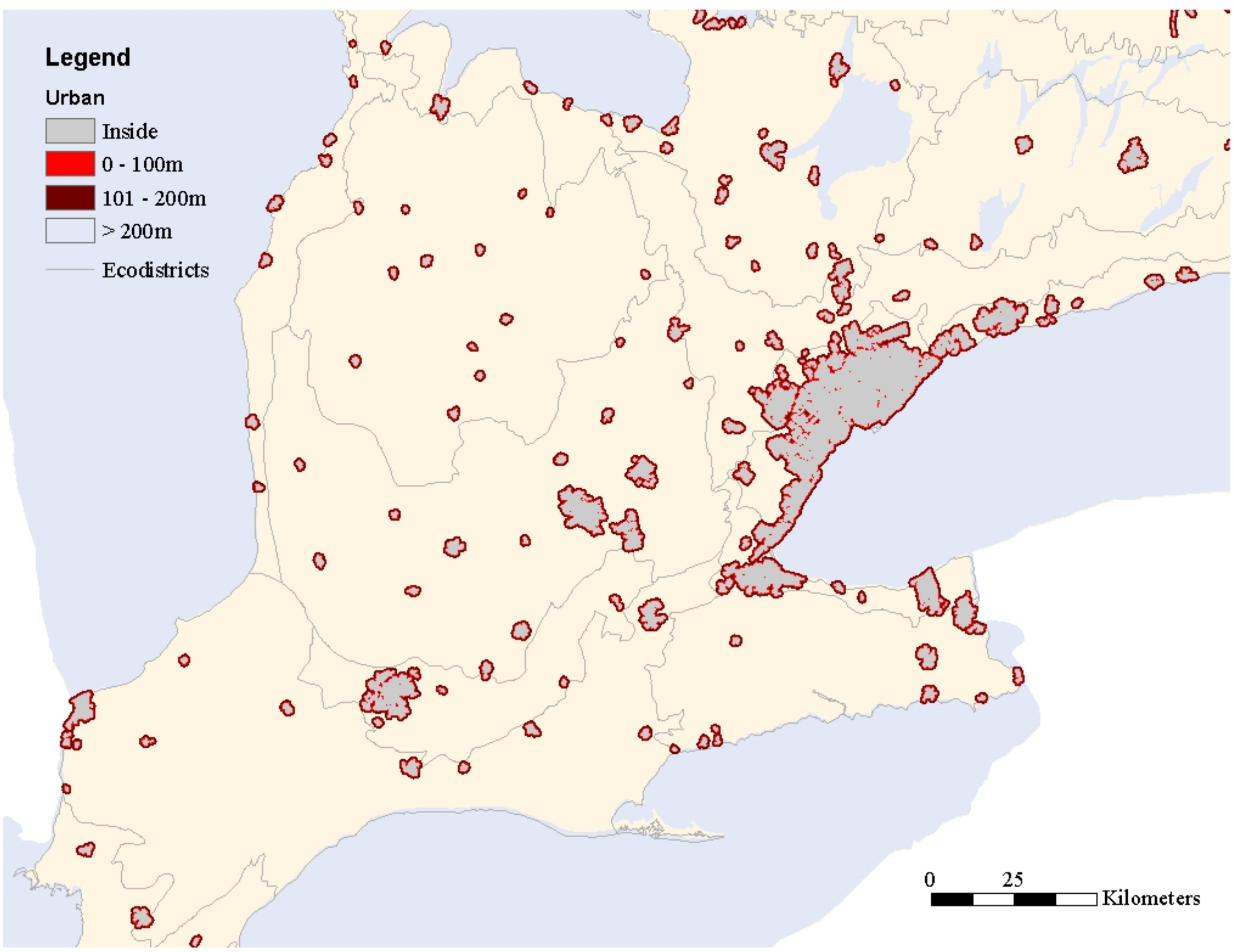


Figure 14. Proximity to urban and settled areas.

Presence of Pits and Quarries

Granular deposits are mined in pits, and solid rock or shale is mined in quarries. Both of these extractive processes expose rock and subsoils, resulting in low fertility, low organic matter in substrates, and low capacity to retain soil moisture, combined with increased exposure to summer temperatures. With little topsoil or overburden, compacted site floors and steep eroding banks are unable to provide good cover, food or water to wildlife and deter plant growth from stabilizing soils (Michalski *et al.*, 1987).

Wildlife habitat can be fragmented and dispersal patterns can be altered by pits and quarries. Complete habitat loss can also occur for some species. Road development, increased traffic and the ingress of non-native species are significant impacts to these areas. These impacts can continue even if sites are returned to recreation use or other development.

The rehabilitation of pits and quarries is required once extraction is complete, and sometimes this can result in entirely new habitats such as new slopes, or permanent or intermittent water features (OMNR, 1983b). Ecological restoration to pre-impact natural conditions is normally not the goal of such rehabilitation efforts.

The presence of pits and quarries layer was generated from the NRVIS pits and quarries mapping. Sites were given negative scores if they occurred within identified pit and quarry sites. Sites that did not coincide with pits and quarries were assigned a score of 0 (Figure 15; Appendix 9).

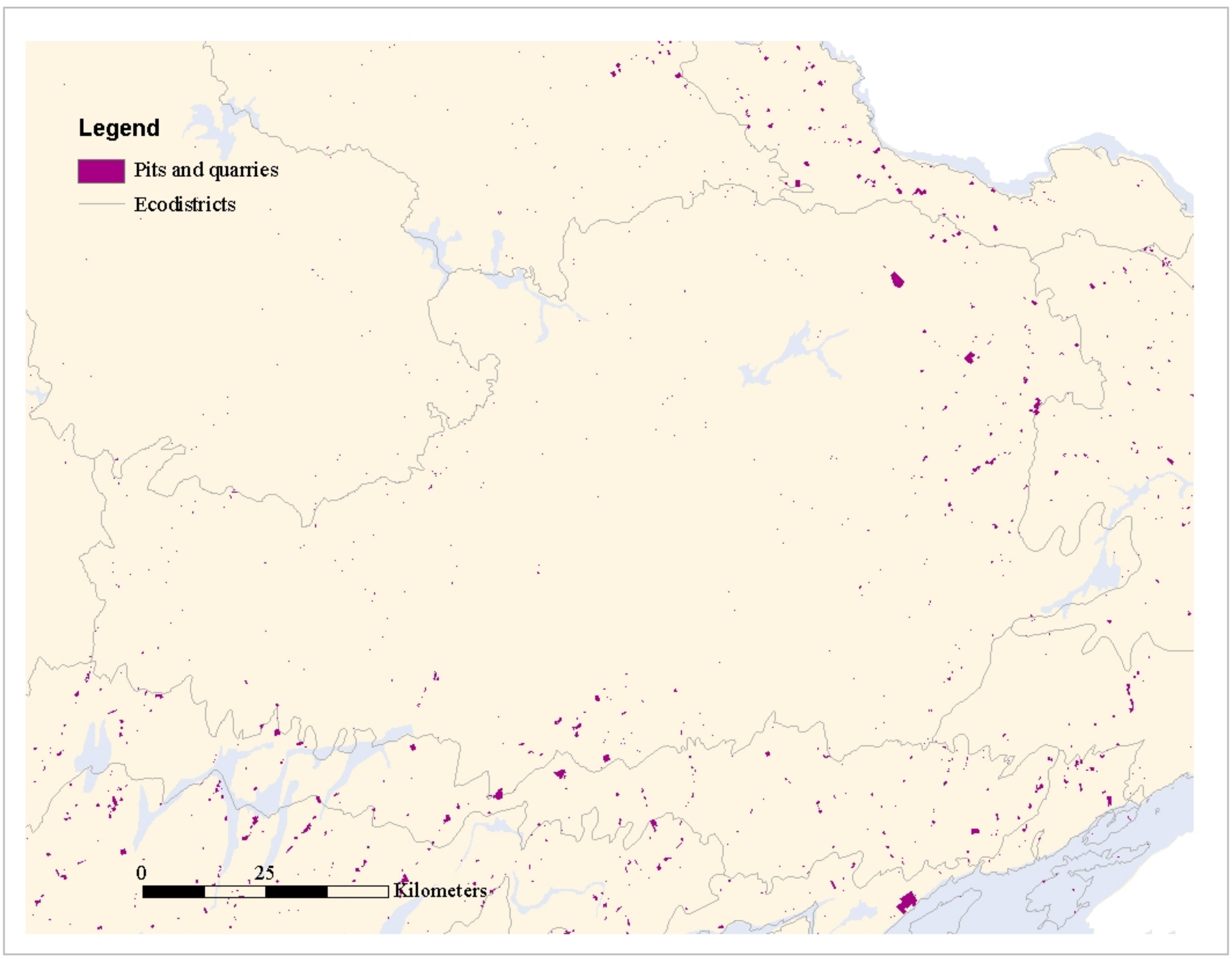


Figure 15. Presence of gravel pits and quarries.

Distance from Mines

Ontario has the largest metal mining sector among Canadian provinces, and one-third of Canada's mineral production. There are a dozens of active metal mines in operation and thousands of inactive or abandoned exploration or mining sites throughout the province (MiningWatch Canada, 2001). Common ecological impacts of mining include wildlife habitat loss or alteration, habitat fragmentation, and blockage of wildlife's seasonal and dispersal movements.

Mine access roads and cleared mine sites provide increased opportunity for recreation use, development and hunting, which increases the potential for disturbance to wildlife (AXYS Environmental Consulting Ltd., 2002). Associated roads also introduce non-native species, and result in increased vehicle traffic and public access. Impacts include direct and indirect mortality of wildlife from road kills and from the creation of winter predator access and wildlife habituation, by which animals such as bears choose dens closer to mine sites and feed around mine reclamation sites.

Additional impacts of mining include water withdrawal, treatment of tailings and the use of chemicals, which can have direct impacts on the hydrology and water quality. Restoration of these lands is increasingly important to re-establish natural processes (Cooke and Johnson, 2002).

The distance from mines layer was generated from the NRVIS mines mapping and used in the Canadian Shield portion of the analysis. Natural areas that were farther from mine sites were higher priority than sites adjacent to mines. Sites were given progressively higher scores with the increasing distance away from mines (Figure 16; Appendix 9).

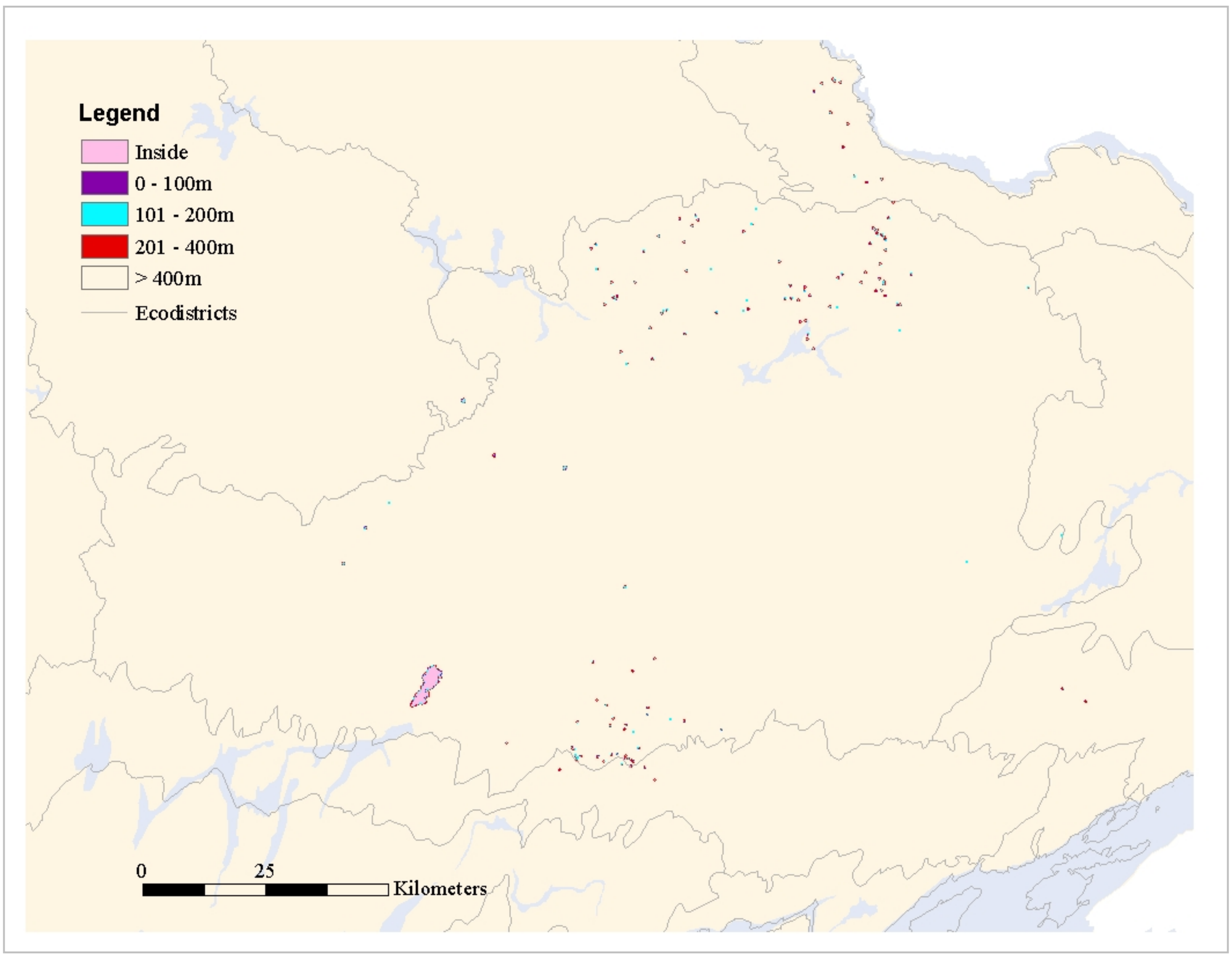


Figure 16. Proximity to mines.

Hydro Corridors and Transmission Lines

Creating and maintaining hydro corridors negatively impacts some species while providing benefits to other species. Such corridors can benefit raptors, providing stable nesting platforms and perches for hunting. Other species may use the vegetation in the corridor for food and cover, or use as a travel corridor (Manitoba Hydro, 1995). Some bird and herpetofaunal species that prefer early successional habitat increase in abundance in hydro corridors (Yahner *et al.*, 2001; Yahner *et al.*, 2002).

Brown-headed Cowbird is an open-country species that often parasitizes the nests of forest bird species nesting near the forest edge. It takes advantage of utility corridors to access new breeding areas (Manitoba Hydro, 1995). Cleared corridors can also become accessible routes for predator species. Such corridors also provide routes for the general public to sites that may otherwise have been unimpacted by humans.

The noise and vegetation control needed in transmission-line maintenance disturbs wildlife. The transmission corridors themselves create low-competition environments where introduced and exotic species can be dispersed by wind and continue their range expansion into previously unavailable sites (MacLellan and Stewart, 1985). Recent research has also shown that the electromagnetic fields of hydro lines have an impact on wildlife (Havas, 2000).

Research has shown reductions in the abundance of forest-interior neotropical migrant birds on grassy corridor edges compared to interior forest habitats. It appears that these species respond negatively within 200m of the cleared forest edge (Rich *et al.*, 1994).

The hydro corridor layer was generated from the NRVIS mapping and used in the Canadian Shield

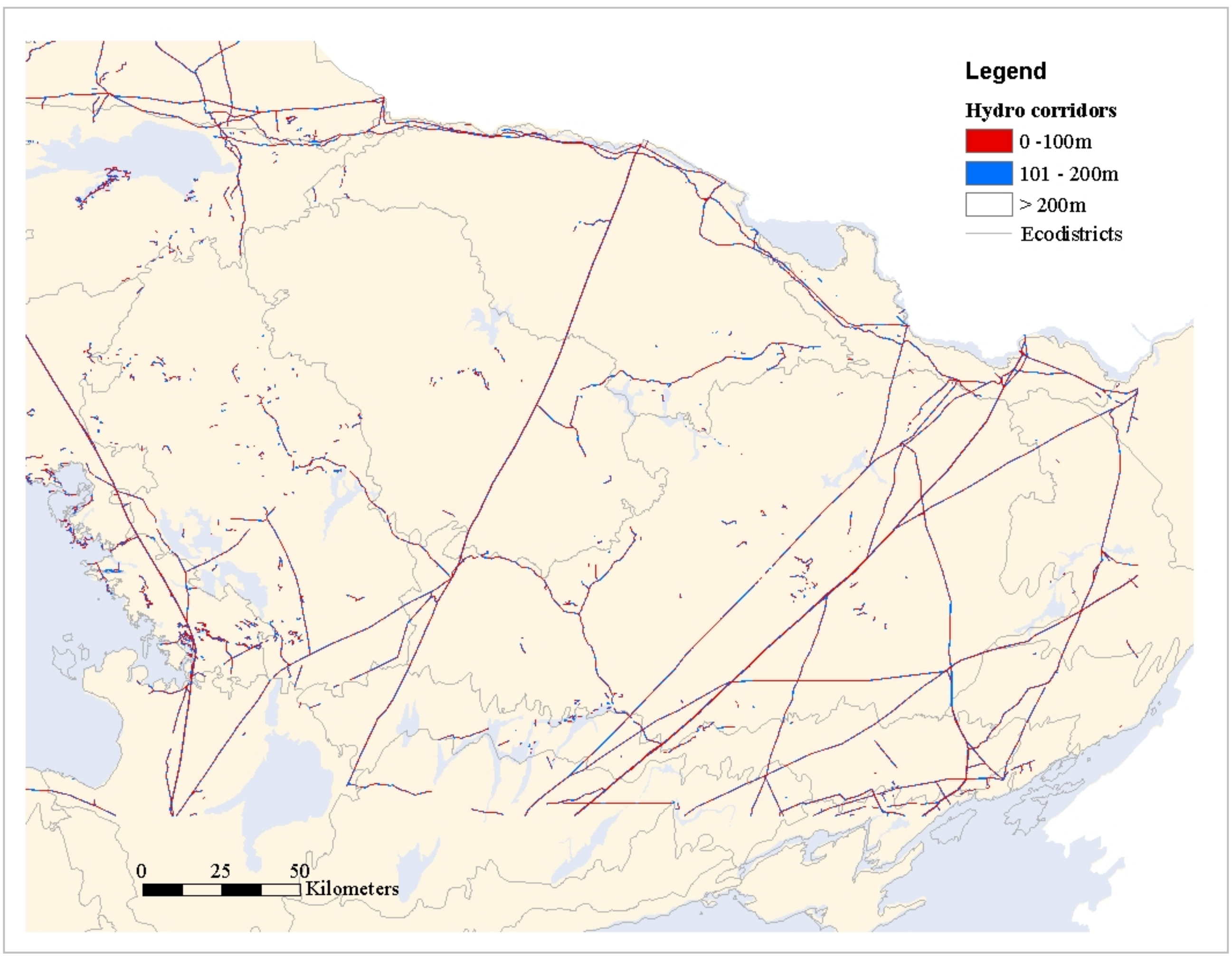


Figure 17. Proximity to hydro corridors and transmission lines.

analysis. Areas closer to hydro corridors were assigned negative values. Areas more than 200 m from a hydro corridor were assigned a score of 0 (Figure 17; Appendix 9).

Railways

Like hydro corridors, railroad right-of-ways increase habitat for introduced non-native species, and result in habitat alteration and fragmentation. On the other hand, in regions where prairie habitats have been lost, railroad embankments may compensate to some extent for the loss of native grasslands, allowing remnant populations of prairie taxa to persist and disperse (Tikka *et al.*, 2001).

Rich *et al.* (1994) demonstrated the negative effects of railway corridors on forest-interior neo-tropical migrant birds and determined that these species exhibit significant reductions in relative abundance.

Amphibian studies suggest that, where railroads bisect amphibian species' routes from terrestrial habitats to water habitats, some species shelter under the rails during the day and are killed by the weight of the passing train. Crawling species (*e.g.*, toads) were unable to climb over rails and were observed to move hundreds of metres along the rails before they found underpassage between the rails and the ballast (Etienne *et al.*, 2003).

The railways layer was generated from the NRVIS railroad layers and used in the Canadian Shield portion of this methodology. Sites that were adjacent to railway lines were assigned negative scores. Any area greater than 200 m from a railway was assigned a score of 0 (Figure 18; Appendix 9).

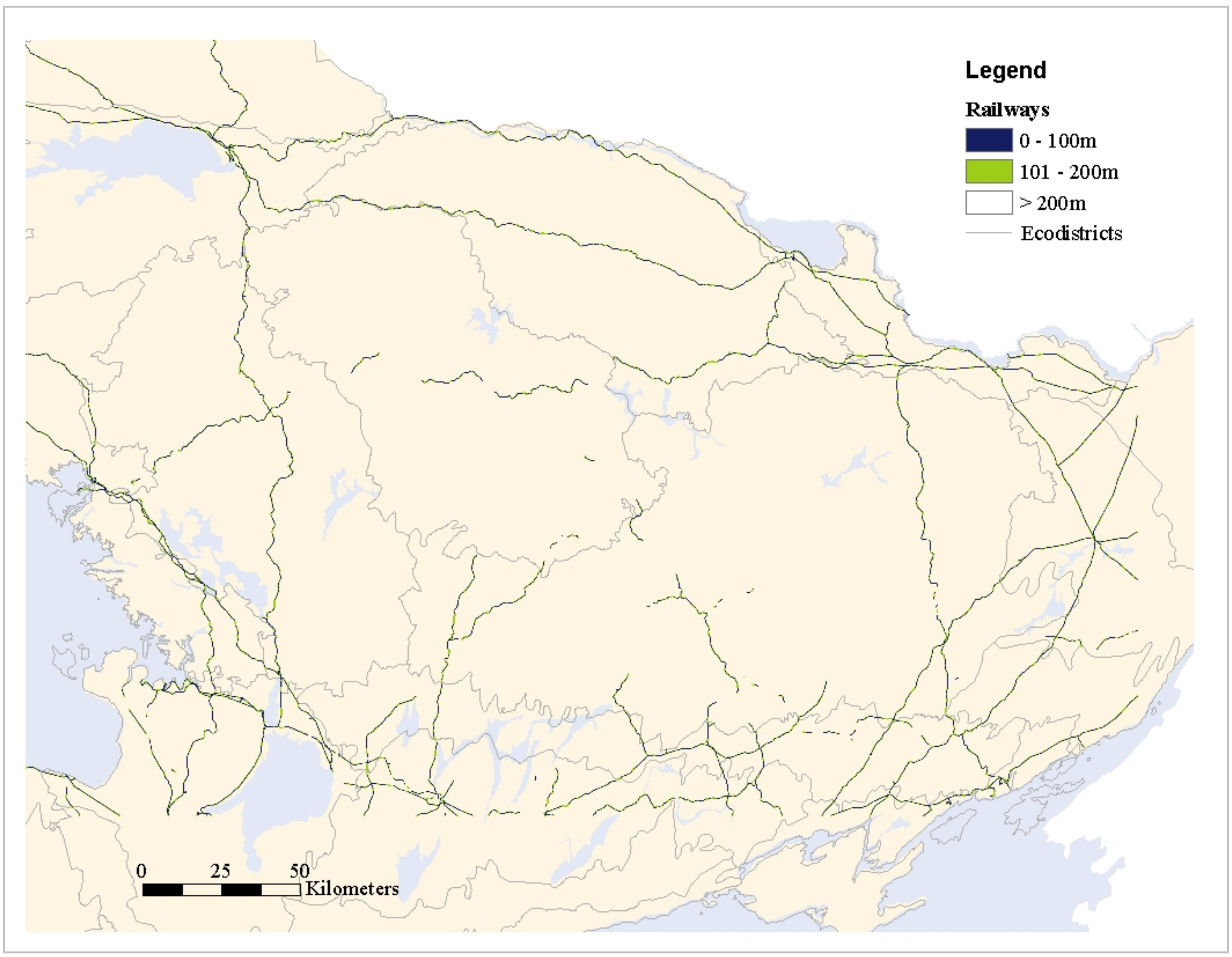


Figure 18. Proximity to railways.

Roadlessness

Although roads may provide edge habitat and dispersal corridors for some native species, their net detrimental ecological effects exceed any benefits. Effects include species mortality, population barriers, habitat alteration and fragmentation, invasion by exotic species, and increases in human interactions with wildlife (Trombulak and Frissell, 2000; Forman and Alexander, 1998; USDA Forest Service, 1998; Tikka *et al.*, 2001; Wildlands League and Sierra Legal Defense Fund, 2003). Many of these detrimental effects vary with the intensity of road use.

Some species tolerate or even use roadways, but many avoid them or are at lower densities near them. Large mammals such as Elk and White-tailed Deer prefer habitat more than 200 m from a road (Rost and Bailey, 1979). Wolf pack survival and fitness decreases significantly in areas with high road densities (Mladenoff, 1995). Forest-nesting birds avoid roads and the adjacent 200 m forested areas and wooded roadsides provide cover and travel corridors for nest and species predators (Bergin *et al.*, 1997; Rich *et al.*, 1994). Amphibians and other water-dependent species decline in richness and abundance as road densities increase, with negative effects evident up to 2km from wetlands but strongest within 200 m (Findlay and Houlahan, 1997; Houlahan and Findlay, 2003).

Stoms (2000) established a "roadedness" index to measure the effects of different types of roads: primary roads (limited access) or highways with biodiversity impacts to a 500 m distance on each side of the roadway; secondary local or rural roads (100 m) and trails (25 m). Forman and Deblinger (2000) determined that the area adjacent to a road had significant direct ecological "road-effects"

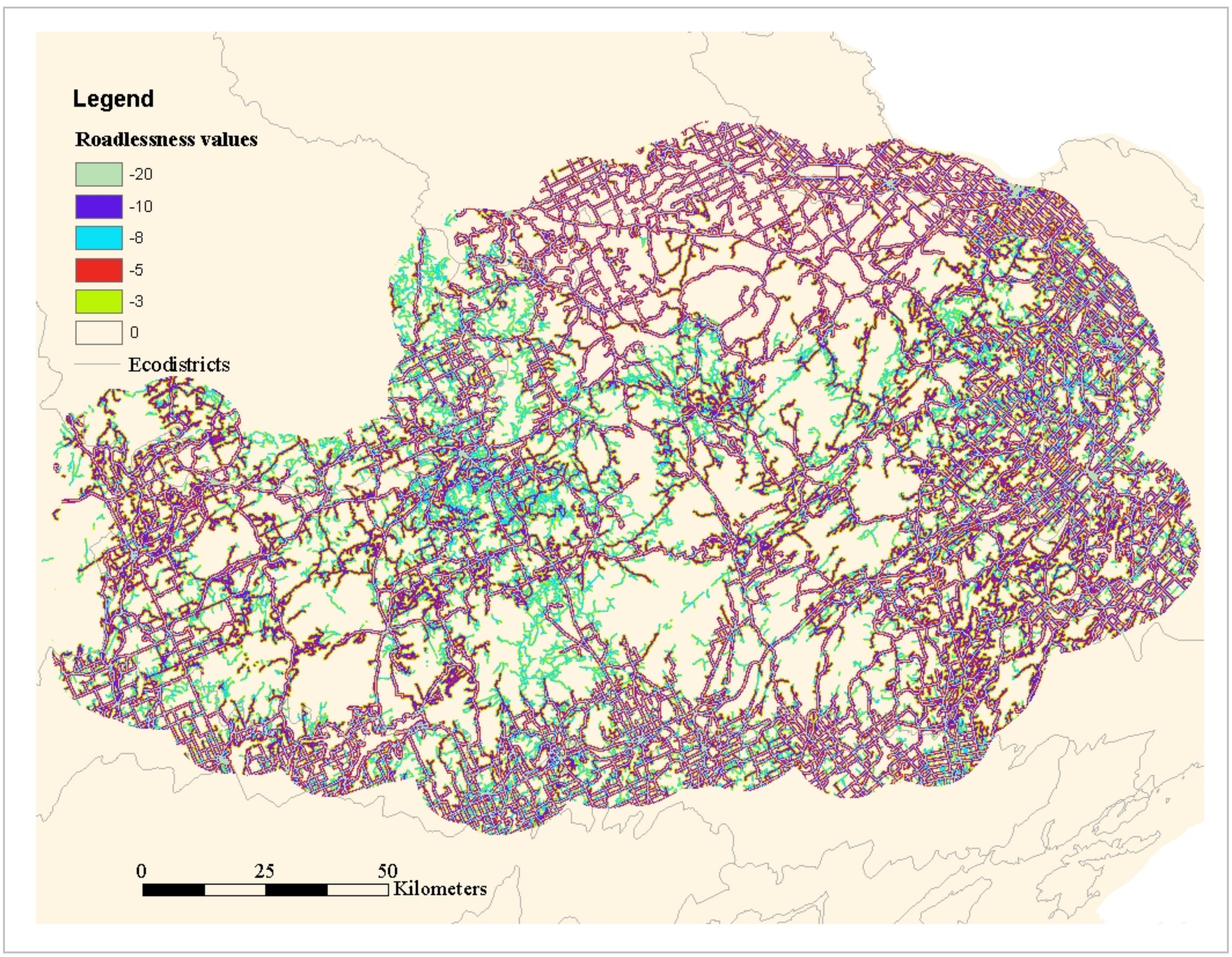


Figure 19. Roadlessness coarse-filter scoring layer in ecodistrict 5E-11.

within an average 600 m-wide strip (300 m on each side) along a typical suburban highway. Other studies suggest that an area should be considered at risk if the land cover patch had more than 20% "roaded area" or was highly fragmented (Theobald, 2003).

The roadlessness layer was generated from the NRVIS roads layers. Polygons that were less fragmented by roads were given a higher value in the Conservation Blueprint. Roads were identified as primary, secondary or tertiary roads, and areas closer to primary roads were given the highest negative score. Areas near tertiary roads or farther from larger roads were given progressively less negative scores. Any area more than 400 m from a road was assigned a score of 0. The extent and concentration of roads differs greatly between the Canadian Shield and southern Ontario, and different distances and scores were assigned to road types for the two study areas (Figure 19; Appendices 8 and 9).

ECOLOGICAL FUNCTIONS CRITERIA

Ecological functions refer to the ecological role of a site within the broader context of the surrounding landscape and watershed. They are the natural processes that maintain functioning landscapes, ecosystems and their component species.

In GIS projects, the assessment of ecological functions usually relies on surrogate measures. In this study, in southern Ontario, the ecological functions were measured in relation to i) the total size of the ecological system, the amount of core area; ii) cores and corridors identified through the Big Picture 2002; iii) proximity to existing protected areas and conservation lands; and iv) hydrological features.

On the Canadian Shield, ecological functions were measured in relation to i) the size of average fire disturbance; ii) size of edge buffers; iii) presence of old-growth forest; iv) proximity to existing protected areas; v) coincidence with existing conservation lands; and vi) hydrological features. In both the north and the south, the ecological functions score was adjusted to 60% of the total score.

<u>**Site Size**</u>

The size of ecological system (or size of patch, or GIS polygon) is the key landscape-level factor affecting the presence and abundance of species, and the diversity of rare species (Mazerolle and Villard, 1999; Lovett-Doust and Kuntz, 2001; Lovett-Doust *et al.*, 2003). For example, small forest patches in southern Ontario have shown declines in species abundance because intensive agriculture, urbanization and other developments create barriers to their movement between habitat patches (Pearce, 1993).

In Great Lakes ecosystems, forest patch size and the amount of landscape in forest cover are important to species conservation (Villard *et al.*, 1999; Lee *et al.*, 2002). Burke and Nol (2000) found that woodlot size was the most important factor in the reproductive success of forest-breeding birds. For all species studied, reproductive success was at or above replacement levels in continuous forest fragments at least 850 ha in size, and reproductive success was below replacement levels in fragments less than 94 ha. They further recommended that forested areas larger than 500 ha should be preserved, and that priority be given to smaller woodlands with at least 90 ha of forest interior core (Burke and Nol, 2000).

The site size layer used in the southern Ontario analysis was based on the ecological systems layer. Larger natural areas were given a higher score than smaller ones. The size (hectares) of each ecological system was calculated and classed into a range of scores (Figure 20; Appendix 8).

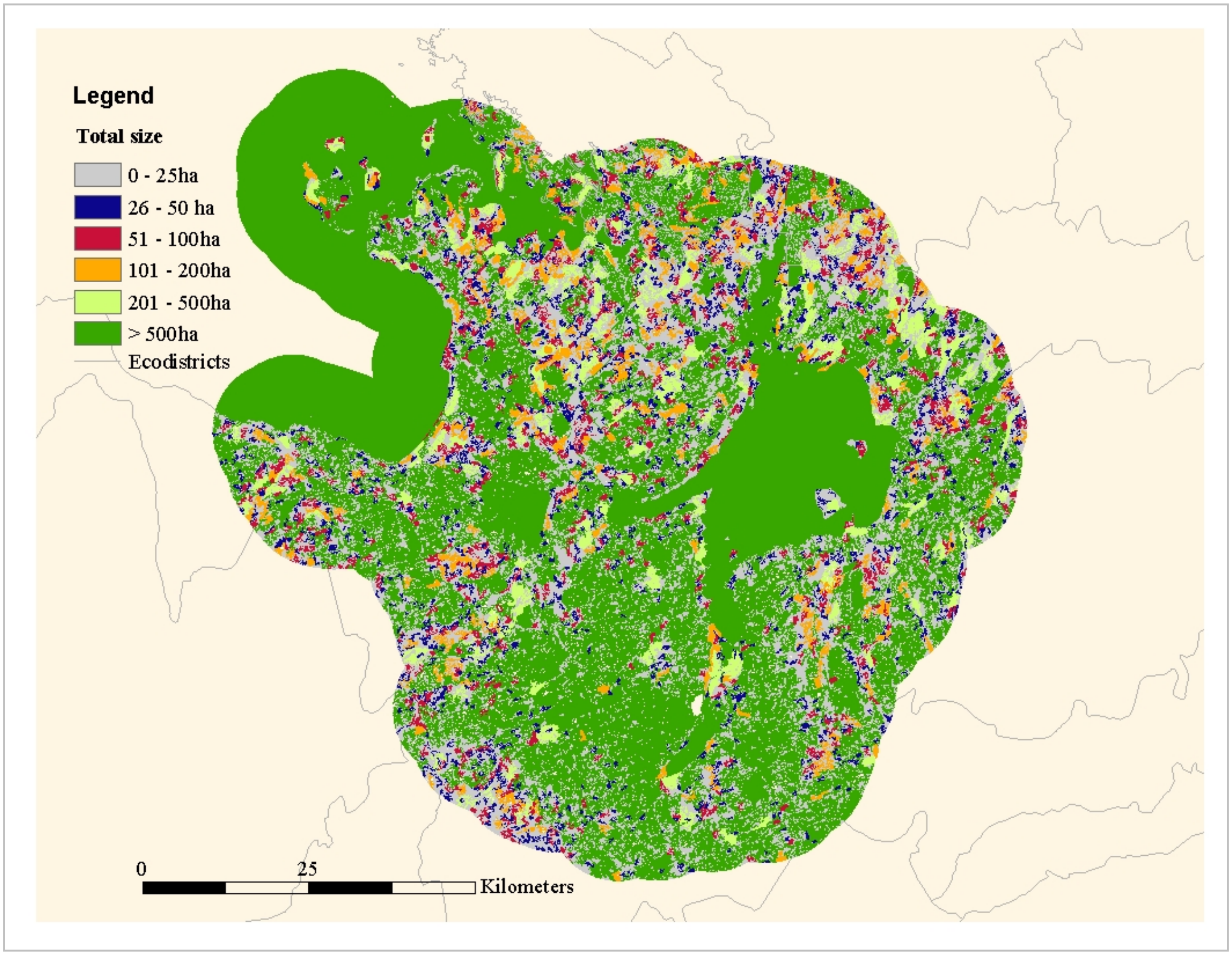


Figure 20. Scores for size of each ecological system polygon in ecodistrict 6E-6.

Fire Disturbance Size

A literature review of the size, scale and frequency of natural disturbances in the Ontario portion of the Great Lakes basin was conducted to assess the size of natural area large enough to persist on the landscape for a century or more given the natural disturbance regime in that particular area.

On mesic and wet sites in the region, and on most fragmented natural areas south of the Canadian Shield, natural disturbances are at scales most frequently related to weather events and their small-scale effects on forest systems (Larson *et al.*, 1999). However, on dry or xeric sites in areas of almost continuous forest cover, fire is the natural mechanism by which ecosystem succession is returned to its earliest state. Fire disturbance is a complicated, interconnected process that varies in size and intensity depending on fuel loads, stand characteristics, moisture content of soil and litter, wind speed and direction, slope and aspect. Wildfires often burn in elliptical shapes due to wind-direction changes, with larger fires losing this shape due to topography, buffers or barriers, and forest type and structure.

Fire is part of the natural Great Lakes ecosystem. The scale, frequency and intensity of disturbance varies across the region (Dickmann and Cleland, 2002; Chen and Popadiouk, 2002). Many ecosystems and their species evolved with fire and depend on fire for maintenance and renewal. Fire disturbance and the following renewal result in a patchwork of forest and shrub ecosystems of different ages and types, which contributes to the complexity and diversity of the landscape. In turn, this diversity provides habitat for species adapted to different stages of succession and creates the conditions for further fires (Perera *et al.*, 1998; Li, 2000; Perera and Baldwin, 2000; Bridge *et al.*, 2000).

Stand-replacing fires were normal events in presettlement conditions, but the scale of those fires is not well documented. Furthermore, modern forest management and fire control have altered the natural fire cycles of the region (Baker, 1992; OMNR, 2001). It is suggested that fire suppression in boreal forests may convert these forests from fire-tolerant conifers to fire-sensitive, shade-tolerant species; and the shade-tolerant hardwood forests in the Great Lakes-St Lawrence forest region are replacing fire-tolerant conifers (Carleton, 2000; Fall *et al.*, 2004). This trend is exacerbated by the preference for harvesting softwood conifers. These changes in forest patterns and complexity that have resulted from forest harvesting may have long-term negative impacts on biota that depend on the forests initiated through natural fire regimes (Hobson and Shieck, 1999; Imbreau *et al.*, 1999; Drapeau *et al.*, 2000; Voigt *et al.*, 2000).

The *Crown Forest Sustainability Act* (1994) requires natural disturbance patterns to serve as the baseline or control for sustainable forest management. Since forests have sustained and adapted themselves in the presence of disturbance, it is widely viewed that forests should be managed in ways that emulate natural disturbance in order to sustain them (OMNR, 2001; McRae *et al.*, 2001; Buse and Perera, 2002; Simon *et al.*, 2002).

For the Canadian Shield analysis, it was accepted that fire sizes and frequencies are influenced by fire suppression activities, and that suppression will continue on the Canadian Shield.

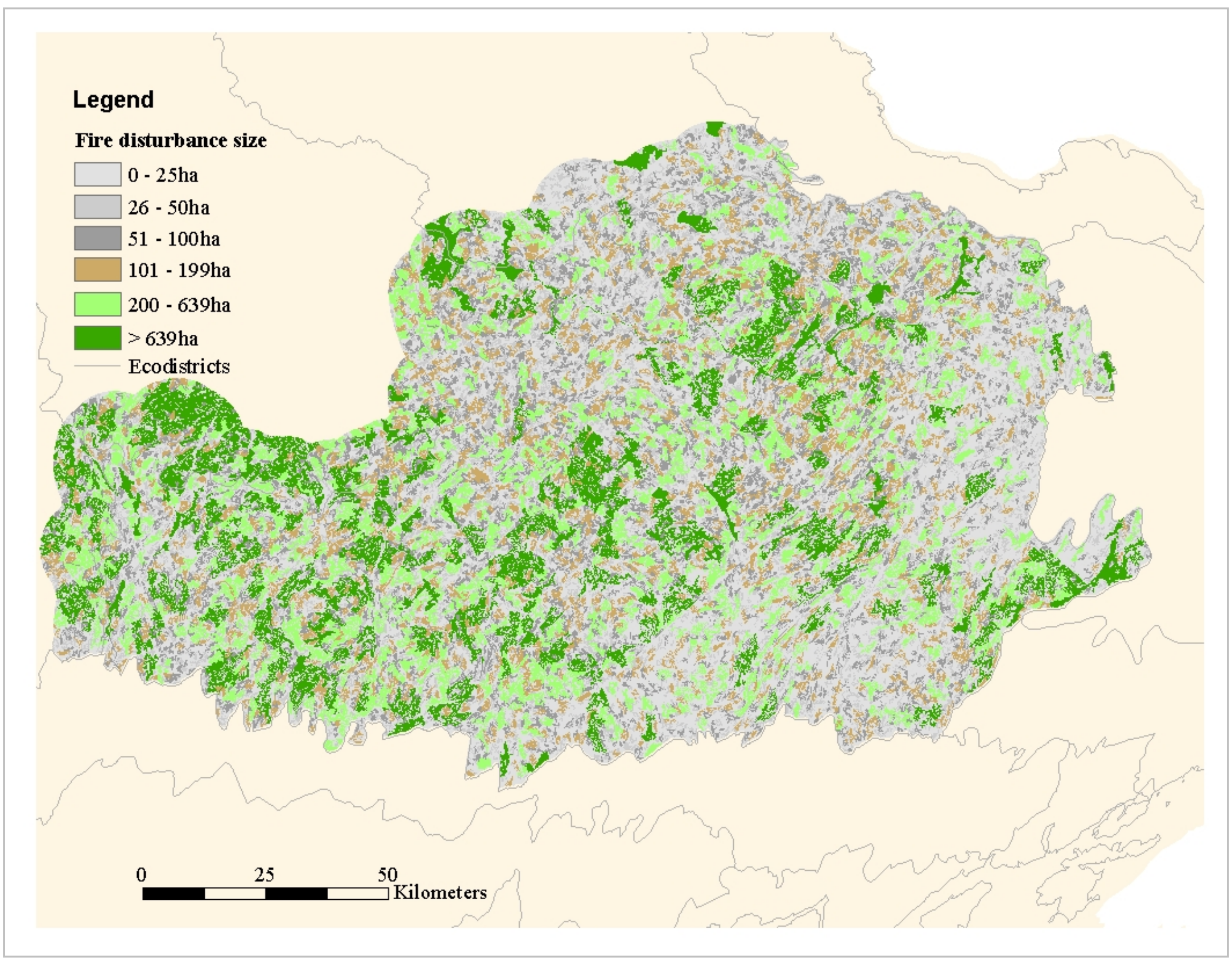


Figure 21. Fire disturbance size in ecodistrict 5E-11.

Anthropogenic structures such as roads, settlements and timber harvesting also affect fire behaviour. Therefore, fire disturbance measures used in this analysis do not reflect pre-suppression fire sizes and frequencies, for which there are insufficient data to base analysis anyway.

For central and northern Ontario, the OMNR has fire databases on all fires from 1976-1998 and all fires greater than 200 ha from 1920 to 1996 (OMNR, 1997a; Frech *et al*., 1999; Bridge, 2001). The databases contain information on area burnt (hectares per year) and fire cycles (in years).

Fire frequency and fire return intervals can be used to measure fire size distribution (Li *et al.*, 1999). The OMNR fire data on fire size and frequency within OMNR ecoregions and forest management units were overlaid with ecodistrict boundaries to calculate an approximate burnt area (in hectares) upon which the minimum size target for the Conservation Blueprint was based. Table 7 lists, for each ecodistrict within the Conservation Blueprint on the Canadian Shield, the calculated minimum size goal to use to increase the probability that Conservation Blueprint sites could persist through time after a natural fire disturbance event. Some ecodistricts have more than one minimum size target due to their diverse landscape and a bi-modal distribution of fire sizes. Otherwise, these minimum sizes do not differentiate among vegetation communities or major ecosystem types.

Pickett and Thompson (1978) suggest that for an area to continue to function as an intact ecosystem after natural disturbance, it should be at least four times the average patch size of such a disturbance. It was believed that the Conservation Blueprint sites would need to be at least this large to sustain an average four-quartile suite of successional stages over the longer term.

A ‘four times’ rule was incorporated into the total size grid (based on the ecological systems grid) and scored accordingly for each ecodistrict in the Canadian Shield (see Appendix 10).

Table 7. Fire disturbance size targeted within each ecodistrict.

Ecodistrict	**Approximate area (ha) burnt in the past 23 years = *minimum size target***	**Approximate total # of fires**	**Total % of ecodistrict disturbed**	**Size (ha) needed for 4x rule**
3E-4	100	240	12	400
3W-3	300	300	6	1200
3W-5	100	300	3	400
4W-2	300	90	7.2	1200
4E-1	120	180	3.6	480
4E-3	50 & 400	180	3.6	200 & 1600
5E-1	60	360	5.4	240
5E-3	20	360	7.9	80
5E-4	200	360	9.7	800
5E-5	200	360	14	800
5E-6	200	360	14	800
5E-7	40	360	2.3	160
5E-8	50	360	2.3	200
5E-9	40	360	1.8	160
5E-10	40 & 160	360	7.2	160 & 640
5E-11	50 & 160	360	3.6	200 & 640
5E-13	60	360	5	240

Rather than setting a specific size goal for ecological systems, a size selection criterion was incorporated into the total size grid to assign large intact systems high priority to flag these large areas. This grid has been created to be flexible enough to change the scoring depending on which ecodistrict was being analyzed or if another size rule was to be applied. In general, larger natural areas are given higher scores than smaller areas; thus higher priority will be given to larger areas and sites that are large enough to adequately withstand natural disturbance. Any areas less than 50 ha were given a negative score. All areas larger than 50 ha were assigned from 2 to 10 points, with the larger sites receiving the higher scores (Figure 21; Appendix 9).

Size of Core Area or Edge Buffer Size

All vegetation patches have 'interior habitat' and 'edge habitat'. The size and shape of a vegetation patch influences the ratio of interior vs. edge. Large, rounded or rectangular vegetation patches have the greatest amount of interior habitat in relation to the amount of edge. Smaller and more irregular vegetation patches have relatively more edge. The amount of edge habitat in a landscape is often associated with topographic diversity, the degree of disturbance the landscape is exposed to, and influences the composition of species (Bridge *et al.*, 2000). For example, in the Great Lakes region, interior habitats are preferred by certain hawks, owls and mammals. Such species often decline in landscapes that are fragmented by agricultural, infrastructural and urban development. However, naturally-occurring ('soft') edges, such as lakeshores, do not appear to have the same effect on such taxa. Species such as raccoons, skunks, crows and jays are usually found in edge habitats, and some are known to be predatory on species of the forest interior.

Perera and Baldwin (2000) measure patch interior based on the proportion of edge that is 'hard' (*i.e.*,

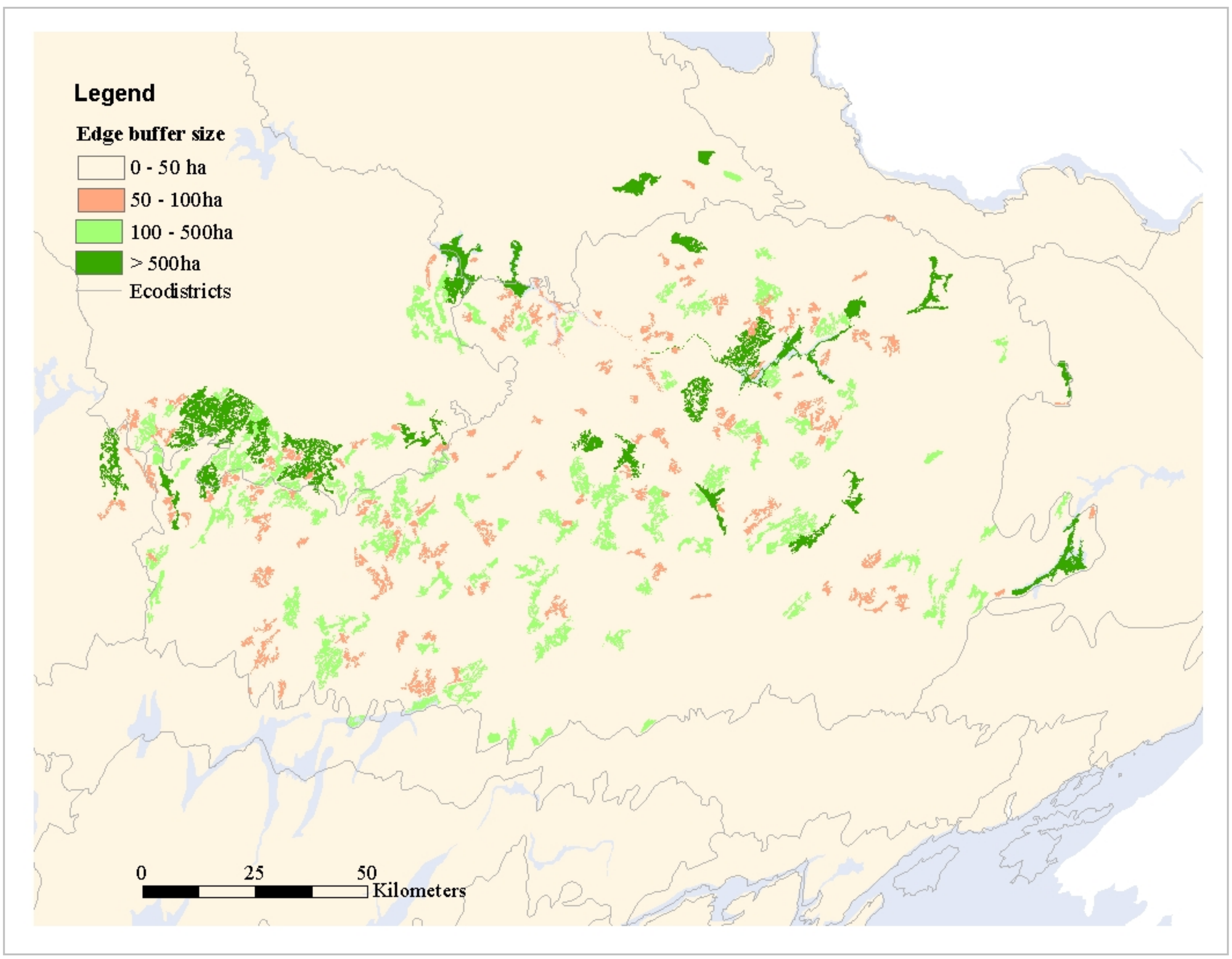


Figure 22. Size of core area for ecodistrict 5E-11.

borders anthropogenic non-forest cover types) within a 120m wide interior buffer. Dense conifer forests in the northern portion of the ecoregion exhibit the largest interior patches compared to the dense deciduous forests in the south. Collectively, the dense deciduous forest patches throughout the ecoregion bordered more hard edges of agriculture and settlement that any other forest cover types in the region (Perera and Baldwin, 2000).

The size of an ecological system patch relates directly to the amount and, in many respects, the quality of habitat services provided by that patch. The 'core area', which in the case of forest systems, is the forest interior, is that part of a patch that is buffered from its surrounding patches and its external edge. Matlack (1994) suggests that plant species characteristic of early succession often occur within the forest up to 100 m from the edge, as do non-native invasives. Other studies demonstrate that microclimates vary significantly between the edge and forest interiors (Matlack, 1993; Chen *et al.*, 1995). Air temperature, soil temperature, relative humidity and wind speed all have gradient effects along the edge and typically extend from 30 m to greater than 240 m into the forest (Chen *et al.*, 1995). Nest parasitism often occurs within 100 m from an edge and can extend beyond this range into the interior of the stand (Paton, 1994). Forest-breeding bird reproductive success generally occurs in continuous forests or patches with an average core area of 121 ha (Burke and Nol, 2000).

Resident species that depend on forest interior for habitats decline in population size as a direct effect of habitat fragmentation, often more so than predicted by habitat loss alone. This is not the same with generalist species that use both edge and interior habitats or other migratory species (Bender *et al.*, 1997). Burke and Nol (2000) recommend preserving forest patches with at least a 90 ha core area, and Bridge *et al.* (2000) recommend using an edge distance of 200 m to calculate forest interior.

The amount of 'edge' between vegetated patches influences the diversity of the landscape, the degree of disturbance the landscape is exposed to, and the presence of species across the landscape (Bridge *et al.*, 2000). Perera and Baldwin (2000) measured patch interior based on the proportion of edge that is 'hard', or borders anthropogenic non-forest cover types within a 120 m wide interior buffer. Dense conifer forests in the northern portions of the ecoregion exhibit the largest interior patches compared to the dense deciduous forests in the south. Collectively, the dense deciduous forest patches throughout the ecoregion bordered more hard edges of agriculture and settlement than any other forest cover types in the region (Perera and Baldwin, 2000).

The size of 'core', excluding edge buffer, was used in both the southern Ontario and the Canadian Shield analysis and was generated from their respective ecological systems grids. Areas that had a larger interior size (defined as the area greater than 100 m and/or 200 m from the edge) were given higher priority than those areas that had smaller interior areas (Figure 22; Appendices 8 and 9).

<u>Cores and Corridors</u>

The conservation or planning of connected networks of natural habitat, often referred to as 'core, corridors and connecting links', or 'natural heritage systems', is considered a key strategy in mitigating the ecological consequences of habitat fragmentation across a settled landscape (Riley and Mohr, 1994; Dale *et al*., 2000; Goodwin, 2003). Cores are discussed above, and corridors can serve as dispersal routes between suitable habitat patches within a fragmented landscape, especially where surrounding patches are dominated by non-native habitats, concrete, monoculture crops, non-forested hedgerows, fencelines and narrow forest strips along river valleys and ravines (Pearce, 1993; Claire *et al.*, 2002). With the increase in connectivity of otherwise isolated patches in the landscape, corridor habitat patches provide potential for improved seed dispersal, species richness and diversity, themselves related to increased populations and sustainability.

With the improvement of GIS technology and project automation, core and corridor models have become useful tools for resource management and conservation planning where detailed baseline information is uneven and needing extrapolation across larger areas, or where there are constraints on intensive field data collection (Clevenger *et al.*,

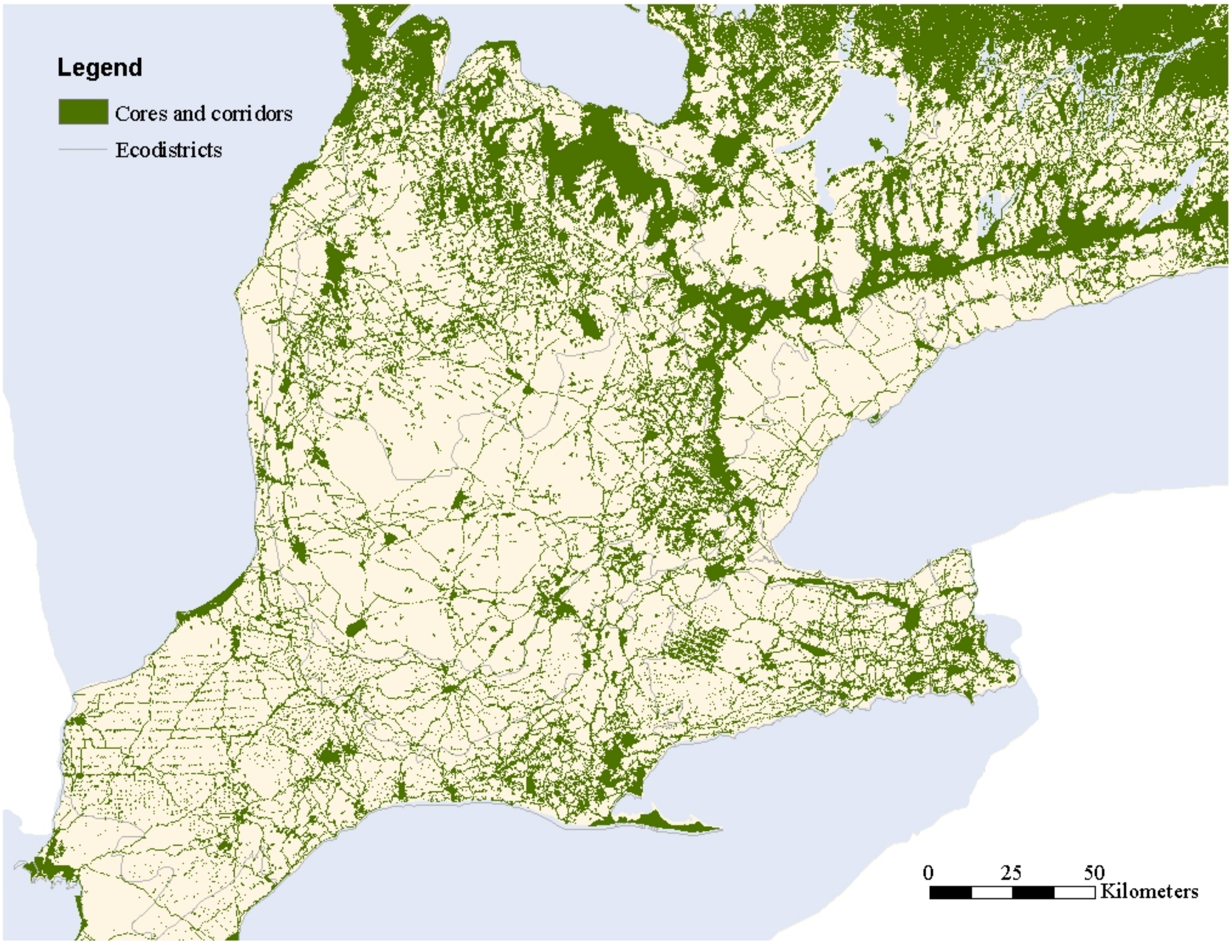


Figure 23. Cores and corridors from Big Picture 2002 Project (Riley *et al.*, 2003).

2002). The Big Picture 2002 project was a GIS-based landscape analysis to identify a linked natural heritage system across southern Ontario. This project was completed by the NHIC and the NCC with the input of a core science team comprised of other individuals from other organizations, including the Federation of Ontario Naturalists, Ducks Unlimited, Carolinian Canada, Ontario Power Generation and Ontario Parks (Jalava *et al.*, 2002; McMurtry *et al.*, 2002; Riley *et al.*, 2003, or for more information go to http://nhic.mnr.gov.on.ca/MNR/nhic/documents/projects.cfm).

This layer was used in the southern Ontario analysis, based on the ecological systems grid. Areas that overlapped with cores and corridors that have been identified in the Big Picture 2002 were given higher priority than others, through additional scores for 'core natural areas' and 'potential linkages' (including linkages on the Oak Ridges Moraine and Niagara Escarpment), and with additional but lower scores for 'island cores' (Figure 23; Appendix 8).

Presence of Old Growth Forest

Older-growth forests are extremely rare in southern Ontario (Riley and Mohr, 1994; Larson *et al.*, 1999) and rare to uncommon on the Canadian Shield. Mature forests provide multiple ecological benefits including nutrient cycling and specialized species habitat, and are characterized by multiple age class structure, pit-mound topography, and an abundance of tree cavities, snags and downed woody debris. However, specific characteristics of old growth forests vary among forest regions (Harper *et al.*, 2003; Kneeshaw and Gauthier, 2003).

Old growth forests have been valued for their ability to maintain biodiversity and provide critical habitat for a range of species. They are considered to be natural reservoirs of genetic diversity and reproductive fitness for tree species (OMNR, 1994; Carleton, 2003; Mosseler *et al.*, 2003), which may have implications with regard to responding to trends in global warming. Old growth forests also provide a benchmark against which to compare natural disturbance and forestry practices, and in maintaining species richness and natural genetic diversity (Frelich and Reich, 2003).

The *2001 State of the Forest Report* (OMNR, 2002) stated that old growth forests represent 21% of all the forest types in managed and protected forest types in Ontario. The 1994 Timber Class Environmental Assessment stated that about half of these old growth forests were in provincial parks and conservation reserves (OMNR, 1994). This assessment resulted in the development of an old growth forest conservation strategy.

An old growth forest layer was used in the Canadian Shield analysis, generated from the Forest Resource Inventory (FRI) data used for the ecological systems layer. A comparable digital data set was not available for southern Ontario. FRI data includes the age of each forest stand, which was adjusted to the current age of the forest stand. OMNR has defined old growth forest for the four forest regions in Ontario within the framework of the Provincial Ecological Land Classification (Uhlig *et al.*, 2001). The minimum ages for these old growth forested ecosites were extrapolated to the 15 Conservation Blueprint forest ecological systems on the Canadian Shield (Appendix 11). FRI data were queried to identify all forest polygons that were equal to or greater than this old growth onset age, resulting in the old growth forest layer. These old growth areas were given additional scores (Figure 24; Appendix 9).

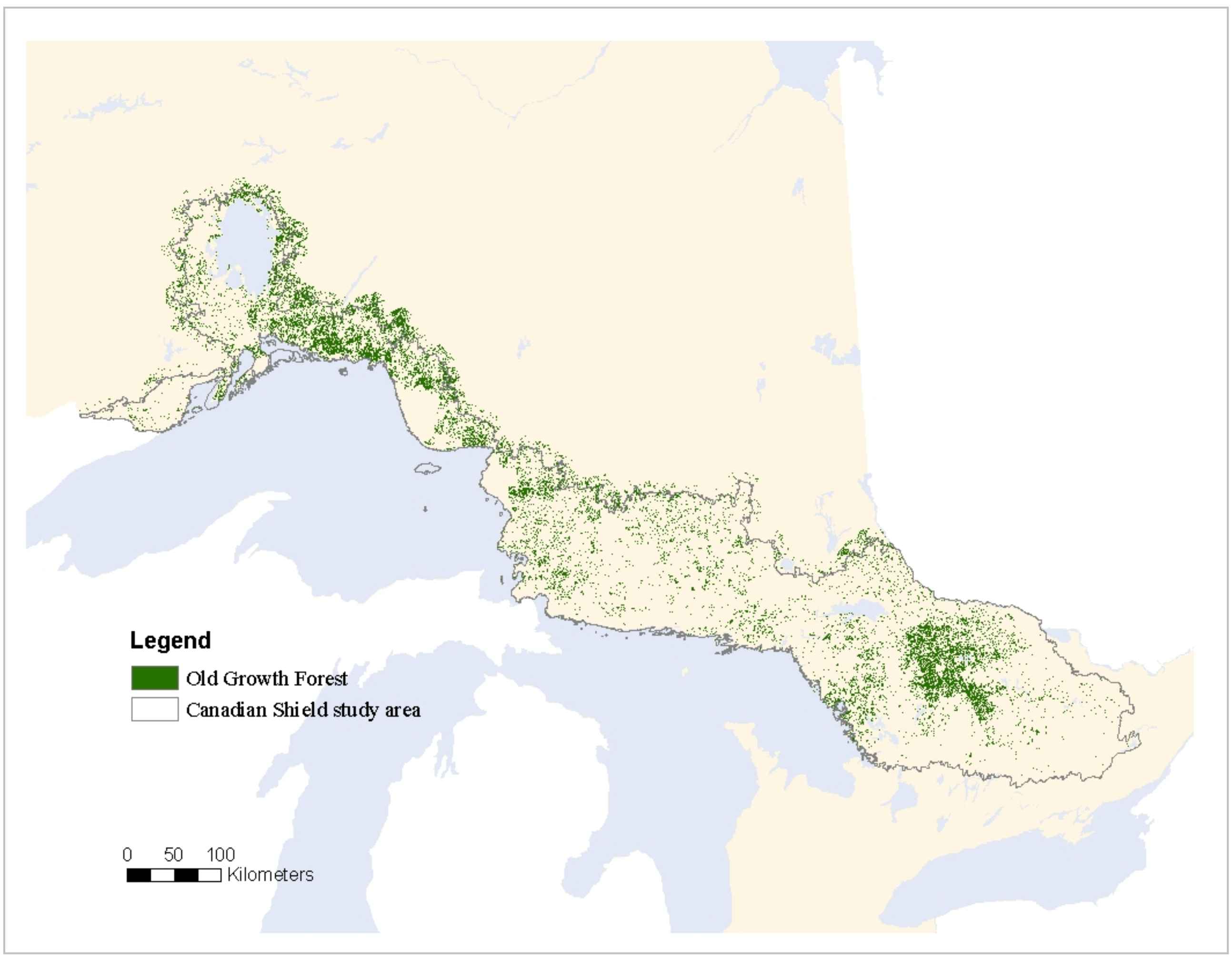


Figure 24. Old growth forest.

Proximity to Existing Protected Areas

Protected areas conserve biological and geological diversity, contribute to the maintenance of ecosystem health, provide protection for rare species and their habitats, and provide reference sites in which to learn and develop conservation strategies (OMNR, 1997b). Throughout southern Ontario it has also been determined that publicly owned natural areas, including protected areas, provide habitat for a variety of rare species; a key focus of conservation in highly fragmented landscapes (Lovett-Doust and Kuntz, 2001; Lovett-Doust *et al.*, 2003).

Key goals of the OMNR Parks and Natural Heritage program in Ontario were to "1) ensure the long term health of ecosystems by protecting and conserving our valuable soil, aquatic resources, forests and wildlife resources, as well as their biological foundations and 2) to protect natural heritage and biological features of provincial significance" (OMNR, 1992). Provincial protected areas are regulated and offer long-term legal protection for their ecological values on public land (OMNR, 1997b). National parks are now held to standards based on their ecological integrity, which involves the sustainability of land and waters beyond park boundaries, the "greater park ecosystem". Management decisions for areas proximal to protected areas are increasingly seen as important to their ecological integrity (Zorn *et al.*, 2001).

The proximity to existing protected areas layer was generated from the data sets obtained from NRVIS and Ontario Parks. The protected areas include regulated provincial parks, regulated national parks, conservation reserves, unregulated provincial parks and conservation reserves

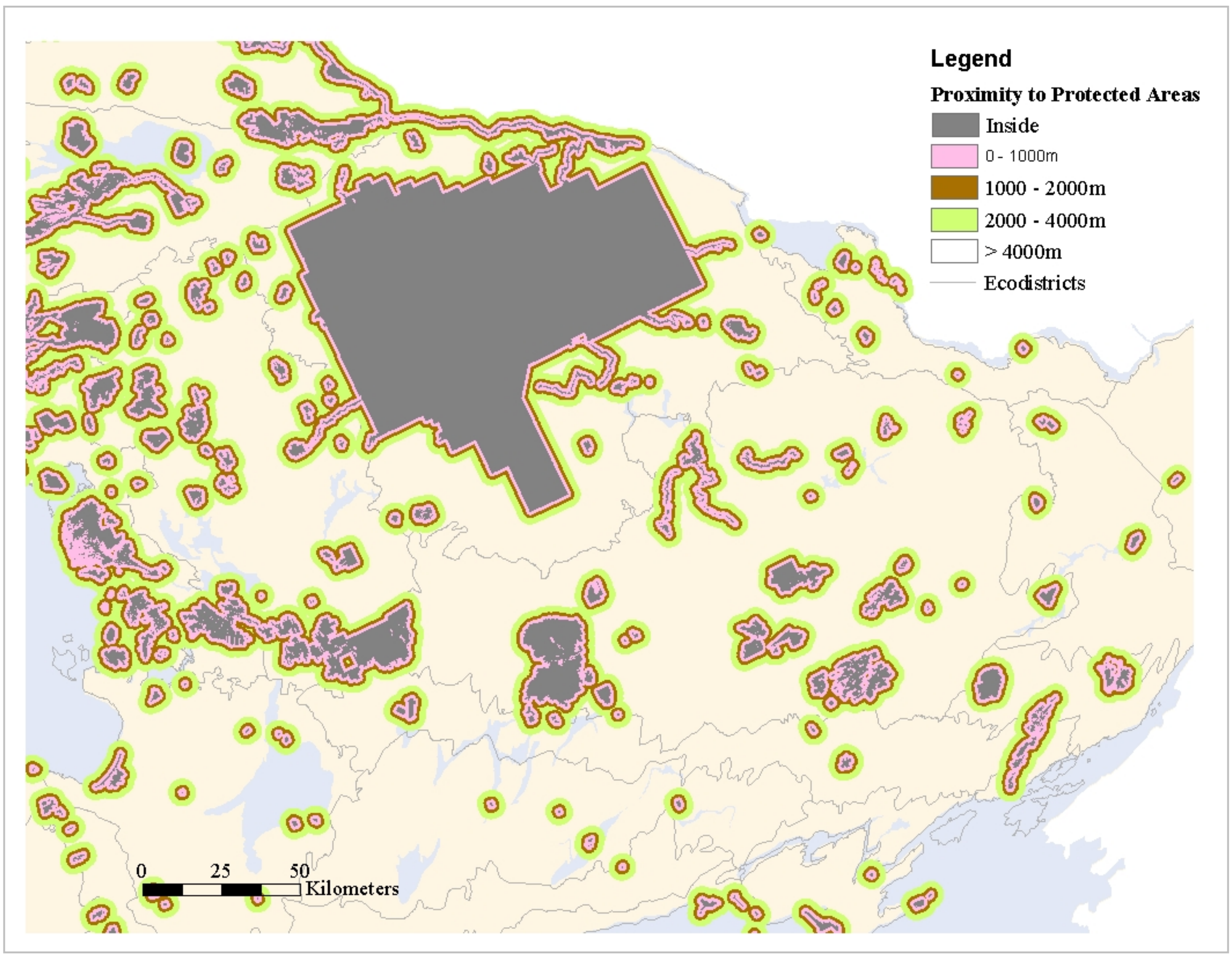


Figure 25. Proximity to protected areas.

identified through the Ontario Living Legacy, and the proposed Lake Superior National Marine Conservation Area. These area boundaries were buffered by 1 km, 2 km and 4 km, with natural areas closer to existing protected areas given higher scores then those that were farther away (Figure 25; Appendices 8 and 9).
.

Coincidence with Existing Conservation Lands

There is a range of additional conservation lands across Ontario that are publicly or privately owned and are identified as having natural heritage values. Some of these conservation designations overlap with existing protected areas, or are contiguous and indicate landscape patterns and systems across wider areas. For example, provincial parks can overlap with ANSIs, wetlands and areas identified as significant woodlands. There are varying degrees of protection for these lands. Conservation Authority lands were acquired for conservation purposes and can only be sold by permission of the Minister of Natural Resources. National Wildlife Areas and Migratory Bird Sanctuaries are regulated for wildlife conservation. Provincially significant wetlands and ANSIs are conserved by policies under the *Planning Act*, and through property-tax reductions under the *Conservation Lands Act*. These are important lands for biodiversity conservation, especially in southern Ontario where there are well-documented areas of high biodiversity on non-regulated public and private lands (Lovett-Doust and Kuntz, 2001; Lovett-Doust *et al.*, 2003; Theobald, 2003). These areas represent important investments in biodiversity conservation, and are key elements of local and regional conservation strategies.

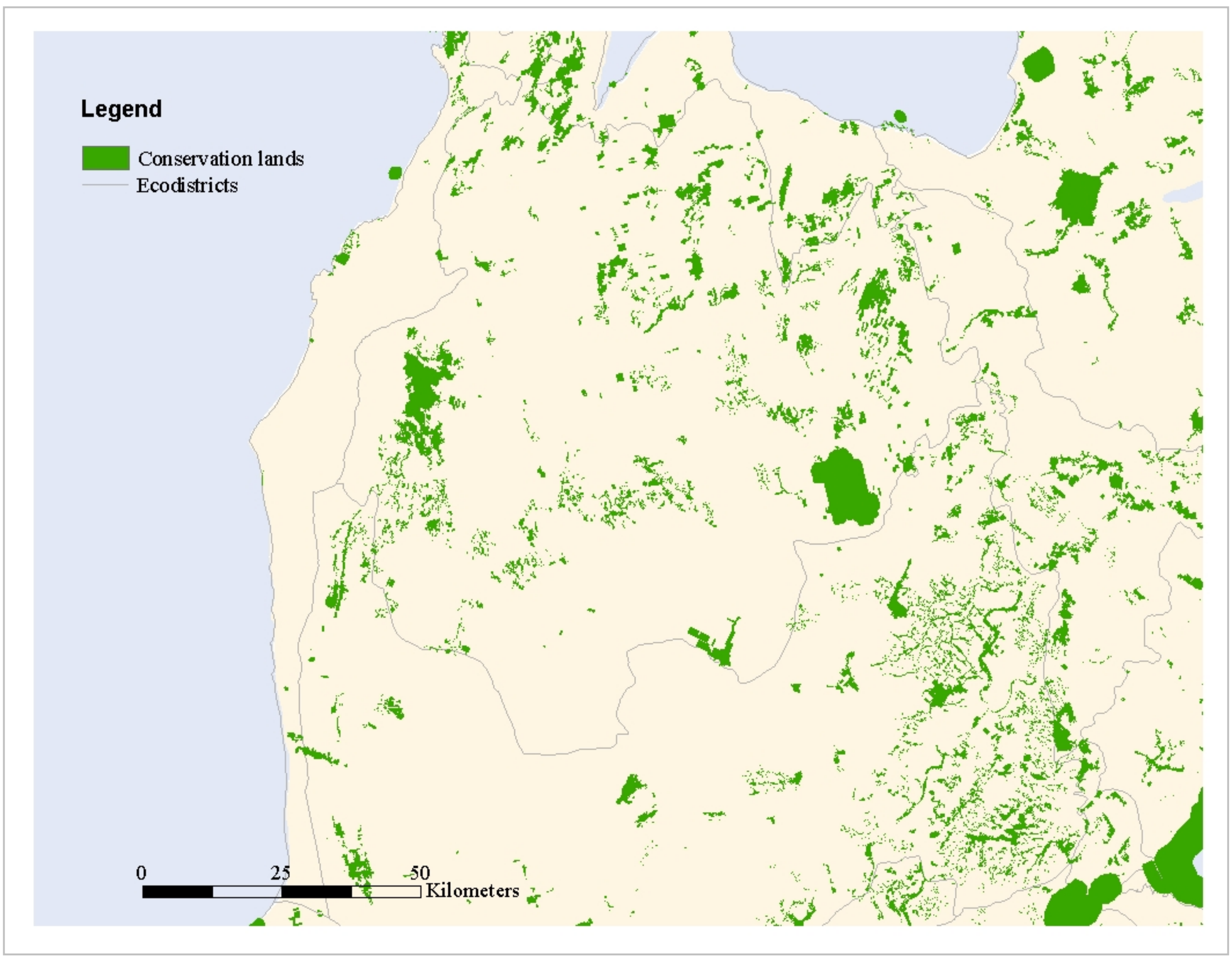


Figure 26. Coincidence with conservation lands.

This layer was generated from data sets obtained from NRVIS, Ontario Parks, NCC, individual Conservation Authorities, and Environment Canada. This grid is composed of life science ANSIs (with provincially significant ANSIs scoring higher than regionally significant), provincially significant wetlands, Conservation Authority lands, Nature Conservancy of Canada properties and Important Bird Areas across the ecoregion. It also includes significant woodlands identified by Larson *et al.* (1999) for the southern Ontario portion of the analysis. Natural areas that coincided with these conservation lands were scored more highly. Those sites that did not occur in one of these areas did not receive any points (Figure 26; Appendices 8 and 9).

<u>Hydrological Functions:</u>

A surrogate assessment of the hydrologic function of natural areas was based on compilation of four criteria: whether an ecological system was part of the riparian area along a stream, an inland lake, along the Great Lakes shoreline, or was part of a wetland. Sarakinos *et al.* (2001) demonstrated the importance of coastal and riparian areas to biological diversity, and strongly suggested the importance of an integrated coastal, riverbank and wetland management strategy for biodiversity conservation.

Wetlands

Human impacts have greatly reduced the extent and quality of wetlands, particularly in southern Ontario, over the past century. Wetlands are critical habitat for a great variety of flora and fauna, including migratory and resident birds, as well as numerous at-risk reptiles, and almost all amphibians of Ontario. Strobl (2003) estimates that 50 species of birds and 28 species of

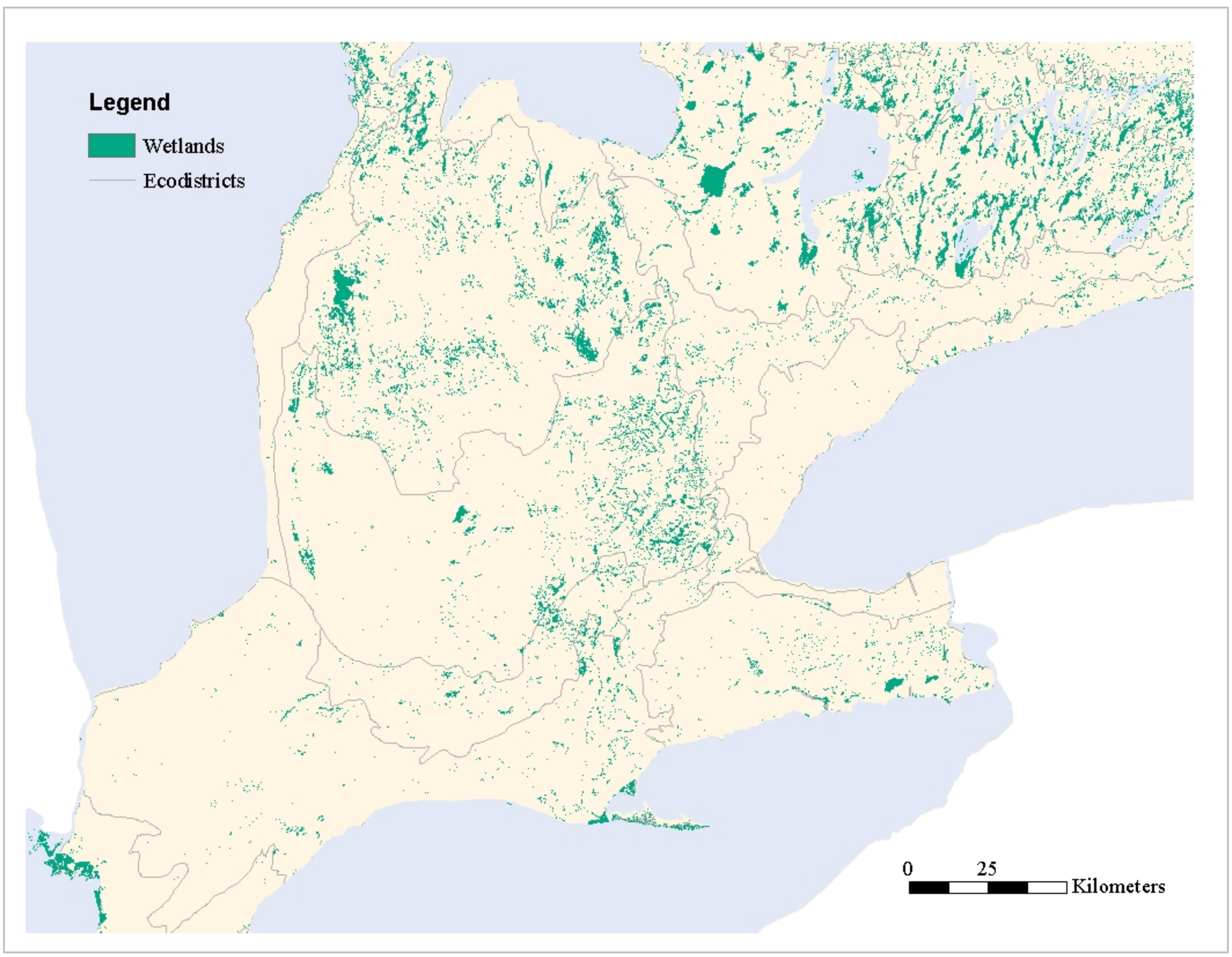


Figure 27. Wetlands.

amphibians and reptiles depend on wetlands for at least part of their life cycle, and many of these species need unimpeded travel routes between wetland and upland ecosystems to complete their life cycles. Herpetofaunal species richness and abundance increase in proportion to the amount of wetland area, forest cover and adjacent wetlands (Findlay and Houlahan, 1997; Houlahan and Findlay, 2003). Semlitsch and Bodie (2003) suggest that the size of core terrestrial habitat around wetlands that is needed to maintain population viability and biodiversity should extend 127 m to 290 m from the edge of its aquatic habitat. The creation of naturally vegetated buffer strips around wetlands (and streams and lakes within their associated catchment) is integral to maintaining aquatic diversity in wetlands surrounded by traditional agriculture and forestry (Dillon *et al.*, 1991; Crosbie and Chow-Fraser, 1999).

Wetlands deliver critical ecological functions across the landscape, including the protection of surface water and groundwater resources to ensure a stable, long-term supply of water (Devito *et al.*, 2000; Baker *et al.*, 2003). Wetlands filter and transport near-surface and surface water and their associated water-soluble nutrients.

Wetlands mapping for southern Ontario was based on the provincial Land Cover mapping and the NRVIS wetland mapping. Wetlands on the Canadian Shield were based on the FRI data, provincial Land Cover mapping and Ontario Peatland Inventory data. Natural ecological systems were scored if they coincided with a wetland. No scores were applied if systems were outside a wetland (Figure 27; Appendices 8 and 9).

Riparian Areas of Streams:

Riparian zones are important to biodiversity in terms of nutrient cycling, retention and filtration of

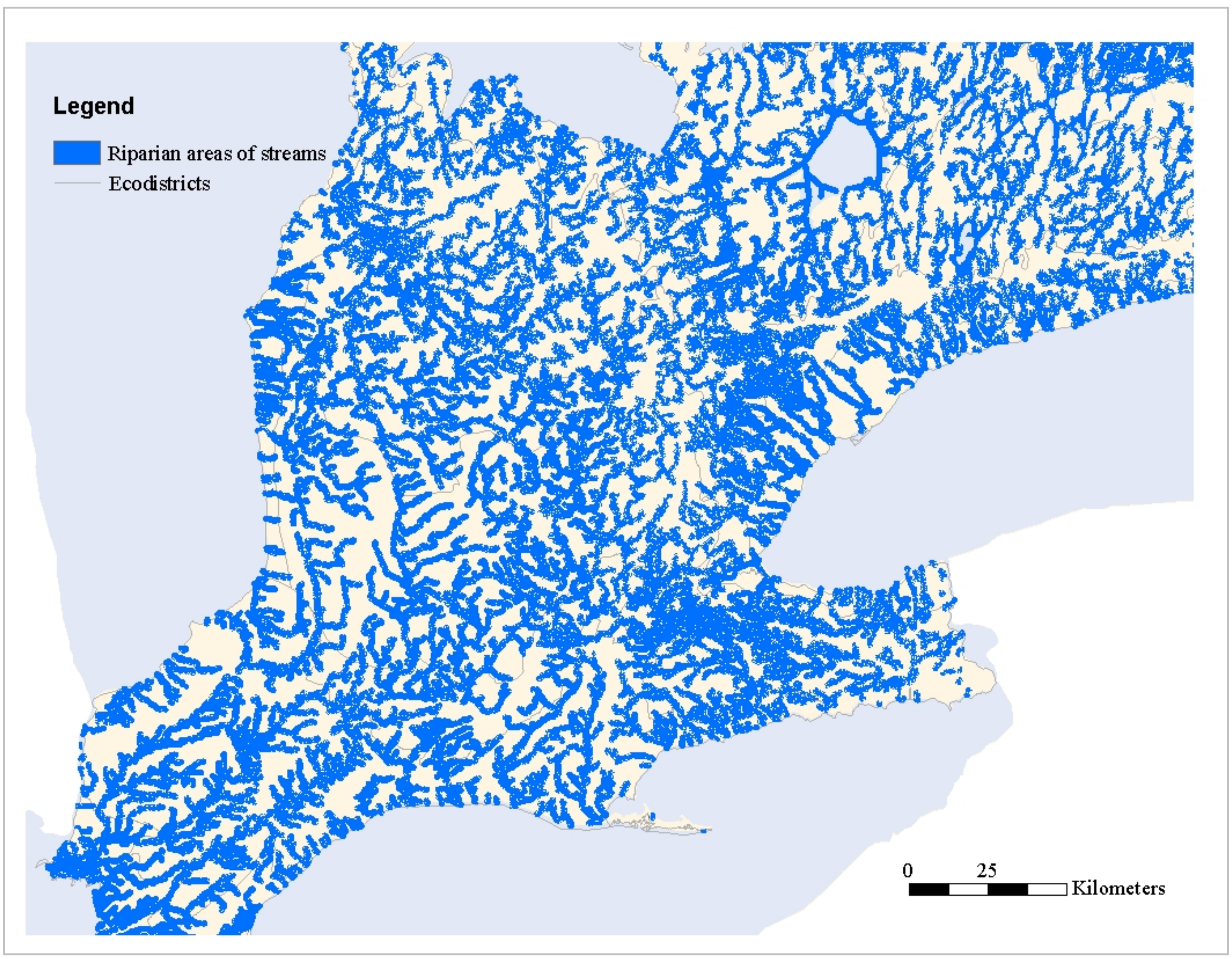


Figure 28. Riparian areas of streams.

water. They provide essential habitat and movement routes for a wide variety of species. Species abundance and diversity in riparian zones are related to both surface and groundwater and how these connect to their adjacent landscapes (Tabacchi *et al.*, 1998). Urban and agricultural land use often directly disrupts water flow, reduces water quality and alters stream channels, resulting in the loss of biological integrity of streams and their associated riparian areas (Snyder *et al.*, 2003).

Riparian areas along undisturbed streams in boreal forests show an increased abundance of flying insects and the associated breeding by insectivorous birds (Whitaker *et al.*, 2000). Such riparian buffers may act as windbreaks that allow insects from adjacent clearcuts and lakes to congregate which, in turn increases the food availability for associated birds.

Numerous studies and guidelines suggest appropriate riparian buffer widths. Timber management operations along riparian areas take into consideration the slope, soil type and other variables to calculate an appropriate buffer strip, for example, at least 3 m in width for streams with slopes less than 40% (OMNR, 1991). A naturally-vegetated terrestrial buffer width based on habitat needs of herpetofauna has been estimated at 127 m to 290 m from the edge of the stream to ensure population viability and biodiversity (Semlitsch and Bodie, 2003). The Massachusetts Resource Identification Project applied a 100 m buffer width for riparian corridors along perennial streams and rivers to conserve a functional corridor for species dispersal and for the provision of hydrological functions (Schartz and Goodwin, 1999).

This layer was created from the provincial waterflow stream data that was used from the Aquatic Conservation Blueprint project (Wichert *et al.*, 2005). Natural ecological systems were selected if they were within 100 m of the stream. The southern Ontario analysis selected only Strahler stream orders of three or greater, and natural ecological systems were identified as riparian areas that were were within 100 m of the stream and up to 1000 m away. The Canadian Shield analysis selected all Strahler stream orders and natural ecological systems were considered riparian where they were within 100 m of a stream (Figure 28; Appendices 8 and 9).

Great Lakes Shoreline:

The Great Lakes coast is diverse, ranging from coastal wetlands to beaches, sand dunes and rocky shores. The waterbodies are so large that they drive near-oceanic geomorphological processes. The waves and currents, winds and weather coming off the lake affect the immediate shore as well as inland ecosystems, and there are many common and Great Lakes-specific vegetation communities and species in these zones. However, development, eutrophication, pollution and invasive species introduction have all contributed to the decline of wetlands (Beeton, 2002) and other coastal ecosystems of the Great Lakes.

Characteristic near-shore and shoreline vegetation types include Great Lakes coastal meadow marshes, sand beaches, bedrock shorelines, marshes and dune systems. These communities are host to a great variety of rare species, including some, such as Pitcher’s Thistle and Houghton’s Goldenrod, that are endemic to the Great Lakes basin. Other globally rare and restricted habitats occurring along the Great Lakes include alvars, with their distinctive and endemic species, and on-shore Canadian Shield cliffs and basalt talus, with their distinct set of disjunct arctic-alpine species.

Sand beaches and their associated sandbars, shoals and spits are the most common types of shoreline along the Great Lakes. These often provide critical feeding grounds for migratory shorebirds and substrates for marshes and other coastal wetlands. The Great Lakes ecoregion includes the largest freshwater coastal dunes in the world, the result of offshore sandbars, fluctuating water levels, strong winds, and stabilizing reeds and grasses that build the dune and set the stage for shrubs and trees to establish. The freshwater wetlands vary from small wetlands to huge freshwater delta marshes such as on Lake St. Clair. Wetlands vegetation in turn traps sediment and reduces erosion, thus providing important species habitat.

The shoreline layer that was created was based on the ecological systems layer, selecting natural ecological systems within 1 km of the shore and

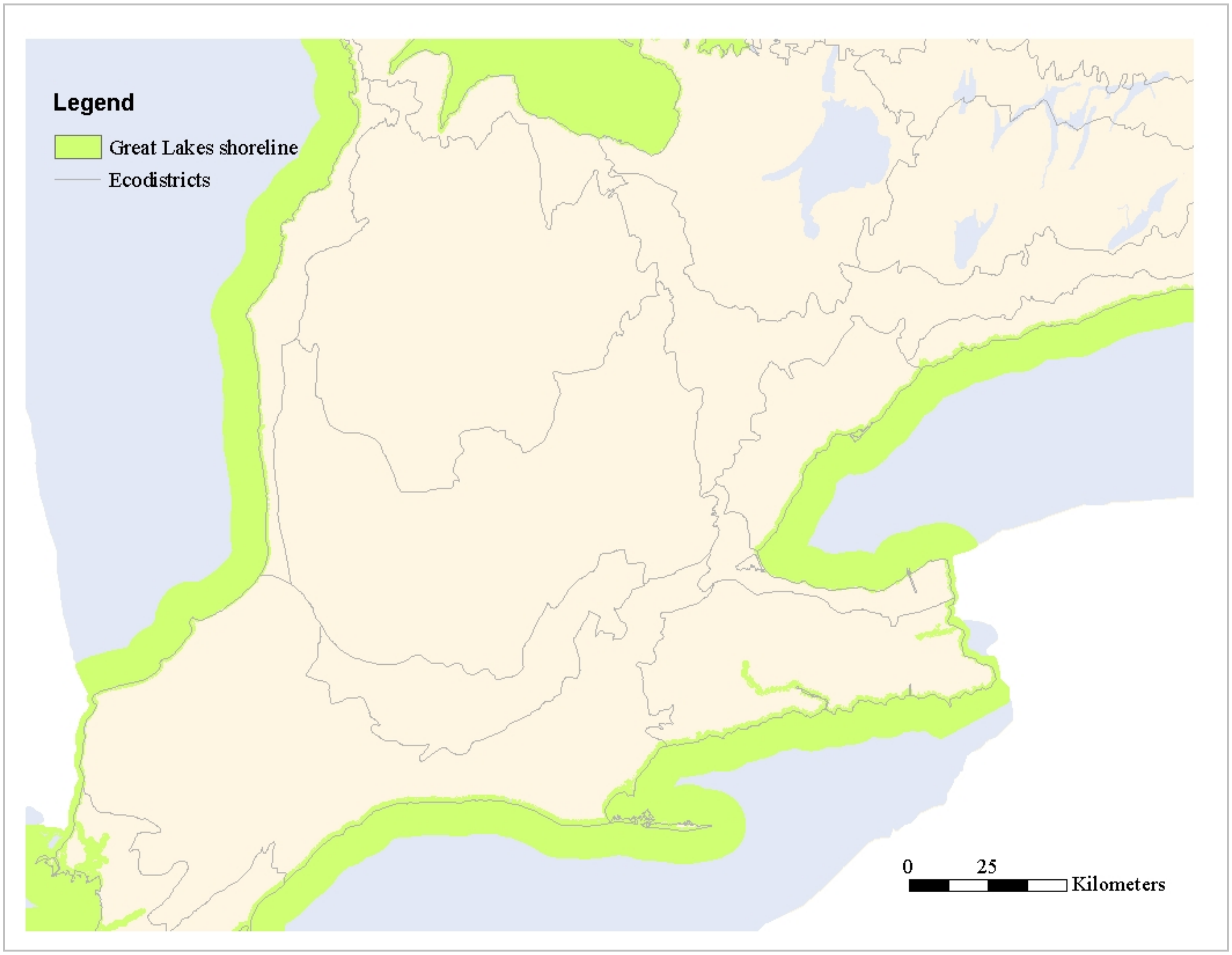


Figure 29. Great Lakes shoreline.

adjacent to the shore. Watercourses directly connected to the Great Lakes and at the same water level (*e.g.*, Lower Grand) were built into the grid to represent the Great Lakes and St. Lawrence River system as a whole (Figure 29; Appendices 8 and 9).

Riparian Areas of Inland Lakes:
The term 'riparian' is normally used to denote areas adjacent to rivers and streams. It is also occasionally applied to such zones around lakes and other waterbodies. Like riparian zones along streams, the lands adjacent to lakes are also important to nutrient cycling, water retention and filtration, and provision of habitat and corridors for many species. Species abundance and diversity in riparian zones are related to both surface and groundwater, and how these are connected to adjacent landscapes (Tabacchi *et al.*, 1998). Riparian areas of lakes also have important social values. 'Waterfront' home and cottage properties are among the most highly valued lands, both for the aesthetic and recreational values they offer. Haider and Hunt (2002) studied the aesthetics of Ontario's boreal lakes and shores, and related the aesthetic values of riparian forests to the forest ecosystem classification systems, suggesting how to incorporate such values into conservation and management strategies.

Numerous studies and guidelines suggest appropriate riparian buffer widths. Timber management operations along riparian areas take into consideration the slope, soil type and other variables to calculate an appropriate buffer strip, for example at least 3 m in width for areas with slopes less than 40% (OMNR, 1991). Timber management guidelines for protecting significant

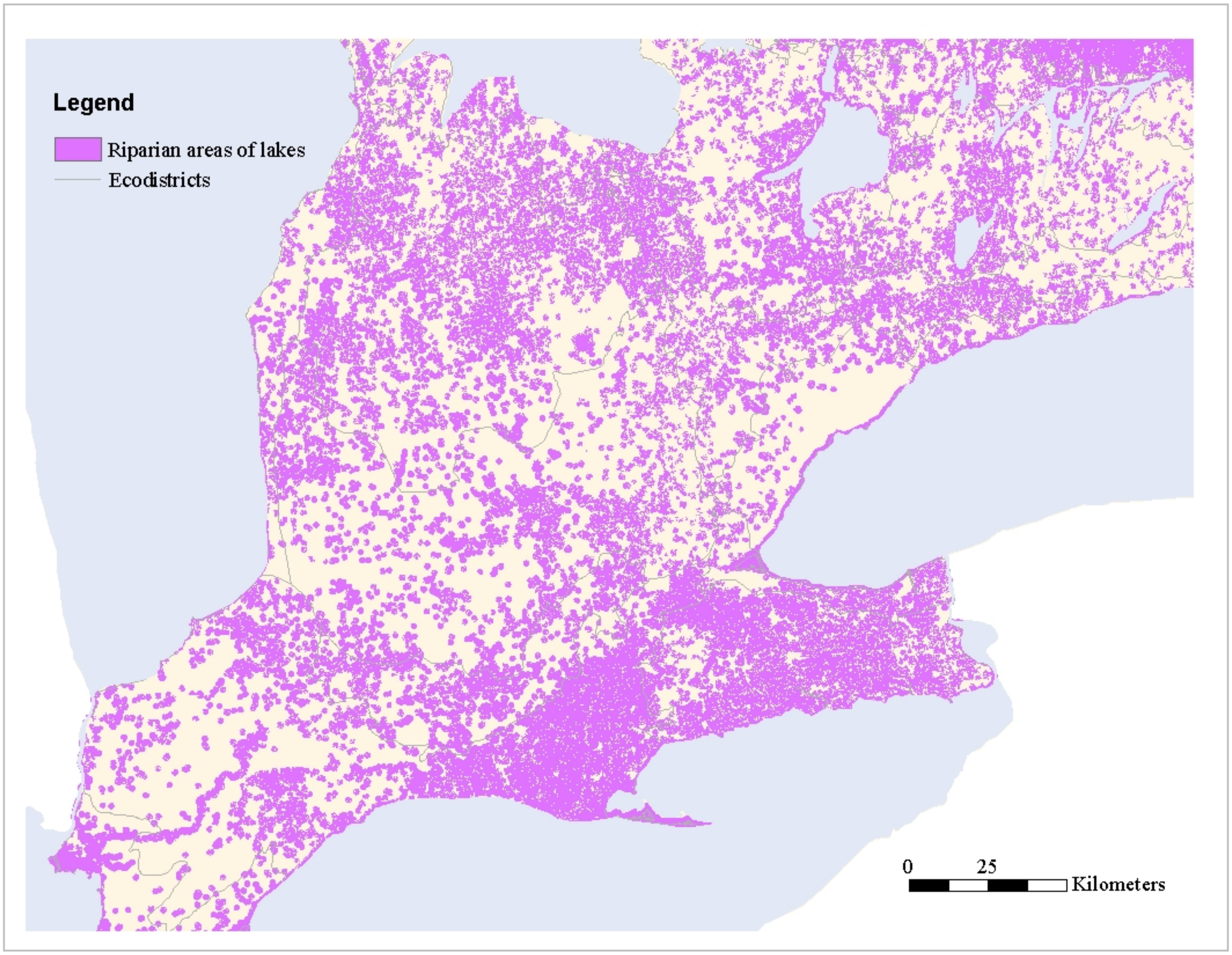


Figure 30. Riparian areas of inland lakes.

fisheries and fish habitat require a buffer width ranging from 30 m to 90 m (depending on shore slope) for all headwater lakes, lakes greater than 10 ha in size and those with significant fisheries or spawning habitat (Allin, 1988). A buffer width based on the habitat needs of herpetofauna has been estimated at 127 m to 290 m from the edge of water to ensure population viability and biodiversity; this includes a 30 m to 60 m aquatic buffer to protect water resources (Semlitsch and Bodie, 2003).

This layer was based on the lake data used in the Aquatic Conservation Blueprint project, in which all inland lakes were mapped. For the Canadian Shield analysis, natural ecological systems were selected if they were within 100 m of a lake. The southern Ontario analysis selected systems within 1 km of a lake that were on the lake (Figure 30; Appendices 8 and 9).

Presence of Potential Valley Systems:
Valley systems are defined by streams and rivers as they erode natural troughs into the landscape in their downslope journey towards the ocean. Other valley bottoms were molded by the movement of ice during the retreat of glaciers. Still others occur as the result of geological activity as the plates of the Earth's crust move, collide and are thrust upwards or downwards. In any case, many valley bottoms have flowing streams, flat terrain and fertile silt soils, often making these areas rich in native species, but also prime locations for power generation, infrastructure and agriculture. Valleys and their landform heterogeneity and water features are fundamental conservation strategies (Wiens, 2002). By the 1930s and 1940s, southern Ontario realized it had become a showcase for decades of poor land, water and forestry practices that resulted in less than 5% of the landbase remaining in original forests, wholesale removal of

swamps and ponds and excessive soil erosion (Larson *et al.*, 1999). There was less water-holding capacity on the land, groundwater levels were reduced and water quickly drained from the headwaters (Carman, 1941). The river valleys flooded in the spring and dried out in the summer (Coventry, 1945). The need to exercise wise river valley conservation through reforestation and regeneration coincided with available post-war manpower, to result in the *Conservation Authorities Act* of 1946 and the establishment of watershed-based conservation across southern and central Ontario since then.

Parson and Gilvear (2002) studied the abandonment of anthropogenic activities on river valleys over several decades and documented the recovery of landform and vegetation mosaics and increases in habitat diversity and natural conditions. Valleys are areas of high natural habitat diversity, and their relative recovery across most of southern Ontario was one of the great environmental successes of the 20th century.

This layer was used in the southern Ontario analysis, based on the natural ecological systems, the proximity of an area to a river (ordered streams of 3 or greater for southern Ontario based on Strahler), and the critical value of Topographic index. The Topographic index measures the accumulation of water in a specific area and is related in part to the area's slope and terrain. (Figure 31; Appendix 8).

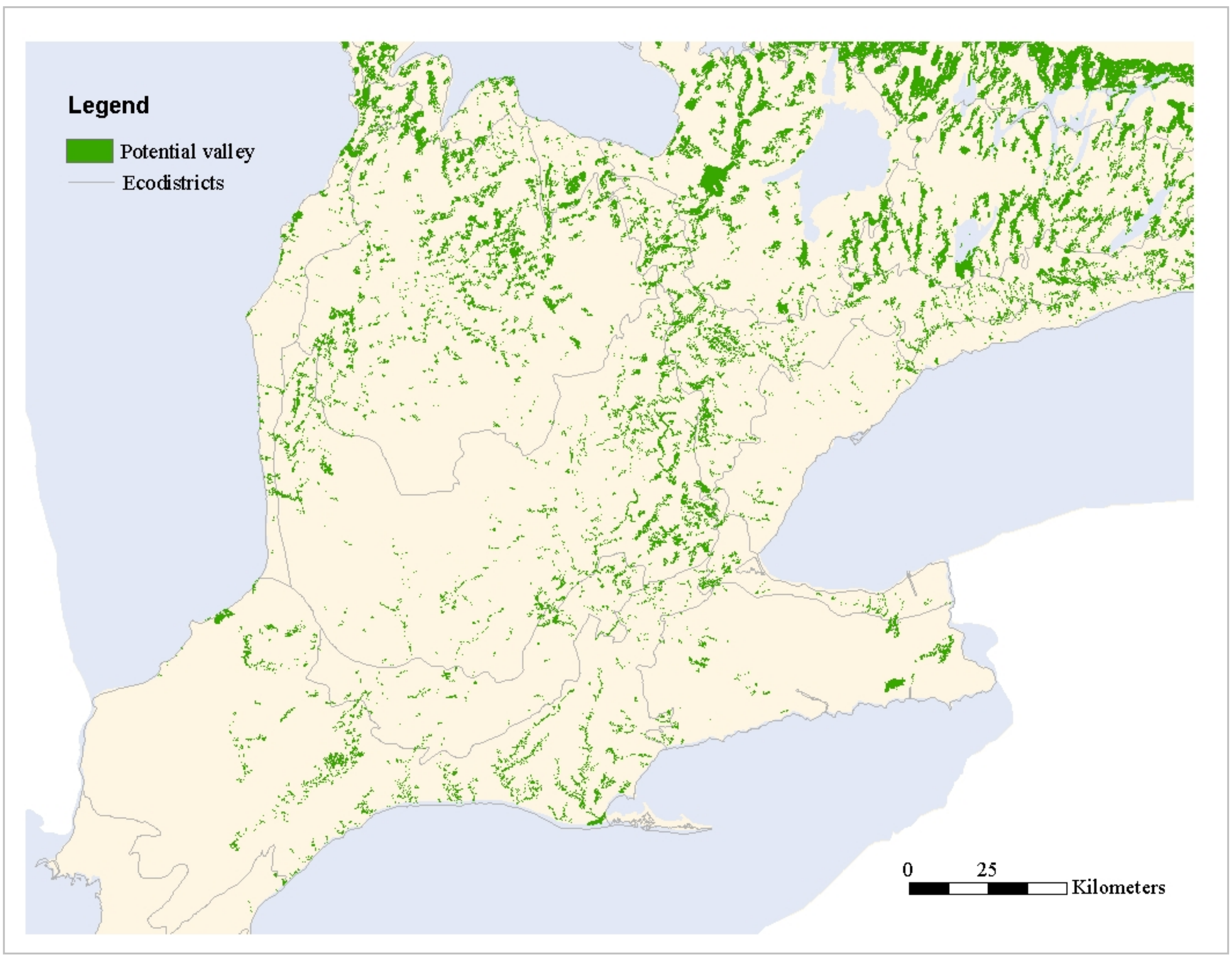


Figure 31. Presence of potential valley systems.

SPECIAL FEATURES CRITERIA

'Special features' refer to rare species and vegetation community occurrences, and other unique features considered to be of ecological or aesthetic importance. The specific habitats of species at risk or species of other conservation interest in a region are widely used to guide conservation strategies (Lesica and Allendorf, 1995; Lomolino and Channell, 1995). Identifying particular concentration areas of such species has also been used as a surrogate for general species diversity, as a way to prioritize natural areas for biodiversity conservation. However, using species diversity to represent general biodiversity may not accurately reflect biodiversity at other scales (Sarakinos *et al.*, 2001).

In the Conservation Blueprint analysis, species diversity and occurrence density are used to enhance the site selection, as one criterion among a suite of criteria. Special features are analyzed in two ways in the Conservation Blueprint analysis: 1) as a general criterion in the coarse-filter analysis, described here for all target species and community types listed in Appendices 2 and 3, and 2) as a fine-filter analysis that requires the inclusion of enough sites (occurrences) to meet specific conservation goals (or inclusion goals) for the primary (not secondary) target species and communities in Appendices 2 and 3 (see Section 5.5.3).

In the coarse-filter analysis, ecological system polygons were scored higher based on whether they included occurrences of species targets and other provincially rare species and communities. In generating this scoring layer, extant populations were given higher scores than historic populations, with the southern analysis considering species to be extant if they were observed in the last 20 years. The Canadian Shield analysis follows the

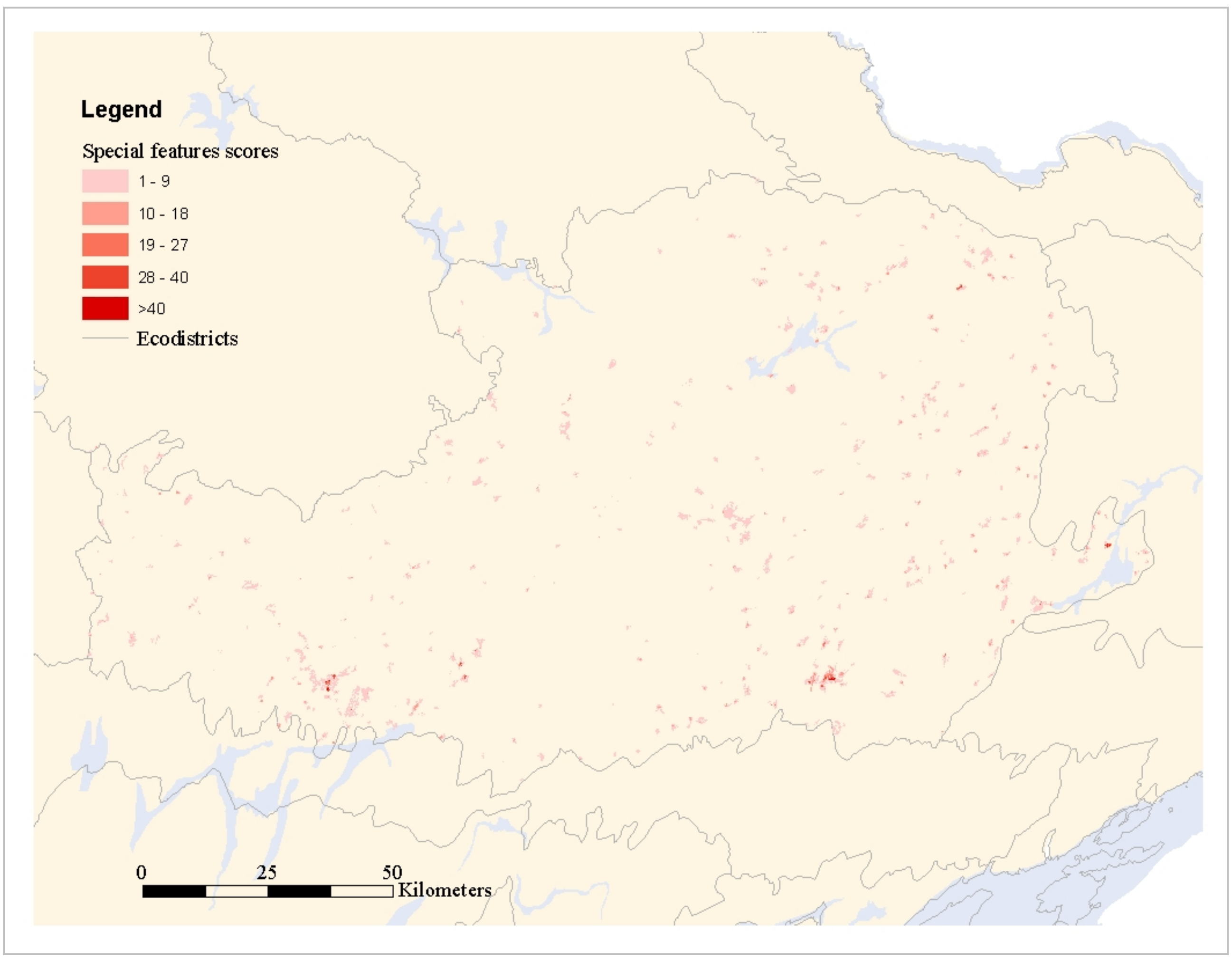


Figure 32. Special features scores of ecodistrict 5E-11.

same rule except that plant species were considered extant if they were observed in the last 40 years. These additional plant species were considered extant because of less frequent botanical surveys and slower land use change in northern Ontario. The density of the points was measured based on their distance to each other within a radius of 1000 metres. The final grid used in the analysis represents a smoothed count of rare species and vegetation communities concentrated in an area. The total special features score was adjusted to a maximum score of 40 points, to a maximum of 20% of the total score in southern Ontario, and 15% of the total score on the Canadian Shield (Figure 32; Appendices 8 and 9).

DIVERSITY CRITERIA

A landscape that has many ecological system types can be considered more diverse than a landscape with fewer system types, excluding those systems for which size and homogeneity are part of the ecological identity of the system (*e.g.*, Jack Pine flats, bogs). Recent studies have concluded that natural areas of larger size and forest interior, and greater landform heterogeneity usually have significantly higher biotic diversity (Lovett-Doust and Kuntz, 2001; Riffell *et al.*, 2003).

In this analysis, the diversity of an ecological system polygon was scored based on a single grid, and the total diversity score was adjusted to 5% of the total score of the coarse-filter analysis. The grid was generated from the ecological systems layer by using a 'regiongroup' command that was applied to create regions by grouping adjacent grid cells of the same value. These regions were then used to represent unique, contiguous ecological systems.

A 'focalvariety' command was then applied to the ecological systems grid, and a 5 x 5 cell or 1.5 ha window was run over the ecological systems layer

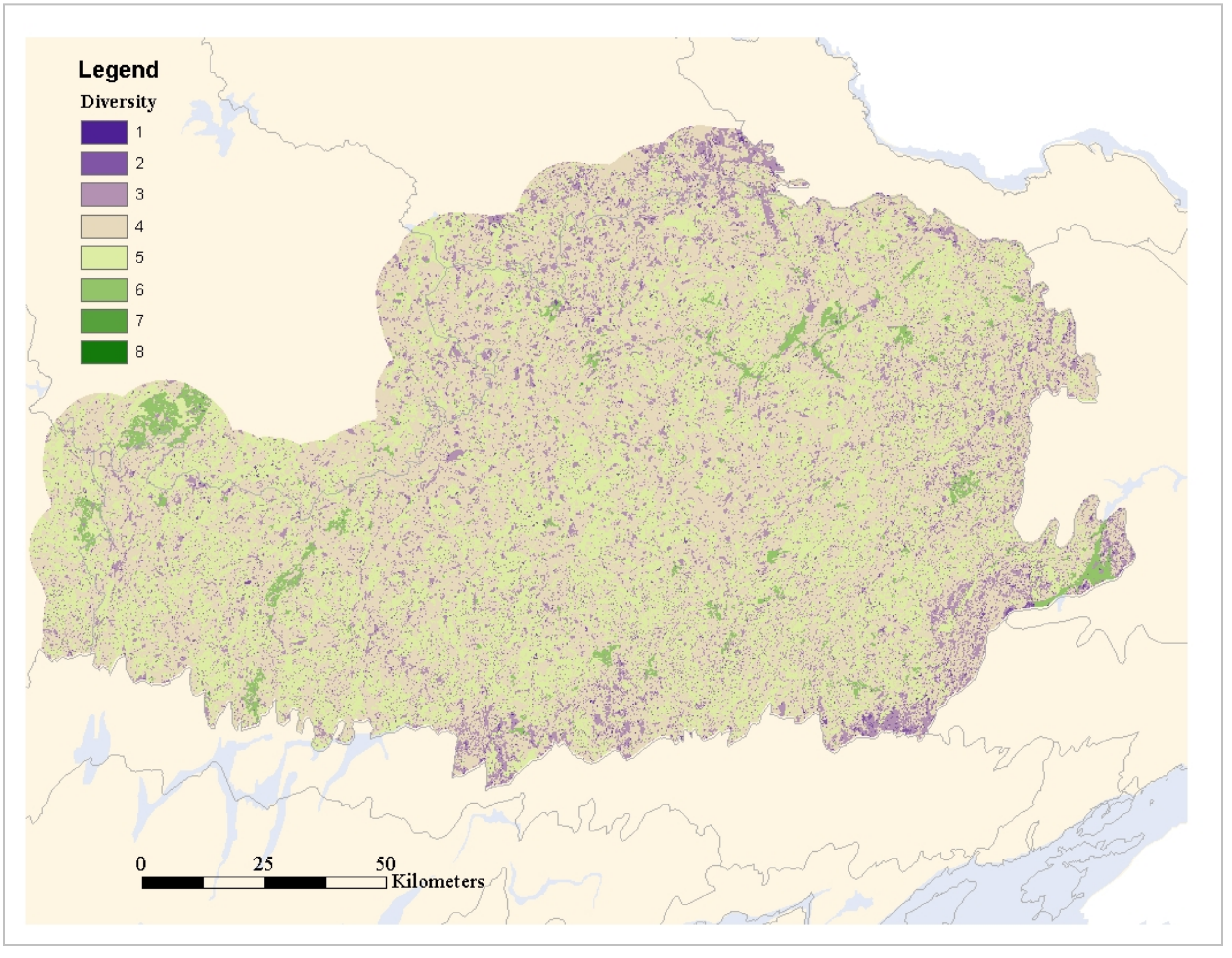


Figure 33. Diversity of ecodistrict 5E-11.

comparing each grid cell with the grid cells surrounding it. Each 25 m grid cell was given a value based on the number of unique ecological system types found adjacent to it, essentially delineating the perimeter of each unique system. For example, if a grid cell was located at the intersection of three ecological systems, it was given a value of 3. Areas that were more diverse in a small geographical area were given a higher pixel score at this stage.

The outputs of the regiongroup and the focal variety were fed into a 'zonal maximum' where the regions were classified according to the highest focal variety score associated with the region (Figure 33, Appendices 8 and 9). See Henson and Brodribb (2004) for details and screen captures.

5.5.1.3 Wide-ranging Mammal Information

Soule *et al*. (2003) states that because wide-ranging species occur in a wide variety of ecosystems, the conservation and recovery of these species should occur at landscape or regional scales. A species that is highly interactive with other species in an ecosystem, such as a predator, can alter a part of that landscape based on changes in its abundance, distribution and behaviour. These species can be keystone species whose influences are disproportionate to their population size, or they can be foundation species that are abundant or ecologically dominant.

Umbrella species, usually wide-ranging mammals, have also been identified as those for which calculations of minimum area needs may serve as an inclusive surrogate for multiple co-existing species. Such area needs have been used to define reserve networks at large geographic scales (Kerr, 1997; Roberge and Angelstam, 2004), and may be useful in designing networks of adequate sites meeting minimum standards for composition, structure and function of ecosystems for multiple interacting species on the landscape (Bruinderink *et al.*, 2003; Soule *et al.*, 2003; Roberge, 2004).

The distribution of many Ontario mammals is dynamic with respect to the extent of the habitat needs, depending on interconnected factors and processes, many of which are influenced by human activities in that landscape (Thompson, 2000). For example, Caribou and Pine Marten habitat is associated with old growth forests. If human interactions and habitat conversion continue to increase on the landscapes and extend further north, suitable habitat for these species will almost inevitably be reduced.

The Fisher exhibits large fluctuations across its range, perhaps reflecting increased snow depth resulting from climate change. This, and the increase in Porcupine across the province, may be having a strong influence on the Fisher (Voigt *et al.*, 2000). Moose also exhibit the strong interaction between landscape disturbance patterns (density-independent) and mortality stemming from human and natural predation (density-dependent) (Voigt *et al.*, 2000).

However difficult, the ecological requirements of wide-ranging mammals in the Great Lakes ecoregion were considered part of the Conservation Blueprint goal of maintaining conservation biodiversity at landscape scales. So, the Canadian Shield region was used to test the apparent adequacy of Conservation Blueprint sites to sustain these species (Section 6.6). It is acknowledged that this analysis based on the patch sizes of ecological systems does not address species that have extensive home range requirements or specialized habitat needs.

Additional population viability analyses and specific habitat and home range requirements for individual species would be required to fully address the suitability and contribution of Conservation Blueprint sites and the rest of the landscape to the long-term survival of the species population.

Literature relating to the habitat and range requirements of wide-ranging mammals in the Great Lakes ecoregion was reviewed (see Table 8; Appendix 12). These species make use of total landscapes by definition, including protected, set-aside and working parts of the landscape. A biodiversity analysis like the Conservation Blueprint, which attempts to meet representation and inclusion requirements for *in situ* ecological systems and for the whole range of species of

Table 8. Range size requirements for wide-ranging mammals in the Great Lakes ecoregion.

Species		Range Size Threshold (based on 1-4 reproductive units)
Primary Wide-ranging Mammal Targets		
	Fisher (*Martes pennanti*)	1,000 ha
	Black Bear (*Ursus americanus*)	2,500 ha
	Lynx (*Lynx canadensis*)	2,500 ha
Secondary Wide-ranging Mammal Targets		
	Wolverine (*Gulo gulo*)	10,000 ha
	Caribou (*Rangifer tarandus*)	400,000 ha
Other Wide-ranging Mammals not targeted		
	Moose (*Alces alces*)	2,000 ha
	Gray Wolf (*Canis lupus*)	10,000 ha
	Pine Marten (*Martes americana*)	4,000 ha

conservation concern, generates portfolios of sites that are less than the total landscape. Such analyses assume that land management of the intervening, dominant landscape must also be supportive of the needs of wide-ranging species.

The figures of 'adequate' range size in Table 8 are estimates of the size of home range of one to four reproductive units or pairs. Figures for 'viable populations' are not available for this region, and such figures would, of course, need to consider the habitat provided by the total landscape, not just identified biodiversity conservation sites. These habitat-size requirements could have been used to drive the scoring of the Conservation Blueprint's coarse-filter analysis, but would have required a separate run for that purpose and would have resulted in questionable outputs given that habitat conservation is only one factor in the success of these species' populations, others being hunting, trapping, disease and species interactions themselves. Instead, it was decided that the data on habitat-size requirements would be used retroactively to test the apparent adequacy of Conservation Blueprint outputs to meet those habitat-size needs. For example, if a figure of 2,500 ha is used to estimate habitat needed by a pair of Black Bear, and if 75% of the Conservation Blueprint portfolio for the Canadian Shield is thus available to Black Bear, the portfolio might support something in the order of 1,000 pair of Black Bear. Clearly, the Canadian Shield part of the Great Lakes region supports significantly larger numbers of Black Bear, for which discrete biodiversity conservation areas play only a limited role (Section 6.6 illustrates these results).

5.5.2 Assembling the Coarse-filter Results

All respective cost/value grids were summed together to create four coverages, each representing one of the four selection criteria. These four criteria were assigned overall scores in proportion to each other, based on consensus among Core Science Team members reviewing multiple pilot runs of results (Figure 34 and 35). A 'costgrid' of the final adjusted score for each ecological system polygon was then created. Each ecological system type in each ecodistrict was then queried to identify the top scoring polygons or patches, based on the conservation goals for the coarse-filter biodiversity targets. These sites were added to the Conservation Blueprint portfolio.

A 'tenure' coverage was then created to identify i) all natural ecological systems that will be available for selection in the fine-filter, and ii) the 'locked-in sites' which included all protected areas, conservation lands, and top-scoring sites identified through the coarse-filter analysis.

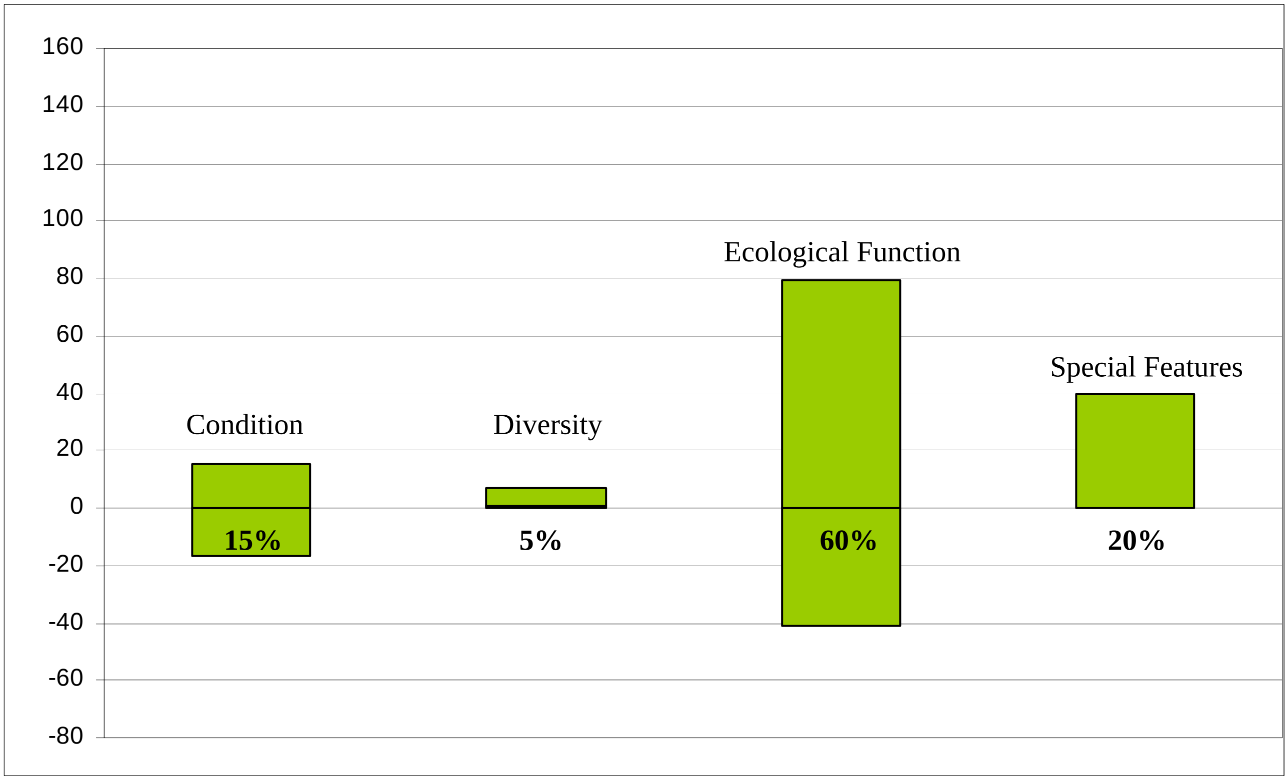


Figure 34. Ranges of the scoring criteria for Southern Ontario.

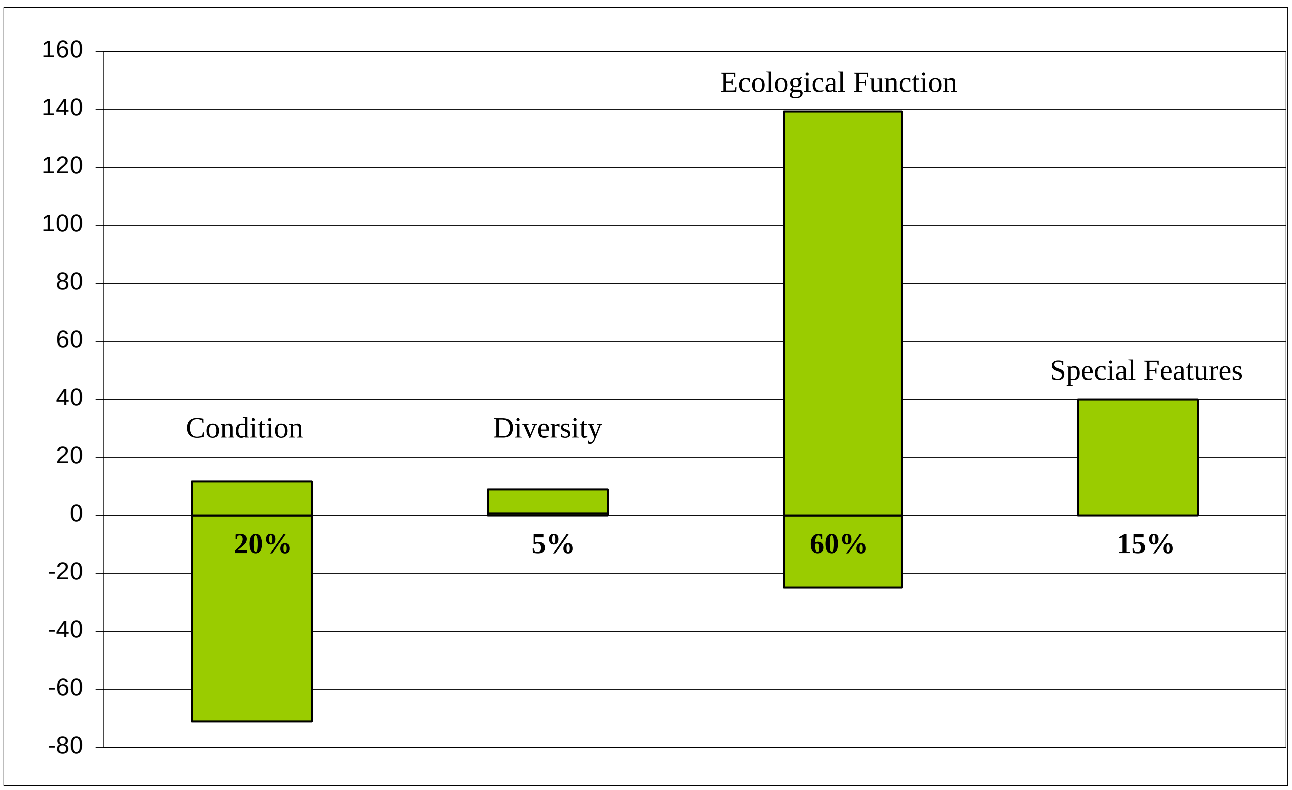


Figure 35. Ranges of the scoring criteria for the Canadian Shield.

5.5.3 Fine-filter Approach and Criteria

Advancements have been made in developing decision support systems for conservation planning, particularly in terms of values such as irreplaceability, to inform site selection projects (Pressey *et al.*, 1994; Noss *et al.*, 2002; Warman *et al.*, 2004). This is often achieved through the integration of ecosystem representation, and inclusion of protected special species or features including, in some cases, the habitat needs of focal species.

The decision support software "C-Plan" was used to perform the fine-filter analysis of the Conservation Blueprint's biodiversity targets. For more information on C-Plan, view the New South Wales National Parks and Wildlife Service C-Plan website at http://members.ozemail.com.au/~cplan/.

C-Plan determines the minimum number of polygons that are required to fulfill conservation goals for the biodiversity targets. An overlay of the extant occurrences of biodiversity targets within existing protected areas and conservation lands was performed in order to understand the inclusion of those targets in already-identified sites, and to calculate the gaps to be met by additional sites to meet those goals. Each target species and community has a predefined conservation goal (Appendices 8 and 9). For example, the Eastern Foxsnake (*Elaphe gloydi*) is endemic to the Great Lakes basin, with a target of selecting four occurrences per ecodistrict in the portfolio. If two of these occurrences were within a protected area, this leaves a gap of two occurrences, which C-Plan addresses.

C-Plan simultaneously fills all other species and community gaps in order to then be able to assess the most efficient portfolio for biodiversity conservation (minimizing the number of additional sites). This is achieved by using irreplaceability scores to optimize the areas where multiple biodiversity targets occur. In addition, if any of the occurrences fall outside a protected area and do not coincide with other biodiversity targets, then the conservation scores assigned to the natural areas through the coarse-filter are applied to weight the decision process. Therefore, C-Plan will choose the occurrence that coincides with the natural area with the highest conservation value.

An occurrence of a target is associated with the ecological system polygon in which it occurs, and this polygon is the site that is brought into the Conservation Blueprint portfolio. However, on the Canadian Shield, some very large natural ecological systems were selected on this basis. In order to resist including extensive systems in the Conservation Blueprint only due to the presence of a single species occurrence, these ecological system polygons were clipped to a 1-kilometre radius around the element occurrence centroid, and only this area was brought into the portfolio.

A polygon coverage of all "available" sites is a required input dataset for C-Plan. This is composed of all polygons of natural ecological systems. C-Plan also requires a polygon coverage of "mandatory" sites in which these sites are "locked-in" to the Conservation Blueprint as protected conservation areas. This layer is composed of the following:

- National Parks
- Provincial Parks
- Conservation Reserves
- Ontario Living Legacy sites (unregulated provincial parks and conservation reserves at the time of the analysis)
- Provincially Significant Life Science ANSIs
- Provincially Significant Wetlands
- National Wildlife Areas
- Migratory Bird Sanctuaries
- Conservation Authority Areas
- NCC lands
- Rouge Park
- Sites identified through the coarse-filter analysis (*i.e.*, top 1, 2 and/or 3 patches of each target ecological system)

A "features point" data set is required for all biodiversity targets. This consists of all extant element occurrence data with reasonable spatial accuracy (a UTM accuracy less than 5, or accurate to within 10km). Element occurrences that had EO 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) Select from this, the subset of polygons with the highest summed feature irreplacibility that emphasizes efficiency by looking at multiple species being met by one site.

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 need to meet their conservation goals.

5) Select the first sites that meet the requirements of the above rules in the most efficient manner.

6.0 Results of the Conservation Blueprint

6.1 Great Lakes Conservation Blueprint Portfolio

A Conservation Blueprint attempts to assemble, catalogue, classify, map and analyze the available information on the biological diversity of a natural region. The particular application that is reported on here is "*the identification and assessment of the places across the Great Lakes ecoregion that, if appropriately conserved, would sustain the essential biodiversity of the region.*"

On this basis, the sites that comprise the Conservation Blueprint include (1) those that are already protected for biodiversity conservation or already identified as having significant natural heritage values and (2) those that are additional, potential sites needed to meet the conservation goals set for the biodiversity targets in the region. The combined portfolio of sites from the Great Lakes Conservation Blueprint is illustrated in Figure 36 for the Great Lakes basin, and Figure 37 illustrates that part of the portfolio that is already set aside or otherwise identified as protected area or conservation land.

The Conservation Blueprint identified 9.8% of southern Ontario as existing conservation lands or lands needed to meet the stated conservation goals. These are core biodiversity conservation areas. They include a small part of the landbase (0.76%) that is regulated as protected areas (national parks, existing and committed provincial parks or conservation reserves). A further 1.21% of southern Ontario has been secured by Conservation Authorities, and just over 5% of southern Ontario has been designated as other conservation lands, mostly privately-owned wetlands and areas of natural and scientific interest. In total, this 7.41% of the southern Ontario landbase represents a significant conservation achievement. It was this existing conserved landbase that was assessed to see to what extent it met the conservation goals that the Conservation Blueprint set for the region's biodiversity targets. Where these goals were not met on this landbase, the Conservation Blueprint identified the additional sites that would be needed to meet the goals set for those targets. Across southern Ontario, an additional 1.4% of the landbase was identified as critical additional area needed to meet those conservation goals.

The Conservation Blueprint identified 22.5% of the Canadian Shield portion of the Great Lakes region on the basis of its analysis. This includes a protected area system that covers 18.1% of the landbase and is regulated as protected area. This is the most significant overall contributor to biodiversity conservation in the Great Lakes basin. A further 0.06% of the area has been secured by Conservation Authorities, and 0.4% has been designated as other conservation land, the majority public-land wetlands and areas of natural and scientific interest. In total, this 18.6% of the Canadian Shield part of the basin is a major conservation achievement, which the Conservation Blueprint analyzed to see to what extent it met the conservation goals set for the region's biodiversity targets. Where these conservation goals were not met, the Conservation Blueprint identified additional sites to meet the conservation goals for those targets. On this basis, a further 3.9% of the landbase was identified as critical additional area needed to meet those goals.

The core biodiversity conservation areas that comprise the Conservation Blueprint portfolio can be further considered within the overall extent of natural cover or other potential conservation lands in the region. To map this for southern Ontario, the Conservation Blueprint portfolio is overlaid on the "natural heritage system" (cores and corridors) identified by the *Big Picture* project (Jalava *et al.*, 2001, 2002; Riley *et al.*, 2003; and http://www.mnr.gov.on.ca/MNR/nhic/projects/bp/bigpict_2002_main.cfm). The ecodistrict maps in Volume 2 of this report show Conservation Blueprint portfolio sites set within the broader conservation lands of the *Big Picture*, and Table 9 documents the aerial extent of *Big Picture* cores and corridors in each ecodistrict in relation to the extent of Conservation Blueprint sites.

On the Canadian Shield, to provide the same framework of core biodiversity conservation areas within the context of the broader landscape of natural cover, the Conservation Blueprint portfolio was draped on the mapping of "total conservation scores" that the landscape received in the analysis. Mapping, text and tabular statistics on the ecological systems and features of each ecodistrict can also be reviewed in Volume 2 of this report.

Table 9. Total area of the Big Picture and Conservation Blueprint sites within southern Ontario ecodistricts.

Ecodistrict	Ecodistrict total area (ha)	Big Picture Cores	% of ecodistrict as Big Picture Cores	Big Picture Corridors	% of ecodistrict as Big Picture Corridors	Blueprint (ha)	% ecodistrict in Blueprint
7E-1	379,328.28	19,155.04	5.05	16,994.17	4.48	13,954.81	3.68
7E-2	944,485.75	93,785.04	9.93	99,488.88	10.53	47,551.69	5.03
7E-3	83,864.62	13,980.28	16.67	16,651.26	19.85	7,469.50	8.91
7E-4	191,192.73	5,432.17	2.84	15,388.02	8.05	11,022.88	5.77
7E-5	361,785.39	46,082.24	12.74	51,213.06	14.16	16,574.13	4.58
7E-6	225,181.73	11,718.22	5.20	21,507.11	9.55	9,966.50	4.43
7E total	2,185,838.5	190,152.99	8.70	221,242.50	10.12	106,539.51	4.87
6E-1	926,054.46	66,414.34	7.17	91,325.31	9.86	56,998.69	6.16
6E-2	147,253.62	22,480.93	15.27	16,078.98	10.92	10,902.88	7.40
6E-4	171,678.47	96,419.11	56.16	17,515.20	10.20	39,641.00	23.09
6E-5	867,659.01	125,389.69	14.45	223,395.00	25.75	72,399.38	8.34
6E-6	560,878.16	124,897.20	22.27	64,374.98	11.48	58,337.50	10.40
6E-7	442,544.43	125,132.05	28.28	95,602.30	21.60	39,214.25	8.86
6E-8	532,068.93	85,661.30	16.10	89,831.35	16.88	55,795.94	10.49
6E-9	421,168.15	227,908.63	54.11	52,014.50	12.35	61,923.56	14.70
6E-10	149,891.34	90,872.01	60.63	11,355.02	7.58	41,965.38	28.00
6E-11	353,567.21	175,284.51	49.58	33,656.58	9.52	55,398.31	15.67
6E-12	774,846.67	200,140.37	25.83	65,632.83	8.47	59,437.69	7.67
6E-13	99,355.74	8,774.12	8.83	17,811.80	17.93	6,647.19	6.69
6E-14	62,346.47	64,394.01	100.00	256.63	0.41	38,851.75	62.32
6E-15	237,228.83	61,786.92	26.05	34,197.91	14.42	24,470.75	10.32
6E-16	196,373.83	27,233.26	13.87	16,613.48	8.46	19,824.00	10.10
6E total (excluding 6E17)	5,942,915.32	1,502,788.44	25.29	829,661.87	13.96	641,808.27	10.80
6E7E total (excluding 6E17)	8,128,753.82	1,692,941.44	20.83	1,050,904.37	12.93	748,347.78	9.21
6E-17	369,042.31	224,179.25	60.75	5,304.85	1.44	84,064.25	22.78
6E7E total	8,497,796.13	1,917,120.69	22.56	1,056,209.22	12.43	832,412.03	9.80

Figure 26. Great Lakes Conservation Blueprint for terrestrial biodiversity.

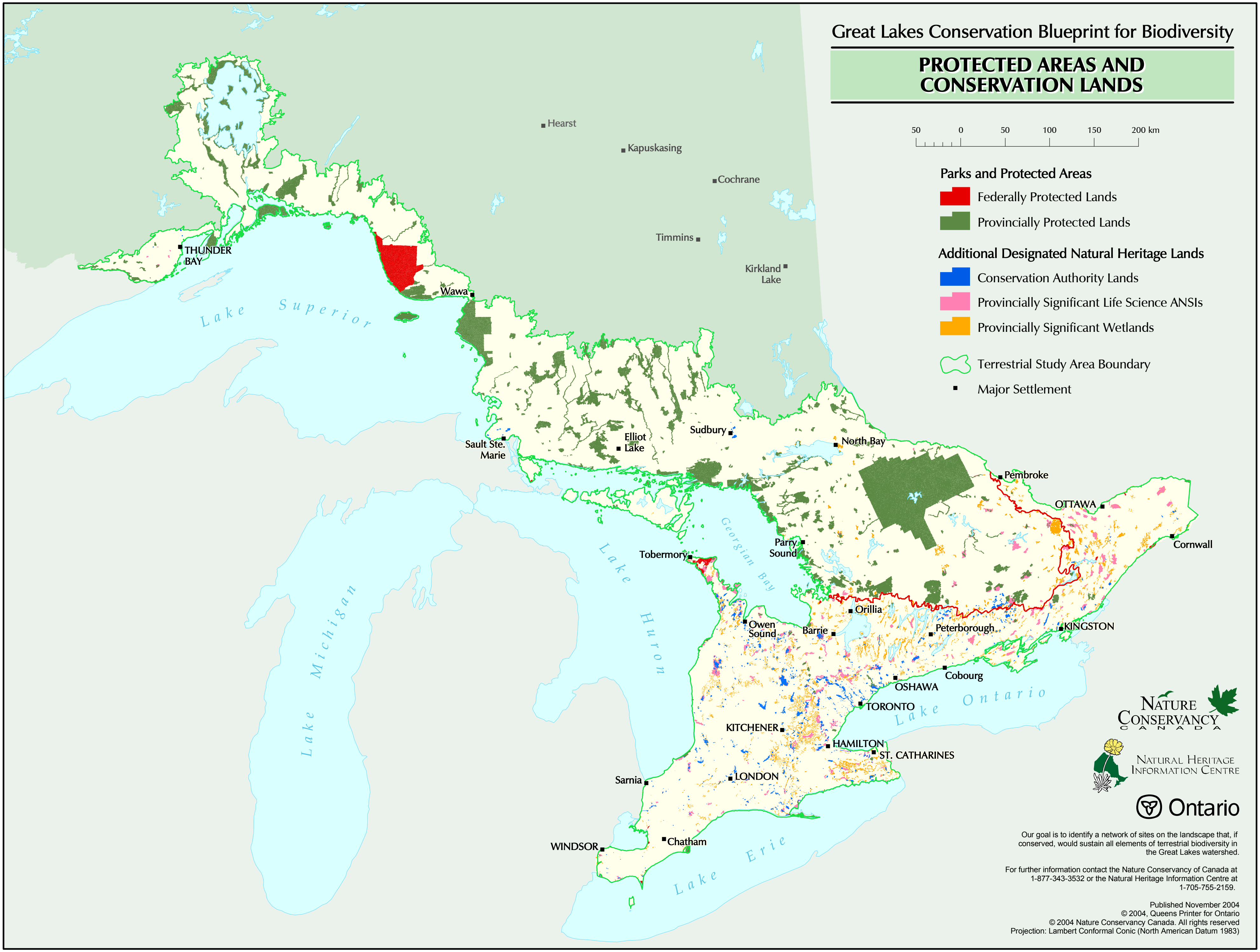


Figure 37. Great Lakes Conservation Blueprint and protected areas and conservation lands.

6.2 Ecological Systems

Fifty-eight ecological systems (or landform-vegetation types) were classified and mapped across southern Ontario, of which 48 were targeted in the Conservation Blueprint analysis. These were 37 forested ecological systems, four wetland systems, and seven other systems (*e.g.*, alvars, prairies and savannahs). Systems not targeted in the analysis were open water, pasture and abandoned fields, settlements and agricultural cropland (Appendix 5).

Two hundred and fifty ecological systems were classified and mapped across the Canadian Shield, of which 182 were targeted in the analysis. These targets consisted of 174 forested ecological systems and 8 wetland systems (Appendix 7). The analysis was not applied to some parts of the region because key descriptive information was missing (approx. 5% of area). Open water, converted lands and developed areas were not targeted in the analysis.

Volume 2 of this report includes detailed lists of the ecological systems in each ecodistrict and in the Conservation Blueprint portfolio. Table 10 provides a summary of the ecological systems comprising the Conservation Blueprint portfolio.
In summary, the portfolio included significant portions of the natural forests (16%), wetlands (63%), prairies and savannahs (88%) and alvars (28%) of southern Ontario. On the Canadian Shield, the portfolio included significant portions of the natural forests (21%) and wetlands (22%) of the region.

The coarse-filter analysis was designed to identify the best examples of each ecological system within each ecodistrict and, where appropriate, the associated physiographic region. Ecological systems were scored for a variety of coarse-filter criteria (condition, ecological functions, diversity and special features). These scores were weighted following an iterative process of expert discussion of pilot results, and were then combined to yield a total score for each ecological system polygon. In southern Ontario, the goal was to select the top-scoring example of each targeted system per physiographic region, and the two top scoring examples of each targeted system in each ecodistrict. The goal on the Canadian Shield was to select the three top-scoring examples of each targeted system within each ecodistrict.

In total, the Conservation Blueprint identified nearly four million hectares of land, nearly 18% of the total area of the Ontario portion of the Great Lakes region.

Table 10. Conservation Blueprint portfolio site contribution, in hectares, by ecological system type (in hectares).

	Targeted Forested Systems	Alvars	Prairies and Savannahs	Wetlands	All Targeted Systems	All Systems
Southern Ontario	1,986,271.13	78,455.62	3,544.50	586,325.94	2,654,597.19	8,497,796.13
Southern Ontario Blueprint	318,517.00	22,009.25	3,107.94	370,552.00	714,186.19	840,753.06
Southern Ontario Blueprint % of total area	16.04	28.05	87.68	63.20	26.90	9.89
Canadian Shield	9,666,322.88	n/a	n/a	207,651.14	9,873,974.02	13,658,706.11
Canadian Shield Blueprint	1,990,940.88	n/a	n/a	46,197.31	2,037,138.19	3,077,718.06
Canadian Shield Blueprint % of total area	20.60	n/a	n/a	22.25	20.63	22.53
Total	11,652,594.01	78,455.62	3,544.50	793,977.08	12,528,571.21	22,156,502.24
Conservation Blueprint Total	**2,309,457.88**	**22,009.25**	**3,107.94**	**416,749.31**	**2,751,324.38**	**3,918,471.12**
% included in the Conservation Blueprint	**19.82**	**28.05**	**87.68**	**52.49**	**21.96**	**17.69**

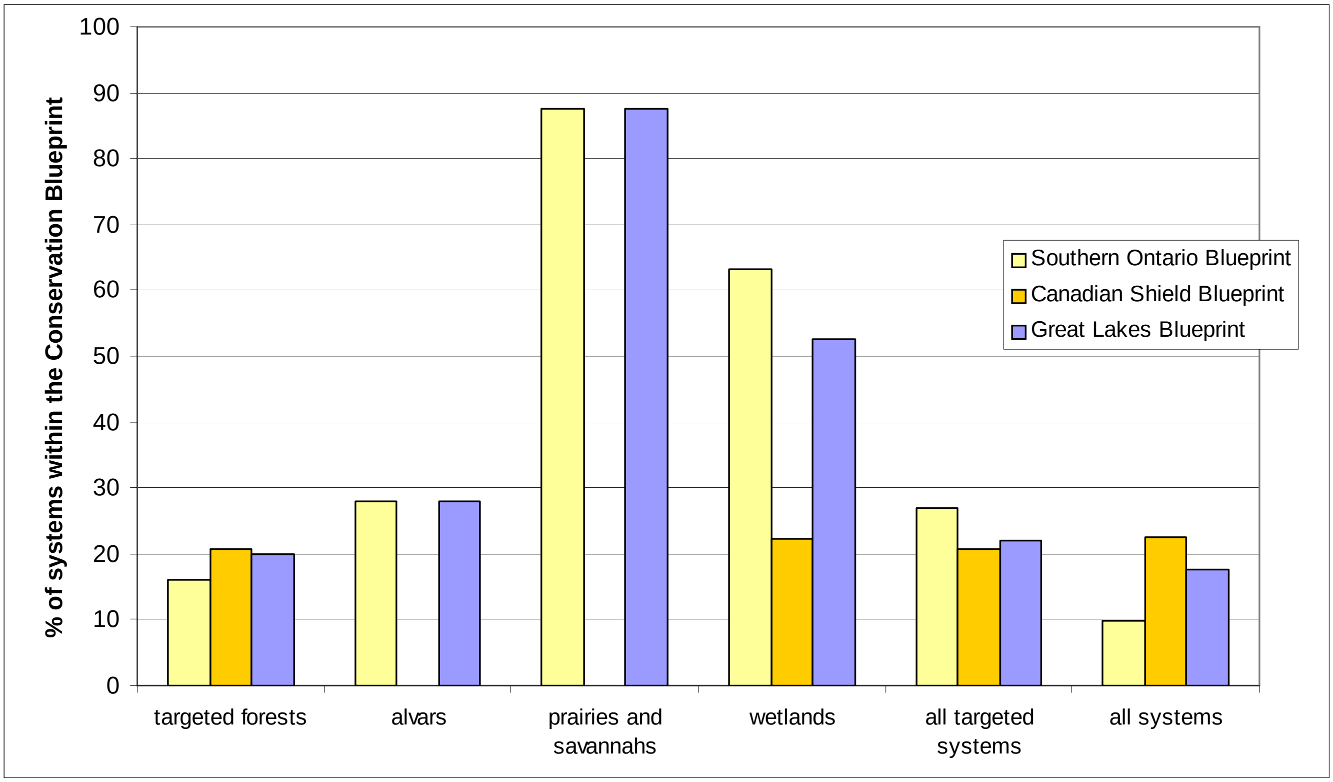


Figure 38. Percentage of system types within the Conservation Blueprint.

This was done efficiently: over 25% of the targeted systems in southern Ontario and 20% of the targeted systems on the Canadian Shield were included in the portfolio. Figure 38 above illustrates the percentage of general ecological system types that were included in the Conservation Blueprint for southern Ontario, the Canadian Shield, and the Ontario Great Lakes region as a whole.

Approximately 61% of the area of top-scoring targeted ecological systems in the southern Ontario Conservation Blueprint occurs outside existing protected areas and conservation lands (Figure 39). Among the different types of protected areas and conservation lands, the majority of the area's top systems occur within provincially significant wetlands and provincially significant life sicence ANSIs. However, federally regulated lands, provincial parks and all other types of conservation lands also support top scoring ecological systems. Figure 39 illustrates that all conservation land initiatives help maintain best quality examples of ecological systems within southern Ontario, and that such conservation lands include nearly half of southern Ontario's top-scoring ecological systems. Together, these figures reflect the scarcity of lands formally regulated to conserve biodiversity in southern Ontario, with the majority of best quality ecosystems supported through the stewardship of private landowners.

Existing protected areas and conservation lands support relatively fewer top-scoring ecological systems on the Canadian Shield. Approximately 70% of the total area of the identified top-scoring targeted ecological systems in the Canadian Shield Conservation Blueprint occur outside of existing protected areas and conservation lands (Figure 40). In part, this result stems from the lack of identification of significant natural heritage features on the private lands on the Canadian Shield area, in contrast to the more advanced work done to identify significant wetlands and representative natural areas (ANSIs) on all lands (including private) in southern Ontario. Approximately 46% of the top-scoring ecological systems on the Canadian Shield occur on private lands, which have never before been assessed in terms of their representation potential (private lands comprise 21% of the Shield study area).

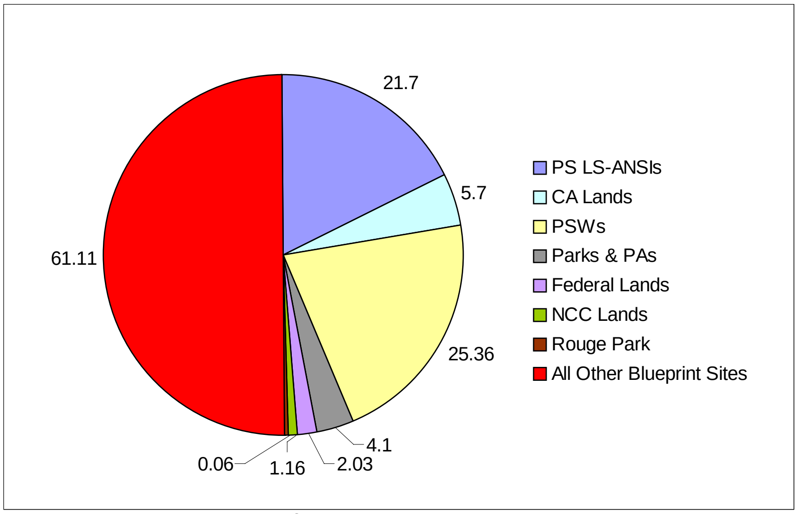


Figure 39. Distribution of top systems in the southern Ontario Blueprint.

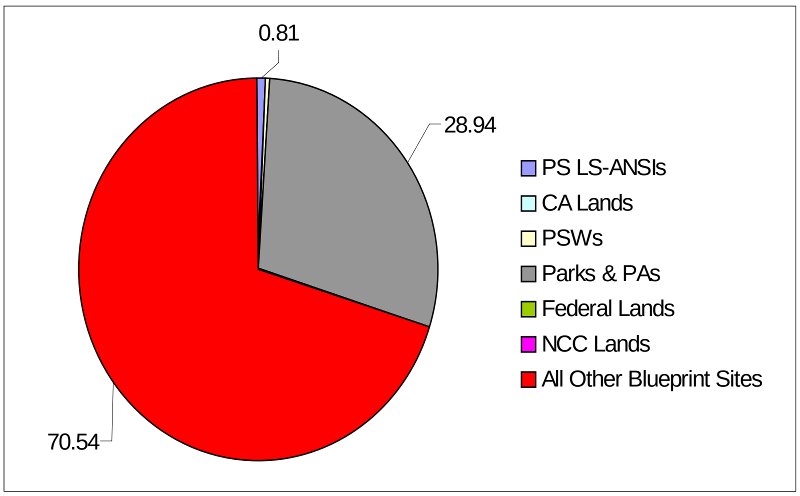


Figure 40. Distribution of top systems in the Canadian Shield Blueprint. (There is overlap of ANSIs and PSWs with other conservation land types, and the totals presented here are not mutually exclusive.)

Among existing public land conservation land types, almost all of the area's top systems occur in provincial parks or conservation reserves. (Note that the available data on private/patent lands on the Canadian Shield is considered accurate within only +/- 2-3%.)

Existing protected areas and conservation lands protect a significant portion of high quality, representative ecological systems, but the top scoring systems from the Conservation Blueprint analysis cover less than one-third of the total area of any particular conservation land type. Figure 41 displays the amount of area of top scoring ecological systems as a percentage of the total areas of each conservation land type in southern Ontario. Provincial parks and ANSIs contain the highest percentages of top-scoring systems, attributable to the commitment to select such sites based on best representative landform-vegetation features within ecodistricts (see Section 5.1).

In southern Ontario, Conservation Authority (CA) lands cover an area almost twice as large as provincial and national parks. Conservation of water quality and quantity were the primary goals in securing those lands, not biodiversity conservation, but CA lands are an important component of the Conservation Blueprint.

Figure 42 displays the extent of top scoring ecological systems as a percentage of the total area of each conservation land type on the Canadian Shield. Top-scoring ecological systems do not comprise more than 11% of the overall area of any of the conservation land types.

With a lack of targeted ecological systems in the national parks due to unavailable FRI mapping for proper vegetation classification, the statistics presented in these figures do not necessarily reflect the contribution of top-scoring systems provided by the national parks on the Canadian Shield. In any case, national park lands are included in the Conservation Blueprint portfolio regardless of the occurrence of top-scoring systems within their boundaries.

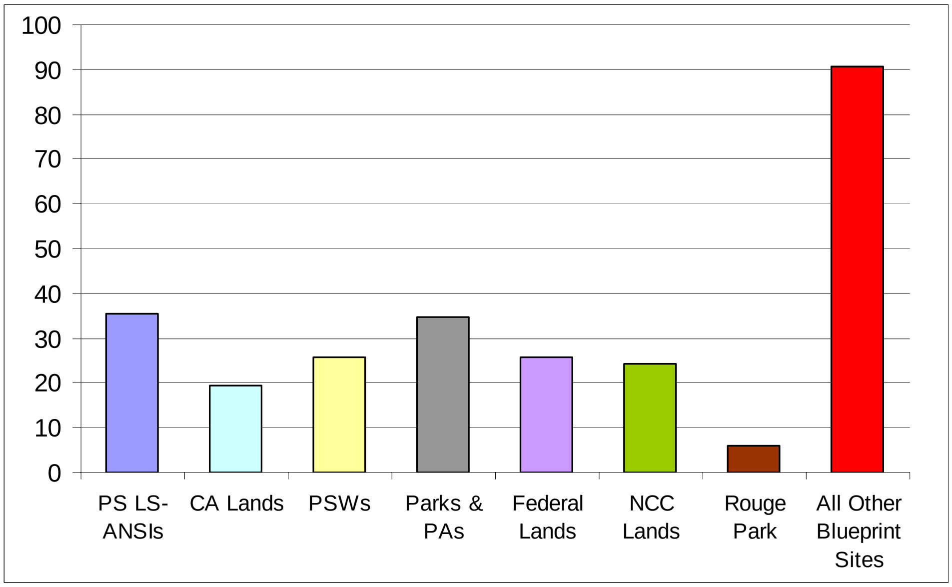


Figure 41. Percent of area by land type that represents top-scoring systems within the Southern Ontario Conservation Blueprint. (There is overlap of ANSIs and PSWs with other conservation land types, and the totals presented here are not mutually exclusive.)

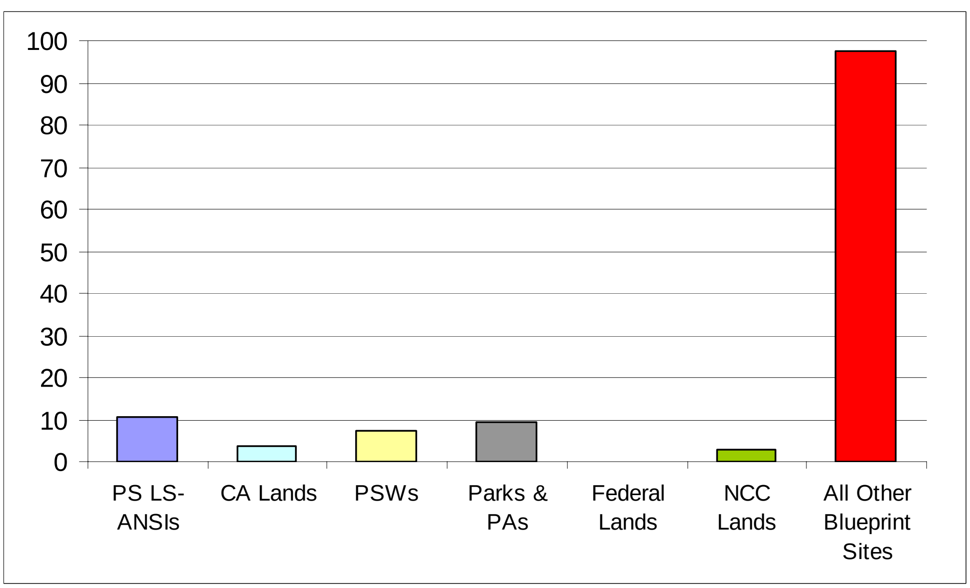


Figure 42. Percent of area by land type that represents top-scoring systems within the Canadian Shield Conservation Blueprint. (There is overlap of ANSIs and PSWs with other conservation land types, and the totals presented here are not mutually exclusive.)

6.3 Species and Vegetation Communities

In addition to including sites representing top quality ecological systems, the Conservation Blueprint includes the habitat and occurrences of a large suite of species and vegetation community types of conservation concern. A total of 428 species and 172 vegetation communities were identified as additional biodiversity targets for the terrestrial Conservation Blueprint (Table 3; Appendices 2 and 3). For each of these targets, a conservation goal was set, based on specific inclusion rates (Tables 4 and 5).

Approximately 66% of all documented extant occurrences of target species and vegetation communities are included in the Conservation Blueprint portfolio in order to meet the conservation goals set for those targets. More than half of the occurrences included in the Conservation Blueprint are vascular plants and a further one-quarter of the occurrences are vegetation communities (Figure 43). The Conservation Blueprint portfolio includes all extant primary species targets and vegetation community targets with available occurrence data in the Great Lakes region, as well as the majority of the secondary targets (Figure 44).

The Conservation Blueprint applied a systematic fine-filter analysis, based on widely-accepted conservation planning tools (C-Plan), to meet documented conservation goals for both species and vegetation communities within each ecodistrict. However, precise and recent occurrence information is not available for all the targets known in the region, so not all conservation goals could be met with the available data (Figure 45). For example, some of the primary vascular plant targets in the region lacked extant occurrence information (within the last 20 years in the south, and 40 years on the Canadian Shield) and were not incorporated into the Conservation Blueprint. This illustrates the importance of continued inventory and update of element occurrence data, particularly for poorly documented taxonomic groups and certain species. For details on the targets and ecodistricts for which conservation goals were not fully achieved, consult Volume 2 of this report (Henson and Brodribb, 2005).

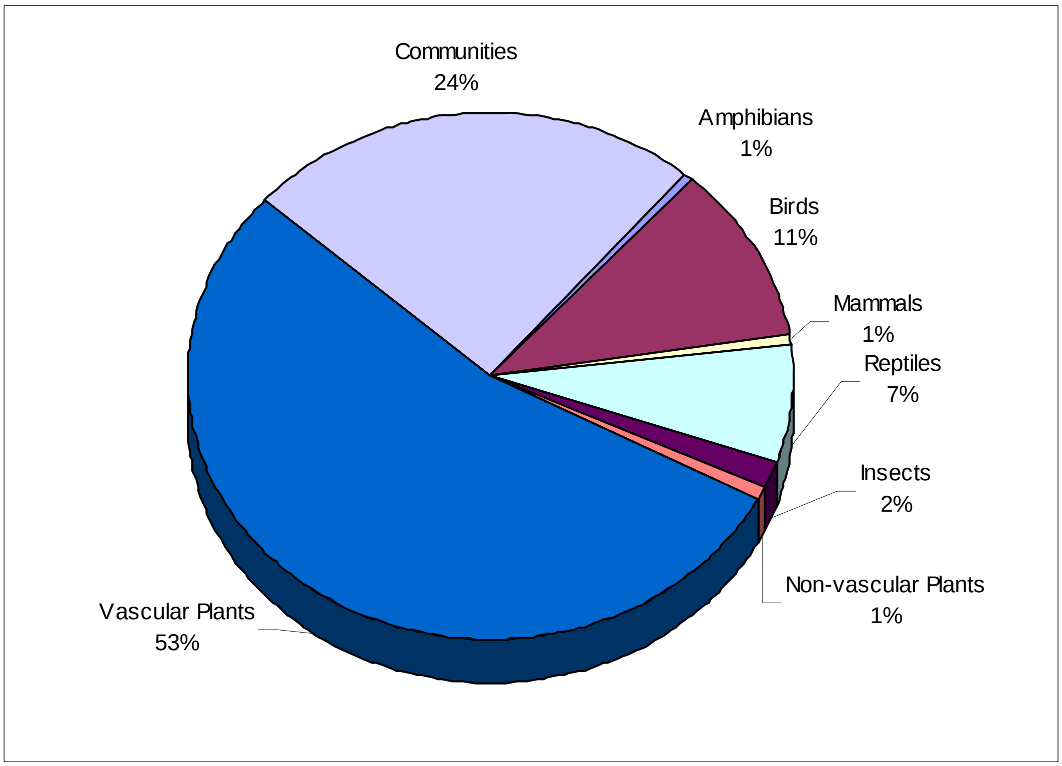


Figure 43. Percent of extant species target occurrences within the Terrestrial Conservation Blueprint, by taxonomic group.

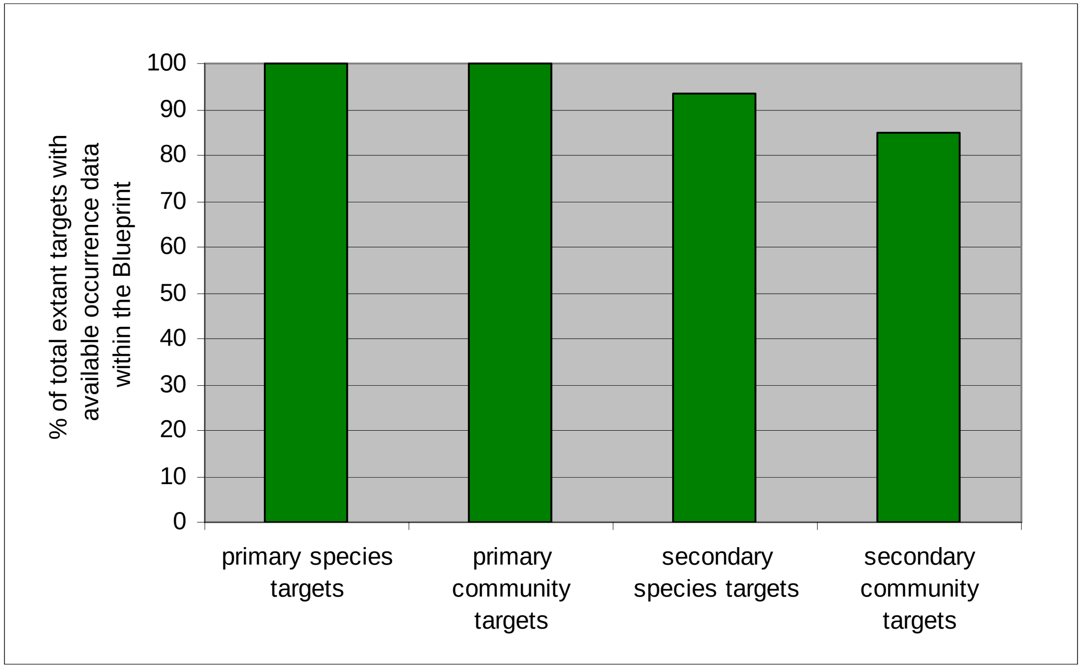


Figure 44. Percent of targets with documented extant occurrence data within the terrestrial Conservation Blueprint.

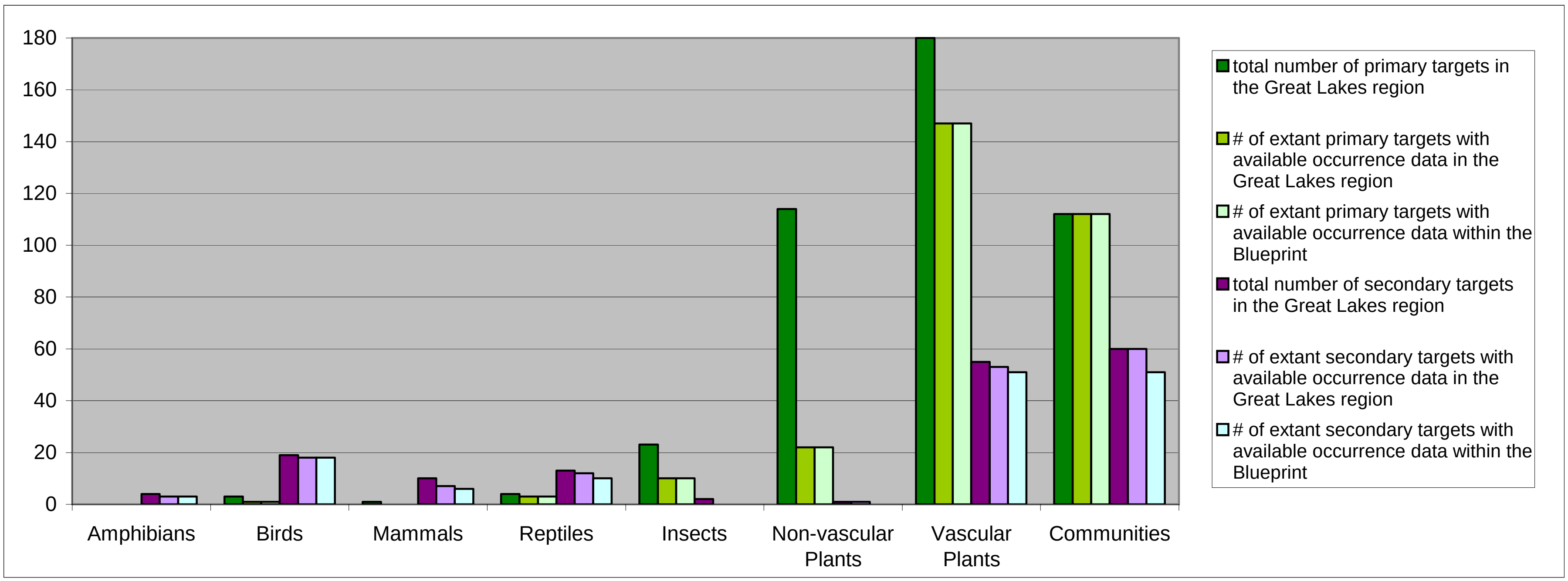


Figure 45. Number of primary and secondary targets within the Great Lakes region and the terrestrial Conservation Blueprint.

Nearly two-thirds of all extant documented fine-filter target occurrences in southern Ontario are in the Conservation Blueprint. Approximately 70% of all extant targets in the southern Ontario Conservation Blueprint portfolio occur in existing protected areas and conservation lands, with 47% of extant occurrences in provincially significant life science ANSIs, 14% in provincial parks and protected areas, 13% in Conservation Authority lands and 4% in federally regulated lands (Figure 46). (Note that there is an overlap of ANSIs and PSWs with other conservation lands types, so the totals presented in Figure 46 for conservation lands are not mutually exclusive.)

Approximately 68% of all the extant fine-filter target occurrences in the Canadian Shield portion are in the Conservation Blueprint portfolio. Approximately 68% of all extant targets in the Canadian Shield Conservation Blueprint portfolio occur in existing protected areas and conservation lands, with 60% of extant occurrences in the Conservation Blueprint occurring in provincial parks and conservation reserves, 7% in ANSIs, 4% in federally regulated lands, and less than 1% in Conservation Authority areas (Figure 47).

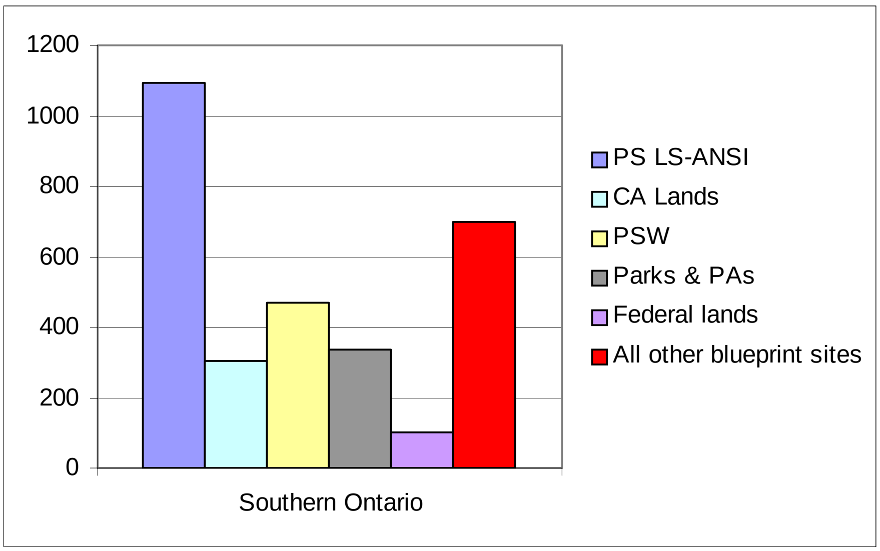


Figure 46. Number of extant target occurrences in the southern Ontario Conservation Blueprint, by land type.

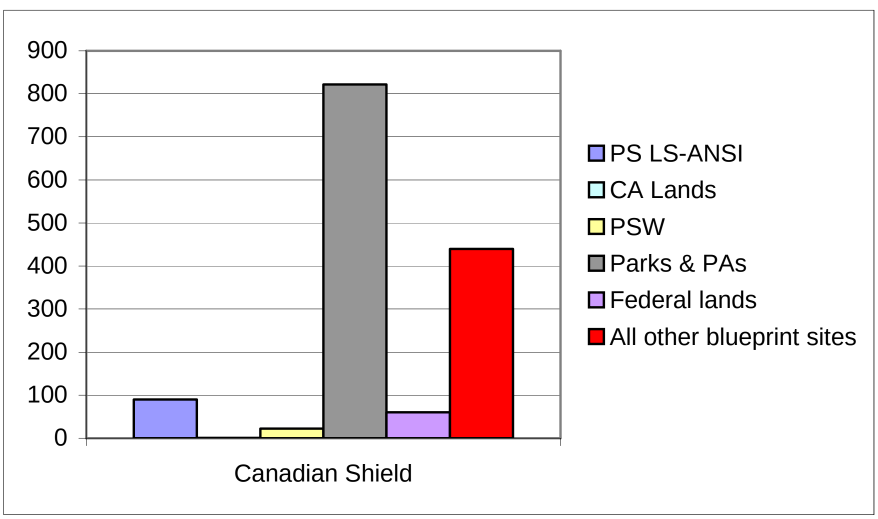


Figure 47. Number of extant target occurrences in the Canadian Shield Conservation Blueprint, by land type.

6.4 Protected Areas and Other Conservation Lands

Mapping was available to the Conservation Blueprint project for most of the protected areas and conservation lands in the study area: national parks, National Wildlife Areas, Migratory Bird Sanctuaries, provincial parks, conservation reserves, provincially significant life science ANSIs, provincially significant wetlands, Conservation Authority lands, Nature Conservancy of Canada lands, and the Rouge Park. Section 6.1 provides a summary of results.

A spatial correlation analysis was done to determine if scoring protected areas and conservation lands in both the coarse-filter and fine-filter assessments favoured the selection of the ecological systems within these areas over areas elsewhere. The correlation analysis was conducted by removing all protected areas and conservation lands from scoring values. All other scoring values of ecological systems within and outside of conservation lands were then compared. The results indicated that all the ecological systems selected within existing protected areas and conservation lands received higher total scores than systems elsewhere even with the scoring for protected areas and conservation lands removed. Sites were therefore not selected for the Conservation Blueprint directly as a result of their occurrence within existing protected areas or other conservation lands. This result confirmed the project's intention to provide an equitable analysis of biodiversity features across the whole region.

Table 11 below illustrates the extent of conservation lands in the Great Lakes region and their relative contribution to the Conservation Blueprint. These areas combine to represent approximately 80% of the Conservation Blueprint. Many top-scoring examples of targeted ecological systems, rare extant species and vegetation communities are found within their boundaries, underscoring the collective achievement and contribution by existing conservation lands to the protection of biodiversity in the Great Lake region. This also reinforces the need for both public and private lands to be managed to sustain and enhance the biodiversity targets occurring on them.

In southern Ontario, over 90% of the Conservation Blueprint occurs on private land, paralleling the extent of private lands as a whole (93%). On the Canadian Shield, 7.5% of the Conservation Blueprint occurs on private land, less than the extent of private lands here as a whole (21%). It is clear that private-land stewardship in the north is a critical component of biodiversity conservation.

Tables 12 and 13 present detailed statistics on the extent of the different types of protected areas and conservation lands for each ecodistrict and ecoregion. Volume 2 provides further detail on the contribution of conservation lands within each ecodistrict in relation to the Conservation Blueprint's targets and conservation goals (Henson and Brodribb, 2005).

Table 11. Conservation Blueprint portfolio sites by type of protected area of conservation land (in hectares).

	Federally Protected	**Provincially Protected**	**Provincially Significant Life Science ANSI**	**Provincially Significant Wetland**	**Conservation Authority Lands**	**All Protected Areas and Conservation Lands**
Southern Ontario (ha)	**22,539.75**	**42,005.87**	**215,758.82**	**347,811.84**	**103,047.44**	**629,595.32**
% of Blueprint	2.68	5.00	25.66	41.37	12.26	74.88
% of entire landbase	0.27	0.49	2.54	4.09	1.21	7.41
Canadian Shield (ha)	**185,339.26**	**2,287,318.20**	**58,061.82**	**34,173.32**	**8,095.57**	**2,540,252.88**
% of Blueprint	6.02	74.32	1.89	1.11	0.26	82.54
% of entire landbase	1.36	16.75	0.43	0.25	0.06	18.60
Great Lakes Ecoregion (ha)	**208,918.02**	**2,332,541.33**	**278,840.01**	**381,985.16**	**116,750.32**	**3,184,691.26**
% of Great Lakes Conservation Blueprint	5.31	59.44	6.99	9.75	2.84	80.90
% of entire landbase	0.94	10.51	1.24	1.72	0.50	14.31

Table 12. Conservation Blueprint portfolio site contribution in southern Ontario (ecoregions 6E and 7E).

Ecodistrict	Ecodistrict total area (ha)	Federally Protected Areas (ha)	% ecodistrict in Fed. Prot. Areas	Provincially Protected Areas (ha)	% ecodistrict in Prov. Prot. Areas	CA lands (ha)	% ecodistrict in CA lands	Prov. Life Science ANSIs (ha)	% ecodistrict in PS LS-ANSIs	All Protected Areas and Conservation Lands (ha)	% ecodistrict in Prot. Areas & Cons. Lands	Blueprint (ha)	% ecodistrict in Blueprint
7E-1	379,328.28	1,918.06	0.51	3,827.69	1.01	817.2	0.22	6,129.81	1.62	11,859.5	3.13	13,954.81	3.68
7E-2	944,485.75	4,215.00	0.45	3,342.63	0.35	9,321.94	0.99	18,517.38	1.96	39,875.13	4.22	47,551.69	5.03
7E-3	83,864.62	n/a	0.00	496.25	0.59	3,005.44	3.58	4,001.69	4.77	6,735.31	8.03	7,469.5	8.91
7E-4	191,192.73	n/a	0.00	679.5	0.36	6,299.25	3.29	2,703.25	1.41	10,759.38	5.63	11,022.88	5.77
7E-5	361,785.39	146.75	0.04	777.94	0.22	3,034.625	0.84	4,429.31	1.22	14,443.06	3.99	16,574.13	4.58
7E-6	225,181.73	n/a	0	10.31	0.00	2,938.81	1.31	1,837.69	0.82	9,371.00	4.16	9,966.5	4.43
7E total	2,185,838.5	6,279.81	0.29	9,134.32	0.42	25,417.26	1.16	37,619.13	1.72	93,043.38	4.26	106,539.51	4.87
6E-1	926,054.46	n/a	0.00	621.5	0.07	14,709.06	1.59	6,647.88	0.72	54,699.06	5.91	56,998.69	6.16
6E-2	147,253.62	118.19	0.08	1,815.25	1.23	1,264.94	0.86	2,488.19	1.69	7,312.81	4.97	10,902.88	7.40
6E-4	171,678.47	n/a	0.00	2,434.19	1.42	6,681.31	3.89	18,738.69	10.91	29,803.25	17.36	3,9641	23.09
6E-5	867,659.01	n/a	0.00	195.56	0.02	22,401.75	2.58	21,009.00	2.42	65,010.63	7.49	72,399.38	8.34
6E-6	560,878.16	437.5	0.08	6,064.81	1.08	4,656.06	0.83	15,083.38	2.69	46,182.00	8.23	58,337.50	10.40
6E-7	442,544.43	n/a	0.00	1,459	0.33	10,183.56	2.30	17,411.00	3.93	32,430.38	7.33	39,214.25	8.86
6E-8	532,068.93	n/a	0.00	343.19	0.06	3,096.44	0.58	10,053.19	1.89	51,339.88	9.65	55,795.94	10.49
6E-9	421,168.15	n/a	0.00	2,155.13	0.51	7,532.00	1.79	8,523.19	2.02	36,325.88	8.63	61,923.56	14.70
6E-10	149,891.34	908.88	0.61	7,680.00	5.12	1,651.88	1.10	7,146.75	4.77	18,463.63	12.32	41,965.38	28.00
6E-11	353,567.21	999.06	0.28	515.31	0.15	1,423.75	0.40	18,646.38	5.27	47,755.88	13.51	55,398.31	15.67
6E-12	774,846.67	2,687.69	0.35	1,514.69	0.20	981.50	0.13	16,019.13	2.07	43,916.13	5.67	59,437.69	7.67
6E-13	99,355.74	n/a	0.00	1,097.5	1.10	1,700.06	1.71	1,235.75	1.24	5,477.75	5.51	6,647.19	6.69
6E-14	62,346.47	9,459.88	15.17	2,443.88	3.92	n/a		23,732.94	38.07	29,909.75	47.97	38,851.75	62.32
6E-15	237,228.83	738.56	0.31	1,785.31	0.75	1,347.88	0.57	6,332.50	2.67	20,574.44	8.67	24,470.75	10.32
6E-16	196,373.83	n/a	0.00	1,354.69	0.69	n/a		5,071.75	2.58	10,958.25	5.58	19,824	10.10
6E total (excluding 6E-17)	5,942,915.32	15,349.76	0.26	31,480.01	0.53	77,630.19	1.31	178,139.72	3.00	500,159.72	8.42	641,808.27	10.80
6E7E total (excluding 6E-17)	8,128,753.82	21,629.57	0.27	40,614.33	0.50	103,047.46	1.27	215,758.85	2.65	593,203.10	7.30	748,347.78	9.21
6E-17	369,042.31	910.19	0.25	1,391.56	0.38	n/a	0.00	n/a	0.00	36,392.25	9.86	84,064.25	22.78
All 6E7E total	8,497,796.13	22,539.76	0.27	42,005.89	0.49	103,047.46	1.27	215,758.85	2.65	629,595.35	7.41	832,412.03	9.80

Federally protected areas = National Parks, National Wildlife Areas and Migratory Bird Sanctuaries
Provincially protected areas = Provincial Parks, Conservation Reserves and Ontario Living Legacy sites
All Protected Areas and Conservation Lands = federally protected lands (as defined above), provincially protected areas (as defined above), Conservation Authority lands (CAs), provincially significant wetlands (PSWs), provincially significant life science Areas of Natural and Scientific Interest (PS LS-ANSIs), Nature Conservancy of Canada lands (NCC) and Rouge Park.
Statistics based on Lambert Conic Conformal base data layers

Table 13. Conservation Blueprint portfolio site contribution on the Canadian Shield.

Ecodistrict	Ecodistrict total area (ha)	Federally Protected Areas (ha)	% ecodistrict in Fed. Prot. Areas	Provincially Protected Areas (ha)	% ecodistrict in Prov. Prot. Areas	CA lands (ha)	% ecodistrict in CA lands	Prov. Life Science ANSIs (ha)	% ecodistrict in PS LS-ANSIs	All Protected & Conservation Lands (ha)	% ecodistrict in Prot. Areas & Cons. Lands	Blueprint (ha)	% ecodistrict in Blueprint
5E-1	398819.75	n/a	-----	41844.63	10.49	1122.63	0.28	n/a	-----	42967.25	10.77	70849.06	17.76
5E-3	89270.33	n/a	-----	54217.38	60.73	n/a	-----	n/a	-----	54284.19	60.81	59490.00	66.64
5E-4	731331.77	n/a	-----	30971.38	4.23	1656.88	0.23	n/a	-----	32628.25	4.46	65861.44	9.01
5E-5	511764.11	n/a	-----	33365.75	6.52	n/a	-----	n/a	-----	35553.88	6.95	60884.19	11.90
5E-6	518193.52	n/a	-----	43271.25	8.35	n/a	-----	n/a	-----	43478.31	8.39	75126.44	14.50
5E-7	625967.29	1309.25	0.21	165369.94	26.42	n/a	-----	6438.75	1.03	173422.44	27.70	197883.69	31.61
5E-8	847130.05	6.31	0.00	67440.69	7.96	n/a	-----	1057.00	0.12	70915.13	8.37	95630.75	11.29
5E-9	876360.53	n/a	-----	447572.69	51.07	n/a	-----	1910.13	0.22	449799.06	51.33	466635.13	53.25
5E-10	796299.88	n/a	-----	330427.56	41.50	n/a	-----	6643.31	0.83	335080.19	42.08	347166.56	43.60
5E-11	1631204.66	1534.56	0.09	81159.25	4.98	3655.38	0.22	36020.81	2.21	125051.94	7.67	158747.44	9.73
5E-13	421496.12	n/a	-----	20075.75	4.76	917.19	0.22	n/a	-----	20992.94	4.98	63304.13	15.02
5E total	7447838.01	2850.12	0.04	1315716.27	17.67	7352.08	0.10	52070.00	0.70	1384173.58	18.58	1661578.83	22.31
4E-1	495696.57	n/a	-----	160257.00	32.33	n/a	-----	115.31	0.02	160257.00	32.33	189583.13	38.25
4E-3	2267027.23	n/a	-----	301891.63	13.32	n/a	-----	2268.81	0.10	301947.63	13.32	363658.31	16.04
4E total	2762723.80	0	0.00	462148.63	16.73	0	0.00	2384.12	0.09	462204.63	16.73	553241.44	20.03
3W-3	1703523.18	n/a	-----	347092.31	20.37	389.38	0.02	1867.63	0.11	347638.75	20.41	400206.38	23.49
3W-5	735347.42	n/a	-----	82055.44	11.16	n/a	-----	n/a	-----	82055.44	11.16	146802.63	19.96
3W total	2438870.60	0	0.00	429147.75	17.60	389.38	0.02	1867.63	0.08	429694.19	17.62	547009.01	22.43
3E-4	640688.02	182489.13	28.48	62653.88	9.78	n/a	-----	n/a	-----	245143.00	38.26	271023.81	42.30
4W-2	369223.82	n/a	-----	17651.69	4.78	354.13	0.10	1740.13	0.47	19037.50	5.16	44865.00	12.15
Shield total	13659344.25	185339.25	1.36	2287318.22	16.75	8095.59	0.06	58061.88	0.43	2540252.9	18.60	3077718.09	22.53

Federally protected areas = National Parks, National Wildlife Areas and Migratory Bird Sanctuaries
Provincially protected areas = Provincial Parks, Conservation Reserves and Ontario Living Legacy sites
All Protected Areas and Conservation Lands = federally protected lands (as defined above), provincially protected areas (as defined above), Conservation Authority lands (CAs), provincially significant wetlands (PSWs), provincially significant life science Areas of Natural and Scientific Interest (PS LS-ANSIs), Nature Conservancy of Canada lands (NCC) and Rouge Park.
Statistics based on Lambert Conic Conformal base data layers

6.5 Portfolio Sites Large Enough to Withstand Fire Disturbance

The Canadian Shield is a region of relatively continuous natural cover, so maintaining (and maintaining the potential for) natural disturbance and natural regeneration is important to long-term biodiversity conservation. As discussed in Section 5.6.1.2, a fire disturbance size criterion was highly influential in the scoring of ecological systems on the Canadian Shield. Following identification of top scoring systems as portfolio sites, all adjacent portfolio sites were amalgamated into larger contiguous sites, and an analysis was conducted to determine whether these combined sites were four times larger than the average-size natural fire disturbance in each ecodistrict, the test set in the Conservation Blueprint methods to identify an adequately sized conservation site. Overall, approximately 94% of the area of portfolio sites on the Canadian Shield was considered large enough to withstand average fire disturbance based on this 4X rule (Figure 48).

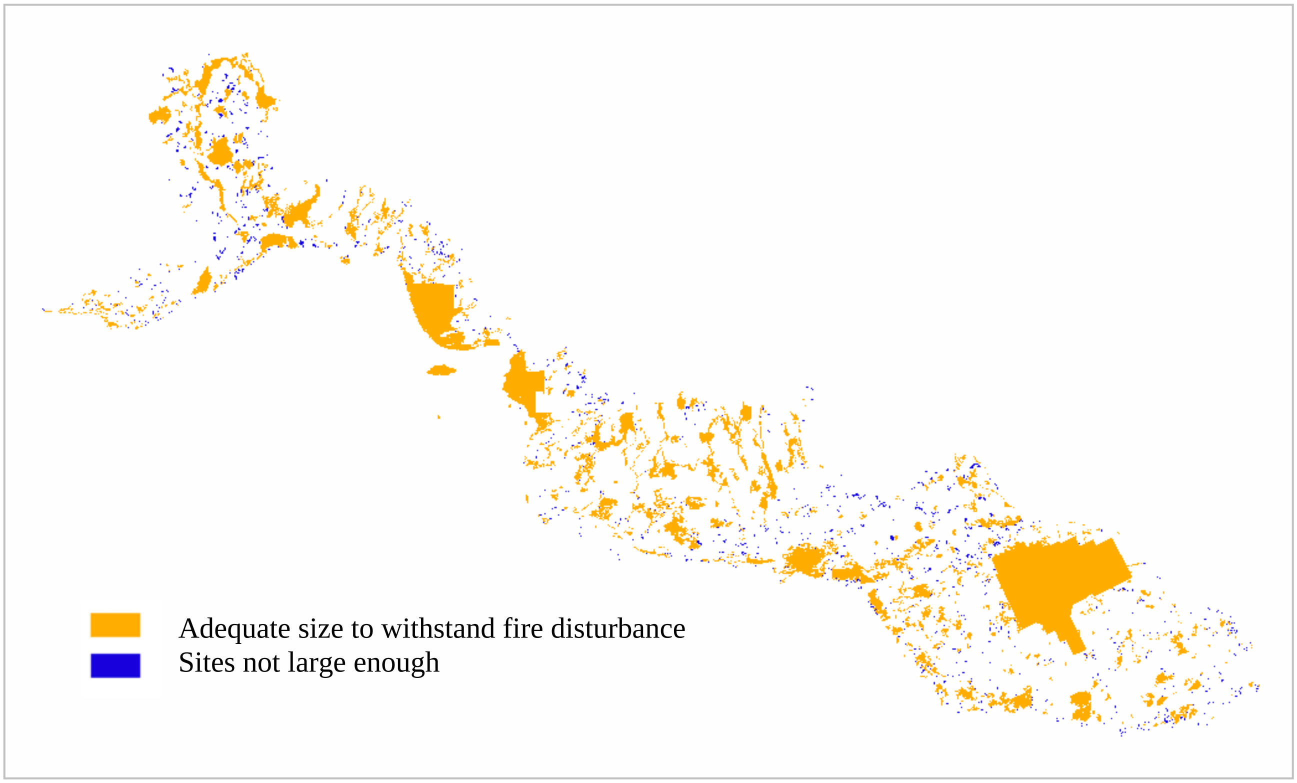


Figure 48. Conservation Blueprint areas large enough to withstand natural fire disturbance (4X rule).

6.6 Wide-ranging Mammal Review

Following the same method used in the fire disturbance analysis (Section 6.5), adjacent Conservation Blueprint sites were merged into larger contiguous sites, and these larger areas were analyzed to determine which were large enough to meet the range-size thresholds for wide-ranging mammals, according to the criteria outlined in Section 5.6.1.3 (Table 8). This analysis used the total area of each site, and did not consider specialized habitat requirements or stand composition and structure, or the intervening landscapes.

Most of the wide-ranging mammals treated in this analysis are widespread in the Canadian Shield portion of the study area, and the majority of portfolio sites met the size threshold estimated for one to four reproductive units of the primary wide-ranging mammal targets (Fisher, Black Bear and Lynx) within their current ranges (Figure 49).

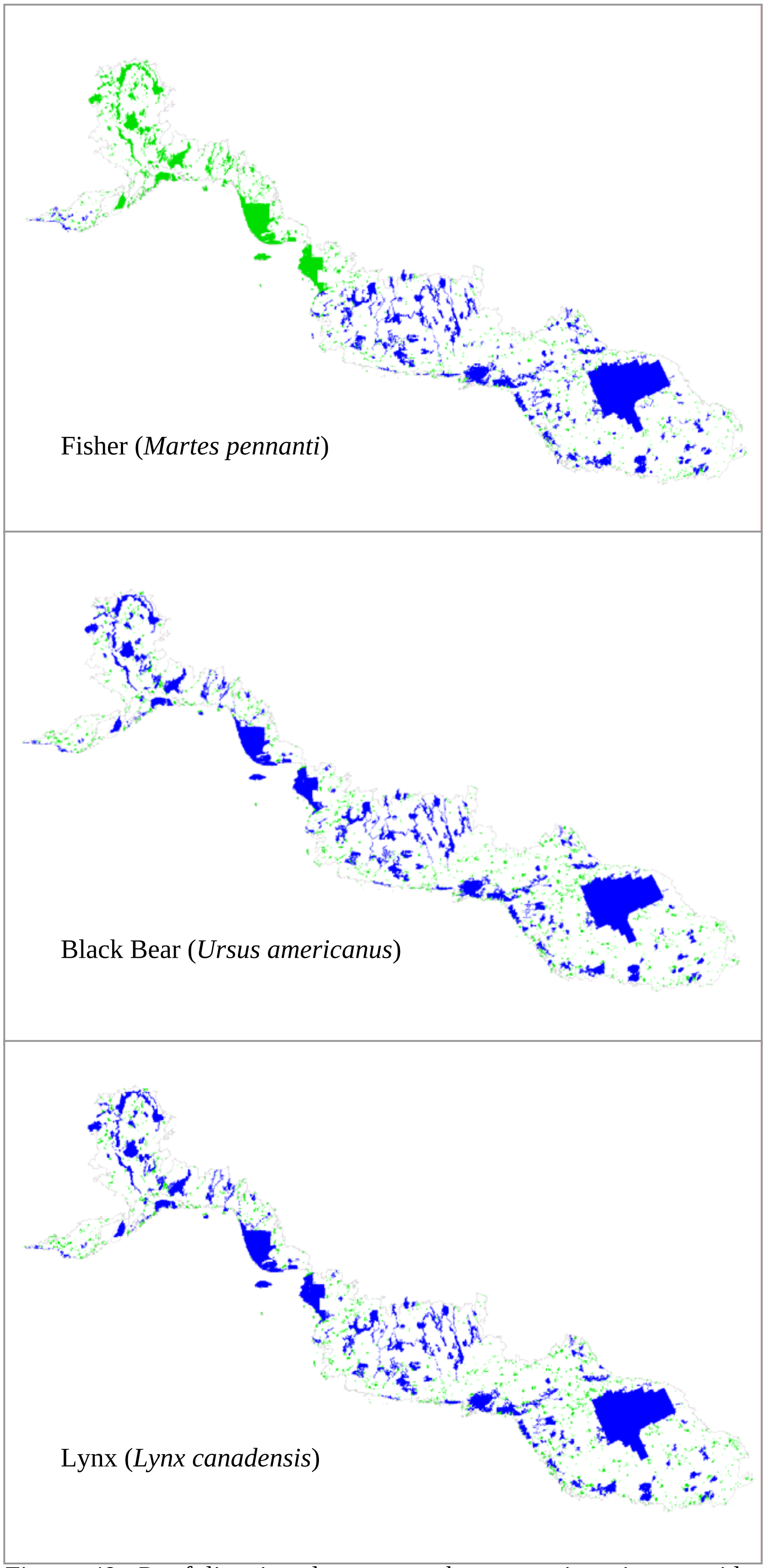
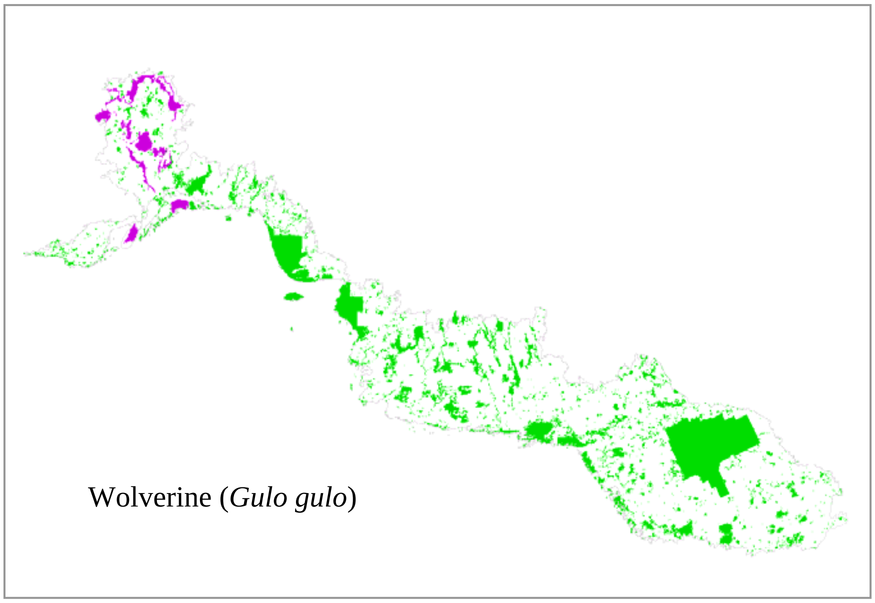


Figure 49. Portfolio sites large enough to sustain primary wide-ranging mammal targets. Blue areas denote portfolio sites large enough to support the species home range; green areas denote sites that are too small or out of the species current range.

Note that the Fisher's range does not extend around Lake Superior.

Two secondary species targets, Wolverine and Caribou, were also assessed, again within their existing range of occurrence. However, the current distributions of both species are predominantly north of the study area, except in isolated pockets (Figure 50). None of the portfolio sites are large enough to support the range size of Woodland Caribou. Three other non-target species, Moose, Gray Wolf and Pine Marten, were also assessed (Figure 51). The majority of portfolio sites are adequate for these species.

Overall, this assessment reinforces the conclusion that the integrity of the landscape as a whole, and the human actions and human-species interactions on it, are central to the conservation of wide-ranging mammals (Soule *et al.*, 2003). "Size of conserved site" (existing or potential) may be a secondary variable in the conservation of these species, more related to "source" protection and maintenance of *in situ* genetic stock.



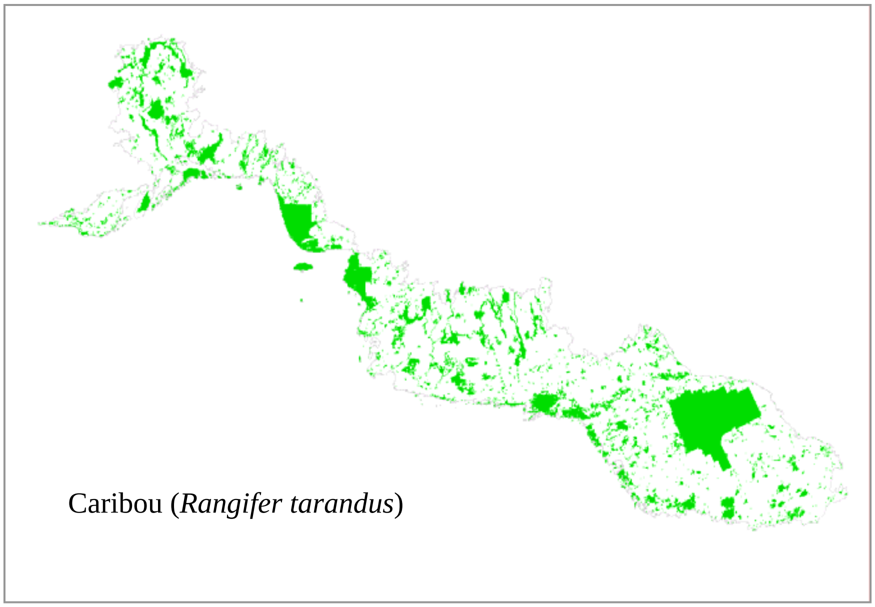


Figure 50. Portfolio sites large enough to sustain secondary wide-ranging mammal targets. Purple areas denote portfolio sites large enough to support the species home range; green areas denote portfolio sites that are too small or out of the species current range.

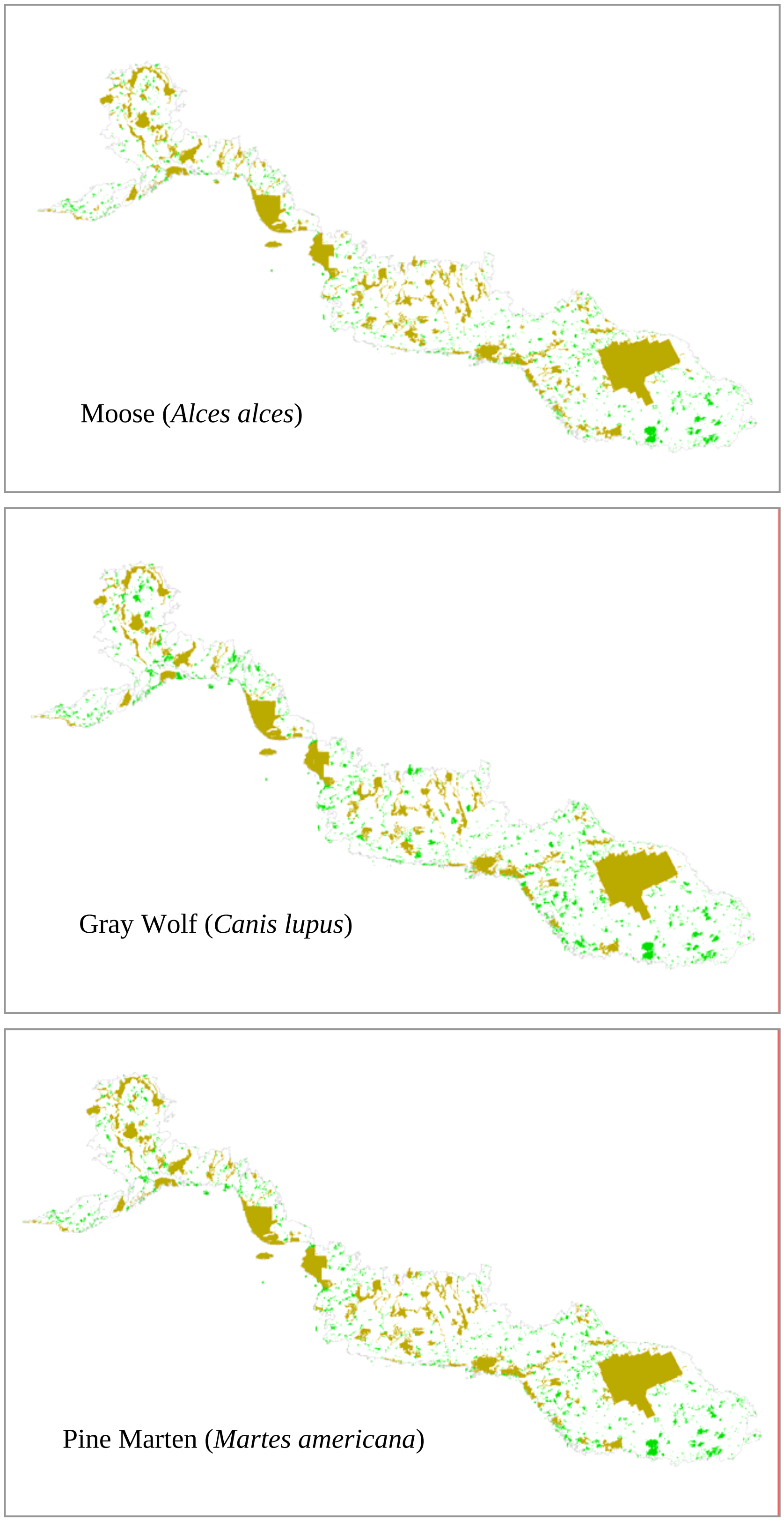


Figure 51. Portfolio sites large enough to sustain other wide-ranging mammals not targeted. Brown areas denote portfolio sites large enough to support the species home range; green areas denote portfolio sites that are too small or out of the species current range.

6.7 IUCN Classification of Ontario's Conservation Lands

The World Conservation Union (IUCN) has developed a classification system that is applied internationally to compare levels of protection and types of management of parks, protected areas and conservation lands (IUCN, 1994; Turner and Wiken, 2001) (see Table 14).

In Ontario alone, there are more than 40 natural heritage designations among federal, provincial, municipal and private conservation lands. Paleczny *et al.* (2000) applied the IUCN classification to Ontario's protected areas and conservation lands, suggesting their use would:

- strengthen the cooperation among agencies and organizations that secure and manage such lands;
- provide a consistent overview of area attributes and management objectives across the province and beyond;
- standardize the reporting of statistics; and
- identify gaps in protected areas coverage where additional areas may be required to protect representative and special heritage values.

The protected areas and conservation lands identified in the Conservation Blueprint fall into various IUCN categories (Table 15). IUCN categories I and II are strictly regulated protected areas. In southern Ontario, categories I/II occur on less than 1% of the landbase, and comprise almost 8% of the total Conservation Blueprint portfolio of core biodiversity conservation areas. On the Canadian Shield, categories I/II occur on more than 18% of the landbase, and comprise about 80% of the total Conservation Blueprint portfolio of biodiversity conservation areas. Combined, sites in IUCN categories I/II cover 11.5% of the Great Lakes region in Canada, and comprise almost 65% of the total Conservation Blueprint portfolio.

Table 14. IUCN Protected area management categories (IUCN 1994).

IUCN Category		Management Goals or Practices
I.a.	Nature reserve or wilderness area nature reserve	Primarily for scientific research or ecological monitoring
I.b.	Wilderness Area	Preservation of natural conditions
II.	National park (or provincial/territorial equivalent)	Ecosystem protection and recreation
III.	Natural monument	Protection of specific outstanding natural features, provision of opportunities for research and education, and prevention of exploitation or occupation
IV.	Habitat/species management areas	Securement and maintenance of habitat conditions necessary to protect species and ecosystem features where these require human manipulation for optimum management
V.	Protected landscape or seascape	Conservation, education, recreation, and provision of natural products aimed at safeguarding the integrity or harmonious interactions of nature and culture
VI.	Managed resource protected areas	Long-term protection and maintenance of biodiversity and other natural values and the promotion of sound management practices for sustainable production purposes

Table 15. Protected areas and conservation lands in the Conservation Blueprint classified with IUCN categories (excerpts from Paleczny *et al.*, 2000). 'CF' are protected areas and conservation lands included in the Conservation Blueprint (both the coarse-filter and fine-filter analyses). 'C' are conservation lands included only in the coarse-filter analysis and which may or may not be included in the Conservation Blueprint. 'o' is the IUCN category that the area is classified under (which may vary on a case-by-case basis).

Area/Mechanism in Ontario	Degree of Protection	IUCN Protected Area Category							No Category	Conservation Blueprint
		Ia	Ib	II	III	IV	V	VI		
International										
Important Bird Areas	Full, Partial, and None	o	o	o	o	o				C
National										
National Parks	Full		o	o						CF
Migratory Bird Sanctuaries	Full and Partial	o		o	o	o			o	CF
National Wildlife Areas	Full	o	o	o	o	o				CF
Provincial										
Provincial Wilderness Parks	Full		o							CF
Provincial Nature Reserve Parks	Full	o								CF
Provincial Waterway Parks	Full			o						CF
Provincial Natural Environment Parks	Full			o						CF
Provincial Historic Parks	Full				o					CF
Provincial Recreation Parks	Full			o						CF
Conservation Reserves	Full	o	o	o	o					CF
Ontario Living Legacy Sites (Provincial Parks and Conservation Reserves only)	Full	o	o	o	o					CF
Provincially Significant Wetlands	Full and Partial								o	CF
Provincially Significant Life Science ANSIs	Partial								o	CF
Regionally Significant Life Science ANSIs	Partial								o	C
Conservation Authority Areas	Partial			o	o	o			o	CF
Municipal										
Natural Heritage features in urban and rural areas (wetlands, ANSI, valleylands, wildlife habitat, endangered and threatened species habitat, woodlands)	Full and Partial	o		o		o				C
Rouge Park	Full			o						CF
Private										
Nature Conservancy of Canada properties	Full	o								CF

7.0 Strengths and Innovations

The Great Lakes Conservation Blueprint for Terrestrial Biodiversity represents the first assessment of the geography of present conservation success and future conservation needs across the Canadian Great Lakes basin. A similar analysis is in place for the U.S. portion of the Great Lakes basin (Harkness *et al.*, 1999), and parallel projects are underway across Canada.

This summary report documents the methods used by the project so that comparative analyses may be undertaken in the future to measure future success in biodiversity conservation in the region. The detailed results of the analysis, which will be useful to the many partners in conservation across the region, are in (1) Volume 2, the catalogue of ecodistrict-by-ecodistrict summaries and mapping of results, and in (2) the shared GIS data layers and approaches that have been archived for sharing with others. (See NCC and NHIC websites, and Ontario Geospatial Data Exchange).

The expertise and experience of the Core Science Team contributed significantly to the success of this project. The Core Science Team members were strategically chosen for their expertise and their relationships with other conservation professionals in the study area. The overall methodology for the project was developed with the direction, support and consensus of the Core Science Team and other experts. The Team also took responsibility for decision-making on issues not based directly on scientific information (for example, setting conservation goals).

A formal project charter was developed between NCC, Ontario Parks and OMNR (including the NHIC). This formal agreement helped recruit support from biologists from different provincial and federal agencies and NGOs. The formal agreement was also instrumental in gaining access to key GIS layers and other natural heritage databases maintained by provincial agencies.

The decision to use the conservation framework and terminology familiar to conservation planners across Ontario, while still pioneering new methods using new technologies, allowed the project to access the experience of individuals who had pursued comparable assessments, albeit for smaller areas and without GIS technology.

Previous landscape-level biodiversity analyses in southern Ontario provided a foundation on which to build the Conservation Blueprint analysis. As well, by integrating Conservation Blueprint results with Ontario's Big Picture project, a landscape-level analysis of a natural heritage system on the landscape of southern Ontario, the core biodiversity conservation areas identified by the Conservation Blueprint could be portrayed as part of the broader, ecologically connected landscape of natural cover across the south.

The Great Lakes Conservation Blueprint for Biodiversity was based on fine scale data (*e.g.*, 25m pixel resolution and digital Forest Resource Inventory attributes). Conducting the analysis at this fine level of resolution enables the communication of results at the scale of individual sites and properties. However, at the same time, results can be rolled-up to landscape scales. Throughout the analysis a set of attributes was maintained on the GIS files so that the portfolio can be queried in a GIS for the underlying biodiversity values and the rationale for inclusion in the portfolio. The detailed, documented and transparent methods of the project permit communication of the Conservation Blueprint portfolio of sites as the testable results of perfectible methods, rather than opinion.

The automation of the portfolio selection algorithm allows the data to be re-analyzed if there is a wish to change scores, goals or digital layers as conservation science changes over the coming years. This enables the model to be adaptable and useful to further iterations of such studies in the Great Lakes ecoregion, or in other geographic areas, or for more in-depth assessments of particular ecodistricts.

Throughout the project, a number of valuable digital data layers and applications were created. These include the ecological systems layer, the analysis of fire disturbance regime data across the region, multiple conservation value layers, and the assembly of protected areas and conservation lands spatial data, including Conservation

Authority lands for the first time. Considerable amounts of data have been archived on natural heritage features, threats and condition that may be useful to all partners in conservation across Ontario.

8.0 Data Gaps and Lessons Learned

Great progress has been made in gathering natural heritage information across the Great Lakes ecoregion but significant information gaps remain. It is important to recognize these gaps so that future inventory, monitoring and data processing can address them.

The inventory and monitoring of known high-biodiversity areas and populations of rare species has not been routine, regular or consistent. In Ontario, much of the focus of natural heritage inventories has traditionally been in the south, with considerably less survey work on the Canadian Shield. As development pressures increase, the need for further inventories grows. Many existing site inventories are considerably out of date, and there have been no surveys of some sites since the 1980s, or earlier. Inventory and monitoring efforts in provincial parks and protected areas have increased as new sites are regulated under the Ontario Living Legacy (OLL) process, but data for pre-OLL parks, ANSIs, wetlands and Conservation Authority lands need to be gathered according to current standards if long-term ecological monitoring is to be possible.

In southern Ontario, threats to biodiversity are often most severe on private lands because of the intensity of land use and development, yet permission to survey such lands is often difficult to obtain. There are also gaps in digital data for certain other types of conservation lands, including county forests, provincial and municipal public lands, and land trust properties.

Maintaining information on the current status and distribution of species of conservation concern continues to be a challenge despite the substantial advances made with the creation of the NHIC in 1993. Documented occurrences of species from more than 20 years ago were considered 'historic' (*i.e.*, no longer extant) simply because they have not been surveyed since, and were therefore not included in the present analysis. Except for regulated parks and for particular biota such as breeding birds, herpetofauna and species-at-risk, there appears to have been a decline in natural area inventories and data collection in the past decade. Compounding this, the standard data needed to assess the viability of species occurrences are usually lacking. Very few data have been processed for certain taxonomic groups, particularly invertebrates and non-vascular plants.

Much research needs to be done on the biology and ecological requirements of many at-risk, rare and declining species. Studies on the impacts of invasive and exotic species, habitat fragmentation and other threats to biodiversity need to continue.

A standard provincial vegetation community classification, nested within a standard ecological system classification and mapping, is a serious gap. More comprehensive community occurrence data will be necessary to adequately identify rare and representative communities across the ecoregion.

The NHIC plays a critical role in addressing these data gaps. It has had the data-repository role and dedicated professionals who have made it possible to develop a Conservation Blueprint project. Without centralized natural heritage data, processed according to the strict standards of the international network of conservation data centres to which the Ontario NHIC belongs, regional and landscape scale GIS analyses such as the Conservation Blueprint would not be possible.

Ontario has made a remarkable investment in the digitization of landcover and vegetation data compared to other jurisdictions, but gaps remain. There are no Forest Resources Inventory (FRI) digital data for southern Ontario and some of the parks on the Canadian Shield, and the Conservation Blueprint had to default to Provincial Land Cover mapping instead. This raster dataset was interpreted from satellite data recorded between 1986 and 1997, with the majority from the early 1990s. As well, the FRI datasets also have varying degrees of currency and accuracy.

Several more-refined digital layers are under development, or are only available for parts of the province (*e.g.*, Surficial Geology and the Northern Ontario Engineering Geology Terrain Study) so they could not be used for this study. The Southern Ontario Land Resource Information System (SOLRIS) continues to accurately map current land cover through GIS and remote sensing techniques using Ecological Lands Classification standards. This will eventually result in an up-to-date, complete and consistent land cover layer for southern Ontario.

Comprehensive, standard natural area inventories, enhanced long-term ecological and rare-species monitoring, continued processing and maintenance of occurrence data, and digitization of essential data layers, will all help to strengthen and refine the selection of sites required to protect the biodiversity of the Great Lakes region.

The Conservation Blueprint was the first GIS-based landscape-level analysis of biodiversity in the Ontario portion of the Great Lakes basin. In future projects such as this, it is recommended that a data sharing policy with key partners be established early in the project to allow response to data requests 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 efficiently addressed and consensus on methods is achieved in a timely way.

Future 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 require 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.

Finally, it must be noted that there is no clear public-agency commitment to excellence in conservation planning in the Canadian Great Lakes basin. The Ontario Ministry of Natural Resources and its Biodiversity Section (including NHIC) and Ontario Parks, offers the best prospect for the kind of integration and capacity needed for such a centre for excellence. On-the-ground, science-based commitments by federal and municipal agencies are practically non-existent other than through the offices of a number of Conservation Authorities. In this relative void, non-government organizations are independently investing in conservation planning. The Conservation Blueprint was a successful, multi-party, private-public undertaking that should serve as a model for future assessments of biodiversity conservation in the region.

Biodiversity conservation will never be achieved solely on public lands, or solely through private-land stewardship, or any other single approach. This reality should help inform how we collectively, even binationally, pursue biodiversity planning and conservation in the future.

9.0 Next Steps

Implementation Strategy: Results from the Conservation Blueprint will inform a number of activities of the NCC and OMNR. An important application for the NCC is to provide strategic direction for setting land protection priorities. Approximately 55% of the lands in Ontario's 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 TNC 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 should benefit a broad range of conservation actions by various organizations.

Ontario has an enviable tradition of innovative conservation planning, in pursuit of economic and effective approaches to region-wide conservation. Much of this stemmed from past investments in assessments and inventories of significant natural areas (ANSIs) and wetlands. At present, the emphasis has changed more to the assessment of species-at-risk needs and the design of natural heritage systems (cores, corridors, connecting links). The results and data from the Conservation Blueprint are likely to be very useful in the development of a new generation of ecodistrict assessments of natural heritage features and systems, especially across southern Ontario.

Remote, computer-based assessments of conservation priorities, dependent as they are on best available data and expertise, will never replace local experience and knowledge. The Conservation Blueprint results should be used within the scope of community discussions about how to use its results in conjunction with on-the-ground local knowledge, to field-truth and fine-tune results to achieve best local conservation outcomes.

On the Canadian Shield, the working forest landscape of Ontario is guided by the process of Forest Management Planning (FMP) on its public lands, and Conservation Blueprint results will be made available to the forestry sector, both for development of new FMPs and for use in any forest-certification set-aside planning that may be undertaken (such as High Conservation Value Forest assessments for Forest Stewardship Council certification.). On private lands on the Canadian Shield, there is, for the first time through the Conservation Blueprint, good documentation of private-land prospects for biodiversity conservation.

Data Management Strategy: The digital data layers compiled during the project have been documented and catalogued, and will be made available to conservation practitioners. The data-catalogue will be used as a platform for developing a more comprehensive data sharing protocol. GIS layers used in the Conservation Blueprint held by other custodians, and digital layers that contain sensitive or proprietary information, will be addressed accordingly, as many are not allowed to be re-distributed. NCC and NHIC websites, and the Ontario Geospatial Data Exchange will be vehicles for data sharing.

Communication Strategy: A number of communication products are planned to convey key messages of the Conservation Blueprint, as well as issues, data products, timelines, budgets and measures of success. A variety of strategies and information products with varying levels of technical detail are planned. The products will be shared with an array of conservation practitioners throughout Ontario and the Great Lakes states.

Cross-Border Integration:
Discussions have been initiated to integrate the Ontario Great Lakes Conservation Blueprint with The (U.S.) Nature Conservancy's (TNC) ecoregional plan for the Great Lakes basin. Early discussions have inspired TNC to consider the need for more multi-scaled, landscape-wide assessments of biodiversity on the U.S. side. This has inspired NCC staff to consider approaches by which suites of sites and features, especially in southern Ontario, may be aggregated as 'conservation focus areas' or 'potential functional landscapes', combining feature conservation with potential restoration of intervening lands.

Merging Terrestrial and Aquatic Portfolios: The results from the terrestrial Conservation Blueprint will be integrated with the results from the parallel Great Lakes Conservation Blueprint for Aquatic Biodiversity. 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.

10.0 Literature Cited

Allardice, D.R., and S. Thorp. 1995. A Changing Great Lakes Economy: Economic and Environmental Linkages. SOLEC Working Paper presented at State of the Lakes Ecosystem Conference. EPA 905-R-95-017. Chicago, Ill.: U.S. Environmental Protection Agency. 26pp.

Allin, J. 1988. Timber Management Guidelines for the Protection of Fish Habitat. Ontario Ministry of Natural Resources. Queen's Printer for Ontario. 14pp.

AXYS Environmental Consulting Ltd. 2002. Scoping of Ecological Impacts of Mining on Canada's National Parks. Prepared for The Canadian Nature Federation and Mining Association of Canada. 48pp.

Bailey, R.G. 2002. Ecoregion-based Design for Sustainability. Springer-Verlag. 232pp.

Baker W.L. 1992. The Landscape Ecology of Large Disturbances in the Design and Management of Nature Reserves. Landscape Ecology 7(3):181-194.

Baker, M.E., M.J. Wiley, P.W. Seelbach and M.L. Carlson. 2003. A GIS Model of Subsurface Water Potential for Aquatic Resource Inventory, Assessment, and Environmental Management. Environmental Management 32(6):706-719.

Bakowsky, W.D. 1999. Rare Vegetation of Ontario: Tallgrass Prairie and Savannah. Ontario Natural Heritage Information Centre Newsletter 5(1).

Bakowsky, W.D. 1993. A Review and Assessment of Prairie, Oak Savannah and Woodland in Site Regions 7 and 6 (Southern Region). Gore and Storrie Ltd. for Ontario Ministry of Natural Resources, Southern Region, Aurora. 89 pp. + appendices.

Bakowsky, W. and J.L. Riley. 1994. A survey of the prairies and savannahs of southern Ontario. Pp.7-16 *In* Wickett, R.G., P.D. Lewis, A. Woodliffe and P. Pratt (Editors). Proceedings of the Thirteenth North American Prairie Conference, "Spirit of the Land, Our Prairie Legacy". Windsor Dept. of Parks and Recreation. 262pp.

Barnett, P.J. 1992. Quaternary geology of Ontario. Pp. 1011-1088, *In* Thurston, P.C., H.R. Williams, R.H. Sutcliffe and G.M. Stott (Editors). Geology of Ontario. Ontario Ministry of Northern Development and Mines, Ontario Geological Survey, Special Volume 4, Vols. 1 (1991) and 2 (1992). 1525pp.

Beeton, A.M. 2002. Large Freshwater Lakes: Present State, Trends, and Future. Environmental Conservation 29(1):21-38.

Belanger, L. and M. Grenier. 2002. Agriculture Intensification and Forest Fragmentation in the St. Lawrence Valley, Quebec, Canada. Landscape Ecology 17(6):495-507.

Bender, D.J., T.A. Contreras and L. Fahrig. 1997. Habitat Loss and Population Decline: A Meta-analysis of the Patch Size Effect. Ecology 79(2):517-533.

Benton, T.G., D.M. Bryant, L. Cole and H.Q.P. Crick. 2002. Linking Agricultural Practice to Insect and Bird Populations: A Historical Study Over Three Decades. Journal of Applied Ecology 39(4):673-687.

Bergin, T.M., L.B. Best and E.K. Freemark. 1997. An Experimental Study of Predation on Artificial Nests in Roadsides Adjacent to Agricultural Habitats in Iowa. Wilson Bulletin 109:437-448.

Blair R.B. 1996. Landuse and Avian Species Diversity Along an Urban Gradient. Ecological Applications 6:506-519.

Blasutti, A., W.J. Crins, K. Kavanagh, J. Boan and M. Gluck. 2001. Combining Gap Analysis Approaches. Final Report to the Room to Grow Working Group. 19pp.

Boutin C. and B. Jobin. 1998. Intensity of Agricultural Practices and Effects on Adjacent Habitats. Ecological Applications 8:544-557.

Bowker, G.C. 2000. Mapping Biodiversity. International Journal of Geographical Information Science 14(8):739-754.

Bridge, S.R.J. 2001. Spatial and Temporal Variations in the Fire Cycle Across Ontario. Ontario Ministry of Natural Resources, Northeast Science and Technology. NEST Technical Report TR-043. Queen's Printer for Ontario. 41pp.

Bridge, S., W.R. Watt, G. Lucking and B. Naylor. 2000. Landscape Analysis for Forest Management Planning in Boreal Northeastern Ontario. Ontario Ministry of Natural Resources, Northeast Science & Technology. NEST Technical Report TR-040. Queen's Printer for Ontario. 36pp.

Brinson, M.M. and A.I. Malvárez. 2002. Temperate Freshwater Wetlands: Types, Status, and Threats. Environmental Conservation 29(2):115-133.

Brodribb K.E. and R. Jahncke. 2003. Great Lakes Conservation Blueprint Project for Terrestrial Biodiversity. Technical Methodology for Southern Ontario. October 2003. 42pp.

Brooks, T.M., R.A. Mittermeier, C.G. Mittermeier, G.A. B. da Fonseca, A.B. Rylands, W.R. Konstant, P. Flick, J. Pilgrim, S. Oldfield, G. Magin and C. Hilton-Taylor.

2002. Habitat Loss and Extinction in the Hotspots of Biodiversity. Conservation Biology 16(4):909-923.

Brown, D.M., G.A. McKay and C.C. Chapman. 1980. The climate of southern Ontario. Climatological Studies 5. Environment Canada, Atmospheric Environment Services, Toronto. 66pp.

Brownell, V.R. and J.L. Riley. 2000. The Alvars of Ontario: Significant Alvar Natural Areas in Ontario's Great Lakes Region. Federation of Ontario Naturalists, Don Mills, Ontario. 269pp.

Bruinderink, G.G., T. Van Der Sluis, D. Lammertsma, P. Opdam and R. Pouwels. 2003. Designing a Coherent Ecological Network for Large Mammals in Northwestern Europe. Conservation Biology 17(2):549-557.

Burke, D.M. and E. Nol. 2000. Landscape and Fragment Size Effects on Reproductive Success of Forest-breeding Birds in Ontario. Ecological Applications 10:1749-1761.

Buse, L.J. and A.H. Perera (compilers). 2002. Emulating National Forest Landscape Disturbances: Concepts and Applications. Popular Summaries. Forest Research Information Paper No. 149. Ontario Forest Research Institute, Ontario Ministry of Natural Resources. Queen's Printer for Ontario. 100pp.

Cam, E., J.D. Nichols, J.R. Sauer, J.E. Hines and H.C. Flather. 2000. Relative Species Richness and Community Completeness: Birds and Urbanization in the Mid-Atlantic States. Ecological Applications 10:1196-1210.

Canadian Boreal Initiative. 2003. The Boreal Forest at Risk: A Progress Report. June 23, 2003. Fourth Anniversary of Competing Realities: The Boreal Forest at Risk by the Senate Committee on Agriculture and Forestry. 18pp.

Canadian Wildlife Service, Environment Canada. 2004. Environmental Assessment Best Practice Guide for Wildlife at Risk in Canada. First Edition. 63pp.

Carleton, T.J. 2003. Old Growth in the Great Lakes Forest. Environmental Reviews 11:115-134. Supplement 1.

Carleton T.J. 2000. Vegetation Responses to the Managed Forest Landscape of Central and Northern Ontario. *In* A.H. Perera, D.L. Euler and I.D. Thompson (Editors). Ecology of a Managed Terrestrial Landscape: Patterns and Processes in Forest Landscapes in Ontario. Vancouver, British Columbia: University of British Columbia Press. 336pp.

Carman, R.S. 1941. The glacial pot hole area, Durham County, Ontario. Forestry Chronicle. Sept.1941:110-120.

Catling, P.M., J.E. Cruise, K.L. McIntosh and S.M. McKay. 1975. Alvar vegetation in southern Ontario. Ontario Field Biology 29(2):1-25.

Chapman, L.J. and D.F. Putnam. 1984. Physiography of Southern Ontario. 3rd Edition. OMNR, Ontario Geological Survey, Special Vol. 2. 270pp.

Chapman, L.J. and M.K. Thomas. 1968. The climate of northern Ontario. Climatological Studies 6. Environment Canada, Atmospheric Environment Services, Toronto. 58pp.

Chen, H.Y.H. and R.V. Popadiouk. 2002. Dynamics of North American Boreal Mixedwoods. Environmental Reviews 10(3):137-166.

Chen, J., J.F. Franklin and T.A. Spies. 1995. Growing-season Microclimate Gradients from Clearcut Edges into Old-growth Douglas-Fir Forests. Ecological Applications 5:74-86.

Claire, C., H.B. Vos and C.J. Grashof-Bokdam. 2002. Corridors and Species Dispersal. *In* Gutzwiller, K.J. (Editor). 2002. Applying Landscape Ecology in Biological Conservation. Spring-Verlag New York, Inc. 518pp.

Clevenger, A.P., J. Wierzchowski, B. Chruszcz and K. Gunson. 2002. GIS-Generated, Expert-Based Models for Identifying Wildlife Habitat Linkages and Planning Mitigation Passages. Conservation Biology 16(2):503-514.

Cody, W.J. 1982. A comparison of the northern limits of distribution of some vascular plant species in southern Ontario. Canadian Field-Naturalist 109:63-90.

Colombo, S.J., M.L. Cherry, C. Graham, S. Greifenhagen, R.S. McAlpine, C.S. Papadopol, W.C. Parker, T. Scarr, and M.T. Ter-Mikaelian. 1998. The Impacts of Climate Change on Ontario's Forests. Forest Research Information Paper No. 143, Ontario Forestry Research Institute, Ontario Ministry of Natural Resources, Sault Ste. Marie, Ontario, Canada. 50pp.

Comer, P. 2003. Memo Regarding Conservation Goals and Scenario Building in the Utah High Plateaus Assessment. NatureServe. 10pp.

Comer, P., D. Faber-Langendoen, R. Evans, S. Gawler, C. Josse, G. Kittel, S. Menard, M. Pyne, M. Reid, K. Schulz, K. Snow and J. Teague. 2003. Ecological Systems of the United States: A Working Classification of U.S. Terrestrial Systems. NatureServe, Arlington, Virginia. 83pp.

Cooke, J.A. and M.S. Johnson. 2002. Ecological Restoration of Land with Particular Reference to the Mining of Metals and Industrial Minerals: A Review of Theory and Practice. Environmental Reviews 10:41-71.

Coventry, A.F. 1945. The Need of River Valley Development in Ontario. *In* Department of Planning and Development. River Valley Development in Southern Ontario. Papers and proceedings of the Conference on

River Valley Development in Southern Ontario, London, Ontario. Oct 13 and 14, 1944. T.E. Bowman Printers. Toronto. 134pp.

Crins, W.J. 2000 (updated 2002). Ecozones, ecoregions and ecodistricts of Ontario. Ontario Ministry of Natural Resources, Ontario Parks, Peterborough, ON. Prepared for Ecological Land Classification Working Group. Ms.

Crins, W.J. and P.S.G. Kor. 2000. Natural Heritage Gap Analysis Methodologies Used by the Ontario Ministry of Natural Resources. Open File National Heritage Technical Report 2000-1. Jan. 2000. Ontario Ministry of Natural Resources. Lands and Natural Heritage Branch, Natural Heritage Section, Peterborough, Ontario. 31pp.

Crist, P.J., T. W. Kohley and J. Oakleaf. 2000. Assessing Land-use Impacts on Biodiversity Using an Expert Systems Tool. Landscape Ecology 15(1):47-62.

Crosbie, B. and P. Chow-Fraser. 1999. Percentage Land Use in the Watershed Determines the Water and Sediment Quality of 22 Marshes in the Great Lakes Basin. Canadian Journal of Fisheries and Aquatic Sciences 56(10):1781-1791.

Crump, D. 2001. The Effects of UV-B Radiation and Endocrine-disrupting Chemicals (EDCs) on the Biology of Amphibians. Environmental Reviews 9(2):61-80.

Cuddy, D.G., K.M. Lindsay and I.D. Macdonald. 1976. Significant Areas along the Niagara Escarpment: A Report on Nature Reserve Candidates and other Significant Natural Areas in the Niagara Escarpment Planning Area. OMNR, Parks Planning Branch, Toronto. 426pp.

Dadswell, M.J. 1974. Distribution, ecology and postglacial dispersal of certain crustaceans and fishes in eastern North America. National Museum of Natural Sciences, Ottawa, Publications in Zoology, No. 11. 110pp.

Dale, V.H., S. Brown, R.A. Haeuber, N.T. Hobbs, N. Huntly, R.J. Naiman, W.E. Riebssame, M.G. Turner and T. Valone. 2000. Ecological Principles and Guidelines for Managing the Use of Land. Ecological Applications 10(3):639-670.

Darveau, M., J. Martel, J. DesGranges and Y. Mauffette. 1997. Associations Between Forest Decline and Bird and Insect Communities in Northern Hardwoods. Canadian Journal of Forest Research 27(6):876-882.

De Simone Borma, L., M. Ehrlich and M. Barbosa. 2003. Acidification and Release of Heavy Metals in Dredged Sediments. Canadian Geotechnical Journal 40(6):1154-1163.

Devito, K.J., I.F. Creed, R.L. Rothwell and E.E. Prepas. 2000. Landscape Controls on Phosphorus Loading to Boreal Lakes: Implications for the Potential Impacts of Forest Harvesting. Canadian Journal of Fisheries and Aquatic Sciences 57(10):1977-1984.

Dickmann, D.I. and D.T. Cleland. 2002. Fire Return Intervals and Fire Cycles for Historic Fire Regimes in the Great Lakes Region: A Synthesis of the Literature**.** Draft 8/02. 21pp.

Dillon, P.J., L.A. Molot and W.A. Scheider. 1991. Phosphorous and Nitrogen Export from Forested Stream Catchments in Central Ontario. Journal of Environmental Quality 20:857-864.

Drapeau, P., A. Leduc, J-F. Giroux, J-P.L. Savaard, Y. Bergeron and W.L. Vickery. 2000. Landscape-scale Disturbances and Changes in Bird Communities of Boreal Mixed-wood Forests. Ecological Monographs 70:423-444.

Environment Canada. 1982a. Canadian Climate Normals. Vol. 6: Frost, 1951-1980. Canadian Climate Program, Environment Canada, Atmospheric Environment Service. 276pp.

Environment Canada. 1982b. Canadian Climate Temperatures and Precipitation, 1951-1980. Canadian Climate Program, Environment Canada, Atmospheric Environment Service. 254pp.

ESWG (Ecological Stratification Working Group). 1995. A national ecological framework for Canada. Agriculture and Agri-food Canada, Research Branch, Centre for Land and Biological Resources Research; and Environment Canada, State of the Environment Directorate, Ecozone Analysis Branch, Ottawa/Hull, Ontario, Canada. 125pp. Report and national map at 1:7,500,000 scale.

Etienne, R.S., C.C. Vos and M.J.W. Jansen. 2003. Ecological Impact Assessment in Data-Poor Systems: A Case Study on Metapopulation Persistence. Environmental Management 32(6):760-777.

Fall, A., M. Fortin, D.D. Kneeshaw, S.H. Yamasaki, C. Messier, L. Bouthillier and C. Smyth. 2004. Consequences of Various Landscape-scale Ecosystem Management Strategies and Fire Cycles on Age-class Structure and Harvest in Boreal Forests. Canadian Journal of Forest Research 34(2):310-322.

Findlay, S. and J. Houlahan, 1997. Anthropogenic Correlates of Species Richness in Southeastern Ontario Wetlands. Conservation Biology 11(4):1000-1009.

Frech, R.J., J.A. Caputo and K. McCulloch. 1999. Forest Fire Cycle Analysis for Applications in Forest Management Planning. Ontario Ministry of Natural Resources Internal Document. AFFM Publication No. 362. 15pp.

Freemark, K.E., C. Boutin and C.J. Keddy. 2002. Importance of Farmland Habitats for Conservation of Plant Species. Conservation Biology 16(2):399-412.

Freemark, K.E. and D.A. Kirk. 2001. Birds on Organic and Conventional Farms in Ontario: Partitioning Effects of Habitat and Practices on Species Composition and Abundance. Biological Conservation 101(3): 337-350.

Frelich, L.E. and P.B. Reich. 2003. Perspectives on Development of Definitions and Values Related to Old-growth Forests. Environmental Reviews 11:9-22. Supplement 1.

Forman, R.T.T. and L.E. Alexander. 1998. Roads and their Major Ecological Effects. Annual Review of Ecology, Evolution and Systematics 29:207-231.

Forman, R.T.T. and R.D. Deblinger. 2000. The Ecological Road-Effect Zone of a Massachusetts (U.S.A.) Suburban Highway. Conservation Biology 14(1):36-46.

Friesen, L.E., P.F. Eagles and R.J. MacKay. 1995. Effects of Residential Development on Forest-dwelling Neotropical Migrant Songbirds. Conservation Biology 9(6):1408-1414.

Goodwin, B.J. 2003. Is Landscape Connectivity a Dependent or Independent Variable? Landscape Ecology 18:687-699.

Government of Canada and United States Environmental Protection Agency. 1995. The Great Lakes: An Environmental Atlas and Resource Book. Third Edition. 45pp.

Groves, C.R. 2003. Drafting a Conservation Blueprint: A Practitioner's Guide to Planning for Biodiversity. The Nature Conservancy. Island Press. Washington, D.C. 455pp.

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 to Ecoregional Conservation Planning. 2nd edition. Volumes 1 and 2. The Nature Conservancy.

Haider, W. and L. Hunt. 2002. Visual Aesthetic Quality of Northern Ontario's Forested Shorelines. Environmental Management 29(3):324-334.

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

Harper, K., C. Boudreault, L. DeGrandpre, P. Drapeau, S. Gauthier and Y. Bergeron. 2003. Structure, composition, and diversity of old-growth Black Spruce boreal forest of the Clay Belt Region in Quebec and Ontario. Environmental Reviews 11:79-98. Supplement 1.

Havas, M. 2000. Biological Effects on Non-ionizing Electromagnetic Energy: A Critical Review of the Reports by the US National Research Council and the US National Institute of Environmental Health Sciences as they Relate to the Broad Realm of EMF Bioeffects. Environmental Reviews 8:173-253.

Havinga D. and Ontario Invasive Plants Working Group. 2000. Sustaining Biodiversity: A Strategic Plan for Managing Invasive Plants in Southern Ontario. 28pp.

Heagy A. (Editor). 1993. Hamilton-Wentworth Natural Areas Inventory. Volume I and II. Hamilton Conservation Authority, Hamilton Ontario, Canada.

Hemson (Consulting Ltd.) January 2005. The Growth Outlook for the Greater Golden Horseshoe.

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

Henson, B.L. and K.E. Brodribb. 2004. Great Lakes Conservation Blueprint Project for Terrestrial Biodiversity: Technical Methodology for the Canadian Shield. May 2004. 43pp.

Hills, G.A. 1961, reprinted in 1966. The Ecological Basis for Land-Use Planning. Ontario Department of Lands and Forests, Research Branch, Research Report 46. 204pp.

Hills, G.A. 1959. A Ready Reference to the Description of the Land of Ontario and its Productivity. Maple Division of Research, Ontario Department of Lands and Forests. 142pp.

Hobson, K.A. and J. Schieck. 1999. Changes in Bird Communities in Boreal Mixedwood Forest: Harvest and Wildfire Effects over 30 years. Ecological Applications 9:849-863.

Houlahan, J.E. and S.C. Findlay. 2003. The Effects of Adjacent Land Use on Wetland Amphibian Species Richness and Community Composition. Canadian Journal of Fisheries and Aquatic Sciences 60(9):1078-1094.

Imbreau, L., J-P L. Savard and R. Gagnon. 1999. Comparing Bird Assemblages in Successional Black Spruce Stands Originating from Fire and Logging. Canadian Journal of Zoology 77:1850-1860.

IUCN. 1994. Guidelines for Protected Area Management Categories. International Union for the Conservation of Nature, Morgues, Switzerland. 20pp.

Jalava, J.V., W.L. Cooper and J.L. Riley. 2005. Ecological Survey of the Eastern Georgian Bay Coast. The Nature Conservancy of Canada and the Ontario Ministry of Natural Resources. 180pp. + CD.

Jalava, J.V., J.L. Riley, A.E. Zammit, P.J. Sorrill, T. Holden and J. Henson. 2002. Big Picture Applications of Bioregional Planning in Ontario. *In* Bondrup-Neilsen, S., N.W. Munro, G. Nelson, J.H.M. Willison, T.B. Herman, and P. Eagles (Editors). 2002. Managing Protected Areas in a Changing World. Proceedings of the Fourth International Conference on Science and Management of Protected Areas. 1600pp.

Jalava, J.V., J.L. Riley, A.E. Zammit, P.J. Sorrill, T. Holden and J. Henson. 2001. Big Picture Application of Bioregional Planning in Ontario. pp. 25-36, *In* J. Porter and J.G. Nelson (Editors). Ecological Integrity and Protected Areas. Parks Research Forum of Ontario, 2001. University of Waterloo, Faculty of Environmental Studies. 467pp.

Jalava, J.V., J.L. Riley, D.G. Cuddy and W.J. Crins. 1997. Natural Heritage Resources of Ontario: Revised Site Districts in Ecological Site Regions 6E and 7E: Rationale and Methodology. Natural Heritage Information Centre, OMNR, Peterborough. 17pp.

Johnston-Main, D., L. Casselman, R. Jahncke and B. Henson. 2004a. GIS Technical Methodology. Great Lakes Biodiversity Conservation Blueprint: Terrestrial Component - Phase 1. 63pp.

Johnston-Main, D., L. Casselman, R. Jahncke, B. Henson and T. Krahn. 2004b. On-shield Technical Methodology. Great Lakes Biodiversity Conservation Blueprint: Terrestrial Component - Phase 3. 72pp.

Kaiser, J. 1983. Native and Exotic Plant Species in Ontario: A Numerical Synopsis. The Plant Press 1:25-26.

Kerr, J.T. 1997. Species richness, endemism, and the choice of areas for conservation. Conservation Biology 11:1094-1100.

Kintsch, J.A. and D.L. Urban. 2002. Focal Species, Community Representation, and Physical Proxies as Conservation Strategies: A Case Study in the Amphibolite Mountains, North Carolina, U.S.A. Conservation Biology 16(4):936-947.

Kling, G.W., K. Hayhoe, L.B. Johnson, J.J. Magnuson, S. Polasky, S.K. Robinson, B.J. Shuter, M.M. Wander, D.J. Wuebbbles, D.R. Zak, R.L. Lindroth, S.C. Moser and M.L. Wilson. 2003. Confronting Climate Change in the Great Lakes Region: Impacts on our Communities and Ecosystems. Union of Concerned Scientists. USC Publications. Cambridge, Massachusetts and Ecological Society of America. Washington D.C. 91pp.

Kneeshaw, D. and S. Gauthier. 2003. Old Growth in the Boreal Forest: A Dynamic Perspective at the Stand and Landscape Level. Environmental Reviews 11:99-114. Supplement 1.

Kor, P.S.G., J. Shaw and D.R. Sharpe. 1991. Erosion of bedrock by subglacial meltwater, Georgian Bay, Ontario: a regional overview. Canadian Journal of Earth Sciences 28:623-642.

Larson, B.M., J.L. Riley, E.A. Snell and H.G. Godschalk. 1999. The Woodland Heritage of Southern Ontario. A Study of Ecological Change, Distribution and Significance. Federation of Ontario Naturalists. 262pp.

Lee, M., L. Fahrig, K. Freemark and D.J. Currie. 2002. Importance of Patch Scale vs Landscape Scale on Selected Forest Birds. Oikos 96(1):110-118.

Lesica, P. and F.W. Allendorf. 1995. When are Peripheral Populations Valuable for Conservation. Conservation Biology 9(4):753-760.

Li, C. 2000. Fire Regimes and their Simulation with Reference to Ontario. *In* Perera A.H., D.L. Euler and I.D. Thompson (Editors). 2000. Ecology of a Managed Terrestrial Landscape: Patterns and Processes of Forest Landscapes in Ontario. UBC Press and OMNR. 336pp.

Li, C., I.G.W. Corns and R.C. Yang. 1999. Fire Frequency and Size Distribution under Natural Conditions: A New Hypothesis. Landscape Ecology 14:533-542.

Lipsett-Moore, G., N. Bookey, S. Kingston and J. Shuter. 2004. Representation, Focal Species and Systematic Conservation Planning for the Northern Boreal Initiative. *In* C.J. Lemieux, J.G. Nelson, T.J. Beechey and M.J. Troughton (Editors). Protected Areas and Watershed Management. Parks Research Forum of Ontario, 2003. PRFO, University of Waterloo. 560pp.

Lomolino, M.V. and R. Channell. 1995. Splendid Isolation: Patterns of Geographic Range Collapse in Endangered Mammals. Journal of Mammalogy 76:335-347.

Lovett-Doust, J., M. Biernacki, R. Page, M. Chan, R. Natgunarajah and G. Timis. 2003. Effects of Land Ownership and Landscape-level Factors on Rare-species Richness in Natural Areas of Southern Ontario, Canada. Landscape Ecology 18:621-633.

Lovett-Doust, J. and K. Kuntz. 2001. Land Ownership and other Landscape-level Effects on Biodiversity in Southern Ontario's Niagara Escarpment Biosphere Reserve, Canada. Landscape Ecology 16:743-755.

Low, G., C. Groves and others. Undated. Selecting Sites for Ecoregional Portfolios and TNC Conservation Action. Ms.

MacArthur, R.H. and E.O. Wilson. 1967. The Theory of Island Biogeography. Monographs in Population Biology No 1. Princeton University Press. Princeton, N.J. 224pp.

MacDougall, A.S. and J.A. Loo. 2002. Predicting Occurrences of Geographically Restricted Rare Floral Elements with Qualitative Habitat Data. Environmental Reviews 10(3):167-190.

MacLellan, P. and J.M. Stewart. 1985. Latitudinal Gradients in Vegetation along a Disturbed Transmission Line Right-of-way in Manitoba. Canadian Journal of Botany 64(7):1311-1320.

Manitoba Hydro. 1995. Fur, Feathers & Transmission Lines: How Rights of Way Affect Wildlife. Second Edition. 62pp.

Matlack, G.R. 1994. Vegetation Dynamics of the Forest Edge - Trends in Space and Time. Journal of Ecology 82:113-123.

Matlack G.R. 1993. Microenvironment Variation Within and Among Forest Edge Sites in the Eastern United States. Biological Conservation 66:185-194.

Mattson, W.J., P. Niemela, I. Millers and Y. Inguanzo. 1994. Immigrant phytophagous insects on woody plants in the United States and Canada: An annotated list. Gen. Tech. Rep. NC-169. St. Paul, MN: USDA Forest Service.

Mazerolle, M.H. and M.A. Villard. 1999. Patch Characteristics and Landscape Context as Predicators of Species Presence and Abundance: A Review. Ecoscience 6:117-124.

McLaughlin, D. 1998. A Decade of Forest Tree Monitoring in Canada: Evidence of Air Pollution Effects. Environmental Reviews 6(3-4):151-171.

McMurtry, M., J. Riley, P. Sorrill and T. Sorrill. 2002. Summary of Methodology for Big Picture, 2002. 11pp.

McRae, D.J., L.C. Duchesne, B. Freedman, T.J. Lynham and S. Woodley. 2001. Comparisons Between Wildfire and Forest Harvesting and Their Implications in Forest Management. Environmental Reviews 9:223-260.

Medley, K.E., B.W. Okey, G.W. Barrett, M.F. Lucas and W.H. Renwick. 1995. Landscape Change with Agricultural Intensification in a Rural Watershed, Southeastern Ohio, USA. Landscape Ecology 10(3):161-176.

Michalski, M.F.P., D.R. Gregory and A.J. Usher. 1987. Rehabilitation of Pits and Quarries for Fish and Wildlife. Ontario Ministry of Natural Resources, Land Management Branch and Michael Michalski Associates. 59pp.

MiningWatch Canada. 2001. The Boreal Below: Mining Issues and Activities in Canada's Boreal Forest Region. 184pp.

Mladenoff, D.J., 1995. A Regional Landscape Analysis and Prediction of Favourable Gray Wolf Habitat in Northern Great Lakes Region. Conservation Biology 9(2):278-293.

Moore, P.D. 2002. The Future of Cool Temperate Bogs. Environmental Conservation 29(1):3-20.

Mosseler, A., I. Thompson and B.A. Pendre. 2003. Overview of Old-growth Forests in Canada from a Science Perspective. Environmental Reviews 11:1-7. Supplement 1.

Niemelä, P. and W.J. Mattson. 1996. Invasion of north American forests by European phytophagous insects. BioScience 46:741-753

Norris, K. 2004. REVIEW Managing Threatened Species: The Ecological Toolbox, Evolutionary Theory and Declining-population Paradigm. Journal of Applied Ecology 41(3):413-426.

Noss, R.F. 1990 Indicators for monitoring biodiversity: a hierarchical approach. Conservation Biology 4:2-13.

Noss, R.F., C. Carroll, K. Vance-Borland and G. Wuerthner. 2002. A Multicriteria Assessment of the Irreplaceability and Vulnerability of Sites in the Greater Yellowstone Ecosystem. Conservation Biology 16(4):895-908.

Oliver, I., A. Holmes, J.M. Dangerfield, M. Gillings, A.J. Pik, D.R. Britton, M. Holley, M.E. Montgomery, M. Raison, V. Logan, R.L. Pressey and A.J. Beattie. 2004. Land Systems as Surrogates for Biodiversity in Conservation Planning. Ecological Applications 14(2):485-503.

Ontario (Ontario Ministry of Natural Resources) 1983. Ontario Land Use Guidelines.

Ontario (Ontario *Parks Act*) 1978. Goals & objectives. http://www.ontarioparks.com/english/welcome2.html

Ontario Ministry of Natural Resources. 2002. State of the Forest Report 2001. Queen's Printer for Ontario. 200pp.

Ontario Ministry of Natural Resources. 2001. Forest Management Guide for Natural Disturbance Pattern Emulation, Version 3.1. Ontario Ministry of Natural Resources, Queen's Printer for Ontario. 40pp.

Ontario Ministry of Natural Resources. 1999. Ontario Living Legacy: Land Use Strategy. July 1999. Queen's Printer for Ontario. 136pp.

Ontario Ministry of Natural Resources, 1997a. Forest Management Guidelines for the Emulation of Fire Disturbance Patterns – Analysis Results. 58pp.

Ontario Ministry of Natural Resources. 1997b. Nature's Best. Ontario's Parks and Protected Areas. A Framework and Action Plan. Lands and Natural Heritage Branch, The Natural Heritage Section. Queen's Printer for Ontario. 37pp.

Ontario Ministry of Natural Resources, 1994. Conserving Ontario's Old Growth Forest Ecosystems: Final Report of the Old Growth Forests Policy Advisory Committee. Queen's Printer for Ontario. 113pp.

Ontario Ministry of Natural Resources, 1992. Ontario Provincial Parks: Planning and Management Policies. 1992 Update. Provincial Parks and Natural Heritage Policy Branch. 119pp.

Ontario Ministry of Natural Resources. 1991. Code of Practice for Timber Management Operations in Riparian Areas. Queen's Printer for Ontario. 9pp.

Ontario Ministry of Natural Resources. 1983. Pit and Quarry Rehabilitation: The State of the Art in Ontario. Queen's Printer for Ontario. 1v.

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. Ontario Parks and Natural Heritage Information Centre, Ontario Ministry of Natural Resources. 12pp.

Paoletti, M.G., D. Pimental, B.R Stinner and D. Stinner. 1992. Agroecosystem Biodiversity: Matching Production and Conservation Biology. Agriculture, Ecosystems and Environment 40:3-23.

Parsons, H. and D. Gilvear. 2002. Valley Floor Landscape Change Following almost 100 years of Flood Embankment Abandonment on a Wandering Gravel-bed River. River Research and Applications 18(5):461-479.

Paton, P.W.C. 1994. The Effect of Edge on Avian Nest Success: How Strong is the Evidence. Conservation Biology 8:17-26.

Pearce, C.M. 1993. Coping with Forest Fragmentation in Southwestern Ontario. *In* Poser, S.F., W.J. Crins, T.J. Beechey (Editors). 1993. Size and Integrity Standards for Natural Heritage Areas in Ontario. Proceedings of a Seminar. Parks and Natural Heritage Policy Branch, Ontario Ministry of Natural Resources, Huntsville, Ontario. 138pp.

Perera, A.H. and D.J.B. Baldwin. 2000. Spatial Patterns in the Managed Forest Landscape of Ontario. *In*: Perera, A.H., D.L. Euler and I.D. Thompson (Editors). 2000. *Ecology of a Managed Terrestrial Landscape: Patterns and Processes of Forest Landscapes in Ontario.* UBC Press and OMNR. 336pp.

Perera, A.H., D.J.B. Baldwin, F. Schnekenburger, J.E. Osborne and R.E. Bae. 1998. Forest Fires in Ontario: A Spatiao-temporal Perspective. Forest Research Report No 147. Sault Ste. Marie, Ontario. Ontario Forest Research Institute, Science Development and Transfer Branch, Ontario Ministry of Natural Resources. 22pp.

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. and J. Thompson. 1978. Patch Dynamics and the Design of Nature Reserves. Biological Conservation 13:27-37.

Poiani, K.A., M.D. Merrill and K.A. Chapman. 2001. Identifying Conservation-Priority Areas in a Fragmented Minnesota Landscape Based on the Umbrella Species Concept and Selection of Large Patches of Natural Vegetation. Conservation Biology 15(2):513-522.

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.

PPS (Provincial Policy Statement). 2005. Ontario Provincial Policy Statement. Queen’s Printer for Ontario. 37pp.

Pressey, R.L., I.R. Johnson and P.D. Wilson. 1994. Shades of Irreplaceability: Towards a Measure of the Contribution of Sites to a Reservation Goal. Biodiversity and Conservation 3:242-262.

Reschke, C., R. Reid, J. Jones, T. Feeney and H. Potter. 1999. Conservation Great Lakes Alvars. The Nature Conservancy, Great Lakes Program, Chicago. 230pp.

Rich, A.C., D.S. Dobkin and L.J. Niles. 1994. Defining Forest Fragmentation by Corridor Width: The Influence of Narrow Forest-Dividing Corridors on Forest-Nesting Birds in Southern New Jersey. Conservation Biology 8(4):1109-1121.

Ricketts, T.H., E. Dinerstein, D.M. Olson and C.J. Loucks. 1999. Terrestrial ecoregions of North America: a conservation assessment. Island Press. 508pp.

Riffell, S.K., B.E. Keas and T.M. Burton. 2003. Birds in North American Great Lakes Coastal Wet Meadows: Is Landscape Context Important? Landscape Ecology, 18(2):95-111.

Riley, J.L. 2003. Flora of the Hudson Bay Lowland and its Postglacial Origins. National Research Council of Canada, Research Press. Ottawa. 236pp.

Riley, J.L. 2002. Conservation Blueprints and the Nature Conservancy of Canada. Discussion Paper. Ms. 7pp.

Riley, J.L. 1999. Planning for Natural Heritage Systems on the Settled Landscapes of Southern Ontario. Pp. 145-151, *In* Beechey, T.J., G.R. Francis and D.M. Powell (Editors). Caring for Southern Remnants: Special Species, Special Spaces. Conference Proceedings, 12th Annual Meeting, Canadian Council on Ecological Areas, 10-15 Aug. 1993, Windsor, & CCEA, Ottawa, Canada. 305pp.

Riley, J.L. 1998. The identification of candidate protected areas for the Lands for Life planning process by the Partnership for Public Lands. Pp. 287-291, *In* J.G. Nelson and K. Van Osch (Editors). Parks and Protected Areas Research in Ontario. Heritage Resources Centre, University of Waterloo, Waterloo. Ontario. 410pp.

Riley, J.L. 1994a. Peat and Peatland Resources of Southeastern Ontario. Ontario Geological Survey, Miscellaneous Paper 154. 167pp.

Riley, J.L. 1994b. Peat and Peatland Resources of Northeastern Ontario. Ontario Geological Survey, Miscellaneous Paper 153. 155pp.

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

Riley, J.L., A. Blasutti, T. Iacobelli and K. Kavanagh. 1999. Conservation suitability mapping across the Lands for Life planning process in Ontario, Canada. ESRI ARC News Summer 1999.

Riley, J.L., J.V. Jalava, M.J. Oldham and H. Godschalk. 1997. Natural Heritage Resources of Ontario: Bibliography of the Life Science Areas of Natural and Scientific Interest in Ecological Site Regions 6E and 7E, Southern Ontario. OMNR, Natural Heritage Information Centre, Peterborough. 156pp.

Riley, J.L., J.V. Jalava and S. Varga. 1996. Ecological Survey of the Niagara Escarpment Biosphere Reserve: Vol. 1 Significant Natural Areas, Vol. 2 Technical Appendices. OMNR Southcentral Region and Ontario Heritage Foundation. OFSR 9601. 629pp., 310pp.

Riley, J.L., J.V. Jalava, S. Varga and P.S.G. Kor. 1995. Monitoring and Base-line Inventory: A Survey of the Geology and Ecology of Ontario’s Niagara Escarpment Biosphere Reserve. Pp. 21-32, *In* S. Carty, G. Whitelaw, J. Connolly and M. Alles-deVos (Editors). The Leading Edge, Proceedings of a Conference on Research on the Niagara Escarpment. Hockley Valley, September 1994. 521pp.

Riley, J.L., M. McMurtry, P.J. Sorrill and T. Holden. 2003. Big Picture 2002. Identifying Key Natural Heritage Areas and Linkages on the Southern Ontario Landscape. CD, PowerPoint, maps. Nature Conservancy of Canada and Ontario Natural Heritage Information Centre, Peterborough, Ontario

Riley, J.L. and L. Michaud. 1994. Ontario Peatland Inventory: Field-work Methods. Ontario Geological Survey, Miscellaneous Paper 155. 62pp.

Riley, J.L. and P. Mohr. 1994. The Natural Heritage of Southern Ontario's Settled Landscapes. A review of conservation biology and restoration ecology for land-use and landscape planning. OMNR, Southern Region, Aurora, Science and Technology Transfer, Technical Report TR-001. 78pp.

Roberge, J.M. and P. Angelstam. 2004. Usefulness of the Umbrella Species Concept as a Conservation Tool. Conservation Biology 18(1):76-85.

Rost, G.R. and J.A. Bailey. 1979. Distribution of Mule Deer and Elk in Relation to Roads. Journal of Wildlife Management 43:634-641.

Rowe, J.S. 1972. Forest Regions of Canada. Canada, Department of the Environment. Canadian Forestry Service Publication 1300. 172pp.

Sarakinos, H., A.O. Nicholls, A. Tubert, A. Aggarwal, C.R. Margules and S. Sarkar. 2001. Area Prioritization for Biodiversity Conservation in Quebec on the Basis of Species Distributions: A Preliminary Analysis. Biodiversity and Conservation 10:1419-1472.

Schartz, M. and M.F. Goodwin. 1999. The Massachusetts Resource Identification Project: Project Report. 19pp.

Scott, J.M., M. Murray, R.G. Wright, B. Csuti, P. Morgan, and R.L. Pressey. 2001. Representation of Natural Vegetation in Protected Areas: Capturing the Geographic Range. Biodiversity and Conservation 10:1297-1301.

Semlitsch, R.D. and J.R. Bodie. 2003. Biological Criteria for Buffer Zones around Wetlands and Riparian Habitats for Amphibians and Reptiles. Conservation Biology 17(5):1219-1228.

Simon, N.P.P., F.E. Schwab and R.D. Otto. 2002. Songbird Abundance in Clear-cut and Burned Stands: A Comparison of Natural Disturbance and Forest Management 32:1343-1350.

Snell, E.A. 1987. Wetland Distribution in Southern Ontario. Working Paper No. 48. Canada Land Use Monitoring Program, Environment Canada. 53pp.

Snyder, C.D., J.A. Young, R. Villella and D.P. Lemarié. 2003. Influences of Upland and Riparian Land Use Patterns on Stream Biotic Integrity. Landscape Ecology 18(7):647-664.

Soper, J.H. 1962. Some genera of restricted range in the Carolinian flora of Canada. Transactions of the Royal Canadian Institute No. 34:2-56.

Soulé, M.E., J.A. Estes, J. Berger and C. Martinez Del Rio. 2003. Ecological Effectiveness: Conservation Goals for Interactive Species. Conservation Biology 17(5):1238-1250.

Stoms, D.M. 2000. GAP Management Status and Regional Indicators of Threats to Biodiversity. Landscape Ecology 15(1):21-33.

Strobl, S. 2003. The Forest and Wetland Connection. *In* Buse, L.J. and A.H. Perera (compilers). 2003. Meeting Emerging Ecological, Economic and Social Challenges in the Great Lakes Region: Popular Summaries. Forest Research Information Paper No. 155. Ontario Forest Research Institute, OMNR. 167pp

Tabacchi, E., D.L. Correll, R. Hauer, G. Pinay, A.M. Planty-Tabacchi and R.C. Wissmar. 1998. Development, Maintenance and Role of Riparian Vegetation in the River Landscape. Freshwater Biology 40(3):497-516.

Taylor, R. and K. Gowanlock. 2003. Healthy Communities through Nature: Linking Quality of Life to Managing the Natural Environment. Southcentral Region Planning Unit. Ontario Ministry of Natural Resources. 29pp.

Theobald, D.M. 2003. Targeting Conservation Action through Assessment of Protection and Exurban Threats. Conservation Biology 17(6):1624-1637.

Thompson, I.D. 2000. Forest Vertebrates of Ontario: Patterns of Distribution. *In* Perera, A.H, D.L. Euler and I.D. Thompson (Editors). Ecology of a Managed Terrestrial Landscape: Patterns and Processes of Forest Landscapes in Ontario. UBC Press & OMNR. 336pp.

Thompson-Roberts, E.S. and F.R. Pick. 2000. Total Mercury in the Water and Sediments of St. Lawrence River Wetlands Compared with Inland Wetlands of Temagami - North Bay and Muskoka-Haliburton. Canadian Journal of Fisheries and Aquatic Sciences 57:148-154. Supplement 1.

Thorp, S., R. Rivers and V. Pebbles. 1997. Impacts of Changing Land Use. State of the Lakes Ecosystem Conference 1996 Background Paper. ISBN 0-662-26034-1. 130pp.

Thurston, E. and R.J. Reader. 2001. Impacts of Experimentally Applied Mountain Biking and Hiking on Vegetation and Soil of a Deciduous Forest. Environmental Management 27(3):397-409.

Thurston, P.C., H.R. Williams, R.H. Sutcliffe and G.M. Stott (Editors). 1991-92. Geology of Ontario. Ontario Ministry of Northern Development and Mines, Ontario Geological Survey, Special Volume 4, 2 Vols. 1525pp.

Tikka, P.M., H. Högmander and P.S. Koski. 2001. Road and Railway Verges Serve as Dispersal Corridors for Grassland Plants. Landscape Ecology 16(7):659-666.

TNC (The Nature Conservancy). 1997. Designing a Geography of Hope. The (U.S.) Nature Conservancy, Arlington, West Virginia. 84pp.

Trombulak, S.C. and C.A. Frissell. 2000. Review of Ecological Effects of Roads on Terrestrial and Aquatic Communities. Conservation Biology 14(1):18-30.

Turner, T. and E. Wiken. 2001. CCEA Workshop 2001: IUCN Classification of Protected Areas. ECO (Newsletter of the Canadian Council on Ecological Areas). No 14.

Uhlig, P., A. Harris, G. Craig, C. Bowling, B. Chambers, B. Naylor and G. Beemer. 2001. Old Growth Forest Definitions for Ontario. Ontario Ministry of Natural Resources, Queen's Printer for Ontario. 27pp.

USDA Forest Service. 1998. Forest Service Roads: A Synthesis of Scientific Information (Draft). 11pp.

Varga, S. 2003, In prep. Natural Heritage Features of the Oak Ridges Moraine. Ontario Ministry of Natural Resources, Southcentral Region, Aurora, ON.

Villard, M.A., M.K. Trzcinski and G. Merriam. 1999. Fragmentation Effects on Forest Birds: Relative Influence of Woodland Cover and Configuration on Landscape Occupancy. Conservation Biology 13(4):774-783.

Voigt, D.R., J.A. Baker, R.S. Rempel and I.D. Thompson. 2000. Forest Vertebrate Responses to Landscape-level Changes in Ontario. *In* A.H. Perera, D.L. Euler, and I.D. Thompson (Editors). Ecology of a Managed Terrestrial Landscape: Patterns and Processes in Forest Landscapes of Ontario. Vancouver, BC: UBC Press. 336pp.

Warman, L.D., A.R.E. Sinclair, G.G.E. Scudder, B. Klinkenberg and R.L. Pressey. 2004. Sensitivity of Systematic Reserve Selection to Decisions about Scale, Biological Data, and Targets: Case Study from Southern British Columbia. Conservation Biology 18(3):655-666.

Weber, M.G. and M.D. Flannigan. 1997. Canadian Boreal Forest Ecosystem Structure and Function in a Changing Climate: Impact on Fire Regimes. Environmental Reviews 5(3-4):145-166.

Whitaker, D.M., A.L Carroll and W.A Montevecchi. 2000. Elevated Numbers of Flying Insects and Insectivorous Birds in Riparian Buffer Strips. Canadian Journal of Zoology 78(5):740-747.

White D.J., E. Haber and C. Keddy. 1993. Invasive Plants of Natural Habitats in Canada: An Integrated Review of Wetland and Upland Species and Legislation Governing their Control. Canadian Wildlife Service, Ottawa, Canada. 121pp.

White, D., P.G. Minotti, M.J. Barczak, J.C. Sifneos, K.A. Freemark, M.V. Santelmann, C.F. Steinitz, A.R. Kiester and E.M. Preston. 1996. Assessing Risks to Biodiversity from Future Landscape Change. Conservation Biology 11(2):349-360.

Wichert, G.A., K.E. Brodribb, B.L. Henson and C. Phair. 2005. Great Lakes Conservation Blueprint for Aquatic Biodiversity. Volume 1. Nature Conservancy of Canada. 86pp.

Wiens, J.A. 2002. Riverine Landscapes: Taking Landscape Ecology into the Water. Freshwater Biology 47:501-515.

Wildlands League and Sierra Legal Defence Fund. Feb 2003. The Road Less Travelled? A Report on the Effectiveness of Controlling Motorized Access in Remote Areas in Ontario. A Case Study in Temagami. 39pp.

Yahner, R.H., W.C. Bramble and W.R. Byrnes. 2001. Effect of Vegetation Maintenance of an Electric Transmission Right-of-Way on Reptile and Amphibian Populations. Journal of Arboriculture 27(1):24-29.

Yahner, R.H., R.J. Hutnik and S.A. Liscinsky. 2002. Bird Populations Associated with an Electric Transmission Right-of-way. Journal of Arboriculture 28(3):123-130.

Zhou, Y. and S. Narumalani. 2003. A GIS-based Spatial Pattern Analysis Model for Eco-region Mapping and Characterization. International Journal of Geographical Information Science 17(5):445-462.

Zorn, P., W. Stephenson and P. Grigoriev. 2001. An Ecosystem Management Program and Assessment Process for Ontario National Parks. Conservation Biology 15(2):353-362.

11.0 Appendices

Appendix 1. 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 has 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: 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, focal species, wide-ranging species and rare vegetation communities.

Focal Species: have spatial, compositional, and functional requirements that may encompass those of other species in the region and may help address the functionality of ecological systems. Examples include keystone species, wide-ranging species, and cave-dwelling species.

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) and 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.

Appendix 2. 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
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 ecodistrict	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
Buteo lineatus	Red-shouldered Hawk	G5	S4B,SZN	SC	SC	secondary target	widespread	SAR
Aquila chrysaetos	Golden Eagle	G5	S1B,SZN	NAR	END-R	secondary target		SAR
Falco peregrinus anatum	Peregrine Falcon	G4T3	S2S3B,SZN	THR	END-R	secondary target	widespread	GRank SAR
Colinus virginianus	Northern Bobwhite	G5	S1S2	END	END	secondary target	peripheral	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 ecodistrict	widespread	GRank SAR
Chlidonias niger	Black Tern	G4	S3B,SZN	NAR	SC	secondary target	widespread	SAR
Tyto alba	Barn Owl	G5	S1	END	END	secondary target	peripheral	SAR
Melanerpes erythrocephalus	Red-headed Woodpecker	G5	S3B,SZN	SC	SC	secondary target	widespread	SAR
Empidonax virescens	Acadian Flycatcher	G5	S2B,SZN	END	END	secondary target	peripheral	SAR
Lanius ludovicianus	Loggerhead Shrike	G4	S2B,SZN	END	END-R	secondary target	widespread	SAR
Dendroica kirtlandii	Kirtland's Warbler	G1	SHB,SZN	END	END-R	all viable occurrences	endemic	GRank SAR
Dendroica cerulea	Cerulean Warbler	G4	S3B,SZN	SC	SC	secondary target	peripheral	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
Wilsonia citrina	Hooded Warbler	G5	S3B,SZN	THR	THR	secondary target	peripheral	SAR
Icteria virens	Yellow-breasted Chat	G5	S2S3B,SZN	SC	SC	secondary target	peripheral	SAR
Ammodramus henslowii	Henslow's Sparrow	G4	S1B,SZN	END	END-R	secondary target	widespread	SAR
Mammals								
Scalopus aquaticus	Eastern Mole	G5	S2	SC	SC	secondary target	peripheral	SAR
Myotis leibii	Small-footed Bat	G3	S2S3			2 per ecodistrict	widespread	GRank
Myotis septentrionalis	Northern Long-eared Bat	G4	S3?			secondary target		focal species
Pipistrellus subflavus	Eastern Pipistrelle	G5	S3?			secondary target		focal species
Glaucomys volans	Southern Flying Squirrel	G5	S3	SC	SC	secondary target	widespread	SAR

Scientific Name	Common Name	GRANK	SRANK	COSEWIC	OMNR	Conservation Goal	Great Lakes Range	Justification
Mammals continued								
Microtus pinetorum	Woodland Vole	G5	S3?	SC	SC	secondary target	peripheral	SAR
Urocyon cinereoargenteus	Grey Fox	G5	SZB?	THR	THR	secondary target	peripheral	SAR
Ursus americanus	Black Bear	G5	S5	NAR	NAR			wide-ranging
Martes pennanti	Fisher	G5	S5					wide-ranging
Gulo gulo	Wolverine	G4	S2	SC	THR	secondary target	widespread	SAR
Taxidea taxus	American Badger	G5	S2	END	END	secondary target	widespread	SAR
Felis concolor couguar	Eastern Cougar	G5TH	SH	DD	END-R	secondary target	widespread	SAR
Lynx canadensis	Lynx	G5	S5	NAR	NAR			wide-ranging
Rangifer tarandus pop. 14	Woodland Caribou - Boreal	G5TNR	S3?	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
Eumeces fasciatus	Five-lined Skink	G5	S3	SC	SC	secondary target	peripheral	SAR
Coluber constrictor foxii	Blue Racer	G5T5	S1	END	END-R	secondary target	peripheral	SAR
Elaphe obsoleta	Eastern Ratsnake	G5	S3	THR	THR	secondary target	peripheral	SAR
Elaphe gloydi	Eastern Foxsnake	G3	S3	THR	THR	4 per ecodistrict	endemic	GRank SAR
Heterodon platirhinos	Eastern Hog-nosed Snake	G5	S3	THR	THR	secondary target	peripheral	SAR
Lampropeltis triangulum	Milksnake	G5	S3	SC	SC	secondary target	peripheral	SAR
Nerodia sipedon insularum	Lake Erie Watersnake	G5T2	S2	END	END-R	4 per ecodistrict	endemic	GRank SAR endemic
Regina septemvittata	Queen Snake	G5	S2	THR	THR	secondary target	peripheral	SAR
Thamnophis butleri	Butler's Gartersnake	G4	S2	THR	THR	secondary target	limited	SAR
Thamnophis sauritus	Eastern Ribbonsnake	G5	S3	SC	SC	secondary target	peripheral	SAR
Sistrurus catenatus	Massasauga	G3G4	S3	THR	THR	4 per ecodistrict	limited	GRank SAR
Insects								
Tachysphex pechumani	A Sphecid Wasp	G3?	S2S3			4 per ecodistrict	limited	GRank
Erynnis martialis	Mottled Duskywing	G3G4	S2			2 per ecodistrict	peripheral	GRank
Oarisma garita	Garita Skipperling	G5	S1			3 per ecodistrict	disjunct	disjunct
Euphyes dukesi	Duke's Skipper	G3	S2			4 per ecodistrict	disjunct	GRank
Pieris virginiensis	West Virginia White	G3G4	S3		SC	4 per ecodistrict	limited	GRank SAR
Callophrys lanoraieensis	Bog Elfin	G3G4	S1			2 per ecodistrict	peripheral	GRank
Chlosyne gorgone	Gorgone Crescentspot	G5	S2			3 per ecodistrict	disjunct	disjunct

Scientific Name	Common Name	GRANK	SRANK	COSEWIC	OMNR	Conservation Goal	Great Lakes Range	Justification
Insects continued								
Danaus plexippus	Monarch	G4	S4	SC	SC	secondary target	widespread	SAR
Anisota finlaysoni	Finlayson's Oakworm Moth	G1G2	S?			all viable occurrences	endemic	GRank
Hemileuca sp 1	Bogbean Buckmoth	G1Q	S1			all viable occurrences	endemic	GRank
Hemaris gracilis	Slender Clearwing	G3G4	S3?			2 per ecodistrict	widespread	GRank
Syngrapha altera	A Moth	G3G4	S2?			4 per ecodistrict	disjunct	GRank
Syngrapha selecta	A Moth	G3G4	S2?			secondary target	widespread	GRank
Cerma cora	Bird Dropping Moth	G3G4	S1?			4 per ecodistrict	disjunct	GRank
Acronicta albarufa	Barrens Daggermoth	G3G4	S1			4 per ecodistrict	disjunct	GRank
Papaipema sp 2	A Moth	G3G4	S?			2 per ecodistrict	widespread?	GRank
Chaetaglaea cerata	A Moth	G3G4	S1?			4 per ecodistrict	disjunct?	GRank
Richia sp 1	A Moth	G2G3	S?			all viable occurrences		GRank
Gomphus ventricosus	Skillet Clubtail	G3	S1			2 per ecodistrict	peripheral	GRank
Gomphus quadricolor	Rapids Clubtail	G3G4	S1			2 per ecodistrict	peripheral	GRank
Gomphus viridifrons	Green-faced Clubtail	G3	S1			2 per ecodistrict	widespread	GRank
Ophiogomphus anomalus	Extra-striped Snaketail	G3	S2			4 per ecodistrict	limited	GRank
Aeshna mutata	Spatterdock Darner	G3G4	S1			2 per ecodistrict	peripheral	GRank
Williamsonia fletcheri	Ebony Boghaunter	G3G4	S2			2 per ecodistrict	widespread	GRank
Stylurus notatus	Elusive Clubtail	G3	S2			2 per ecodistrict	widespread	GRank
Mosses, Liverworts, Hornworts and Lichens								
Aspiromitus macounii	A Hornwort	G3G4	S1			4 per ecodistrict	disjunct?	GRank
Anastrophyllum saxicola	A Liverwort	G3G4	S1S2			4 per ecodistrict	disjunct	GRank disjunct
Anastrophyllum tenue	A Liverwort	G1G2	S1			all viable occurrences	endemic	GRank endemic
Arnellia fennica	A Liverwort	G5	S1S3			3 per ecodistrict	disjunct	disjunct
Asterella gracilis	A Liverwort	G5	S1			3 per ecodistrict	disjunct	disjunct
Athalamia hyalina	A Liverwort	G5	S1			3 per ecodistrict	disjunct	disjunct
Barbilophozia quadriloba	A Liverwort	G5	S1S2			3 per ecodistrict	disjunct	disjunct
Bazzania denudata	A Liverwort	G4G5	S1			3 per ecodistrict	disjunct	disjunct
Bazzania tricrenata	A Liverwort	G4	S1			3 per ecodistrict	disjunct	disjunct
Cephalozia lacinulata	A Liverwort	G3	S1?			2 per ecodistrict	widespread?	GRank
Cephalozia macounii	A Liverwort	G3	S1			4 per ecodistrict	disjunct?	GRank
Cephaloziella rubella var. bifida	A Liverwort	G5T3?	S1			3 per ecodistrict	disjunct?	GRank
Cephaloziella rubella var. elegans	A Liverwort	G5T3?	S1			3 per ecodistrict	disjunct	GRank disjunct
Tetralophozia setiformis	A Liverwort	G5	S1			3 per ecodistrict	disjunct	disjunct
Diplophyllum obtusatum	A Liverwort	G2?	S1			all viable occurrences	disjunct?	GRank

Scientific Name	Common Name	GRANK	SRANK	COSEWIC	OMNR	Conservation Goal	Great Lakes Range	Justification
Mosses, Liverworts, Hornworts and Lichens continued								
Diplophyllum taxifolium	A Liverwort	G5	S1S2			3 per ecodistrict	disjunct	disjunct
Frullania bolanderi	A Liverwort	G4	S2S3			3 per ecodistrict	disjunct	disjunct
Frullania selwyniana	A Liverwort	G2G3	S1S2			all viable occurrences	limited?	GRank
Jungermannia exsertifolia ssp. cordifolia	A Liverwort	G5?T3T5	SH			3 per ecodistrict	disjunct	disjunct
Kurzia pauciflora	A Liverwort	G3G5	S1S2			4 per ecodistrict	disjunct	disjunct
Lophozia capitata	A Liverwort	G4	S2?			3 per ecodistrict	disjunct	disjunct
Lophozia rutheana	A Liverwort	G4?	S1S2			3 per ecodistrict	disjunct	disjunct
Lophozia schusterana	A Liverwort					3 per ecodistrict	disjunct	disjunct
Mannia pilosa	A Liverwort	G4?	S1			3 per ecodistrict	disjunct	disjunct
Mannia sibirica	A Liverwort	G4?	S1			3 per ecodistrict	disjunct	disjunct
Mannia triandra	A Liverwort	G3G4	SH			2 per ecodistrict	peripheral?	GRank
Marsupella paroica	A Liverwort	G3	S1			4 per ecodistrict	disjunct	GRank
Marsupella sparsifolia	A Liverwort	G3G4	S1S2			2 per ecodistrict	widespread	GRank
Mylia taylorii	A Liverwort	G5	S1			3 per ecodistrict	disjunct	disjunct
Nardia insecta	A Liverwort	G4	S1?			3 per ecodistrict	disjunct	disjunct
Odontoschisma elongatum	A Liverwort	G3G4	S1S2			4 per ecodistrict	disjunct?	GRank
Odontoschisma macounii	A Liverwort	G4?	S1S2			3 per ecodistrict	disjunct	disjunct
Scapania degenii	A Liverwort	G4?	S1			3 per ecodistrict	disjunct	disjunct
Scapania gymnostomophila	A Liverwort	G3G4	S3?			4 per ecodistrict	disjunct?	GRank
Scapania subalpina	A Liverwort	G4G5	S3?			3 per ecodistrict	disjunct	disjunct
Scapania umbrosa	A Liverwort	G4G5	S1S2			3 per ecodistrict	disjunct	disjunct
Acaulon triquetrum	A Moss	G2G4	S1			all viable occurrences	limited?	GRank
Amblyodon dealbatus	A Moss	G3G5	S1			4 per ecodistrict	disjunct	disjunct
Amphidium mougeotii	A Moss	G5	S1			3 per ecodistrict	disjunct	disjunct
Aulacomnium acuminatum	A Moss	G3?	S2			4 per ecodistrict	disjunct	GRank disjunct
Aulacomnium turgidum	A Moss	G5	S2			3 per ecodistrict	disjunct	disjunct
Brachythecium albicans	A Moss	G5	S1			3 per ecodistrict	disjunct	disjunct
Brachythecium calcareum	A Moss	G3G4	S2			2 per ecodistrict	widespread	GRank
Bryum blindii	A Moss	G3G5	S2			4 per ecodistrict	disjunct	disjunct
Bryum calophyllum	A Moss	G5?	S2			3 per ecodistrict	disjunct?	disjunct?
Bryum gemmiparum	A Moss	G3G5	S1			4 per ecodistrict	disjunct?	disjunct?
Bryum miniatum	A Moss	G3G4	S1			2 per ecodistrict	widespread	GRank
Bryum pallens	A Moss	G4G5	S1			3 per ecodistrict	disjunct?	disjunct?
Bryum violaceum	A Moss	G5?	S1			3 per ecodistrict	disjunct?	disjunct?
Buxbaumia minakatae	Hump-backed Elves	G2G3	S1			all viable occurrences	widespread	GRank

Scientific Name	Common Name	GRANK	SRANK	COSEWIC	OMNR	Conservation Goal	Great Lakes Range	Justification
Mosses, Liverworts, Hornworts and Lichens continued								
Calliergon obtusifolium	A Moss					3 per ecodistrict	disjunct?	disjunct?
Desmatodon cernuus	A Moss	G3G5	S1			4 per ecodistrict	disjunct	disjunct
Desmatodon porteri	A Moss	G3?	S1			2 per ecodistrict	widespread	GRank
Dichelyma uncinatum	A Moss	G3G5	S1			4 per ecodistrict	disjunct	disjunct
Dicranella crispa	A Moss	G3G5	S1			4 per ecodistrict	disjunct	disjunct
Dicranella grevilleana	A Moss	G2G4	S2			all viable occurrences	widespread	GRank
Dicranum majus	A Moss	G4G5	S1			3 per ecodistrict	disjunct	disjunct
Dicranum brevifolium	A Moss	GU	S1			all viable occurrences	disjunct	disjunct
Fissidens exilis	Pygmy Pocket Moss	G3G4	S1	SC		2 per ecodistrict	widespread	GRank SAR
Fontinalis sphagnifolia	A Moss	G3G5	S1			4 per ecodistrict	disjunct?	disjunct?
Grimmia teretinervis	A Moss	G3G5	S2			4 per ecodistrict	disjunct?	disjunct?
Grimmia torquata	A Moss	G3G5	S1			4 per ecodistrict	disjunct	disjunct
Grimmia anomala	A Moss	G5	S1			3 per ecodistrict	disjunct	disjunct
Grimmia hermanii	A Moss	G3G5	S1			4 per ecodistrict	endemic	endemic
Gyroweisia reflexa	A Moss	G4	S1			3 per ecodistrict	disjunct	disjunct
Gyroweisia tenuis	A Moss	G3G5	S1			4 per ecodistrict	disjunct?	disjunct?
Hygrohypnum alpestre	A Moss	G3G5	S1			4 per ecodistrict	disjunct	disjunct
Hypnum plicatulum	A Moss	G5	S1			3 per ecodistrict	disjunct	disjunct
Hypnum revolutum	A Moss	G5	S2			3 per ecodistrict	disjunct?	disjunct?
Hypnum recurvatum	A Moss	G3G5	S1			4 per ecodistrict	disjunct	disjunct
Isothecium mysuroides	A Moss	G5	S1			3 per ecodistrict	disjunct	disjunct
Isothecium alopecuroides	A Moss	G3G5	S1			4 per ecodistrict	disjunct	disjunct
Meesia uliginosa	A Moss	G4	S3			3 per ecodistrict	disjunct	disjunct
Mielichhoferiana mielichhoferiana	A Moss	G4?	S1			3 per ecodistrict	disjunct?	disjunct?
Myurella tenerrima	A Moss	G3G4	S1			2 per ecodistrict	widespread	GRank
Orthothecium intricatum	A Moss	G4G5	S1			3 per ecodistrict	disjunct	disjunct
Orthotrichum alpestre	A Moss	G4G5	S1			3 per ecodistrict	disjunct	disjunct
Orthotrichum pallens	A Moss	G5	S1			3 per ecodistrict	disjunct	disjunct
Othothecium chryseum	A Moss					3 per ecodistrict	disjunct	disjunct
Physcomitrium immersum	A Moss	G2G3	S1			all viable occurrences	widespread	GRank
Plagiothecium latebricola	Lurking Leskea	G3G4	S2			2 per ecodistrict	widespread	GRank
Platydictya minutissima	A Moss	G3	S1			2 per ecodistrict	widespread?	GRank
Pohlia melanodon	A Moss	G4?	S1			3 per ecodistrict	disjunct	disjunct
Pseudoleskeella tectorum	A Moss	G5	S2			3 per ecodistrict	disjunct?	disjunct?
Pseudoleskeella sibirica	A Moss	G5?	S1			3 per ecodistrict	disjunct	disjunct

Scientific Name	Common Name	GRANK	SRANK	COSEWIC	OMNR	Conservation Goal	Great Lakes Range	Justification
Mosses, Liverworts, Hornworts and Lichens continued								
Rhacomitrium lanuginosum	A Moss					3 per ecodistrict	disjunct?	disjunct?
Seligeria recurvata	A Moss	G4?	S1			3 per ecodistrict	disjunct	disjunct
Seligeria brevifolia	A Moss	G2G3	S1			all viable occurrences	disjunct?	GRank
Splachnum luteum	A Moss	G3	S1			2 per ecodistrict	widespread	GRank
Splachnum rubrum	A Moss	G3	S2			2 per ecodistrict	widespread	GRank
Tayloria serrata	A Moss	G4	S1			3 per ecodistrict	disjunct	disjunct
Tetrodontium brownianum	Little Georgia	G3G4	S1			2 per ecodistrict	widespread	GRank
Tetraplodon mnioides	A Moss	G4	S2			3 per ecodistrict	disjunct	disjunct
Tortula cainii	A Moss	G1	S1			all viable occurrences	endemic	GRank endemic
Tortula norvegica	A Moss	G5	S1			secondary target	widespread	
Trichodon cylindricus	A Moss	G4G5	S1			3 per ecodistrict	disjunct	disjunct
Ulota curvifolia	A Moss	G3G5	S1			4 per ecodistrict	disjunct	disjunct
Oxystegus spiralis	A Moss	G1	S1			all viable occurrences		GRank
Coscinodon cribrosus	Copper Coscinodon	G3G4	S1			2 per ecodistrict	widespread	GRank
Rhizomnium gracile	A Moss	G3G4	S1			4 per ecodistrict	disjunct	GRank disjunct
Lobaria scrobiculata	A Lichen	G3G4	SU			2 per ecodistrict	widespread	GRank
Umbilicaria arctica	A Lichen	G3	S1S3			4 per ecodistrict	disjunct?	GRank
Phaeophyscia imbricata	A Lichen	G3G4	S1S3			4 per ecodistrict	disjunct?	GRank
Porpidia diversa	A Lichen	G2G3	S1S3			all viable occurrences		GRank
Porpidia herteliana	A Lichen	G2G3	S1S3			all viable occurrences		GRank
Stereocaulon glaucescens	A Lichen	G3	S1			2 per ecodistrict	widespread?	GRank
Stereocaulon subcoralloides	A Lichen	G3?	SU			2 per ecodistrict	widespread?	GRank
Pannaria conoplea	A Lichen	G3G4	SU			4 per ecodistrict	disjunct?	GRank
Phaeophyscia endococcina	A Lichen	G3G4	S1S2			4 per ecodistrict	disjunct?	GRank
Phaeophyscia hirsuta	A Lichen	G3	S1S3			4 per ecodistrict	disjunct?	GRank
Phaeophyscia kairamoi	A Lichen	G3G4	SU			4 per ecodistrict	disjunct?	GRank
Peltigera collina	A Lichen	G3G4	SU			2 per ecodistrict	widespread	GRank
Bryoria trichodes ssp. americana	A Lichen	G3G5T3	S1S3			4 per ecodistrict	disjunct?	GRank
Cladonia bacilliformis	A Lichen	G3G4	SU			2 per ecodistrict	widespread?	GRank
Anaptychia setifera	A Lichen	G3G4	S1S3			4 per ecodistrict	disjunct?	GRank
Vascular Plants								
Justicia americana	American Water-willow	G5	S1	THR	THR	secondary target	peripheral	SAR
Chaerophyllum procumbens var. shortii	Spreading Chervil	G5T3T4Q	S1			secondary target	peripheral	GRank
Osmorhiza berterii	Sweet-cicely	G5	S4			3 per ecodistrict	disjunct	disjunct

Scientific Name	Common Name	GRANK	SRANK	COSEWIC	OMNR	Conservation Goal	Great Lakes Range	Justification
Vascular Plants continued								
Osmorhiza depauperata	Blunt-fruited Sweet-cicely	G5	S4			3 per ecodistrict	disjunct	disjunct
Rhacomitrium lanuginosum	A Moss					3 per ecodistrict	disjunct?	disjunct?
Oplopanax horridus	Devil's Club	G4	S1			3 per ecodistrict	disjunct	disjunct
Panax quinquefolius	American Ginseng	G3G4	S2	END	END	2 per ecodistrict	peripheral	GRank SAR
Adenocaulon bicolor	Trail-plant	G5?	S1			3 per ecodistrict	disjunct	disjunct
Antennaria parvifolia	Pussy-toes	G5	S1			3 per ecodistrict	disjunct	disjunct
Antennaria rosea	Pussy-toes	G5	S1			3 per ecodistrict	disjunct	disjunct
Arnica cordifolia	Heartleaf Arnica	G5	S1			3 per ecodistrict	disjunct	disjunct
Arnica lonchophylla ssp. chionopappa	Arnica	G1G2Q	S1			all viable occurrences	disjunct	GRank disjunct
Eurybia divaricata	White Wood Aster	G5	S2	THR	THR	secondary target	peripheral	SAR
Symphyotrichum dumosum var. strictior	Bushy Aster	G5T4	S2			3 per ecodistrict	disjunct	disjunct
Symphyotrichum praealtum	Willowleaf Aster	G5	S2	THR	THR	secondary target	peripheral	SAR
Symphyotrichum prenanthoides	Crooked-stem Aster	G4G5	S2	THR	THR	secondary target	peripheral	SAR
Symphyotrichum sericeum	Western Silvery Aster	G5	S1	THR	END-R			SAR
Cirsium drummondii	Drummond's Thistle	G5	S1			3 per ecodistrict	disjunct	disjunct
Cirsium hillii	Hill's Thistle	G3	S3	THR		4 per ecodistrict	limited	GRank SAR
Cirsium pitcheri	Pitcher's Thistle	G3	S2	END	END	4 per ecodistrict	endemic	GRank endemic
Erigeron philadelphicus ssp. provancheri	Provancher's Philadelphia Fleabane	G5T1T3Q	SU			secondary target	limited	GRank
Liatris spicata	Dense Blazing Star	G5	S2	THR	THR	secondary target	peripheral	SAR
Senecio congestus	Marsh Ragwort	G5	S5			3 per ecodistrict	disjunct	disjunct
Senecio eremophilus	Desert Groundsel	G5	S1			3 per ecodistrict	disjunct	disjunct
Solidago hispida var. huronensis	Lake Huron Hairy Goldenrod	G5T3?	S3?			all viable occurrences	endemic	GRank endemic
Solidago houghtonii	Houghton's Goldenrod	G3	S2	SC		4 per ecodistrict	endemic	GRank SAR endemic
Solidago multiradiata	Alpine Goldenrod	G5	S5			3 per ecodistrict	disjunct	disjunct
Solidago riddellii	Riddell's Goldenrod	G5	S3	SC	SC	secondary target	peripheral	SAR
Solidago speciosa	Showy Goldenrod	G5	S1	END	END	secondary target	peripheral	SAR
Solidago lepida	Elegant Goldenrod	G4	S4?			3 per ecodistrict	disjunct	disjunct
Solidago simplex var. gillmanii	Gillman's Goldenrod	G5T3?	S1			4 per ecodistrict	endemic	GRank endemic
Solidago simplex var. ontarioensis	Ontario Goldenrod	G5T3?	S3?			4 per ecodistrict	endemic	GRank endemic
Tanacetum bipinnatum ssp. huronense	St. John Tansy	G5T4T5	S4			3 per ecodistrict	disjunct	disjunct

Scientific Name	Common Name	GRANK	SRANK	COSEWIC	OMNR	Conservation Goal	Great Lakes Range	Justification
Vascular Plants continued								
Taraxacum ceratophorum	Horned Dandelion	G5	S5			3 per ecodistrict	disjunct	disjunct
Arnoglossum plantagineum	Tuberous Indian-plantain	G4G5	S3	SC	SC	secondary target	peripheral	SAR
Hymenoxys herbacea	Lakeside Daisy	G2	S2	THR	THR	all viable occurrences	endemic	GRank endemic SAR
Erigeron lonchophyllus	Short-ray Fleabane	G5	S4?			3 per ecodistrict	disjunct	disjunct
Betula minor	Dwarf Birch	G3G4Q	SU			2 per ecodistrict	peripheral	GRank
Arabis holboellii	Holboell Rock-cress	G5	S4?			3 per ecodistrict	disjunct	disjunct
Cakile edentula	American Sea-rocket	G5	S4			3 per ecodistrict	disjunct	disjunct
Draba aurea	Golden Draba	G5	S5			3 per ecodistrict	disjunct	disjunct
Draba cana	Hoary Draba	G5	S4			3 per ecodistrict	disjunct	disjunct
Draba glabella	Rock Whitlow-grass	G4G5	S4S5			3 per ecodistrict	disjunct	disjunct
Opuntia fragilis	Little Prickly Pear Cactus	G4G5	S2			3 per ecodistrict	disjunct	disjunct
Opuntia humifusa	Eastern Prickly Pear Cactus	G5	S1	END	END-R	secondary target	peripheral	SAR
Arenaria humifusa	Low Sandwort	G4	S2S3			3 per ecodistrict	disjunct	disjunct
Cerastium alpinum	Alpine Mouse-ear Chickweed	G5?	S3?			3 per ecodistrict	disjunct	disjunct
Moehringia macrophylla	Large-leaved Sandwort	G4	S2			3 per ecodistrict	disjunct	disjunct
Sagina nodosa	Knotted Pearlwort	G5	S4S5			3 per ecodistrict	disjunct	disjunct
Silene acaulis	Moss Campion	G5	S1			3 per ecodistrict	disjunct	disjunct
Chenopodium foggii	Fogg's Goosefoot	G3Q	S2			4 per ecodistrict	limited	GRank
Lechea pulchella	Pinweed	G5	S1			3 per ecodistrict	disjunct	disjunct
Cornus florida	Flowering Dogwood	G5	S2			secondary target	peripheral	declining
Triosteum angustifolium	Yellowleaf Tinker's-weed	G5	S1			3 per ecodistrict	disjunct	disjunct
Empetrum nigrum	Black Crowberry	G5	S5			3 per ecodistrict	disjunct	disjunct
Vaccinium membranaceum	Mountain Bilberry	G5Q	S1			3 per ecodistrict	disjunct	disjunct
Vaccinium ovalifolium	Blue Bilberry	G5	S2			3 per ecodistrict	disjunct	disjunct
Vaccinium stamineum	Deerberry	G5	S1	THR	THR	secondary target	peripheral	SAR
Chamaesyce polygonifolia	Seaside Spurge	G5?	S4			3 per ecodistrict	disjunct	disjunct
Astragalus adsurgens	Rattle Milk-vetch	G5	SH			3 per ecodistrict	disjunct	disjunct
Astragalus alpinus	Alpine Milkvetch	G5	S5			3 per ecodistrict	disjunct	disjunct
Gymnocladus dioica	Kentucky Coffee-tree	G5	S2	THR	THR	secondary target	peripheral	SAR
Hedysarum alpinum	Alpine Sweet-vetch	G5	S4S5			3 per ecodistrict	disjunct	disjunct
Lespedeza virginica	Slender Bush-clover	G5	S1	END	END-R	secondary target	peripheral	SAR
Oxytropis splendens	Showy Oxytrope	G5	S3			3 per ecodistrict	disjunct	disjunct
Oxytropis viscida var. viscida	Nuttall's Oxytrope	G5T4?	S1			3 per ecodistrict	disjunct	disjunct
Tephrosia virginiana	Virginia Goat's-rue	G5	S1	END	END-R	secondary target	peripheral	SAR
Castanea dentata	American Chestnut	G4	S3	END	THR	secondary target	peripheral	SAR

Scientific Name	Common Name	GRANK	SRANK	COSEWIC	OMNR	Conservation Goal	Great Lakes Range	Justification
Vascular Plants continued								
Quercus ilicifolia	Scrub Oak	G5	S1			3 per ecodistrict	disjunct	disjunct
Quercus shumardii	Shumard Oak	G5	S3	SC	SC	secondary target	peripheral	SAR
Bartonia paniculata ssp. paniculata	Branched Bartonia	G5T5	S1	THR	THR	3 per ecodistrict	disjunct	SAR disjunct
Frasera caroliniensis	American Columbo	G5	S2	SC	SC	secondary target	peripheral	SAR
Gentiana alba	White Prairie Gentian	G4	S1	END	END	secondary target	peripheral	SAR
Phacelia franklinii	Wild Heliotrope	G5	S2			3 per ecodistrict	disjunct	disjunct
Juglans cinerea	Butternut	G3G4	S3?	END	END	2 per ecodistrict	peripheral	GRank SAR declining
Pycnanthemum incanum	Hoary Mountain-mint	G5	S1	END	END-R	secondary target	peripheral	SAR
Linum medium var. medium	Stiff Yellow Flax	G5T3T4	S3			4 per ecodistrict	endemic	GRank endemic
Linum striatum	Ridged Yellow Flax	G5	S1			3 per ecodistrict	disjunct	disjunct
Pinguicula vulgaris	Common Butterwort	G5	S5			3 per ecodistrict	disjunct	disjunct
Utricularia geminiscapa	Hidden-fruited Bladderwort	G4G5	S3			3 per ecodistrict	disjunct	disjunct
Ammannia robusta	Scarlet Ammannia	G5	S1	END	END	secondary target	peripheral	SAR
Rotala ramosior	Toothcup	G5	S1	END	END	secondary target	peripheral	SAR
Magnolia acuminata	Cucumber Tree	G5	S2	END	END-R	secondary target	peripheral	SAR
Hibiscus moscheutos	Swamp Rose-mallow	G5	S3	SC	SC	secondary target	peripheral	SAR
Sida hermaphrodita	Virginia Mallow	G2	S1			all viable occurrences	peripheral	GRank
Myrica pensylvanica	Bayberry	G5	S1			3 per ecodistrict	disjunct	disjunct
Rhexia virginica	Virginia Meadow-beauty	G5	S3S4			3 per ecodistrict	disjunct	disjunct
Nymphoides cordata	Floating-heart	G5	S4?			3 per ecodistrict	disjunct	disjunct
Morus rubra	Red Mulberry	G5	S2	END	END	secondary target	peripheral	SAR
Fraxinus quadrangulata	Blue Ash	G5	S3	SC	SC	secondary target	peripheral	SAR
Epilobium hornemannii	Hornemann's Willow-herb	G5	S1			3 per ecodistrict	disjunct	disjunct
Orobanche fasciculata	Broomrape	G4	S1			3 per ecodistrict	disjunct	disjunct
Stylophorum diphyllum	Wood-poppy	G5	S1	END	END-R	secondary target	peripheral	SAR
Polygala incarnata	Pink Milkwort	G5	S1	END	END-R	secondary target	peripheral	SAR
Polygonum careyi	Carey's Smartweed	G4	S3S4			3 per ecodistrict	disjunct	disjunct
Polygonum viviparum	Viviparous Knotweed	G5	S5			3 per ecodistrict	disjunct	disjunct
Polygonum franktonii	Knotweed	G2G4	S1?			all viable occurrences		GRank
Plantago cordata	Heart-leaved Plantain	G4	S1	END	END-R	secondary target	peripheral	SAR
Chimaphila maculata	Spotted Wintergreen	G5	S1	END	END-R	secondary target	peripheral	SAR
Pyrola grandiflora	Arctic Wintergreen	G5	S4			3 per ecodistrict	disjunct	disjunct
Anemone multifida	Early Anemone	G5	S5			3 per ecodistrict	disjunct	disjunct
Anemone parviflora	Small-flower Anemone	G5	S5			3 per ecodistrict	disjunct	disjunct

Scientific Name	Common Name	GRANK	SRANK	COSEWIC	OMNR	Conservation Goal	Great Lakes Range	Justification
Vascular Plants continued								
Hydrastis canadensis	Goldenseal	G4	S2	THR	THR	secondary target	peripheral	SAR
Enemion biternatum	False Rue-anemone	G5	S2	THR	SC	secondary target	peripheral	SAR
Crataegus apiomorpha	A Hawthorn	G3G4Q	S1S2			4 per ecodistrict	limited?	GRank
Crataegus beata	A Hawthorn	G2G4Q	S1			all viable occurrences	endemic	GRank endemic
Crataegus douglasii	Douglas's Hawthorn	G5	S4			3 per ecodistrict	disjunct	disjunct
Crataegus nitidula	A Hawthorn	G1G3Q	SH			all viable occurrences	peripheral	GRank
Crataegus suborbiculata	Hawthorn	G3?	S1			4 per ecodistrict	limited	GRank
Crataegus formosa	A Hawthorn	G2G3Q	S2			all viable occurrences	endemic	GRank endemic
Crataegus lumaria	A Hawthorn	G3G4	S3?			4 per ecodistrict	limited	GRank
Crataegus perjucunda	Middlesex Frosted Hawthorn	G1?Q	S1?			all viable occurrences	endemic	GRank endemic
Crataegus sylvestris	A Hawthorn	G3?Q	SU			4 per ecodistrict	limited	GRank
Dryas drummondii	Yellow Dryas	G5	S1			3 per ecodistrict	disjunct	disjunct
Dryas integrifolia	Entire-leaved Mountain-avens	G5	S4			3 per ecodistrict	disjunct	disjunct
Potentilla gracilis	Cinquefoil	G5	S2			3 per ecodistrict	disjunct	disjunct
Potentilla hippiana	Cinquefoil	G5	S1			3 per ecodistrict	disjunct	disjunct
Potentilla multifida	Cinquefoil	G5	SH			3 per ecodistrict	disjunct	disjunct
Potentilla paradoxa	Bushy Cinquefoil	G5	S3			3 per ecodistrict	disjunct	disjunct
Potentilla rivalis	Cinquefoil	G5	SH			3 per ecodistrict	disjunct	disjunct
Prunus pumila var. pumila	Sand Cherry	G5T4	S4?			2 per ecodistrict	restricted	declining
Rosa setigera	Climbing Prairie Rose	G5	S3	SC	SC	secondary target	peripheral	SAR
Rubus parviflorus	A Bramble	G5	S4			3 per ecodistrict	disjunct	disjunct
Galium kamtschaticum	Boreal Bedstraw	G5	S2			3 per ecodistrict	disjunct	disjunct
Ptelea trifoliata	Common Hoptree	G5	S3	THR	THR	secondary target	peripheral	SAR
Salix myrtillifolia	Myrtle-leaf Willow	G5	S5			3 per ecodistrict	disjunct	disjunct
Saxifraga oppositifolia	Purple Mountain Saxifrage	G4G5	S1			3 per ecodistrict	disjunct	disjunct
Saxifraga paniculata	White Mountain-saxifrage	G5	S4			3 per ecodistrict	disjunct	disjunct
Saxifraga tricuspidata	Prickly Saxifrage	G4G5	S4			3 per ecodistrict	disjunct	disjunct
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 ecodistrict	peripheral	GRank SAR
Buchnera americana	Bluehearts	G5?	S1	END	END	secondary target	peripheral	SAR
Castilleja septentrionalis	Labrador Indian-paintbrush	G5	S5			3 per ecodistrict	disjunct	disjunct
Collinsia parviflora	Small-flowered Blue-eyed Mary	G5	S3			3 per ecodistrict	disjunct	disjunct
Euphrasia hudsoniana	Hudson Bay Eyebright	G5?	S4?			3 per ecodistrict	disjunct	disjunct
Gratiola aurea	Golden Hedge-hyssop	G5	S4?			3 per ecodistrict	disjunct	disjunct

Scientific Name	Common Name	GRANK	SRANK	COSEWIC	OMNR	Conservation Goal	Great Lakes Range	Justification
Vascular Plants continued								
Mimulus moschatus	Muskflower	G4G5	S2?			3 per ecodistrict	disjunct	disjunct
Leucophysalis grandiflora	Large-flowered Ground-cherry	G3?	S3?			4 per ecodistrict	endemic?	GRank
Celtis tenuifolia	Dwarf Hackberry	G5	S2	THR	THR	3 per ecodistrict	disjunct	SAR
Valeriana edulis ssp. ciliata	Hairy Valerian	G5T3	S1			secondary target	limited	GRank
Viola epipsila	Northern Marsh Violet	G4	S3			3 per ecodistrict	disjunct	disjunct
Viola pedata	Bird's-foot Violet	G5	S1	END	END	secondary target	peripheral	SAR
Arisaema dracontium	Green Dragon	G5	S3	SC	SC	secondary target	peripheral	SAR
Carex atratiformis	Black Sedge	G5	S2			3 per ecodistrict	disjunct	disjunct
Carex glacialis	Alpine Sedge	G5	S4			3 per ecodistrict	disjunct	disjunct
Carex lupuliformis	False Hop Sedge	G4	S1	END	END-R	secondary target	peripheral	SAR
Carex nigromarginata	Black-edged Sedge	G5	S1			3 per ecodistrict	disjunct	disjunct
Carex rossii	Ross' Sedge	G5	S2			3 per ecodistrict	disjunct	disjunct
Carex saxatilis	Russett Sedge	G5	S5			3 per ecodistrict	disjunct	disjunct
Carex schweinitzii	Schweinitz's Sedge	G3	S3			2 per ecodistrict	widespread?	GRank
Carex scirpoidea ssp. convoluta	Sedge	G5TNR	S3?			all viable occurrences	endemic	endemic
Carex scirpoidea ssp. scirpoidea	Sedge	G5T4T5	S5			3 per ecodistrict	disjunct	disjunct
Carex supina	Sedge	G5	S1			3 per ecodistrict	disjunct	disjunct
Carex wiegandii	Wiegand's Sedge	G3	S1			2 per ecodistrict	peripheral	GRank
Carex xerantica	White-scaled Sedge	G5	S1			3 per ecodistrict	disjunct	disjunct
Carex juniperorum	Juniper Sedge	G2	S1	END	END-R	all viable occurrences	limited	GRank SAR
Cyperus dentatus	Toothed Umbrella-sedge	G4	S1			3 per ecodistrict	disjunct	disjunct
Eleocharis equisetoides	Horsetail Spike-rush	G4	S1	END	END-R	3 per ecodistrict	disjunct	SAR disjunct
Eleocharis geniculata	Spike-rush	G5	S1			3 per ecodistrict	disjunct	disjunct
Eleocharis nitida	Slender Spike-rush	G3G4	S2			2 per ecodistrict	widespread	GRank
Lipocarpha micrantha	Small-flowered Lipocarpha	G4	S1	END	END	secondary target	peripheral	SAR
Trichophorum planifolium	Few-flowered Club-rush	G4G5	S1	END	END-R	secondary target	peripheral	SAR
Iris lacustris	Dwarf Lake Iris	G3	S3			4 per ecodistrict	endemic	GRank endemic
Juncus militaris	Bayonet Rush	G4	S3S4			3 per ecodistrict	disjunct	disjunct
Juncus subtilis	Creeping Rush	G3	S3			4 in south, 2 on shield	limited?	GRank
Aletris farinosa	Colicroot	G5	S2	THR	THR	secondary target	peripheral	SAR
Allium schoenoprasum var. sibiricum	Wild Chives	G5T5	S4			3 per ecodistrict	disjunct	disjunct
Camassia scilloides	Wild Hyacinth	G4G5	S2	THR	THR	secondary target	peripheral	SAR
Tofieldia pusilla	Scotch False Asphodel	G5	S5			3 per ecodistrict	disjunct	disjunct

Scientific Name	Common Name	GRANK	SRANK	COSEWIC	OMNR	Conservation Goal	Great Lakes Range	Justification
Vascular Plants continued								
Polygonatum biflorum var. melleum	Honey-flowered Solomon-seal	G5TH	SH			4 per ecodistrict	endemic	GRank endemic
Trillium flexipes	Drooping Trillium	G5	S1	END	END-R	secondary target	peripheral	SAR
Cypripedium arietinum	Ram's-head Lady's-slipper	G3	S3			4 per ecodistrict	limited?	GRank
Cypripedium candidum	Small White Lady's-slipper	G4	S1	END	END-R	secondary target	peripheral	SAR
Cypripedium passerinum	Sparrow's-egg Lady's-slipper	G4G5	S4			3 per ecodistrict	disjunct	disjunct
Goodyera oblongifolia	Giant Rattlesnake-plantain	G5?	S4			3 per ecodistrict	disjunct	disjunct
Isotria medeoloides	Small Whorled Pogonia	G2	S1	END	END-R	all viable occurrences	peripheral	GRank SAR
Isotria verticillata	Large Whorled Pogonia	G5	S1	END	END-R	secondary target	peripheral	SAR
Liparis liliifolia	Purple Twayblade	G5	S2	END	END	secondary target	peripheral	SAR
Listera auriculata	Auricled Twayblade	G3	S3			4 in south, 2 on shield	limited?	GRank
Listera borealis	Northern Twayblade	G4	SH			3 per ecodistrict	disjunct	disjunct
Piperia unalascensis	Alaskan Rein-orchid	G5	S4			3 per ecodistrict	disjunct	disjunct
Platanthera leucophaea	Eastern Prairie Fringed-orchid	G2	S2	END	END	all viable occurrences	peripheral	GRank SAR
Triphora trianthophora	Nodding Pogonia	G3G4	S1	END	END-R	2 per ecodistrict	peripheral	GRank SAR
Ammophila breviligulata	American Beachgrass	G5	S3			3 per ecodistrict	disjunct	disjunct
Aristida basiramea	Forked Three-awned Grass	G5	S1	END	END	secondary target	peripheral	SAR
Bromus inermis ssp. pumpellianus	Pumpell's Brome Grass	G5T?	SH			3 per ecodistrict	disjunct	disjunct
Bromus nottowayanus	Nottoway Brome Grass	G3G4	S1?			2 per ecodistrict	peripheral	GRank
Calamagrostis purpurascens	Purple Reed Grass	G5?	S1			3 per ecodistrict	disjunct	disjunct
Calamovilfa longifolia var. magna	Sand Reed Grass	G5T3T5	S3			4 per ecodistrict	endemic	GRank endemic
Panicum spretum	Panic Grass	G5	S2			3 per ecodistrict	disjunct	disjunct
Panicum meridionale	Panic Grass	G5	S1			3 per ecodistrict	disjunct	disjunct
Elymus glaucus	Blue Wild-rye	G5	S1			3 per ecodistrict	disjunct	disjunct
Elymus lanceolatus ssp. psammophilus	Great Lakes Wheatgrass	G5T3	S3			4 per ecodistrict	endemic	GRank endemic
Festuca occidentalis	Western Fescue	G5	S4?			3 per ecodistrict	disjunct	disjunct
Melica smithii	Smith Melic Grass	G4	S4?			3 per ecodistrict	disjunct	disjunct
Muhlenbergia richardsonis	Soft-leaf Muhly	G5	S2			3 per ecodistrict	disjunct	disjunct
Piptochaetium avenaceum	Black Oat-grass	G5	SH			3 per ecodistrict	disjunct	disjunct
Poa alpina	Alpine Bluegrass	G5	S4			3 per ecodistrict	disjunct	disjunct
Poa glauca ssp. glauca	White Bluegrass	G5T5?	S4			3 per ecodistrict	disjunct	disjunct
Poa languida	Drooping Bluegrass	G3G4Q	S3			2 per ecodistrict	widespread	GRank
Poa secunda	Canby Blue Grass	G5	S1			3 per ecodistrict	disjunct	disjunct

Scientific Name	Common Name	GRANK	SRANK	COSEWIC	OMNR	Conservation Goal	Great Lakes Range	Justification
Vascular Plants continued								
Puccinellia ambigua	Alberton Alkali Grass	G2G4	S2			all viable occurrences		GRank
Leymus mollis	Sea Lyme-grass	G5	S4			3 per ecodistrict	disjunct	disjunct
Potamogeton bicupulatus	Snail-seed Pondweed	G4?	S3S4			3 per ecodistrict	disjunct	disjunct
Potamogeton confervoides	Algae-like Pondweed	G4	S2			3 per ecodistrict	disjunct	disjunct
Potamogeton hillii	Hill's Pondweed	G3	S2	SC	THR	4 per ecodistrict	limited	GRank SAR
Potamogeton pulcher	Spotted Pondweed	G5	SH			3 per ecodistrict	disjunct	disjunct
Potamogeton ogdenii	Ogden's Pondweed	G1	SH			all viable occurrences	limited	GRank
Smilax rotundifolia	Round-leaved Greenbrier	G5	S2	THR	THR	secondary target	peripheral	SAR
Xyris difformis	Carolina Yellow-eyed-grass	G5	S3?			3 per ecodistrict	disjunct	disjunct
Cryptogramma acrostichoides	Mountain Parsley	G5	S2			3 per ecodistrict	disjunct	disjunct
Pellaea atropurpurea	Purple-stemmed Cliffbrake	G5	S3			3 per ecodistrict		widespread?
Asplenium scolopendrium var. americanum	American Hart's-tongue Fern	G4T3	S3	SC	SC	4 per ecodistrict	limited	GRank SAR
Cystopteris laurentiana	Laurentian Bladder Fern	G3	S2S3			2 per ecodistrict	peripheral	GRank
Cystopteris montana	Mountain Bladder Fern	G5	S1			3 per ecodistrict	disjunct	disjunct
Dryopteris filix-mas	Male Fern	G5	S4			3 per ecodistrict	disjunct	disjunct
Polystichum lonchitis	Northern Holly-fern	G5	S4			3 per ecodistrict	disjunct	disjunct
Woodsia alpina	Northern Woodsia	G4	S2			3 per ecodistrict	disjunct	disjunct
Woodsia glabella	Smooth Woodsia	G5	S3			3 per ecodistrict	disjunct	disjunct
Woodsia obtusa	Blunt-lobed Woodsia	G5	S1	END	END-R	secondary target	peripheral	SAR
Isoetes engelmannii	Engelmann's Quillwort	G4	S1	END	END	3 per ecodistrict	disjunct	SAR disjunct
Isoetes tuckermanii	Tuckerman's Quillwort	G4?	S1			3 per ecodistrict	disjunct	disjunct
Huperzia porophila	Rock Fir-clubmoss	G4	S1			3 per ecodistrict	disjunct	disjunct
Huperzia appalachiana	Appalachian Fir-clubmoss	G4G5	S3?			3 per ecodistrict	disjunct	disjunct
Botrychium rugulosum	Rugulose Grapefern	G3	S2			4 per ecodistrict	limited	GRank
Botrychium hesperium	Western Moonwort	G3	S1			4 per ecodistrict	disjunct	GRank disjunct
Botrychium campestre	Prairie Dunewort	G3	S1			4 per ecodistrict	disjunct	GRank disjunct
Botrychium acuminatum	Moonwort	G1	S1			all viable occurrences	endemic	GRank endemic
Botrychium pseudopinnatum	Moonwort	G1	S1			all viable occurrences	endemic	GRank endemic
Botrychium pallidum	Pale Moonwort	G3	S1			4 per ecodistrict	limited	GRank
Botrychium spathulatum	Spoon-leaf Moonwort	G3	S1			2 per ecodistrict	peripheral?	GRank
Selaginella selaginoides	Low Spike-moss	G5	S4			3 per ecodistrict	disjunct	disjunct
Phegopteris hexagonoptera	Broad Beech Fern	G5	S3	SC	SC	secondary target	peripheral	SAR
Thelypteris simulata	Bog Fern	G4G5	S1			3 per ecodistrict	disjunct	disjunct

Appendix 3. Vegetation Community Targets

Common Name	GRank	SRank	Conservation Goal	Justification
Acid Treed Talus Ecosite	G4G5Q	S3S4	3 per ecodistrict	SRank
Acidic Granite Open Cliff Type	G?	S3S4	3 per ecodistrict	SRank
Acidic Open Bedrock Shoreline Type	G?	S5	secondary target	high quality
Acidic Open Granite Talus Type	G4G5	S3S4	3 per ecodistrict	SRank
American Dune Grass - Beach Pea - Sand Cherry Dune Grassland Type	G3G5	S2	all viable occurrences	GRank
Atlantic Coastal Plain Forb Bedrock Meadow Marsh Type	G?	S2?	3 per ecodistrict	SRank
Atlantic Coastal Plain Shallow Marsh Type	G2?	S3	all viable occurrences	GRank
Basic Open Cliff Type	G?	S3S4	3 per ecodistrict	SRank
Basic Open Glaciere Talus Type	G?	S1	3 per ecodistrict	SRank
Basswood - White Ash - Butternut Moist Treed Limestone Talus Type	G3G5	S2	all viable occurrences	GRank
Black Ash Mineral Deciduous Swamp Type	G4	S5	secondary target	high quality
Black Spruce - Tamarack - Leatherleaf Patterned Fen Type	G4	S5	secondary target	high quality
Black Spruce Coniferous Organic Swamp Type	G5	S5	secondary target	high quality
Black Spruce Treed Bog Type	G5	S5	secondary target	high quality
Blueberry Granite Shrubland Barren Type	G?	S5	secondary target	high quality
Boreal Acidic Sandstone Open Cliff Type	G4G5	S2	3 per ecodistrict	SRank
Boreal Open Seepage Fen Type	G2Q	S2S3	all viable occurrences	GRank
Bracken Fern Sand Barren Type	G?	S2	3 per ecodistrict	SRank
Broad-leaved Sedge Organic Shallow Marsh Type	G4G5Q	S5	secondary target	high quality
Bulblet Fern - Herb Robert Open Shaded Limestone / Dolostone Cliff Face Type	G5	S3	3 per ecodistrict	SRank
Bulrush Organic Shallow Marsh Type	G?	S5	secondary target	high quality
Bur Oak - Saskatoon Berry Dry Deciduous Woodland Type	G3	S2	all viable occurrences	GRank
Bur-reed Submerged - Floating-leaved Shallow Aquatic Type	G5Q	S5	secondary target	high quality
Buttonbush - Sweet Gale Mineral Thicket Swamp Type	G?	S2S3?	3 per ecodistrict	SRank
Buttonbush Mineral Thicket Swamp Type	G4	S3	3 per ecodistrict	SRank
Buttonbush Organic Thicket Swamp Type	G4	S3	3 per ecodistrict	SRank
Canada Bluegrass - Nodding Onion Alvar Grassland Type	G1?	S1	all viable occurrences	GRank
Cattail Organic Shallow Marsh Type	G5	S5	secondary target	high quality
Chinquapin Oak - Nodding Onion Treed Alvar Grassland Type	G1?	S1	all viable occurrences	GRank
Cliffbrake - Lichen Open Unshaded Limestone / Dolostone Cliff Face Type	G5	S3	3 per ecodistrict	SRank
Common Juniper - Creeping Juniper - Shrubby Cinquefoil Alvar Shrubland Type	G2?	S2	all viable occurrences	GRank
Common Juniper - Fragrant Sumac - Hairy Beardtongue Alvar Shrubland Type	G2?	S2	all viable occurrences	GRank
Common Juniper Acidic Shrub Rock Barren Type	G?	S2	3 per ecodistrict	SRank
Common Juniper Open Limestone / Dolostone Cliff Rim Shrubland Type	G?	S2S3	3 per ecodistrict	SRank
Common Reed Grass Organic Shallow Marsh Type	G3G4	S4	all viable occurrences	GRank
Cottongrass - Beak-rush/Yellow-eyed Grass Open Fen	G3G4?	S3S4?	all viable occurrences	GRank
Cotton-grass Graminoid Bog Type	G3G4	S5	all viable occurrences	GRank

Common Name	GRank	SRank	Conservation Goal	Justification
Cottonwood Dune Savannah Type	G1G2	S1	all viable occurrences	GRank
Dry - Fresh Aspen - Poplar Deciduous Forest Type	G5	S5	secondary target	high quality
Dry - Fresh Aspen Mixed Forest Ecosite	G5	S5	secondary target	high quality
Dry - Fresh Hackberry Deciduous Forest Type	G?	S2	3 per ecodistrict	SRank
Dry - Fresh Hemlock - Oak Mixed Forest	G?	S3-S3S4?	3 per ecodistrict	SRank
Dry - Fresh Hickory Deciduous Forest Type	G4?	S3S4	3 per ecodistrict	SRank
Dry - Fresh Mixed Oak Deciduous Forest Type	G?	S3S4	3 per ecodistrict	SRank
Dry - Fresh Oak - Red Maple Deciduous Forest Type	G?	S5	secondary target	high quality
Dry - Fresh Oak - Sugar Maple Deciduous Forest Type	G?	S5	secondary target	high quality
Dry - Fresh Red Oak Deciduous Forest Type	G?	S5	secondary target	high quality
Dry - Fresh Sugar Maple - Basswood Deciduous Forest Type	G?	S5	secondary target	high quality
Dry - Fresh Sugar Maple - Ironwood Deciduous Forest Type	G?	S5	secondary target	high quality
Dry - Fresh Sugar Maple - Oak Deciduous Forest Type	G?	S5	secondary target	high quality
Dry - Fresh White Ash Deciduous Forest Type	G?	S5	secondary target	high quality
Dry - Fresh White Birch Deciduous Forest Type	G4?	S5	secondary target	high quality
Dry - Fresh White Cedar Coniferous Forest Type	G4	S5	secondary target	high quality
Dry - Fresh White Oak Deciduous Forest Type	G?	S4	secondary target	high quality
Dry - Fresh White Pine - Oak Mixed Forest Type	G4G5	S5	secondary target	high quality
Dry - Fresh White Pine - Red Maple Mixed Forest Type	G4G5	S5	secondary target	high quality
Dry - Fresh White Pine - Sugar Maple Mixed Forest Type	G?	S5	secondary target	high quality
Dry - Fresh White Pine Coniferous Forest Type	G3G4	S4S5	all viable occurrences	GRank
Dry Black Oak - White Oak Tallgrass Woodland Type	G?	S1	3 per ecodistrict	SRank
Dry Black Oak Deciduous Forest Type	G4?	S3	3 per ecodistrict	SRank
Dry Black Oak Tallgrass Savannah Type	G3	S1	all viable occurrences	SRank
Dry Black Oak-Pine Tallgrass Savannah Type	G?	S1	3 per ecodistrict	SRank
Dry Bur Oak - Shagbark Hickory Tallgrass Woodland Type	G?	S1	3 per ecodistrict	SRank
Dry Fescue Mixedgrass Prairie Type	G?	S1	3 per ecodistrict	SRank
Dry Granite Barren Type	G?	S5	secondary target	high quality
Dry Herbaceous Limestone / Dolostone Talus	G?	S2	3 per ecodistrict	SRank
Dry Jack Pine Coniferous Forest Type	G4G5	S5	secondary target	high quality
Dry Oak - Hickory Deciduous Forest Type	G4?	S3S4	3 per ecodistrict	SRank
Dry Red Pine - White Pine Coniferous Forest Type	G3G4	S4	all viable occurrences	GRank
Dry Tallgrass Prairie Type	G3	S1	all viable occurrences	SRank
Few-seeded Sedge Graminoid Bog Type	G3G4	S5	all viable occurrences	GRank
Fresh Sugar Maple - Beech Deciduous Forest Type	G5?	S5	secondary target	high quality
Fresh Sugar Maple - Red Maple Deciduous Forest Type	G?	S5	secondary target	high quality
Fresh Sugar Maple - White Ash Deciduous Forest Type	G?	S5	secondary target	high quality
Fresh Sugar Maple Deciduous Forest Type	G5?	S5	secondary target	high quality
Graminoid Coastal Meadow Marsh Type	G2?	S2	all viable occurrences	GRank
Graminoid Open Poor Fen Type	G3G4	S5	all viable occurrences	GRank
Gray Birch Treed Fen Type	G4?	S2S3	3 per ecodistrict	SRank
Great Lakes Arctic-Alpine Basic Open Bedrock Shoreline Type	G?	S3	3 per ecodistrict	SRank
Hay Sedge Sand Barren Type	G?	S1	all viable occurrences	SRank
Hemlock - Sugar Maple Moist Limestone Talus Type	G?	S2	3 per ecodistrict	SRank
Hop-tree Dune Shrubland Type	G2Q	S1	all viable occurrences	GRank
Huckleberry Organic Thicket Swamp Type	G2Q	S1	all viable occurrences	GRank

Common Name	GRank	SRank	Conservation Goal	Justification
Jack Pine - White Cedar - Common Juniper Treed Alvar Shrubland Type	G2?	S2	all viable occurrences	GRank
Jack Pine - White Cedar - Low Calamint Treed Alvar Grassland Type	G1?	S1	all viable occurrences	GRank
Jack Pine Treed Granite Barren Type	G5	S5	secondary target	high quality
Juniper Dune Shrubland Type	G?	S2	3 per ecodistrict	SRank
Leatherleaf - Chain fern / St. John's-wort Shrub Fen	G3G4	S3	all viable occurrences	GRank
Leatherleaf - Forb Shrub Fen Type	G5	S5	secondary target	high quality
Leatherleaf Shrub Bog Type	G5	S5	secondary target	high quality
Leatherleaf Shrub Kettle Peatland Type	G3G4	S3	all viable occurrences	GRank
Little Bluestem - Long-leaved Reed Grass - Great Lakes Wheat Grass Dune Grassland Type	G?	S2	3 per ecodistrict	SRank
Little Bluestem - Switchgrass - Beachgrass Dune Grassland Type	G?	S2	3 per ecodistrict	SRank
Low Sedge - Clubrush Graminoid Fen Type	G2G4Q	S4	all viable occurrences	GRank
Moist - Fresh Black Oak - White Oak Tallgrass Woodland Type	G2	S1	all viable occurrences	GRank
Moist - Fresh Black Oak Tallgrass Savannah Type	G2	S1	all viable occurrences	GRank
Moist - Fresh Black Walnut Deciduous Forest Type	G4?	S2S3	3 per ecodistrict	SRank
Moist - Fresh Hemlock - Sugar Maple Mixed Forest Type	G4G5	S4S5	secondary target	high quality
Moist - Fresh Pin Oak - Bur Oak Tallgrass Savannah Type	G1	S1	all viable occurrences	GRank
Moist - Fresh Sugar Maple - Black Maple Deciduous Forest Type	G?	S3?	3 per ecodistrict	SRank
Moist - Fresh Sugar Maple - Yellow Birch Deciduous Forest Type	G5?	S5	secondary target	high quality
Moist - Fresh Tallgrass Prairie Type	G2	S1	all viable occurrences	GRank
Moist - Fresh White Cedar - Birch - Aspen Mixed Forest Type	G5Q	S5	secondary target	high quality
Moist - Fresh White Cedar - Hemlock Coniferous Forest Type	G4?	S5	secondary target	high quality
Mountain Holly Organic Thicket Swamp Type	G?	S3S4	3 per ecodistrict	SRank
Mountain Holly Shrub Fen Type	G3G4	S3S4	all viable occurrences	GRank
Mountain Maple Open Limestone Talus Shrubland Type	G?	S3	3 per ecodistrict	SRank
Narrow-leaved Sedge Organic Shallow Marsh Type	G4?	S5	secondary target	high quality
Northern Dropseed - Little Bluestem - Scirpus-like Sedge Alvar Grassland Type	G2G3?	S2S3	all viable occurrences	GRank
Oak - Red Maple - Pine Treed Granite Barren Type	G?	S4S5	secondary target	high quality
Oak Acidic Treed Rock Barren	G?	S3-S3S4	3 per ecodistrict	SRank
Open Limestone / Dolostone Cliff Rim Type	G5	S2	3 per ecodistrict	SRank
Open Limestone / Dolostone Seepage Cliff Type	G?Q	S3	3 per ecodistrict	SRank
Perched Mineral Prairie Fen Type	G3G4	S1	all viable occurrences	GRank
Philadelphia Panic Grass - False Pennyroyal Alvar Pavement Type	G1Q	S1	all viable occurrences	GRank
Pin Oak Mineral Deciduous Swamp Type	G2	S2S3	all viable occurrences	GRank
Pitch Pine Treed Granite Barren Type	G3G5	S1	all viable occurrences	GRank
Poison Sumac Organic Thicket Swamp Type	G4?	S3	3 per ecodistrict	SRank
Pondweed Submerged - Floating-leaved Shallow Aquatic Type	G5Q	S5	secondary target	high quality

Common Name	GRank	SRank	Conservation Goal	Justification
Prairie Slough Grass Mineral Meadow Marsh Type	G2G3	S3	all viable occurrences	GRank
Prairie Slough Grass Organic Meadow Marsh Type	G2G3	S3	all viable occurrences	GRank
Red / Green Ash Mineral Deciduous Swamp Type	G?	S5	secondary target	high quality
Red Cedar - Early Buttercup Treed Alvar Grassland Type	G2?	S2	all viable occurrences	GRank
Red Cedar Dune Savannah Type	G?	S1	3 per ecodistrict	SRank
Red Cedar Treed Granite Barren Type	G?	S1	3 per ecodistrict	SRank
Red Cedar Treed Limestone Barren Type	G?	S1	3 per ecodistrict	SRank
Red Maple - Hemlock Mixed Organic Swamp Type	G3	S3S4	all viable occurrences	GRank
Round-leaved Dogwood Limestone / Dolostone Shrubland Barren Type	G?	S3	3 per ecodistrict	SRank
Round-leaved Dogwood Open Limestone / Dolostone Cliff Rim Shrubland Type	G?	S3	3 per ecodistrict	SRank
Sand Cherry Dune Shrubland Type	G2Q	S2	all viable occurrences	GRank
Sea Rocket Sand Beach Type	G2G4	S2S3	all viable occurrences	GRank
Shagbark Hickory - Prickly Ash - Philadelphia Panic Grass Treed Alvar Grassland Type	G1Q	S1	all viable occurrences	GRank
Shrubby Cinquefoil - Creeping Juniper - Scirpus-like Sedge Alvar Pavement Type	G2?	S2	all viable occurrences	GRank
Shrubby Cinquefoil Coastal Meadow Marsh Type	G2?	S1	all viable occurrences	GRank
Shrubby Cinquefoil Limestone Beach Type	G3G4	S2	all viable occurrences	GRank
Shrubby Cinquefoil Shrub Fen Type	G3G4	S4	all viable occurrences	GRank
Silky Dogwood Mineral Thicket Swamp Type	G5	S3S4	3 per ecodistrict	SRank
Silver / Red Maple Deciduous Organic Swamp Type	G4?	S5	secondary target	high quality
Silver / Red Maple Mineral Deciduous Swamp Type	G4?	S5	secondary target	high quality
Slender Sedge Graminoid Fen Type	G4G5	S5	secondary target	high quality
Sugar Maple - Ironwood - White Ash Treed Limestone Cliff Type	G?	S3	3 per ecodistrict	SRank
Sugar Maple Moist Treed Limestone Talus Type	G3G5	S3	all viable occurrences	GRank
Sweet Gale Shrub Fen Type	G?	S5	secondary target	high quality
Tamarack - Black Spruce Coniferous Organic Swamp Type	G5Q	S5	secondary target	high quality
Tamarack - White Cedar Treed Fen Type	G4?	S5	secondary target	high quality
Tamarack Coniferous Organic Swamp Type	G4	S5	secondary target	high quality
Tamarack Treed Fen Type	G4?	S5	secondary target	high quality
Tufted Hairgrass - Canada Bluegrass - Philadelphia Panic Grass Alvar Grassland Type	G2G3?	S2S3	all viable occurrences	GRank
Twig-rush Graminoid Fen Type	G3Q	S3?	all viable occurrences	GRank
Virginia Chain Fern Open Bog Type	G3G4	S3	all viable occurrences	GRank
Water Lily - Bullhead Lily Floating-leaved Shallow Aquatic Type	G5	S5	secondary target	high quality
Water Star-grass Submerged Shallow Aquatic Type	G5Q	S3S4	3 per ecodistrict	SRank
Wet Herbaceous Limestone / Dolostone Talus	G?	S2	3 per ecodistrict	SRank
White Birch Dry Treed Limestone Talus Type	G3G5	S3	all viable occurrences	GRank
White Cedar - Hemlock Coniferous Mineral Swamp Type	G?	S3S4	3 per ecodistrict	SRank
White Cedar - Hemlock Coniferous Organic Swamp Type	G?	S3S4	3 per ecodistrict	SRank
White Cedar - Jack Pine - Shrubby Cinquefoil Treed Alvar Pavement	G1G2	S1	all viable occurrences	GRank
White Cedar - Tamarack Coniferous Organic Swamp Type	G4G5	S5	secondary target	high quality

Common Name	GRank	SRank	Conservation Goal	Justification
White Cedar - White Spruce - Philadelphia Panic Grass Treed Alvar Grassland Type	G3?	S3	all viable occurrences	GRank
White Cedar - White Spruce Coniferous Organic Swamp Type	G4	S5	secondary target	high quality
White Cedar - Yellow Birch Mixed Organic Swamp Type	G4?	S5	secondary target	high quality
White Cedar Coniferous Swamp	G5	S5	secondary target	high quality
White Cedar Coniferous Organic Swamp Type	G4	S5	secondary target	high quality
White Cedar Dry Treed Limestone Talus Type	G?	S3	3 per ecodistrict	SRank
White Cedar Treed Limestone Cliff Type	G2Q	S3	all viable occurrences	GRank
White Elm Mineral Deciduous Swamp Type	G?	S5	secondary target	high quality
White Pine - White Birch Mineral Mixed Swamp Type	G3G4	S3	all viable occurrences	GRank
White Pine Coniferous Mineral Swamp Type	G3G4	S2	all viable occurrences	GRank
Wild-rice Mineral Shallow Marsh Type	G?	S5	secondary target	high quality
Willow Mineral Thicket Swamp Type	G5	S5	secondary target	high quality
Willow Organic Thicket Swamp Type	G5	S5	secondary target	high quality
Winterberry Organic Thicket Swamp Type	G3G4Q	S3S4	all viable occurrences	GRank

Appendix 4. Comparison of Conservation Values for Southern Ontario and the Canadian Shield

Criteria	Southern Ontario layers	Canadian Shield layers
Condition	***Adjusted to 15% of total score***	***Adjusted to 20% of total score***
	% natural cover within a 2km radius	% natural cover within a 2 km radius
	Distance from cropland	Distance from cropland
	Distance from urban-settlement	Distance from urban and settlement areas
	Roadlessness	Roadlessness
		Distance from mines
		Hydro corridors (aka transmission lines)
		Railways
		Presence of pit/quarry
Diversity	***Adjusted to 5% of total score***	***Adjusted to 5% of total score***
	Diversity of lv types	Diversity of lv types
Ecological Functions	***Adjusted to 60% of total score***	***Adjusted to 60% of total score***
	Total Size	Fire disturbance size
	Interior Size (>100m from edge)	
	Interior Size (>200m from edge)	Edge buffer size (>200m from edge)
	Cores and Corridors ♦ Big Picture Cores ♦ Bigger Picture Cores ♦ Oak Ridges Moraine cores ♦ Corridors ♦ Oak Ridges Moraine Linkages ♦ Niagara Escarpment Commission linkages ♦ Big Picture Island Cores ♦ Island Cores	♦ Presence of old-growth forest
	<u>Proximity to existing conservation lands:</u> ♦ Provincial Parks ♦ Significant Woodlands ♦ ANSIs ♦ PSWs ♦ CA areas ♦ N Parks ♦ NWA ♦ MBS ♦ IBA	<u>Proximity to existing protected areas:</u> ♦ Provincial Parks ♦ National Parks ♦ Conservation Reserves ♦ OLL sites ♦ Lake Superior National Marine CA <u>Coincidence with existing conservation lands:</u> ♦ ANSIs (LS) ♦ PSW ♦ CAA ♦ NCC ♦ Important Bird Areas
	Hydrological functions: ♦ Wetlands (bog, fen, marsh, swamp) ♦ Potential valleys ♦ Riparian areas ♦ GL shorelines ♦ Lakeshore areas	Hydrological functions: ♦ Wetlands (bog, fen, marsh, swamp, '*muskeg*') ♦ Riparian areas (streams, lakes and Great Lakes shorelines)
Special Features	***Adjusted to 20% of total score (max score of 40 points)***	***Adjusted to 15% of total score (max score of 40 points)***
	Presence of rare species targets	Presence of rare species targets
	Presence of community EO	Presence of community EO
	Presence of EO (non-target)	Presence of EO (non-target)

Appendix 5. Ecological Systems in Southern Ontario (6E and 7E)

System Description	Target	Natural	Type
Alvar	Y	Y	Other natural
Alvar Grassland	Y	Y	Other natural
Alvar Pavement	Y	Y	Other natural
Alvar Savannah	Y	Y	Other natural
Alvar Shrubland	Y	Y	Other natural
Bare Rock Ridge and Shallow Till Coniferous Forest Complex	Y	Y	Forest
Bare Rock Ridge and Shallow Till Mixed Forest Complex	Y	Y	Forest
Bare Rock Ridge and Shallow Till Deciduous Forest Complex	Y	Y	Forest
Beach and Shorecliff Coniferous Forest Complex	Y	Y	Forest
Beach and Shorecliff Mixed Forest Complex	Y	Y	Forest
Beach and Shorecliff Deciduous Forest Complex	Y	Y	Forest
Bedrock Outcrop	Y	Y	Other natural
Bog Complex	Y	Y	Wetland
Clay Plain Coniferous Forest Complex	Y	Y	Forest
Clay Plain Mixed Forest Complex	Y	Y	Forest
Clay Plain Deciduous Forest Complex	Y	Y	Forest
Coniferous Plantation Forest	Y	Y	Forest
Fen Complex	Y	Y	Wetland
Coniferous Forest Complex	N	Y	Forest
Mixed Forest Complex	N	Y	Forest
Deciduous Forest Complex	N	Y	Forest
Coniferous Forest Complex on Peat and Muck	Y	Y	Forest
Mixed Forest Complex on Peat and Muck	Y	Y	Forest
Deciduous Forest Complex on Peat and Muck	Y	Y	Forest
Kame Moraine Coniferous Forest Complex	Y	Y	Forest
Kame Moraine Mixed Forest Complex	Y	Y	Forest
Kame Moraine Deciduous Forest Complex	Y	Y	Forest
Limestone Plain Coniferous Forest Complex	Y	Y	Forest
Limestone Plain Mixed Forest Complex	Y	Y	Forest
Limestone Plain Deciduous Forest Complex	Y	Y	Forest
Marsh Complex	Y	Y	Wetland
Niagara Escarpment Coniferous Forest Complex	Y	Y	Forest
Niagara Escarpment Mixed Forest Complex	Y	Y	Forest
Niagara Escarpment Deciduous Forest Complex	Y	Y	Forest
Sand Plain Coniferous Forest Complex	Y	Y	Forest
Sand Plain Mixed Forest Complex	Y	Y	Forest
Sand Plain Deciduous Forest Complex	Y	Y	Forest
Prairies and Savannahs	Y	Y	Other natural
Shale Plain Coniferous Forest Complex	Y	Y	Forest
Shale Plain Mixed Forest Complex	Y	Y	Forest
Shale Plain Deciduous Forest Complex	Y	Y	Forest
Swamp Complex	Y	Y	Wetland
Till Moraine Coniferous Forest Complex	Y	Y	Forest
Till Moraine Mixed Forest Complex	Y	Y	Forest
Till Moraine Deciduous Forest Complex	Y	Y	Forest
Till Plain Coniferous Forest Complex	Y	Y	Forest

System Description	Target	Natural	Type
Till Plain Mixed Forest Complex	Y	Y	Forest
Till Plain Deciduous Forest Complex	Y	Y	Forest
Cutovers	N	N	Anthropogenic
Old Cuts and Burns	N	N	Anthropogenic
Pasture and Abandoned Fields	N	N	Anthropogenic
Recent Burns	N	N	Fire
Settlement and Developed Land	N	N	Anthropogenic
Unclassified (Cloud and Shadow)	N	N	unknown
Water	N	N	Water
Cropland	N	N	Anthropogenic
NRVIS pit or quarry	N	N	Anthropogenic
Unknown landcover	N	N	unknown

Appendix 6. Landform Descriptions for Ecological Systems on the Canadian Shield

Unit	Geological Deposition	Parent Material Description
1	Bedrock	Undifferentiated carbonate and clastic sedimentary rock, exposed at surface or covered by a discontinuous, thin layer of drift
2	Bedrock	Undifferentiated igneous and metamorphic rock, exposed at surface or covered by a discontinuous, thin layer of drift
3	Fluvial deposits	Gravel, sand, silt and clay, deposited on flood plains
4	Glaciofluvial ice-contact deposits	Gravel and sand, minor till, includes esker, kame, end moraine, ice-marginal delta and subaqueous fan deposits
5	Glaciofluvial outwash deposits	Gravel and sand, includes proglacial river and deltaic deposits
6	Glaciolacustrine deposits	Sand, gravelly sand and gravel, nearshore and beach deposits
7	Glaciolacustrine deposits	Silt and clay, minor sand, basin and quiet water deposits
8	Glaciomarine and marine deposits	Sand, gravelly sand and gravel, nearshore and beach deposits or silt and clay, basin and quiet water deposits
9	Lacustrine deposits	Gravel, sand, silt and clay, deposited on modern flood plains
10	Organic deposits	Peat, muck and marl
11	Till	Undifferentiated, predominantly sand matrix, extremely stony, bouldery and high in total matrix carbonate, often associated with stratified sediments
12	Till	Undifferentiated, predominantly sand to silty sand matrix, high content of clasts, often low in matrix carbonate content
13	Till	Undifferentiated, predominantly sandy silt to silt matrix, commonly rich in clasts, often high in total matrix carbonate content

Appendix 7. Ecological Systems on the Canadian Shield

Ecological System Description	Target	Natural	Type
Aspen on unknown landform	N	Y	Forest
Aspen on bedrock with undifferentiated carbonate and clastic sedimentary rock, exposed at surface or covered by a discontinuous, thin layer of drift	Y	Y	Forest
Aspen on bedrock with undifferentiated igneous and metamorphic rock, exposed at surface or covered by a discontinuous, thin layer of drift	Y	Y	Forest
Aspen on fluvial (gravel, sand, silt and clay, deposited on flood plains)	Y	Y	Forest
Aspen on glaciofluvial ice-contact deposits (gravel and sand, minor till, includes esker, kame, end moraine, ice-marginal delta and subaqueous fan deposits)	Y	Y	Forest
Aspen on glaciofluvial outwash deposits (gravel and sand, includes proglacial river and deltaic deposits)	Y	Y	Forest
Aspen on glaciolacustrine deposits (sand, gravelly sand and gravel, nearshore and beach deposits)	Y	Y	Forest
Aspen on glaciolacustrine deposits (silt and clay, minor sand, basin and quiet water deposits)	Y	Y	Forest
Aspen on glaciomarine and marine deposits (sand, gravelly sand and gravel, nearshore and beach deposits or silt and clay, basin and quiet water deposits)	Y	Y	Forest
Aspen on organic deposits (peat, muck and marl)	Y	Y	Forest
Aspen on till with undifferentiated, predominantly sand to silty sand matrix, high content of clasts, often low in matrix carbonate content	Y	Y	Forest
Aspen on till with undifferentiated, predominantly sand matrix, extremely stony, bouldery and high in total matrix carbonate, often associated with stratified sediments	Y	Y	Forest
Aspen on till with undifferentiated, predominantly sandy silt to silt matrix, commonly rich in clasts, often high in total matrix carbonate content	Y	Y	Forest
Barren and Scattered	N	Y	Other Natural
Brush and Alder	N	Y	Other Natural
White Birch on unknown landform	N	Y	Forest
White Birch on bedrock with undifferentiated carbonate and clastic sedimentary rock, exposed at surface or covered by a discontinuous, thin layer of drift	Y	Y	Forest
White Birch on bedrock with undifferentiated igneous and metamorphic rock, exposed at surface or covered by a discontinuous, thin layer of drift	Y	Y	Forest
White Birch on fluvial (gravel, sand, silt and clay, deposited on flood plains)	Y	Y	Forest
White Birch on glaciofluvial ice-contact deposits (gravel and sand, minor till, includes esker, kame, end moraine, ice-marginal delta and subaqueous fan deposits)	Y	Y	Forest
White Birch on glaciofluvial outwash deposits (gravel and sand, includes proglacial river and deltaic deposits)	Y	Y	Forest
White Birch on glaciolacustrine deposits (sand, gravelly sand and gravel, nearshore and beach deposits)	Y	Y	Forest
White Birch on glaciolacustrine deposits (silt and clay, minor sand, basin and quiet water deposits)	Y	Y	Forest
White Birch on lacustrine deposits (gravel, sand, silt and clay, deposited on modern flood plains)	Y	Y	Forest
White Birch on organic deposits (peat, muck and marl)	Y	Y	Forest
White Birch on till with undifferentiated, predominantly sand to silty sand matrix, high content of clasts, often low in matrix carbonate content	Y	Y	Forest
White Birch on till with undifferentiated, predominantly sand matrix, extremely stony, bouldery and high in total matrix carbonate, often associated with stratified sediments	Y	Y	Forest
White Birch on till with undifferentiated, predominantly sandy silt to silt matrix, commonly rich in clasts, often high in total matrix carbonate content	Y	Y	Forest

Ecological System Description	**Target**	**Natural**	**Type**
Yellow Birch on unknown landform	N	Y	Forest
Yellow Birch on bedrock with undifferentiated igneous and metamorphic rock, exposed at surface or covered by a discontinuous, thin layer of drift	Y	Y	Forest
Yellow Birch on glaciofluvial ice-contact deposits (gravel and sand, minor till, includes esker, kame, end moraine, ice-marginal delta and subaqueous fan deposits)	Y	Y	Forest
Yellow Birch on glaciofluvial outwash deposits (gravel and sand, includes proglacial river and deltaic deposits)	Y	Y	Forest
Yellow Birch on glaciolacustrine deposits (sand, gravelly sand and gravel, nearshore and beach deposits)	Y	Y	Forest
Yellow Birch on glaciolacustrine deposits (silt and clay, minor sand, basin and quiet water deposits)	Y	Y	Forest
Yellow Birch on organic deposits (peat, muck and marl)	Y	Y	Forest
Yellow Birch on till with undifferentiated, predominantly sand to silty sand matrix, high content of clasts, often low in matrix carbonate content	Y	Y	Forest
Yellow Birch on till with undifferentiated, predominantly sandy silt to silt matrix, commonly rich in clasts, often high in total matrix carbonate content	Y	Y	Forest
Conifer Swamp	Y	Y	Wetland
Coniferous Forest on unknown landform	N	Y	Forest
Coniferous Forest on bedrock with undifferentiated carbonate and clastic sedimentary rock, exposed at surface or covered by a discontinuous, thin layer of drift	N	Y	Forest
Coniferous Forest on bedrock with undifferentiated igneous and metamorphic rock, exposed at surface or covered by a discontinuous, thin layer of drift	N	Y	Forest
Coniferous Forest on fluvial (gravel, sand, silt and clay, deposited on flood plains)	N	Y	Forest
Coniferous Forest on glaciofluvial ice-contact deposits (gravel and sand, minor till, includes esker, kame, end moraine, ice-marginal delta and subaqueous fan deposits)	N	Y	Forest
Coniferous Forest on glaciofluvial outwash deposits (gravel and sand, includes proglacial river and deltaic deposits)	N	Y	Forest
Coniferous Forest on glaciolacustrine deposits (sand, gravelly sand and gravel, nearshore and beach deposits)	N	Y	Forest
Coniferous Forest on glaciolacustrine deposits (silt and clay, minor sand, basin and quiet water deposits)	N	Y	Forest
Coniferous Forest on glaciomarine and marine deposits (sand, gravelly sand and gravel, nearshore and beach deposits or silt and clay, basin and quiet water deposits)	N	Y	Forest
Coniferous Forest on lacustrine deposits (gravel, sand, silt and clay, deposited on modern flood plains)	N	Y	Forest
Coniferous Forest on organic deposits (peat, muck and marl)	N	Y	Forest
Coniferous Forest on till with undifferentiated, predominantly sand to silty sand matrix, high content of clasts, often low in matrix carbonate content	N	Y	Forest
Coniferous Forest on till with undifferentiated, predominantly sand matrix, extremely stony, bouldery and high in total matrix carbonate, often associated with stratified sediments	N	Y	Forest
Coniferous Forest on till with undifferentiated, predominantly sandy silt to silt matrix, commonly rich in clasts, often high in total matrix carbonate content	N	Y	Forest
Coniferous Forest	N	Y	Forest
Developed and Agricultural Land	N	N	Anthropogenic
Deciduous Forest on unknown landform	N	Y	Forest
Deciduous Forest on bedrock with undifferentiated carbonate and clastic sedimentary rock, exposed at surface or covered by a discontinuous, thin layer of drift	N	Y	Forest

Ecological System Description	Target	Natural	Type
Deciduous Forest on bedrock with undifferentiated igneous and metamorphic rock, exposed at surface or covered by a discontinuous, thin layer of drift	N	Y	Forest
Deciduous Forest on fluvial (gravel, sand, silt and clay, deposited on flood plains)	N	Y	Forest
Deciduous Forest on glaciofluvial ice-contact deposits (gravel and sand, minor till, includes esker, kame, end moraine, ice-marginal delta and subaqueous fan deposits)	N	Y	Forest
Deciduous Forest on glaciofluvial outwash deposits (gravel and sand, includes proglacial river and deltaic deposits)	N	Y	Forest
Deciduous Forest on glaciolacustrine deposits (sand, gravelly sand and gravel, nearshore and beach deposits)	N	Y	Forest
Deciduous Forest on glaciolacustrine deposits (silt and clay, minor sand, basin and quiet water deposits)	N	Y	Forest
Deciduous Forest on glaciomarine and marine deposits (sand, gravelly sand and gravel, nearshore and beach deposits or silt and clay, basin and quiet water deposits)	N	Y	Forest
Deciduous Forest on lacustrine deposits (gravel, sand, silt and clay, deposited on modern flood plains)	N	Y	Forest
Deciduous Forest on organic deposits (peat, muck and marl)	N	Y	Forest
Deciduous Forest on till with undifferentiated, predominantly sand to silty sand matrix, high content of clasts, often low in matrix carbonate content	N	Y	Forest
Deciduous Forest on till with undifferentiated, predominantly sand matrix, extremely stony, bouldery and high in total matrix carbonate, often associated with stratified sediments	N	Y	Forest
Deciduous Forest on till with undifferentiated, predominantly sandy silt to silt matrix, commonly rich in clasts, often high in total matrix carbonate content	N	Y	Forest
Deciduous Swamp	Y	Y	Wetland
Grass and meadow	N	Y	Anthropogenic
Upland hardwood and mixed conifer on unknown landform	N	Y	Forest
Upland hardwood and mixed conifer on bedrock with undifferentiated carbonate and clastic sedimentary rock, exposed at surface or covered by a discontinuous, thin layer of drift	Y	Y	Forest
Upland hardwood and mixed conifer on bedrock with undifferentiated igneous and metamorphic rock, exposed at surface or covered by a discontinuous, thin layer of drift	Y	Y	Forest
Upland hardwood and mixed conifer on fluvial (gravel, sand, silt and clay, deposited on flood plains)	Y	Y	Forest
Upland hardwood and mixed conifer on glaciofluvial ice-contact deposits (gravel and sand, minor till, includes esker, kame, end moraine, ice-marginal delta and subaqueous fan deposits)	Y	Y	Forest
Upland hardwood and mixed conifer on glaciofluvial outwash deposits (gravel and sand, includes proglacial river and deltaic deposits)	Y	Y	Forest
Upland hardwood and mixed conifer on glaciolacustrine deposits (sand, gravelly sand and gravel, nearshore and beach deposits)	Y	Y	Forest
Upland hardwood and mixed conifer on glaciolacustrine deposits (silt and clay, minor sand, basin and quiet water deposits)	Y	Y	Forest
Upland hardwood and mixed conifer on glaciomarine and marine deposits (sand, gravelly sand and gravel, nearshore and beach deposits or silt and clay, basin and quiet water deposits)	Y	Y	Forest
Upland hardwood and mixed conifer on lacustrine deposits (gravel, sand, silt and clay, deposited on modern flood plains)	Y	Y	Forest
Upland hardwood and mixed conifer on organic deposits (peat, muck and marl)	Y	Y	Forest
Upland hardwood and mixed conifer on till with undifferentiated, predominantly sand to silty sand matrix, high content of clasts, often low in matrix carbonate content	Y	Y	Forest

Ecological System Description	Target	Natural	Type
Upland hardwood and mixed conifer on till with undifferentiated, predominantly sand matrix, extremely stony, bouldery and high in total matrix carbonate, often associated with stratified sediments	Y	Y	Forest
Upland hardwood and mixed conifer on till with undifferentiated, predominantly sandy silt to silt matrix, commonly rich in clasts, often high in total matrix carbonate content	Y	Y	Forest
Hemlock on Unknown landform	N	Y	Forest
Hemlock on bedrock with undifferentiated carbonate and clastic sedimentary rock, exposed at surface or covered by a discontinuous, thin layer of drift	Y	Y	Forest
Hemlock on bedrock with undifferentiated igneous and metamorphic rock, exposed at surface or covered by a discontinuous, thin layer of drift	Y	Y	Forest
Hemlock on glaciofluvial ice-contact deposits (gravel and sand, minor till, includes esker, kame, end moraine, ice-marginal delta and subaqueous fan deposits)	Y	Y	Forest
Hemlock on glaciofluvial outwash deposits (gravel and sand, includes proglacial river and deltaic deposits)	Y	Y	Forest
Hemlock on glaciolacustrine deposits (sand, gravelly sand and gravel, nearshore and beach deposits)	Y	Y	Forest
Hemlock on glaciolacustrine deposits (silt and clay, minor sand, basin and quiet water deposits)	Y	Y	Forest
Hemlock on organic deposits (peat, muck and marl)	Y	Y	Forest
Hemlock on till with undifferentiated, predominantly sand to silty sand matrix, high content of clasts, often low in matrix carbonate content	Y	Y	Forest
Hemlock on till with undifferentiated, predominantly sand matrix, extremely stony, bouldery and high in total matrix carbonate, often associated with stratified sediments	Y	Y	Forest
Hemlock on till with undifferentiated, predominantly sandy silt to silt matrix, commonly rich in clasts, often high in total matrix carbonate content	Y	Y	Forest
Intolerant hardwoods on unknown landform	N	Y	Forest
Intolerant hardwoods on bedrock with undifferentiated carbonate and clastic sedimentary rock, exposed at surface or covered by a discontinuous, thin layer of drift	Y	Y	Forest
Intolerant hardwoods on bedrock with undifferentiated igneous and metamorphic rock, exposed at surface or covered by a discontinuous, thin layer of drift	Y	Y	Forest
Intolerant hardwoods on fluvial (gravel, sand, silt and clay, deposited on flood plains)	Y	Y	Forest
Intolerant hardwoods on glaciofluvial ice-contact deposits (gravel and sand, minor till, includes esker, kame, end moraine, ice-marginal delta and subaqueous fan deposits)	Y	Y	Forest
Intolerant hardwoods on glaciofluvial outwash deposits (gravel and sand, includes proglacial river and deltaic deposits)	Y	Y	Forest
Intolerant hardwoods on glaciolacustrine deposits (sand, gravelly sand and gravel, nearshore and beach deposits)	Y	Y	Forest
Intolerant hardwoods on glaciolacustrine deposits (silt and clay, minor sand, basin and quiet water deposits)	Y	Y	Forest
Intolerant hardwoods on glaciomarine and marine deposits (sand, gravelly sand and gravel, nearshore and beach deposits or silt and clay, basin and quiet water deposits)	Y	Y	Forest
Intolerant hardwoods on lacustrine deposits (gravel, sand, silt and clay, deposited on modern flood plains)	Y	Y	Forest
Intolerant hardwoods on organic deposits (peat, muck and marl)	Y	Y	Forest
Intolerant hardwoods on till with undifferentiated, predominantly sand to silty sand matrix, high content of clasts, often low in matrix carbonate content	Y	Y	Forest

Ecological System Description	Target	Natural	Type
Intolerant hardwoods on till with undifferentiated, predominantly sand matrix, extremely stony, bouldery and high in total matrix carbonate, often associated with stratified sediments	Y	Y	Forest
Intolerant hardwoods on till with undifferentiated, predominantly sandy silt to silt matrix, commonly rich in clasts, often high in total matrix carbonate content	Y	Y	Forest
Marsh	Y	Y	Wetland
Midtolerant hardwoods on unknown landform	N	Y	Forest
Midtolerant hardwoods on bedrock with undifferentiated carbonate and clastic sedimentary rock, exposed at surface or covered by a discontinuous, thin layer of drift	Y	Y	Forest
Midtolerant hardwoods on bedrock with undifferentiated igneous and metamorphic rock, exposed at surface or covered by a discontinuous, thin layer of drift	Y	Y	Forest
Midtolerant hardwoods on glaciofluvial ice-contact deposits (gravel and sand, minor till, includes esker, kame, end moraine, ice-marginal delta and subaqueous fan deposits)	Y	Y	Forest
Midtolerant hardwoods on glaciofluvial outwash deposits (gravel and sand, includes proglacial river and deltaic deposits)	Y	Y	Forest
Midtolerant hardwoods on glaciolacustrine deposits (sand, gravelly sand and gravel, nearshore and beach deposits)	Y	Y	Forest
Midtolerant hardwoods on glaciolacustrine deposits (silt and clay, minor sand, basin and quiet water deposits)	Y	Y	Forest
Midtolerant hardwoods on glaciomarine and marine deposits (sand, gravelly sand and gravel, nearshore and beach deposits or silt and clay, basin and quiet water deposits)	Y	Y	Forest
Midtolerant hardwoods on organic deposits (peat, muck and marl)	Y	Y	Forest
Midtolerant hardwoods on till with undifferentiated, predominantly sand to silty sand matrix, high content of clasts, often low in matrix carbonate content	Y	Y	Forest
Midtolerant hardwoods on till with undifferentiated, predominantly sand matrix, extremely stony, bouldery and high in total matrix carbonate, often associated with stratified sediments	Y	Y	Forest
Midtolerant hardwoods on till with undifferentiated, predominantly sandy silt to silt matrix, commonly rich in clasts, often high in total matrix carbonate content	Y	Y	Forest
Mixed Forest on unknown landform	N	Y	Forest
Mixed Forest on bedrock with undifferentiated carbonate and clastic sedimentary rock, exposed at surface or covered by a discontinuous, thin layer of drift	N	Y	Forest
Mixed forest on bedrock with undifferentiated igneous and metamorphic rock, exposed at surface or covered by a discontinuous, thin layer of drift	N	Y	Forest
Mixed forest on fluvial (gravel, sand, silt and clay, deposited on flood plains)	N	Y	Forest
Mixed forest on glaciofluvial ice-contact deposits (gravel and sand, minor till, includes esker, kame, end moraine, ice-marginal delta and subaqueous fan deposits)	N	Y	Forest
Mixed forest on glaciofluvial outwash deposits (gravel and sand, includes proglacial river and deltaic deposits)	N	Y	Forest
Mixed forest on glaciolacustrine deposits (sand, gravelly sand and gravel, nearshore and beach deposits)	N	Y	Forest
Mixed forest on glaciolacustrine deposits (silt and clay, minor sand, basin and quiet water deposits)	N	Y	Forest
Mixed forest on glaciomarine and marine deposits (sand, gravelly sand and gravel, nearshore and beach deposits or silt and clay, basin and quiet water deposits)	N	Y	Forest
Mixed forest on lacustrine deposits (gravel, sand, silt and clay, deposited on modern flood plains)	N	Y	Forest

Ecological System Description	Target	Natural	Type
Mixed forest on organic deposits (peat, muck and marl)	N	Y	Forest
Mixed forest on till with undifferentiated, predominantly sand to silty sand matrix, high content of clasts, often low in matrix carbonate content	N	Y	Forest
Mixed forest on till with undifferentiated, predominantly sand matrix, extremely stony, bouldery and high in total matrix carbonate, often associated with stratified sediments	N	Y	Forest
Mixed forest on till with undifferentiated, predominantly sandy silt to silt matrix, commonly rich in clasts, often high in total matrix carbonate content	N	Y	Forest
Mixed Swamp	Y	Y	Wetland
Mixed Lowland Conifer on unknown landform	N	Y	Forest
Mixed Lowland Conifer on bedrock with undifferentiated carbonate and clastic sedimentary rock, exposed at surface or covered by a discontinuous, thin layer of drift	Y	Y	Forest
Mixed Lowland Conifer on bedrock with undifferentiated igneous and metamorphic rock, exposed at surface or covered by a discontinuous, thin layer of drift	Y	Y	Forest
Mixed Lowland Conifer on fluvial (gravel, sand, silt and clay, deposited on flood plains)	Y	Y	Forest
Mixed Lowland Conifer on glaciofluvial ice-contact deposits (gravel and sand, minor till, includes esker, kame, end moraine, ice-marginal delta and subaqueous fan deposits)	Y	Y	Forest
Mixed Lowland Conifer on glaciofluvial outwash deposits (gravel and sand, includes proglacial river and deltaic deposits)	Y	Y	Forest
Mixed Lowland Conifer on glaciolacustrine deposits (sand, gravelly sand and gravel, nearshore and beach deposits)	Y	Y	Forest
Mixed Lowland Conifer on glaciolacustrine deposits (silt and clay, minor sand, basin and quiet water deposits)	Y	Y	Forest
Mixed Lowland Conifer on glaciomarine and marine deposits (sand, gravelly sand and gravel, nearshore and beach deposits or silt and clay, basin and quiet water deposits)	Y	Y	Forest
Mixed Lowland Conifer on lacustrine deposits (gravel, sand, silt and clay, deposited on modern flood plains)	Y	Y	Forest
Mixed Lowland Conifer on organic deposits (peat, muck and marl)	Y	Y	Forest
Mixed Lowland Conifer on till with undifferentiated, predominantly sand to silty sand matrix, high content of clasts, often low in matrix carbonate content	Y	Y	Forest
Mixed Lowland Conifer on till with undifferentiated, predominantly sand matrix, extremely stony, bouldery and high in total matrix carbonate, often associated with stratified sediments	Y	Y	Forest
Mixed Lowland Conifer on till with undifferentiated, predominantly sandy silt to silt matrix, commonly rich in clasts, often high in total matrix carbonate content	Y	Y	Forest
Oak and Oak/Pine on unknown landform	N	Y	Forest
Oak and Oak/Pine on bedrock with undifferentiated carbonate and clastic sedimentary rock, exposed at surface or covered by a discontinuous, thin layer of drift	Y	Y	Forest
Oak and Oak/Pine on bedrock with undifferentiated igneous and metamorphic rock, exposed at surface or covered by a discontinuous, thin layer of drift	Y	Y	Forest
Oak and Oak/Pine on glaciofluvial ice-contact deposits (gravel and sand, minor till, includes esker, kame, end moraine, ice-marginal delta and subaqueous fan deposits)	Y	Y	Forest
Oak and Oak/Pine on glaciofluvial outwash deposits (gravel and sand, includes proglacial river and deltaic deposits)	Y	Y	Forest
Oak and Oak/Pine on glaciolacustrine deposits (sand, gravelly sand and gravel, nearshore and beach deposits)	Y	Y	Forest

Ecological System Description	Target	Natural	Type
Oak and Oak/Pine on glaciolacustrine deposits (silt and clay, minor sand, basin and quiet water deposits)	Y	Y	Forest
Oak and Oak/Pine on glaciomarine and marine deposits (sand, gravelly sand and gravel, nearshore and beach deposits or silt and clay, basin and quiet water deposits)	Y	Y	Forest
Oak and Oak/Pine on organic deposits (peat, muck and marl)	Y	Y	Forest
Oak and Oak/Pine on till with undifferentiated, predominantly sand to silty sand matrix, high content of clasts, often low in matrix carbonate content	Y	Y	Forest
Oak and Oak/Pine on till with undifferentiated, predominantly sand matrix, extremely stony, bouldery and high in total matrix carbonate, often associated with stratified sediments	Y	Y	Forest
Oak and Oak/Pine on till with undifferentiated, predominantly sandy silt to silt matrix, commonly rich in clasts, often high in total matrix carbonate content	Y	Y	Forest
Open Bog	Y	Y	Wetland
Open Fen	Y	Y	Wetland
Open Muskeg	N	Y	Wetland
Jack Pine on unknown landform	N	Y	Forest
Jack Pine on bedrock with undifferentiated carbonate and clastic sedimentary rock, exposed at surface or covered by a discontinuous, thin layer of drift	Y	Y	Forest
Jack Pine on bedrock with undifferentiated igneous and metamorphic rock, exposed at surface or covered by a discontinuous, thin layer of drift	Y	Y	Forest
Jack Pine on fluvial (gravel, sand, silt and clay, deposited on flood plains)	Y	Y	Forest
Jack Pine on glaciofluvial ice-contact deposits (gravel and sand, minor till, includes esker, kame, end moraine, ice-marginal delta and subaqueous fan deposits)	Y	Y	Forest
Jack Pine on glaciofluvial outwash deposits (gravel and sand, includes proglacial river and deltaic deposits)	Y	Y	Forest
Jack Pine on glaciolacustrine deposits (sand, gravelly sand and gravel, nearshore and beach deposits)	Y	Y	Forest
Jack Pine on glaciolacustrine deposits (silt and clay, minor sand, basin and quiet water deposits)	Y	Y	Forest
Jack Pine on glaciomarine and marine deposits (sand, gravelly sand and gravel, nearshore and beach deposits or silt and clay, basin and quiet water deposits)	Y	Y	Forest
Jack Pine on lacustrine deposits (gravel, sand, silt and clay, deposited on modern flood plains)	Y	Y	Forest
Jack Pine on organic deposits (peat, muck and marl)	Y	Y	Forest
Jack Pine on till with undifferentiated, predominantly sand to silty sand matrix, high content of clasts, often low in matrix carbonate content	Y	Y	Forest
Jack Pine on till with undifferentiated, predominantly sand matrix, extremely stony, bouldery and high in total matrix carbonate, often associated with stratified sediments	Y	Y	Forest
Jack Pine on till with undifferentiated, predominantly sandy silt to silt matrix, commonly rich in clasts, often high in total matrix carbonate content	Y	Y	Forest
Mixed Red and White Pine on unknown landform	N	Y	Forest
Mixed Red and White Pine on bedrock with undifferentiated carbonate and clastic sedimentary rock, exposed at surface or covered by a discontinuous, thin layer of drift	Y	Y	Forest
Mixed Red and White Pine on bedrock with undifferentiated igneous and metamorphic rock, exposed at surface or covered by a discontinuous, thin layer of drift	Y	Y	Forest
Mixed Red and White Pine on fluvial (gravel, sand, silt and clay, deposited on flood plains)	Y	Y	Forest

Ecological System Description	**Target**	**Natural**	**Type**
Mixed Red and White Pine on glaciofluvial ice-contact deposits (gravel and sand, minor till, includes esker, kame, end moraine, ice-marginal delta and subaqueous fan deposits)	Y	Y	Forest
Mixed Red and White Pine on glaciofluvial outwash deposits (gravel and sand, includes proglacial river and deltaic deposits)	Y	Y	Forest
Mixed Red and White Pine on glaciolacustrine deposits (sand, gravelly sand and gravel, nearshore and beach deposits)	Y	Y	Forest
Mixed Red and White Pine on glaciolacustrine deposits (silt and clay, minor sand, basin and quiet water deposits)	Y	Y	Forest
Mixed Red and White Pine on glaciomarine and marine deposits (sand, gravelly sand and gravel, nearshore and beach deposits or silt and clay, basin and quiet water deposits)	Y	Y	Forest
Mixed Red and White Pine on lacustrine deposits (gravel, sand, silt and clay, deposited on modern flood plains)	Y	Y	Forest
Mixed Red and White Pine on organic deposits (peat, muck and marl)	Y	Y	Forest
Mixed Red and White Pine on till with undifferentiated, predominantly sand to silty sand matrix, high content of clasts, often low in matrix carbonate content	Y	Y	Forest
Mixed Red and White Pine on till with undifferentiated, predominantly sand matrix, extremely stony, bouldery and high in total matrix carbonate, often associated with stratified sediments	Y	Y	Forest
Mixed Red and White Pine on till with undifferentiated, predominantly sandy silt to silt matrix, commonly rich in clasts, often high in total matrix carbonate content	Y	Y	Forest
Rock	N	Y	Other Natural
Lowland Black Spruce on unknown landform	N	Y	Forest
Lowland Black Spruce on bedrock with undifferentiated carbonate and clastic sedimentary rock, exposed at surface or covered by a discontinuous, thin layer of drift	Y	Y	Forest
Lowland Black Spruce on bedrock with undifferentiated igneous and metamorphic rock, exposed at surface or covered by a discontinuous, thin layer of drift	Y	Y	Forest
Lowland Black Spruce on fluvial (gravel, sand, silt and clay, deposited on flood plains)	Y	Y	Forest
Lowland Black Spruce on glaciofluvial ice-contact deposits (gravel and sand, minor till, includes esker, kame, end moraine, ice-marginal delta and subaqueous fan deposits)	Y	Y	Forest
Lowland Black Spruce on glaciofluvial outwash deposits (gravel and sand, includes proglacial river and deltaic deposits)	Y	Y	Forest
Lowland Black Spruce on glaciolacustrine deposits (sand, gravelly sand and gravel, nearshore and beach deposits)	Y	Y	Forest
Lowland Black Spruce on glaciolacustrine deposits (silt and clay, minor sand, basin and quiet water deposits)	Y	Y	Forest
Lowland Black Spruce on glaciomarine and marine deposits (sand, gravelly sand and gravel, nearshore and beach deposits or silt and clay, basin and quiet water deposits)	Y	Y	Forest
Lowland Black Spruce on lacustrine deposits (gravel, sand, silt and clay, deposited on modern flood plains)	Y	Y	Forest
Lowland Black Spruce on organic deposits (peat, muck and marl)	Y	Y	Forest
Lowland Black Spruce on till with undifferentiated, predominantly sand to silty sand matrix, high content of clasts, often low in matrix carbonate content	Y	Y	Forest
Mixed Spruce and Pine on unknown landform	N	Y	Forest

Ecological System Description	**Target**	**Natural**	**Type**
Mixed Spruce and Pine on bedrock with undifferentiated carbonate and clastic sedimentary rock, exposed at surface or covered by a discontinuous, thin layer of drift	Y	Y	Forest
Mixed Spruce and Pine on bedrock with undifferentiated igneous and metamorphic rock, exposed at surface or covered by a discontinuous, thin layer of drift	Y	Y	Forest
Mixed Spruce and Pine on fluvial (gravel, sand, silt and clay, deposited on flood plains)	Y	Y	Forest
Mixed Spruce and Pine on glaciofluvial ice-contact deposits (gravel and sand, minor till, includes esker, kame, end moraine, ice-marginal delta and subaqueous fan deposits)	Y	Y	Forest
Mixed Spruce and Pine on glaciofluvial outwash deposits (gravel and sand, includes proglacial river and deltaic deposits)	Y	Y	Forest
Mixed Spruce and Pine on glaciolacustrine deposits (sand, gravelly sand and gravel, nearshore and beach deposits)	Y	Y	Forest
Mixed Spruce and Pine on glaciolacustrine deposits (silt and clay, minor sand, basin and quiet water deposits)	Y	Y	Forest
Mixed Spruce and Pine on glaciomarine and marine deposits (sand, gravelly sand and gravel, nearshore and beach deposits or silt and clay, basin and quiet water deposits)	Y	Y	Forest
Mixed Spruce and Pine on lacustrine deposits (gravel, sand, silt and clay, deposited on modern flood plains)	Y	Y	Forest
Mixed Spruce and Pine on organic deposits (peat, muck and marl)	Y	Y	Forest
Mixed Spruce and Pine on till with undifferentiated, predominantly sand to silty sand matrix, high content of clasts, often low in matrix carbonate content	Y	Y	Forest
Mixed Spruce and Pine on till with undifferentiated, predominantly sand matrix, extremely stony, bouldery and high in total matrix carbonate, often associated with stratified sediments	Y	Y	Forest
Mixed Spruce and Pine on till with undifferentiated, predominantly sandy silt to silt matrix, commonly rich in clasts, often high in total matrix carbonate content	Y	Y	Forest
Upland Black Spruce on unknown landform	N	Y	Forest
Upland Black Spruce on bedrock with undifferentiated igneous and metamorphic rock, exposed at surface or covered by a discontinuous, thin layer of drift	Y	Y	Forest
Upland Black Spruce on fluvial (gravel, sand, silt and clay, deposited on flood plains)	Y	Y	Forest
Upland Black Spruce on glaciofluvial ice-contact deposits (gravel and sand, minor till, includes esker, kame, end moraine, ice-marginal delta and subaqueous fan deposits)	Y	Y	Forest
Upland Black Spruce on glaciofluvial outwash deposits (gravel and sand, includes proglacial river and deltaic deposits)	Y	Y	Forest
Upland Black Spruce on glaciolacustrine deposits (sand, gravelly sand and gravel, nearshore and beach deposits)	Y	Y	Forest
Upland Black Spruce on glaciolacustrine deposits (silt and clay, minor sand, basin and quiet water deposits)	Y	Y	Forest
Upland Black Spruce on organic deposits (peat, muck and marl)	Y	Y	Forest
Upland Black Spruce on till with undifferentiated, predominantly sand to silty sand matrix, high content of clasts, often low in matrix carbonate content	Y	Y	Forest
Settlement and Developed Land	N	N	Anthropogenic
Tolerant hardwoods on unknown landform	N	Y	Forest
Tolerant hardwoods on bedrock with undifferentiated carbonate and clastic sedimentary rock, exposed at surface or covered by a discontinuous, thin layer of drift	Y	Y	Forest

Ecological System Description	Target	Natural	Type
Tolerant hardwoods on bedrock with undifferentiated igneous and metamorphic rock, exposed at surface or covered by a discontinuous, thin layer of drift	Y	Y	Forest
Tolerant hardwoods on fluvial (gravel, sand, silt and clay, deposited on flood plains)	Y	Y	Forest
Tolerant hardwoods on glaciofluvial ice-contact deposits (gravel and sand, minor till, includes esker, kame, end moraine, ice-marginal delta and subaqueous fan deposits)	Y	Y	Forest
Tolerant hardwoods on glaciofluvial outwash deposits (gravel and sand, includes proglacial river and deltaic deposits)	Y	Y	Forest
Tolerant hardwoods on glaciolacustrine deposits (sand, gravelly sand and gravel, nearshore and beach deposits)	Y	Y	Forest
Tolerant hardwoods on glaciolacustrine deposits (silt and clay, minor sand, basin and quiet water deposits)	Y	Y	Forest
Tolerant hardwoods on glaciomarine and marine deposits (sand, gravelly sand and gravel, nearshore and beach deposits or silt and clay, basin and quiet water deposits)	Y	Y	Forest
Tolerant hardwoods on lacustrine deposits (gravel, sand, silt and clay, deposited on modern flood plains)	Y	Y	Forest
Tolerant hardwoods on organic deposits (peat, muck and marl)	Y	Y	Forest
Tolerant hardwoods on till with undifferentiated, predominantly sand to silty sand matrix, high content of clasts, often low in matrix carbonate content	Y	Y	Forest
Tolerant hardwoods on till with undifferentiated, predominantly sand matrix, extremely stony, bouldery and high in total matrix carbonate, often associated with stratified sediments	Y	Y	Forest
Tolerant hardwoods on till with undifferentiated, predominantly sandy silt to silt matrix, commonly rich in clasts, often high in total matrix carbonate content	Y	Y	Forest
Treed Bog	Y	Y	Wetland
Treed Fen	Y	Y	Wetland
Treed Muskeg	N	Y	Wetland
Unclassified	N	N	Unknown
Water	N	Y	Water

Appendix 8. Scores assigned to the conservation values for southern Ontario

Criteria	Value Layer	Scale	Scores
Condition (adjusted to 15% of total score)	% natural cover within a 2 km radius	Each pixel	0 - 100%: gradational from 0 to 12 points
	Distance from Cropland	Each pixel	inside: 0 0 – 100 m from cropland: -2 100 – 200 m from cropland: 1 > 200 m from cropland: 3
	Distance from Urban-settlement	Each pixel	Inside: 0 0 – 200 m from urban: -5 201 – 500 m from urban: -3 > 500 m from urban: -1
	Roadlessness	Each pixel	0-100m / 101-200m / >200m Primary -10 / -5 / -3 Secondary -5 / -3 / 0 Tertiary -5 / -3 / 0 * note that where a pixel is adjacent to more than one road type, it will only be scored once and the score that is assigned will be the lowest
Diversity (adjusted to 5% of total score)	Diversity of l-v types	Intact ecological systems	1 : 0 2 : 2 3 : 3 4 : 4 5 : 5 6 : 6
Ecological functions (adjusted to 60% of total score)	Total Size	Intact ecological systems	0–25 ha: -20 26–50 ha: 2 51-100 ha: 6 101 – 200 ha: 15 201-500 ha: 20 (5) >500 ha: 25
	Interior Size (>100 m from edge)	Intact ecological systems	0–50 ha: -10 51-100 ha: 2 101 – 500 ha: 6 >500 ha: 10
	Interior Size (>200 m from edge)	Intact ecological systems	0–50 ha: -10 51-100 ha: 2 101 – 500 ha: 6 >500 ha: 10
	Cores and corridors	Each pixel	Big Picture cores: 2 Bigger Picture Cores: 2 Oak Ridges Moraine cores: 2 Corridors: 2 Oak Ridges Moraine linkages: 2 Niagara Escarpment Commission linkages: 2 Big Picture Island Cores: 1 Island Cores: 1

Criteria	Value Layer	Scale	Scores
Ecological functions continued *(adjusted to 60% of total score)*	Proximity to, and coincidence with existing protected areas and conservation lands: • Provincial Parks • Sig. Woodlands • ANSIs • Provincially Significant Wetlands (PSW) • Conservation Authority Lands • National Parks • Nat. Wildlife Areas • Migratory Bird Sanctuaries • Important Bird Areas • Nature Conservancy of Canada properties	Each pixel	Provincial Parks, National Parks, Conservation Reserves Inside: 2 0 – 1000 m: 3 1000 – 2000 m: 2 2000 – 4000 m: 1 > 4000 m: 0 Life Science ANSI Provincially significant: 6 Regionally significant: 2 Outside: 0 Significant Woodland, Provincially Significant Wetland, Conservation Authority Areas, National Wildlife Area, Migratory Bird Sanctuary, Important Bird Areas Inside: 2 Outside: 0
	Hydrologic function: • Wetlands (bog, fen, marsh, and swamp) • Potential valleys • Great Lakes shorelines • Riparian areas • Lakeshore areas	Intact ecological system	Presence of wetland Positive: 3 Negative: 0 Potential valley Inside: 1 Outside: 0 Great Lakes shoreline Inside: 3 Outside: 0 Riparian area Inside: 2 Outside: 0 Lakeshore area Inside: 2 Outside: 0
Special Features • maximum score of 40 points (adjusted to 20% of total score)	Presence of rare species targets	Each pixel	Target EO (extant) - count * 4 Target EO (historic) - count * 1
	Presence of community EO	Each pixel	Community EO - count * 2
	Presence of EO (non-target)	Each pixel	Non-target EO (extant) - count * 2 Non-target EO (historic) - count * 1

Appendix 9. Scores assigned to the conservation values for the Canadian Shield

Criteria	Value Layer	Scale	Scores
Condition (adjusted to 20% of total score)	% natural cover within a 2 km radius	Each pixel	0 - 40%: 0 41 - 70%: 4 71 - 90%: 8 91 – 100%: 12
	Distance from cropland	Each pixel	Inside: 0 0 – 100 m from cropland: -8 101 – 200 m from cropland: -5 201 – 400 m from cropland: -3 > 400 m from cropland: 0
	Distance from urban and settlement areas	Each pixel	Inside: 0 0 – 100 m from urban: -10 101 – 200 m from urban: -6 201 – 400 m from urban: -3 > 400 m from urban: 0
	Presence of pit/quarry	Each pixel	Inside: -10 Outside: 0
	Distance from mines	Each pixel	Inside: -10 0– 100 m from mines: -10 101 – 200 m from mines: -6 201 – 400 m from mines: -3 > 400 m from mines: 0
	Hydro corridors (transmission lines)	Each pixel	0 – 100 m: -5 101 – 200 m: -2 > 200 m: 0
	Railways	Each pixel	0 – 100 m: -8 101 – 200 m: -4 > 200 m: 0
	Roadlessness	Each pixel	0-100m / 101-200m / >201-400m / >400m Primary: -20 / -10 / -5 / 0 Secondary: -10 / -5 / -3 / 0 Tertiary: -8 / -3 / 0 / 0
Diversity (adjusted to 5% of total score)	Diversity of ecological systems types	Intact ecological systems	1 : 1 2 : 2 3 : 3 4 : 4 5 : 5 6 : 6 7 : 7 8 : 8
Ecological functions (adjusted to 60% of total score)	Fire disturbance size	Intact ecological systems	*See Appendix 10 for details. Ranges are consistent but scores will change by ecodistrict.
	Edge buffer size (>200m from edge)	Intact ecological systems	0–50 ha: -15 51-100 ha: 0 101 – 500 ha: 8 >500 ha: 15
	Presence of old-growth forest	Intact ecological systems	Inside: 10 Outside: 0

Criteria	Value Layer	Scale	Scores
Ecological functions continued *(adjusted to 60% of total score)*	Proximity to existing protected areas: • Provincial Parks • National Parks • Conservation Reserves • Ontario Living Legacy sites • Lake Superior National Marine Conservation Area	Each pixel	Regulated Protected Areas: Inside: 12 0 – 1000 m: 10 1000 – 2000 m: 8 2000 – 4000 m: 6 > 4000 m: 0
	Coincidence with existing conservation lands: • Life Science ANSIs • Provincially Significant Wetlands (PSW) • Conservation Authority Areas • Nature Conservancy of Canada properties • Important Bird Areas	Each pixel	**Life Science ANSI** Provincially significant: 3 Regionally significant: 1 Outside: 0 **Provincially Significant Wetland** Inside: 1 outside: 0 **Conservation Authority Areas** Inside: 1 Outside: 0 **Nature Conservancy of Canada Properties** Inside: 1 Outside: 0 **Important Bird Areas** Inside: 1 Outside: 0
	Hydrological functions: • Wetlands (bog, fen, marsh, swamp, '*muskeg*') • Riparian areas (streams, lakes and Great Lakes shorelines)	Intact ecological systems	**Presence of wetland** Positive: 8 Negative: 0 **Great Lakes shoreline** Positive: 15 Negative: 0 **Riparian area (streams)** Positive: 4 Negative: 0 **Riparian area (inland lake)** Positive: 4 Negative: 0
Special Features Max score of 40 points (adjusted to 15% of total score)	Presence of rare species targets	Each pixel	target EO (extant) - count * 4 target EO (historic) - count * 1
	Presence of community EO	Each pixel	Community EO - count * 2
	Presence of EO (non-target)	Each pixel	non-target EO (extant) - count * 2 non-target EO (historic) - count * 1

Appendix 10. Ranges and Scoring for "Total Size" as part of the Ecological Functions Criteria with 4x rule

	3E4	3W3	3W5	4W2	4E1	4E3	5E1	5E3	5E4	5E5	5E6	5E7	5E8	5E9	5E10	5E11	5E13
0 – 25ha	-10	-10	-10	-10	-10	-10	-10	-10	-10	-10	-10	-10	-10	-10	-10	-10	-10
26 – 50ha	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2
51 – 79ha	6	6	6	6	6	6	6	6	6	6	6	6	6	6	6	6	6
80 – 100ha	6	6	6	6	6	6	6	40	6	6	6	6	6	6	6	6	6
101 – 159ha	15	15	15	15	15	15	15	40	15	15	15	15	15	15	15	15	15
160 – 199ha	15	15	15	15	15	15	15	40	15	15	15	40	15	40	40	15	15
200 – 239ha	20	20	20	20	20	40	20	40	20	20	20	40	40	40	40	40	20
240 – 399ha	20	20	20	20	20	40	40	40	20	20	20	40	40	40	40	40	40
400 – 479ha	40	20	40	20	20	40	40	40	20	20	20	40	40	40	40	40	40
480 – 500ha	40	25	40	25	40	40	40	40	25	25	25	40	40	40	40	40	40
501 – 639ha	40	25	40	25	40	40	40	40	25	25	25	40	40	40	40	40	40
640 – 799ha	40	25	40	25	40	40	40	40	25	25	25	40	40	40	60	60	40
800 – 1000ha	40	25	40	25	40	40	40	40	40	40	40	40	40	40	60	60	40
1000 – 1199ha	40	25	40	25	40	40	40	40	40	40	40	40	40	40	60	60	40
1200 – 1599ha	40	40	40	40	40	40	40	40	40	40	40	40	40	40	60	60	40
1600 – 1999ha	40	40	40	40	40	60	40	40	40	40	40	40	40	40	60	60	40
2000 – 2499ha	40	40	40	40	40	60	40	40	40	40	40	40	40	40	60	60	40
2500 – 2999ha	40	40	40	40	40	60	40	40	40	40	40	40	40	40	60	60	40
3000 – 4999ha	40	40	40	40	40	60	40	40	40	40	40	40	40	40	60	60	40
5000 – 5999ha	40	40	40	40	40	60	40	40	40	40	40	40	40	40	60	60	40
6000 – 7999ha	40	40	40	40	40	60	40	40	40	40	40	40	40	40	60	60	40
8000 – 9999ha	40	40	40	40	40	60	40	40	40	40	40	40	40	40	60	60	40
10000 – 14999ha	40	40	40	40	40	60	40	40	40	40	40	40	40	40	60	60	40
15000 – 19999ha	40	40	40	40	40	60	40	40	40	40	40	40	40	40	60	60	40
= or > 20000ha	40	40	40	40	40	60	40	40	40	40	40	40	40	40	60	60	40

Appendix 11. Old growth onset age for the Conservation Blueprint

****based on ELC ecosites**	**Old Growth onset stand age (yrs)**	**FU_analysis**	**Query Age (= and >)**
Boreal West (3W,4W)			
Pw, Pr	Pw 150, Pr 130	PWR	130
Pj, Sb (shallow)	Sb 120, Pj 110, Po 100	PJ	110
Pj, Sb (dry)	Pj 110, Sb 120, Po 90	OCLow	100
Pj, Sb (fresh)	Pj 100, Sb 110	SbLow	100
Pj	Pj 110	SbUp	110
Po, Bw, Bf (dry)	Po 100, Bw 110, Bf 70	SbP	n/a
Po, Bw, Bf (wet)	Po 90, Bw 100, Bf 70	He	n/a
Ce	Ce 100	Asp	100
Bf, Sw, Sb	Bf 70, Sw 100, Sb 100, Po 90	Bw	100
Sb, Pj	Sb 120, Pj 110	By	n/a
Po, Bw	Po 100, Bw 100	Opine	n/a
Po, Ab	Po 100, Ab 100	TolHd	100
Sb (wet)	Sb 160	MidHd	n/a
Sb, La (wet)	Sb, 100, La 100	IntHd	100
Ce (wet)	Ce 140, La 100	HdConU	100
Ab, other (wet)	Ab 100, Po 80, Pb 80		
Boreal East (3E)			
Pj, Sb, Sw	Pj 100, Sb 90, Sw 110	PWR	130
Pj	Pj 110	PJ	100
Pj, Sb, Sw, Po, mixedwood	Pj 110, Sb 80, Po 80, Bw 90	OCLow	110
Pj, Sb	Pj 100, Sb 90	SbLow	100
Sb, Pj	Sb 110, Pj 90	SbUp	n/a
Po, Sb, Bf, mixedwood	Po 90, Sb 110, Bf 70	SbP	100
Po, Sb, Pj mixedwood	Po 90, Sb 90, Pj 90	He	n/a
Po, Sw, Bf	Po 100, Sw 120, Bf 70	Asp	90
Po, Sb, Sw	Po 110, Sb 120, Sw 120	Bw	90
Sb	Sb 100	By	n/a
Sw, Bf, Ce	Sw 100, Bf 70, Ce 100	Opine	n/a
Po, Pb, Sb	Po 80, Pb 80, Sb 100, Ab 100	TolHd	90
Sb (wet)	Sb 110 - 150	MidHd	n/a
Sb La, Ce	Sb 120, La 110, Ce 140	IntHd	90
Pw, Pr, Sw	Pw 130, Pr 130, Sw 100	HdConU	100
Hardwood, Mixedwood	By 150, Mh 140, Ms 80, Po 80, Bw 90, Sw 90		
Great Lakes - St. Lawrence (4E, 5E)			
Pw, Pr, Po, Pj, Oak	Pw 150, Pr 140, Or 110, Po 100, Pj 90	PWR	120
Sb, Pj, Pw, Pr	Pw 150, Pr 140, Pj 100, Sb 100	PJ	120
Po, Bw, Sw, Bf, Pj, Sb, Ms	Sw 110, Sb 100, Bw 90, Po 90, Pj 80, Bf 70, Ms 70	OCLow	110
Pw, Ce, Bw, Sw, Bf, Pr, Po	Pw 150, Pr 140, Ce 120, Sw 110, Bw 90, Po 90, Bf 70	SbLow	110
Mh, Bw, Po, Or, Pw, Bd, Be	Pw 150, Be 150, Mh 140, Bd 120, Or 120, Bw 100, Po 90	SbUp	n/a
He, Mh, By, Ce, Ms	He 180, By 160, Mh 140, Ce 120, Ms 100	SbP	120
Sb, Ce, La, Bf	Ce 150, Sb 110, La 90, Bf 70	He	180
Po, Ce, Ab, Ms, By, Mh	Ce 150, By 150, Mh 130, Ab 120, Ms 90, Po 80	Asp	90
Pw, Pr, Pj	Pw 120	Bw	90
Ce (white and red)	Cr 110, Ce 110	By	120
Ce, He	Ce 110, He 140	Opine	120
O-P; O-Hdwd	Or 120, Ow 120, Obl 120	TolHd	120
Tol/Mid-Tol Hdwd	Mh 120, Be 120, Bd 120	MidHd	120
Tol Hdwd - Con Mxwd	Mh 120, He 140	IntHd	120
Lowland Deciduous	Ash 120	HdConU	120
Lowland Hdwd & Mxwd	Obur 120, Msilver 120, Ash 120		

Appendix 12. Wide-ranging Mammals Review

Primary Wide-ranging Mammal Targets for the Great Lakes Conservation Blueprint

Fisher (*Martes pennanti*):

Home Range	*Habitat Requirements*
♦ Home range estimated at 10-800 km^2 by snow tracking, 7-78 km^2 by telemetry. ♦ Generally the ranges of adults of the same sex do not overlap.	♦ Occurs primarily in dense coniferous or mixed forests, including early successional forest with dense overhead cover. ♦ Commonly uses hardwood stands in summer by prefers coniferous or mixed forest in winter. ♦ Avoids open areas. ♦ Optimal conditions: forest tracts of 245 acres or more, interconnected with other large areas of suitable habitat; a dense understory of young conifers, shrubs and herbaceous cover is important in summer.

Thomas, J.W. *et al*., 1993. Viability assessments and management considerations for species associated with late-successional and old growth forests of the Pacific Northwest. The report of the Scientific Analysis Team. USDA Forest Service, Spotted Owl EIS Team, Portland Oregon, 530pp.

Black Bear (*Ursus americanus*):

Home Range	*Habitat Requirements*
♦ Capable of travelling great distances (live trapped bears moved 80 km or more from home ranges sometimes return). ♦ Occupies a range usually of 20-25 km^2, although sometimes up to 40 km^2. The home range of the male is about double the size of that of the female.	♦ Although found in a variety of habitats, prefer heavily wooded areas and dense bushland. Maximum numbers probably occur in areas of mixed coniferous deciduous forests ♦ Denning sites under tree stumps or overturned log, or a hole in a hillside.

CWS Hinterland's Who's Who: http://www.hww.ca/index_e.asp
Enature.com (National Wildlife Federation): www.enature.com

Lynx (*Lynx canadensis*):

Home Range	*Habitat Requirements*
♦ Home range increases, and individuals may become nomadic, when prey is scarce. ♦ Range of male (average often about 15-30 km^2, but up to hundreds of km^2 in Alaska and Minnesota) is larger than that of female.	♦ Generally occurs in boreal and montaine regions dominated by coniferous or mixed forest with thick undergrowth, but also sometimes enters open forest, rock areas, and tundra to forage for abundant prey. ♦ When inactive or birthing, dens typically in hollow tree, under stump or in thick brush. ♦ Den sites tend to be in mature or old growth stands with a high density of logs (Koehler 1990, Koehler and Brittel 1990). ♦ Major limiting factor is abundance of snowshoe hare, which in turn is limited by availability of winter habitat (in Pac NW, primarily early successional lodgepole pine with trees at least 6 feet tall) (USForest Service et al, 1993).

Koehler, G.M. 1990. Population and habitat characteristics of lynx and snowshoe hares in north central Washington. Canadian Journal of Zoology. 68:845-851.

Mech, L.D. 1980. Age, sex, reproduction, spatial organization of lynxes colonizing northeastern Minnesota. Journal of Mammalogy 61:261-267.

Saunders, J.K. 1963. Movements and activities of the lynx in Newfoundland. Journal of Wildlife Management. 27(3) 390-400.

US Forest Service *et al.*, 1993. Draft supplemental environmental impact statement on management of habitat for late-successional and old-growth forest related species within the range of the northern spotted owl. Published separately is Appendix A: Forest Ecosystem Management Assessment Team. 1993. Forest ecosystem management: an ecological, economic, and social assessment (FEMAT Report).

Ward, R.M.P and C.J. Krebs. 1985. Behavioural responses of lynx to declining snowshoe hare abundance. Canadian Journal of Zoology. 63:2817-2824.

Secondary Wide-ranging Mammal Targets for the Great Lakes Conservation Blueprint

Wolverine (*Gulo gulo*):

Home Range	*Habitat Requirements*
♦ Solitary & wide ranging ♦ Home range up to several hundred km^2 ♦ Apparently territory/range size depends on availability of denning sites and food supply	♦ Boreal forests, primarily coniferous ♦ Usually in areas with snow on the ground in winter ♦ Riparian areas may be important winter habitat ♦ When inactive, occupies den in caves, rock crevices, under fallen trees etc.

Wilson, D. E. 1982. Wolverine GULO GULO. Pages 644-652 *In:* J. A. Chapman and G. A. Feldhamer, Editors. Wild mammals of North America: biology, management, and economics. Johns Hopkins Univ. Press, Baltimore. 1147pp.

Caribou (*Rangifer tarandus*):

Home Range	*Habitat Requirements*
♦ Average home-range size of female caribou in boreal forest of northeastern Ont is 4026 km^2 ♦ Overall range sizes of female caribou in NE Ont were larger than those reported for caribou in other Boreal Forest regions across Canada	♦ Mature coniferous woodlands, to conifer tundra ♦ Also open or semi-open bog/fen and riparian palustrine habitats

Brown, G.S., F.F. Mallory and W.J. Rettie.– *in press*. Range size and seasonal movement for female woodland caribou in the boreal forest of northeastern Ontario.

Rettie,W.J., F. Messier. 2001. Range use and movement rates of woodland caribou in Saskatchewan. Canadian Journal of Zoology. 9:1933-1940.

Other Wide-ranging Mammal Species not targeted for the Great Lakes Conservation Blueprint

Moose (*Alces alces*):

Home Range	*Habitat Requirements*
♦ Adults may require 20-40 km^2. This varies greatly depending on habitat quality ♦ Home ranges may be up to several thousand hectares	♦ Prefers mosaic of second-growth forest, openings, swamps, lakes, wetlands. ♦ Requires water bodies for foraging and hardwood-conifer forests for winter cover. ♦ Young are born in protective areas of dense thickets.

Lawson, E.J.G. and A.R. Rodgers. 1997. Differences in home range size computed in commonly used software programs. Wildlife Society Bulletin 25:721-729.

Ontario Ministry of Natural Resources. 1990. The Moose in Ontario: Book 1- Moose Biology, Ecology and Management, Chapters 1-7. Queen's Printer for Ontario, Ontario Canada.

Gray Wolf (*Canis lupus*):

Home Range	*Habitat Requirements*
♦ Summer home ranges are smaller than winter ranges; annual range up to several hundred km^2, but may be much smaller (<50 km^2) ♦ May occasionally move several hundred km, especially dispersing young ♦ Vast areas needed to support wolf packs (549 km^2) and dispersing wolves (2564 km^2) ♦ FWS suggest a minimum of 10000 – 13000 km^2 (with low road density) might be necessary to support a viable population ♦ Max road density of 0.56 km/km^2 (beyond this point, the populations fail to sustain themselves) ♦ Road density threshold of 0.45 km/km^2 or less should be considered (above this, pack survival and fitness will decrease significantly).	♦ No particular habitat preference ♦ Usually occurs in areas with few roads, which increase human access and incompatible land uses but can occupy semi-wild lands if ungulate prey are abundant and if not killed by humans

Mech L.D. *et al.*, 1988. Wolf distribution and road density in Minnesota. Wildlife Society Bulletin. 16:85-87.

Mech L.D. 1989. Wolf population survival in an area of high road density. American Midland Naturalist. 121:387-389.

Mladenoff, D.J., R.G. Haight, T.A. Sickley and A.P. Wydeven. 1997. Causes and implications of species restoration in altered ecosystems. BioScience 47(1):21-31.

Mladenoff, 1995. A regional landscape analysis and prediction of favourable gray wolf habitat in northern Great Lakes region. Conservation Biology 9(2):278-293.

Thiel, R.P. 1985. Relationship between road densities and wolf habitat suitability in Wisconsin. American Midland Naturalist. 113:404-407.

US Fish & Wildlife Service. 1992 (Revised). Recovery Plan for the Eastern Timber Wolf. Original Recovery Plan Approved June 5, 1978. Prepared by the Eastern Timber Wolf Recovery Team for Region 3, US. Fish and Wildlife Service, Twin Cities, Minnesota. 73pp.

Wydeven, A.P., D.J. Mladenoff, T.A. Sickley, B.E. Kohn, R.P. Thiel and J.L. Hansen. 2001. Road Density as a Factor in Habitat Selection by Wolves and Other Carnivores in the Great Lakes Region. Endangered Species UPDATE. School of Natural Resources and Environment, The University of Michigan. July/August 2001. Vol 18(4) 93-192.

Pine Marten: (*Martes americanus*):

Home Range	*Habitat Requirements*
♦ Home range is quite variable, usually averages less than 10 km^2, may be larger when food scarce; male range usually is larger than female range ♦ Suitable marten habitat should be arranged in "core habitat areas" between 30 and 50 km^2 in size. A minimum of 75% of core habitat should be comprised of suitable stands (OMNR Martin Guidelines).	♦ Habitat usually in dense deciduous, mixed or (especially) coniferous upland and lowland forest. May use rocky alpine areas. ♦ When inactive – occupies hole in dead or live tree or stump etc. often associated with coarse, woody debris, in winter

Phillips, D.M., D.J. Harrison and D.C. Payer. 1998. Seasonal changes in home-range area and fidelity of martens. Journal of Mammalogy. 79:180-190.

Slough, B.G. 1989. Movements and habitat use by transplanted marten in the Yukon Territory. Journal of Wildlife Management. 53:991-997.

Watt, W.R., J.A. Baker, D.M. Hogg, J.G. McNicol and B.J. Naylor. 1996. Forest Management Guidelines for the Provision of Marten Habitat. Ontario Ministry of Natural Resources. Queen's Printer for Ontario. 30pp.

2005
ISBN 0-9695980-5-X

Printed on
Recycled Paper