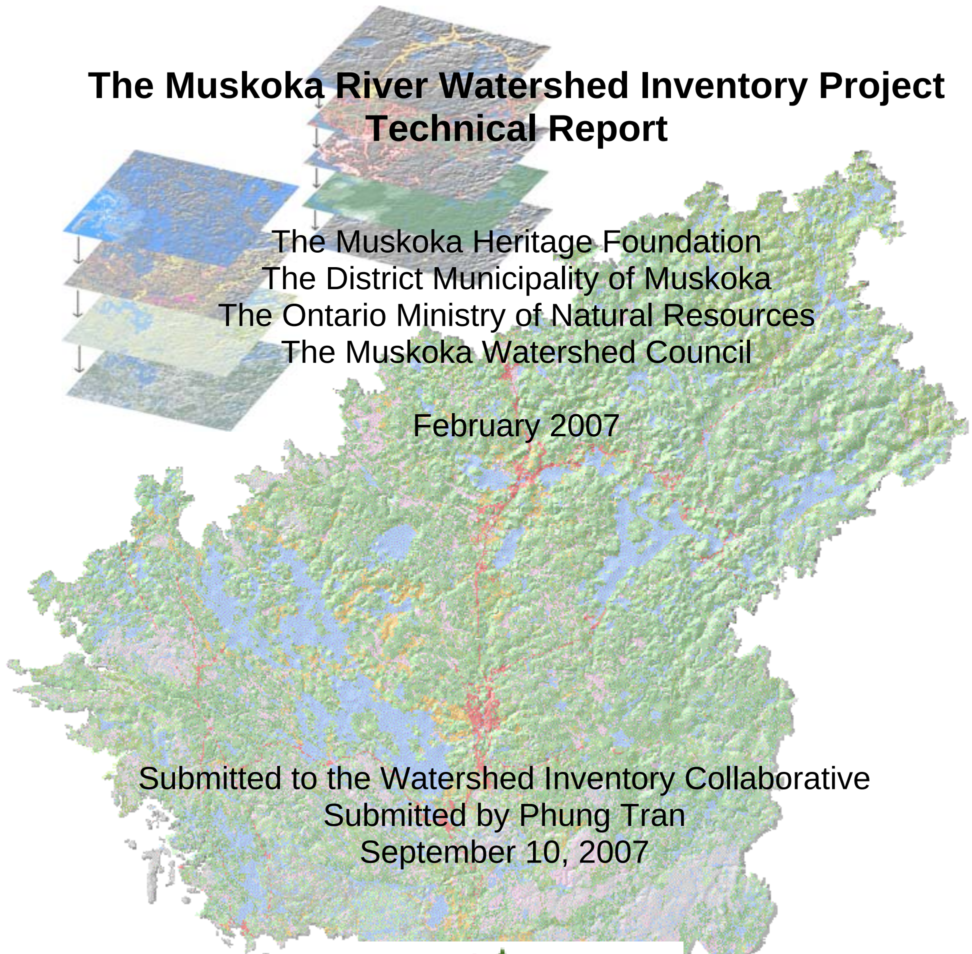

The Muskoka River Watershed Inventory Project
Technical Report

The Muskoka Heritage Foundation
The District Municipality of Muskoka
The Ontario Ministry of Natural Resources
The Muskoka Watershed Council

February 2007

Submitted to the Watershed Inventory Collaborative
Submitted by Phung Tran
September 10, 2007

THE ONTARIO TRILLIUM FOUNDATION
LA FONDATION TRILLIUM DE L'ONTARIO

THE DISTRICT MUNICIPALITY OF MUSKOKA

Ontario
Ministry of Natural Resources
Parry Sound District

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Executive Summary

The Muskoka River watershed is located on the Canadian Shield and contains many distinctive natural features that support a variety of flora, fauna and important ecological functions. The Muskoka River watershed is also an attractive location for people because of the vast number of pristine rivers, lakes, forests and other natural features located in close proximity to major town centres and cities. However, current trends in population growth and increasing development pressures are threatening the integrity and resiliency of these natural areas. On the other hand, these circumstances present a great opportunity to proactively protect natural features within the Muskoka River watershed that are still in exceptional condition and continue to support necessary ecosystem functions.

In 2005, the Muskoka River Watershed Inventory Project (the Inventory) was initiated. The Inventory was undertaken collaboratively by the Muskoka Heritage Foundation, Muskoka Watershed Council, District Municipality of Muskoka, and Ontario Ministry of Natural Resources. The purpose of the Inventory was to identify ecologically significant areas within the Muskoka River watershed using the best available datasets and further, to identify where there was a lack of existing protection for significant areas on both Crown and private land. It also identified whether or not these significant areas were connected across the landscape. The Inventory used a transparent, ecology-based methodology produced by the Nature Conservancy of Canada and the Ontario Ministry of Natural Resources who are leaders in defining and conserving significant areas based on best available ecological principles.

The results of the Inventory were intended for natural heritage planning, conservation, and restoration efforts of the collaborative project members and in the following manner:

1. The Muskoka Heritage Foundation, through the Muskoka Heritage Trust, will be able to establish priority areas for potential acquisition or remediation and therefore use limited resources efficiently.
2. The District Municipality of Muskoka will be able to use this information as background to a natural heritage strategy that will identify core natural areas and connecting systems and recommend levels of protection.
3. The Ontario Ministry of Natural Resources will be able to use the findings to assist with natural heritage planning on crown land throughout the watershed and add new information to the provincial database.
4. The Muskoka Watershed Council will be able to report the changes in the sustainability of natural areas and address watershed health through the Muskoka Watershed Report Card.
5. Along with the Muskoka Heritage Foundation, the Watershed Council will be able to use the products generated from MRWIP to develop education and stewardship programs.
6. All four collaborative members will continue to work together to promote the need for protected areas, and to encourage stewardship and education for natural heritage on both Crown and patent land in order to maintain and enhance a logical and continuous natural system.

This report provides information on the methodology and rationale behind the criteria, indicators and scores used for the Inventory, which is summarized below. It is a supplement to the Final Report, expected to be available in early 2007.

Methodology for the Inventory was developed and carried out to attain the following three goals:

1. Identify unique terrestrial ecosystems
2. Identify areas of high ecological importance
3. Identify stresses on ecosystems and process

To meet these goals, five criteria were considered: representation, ecological function, diversity, special features, and condition. In a GIS (geographic information system) environment, the five criteria were applied using the best available data to represent the objectives of the Inventory. The criteria were based on ecological principles of ecosystem health, which included:

- Representing some portion of each distinct terrestrial ecological system types;
- Representing features that support ecological function;
- The significance of diversity;
- The importance of special features; and
- Considering the stresses on ecosystem health.

Each criterion encompassed objectives by which natural features were evaluated. The objectives included identifying the following:

- Natural areas that exhibit high degrees of integrity and resiliency,
- Wetlands,
- Riparian areas,
- Recharge areas,
- Habitat diversity,
- Species occurrences,
- Wildlife habitat; and
- Condition or quality of natural areas.

Each objective was represented by GIS datasets, or indicators, which were scored accordingly. A higher score identified the feature as being valued for sustaining an ecosystem, while a low score represented the feature as not contributing to a healthy, functioning natural system. As well, each criterion was weighted based on their relative importance or significance to the overall score: ecological function represented 60% of the total score, diversity represented 5%, special features represented 15%, and condition represented 20% of the total score. The representation criterion was not given a score because it was used to identify ecological systems on which the other criteria were evaluated. All scored criteria were then amalgamated and produced a final scored dataset for the Muskoka River watershed.

Acknowledgements

The Muskoka River Watershed Inventory Project technical steering committee, consisting of the Muskoka Heritage Foundation, District Municipality of Muskoka, Muskoka Watershed Council, and Ontario Ministry of Natural Resources would like to thank many people who have given their support and assistance to this project.

The commitment and support of the colleagues within each collaborative organization was inspiring. We would especially like to thank Deb Pella-Keen, Rob Viejou, Anne Collins, Sam Itani, Dave Miles, Kirt Nelson, Andrew Oshier, Steve Scholten, Steve Taylor, Michelle Craigen, and Warren Dunlop of the Ontario Ministry of Natural Resources; Louis Chora of Ontario Parks; as well as Graham Good, Andrew Cooper and Margaret Stead of the District Municipality of Muskoka.

The release of the Great Lakes Conservation Blueprint was instrumental in the completion of this project. We are grateful to the scientific and technical expertise of Dan Kraus, Ric Symmes, Dave Mariott and Kara Brodribb of the Nature Conservancy of Canada; and Mike McMurtry and Bonnie Henson of the Natural Heritage Information Centre.

The tasks of data collection, processing and reviewing were less daunting with the help of Marty Martelle and Steve Munro of Westwind; James Holland of Ducks Unlimited Canada; Jennifer Aikman of the Ministry of Natural Resources; George Gao of the Ministry of Northern Development and Mines; Wendy Cooper of the Georgian Bay Land Trust; Andrew Promaine and Melanie Desjardins of the Georgian Bay Islands National Park; Kevin Houf of Algonquin Provincial Park; Dennis Fraser of Bancroft District MNR; and Wayne Higgins, Patricia Barcelos, and Charles Convis of the Environmental Systems Research Institute for support with software. We also thank Brent Wootton of Sir Sandford Fleming College; Erica Nol and Jennifer Winter at Trent Univeristy; and Reed Noss and Sumita Singh at the University of Central Florida for providing literature and expertise.

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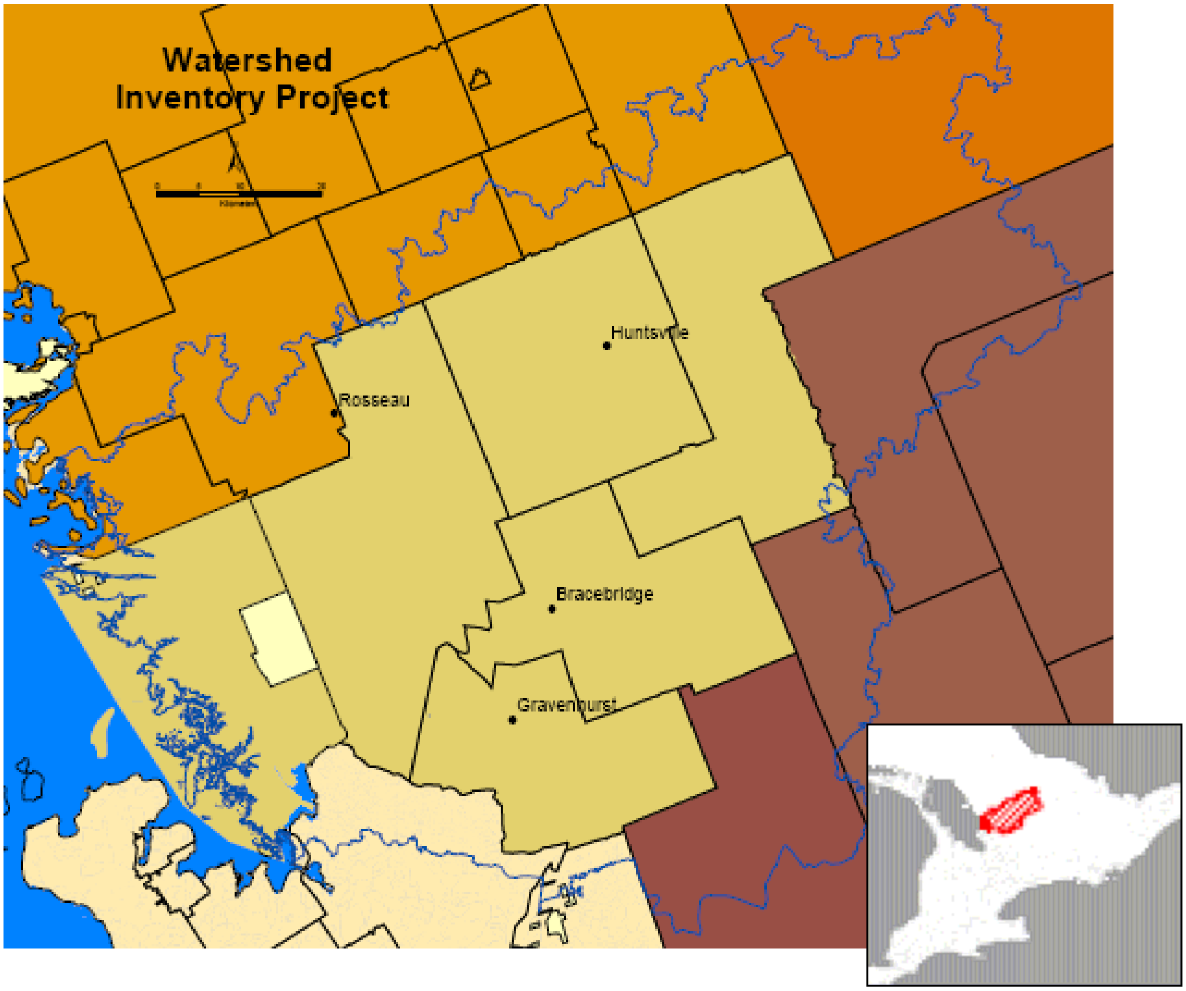

Figure 1. The Muskoka River watershed.

Introduction

The Muskoka River watershed is situated on the southern portion of the Canadian Shield in Ontario. The geographic location of the watershed creates many opportunities for both humans and wildlife. The combination of natural beauty and proximity to large population centres offers an attractive quality of life and generates a thriving tourism and recreation sector. The watershed also supports a variety of flora and fauna, providing a transition zone between the coniferous forest species of the north and the deciduous species of the south.

The Muskoka River watershed is recognized as having many unique and valuable features. Already, the watershed contains land under protection within provincially protected reserves and resource management units, which protect a number of features including ecological, scientific and economic values (OMNR 1997). Municipalities and land trusts within the watershed have also identified areas containing important natural heritage features, and safeguard them through planning policies and by encouraging landowner stewardship.

Existing protected areas within the Muskoka River watershed provide different levels of protection for a variety values. One of the many challenges is to determine whether existing protected lands adequately maintains and safeguards important ecological processes. If there are gaps in existing protection, future decisions based on conservation science will help ensure that significant natural areas are represented in a network of protected lands.

In recent years, organizations concerned with the conservation of natural resources have moved from a site-specific focus to a broader, landscape approach. A landscape approach ensures that a healthy, functioning network of protected areas preserves and maintains biodiversity and ecological function over time, as opposed to individual, independent pieces of protected land that may not be sufficient in supporting a diversity of connected ecological systems. Focusing conservation effort only on specific communities can create isolated patches that do not safeguard a whole suite of ecological processes (Noss 2002).

Watersheds are often used as a natural ecosystem unit to evaluate and manage natural resources on a landscape scale (Conservation Ontario 2006). Watersheds contain a mixture of habitats and ecosystem processes that influence and interact with each other. Watersheds come in a variety of shapes and sizes and often cross municipal, provincial and international borders. Assessing ecological systems and processes using a watershed unit is logical at a landscape scale, since watershed borders are ecologically based, not politically influenced.

One of the most fundamental elements of landscape-scale conservation is the need for organizations to take a systematic approach to ensure that investments in protection meet fundamental principles and concepts of conservation biology (Noss 2002). A network of protection must represent a full variety of biodiversity, promote and maintain ecological processes and the long-term survival of species (Margules and Pressey 2000), as well as maintain healthy, vibrant human communities.

In Ontario, many conservation authorities, municipalities and non-profit organizations have taken on the challenge of identifying and evaluating natural systems based on the best available data, but also accept the fact that new data are constantly becoming available, and that science will invariably progress and provide more information to our understanding of natural systems.

The Muskoka River Watershed Inventory Project provides a solid base for future natural heritage work of the collaborative members by identifying areas of high ecological importance. Along with summaries of the analyses and recommendations for next steps, the Inventory project included the following products:

1. A gap analysis of unprotected vegetation communities and landforms;
2. A gap analysis of biological data and site inventories;
3. A map portraying the significant natural areas and connecting corridors;
4. Identification of significant degraded sites and areas that may require remediation.

To produce these products, the Muskoka River Watershed Inventory used a landscape, ecology-based, and scientifically defensible approach and methodology used by experts with decades of experience in natural heritage and conservation planning. The Muskoka River Watershed Inventory project was guided by a Technical Committee comprising representatives of the four core project collaborators - Muskoka Heritage Foundation, Muskoka Watershed Council, the District Municipality of Muskoka, and the Ontario Ministry of Natural Resources - who are members of their respective communities including: biology, land trust associations and natural resource and urban planning. From this point forward, The Muskoka River Watershed Inventory Project is referred to as the "Inventory".

Background

Coarse Filter and Fine Filter Analysis

In Ontario, the Ministry of Natural Resources (MNR) is a leader in landscape-scale natural heritage analyses, with years of experience in research, and protected areas systems planning (island biogeography, design principles, selection criteria, Areas of Natural and Scientific Interest, management plans, Ontario Lands for Life). The widely accepted approach for setting and filling natural heritage targets follows a "coarse-filter/fine-filter" set of methodologies. The MNR practice five key steps in its natural heritage gap analysis methodology (Crins and Kor 2000):

1. Identify landform features
2. Identify vegetation features on each landform unit
3. Assess existing representation
4. Identify the gaps
5. Identify criteria to fill the gaps

The first step involves using enduring features of a landscape, including geological features such as bare rock, eskers and kames. Enduring features are landform components that form the primary source of ecological diversity (Iacobelli et al. 2003) and provide the basis for creating a network of protected areas that is intended to be permanent (Schneider 2001). This first step is the coarse-filter analysis.

The second step is to identify the vegetation response to the enduring landform features. Specific conditions are required for different types of vegetation, including variations in climate and physiography. These represent unique ecological systems (Iacobelli et al. 2003), and examples include tolerant hardwood forest on bedrock or hemlock on organic deposits. This next step is a fine-filter examination. The coarse-filter and fine-filter are methods to define the landscape as ecological units that would represent a broad range of flora, fauna, and ecological processes.

The remaining steps assess which of the unique ecological systems are represented in protected areas and thus identify systems that are not protected -"the gaps". These gaps in representation need to be evaluated using a set of criteria that will apply key principles of conservation biology and ecology to ensure that the best areas are included for protection (Crins and Kor 2000).

Since it is not possible to place all land under protection, the gap analysis identifies areas that are highly valuable (from an ecological perspective), or areas that require immediate attention (such as the last remnant ecological system that contains a rare species). Current principles in conservation biology and ecology are used to guide the evaluation.

Ecological interactions are complex, and even the most heavily studied natural systems are not fully understood. However, producing a comprehensive inventory will ensure that essential interactions are captured. The coarse-filter is used to catch a very broad range of wildlife and its associated interactions, whereas, the fine-filter picks-up more specific critical habitat of specialized species, which may not be identified in the coarse-filter. The MNR gap analysis process was adapted for the Inventory to produce a comprehensive collection of datasets and help achieve the objectives of identifying significant unprotected vegetation communities and landforms.

The Great Lakes Conservation Blueprint for Biodiversity

In 2005, The Nature Conservancy of Canada and Ontario Ministry of Natural Resources released The Great Lakes Conservation Blueprint for Biodiversity (GLCB). The completed project is a comprehensive, eco-region wide effort to identify the most important areas for conserving native biodiversity within the Great Lakes basin in Canada. The Nature Conservancy of Canada employs a Science Advisory Network (SAN) comprising leading scientists and specialists in the conservation field to assist and advise on science standards and frameworks. Hence, the GLCB used a scientific approach to identify important areas for conservation and protection, and considered a suite of criteria and indicators to represent the most current ecological concepts to sustain all elements of terrestrial biodiversity. In order to identify the best sites and develop a priority for protection, the GLCB assigns numerical scores to multiple datasets. The scores are assigned according to their ecological value to convey the relative ecological influence of a particular dataset, for example, roads are known to have a negative effect on ecological systems and thus scored low, while areas with high percentage of natural cover are scored high. Also, scores are adjusted according to the relative importance of a particular criterion in relation to other criterion and is represented by a percentage of the overall score. For example, the “ecological function” criteria represents 60% of the overall score of an ecological system, and “diversity” represents 5% of the overall score (Henson and Brodribb 2004; Henson et al. 2005).

One objective of the GLCB was to produce an analysis methodology that could be replicated and enhanced with more site-specific data for use in conservation inventory projects by other organizations, realizing that goals and objectives will vary depending on the challenges and availability of data for each organization. GLCB intentionally used the suite of criteria of the previously mentioned coarse-filter/fine-filter MNR Natural Heritage Gap Analysis (Crins and Kor 2000) to ensure that their targets captured a broad collection of requirements for assessing ecological processes.

The completed Great Lakes Conservation Blueprint for Biodiversity required enormous contributions from experts in the fields of biology, landscape ecology, geographic information systems, spatial analyses, and natural heritage planning. The Inventory borrowed the original principles and concepts, as well as the methodologies, of the GLCB, and refined them with additional data to meet more specific goals of the Inventory collaborative. The techniques described in this report parallels the methodologies used for the terrestrial Canadian Shield portion of the Great Lakes

Conservation Blueprint for Biodiversity (See Henson and Brodribb 2004; Henson et al. 2005). The values used for the scoring of each objective is based on the GLCB scoring regime, however the Inventory cautiously manipulated the scores in order to reflect the importance of objectives specific to the Muskoka River watershed. This approach is encouraged by the GLCB project team (D. Kraus pers. comm. March 24, 2006; K. Brodribb pers. comm. June 1, 2006). Appendix A reveals the weighting and scores for the Inventory project.

C-Plan, decision support software

The Great Lakes Conservation Blueprint produced a portfolio of sites that, if conserved, would preserve biodiversity and ecological processes across the Canadian portion of the Great Lakes Basin. Although the Inventory borrowed heavily from the GLCB methodology, there was one major difference that should be mentioned. The GLCB utilized a decision support software that was developed for conservation planning applications known as C-Plan. C-Plan required specific targets be set in order to identify a minimum number of sites that meet defined targets. For GLCB, the Nature Conservancy of Canada (NCC) set species targets (for example, declining species and/or disjunct species) in order to prioritize the highest scored sites identified in the analysis. The main reason for using C-Plan was to identify a "portfolio" of the most desired sites to meet conservation targets set by NCC. By entering the highest scored sites based on the suite of criteria and the sites that contain defined targets into the software, C-Plan identified sites that met the targets. C-Plan was not used for the Inventory because there were no specific conservation targets set. Although, the partners of the Inventory had a similar mandate of identifying high quality sites, the diversity of the collaborative members allows conservation and protection of sites at many different levels. The collaborative members will use the resulting scored sites to support each of their own agendas. For example, the Muskoka Heritage Foundation will have the ability to assess relative scores of sites for prioritizing land acquisition, or identify sites with high ecological value, but contain low condition scores to prioritize for restoration efforts; while the District Municipality of Muskoka has the ability to evaluate scored natural heritage areas and delineate appropriate levels of development around significant sites. As well, the Inventory identified additional significant areas that would link important core sites, thus using the results of the entire scored watershed, and not only the highest scored sites.

The Inventory used a scientific approach to identify ecologically significant sites within the Muskoka River watershed. The Inventory collaborative members chose to utilize the experience and expertise of the Ontario Ministry of Natural Resources and the Nature Conservancy of Canada to help develop a network of ecologically important sites. By borrowing from the coarse-filter/fine-filter natural heritage gap analysis and the GLCB project methodologies, the Inventory ensures that a comprehensive, logical network of significant sites is considered for preserving the unique natural heritage of the Muskoka River watershed.

Goals, criteria, objectives and indicators

Methodology Approach

Table 2 identifies the goals, criteria, objectives, and indicators used for the Inventory. The Inventory defined three specific goals that guided the production of the final products. The first goal was to categorize unique ecological systems across the landscape and identify systems that are not under existing protection. The second goal identified areas of high ecological importance to terrestrial ecological systems, and the third goal identified the stresses upon terrestrial ecological systems and processes. Each goal consisted of a comprehensive list of criteria. Under each criterion, specific objectives were captured by using indicators.

In a GIS environment, the assessment of natural systems required using surrogates, or indicators, to characterize the objectives (Margules and Pressey 2000; Noss 2002). More specifically, the indicators were the digital datasets used to evaluate the objectives of the Inventory. For some objectives, indicators were obvious, such as using a dataset of wetlands to identify wetlands, while other indicators required manipulation in order to achieve the objective, such as selecting specific sizes of natural sites to represent areas that exhibit degrees of ecological integrity and resiliency (Table 2). The indicator was a digital representation of the objective that could be mapped, manipulated, and analyzed in a GIS environment.

Report Organization

This report provides information on the methodology and rationale behind the criteria, indicators and scores used for each goal of the Inventory. This report is organized according to Table 2: under each goal, the criteria and objectives are described, as well as the corresponding indicators.

The datasets and methods described below are general descriptions. For information on each dataset, refer to Appendix B; for GIS flowcharts, refer to Appendix C.

GIS Basics

Spatial and Non-spatial data

Geographical Information Systems (GIS) is a powerful tool for representing and analyzing features found on the Earth’s surface. GIS has the ability to connect spatial data (features on the Earth’s surface) and non-spatial data (attributes or information about the features) in one location. As more and more data are being collected digitally worldwide, GIS provides the ability to store, maintain, retrieve, update, and display a large amount of information. Geographic data link to specific positions on the Earth’s surface and are stored as digital layers which represent specific themes, such as roads or lakes, along with their attributes, such as road names or area measurements. GIS relates these themes and has the ability to define relationships, such as finding the percentage of roads within a defined proximity of a major lake. Many industries now use GIS in their applications, including land-use planning, natural resource management, real estate, and emergency planning.

Vector and raster GIS

There are two main types of geographic data used in the Inventory, vector and raster data. Vector datasets represent themes as points, lines, or polygons. Points can represent features such as stop signs or bird nests; lines represent features such as roads or streams; polygons represent features with area such as large buildings or lakes. Raster datasets store geographic information into a grid or a series of equally-sized cells (or pixels). Each cell represents an area on the Earth’s surface and contains a value that corresponds with that specific feature. Each data type can be used for different purposes because each has advantages and disadvantages in GIS analyses (Figure 2, Table 1).

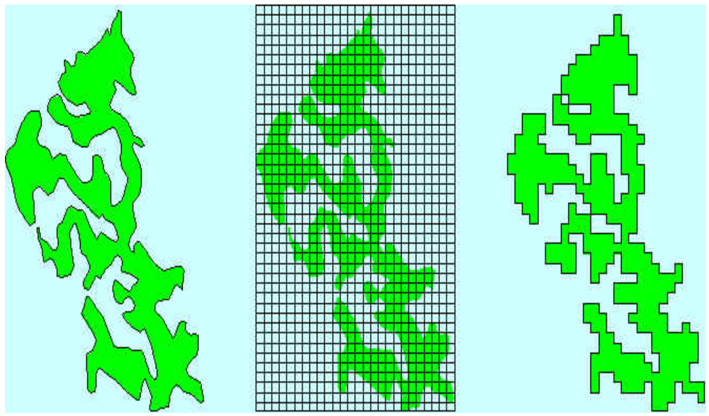

Figure 2. Example of Vector and Raster GIS. Source: University of Rhode Island, http://www.edc.uri.edu.

Table 1. Advantages and disadvantages of raster and vector data types. Source: University of Rhode Island, http://www.edc.uri.edu.

	Advantages	**Disadvantages**
Raster	Good for complex analysis	Large datasets
	Efficient for overlays	Topology hard to represent
	Data structure common for imagery	Maps less "realistic"
Vector	Compact data structure	Complex structure
	Efficient for encoding topology	Overlay operations difficult
	True representation of shape	Might imply false sense of accuracy

The Inventory used both vector and raster types, depending on the type of geoprocessing and/or analysis. Vector data types are easier for simple geoprocessing operations, such as clipping, whereas raster data types are used for more complex analyses, such as analytical/mathematical operations. The cell size used for grids was 25m (5mx5m). This cell size was also used for the GLCB analyses. Cell size is an integral part of using raster GIS. Smaller cell sizes will result in a greater total number of cells within a grid, representing more detail, but contributes to longer computer processing time during analyses. The cell size of 25m matches the Inventory needs at a landscape-scale, but can be used at a site-specific scale, and is appropriate for the time schedule of the project as well. It is important to note that vector data types can be converted into raster and vice versa.

Preparing the Datasets

There were general GIS steps that were applied to each dataset in order to prepare each indicator for analysis:

1. Each vector data layer was clipped to the shape of the Muskoka River watershed.
2. Each layer was projected into NAD83 UTM Zone 17, GRS_1980.
3. After manipulation of the vector data (i.e. applying buffers), each data layer was converted into a raster format and assigned appropriate scores for the remaining analyses.

The Inventory used ESRI ArcView 3.2, ArcGIS 8.2 and 9.1, and available tools including Spatial Analyst, Patch Analyst (Rempel and Carr 2003), and Hawth's Analysis Tools (Beyer 2002) to classify, process, analyze, and map collected digital datasets. All spatial data used in the Inventory were projected to NAD83 UTM Zone 17, GRS_1980 (see Appendix B for information about datasets).

Table 2. The goals of the Muskoka River Watershed Inventory Project, and the criteria, objectives and indicators used to achieve these goals.

Goal	Criterion	Objective	Indicator
Identify terrestrial ecosystems and protected areas	1. Representation	(a) Identify all terrestrial ecosystems within the watershed and their protection status	(i) Landform and vegetation associations (terrestrial ecosystems) (ii) Existing protected areas
Identify areas of high terrestrial ecological importance	2. Ecological Function	(a) Identify natural areas that exhibit high degree of integrity and resiliency	(i) Size of discrete terrestrial ecosystems (ii) Presence of old growth forests (iii) Interior size of discrete terrestrial ecosystems
		(b) Identify wetlands	(i) Presence of wetlands
		(c) Identify riparian areas	(i) Riparian area of stream/rivers, inland lakes, and Great Lakes shoreline
		(d) Identify recharge areas	(i) Highly permeable areas
	3. Diversity	(a) Identify habitat diversity	(i) Habitat diversity
	4. Special Feature	(a) Identify species element occurrences, vegetation communities, and other significant wildlife habitat	(i) Species and vegetation community occurrences (ii) Important habitat areas
Identify stresses on terrestrial ecosystems and processes	5. Condition	(a) Identify condition/quality of watershed	(i) Percentage natural cover (ii) Influence of settled areas (iii) Influence of open cleared areas such as agricultural lands and golf courses) (iv) Influence of pits and quarries (v) Influence of hydro lines (vi) Influence of railways (vii) Influence of roads (viii) Influence of trails

Goal: Identify terrestrial ecological systems and protected areas

As mentioned earlier, the Inventory defined three specific goals that guided the production of the final products. The first goal was to categorize unique ecological systems across the landscape and identify systems that are not under existing protection. For the purpose of this Inventory, terrestrial ecological systems mean unique combinations of landforms (as characterized by quaternary geology data) and vegetation (as characterized by Forest Resource Inventory mapping and satellite imagery). The level of existing protection was then evaluated for the terrestrial ecological systems. The motive for this goal was to ensure that a consistent, rational method was used for evaluating and comparing elements of the landscape and to flag ecological systems that were not represented in any protection. The final report summarizes the ecological systems identified within the Muskoka River watershed and their protection status.

Criterion:

1. **Representation**

In order to identify significant sites, basic land units were chosen on which the criteria were applied. A "coarse-filter" analysis was used which combined landform and vegetation data to identify a range of ecosystem types. The approach ensures that habitat requirements of a whole suite of species were considered within a network of protected areas (Noss 1992; Crins and Kor 2000; OMNR 2001; Schneider 2001). This approach was an efficient method which could capture 85-90% of all species (Noss 1987; Hunter 1991).

Identifying all ecological systems within the watershed identified natural systems that were already represented in existing protected areas. Recognizing natural areas that were already represented would allow focused effort on those sites that are of high terrestrial ecological importance and not currently under sufficient protection status.

Objective:

a. **Identify all terrestrial ecological systems within the watershed and their protection status**

Indicator:

i. **Landform and vegetation associations (terrestrial ecological systems)**

The relationship between landforms and vegetation communities is referred to as ecological systems. Ecological systems (or ecosystems) consist of living and non-living elements of an area and their interactions.

For the Muskoka River watershed study area, ecological systems were made up of dominant vegetation and the landform feature on which they occurred. The combination of non-living elements (landform) and the response of living features (vegetation) to those enduring elements create unique ecological units that support a matrix of animal populations and ecological functions. Ecological systems provided practical, systematically defined units for GIS mapping (Comer et al. 2003). Ecological systems were used as the basic unit in a GIS environment to measure the value of natural areas for the Inventory. Hence, ecological systems were used throughout the methodology to identify specific indicators and from this point forward are referred to as Terrestrial Ecological Systems in this report. The final report summarizes the unique ecological systems found within the Muskoka River watershed.

Dataset(s)

MNDM (Ministry of Northern Development and Mines) quaternary geology was the most up-to-date and comprehensive dataset for landform information for the Muskoka Watershed at the time of this report. Examples of landform types found in the Muskoka River watershed included undifferentiated igneous and metamorphic rock, exposed at the surface or covered by a discontinuous, thin layer of drift (bedrock) and fluvial deposits of gravel, sand, silt and clay (glaciofluvial) (Figure 3).

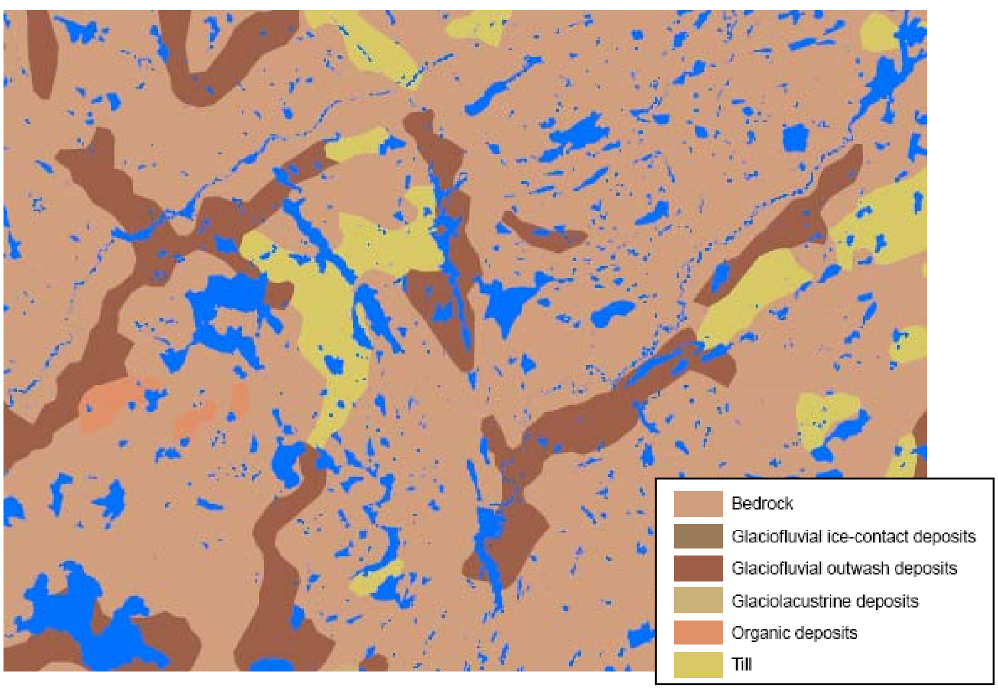

Figure 3. Example screenshot of landform types found in the Muskoka River watershed.

Two datasets were used to capture the vegetation attributes for the Muskoka River watershed. Forest Resource Inventory (FRI) was up-to-date on crown-owned land and about 20-years old for most privately owned land in Muskoka. FRI data was specifically used for forestry, and based primarily on field-collected data and aerial photography, therefore, the database was specific and detailed for species composition and age structure of forested areas. FRI data also included information for non-forested areas, however, the non-forested data was not as comprehensive. Some of the limitations for FRI non-forested areas included, lack of data on wetlands (mostly classified as "muskeg" and "brush and alder" stand types), and areas recorded as "unclassified" (such as for developed areas). To fill this gap, additional wetland datasets and land-cover mapping derived from satellite imagery were used.

Land-cover mapping was based on a remote sensing technique using satellite imagery. Land-cover type was classified according to how light reflected off objects on the ground. As a result, the imagery show the extent of land-cover, but did not identify species for forest stands. For example, patches represented a deciduous forest stand, but not the types of trees within that deciduous forest stand. Although the land-cover mapping database was not as detailed as FRI for forested areas, land-cover mapping did contain data that identified wetlands, and areas that were "unclassified" in the FRI database. Land-cover mapping was used in this project to provide additional wetland classification, and to substitute "unclassified" FRI data, producing a more comprehensive vegetation dataset (Figure 4).

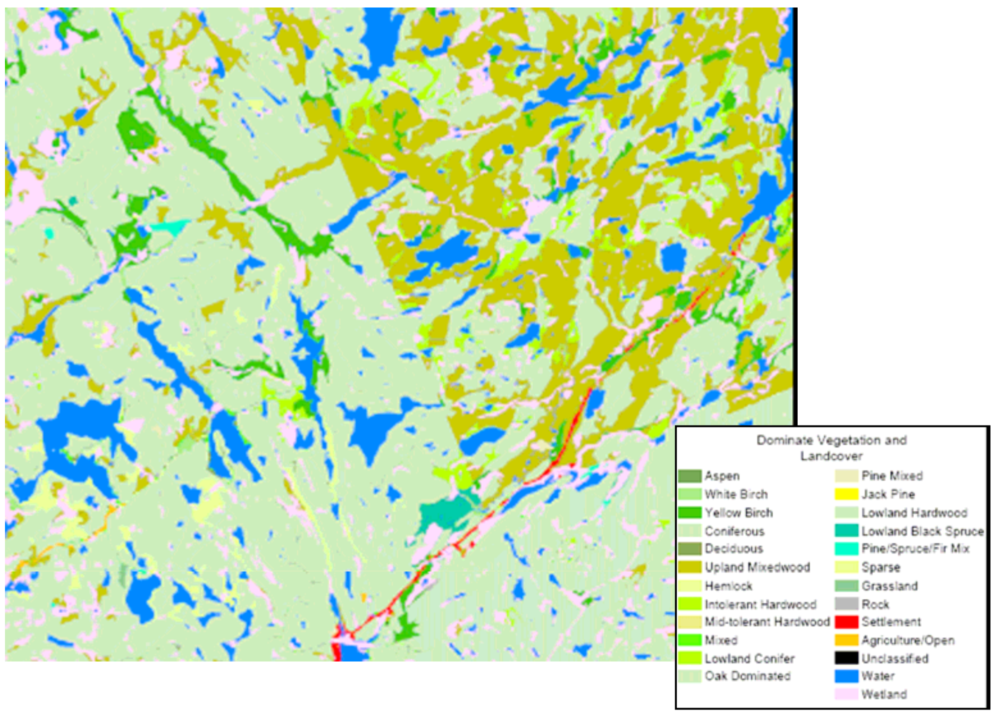

Figure 4. An example screenshot of dominant vegetation and land-cover types found in the Muskoka River watershed.

The combination of MNDM quaternary geology, FRI and Land-cover (2000) mapping covered 99.53% of ecodistrict 5E-7, 99.20% of ecodistrict 5E-8 and 100% of 5E-9 (OMNR 2005).

Methodology

The following datasets were used:

Dataset Name	Time coverage	Responsible Agency
Quaternary Geology of Ontario	1955-1988	Ministry of Northern Development and Mines
Ontario Forest Resource Inventory: Parry Sound, Bancroft, Algonquin Provincial Park	2003-2006	Ontario Ministry of Natural Resources
Provincial Landcover 2000	1999-2002	Ontario Ministry of Natural Resources
Agricultural Land	1998	Ontario Ministry of Natural Resources
Muskoka District Enhanced Wetland Mapping	1988-2002	Ducks Unlimited Canada and Ontario Ministry of Natural Resources
Evaluated Wetland	1980-2006	Ontario Ministry of Natural Resources
Waterbody Segment	1977-2006	Ontario Ministry of Natural Resources
Wetland Unit	1997-2006	Ontario Ministry of Natural Resources

As mentioned earlier, the terrestrial ecological systems dataset was the base layer on which the criteria were applied. Land cover is a complex mixture of natural and anthropogenic influences (Cihlar 2000). Hence, the completed dataset identified terrestrial ecological systems, as well as, developed agricultural lands, other cleared and open areas, settlement areas, wetlands, water and unclassified forest stands (Figure 5). The following were preliminary datasets created and overlaid to produce the terrestrial ecological systems dataset.

A landform layer:

- Quaternary geology by geological deposition and material descriptions

A non-forested ecosystem layer (described from FRI, provincial land-cover mapping, and other provincial datasets):

- Barren and scattered
- Rock
- Developed Agricultural lands
- Cleared and open areas
- Grass and meadow
- Settlement
- Water
- Unclassified/unsurveyed stand types

A wetlands layer:

- Muskeg and brush and alder stand types (FRI)
- Provincial land-cover mapping wetlands
- Ducks Unlimited identified wetlands
- Provincially identified wetlands
- Provincially evaluated wetlands

A forested ecosystems layer:

- FRI forested stand types
- Provincial land-cover mapping (for unclassified/unsurveyed FRI data)

The general approach taken was as follows:

1. Queried and classified quaternary geology based on Age, Geologic Deposition and Material (Appendix C)
2. Queried and classified a forested dataset based on FRI stand working groups
3. Queried, classified, and amalgamated a non-forested dataset based on FRI codes and types, and Provincial Landcover 2000 mapping classifications (Appendix C)
4. Queried, classified, and amalgamated a wetlands dataset based on FRI identified wetlands, Provincial Landcover 2000 classifications (Appendix C), NRVIS wetlands, and Ducks Unlimited Canada wetlands
5. Unioned the geology dataset with the forested dataset to create a landform/vegetation dataset
6. Merged the landform/vegetation dataset with the non-forested dataset and the wetlands dataset to create the final terrestrial ecological systems dataset

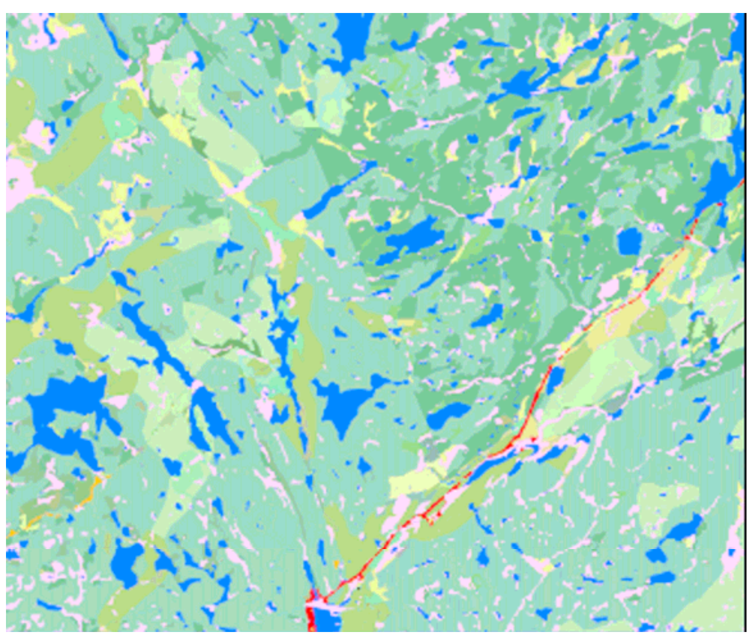

Figure 5. Landform and vegetation associations example screenshot

(Please refer to Appendix D for descriptions of unique landform and vegetation associations, terrestrial ecological systems).

Indicator:

ii. Existing protected areas

There were many portions of the Muskoka River watershed that were under various levels of protection. The Inventory divided these particular lands into three divisions, portraying the levels of protection afforded to these areas:

Level 1:
These areas provide full protection of natural areas through strictly regulated planning policies.

- Conservation Reserves
- Provincial Parks
- National Parks
- Muskoka Heritage Trusts
- Other Trust properties

Level 2:
These areas either fully or partially protect natural areas depending on policies and agreements with a variety of users, including private land-owners, industry and/or other agencies.

- Enhanced Management Areas
- Crown Land
- Provincially Significant Wetlands
- Muskoka Heritage Areas
- Muskoka Heritage Foundation Easements

Level 3:
These areas are protected from incompatible land-use decisions related to development and site alteration through zoning and official plans of municipalities. Only ANSIs and significant evaluated wetlands are protected through the Provincial Policy Statement's Planning Act.

- ANSIs (confirmed)
- All other wetlands

Private land was not considered in any protection level. Although, some privately owned land is protected from various ecologically harmful development or managed in an environmentally conscious manner through different methods (MFTIP, landowner stewardship), it was difficult to partition such variability into rational protection or conservation levels. Although, it should be mentioned that some private land do fall into one or more of the mentioned levels of protection, also.

Methodology

The following datasets were used:

Dataset Name	Time coverage	Responsible Agency
Muskoka District Enhanced Wetland Mapping	1988-2002	Ducks Unlimited Canada and Ontario Ministry of Natural Resources
Terrestrial Ecological Systems	2006	Muskoka River Watershed Inventory
Conservation Reserve Regulated	1994-2006	Ontario Ministry of Natural Resources
Provincial Park Regulated	1900-2004	Ontario Ministry of Natural Resources
Muskoka Heritage Trust Properties	2006	Muskoka Heritage Foundation/Trust
Georgian Bay Land Trust Properties	2006	Georgian Bay Land Trust
Nature Conservancy of Canada Properties	2006	Nature Conservancy of Canada
Ownership Parcel - Digital Ownership Parcel Fabric	1960-2004	Ontario Ministry of Natural Resources
Muskoka Heritage Areas	1993	Muskoka Heritage Foundation and The District Municipality of Muskoka
Muskoka Heritage Trust Properties	2006	Muskoka Heritage Foundation/Trust
ANSI	1997-2006	Ontario Ministry of Natural Resources

For each level of protection, the general approach taken was as follows:

1. Unioned datasets for each level
2. Overlaid onto landform and vegetation dataset
3. Calculated statistics to identify terrestrial ecological systems and their level 1, 2 and 3 protection status respectively

Note: This created three different maps and statistics for each level of protection.

To identify terrestrial ecological systems with no protection status at any level:

1. Unioned datasets for all levels
2. Overlaid onto landform and vegetation dataset
3. Calculated statistics to identify terrestrial ecological systems with no protection status at any level

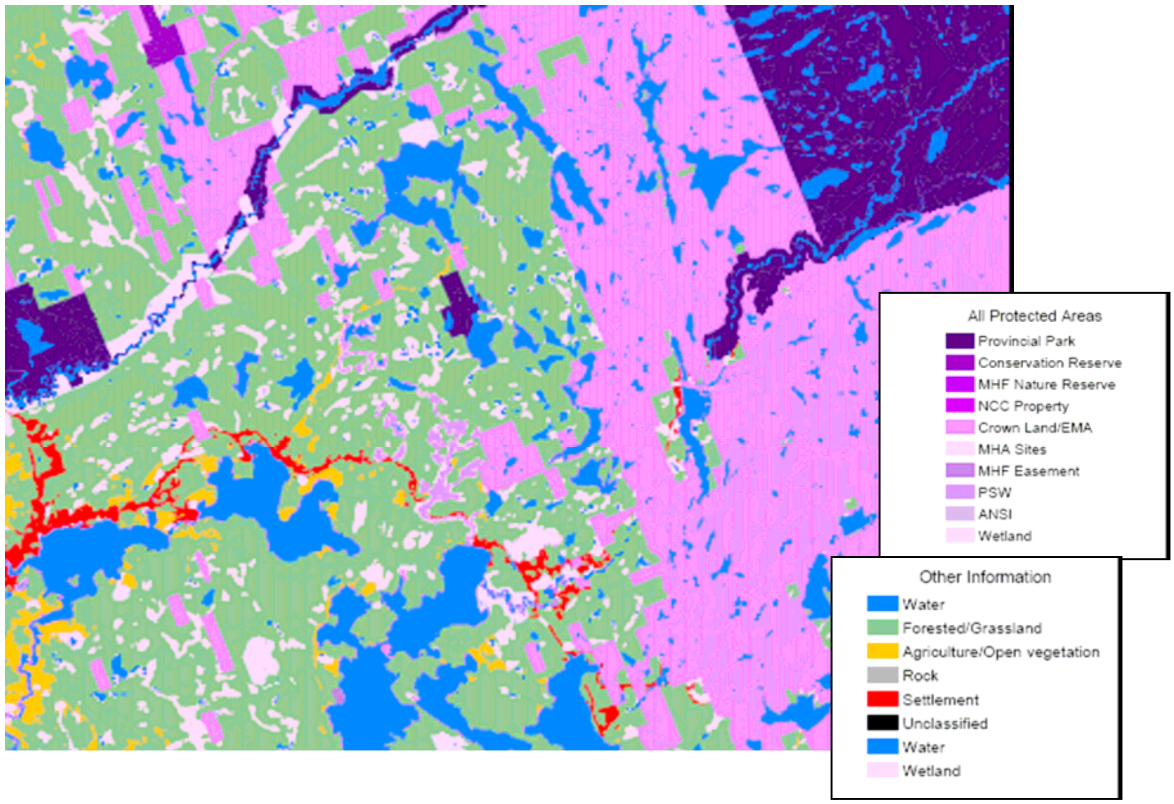

Figure 6. All levels of protection and terrestrial ecological systems example screenshot.

Goal: Identify areas of high terrestrial ecological importance

Again, the Inventory defined three specific goals that guided the production of the final products. The previous section describes the first goal, which was to categorize unique ecological systems across the landscape and identify systems that are not under existing protection. The second goal identified areas of high ecological importance. Based on the most current ecological principles and concepts, ecological systems were evaluated for their ability to support and maintain ecological processes. The motive for this goal was to identify those areas within the Muskoka River watershed that had the greatest value for ecological processes. The criteria, objectives, and indicators for this goal were evaluated based on the expectation for areas to support and maintain ecological processes, not on the quality or condition of these areas. For example, an indicator to represent riparian areas of rivers and shorelines used a specified buffer distance that would be sufficient for certain ecological processes in a riparian area, but this distance was considered regardless of the land uses within the buffer.

Criterion:
1.Ecological Function

Ecological systems consist of unique interactions between biotic (living) and abiotic (non-living) features. The role, or function, of these biotic and abiotic components is involved in maintaining the ecological and evolutionary processes within the system (Noss 1990).

Conserving ecological processes or function was one of the most important elements of ensuring a healthy, functional watershed. Thus, ecological function criterion was weighted heavily compared to the other criteria. The Inventory used the GLCB weighting of 60% of the total score for the ecological function criterion.

Objective:

a. **Identify natural areas that exhibit high degree of integrity and resiliency**

Indicator:

i. **Size of discrete terrestrial ecological systems**

One of the most important factors in maintaining integrity and resiliency of natural areas is size. Size of forested areas is correlated with species richness and affects intricate relationships and conditions for successful species survival (Freemark and Collins 1992; Daigle and Havinga 1996; Burke and Nol 1998; OMNR 1999; Burke and Nol 2000; Debinski and Holt 2000; Austen et al. 2001). Size of natural areas is a factor in the ability for species to move between habitat types (Dorp and Opdom 1987; Buechner 1989), and perform critical evolutionary activities, such as reproduction (Burke and Nol 2000). Size of natural areas also affects the ability for natural areas to recover from disturbances by allowing immigration and emigration of species (Picket and Thompson 1978; Buechner 1989; Romagni and Gries 2000; Wiersma et al. 2004).

Determining appropriate size of natural areas that would retain elements for integrity and resiliency of ecological systems was a challenge. In the literature, minimum patch sizes are recommended for certain elements of biodiversity and ecosystem function. For Southern Ontario, where the landscape is highly fragmented, prioritizing patch sizes by minimum size recommendations preserves what remains of natural areas, however, this method does not necessarily capture elements of integrity or resiliency. In landscapes with more contiguous, unfragmented natural areas, there is a greater opportunity to preserve large patches. The GLCB used fire disturbance size to capture ecological systems that were large enough to recover and persist on the landscape. Using fire disturbance regime as an indicator of size was appropriate for the Muskoka River watershed area because natural disturbance processes are an important part of the natural environment and many species have adapted to these regimes (Picket and Thompson 1978; Baker 1992). For areas on the Canadian Shield, in the Boreal and Great Lakes-St. Lawrence forest regions, natural succession relies on a fire disturbance regime (Picket and Thompson, 1978; Baker 1992; Hunter 1993; OMNR 2001; Schneider 2001; Henson et al. 2005; M. McMurtry, pers. com. April 20, 2006).

The Muskoka River watershed occurs within the Great Lakes-St. Lawrence forest region, which harbors a mix of deciduous tree species commonly found in Southern Ontario, and coniferous species that are commonly found in the Boreal forest region. As a result, historical fire frequency information for Muskoka shows a longer fire return interval than Boreal forest types (Uhlig et al. 2001; OMNR 2003). Fire and other anthropogenic activities and structures, such as roads and timber harvesting have affected the frequency and number of fires in this area (Uhlig et al. 2001; OMNR 2003; Henson et al. 2005). All of these factors affect the fire disturbance data used to calculate patch sizes.

The terrestrial ecological systems layer was used to calculate and select patches of existing terrestrial ecological systems. These patches were compared to average disturbance patch sizes from Ontario fire disturbance databases available through the MNR. The fire databases included all fires from 1976 to 1998 and all fires greater than 200ha from 1920 to 1996, and contained information on area burnt (ha per year) and fire cycles (in years). Taking into account that a disturbed area requires enough surrounding terrestrial ecological systems to persist on the landscape, the GLCB (Henson et al. 2005) applied a four-times rule: an area should be at least four-times the patch size of the disturbance area in order to recover and continue to function as an intact system. The GLCB consensus decision of the four-times rule would sustain an average four-quartile (at least ¾) suite of successional stages over the long term. Hence, the terrestrial ecological systems layer was scored based on discrete terrestrial ecological system patch sizes that were four-times the size of the average disturbance patch size determined from the MNR fire disturbance databases.

Dataset(s)

The MNR fire data on fire size and fire cycles were used by GLCB to calculate the approximate burnt area (in hectares) and this information was used to determine the size targets (Table 3, Henson et al. 2005). The terrestrial ecological systems layer was then dissolved to major ecosystem types in order to determine patch sizes (of similar terrestrial ecological systems) to which the size targets were applied. The size targets and associated scores take into account the four-times rule. The following datasets were used:

Dataset Name	Time coverage	Responsible Agency
Terrestrial Ecological Systems	2006	Muskoka River Watershed Inventory
Conservation Blueprint for Biodiversity	2005	Nature Conservancy of Canada and Ontario Ministry of Natural Resources

Table 3. Conservation Blueprint calculated fire disturbance size (Henson et al. 2005)

Ecodistrict	Approximate area (ha) burnt in the last 23 years = *minimum size target*	Approximate total # of fires	Total % of ecodistrict disturbed	Size (ha) needed for 4x rule
5E-7	40	360	2.3	160
5E-8	50	360	2.3	200
5E-9	40	360	1.8	160

Methodology

The Inventory used the GLCB method of assessing the size of natural areas that would be large enough to persist after a disturbance event. The general approach taken was as follows:

1. Using the terrestrial ecological systems layer, dissolved similar ecosystem types
2. Omitted non-natural polygons from the terrestrial ecological systems dataset
3. Calculated area
4. Queried for selected patch sizes and assigned scores accordingly (Table 4)
5. Converted vector to raster

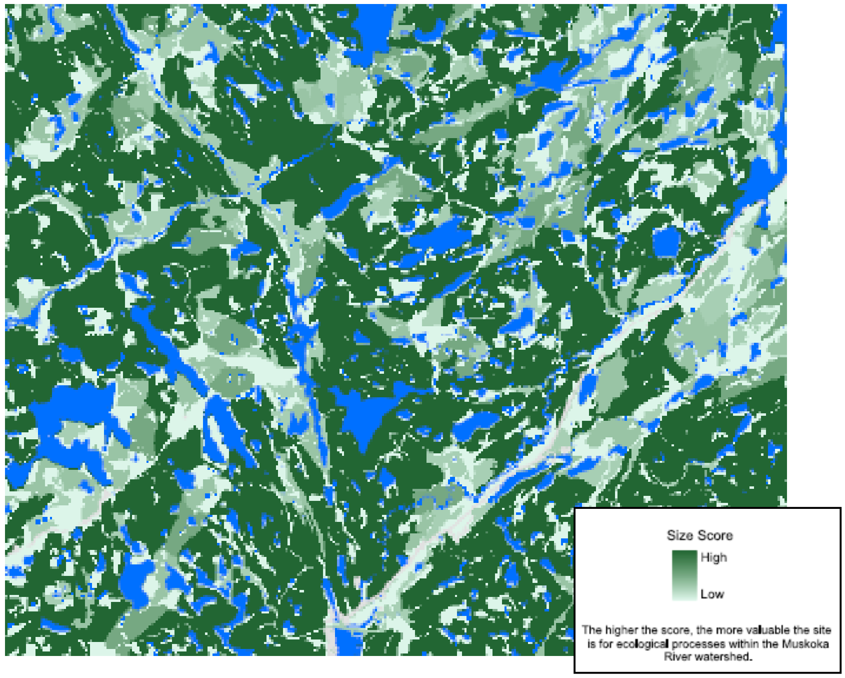

Figure 7. Size of discrete terrestrial ecological system example screenshot.

Table 4. Calculated patch sizes based on fire disturbance regime and associated scores.

Size of discrete terrestrial ecological systems	Score
0 – 25ha	-10
26 – 50ha	2
51 – 100ha	6
101 – 159ha	15
>159 ha	40

Indicator:

ii. Presence of old growth forests

Old growth forests are important features to the landscape. In Ontario, old growth forest stands are rare to uncommon (Henson et al. 2005), but they harbor high species diversity and richness. Old growth forests contain much older than average aged tree species, and consist of a large number of snags (or dead standing trees) and fallen debris, producing a very different structural make-up than younger forest stands. Snags create opportunities for nest cavities, and fallen debris, such as large logs, in various stages of decay, create vertical and horizontal layers of dead-wood (on the forest floor, across streams and rivers) resulting in unique and diverse habitats for a variety of species, including those that have become specialized to old-growth ecosystems (Quinby 1993; Mosseler et al. 2003; Spies et al. 2006). Old growth forests are also involved in nutrient cycling (and retaining large amounts of limiting nutrients), and maintaining soil stability and water quality (Henry and Quinby 2006). Research shows that old growth forests are natural reservoirs of genetic diversity and may be significant in absorbing and storing carbon dioxide (CO_2), thereby acting as a buffer against global warming (Quinby 1993; OMNR 1994; Fredeen et al. 2005). Old growth forests are also used as a baseline to measure and compare changes in other systems (Frelich and Reich 2003).

Dataset(s)

FRI database provided age data of forest stands. GLCB calculated each forested stand age up to the year 2003 from the working definitions for old growth within the framework of the Ontario Ecological Land Classification (Uhlig et al. 2001). The framework defined old-growth by considering many criteria including: large old trees for species and site; complex stand structure; large dead standing trees and downed wood materials, and mounds; specific composition of the forest community; few or no signs of human disturbance; net growth equal to or less than zero; age of dominant species exceeding average natural disturbance interval for the ecosystem; and forest system near or in late successional stage.

The following dataset was used:

Dataset Name	Time coverage	Responsible Agency
Conservation Blueprint for Biodiversity	2005	Nature Conservancy of Canada and Ontario Ministry of Natural Resources

Methodology

The Inventory used the GLCB dataset for old-growth forests. The general approach taken was as follows:

1. Clipped GLCB old_growth raster dataset to the Muskoka River watershed

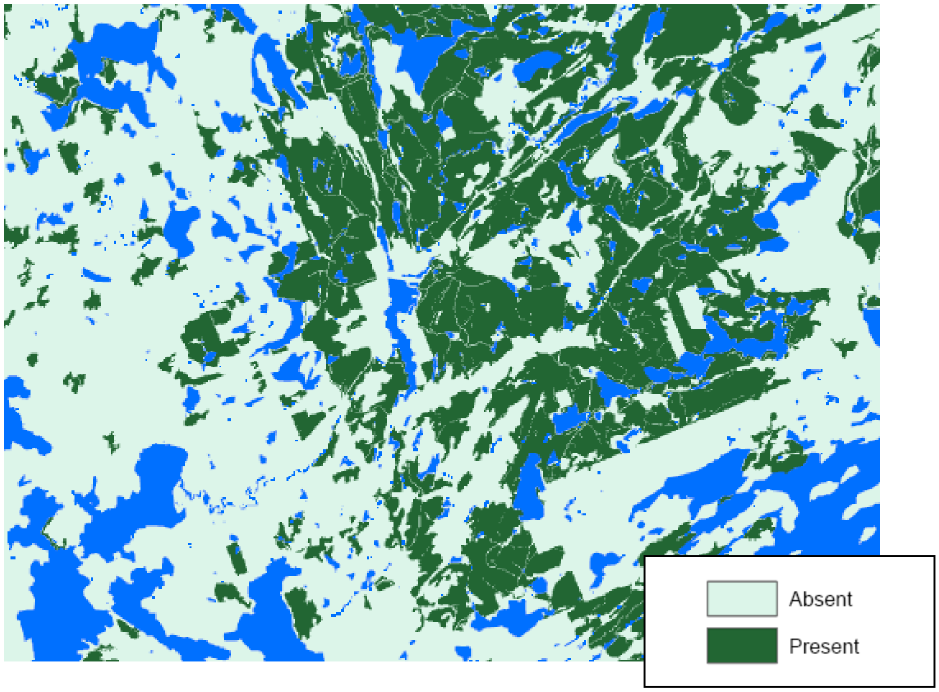

Figure 8. Old growth forests example screenshot.

Table 5. Old-growth and associated scores.

Old growth	Score
Inside	10
Outside	0

Indicator:

iii. Interior size of discrete terrestrial ecological systems

The relationship between core areas and edge communities is a factor in maintaining the integrity of natural systems. In areas with a diversity of ecological systems, edge habitat occurs naturally. There are many species that depend on edge communities as habitat for all, or part of their life cycle (Daigle and Havinga 1996).

Interior habitat or "core area" of a patch is described as an area that is buffered from adjacent patches from the external edge (Henson et al. 2005). Interior habitat provides specific environmental elements necessary for the survival of many species. Interior forested patches maintain specific environmental (i.e. moisture, temperature, light) conditions and vegetation compositions, which many specialized species have evolved to exist, and in many instances, cannot survive under any other conditions (Daigle and Havinga 1996; Saab 1999; Fenton and Frego 2005).

Edge communities greatly affect interior communities. Healthy, vigorous forest edge communities provide buffers against detrimental effects of winds, sun and predators. Wind and sunlight in some forest types can penetrate more than 200m through sparse edge communities into the interior, changing temperature and humidity regimes (Chen et al. 1992; Chen et al. 1995). Edge habitat is used often by a number of predator species, (Burke and Nol 2000; Austen et al. 2001), resulting in increased predation and parasitism near the edge which can decimate interior species populations (Harris 1985; Terborgh 1989). Exotic and invasive species also use edge communities to invade systems and outcompete native species (Daigle and Havinga 1996; Gelbard and Belnap 2003).

Environment Canada (2004) recommends an interior habitat to be a width of at least 100m with 200m as an edge buffer size. Research has shown that forest patch sizes are correlated with species richness, and as the forest patch size increases, edge habitat proportions decreases (Freemark and Collins 1992; Daigle and Havinga 1996; Burke and Nol 1998; OMNR 1999; Burke and Nol 2000; Debinski and Holt 2000; Austen et al. 2001). Burke and Nol (2000) recommend that interior forest patch size should be greater than 90ha to avoid negative effects of predation and parasitism from edge communities.

The Inventory used the GLCB method and scoring regime for patch sizes. The terrestrial ecological systems layer was used to identify discrete patches that are of adequate size. The interior/core size of a patch was determined by any area that had a buffered edge greater than 200m. Patch sizes of 50ha or less did not have an adequate buffered edge, while patch sizes greater than 50ha did often have buffered edges greater than 200m and scored progressively higher values as patch size increased.

Dataset(s)

Patch size was the size of discrete terrestrial ecological systems produced from the Inventory. The following dataset was used:

Dataset Name	Time coverage	Responsible Agency
Terrestrial Ecological Systems	2006	Muskoka River Watershed Inventory

Methodology

The general approach taken was as follows:

1. Omitted non-natural polygons from the terrestrial ecological systems dataset
2. Calculated area
3. Queried for selected patch sizes and assigned scores accordingly (Table 6)
4. Converted vector to raster

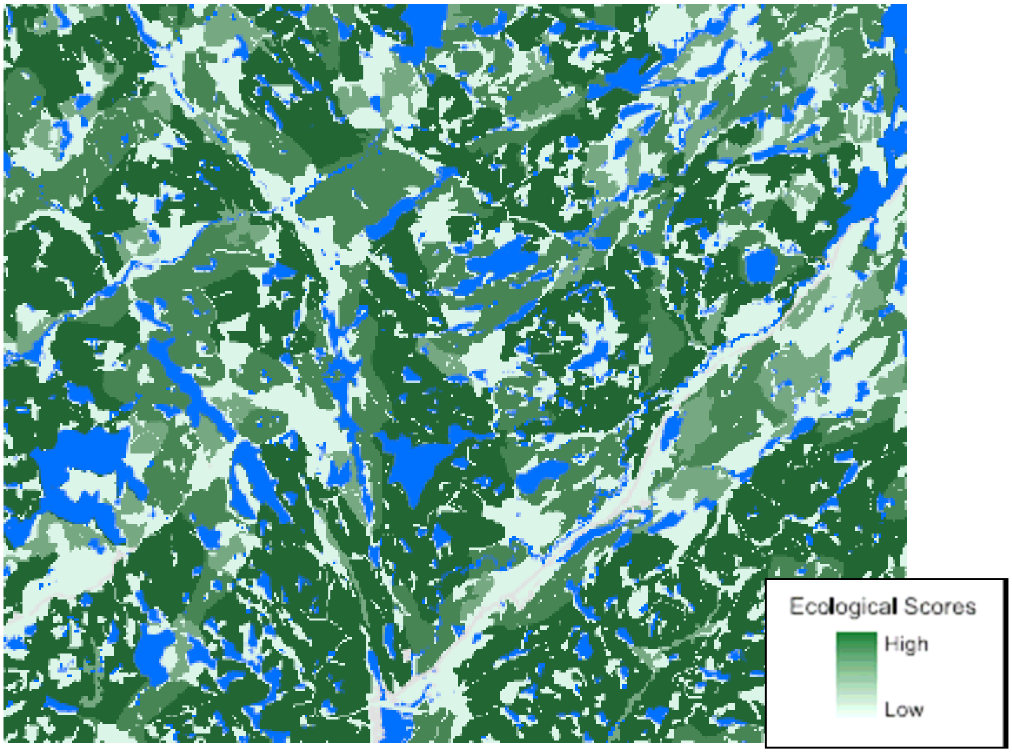

Figure 9. Areas of adequate interior habitat example screenshot.

Table 6. Patch sizes and associated scores for interior habitat.

Size of discrete terrestrial ecological systems	Score
0–50 ha	-15
51-100 ha	0
101 – 500 ha	8
>500 ha	15

Objective:

b. Identify wetlands

Indicator:

i. Presence of wetlands

Wetlands play an essential part of healthy, functional watersheds. Wetlands are areas of land that seasonally or permanently covered by shallow water, or where the water table is close to or at the surface (Ontario Ministry of Municipal Affairs and Housing 2005). Wetlands store, filter, and move water (Daigle and Havinga 1996; Houlahan and Findlay 2004), and buffer water supply from harmful effects of adjacent landuses (Keddy and Fraser 2000; Wei et al. 2004). Wetlands also provide critical habitat for a number of wildlife species (Daigle and Havinga 1996; Schweiger at al. 2002). Many at-risk avian species, insects, reptiles and almost all amphibian species require wetlands for at least part, if not all, of their life cycle (Semlitsch and Bodie 2003).

The indicator for wetlands was the presence of wetlands. In response to a growing concern for conserving wetlands in Northern Ontario, MNR developed the Ontario Wetland Evaluation System (OWES): Northern Manual in 1993, and as a result, locations of wetlands across Ontario were evaluated. There were two evaluation manuals developed to capture the fact that wetlands behave differently on the Canadian Shield than in Southern Ontario. For the Muskoka River watershed, the Northern OWES was used to evaluate wetlands (Appendix E). Ducks Unlimited Canada (DUC) developed a method of identifying wetlands using satellite imagery (Appendix F). The pilot for DUC wetland mapping took place for portions of the Muskoka River watershed, and resulted in a comprehensive inventory of wetlands for the study area. As well, wetland types were identified from Ontario Base map data, FRI and provincial landcover mapping. The creation of the terrestrial ecological systems dataset included all of the available wetland data mentioned. Thus, wetlands from the terrestrial ecological systems were used to represent the presence of wetlands.

Dataset(s)

The following dataset was used:

Dataset Name	Time coverage	Responsible Agency
Terrestrial Ecological Systems	2006	Muskoka River Watershed Inventory

Methodology

The Inventory used the GLCB scoring regime to evaluate wetlands. The general approach taken was as follows:

1. Selected all wetlands from the terrestrial ecological systems layer and exported as new dataset
2. Assigned scores accordingly (Table 7)
3. Converted vector to raster

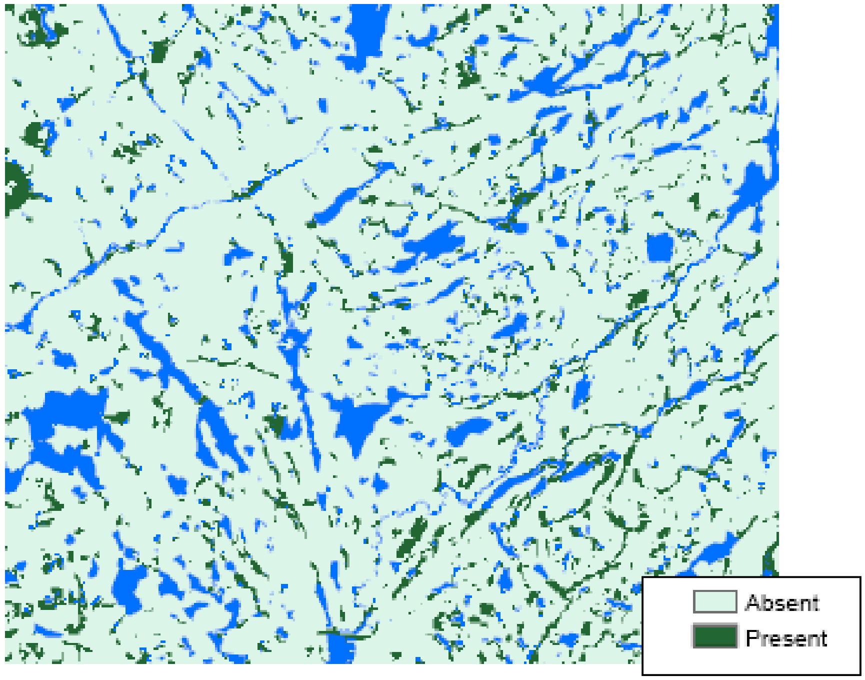

Figure 10. Presence of wetlands example screenshot.

Table 7. Wetlands and associated scores

Wetlands	Score
Inside	15
Outside	0

Objective:

c. **Identify riparian areas**

Indicator:

i. **Riparian area of stream/rivers, inland lakes, and the Great Lakes shorelines**

A riparian area is the portion of land that is directly influenced by water. These areas are the interface between land and water. The influence of water on the land produces unique characteristics that create habitat for a variety of plant and animal species, and is often used by species as critical migration corridors (Monkkonen and Reuanen 1999; Stauffer et al. 2000). Shorelines, for instance, are unique because they experience frequent changes in water level, waves and ice-scour, creating high biological diversity and distinct vegetation types (such as Atlantic Coastal Plain communities, which is a disjunct vegetation community found in Muskoka)(Spackman and Hughes 1995; Keddy and Fraser 2000). Riparian areas of shorelines and streams also show an abundance of insects that take shelter from strong winds, which in turn, attract a variety of bird species that feed on these insects (Whitaker et al. 2000). Riparian areas play a major role in nutrient cycling (Dodds and Oakes 2006), reducing pollutants reaching water sources (Castelle et al. 1994; Polyakov et al. 2005), and buffers from noise, light and invasive species (Castelle et al. 1994).

The Muskoka River watershed contains countless number of lakes and streams, which ultimately drain into Georgian Bay. Many of the unique wildlife species found within the Muskoka River watershed are here because of the habitat diversity afforded by the riparian areas of streams, inland lakes and Georgian Bay. Many human activities also rely on water and the proximity to shorelines. In Muskoka especially, shorelines play an important role in economic, environmental, and human health of communities.

There are several studies recommending a variety of buffer measurements that would be adequate for protecting riparian areas. The Massachusetts Resource Information Project (Schartz and Goodwin 1999) applies a 100m buffer for perennial streams and rivers to conserve for species dispersal and hydrological functions. Herpetofaunal species, which are specifically dependent on healthy riparian areas, require vegetated buffer widths of 127m to 290m to survive successfully (Semlitsch and Bodie 2003). Reasonable minimum buffer widths under typical conditions vary depending on the elements of interest within riparian zones: 30m for wetland protection, 50m for woodlands, 100m for wildlife habitat and 100 to 200m for use as wildlife corridors (Bergsma 2000).

The Great Lakes shoreline deserves particular attention. Shorelines of large waterbodies experience significant waves and currents, winds and weather. These near-ocean geomorphological processes also considerably affect inland ecosystems, resulting in extraordinarily diverse and unique land formations and vegetation communities that should have high conservation considerations (Riffell et al. 2003; Wei et al. 2004; Henson et al. 2005).

The indicators for riparian areas were buffered distances of rivers, streams, inland lakes and the Great Lakes shoreline. A buffer distance for the rivers, streams and inland lakes was set at 100m. The rivers and streams used for this analysis included all Strahler stream orders as identified by the Provincial Water Resource Information Project (Appendix G). For the Great Lakes shoreline, a buffer distance of 1,000m was applied and the score raised to account for the significance of shorelines of large waterbodies. The Great Lakes shoreline was derived from the terrestrial ecological systems layer, which was cut to the delineated tertiary watershed of the Muskoka River. The scoring of riparian areas for the Inventory was different than for the GLCB. The Inventory committee raised the score of all riparian areas to reflect the large ecological importance and role of these areas within the Muskoka River watershed.

Dataset(s)

The following datasets were used:

Dataset Name	Time coverage	Responsible Agency
Water Virtual Flow - Seamless Provincial Data Set	2005	Ontario Ministry of Natural Resources
Terrestrial Ecological Systems	2006	Muskoka River Watershed Inventory

Methodology

Each indicator was processed as its own dataset (i.e. three datasets were processed, representing each objective). The general approach taken was as follows:

1. Buffered each dataset accordingly: Inland lakes buffer of 100m, streams and rivers buffer of 100m, and Great Lakes Shoreline a buffer of 1000m
2. Queried for selected riparian areas and assigned scores accordingly (Table 8)
3. Converted vector to raster

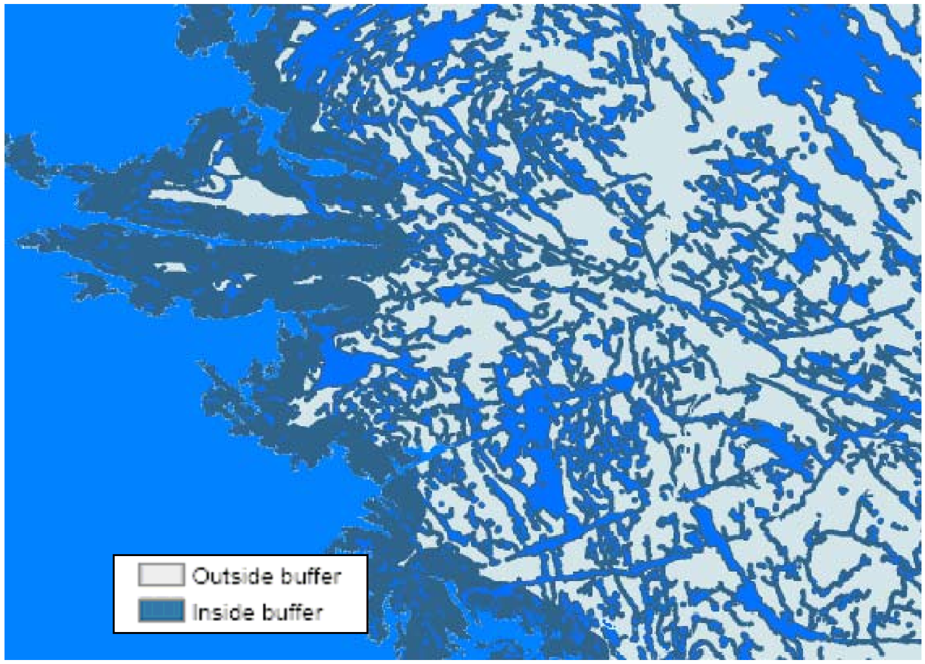

Figure 11. Influence of riparian areas of streams/rivers, inland lakes and the Great Lakes shoreline example screenshot.

Table 8. Riparian areas and associated scores.

Riparian Areas	Score
Great Lakes Shoreline	20
Inland Lakes	15
Rivers and streams	15

Objective:

d. Identify recharge areas

Indicator:

i. Highly permeable areas

Groundwater is a source for drinking water and recharge for surface water. Groundwater is replenished by water (through rain, or snowmelt) that travels through aquifers, bedrock cracks, or porous layers of soil, sand, and/or other substrate. The areas of land where water can reach aquifers are described as recharge areas. Rural residents in Muskoka use groundwater as their main source of drinking water (J. Brouse pers. comm. June 13, 2006). Recharge areas are also essential to the hydrological cycle, which is critical for all life on Earth. Thus, it was essential that recharge areas be identified as important to the ecological functions of the Muskoka River watershed. The GLCB did not take into account recharge areas.

There was no reasonably comprehensive datasets specifically for recharge areas at the time of this analysis. Recharge areas were often identified as wetlands, or where aquifers had been recorded. Aquifers are porous layers of soil, sand or rocks that allow water to infiltrate slowly below the surface. Thus, the Inventory identified recharge areas using surficial geology data of permeable surfaces, and acknowledged the fact that these data were used on a preliminary, landscape level only until more precise data become available.

Dataset(s)

The following dataset was used:

Dataset Name	Time coverage	Responsible Agency
Surficial Geology of Southern Ontario	1950-2003	Ministry of Northern Development and Mines

Methodology

The general approach taken was as follows:

1. Selected all “High” permeability polygons and created new shapefile
2. Assigned scores accordingly (Table 9)
3. Converted vector to raster

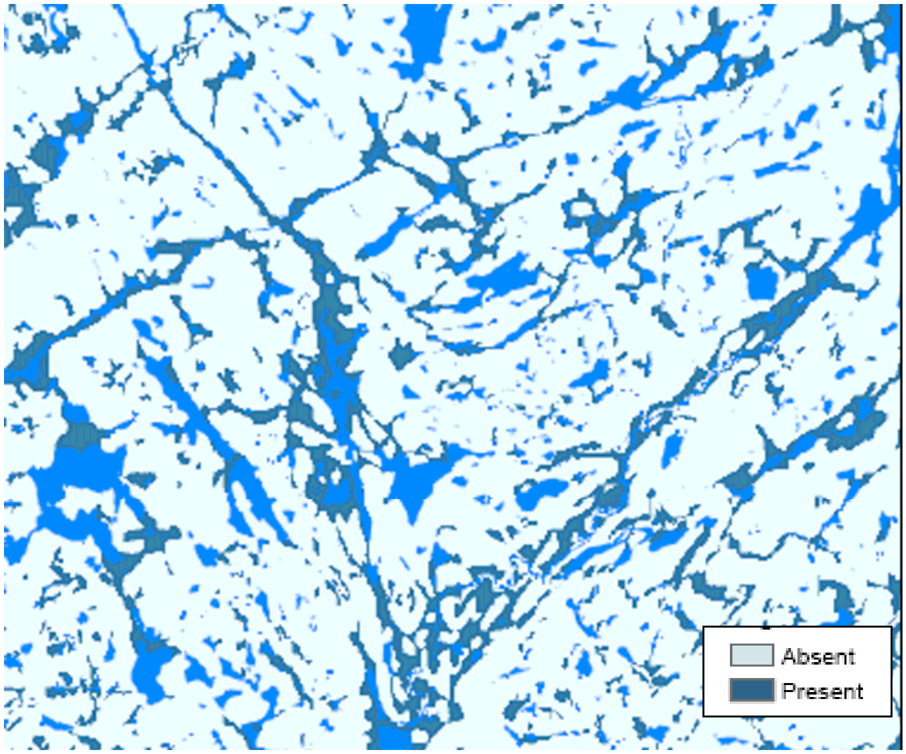

Figure 12. Presence of possible recharge areas example screenshot.

Table 9. Recharge areas and associated score.

Recharge Area	Score
Presence	1
Absence	0

Criterion:

2.Diversity

Diversity is the variety of elements within an area and biological diversity (biodiversity) is the variety of life and its processes, which includes the variety of species, their genetic differences, and the ecosystems in which they occur (Biodiversity Working Group 1994). The role of biodiversity in maintaining ecosystem functions and services has been extensively investigated (Lyons et al. 2005). Experiments show that loss of biodiversity is often associated with loss in ecosystem function (Allison 1999; Naeem 1998). Biodiversity also appears to buffer ecosystems against environmental fluctuations, thus diversity contributes to the stability of ecosystem processes (Naeem 1998; Thebault and Loreau 2005). Diversity was worth 5% of the total score.

Objective:

a. **Identify habitat diversity**

Indicator:

i. **Habitat diversity**

Habitat diversity is the number of different habitats in a given area. Although unique, homogeneous habitat patches have value for the maintenance of unique ecological processes; high diversity of habitat patches is associated with high species richness since more kinds of niches are available for a variety of different organisms, creating complex habitat relationships (Ardron 2002; Riffell et al. 2003).

At a landscape-level analysis, diversity was identified by assessment of the landform and vegetation community (or terrestrial ecological systems). Another method of evaluating diversity is to analyse species richness, however, this assessment is much more valuable at site-specific scales (Crins and Kor 2000). Species richness analyses are also incredibly complex, and require comprehensive datasets.

The terrestrial ecological systems layer was used to analyse habitat diversity. Each terrestrial ecological system was scored based on the number of different ecological systems surrounding it. For example, if one unique ecological system had four other different ecological systems adjacent to its border, the central ecological system received a score of four.

Dataset(s)

The following dataset was used:

Dataset Name	Time coverage	Responsible Agency
Terrestrial Ecological Systems	2006	Muskoka River Watershed Inventory

Methodology

The general approach taken was as follows:

1. Converted terrestrial ecological systems layer into raster dataset based on unique ecological system types
2. Used REGIONGROUP to create first grid
3. Used FOCALVARIETY to create second grid
4. Inputted first and second grid into ZONALMAX analysis
5. Classified cells accordingly (Table 10)

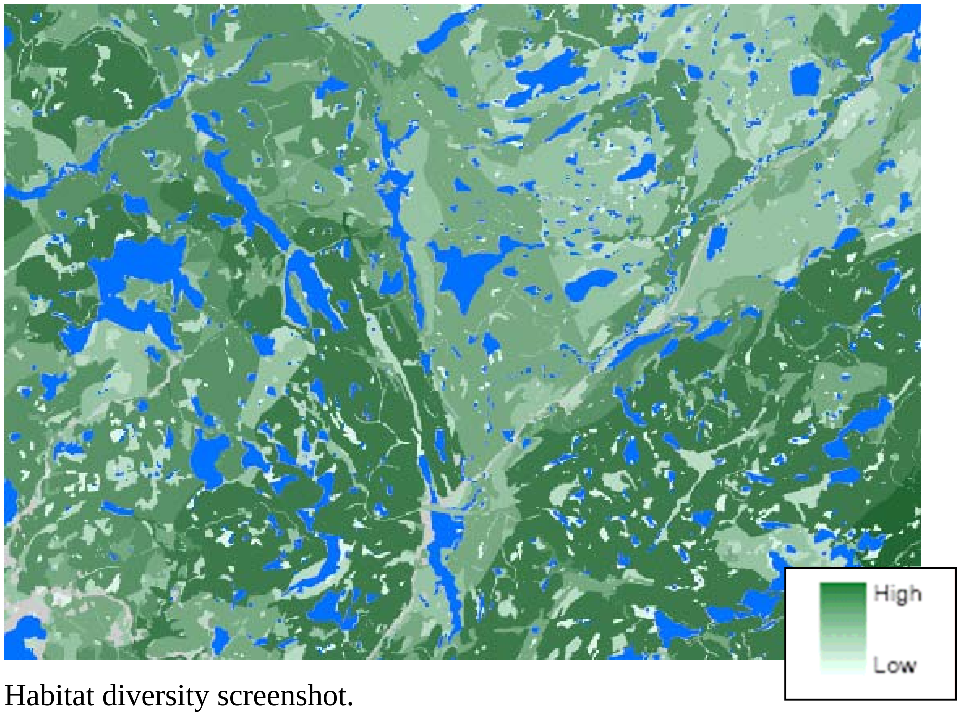

Figure 13. Habitat diversity screenshot.

Table 10. Habitat diversity and associated scores.

Number of habitat types	Score
1	1
2	2
3	3
4	4
5	5
6	6
7	7
8	8
9	9
10	10

Criterion:
3.Special Features

Special features include populations of species-at-risk, unique vegetation communities, and critical wildlife habitat sites. Information for these types of data is extremely comprehensive for areas in Southern Ontario. Unfortunately, in other areas of Ontario, such as the Muskoka River watershed, data for this criterion were lacking at the time of this analysis, especially on privately owned land. The users of such information should be aware that areas which appeared to have no occurrence of elements did not necessarily indicate that there was an absence of these elements, but more likely the site was not surveyed in detail (Crins and Kor 2000). The lack of information should not be a deterrent for using the information that is available, but used to enhance specific sites. Special features indicated the value of an area for the occurrence of species and their community, thus identified the ecological importance of such sites. This criterion was weighted at 15% of the total score.

Objective:

a. **Identify species element occurrences, vegetation communities and other significant wildlife habitat**

Indicator:

i. **Species and vegetation community occurrences**

The occurrence of species or element was an important aspect of identifying ecologically important sites. Occurrence of these individuals or populations indicated that the site contains ecological processes that are supporting, or has supported, these elements. However, this did not necessarily indicate that the site was healthy, and fully-functioning. The importance of this objective for the Inventory was to identify areas that appeared to be able to support elements now, or historically. This information enabled the committee to assess the importance of the area for protection considerations, or possible restoration efforts.

Element occurrence (EO) and local information was available for analysis from the Natural Heritage Information Centre (NHIC) and provided records containing observations of species occurrence, or vegetation communities (Appendix H). Some of these occurrences were species-at-risk, and some were locally common species that had been tracked for a variety of reasons (ie. globally rare, research purposes). Locally-tracked species were included to ensure that species and communities that use unique ecological systems in Muskoka were considered, since even common species are important to ecological processes (Lyons et al. 2005).

This indicator was scored according to several attributes. Element Occurrence (EO) data provided the date of observation(s). Some EO observations occurred in the early 1900s. Some observations occurred only once and not recorded again. It was important to note historical observations to assess the value of certain terrestrial ecological systems that might still be available, or restored to become available, to these species. There is a possibility that if that element was observed there once, and the ecological system is still functioning, ground-truthing can provide evidence that they are still occurring at that site. The Inventory scored each ecological system based on the number of observations made, and if the observation was historical or extant. Faunal observations made within the last 20 years were considered extant. On the Canadian Shield, botanical surveys occurred less frequently than animal surveys, thus floral observations observed in the last 40 years were considered extant (Henson and Brodribb 2004).

Observations were summed for each terrestrial ecological systems layer, and scored according to the number of species occurring in each ecosystem polygon, thus an ecological system with more species occurrences received a higher score. Scores were also higher if they were an extant species compared to historic occurrences. The Inventory did not define species targets as the GLCB had done. Instead, all element occurrences and tracked species were treated as extant or historic regardless of species status.

Dataset(s)

The following datasets were used:

Dataset Name	Time coverage	Responsible Agency
Natural Heritage Information Centre Element Occurrences	1993-2006	Ontario Ministry of Natural Resources
Species Observation, Locally Tracked	1998-2006	Ontario Ministry of Natural Resources

Methodology

The general approach taken was as follows:

1. For NHIC EOs, selected all extant botanical occurrence (observation dated 1965 or later) and created a new shapefile
2. For NHIC EOs, selected all historic botanical occurrence (observations before 1965)
3. For NHIC EOs, selected all extant faunal occurrence (observation dated 1985 or later) and created a new shapefile
4. For NHIC EOs, selected all historic faunal occurrence (observations before 1985)
5. For NHIC EOs, selected all plant communities and created a new shapefile
6. For each shapefile, including the Parry Sound locally tracked species, used Hawth's Analysis Tools to "count points in polygons", using the terrestrial ecological systems layer as the polygon layer
7. Assigned scores accordingly (Table 11)
8. Converted vector to raster

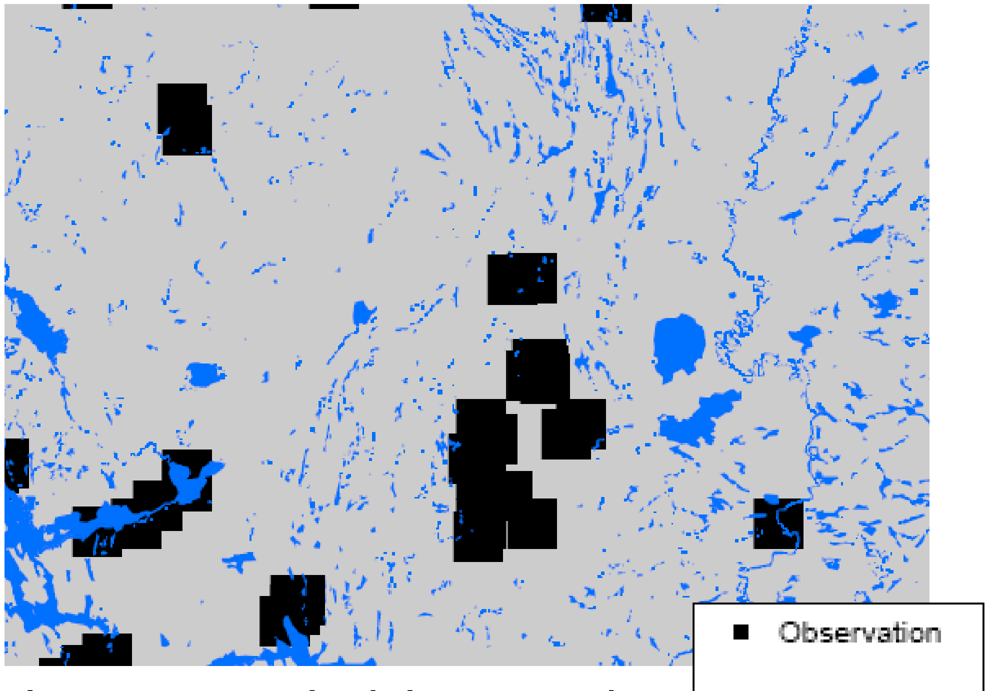

Figure 14. Element occurrences and tracked species screenshot.

Table 11. Element occurrence and associated scores.

Special Feature	Score
EO - Extant	Count*4
EO - Historic	Count*1
EO - Community	Count*2

Indicator:

ii. Important habitat areas

Significant habitat is a geographic area that is required for long-term survival, and/or reproductive success of wildlife species. Many of these species have evolved to use very specific conditions, and if these conditions are unavailable, these species are unable to continue their existence successfully (Hagen and Hodges 2006; Leon-de-La Luz and Breceda 2006; Semlitsch 2002).

There was lack of information for specific significant habitat of species. The Inventory took into account some broad critical habitat elements, such as wetland area, in other criteria (Ecological Function). However, it was necessary to pinpoint more specific sites that were known to be used by wildlife. More specific data were required to ensure that these critical sites did not slip through the cracks of the broader coarse-filter analyses of terrestrial ecological systems. The available data for the Muskoka River watershed included aquatic feeding sites, fish habitat types, nesting sites, and wintering areas.

Fish habitat type modeling was an attempt to gather data as a component of the Habitat Mapping Program lead by the Muskoka Lakes Fisheries Assessment Unit (MLFAU). The database is mainly composed of field data collected from assessments of fish spawning shoals and littoral zone substrate and terrestrial measurements (S. Taylor pers. comm. September 1, 2006; S. Scholten pers. comm. September 1, 2006). The type of data collected included information on substrate type and percentages, vegetation type, water depths, water temperature, observed nest locations, nesting stage, and nest description (Stirling 1990; Taylor 1992). The available data were used to classify shorelines into three fish habitat types. Type 1 habitat types describe specialized spawning, nursery, rearing, shelter, refuge, and/or feeding habitat and are important to fish populations. Type 2 habitat types are more variable, but still important to fish populations. Type 3 habitat types describe areas that do not contribute directly to fish productivity. There were no surveyed locations that were described as Type 3 habitat within the Muskoka River watershed (OMNR 1996; S. Taylor pers. comm. September 12, 2006; appendix I).

Fish habitat data was used slightly differently than the other indicators of significant habitat. Significant habitat was scored based on the presence or absence. However, fish habitat sites were given a buffer. Presently, the Inventory assessed significant *terrestrial* sites within the Muskoka River watershed, and the buffer of significant fish habitat allowed the Inventory to evaluate terrestrial sites that influenced fish habitat areas. Buffers for significant fish habitat vary from 30m to 90m for forestry activities depending on several factors, such as slope of the shore, and substrate (OMNR 1988). At a landscape-level approach, a 30m buffer from fish habitat sites was adequate (S. Scholten, pers. comm. May 23, 2006). As well, since the nesting site dataset was a point layer, nesting sites were given a buffer to account for an *area* of significance to apply scores.

Dataset(s)

The following datasets were used:

Dataset Name	Time coverage	Responsible Agency
Aquatic Feeding Area	1997-2006	Ontario Ministry of Natural Resources
Nesting Site	1997-2006	Ontario Ministry of Natural Resources
Wintering Area	1997-2006	Ontario Ministry of Natural Resources
Spawning Area	1997-2006	Ontario Ministry of Natural Resources
Fish Habitat Type	1996	Ontario Ministry of Natural Resources

Methodology

With the exception of fish habitat and nesting data, the following general approach was taken for all habitat datasets:

1. Assigned scores accordingly (Table 12)
2. Converted vector to raster

For fish spawning and nesting sites, the following general approach was taken:

1. Buffered fish habitat types 1 and 2 polygons and nesting point locations with 30m distance (include inside the polygon)
2. Assigned scores accordingly (Table 12)
3. Converted vector to raster

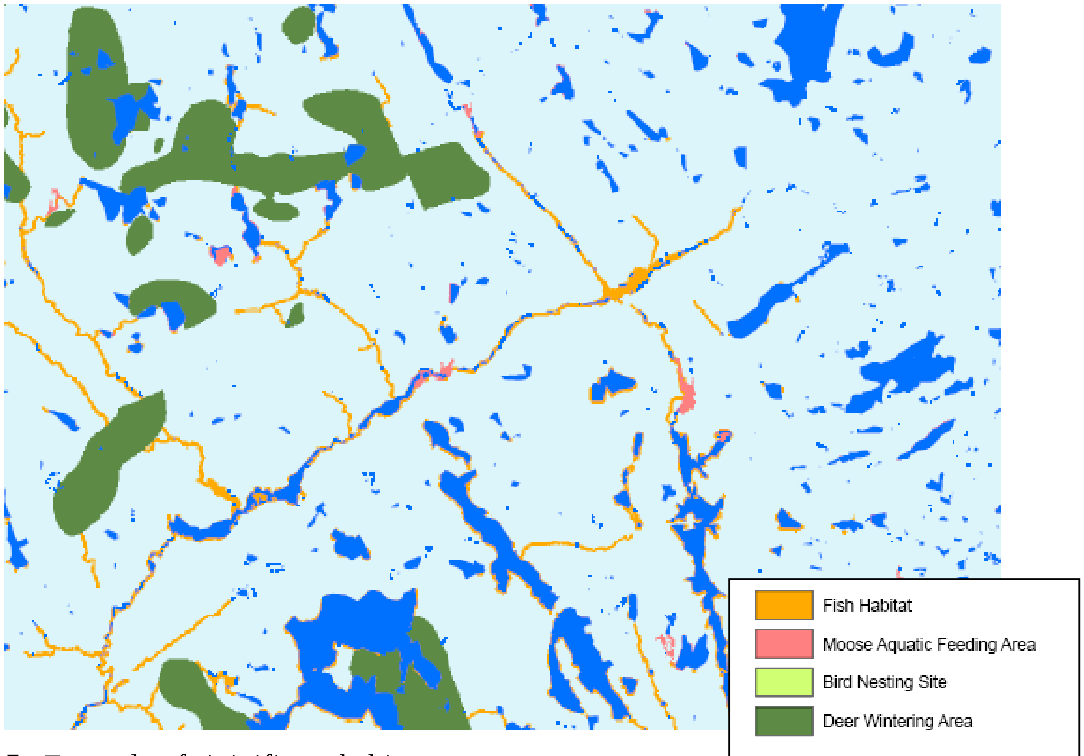

Figure 15. Example of siginificant habitat areas.

Table 12. Significant habitat and associated scores.

Special Feature	Score
Moose aquatic feeding site	5
Bird nesting sites (with 30m buffer)	5
Deer wintering areas	5
Fish habitat type (with 30m buffer)	5

Goal: Identify stresses on terrestrial ecological systems and processes

A crucial part of identifying a healthy, fully functioning ecosystem is to recognize the stresses on an area's ecological integrity. Stress on ecological systems can come in a variety of forms, but all forms will impact the condition of an ecosystem and affect the ability of an ecosystem to maintain ecological functions. Identifying the sources of stress to the ecological integrity of systems within the Muskoka River watershed was an essential part of the Inventory. The collaborative evaluated the condition of ecosystems in order to provide protection of the highest quality sites, but also assess the need for remediation or restoration of degraded sites.

Criterion:
4.Condition

Stress on ecological systems is different from threats to ecosystems. Threats were considered to be *future* risks to ecological systems, whereas the Inventory evaluated *current* stresses or pressures.

Evaluating threats to ecological systems was beyond the scope of the Inventory however, there are a few threats that should be brought to attention. One imminent threat to ecological systems are the affects of global warming. Global warming, or climate change, is the accelerated warming trend of the Earth's atmosphere mainly attributed to human activities (U.S. Environmental Protection Agency 2002). Invasive species is another threat to ecological systems. Exotic invasive species are harmful both ecologically and economically (Ontario Federation of Anglers and Hunters 2006). Exotic species compete with native species for resources, and change the dynamics and composition of ecological systems, often decreasing biodiversity.

The condition criterion achieved the Inventory's third goal of identifying stresses on ecological systems and processes (Table 2). When added to the overall scoring of the project, the condition criterion represented 20% of the total score.

Objective:

a. **Identify condition/quality of watershed**

Indicator:

i. **Percentage natural cover**

The Muskoka River watershed area contains a large percentage of natural cover compared to areas off the Canadian Shield in Southern Ontario where the land is highly fragmented (McMurtry et al. 2002). Natural cover contributes immensely to the maintenance of ecological processes, regulating micro-climate (Saab 1999; Fenton and Frego 2005; Pecot et al. 2005), and supports high species richness and abundance (Riffell et al. 2003; Wiersma et al. 2004). Continuous forest cover helps to maintain vital environmental conditions that promote species interdispersal between habitat types, allowing for suitable gene-flow and recolonisation after a disturbance event (Picket and Thompson 1978; Scrosati 1998; Jakaliemini et al. 2005).

Lack of natural cover can have detrimental effects on the landscape. Natural cover can intercept overland water-flow and increase the amount of water infiltrating into recharge areas. Lack of natural cover can increase soil erosion, and decrease the volume of groundwater recharge (Johnson and Heaven 1999). Larger, continuous natural cover has also developed unique ecological processes that capture and retain large amounts of CO_2 (Lafleur et al. 1998; Hargreaves et al. 2003; Fredeen et al. 2005).

Breeding birds respond positively to forest cover, and appear to be more affected by the amount of forest cover than to forest fragmentation (Trzcinski et al. 1999). Studies on wetland amphibian species show that species richness is affected by anthropogenic activities up to 2km to 3km away from wetland edges (Houlahan and Findlay 2003). Effects of adjacent land-use on wetland sediment and water quality can extend 2km to 4km (Houlahan and Findlay 2004). Environment Canada (2004) recommends that a minimum of 30% forest cover be maintained within a watershed to support wildlife species, however, the most critical time for conservation planning is when the landscape still contains 60-90% of its area in natural vegetation (Forman 1995).

Dataset(s)

The terrestrial ecological systems dataset was used to classify natural and non-natural types. Percentage natural cover was produced by calculating the amount of natural land within a 2km radius of each raster cell. This indicator represented the objective to identify the influence of the density of natural cover. The following dataset was used:

Dataset Name	Time coverage	Responsible Agency
Terrestrial Ecological Systems	2006	Muskoka River Watershed Inventory

Methodology

The general approach taken was as follows:

1. Using neighbourhood statistics, calculate the amount of land in a natural state using a 2km radius circle
2. Assign scores accordingly (Table 13)
3. Convert vector to raster

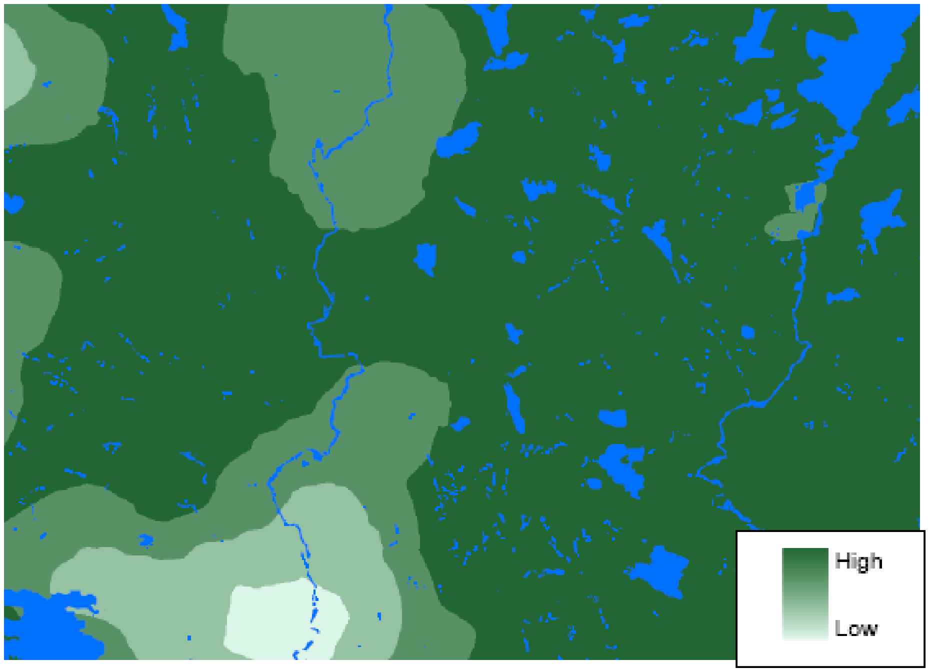

Figure 16. Example screenshot of percentage natural cover.

Table 13. Percentage natural cover and associated scores.

Percent natural cover	Score
0-40%	0
41-70%	4
71-90%	8
91-100%	12

Indicator:

ii. Influence of settled areas

Developed and settled areas convert natural areas, and agricultural sites, into landuses that are unsuitable for ecological systems to perform essential processes, and often the ecological system is destroyed completely. Developed and settled areas are associated with a high density of human populations, resulting in the increase in number and size of road networks, increase noise and water pollution, nutrient loading, temperature changes, extraordinary predation, increased species competition for resources (Daigle and Havinga 1996), pathological stress and disease in wildlife (Deem et al. 2001; Creel et al. 2002; Blumstein et al. 2005), and contamination from landfill sites (Lagro 1998). Urban development is related to the decline or loss of species (Dennis and Hardy 2001; Odell and Knight 2001; Hogsden and Hutchinson 2004), and increases in exotic and weed species (Stiles and Jones 1998; Freemark et al. 2002). Persecution of wildlife is also common in areas where humans encounter animals more often than in undeveloped areas (Galeotti et al. 2000; Woodroffe 2000).

There is a lack of appropriate buffer distances for urban and settlement areas from the literature search. It is accepted knowledge that the impact of developed land, whether landuse or agriculture, varies depending on intensity of the landuse. There is a marked difference in some wildlife densities between developed and undeveloped sites. Odell and Knight (2001) encountered densities of certain avian species higher in undeveloped sites, and foxes and coyotes were detected more frequently up to 330m away from development. The recommended buffer distance by various sources differ from greater than 1km for bird populations (Twedt et al. 2006), 31 to 92m for adequate buffer against urban runoff (Norman 2000), 100m for wildlife movement (Bergsma 2000), 400m for wildfowl (Shannon 2002) and between 127m and 290m for amphibian and reptiles (Semlistch and Bodie 2003).

Dataset(s)

The terrestrial ecological systems layer was used to classify urban and settlement areas. There were two situations to consider for analyses of this dataset. First, the impacts of urban and settlement landuse are generally most intense at the site, and decreases in intensity farther from the site. Second, urban and settlement areas are not a natural area, thus the Inventory acknowledged that the urban/settlement site itself had already been accounted for during the percentage natural cover analyses. As a result, this indicator represented the *influence* of urban/settlement landuse on adjacent natural areas, hence inside the site received no score, while natural areas adjacent to the site received a lower score than areas farther away from the urban/settlement site. The following dataset was used:

Dataset Name	Time coverage	Responsible Agency
Terrestrial Ecological Systems	2006	Muskoka River Watershed Inventory

Methodology

The general approach taken was as follows:

1. Selected from terrestrial ecological systems layer, all developed and settled land and created a new shapefile
2. Buffered shapefile Assign scores accordingly (Table 14)
3. Converted vector to raster

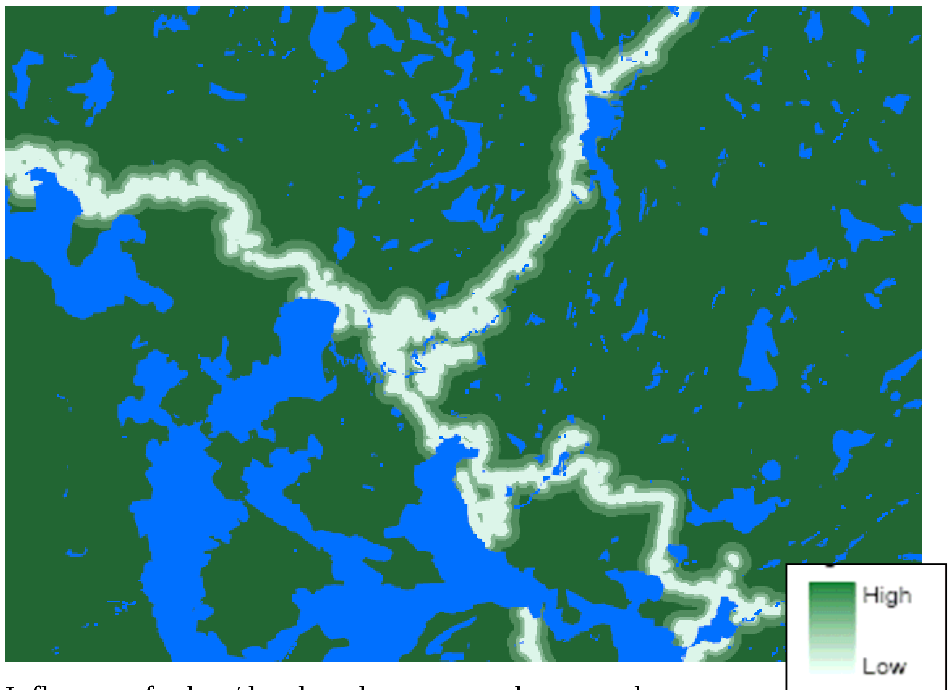

Figure 17. Influence of urban/developed area example screenshot.

Table 14. Influence of developed and settled land and associated scores.

Distance from settled land	Score
0-100m	-10
101-200m	-6
201-400m	-3
>400m	0

Indicator:

iii. Influence of open cleared areas

Natural areas that have been cleared for non-natural land-uses negatively influence the ability for adjacent natural areas to perform important ecological processes. Non-natural open areas include natural areas that have been cleared for agriculture (for the production of plants or animals), and other purposes not included in settled areas (such as golf courses).

Non-natural open land can be intensively managed, where application of fertilizers, pest-control treatments and tillage occurs annually (Dunster and Dunster 1996). The impacts of non-natural open areas, such as agricultural land practices and golf course operations contribute to the fragmentation of natural areas, increasing edge effects, and decreasing interior habitat. Conversion of natural areas to non-natural land-use practices destroys habitat (such as filling and draining of wetlands), replacing complex ecological systems with a more homogeneous pattern, increases road networks and traffic (Pellet et al. 2004), harbour exotic plant species (Freemark et al. 2002) and affect the quality of surrounding water resources, and natural ecological processes (Houlahan and Findlay 2004; Winter et al. 2003). Clearing natural areas reduces continuous natural cover, which can have serious negative effects on the landscape by weakening the terrestrial and aquatic linkages (England and Rosemond 2004), influencing water flow regimes (Johnson and Heaven 1999; Lafleur et al. 1998; Fitzsimmons 2002; Hargreaves et al. 2003; Fredeen et al. 2005), contribute to soil erosion, and affect the amount of carbon released into the atmosphere, as previously mentioned in earlier indicator descriptions (percent natural cover).

Similar to developed urban and settlement areas, appropriate buffer distances from developed to natural areas are difficult to find in the literature. The best available data for buffer distances were found in research for sheltering different conservation values, such as 100-200m from streams for wildlife usage of corridors (Bergsma 2000), and 200m for buffering interior habitat from edge effects (Environment Canada 2004).

Dataset(s)

The terrestrial ecological systems layer was used to identify open and cleared areas. Again, similar to the urban and settlement areas, FRI and Landcover datasets were used together to create the comprehensive representation of cleared land, as well as provincial database to identify agricultural land (see Representation). As mentioned in the Representation section, FRI data for privately owned land was about 20 years old, hence, landcover mapping was used to enhance the location of cleared areas. This indicator was analyzed in the same manner as the urban and settlement areas: represented the *influence* of cleared land on adjacent natural areas. The following dataset was used:

Dataset Name	Time coverage	Responsible Agency
Terrestrial Ecological Systems	2006	Muskoka River Watershed Inventory

Methodology

The general approach taken was as follows:

1. Selected from terrestrial ecological systems layer, all developed agricultural land and open, cleared areas and created a new shapefile
2. Buffered shapefile
3. Assigned scores accordingly (Table 15)
4. Converted vector to raster

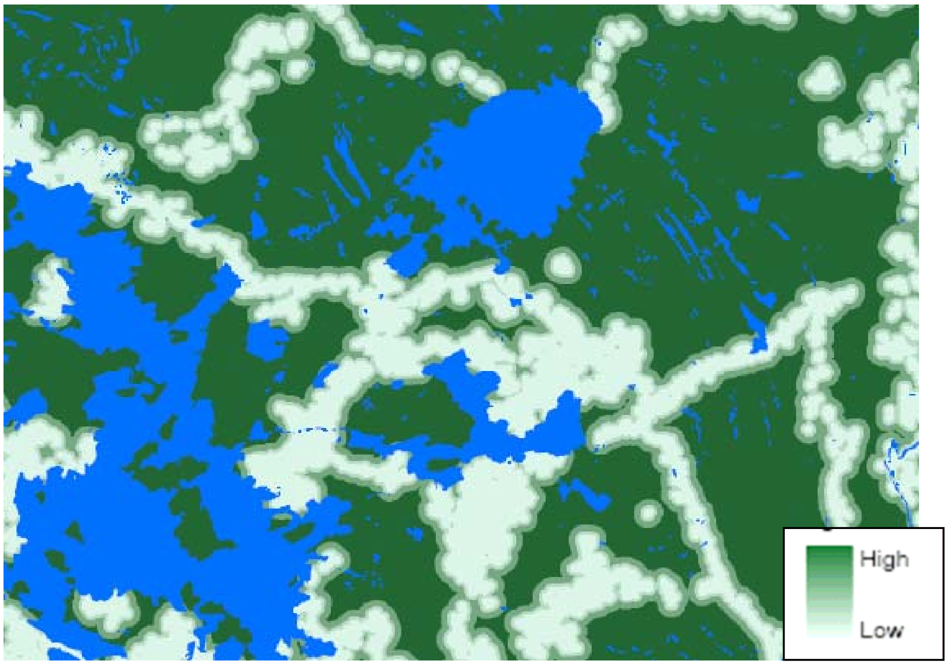

Figure 18. Influence of non-natural open cleared areas example screenshot.

Table 15. Influence of developed agricultural land and open, cleared areas and associated scores.

Distance from area	Score
0-100m	-8
101-200m	-5
201-400m	-3
>400m	0

Indicator:

iv. Influence of pits and quarries

Pits and quarries are created for the extraction of an aggregate or mineral (Dunster and Dunster 1996). There are many associated ecological impacts of pits and quarries including soil erosion and compaction (Michalski et al. 1987; Cooke 2002), habitat fragmentation and destruction (Neel and Ellstrand 2001), change to local hydrology patterns, and contribute to air, water and noise pollution (UNEP 2000). Abandoned pits and quarries still appear to impact the site, and can discourage succession of native vegetation (Price et al. 2005). Rehabilitation of abandoned sites does not return sites back to previous natural conditions, and often facilitates the establishment of non-native vegetation (Henson et al. 2005).

Dataset(s)

Datasets on the location of active and abandoned pits and quarries were used to represent the presence of pits and quarries, and the influence of pits and quarries to adjacent natural areas. The buffer distances used were similar to the buffer distances for influence of open, cleared lands, but the presence of pits and quarries was also given a negative score since location of pits and quarries was not picked up specifically in other objectives of the Inventory. The following dataset was used:

Dataset Name	Time coverage	Responsible Agency
Pit or Quarry	1977-2006	Ontario Ministry of Natural Resources

Methodology

The general approach taken was as follows:

1. Buffered pits and quarries shapefile
2. Assigned scores accordingly (Table 16)
3. Converted vector to raster

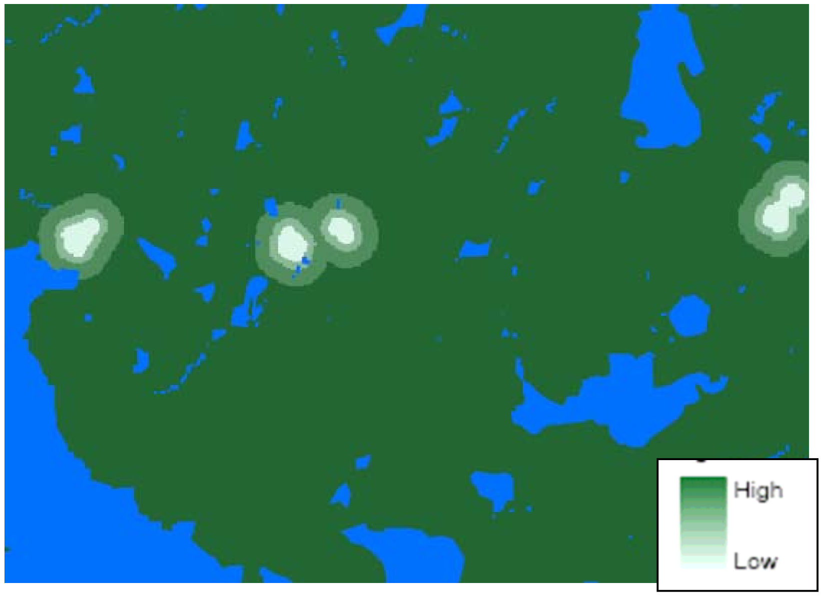

Figure 19. Influence of pits and quarries example screenshot.

Table 16. Influence of pits and quarries and associated scores.

Distance from pits and quarries	Score
Inside	-10
0-100m	-10
101-200m	-6
201-400m	-3
>400m	0

Indicator:

v. Influence of hydro lines

Hydro corridors impact natural areas directly and influences adjacent natural areas. The creation and maintenance of hydro corridors destroys habitat, fragments the landscape, produces noise, introduces herbicides, creates barriers to wildlife movements, and increases access to areas that were once sheltered from predators and humans (Berger 1995; Henson et al. 2005). The associated edge and interior habitat effects of fragmentation, especially apply to linear features of hydro corridors, increasing predator species, parasitism (Berger 1995; Burke and Nol 2000), competition of exotic species (Stiles and Jones 1998), and changing micro-climate patterns (Saab 1999; Fenton and Frego 2005). The physical presence and operation of transmission lines affects wildlife (Berger 1995), and electromagnetic fields appear to have an impact as well (Havas 2000).

The impact of hydro corridors is similar to fragmenting of the landscapes by roads and contributing to the isolation of habitat patches. The Canadian Wildlife Service (Environment Canada 2004) recommends 200m for buffering interior habitat from edge effects.

Dataset(s)

The buffers of location of hydro lines were used to represent the influence of hydro corridors. The buffers were scored according to the distance away from hydro lines, with the closest receiving the lowest score. The following dataset was used:

Dataset Name	Time coverage	Responsible Agency
Utility Line	1977-2006	Ontario Ministry of Natural Resources

Methodology

The general approach taken was as follows:

1. Buffered utility lines shapefile
2. Assigned scores accordingly (Table 17)
3. Converted vector to raster

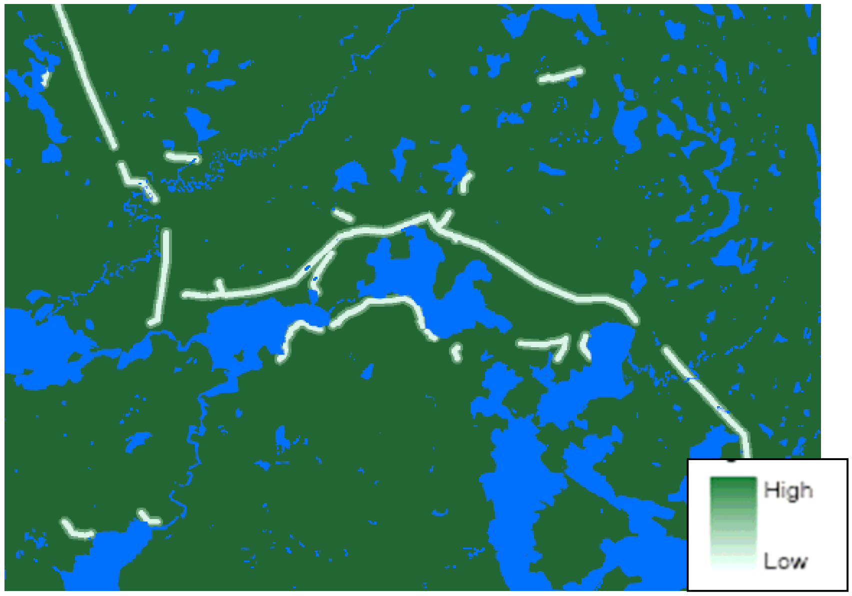

Figure 20. Influence of hydro lines example screenshot.

Table 17. Influence of hydro lines and associated scores.

Distance from hydro lines	Score
0-100m	-5
101-200m	-2
>200m	0

Indicator:

vi. Influence of railways

Railways are a linear feature impacting the landscape in several ways. Railways contribute to habitat fragmentation, and create barriers to wildlife movement (Ito it al. 2005). Passing trains also pose threats to wildlife by injury and mortality (Henson et al. 2005). Railway corridors also contribute to the opportunities for exotic and weed species dispersal (Tikka et al. 2001). However, there is some evidence that railway corridors are able to provide dispersal of native species, as well, such as for grasslands and could compensate for loss of grassland species elsewhere (Tikka 2001). As with hydro corridors, railway corridors appear to affect natural areas up to 200m into adjacent natural areas (Rich et al. 1994).

Dataset(s)

Locations of railways were used to represent the influence of railways. Similar to hydro lines, railway buffers were scored assigned lower scores, the closer the buffer was to the railway. The following dataset was used:

Dataset Name	Time coverage	Responsible Agency
Railway	1977-2005	Ontario Ministry of Natural Resources

Methodology

The general approach taken was as follows:

1. Buffered railways shapefile
2. Assigned scores accordingly (Table 18)
3. Converted vector to raster

Figure 21. Influence of railways example screenshot.

Table 18. Distance from railways and associated scores.

Distance from railways	Score
0-100m	-20
101-200m	-10
>200m	0

Indicator:

vii. Influence of roads

Roads are an increasing concern because of multiple impacts they have on wildlife and ecosystem processes. As with other linear features, roads contribute to habitat loss and fragmentation, increasing the impacts associated with isolation of wildlife populations (i.e. immigration and emigration, inbreeding depression)(Fleury and Brown 1997; Adams and Geiss 1983; Rosenberg et al. 1999; Vos et al. 2001), edge effects (i.e. predation and parasitism), increase opportunity for exotic and invasive species to invade previously inaccessible habitats (Gelbard and Belnap 2003; Watkins 2003; Christen and Matlack 2006), and contain higher concentrations of nutrients and sediments in adjacent water and wetlands (Houlahan and Findlay 2004). Movements of wildlife to and from critical habitat sites are impacted by the inability or refusal of animals to cross roads (Weilgus 2002; Marsh et al. 2005). Road mortality increases for many wildlife species, and could have serious effects of skewed sex ratios, especially for turtle species, where females are most often killed during nesting season (Trombulak and Frissell 2000; Steen and Gibbs 2004). Roads are often associated with housing density (Hawbaker et al. 2004), resulting in impacts related to high density of human population (i.e. persecution of wildlife). The construction of roads also impact wildlife significantly by killing slow-moving animals, injuring wildlife adjacent to construction and altering physical conditions beneath and adjacent to roads (Findlay and Bourdages 2000; Trombulak and Frissell 2000).

Burke and Nol (2000) found nest vulnerability for species of birds within edges created by gravel roads and powerline corridors up to 100m. Recommended buffer distances from Forman (2000) include 100m for preventing wetland degradation, stream channelization, impact of road salt into water bodies, invasion of exotic plants, and minimal impacts on wildlife. Forman (2000) also recommends varying distances from roads of different intensity: 305m for roads supporting 10,000 vehicles/day, 810m for 50,000 vehicles per day.

Dataset(s)

To represent the influence of roads, the type of road was a consideration for this indicator. The presence of primary, secondary and tertiary roads (Appendix J for road definitions) were considered, and buffers were placed on all roads. Scores were assigned to each buffer depending on the type of road and distance away from the road to represent the influence of intensity of impacts.

There were two different datasets available for this indicator. The Road Segment dataset from MNR included all forestry roads, and the type of road as tertiary, secondary or primary. However, Road Segment data was not complete and updated for certain private and municipal roads. The Ontario Roads Network consisted of data collected mainly for municipal and town roads, and included many private and urban roads, but did not include forestry roads. These two datasets were collected using different methods and at different scales, thus did not line-up accurately. As well, the Ontario Roads Network only collected data on roads that were four metres wide or wider, thus a great deal of roads were missing. The Ontario Roads Network for Parry Sound MNR District includes about 8,000,000 metres of roads, while the Road Segment dataset includes approximately 15,500,000 metres of roads for the same area. The attempt to join these two datasets as one complete dataset was being considered by MNR at the time of this analysis. The resource and time limitations of this Inventory did not allow this highly intensive process to be completed in time for the Inventory. Therefore, only the Road Segment dataset was used. At a landscape-level approach, this dataset was considered sufficient (D. Miles pers. comm. August 28, 2006), as it contained forestry roads, roads less than four metres wide, and information on type of road. As well, the roads not contained in the Road Segment data were mainly municipal and urban roads, and those areas were already considered in the scoring of the condition criteria, thus at this level of analysis those areas had already been represented. The following dataset was used:

Dataset Name	Time coverage	Responsible Agency
Road Segment	1977-2006	Ontario Ministry of Natural Resources

Methodology

The general approach taken was as follows:

1. Identified primary, secondary and tertiary roads from road segment shapefile
2. For each road type, created a new shapefile and applied steps 3 to 5:
3. Buffered road segment shapefile
4. Assigned scores accordingly (Table 19)
5. Converted vector to raster
6. Using Union of Inputs in Spatial Analyst, unioned the three buffered raster datasets (ensuring that maximum of inputs is calculated, thus different road type buffers overlapping received the score of the most intense disturbance)

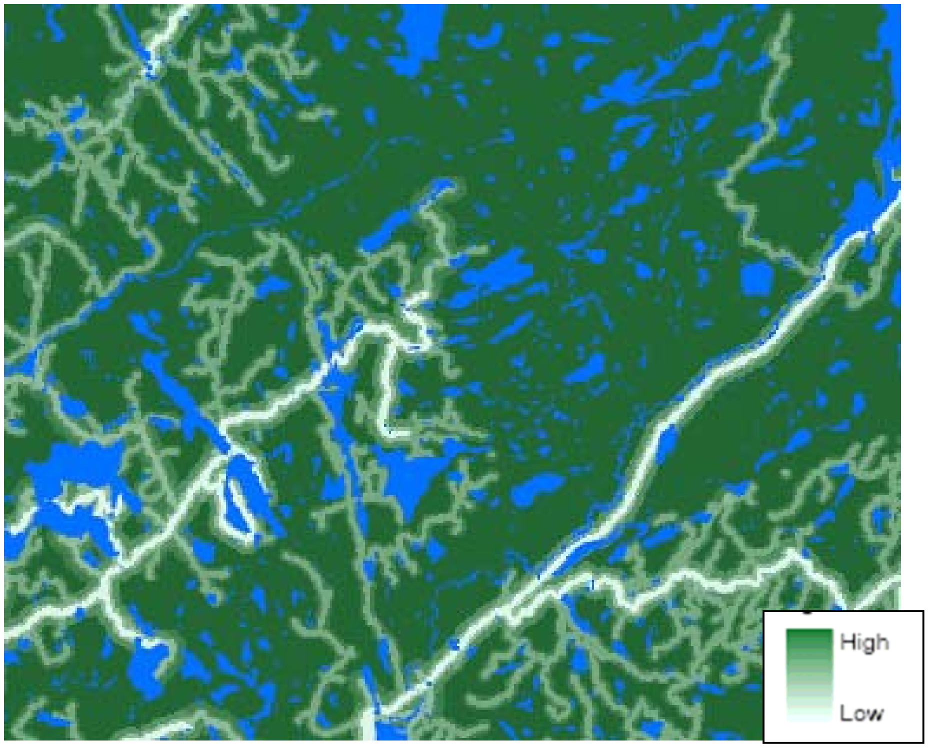

Figure 22. Influence of roads example screenshot.

Table 19. Distance from roads and associated scores.

Distance from roads	Score: Primary Roads	Score: Secondary Roads	Score: Tertiary
0-100m	-20	-10	-8
101-200m	-10	-5	-3
201-400m	-5	-3	0
>400m	0	0	0

Indicator:

viii. Influence of trails

For the Inventory, trails indicated trails used for the following purposes; hiking, backpacking, biking, horseback riding, cross-country skiing or snowmobiling. These anthropogenic disturbances affect animal and plant communities. Blumstein et al. (2005) found that avian species consumed less food items when pedestrian traffic was heavy on trails in parks, while during lighter pedestrian traffic, birds would forage more, and closer to paths. Physiological stress levels in larger mammal species (i.e. wolves) are higher in areas and times of heavy snowmobile use (Creel et al. 2002). Non-native plant species richness and cover is associated with distance from trails by facilitating invasion of non-natives into wilderness areas by altering soil regimes, and providing a mode for dispersal (Dickens et al. 2005).

Dataset(s)

Trail segment was used to represent the influence of trails on the ecological landscape. Trails were scored similar to tertiary roads because of the low intensity impacts of anthropogenic activities associated with this indicator. The following dataset was used:

Dataset Name	Time coverage	Responsible Agency
Trail Segment	1997-2006	Ontario Ministry of Natural Resources

Methodology

The general approach taken was as follows:

1. Buffered trails shapefile
2. Assigned scores accordingly (Table 20)
3. Converted vector to raster

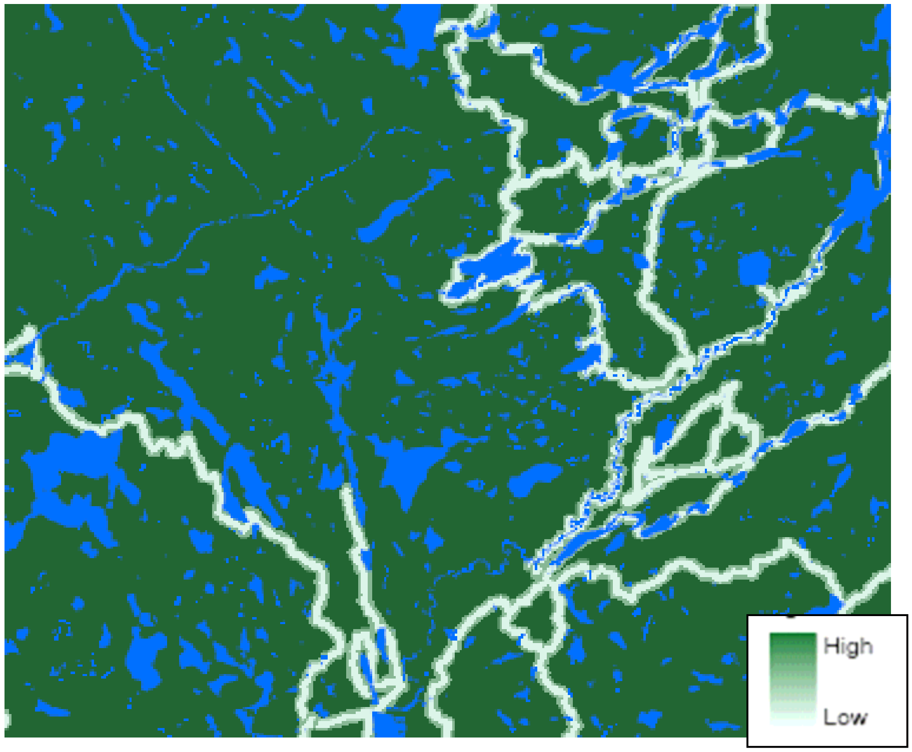

Figure 23. Influence of trails example screenshot.

Table 20. Distance from trails and associated scores.

Distance from trails	Score
0-100m	-8
101-200m	-3
>200m	0

The Scores:

The Inventory assessed the Muskoka River watershed to identify significant natural areas that are not currently represented in existing protected areas and conservation lands. Significant areas were determined by evaluating indicators that support the objectives related to fully-functioning and healthy ecosystems (Table 2). Each indicator was scored based on their relative ecological importance within the Muskoka River watershed. The Great Lakes Conservation Blueprint (GLCB) summed all of their datasets to create one final scored dataset and chose the top-scoring sites to feed into C-Plan, a decision support software (see Introduction). As mentioned, the Inventory did not use C-Plan for decision making. Instead, the Inventory divided the criteria into three goals: the first goal of representation was not scored; the second goal was scored to identify areas of high ecological importance; and the third goal was scored to identify stresses on those ecological systems and processes (see Table 2).

The final report describes in detail the results of the Inventory. The first goal was met by the identification of all ecological systems within the watershed and their protection status. The second goal was met by identifying areas of high ecological importance. This was accomplished by summing the scores from the datasets associated with criteria 2, 3 and 4 (ecological function, diversity and special features); the resulting highest scoring areas were the most important for sustaining terrestrial ecological system processes.

Condition/ quality of areas

The summed datasets of Condition (criterion 5) identified the condition, or quality of the Muskoka River watershed (goal #3). The lowest scored areas were under a high degree of stress, or of low condition or quality.

Final scores

Similar to the GLCB, the Inventory summed the datasets of all the criteria (criteria 2, 3, 4 and 5; Table 2) to create a final scored dataset. This dataset determined significant sites that were highly significant and of high quality, or condition.

The motive for scoring the two goals separately, as well as combined was a result of the variety of interests of the collaborative (MNR, DMM, MHF and MWC) supporting this project (Figure 24). For example, from the overall final scored dataset, the MNR can assess significant sites for regulated protection on crown land and the Muskoka Heritage Trust (of MHF) can focus attention on land acquisition of private land that would capture highly significant and high quality sites. The Muskoka Heritage Foundation can identify ecologically important sites and assess the site’s condition to focus effort on appropriate areas for restoration work (high ecologically significant scored, but low condition scored sites would be the most efficient use of resources if compared to a site that was of low ecological significance). As well, the District Municipality of Muskoka can use the results of the second goal to assess appropriate levels of development surrounding significant sites. The Muskoka Watershed Council will have the ability to monitor significant sites, and their quality or condition by comparing all three datasets.

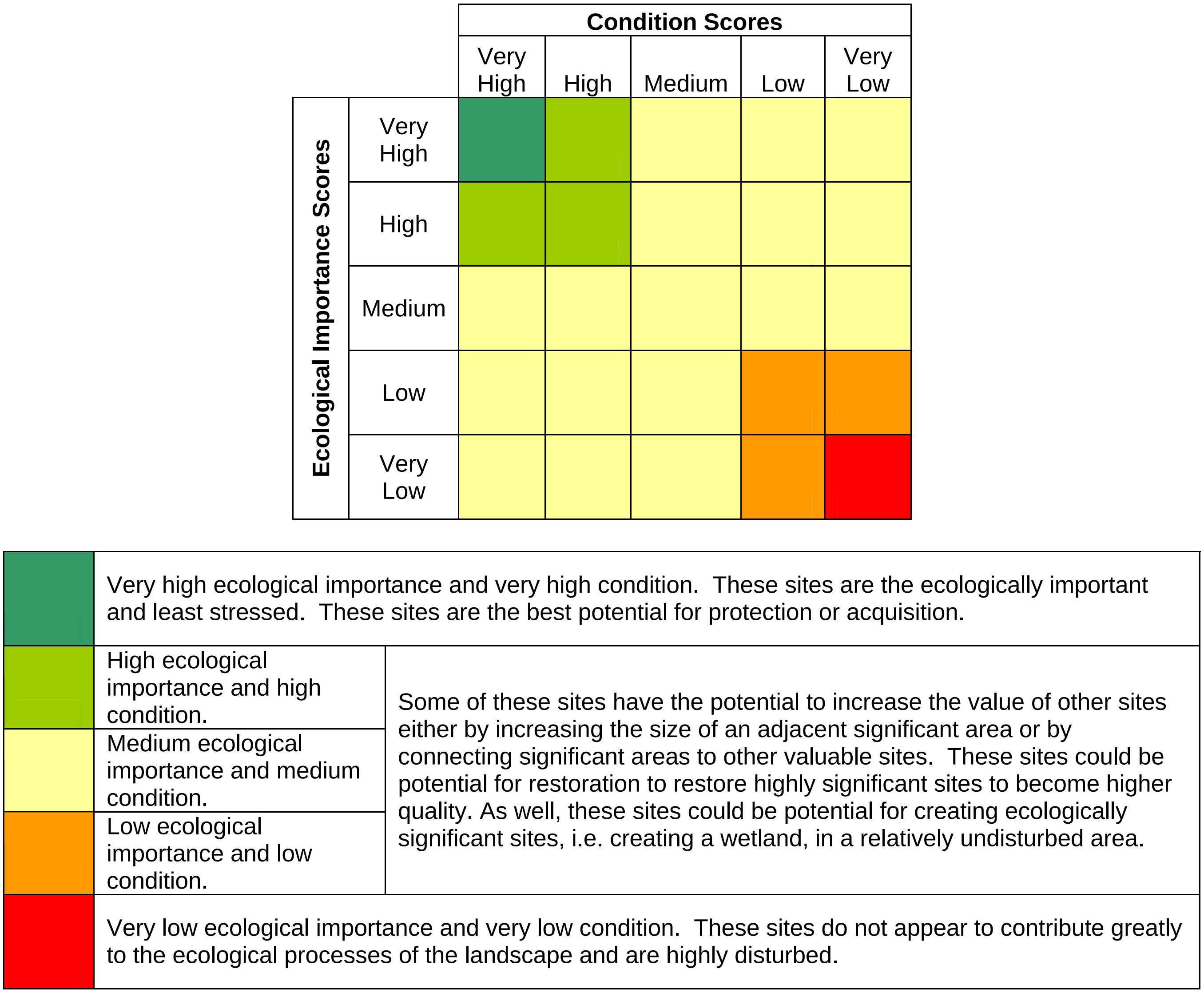

Figure 24. Matrix of the final Inventory scores.

The Products:

The Inventory achieved three main goals (Table 2). The first goal identified ecological systems and protected areas. Accomplishing the first goal allowed the completion of the first product of the Inventory:

(1) A gap analysis of unprotected vegetation communities and landforms (see Introduction).

Inventory Product #1

Product 1:

A gap analysis of unprotected vegetation communities and landforms

Finding gaps in the protection of vegetation communities and landforms was accomplished by the first criterion of Representation. Unique terrestrial ecological systems (vegetation communities and their associated landforms) were overlaid with the existing protection and conservation lands datasets to identify the unprotected ecological systems.

Vegetation communities and landforms were the basic units used in the GIS environment to measure the value of natural areas for the Inventory. Combined, the vegetation communities and landforms on which they occurred created a terrestrial ecological systems layer. The final report describes the number and variety of terrestrial ecological systems found within the Muskoka River watershed. The Inventory also reported on the proportion of each terrestrial ecological system within the entire watershed.

The levels of protection afforded to terrestrial ecological systems were assessed by overlaying a dataset representing existing protected areas and conservation lands (page 22). The final report describes the proportion of each terrestrial ecological system under different levels of protection. Unprotected terrestrial ecological systems or “the gaps” were identified as areas that were not under any level of protection. The final report flagged ecosystems that had very little or no representation in existing protected areas.

The second goal identified areas of high ecological importance and the third goal identified stresses on ecological systems and processes (Table 2). By achieving the second and third goals, the Inventory produced the remaining three products:

(2) A gap analysis of biological data and site inventories;
(3) A map portraying the significant natural areas and connecting corridors and;
(4) Identification of significant degraded sites and areas within the watershed that require remediation.

Inventory Product #2

Product 2:

A gap analysis of biological data and site inventories

The Inventory collection of datasets was comprehensive to ensure that sites captured the significance of ecological processes and biodiversity of the Muskoka River watershed. By assessing the datasets and documenting/verifying the currency and accuracy of each, missing and inaccurate data were identified. This technical report touches on some of the inaccurate and out-of-date data used for the Inventory. The final report summarized these data limitations and reported on future updates for some datasets and their sources. The use of GIS allows the Inventory database to be updated as new data becomes available.

Product 3:

Inventory Product #3

A map portraying the significant natural areas and connecting corridors

The final scored grid achieved the Inventory's third product of identifying significant natural areas and connecting corridors. By scoring the criteria to identify areas of high terrestrial ecological importance (second goal), and combining the "cost" grid of identifying stresses on ecological systems and processes (third goal), the Inventory assessed high quality, ecologically significant natural areas (Figure 24).

Connecting the natural areas in most of Southern Ontario involves identifying remnant natural areas and suitable corridors to connect them. The image of significant natural core areas and linkages would be "islands" of natural areas connected with "bands of green" surrounded by non-natural areas (McMurtry et al. 2002).

Unlike Southern Ontario, the Muskoka River watershed has a large proportion of high quality natural landcover. There is a tremendous opportunity to maintain areas that can adequately support important ecological processes and connect them with other valuable natural areas. In contrast to Southern Ontario, the Muskoka River watershed can be described as "islands of green within a sea of green". The MRWIP has identified the highest quality significant areas and identified remaining natural areas that would contribute to and enhance the overall terrestrial ecological quality of the Muskoka River watershed (Figure 24).

Product 4:

Inventory Product #4

Identification of significant degraded sites and areas within the watershed that require remediation

Restoration and remediation projects are costly and require expertise in most cases to ensure efforts are used efficiently and effectively. Identifying appropriate sites for restoration efforts is an important decision. Restoring a degraded site will repair the site's integrity, but restoring a site that would also contribute to the landscape's ecological function and biodiversity would be best.

The results of the second goal identified highly significant areas. The sites were considered significant based on the most current scientific principles of landscape ecology and biological diversity. The analysis of the second goal did not include any specific stresses upon sites, thus identifying areas that are important to ecological processes regardless of condition. The third goal identified the condition, or quality of sites. By finding areas that are highly significant from the results of the second goal and determining its condition from the third goal, the most appropriate sites to focus restoration efforts can be identified.

Discussion and Limitations:

The Inventory development came at an important time for the Muskoka River watershed. Urban development is continually spreading and the Muskoka region is an increasingly popular location for business and recreational opportunities. The Inventory recognized that healthy, functioning watershed and economic viability are not mutually exclusive. In fact, the seemingly endless beautiful natural areas are the main attraction to the Muskoka region. Therefore, it was imperative to develop a methodology that was transparent and scientifically defensible in order to conserve ecological systems within the Muskoka River watershed and maintain the lifestyle and health of communities.

The GLCB conservation framework was developed to inventory and identify significant natural heritage areas. One of the strengths of using the GLCB framework for the Inventory was the support of a Core Science Team consisting of expertise and experience in conservation and natural heritage planning. The GLCB also used conservation principles and terminology familiar to conservation planners across Ontario, thus developing a framework that was useful to all organizations with similar conservation mandates. The GLCB framework was adaptable and useful for further iterations. The GLCB methodology allow data to be re-analysed as conservation science changes over time, and can be perfected with different datasets, goals, objectives and/or scores.

The Inventory attempted to gather a comprehensive list of attributes that would capture ecological units, ecological processes and their condition or quality. The Inventory was based on current scientific knowledge of ecology and conservation science. However, one aspect of identifying significant areas was missing from the Inventory: threats to ecological systems. Threats were considered to be *future* risks to ecological systems, whereas the Inventory evaluated *current* stresses or pressures. Evaluating threats to ecological systems was beyond the scope of the Inventory, however, the collaborative recognized that some of these threats would need to be addressed, or at the very least flagged, in future iterations.

In Ontario, natural heritage inventories have occurred mostly in the south, off of the Canadian Shield. Many existing site inventories for the Canadian Shield were considerably out-of-date at the time of the Inventory analysis. The Inventory attempted to use more site-specific and local data, however, the Muskoka River watershed crosses three ecodistrict boundaries (5E-7, 5E-8, and 5E-9), three MNR districts (Parry Sound, Bancroft, and Algonquin Provincial Park), several townships (including Dysart, Minden Hills, Algonquin Highlands, Mcmurrich-Monteith, Perry, Kearney, Gravenhurst, Huntsville, Bracebridge, Lake of Bays, and Muskoka Lakes), four district municipalities (Haliburton, Muskoka, Parry Sound, and Nipissing), and two First Nations territories (Moose Deer and Wahta Mohawks). Most data obtained available for, and from, the Parry Sound MNR district, but some data were obtained from other sources, requiring datasets to be examined, merged and combined to adequately represent the watershed. Unfortunately, some datasets were not completely standardized, even across MNR districts, although the process was in progress for FRI data (M. Martell pers. comm. April 20, 2006). Lack of consistent, seamless digital data across regions, and extensive GIS processing and interpretation required creative thinking and management to deal with technical limitations (Henson et al. 2005). However, MNR is a leader in developing and improving ways to collect and maintain land and resources data in a centralized GIS. MNR's GIS accomplishments and commitments have earned them recognition and awards from the greater GIS community (ESRI 2003). Continued comprehensive and standardized datasets will help strengthen future Inventory updates.

Spatial datasets are an approximation of real world objects, and therefore are rarely, if ever, truly free of errors (Heuvelink and Burrough 2002). Datasets that were obtained for the Inventory originated from a variety of sources, and therefore were created using a variety of methods and datasets. Users of project data need to recognize that the Inventory evaluated the Muskoka River watershed at a landscape-level scale. Where some datasets were up-to-date and accurate at more site-specific levels, the appropriate use of such datasets at a landscape-scale needed to be considered, for example the dataset chosen for indicating roads (page 62).

Considering the constraints of time and data availability the Inventory relied heavily on the expertise, techniques, and created datasets of GLCB initiatives. As a result, there were datasets created by GLCB that were used directly in the Inventory (i.e. not recreated specifically for the Muskoka River watershed), for example, the creation of fire disturbance database used in the "size of natural areas" indicator. Although data, such as fire disturbance regimes, were not expected to change considerably over time (and thus updates would be infrequent), future iterations using these data should ensure any new information and calculations are taken into account.

The Inventory was a collaborative of four different agencies. Each collaborative member used the Inventory results in different ways, hence the deliverables must be useful for all members. Maintaining strong communication between members was important to make certain that issues were addressed and that the methods produced a useful project for all agencies. However, establishing strong communication early in projects is essential to ensure that data sharing agreements are in place, technical needs are addressed, and roles of each agency are understood.

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The Muskoka River Watershed Inventory Project: Land Component

Technical Report Appendices

The Muskoka Heritage Foundation
The District Municipality of Muskoka
The Ontario Ministry of Natural Resources
The Muskoka Watershed Council

February 2007
Updated September 10, 2007

List of Appendices:

Appendix A: Weighting and Scoring Values

Criteria scores:

Ecological Function		**60%**									
	Size	*0-25ha*	*26-50ha*	*51-100ha*	*101-159ha*	*>159ha*					
		-10	2	6	15	40					
	Old Growth Forests	*Inside*	*Outside*								
		10	0								
	Core area/edge buffer of areas	*0-50ha*	*51-100ha*	*101-500ha*	*>500ha*						
		-15	0	8	15						
	Wetlands	*Positive*	*Negative*								
		15	0								
	Riparian area of streams/rivers	*Positive*	*Negative*								
		15	0								
	Riparian area of lakes	*Positve*	*Negative*								
		15	0								
	Great lakes shoreline	*Positive*	*Negative*								
		20	0								
	Recharge areas	*Positive*	*Negative*								
		1	0								
Diversity		**15%**									
	Habitat diversity	*One*	*Two*	*Three*	*Four*	*Five*	*Six*	*Seven*	*Eight*	*Nine*	*Ten*
		1	2	3	4	5	6	7	8	9	10
Special Features		**5%**									
	Element Occurrence	*Extant*	*Historic*	*Community*							
		count*4	count*1	count*2							
	Moose aquatic feeding sites	*Positive*	*Negative*								
		5	0								
	Fish spawning areas (with 30m buffer)	*Positive*	*Negative*								
		5	0								
	Bird nesting sites	*Positive*	*Negative*								

	5	0								
Deer wintering areas	*Positive*	*Negative*								
	5	0								
Condition	**20%**									
Percentage natural cover	*0-40%*	*41-70%*	*71-90%*	*91-100%*						
	0	4	8	12						
Open cleared areas	*Inside*	*0-100m*	*101-200m*	*201-400m*	*>400m*					
	0	-8	-5	-3	0					
Urban/developed settlement	*Inside*	*0-100m*	*101-200m*	*201-400m*	*>400m*					
	0	-10	-6	-3	0					
	Inside	*0-100m*	*101-200m*	*201-400m*	*>400m*					
Pits/quarries	-10	-10	-6	-3	0					
	0-100m	*101-200m*	*>200m*							
Hydro corridors	-5	-2	0							
	0-100m	*101-200m*	*201-400m*	*>400m*						
Railways	-20	-10	-5	0						
Roads	*0-100m*	*101-200m*	*201-400m*	*>400m*						
primary	-20	-10	-5	0						
secondary	-10	-5	-3	0						
tertiary	-8	-3	0	0						
	0-100m	*101-200m*	*>200m*							
Trails	-8	-3	0							

Proportion of total scores:

Criteria	Indicator	% of Criteria Score	% of Total Score
Ecological Function (adjusted to 60% of total score)	Size	32.05%	19.23%
	Old Growth	6.41%	3.85%
	Core area/edge buffer	19.23%	11.54%
	Wetlands	9.62%	5.77%
	Riparian area rivers	9.62%	5.77%
	Riparian area inland lakes	9.62%	5.77%
	Riparian area Great Lakes shoreline	12.82%	7.69%
	Recharge areas	0.64%	0.38%
Diversity (adjusted to 5% of total score)	Habitat diversity	100.00%	5.00%
Special Features (adjusted to 15% of total score)	EO	66.67%	10.00%
	Aquatic feeding	8.33%	1.25%
	Fish Habitat (includes spawning areas)	8.33%	1.25%
	Nesting	8.33%	1.25%
	Wintering	8.33%	1.25%
Condition (adjusted to 20% of total score)	% natural cover	12.90%	2.58%
	Urban	10.75%	2.15%
	Open and cleared areas	8.60%	1.72%
	Pits/quarries	10.75%	2.15%
	Hydro	5.38%	1.08%
	Railways	21.51%	4.30%
	Roads	21.51%	4.30%
	Trails	8.60%	1.72%

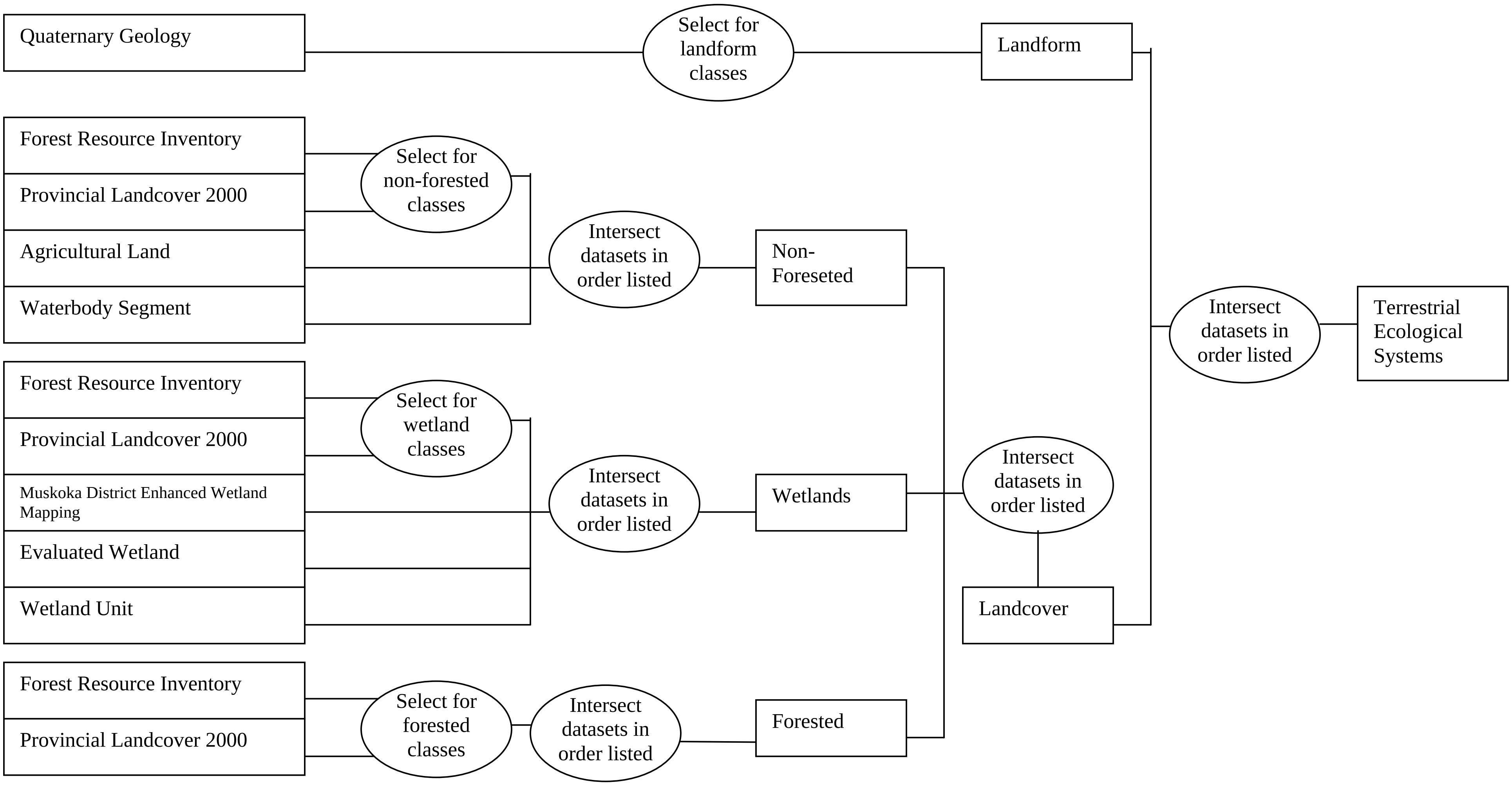
Appendix B: List of data sources and responsible agencies.

Dataset Name	Time coverage	Responsible Agency
Quaternary Geology of Ontario	1955-1988	Ministry of Northern Development and Mines
Ontario Forest Resource Inventory: Parry Sound, Bancroft, Algonquin Provincial Park	2003-2006	Ontario Ministry of Natural Resources
Provincial Landcover 2000	1999-2002	Ontario Ministry of Natural Resources
Agricultural Land	1998	Ontario Ministry of Natural Resources
Muskoka District Enhanced Wetland Mapping	1988-2002	Ducks Unlimited Canada and Ontario Ministry of Natural Resources
Evaluated Wetland	1980-2006	Ontario Ministry of Natural Resources
Waterbody Segment	1977-2006	Ontario Ministry of Natural Resources
Wetland Unit	1997-2006	Ontario Ministry of Natural Resources
Conservation Reserve Regulated	1994-2006	Ontario Ministry of Natural Resources
Provincial Park Regulated	1900-2004	Ontario Ministry of Natural Resources
Muskoka Heritage Trust Properties	2006	Muskoka Heritage Foundation/Trust
Georgian Bay Land Trust Properties	2006	Georgian Bay Land Trust
Nature Conservancy of Canada Properties	2006	Nature Conservancy of Canada
Ownership Parcel - Digital Ownership Parcel Fabric	1960-2004	Ontario Ministry of Natural Resources
Muskoka Heritage Areas	1993	Muskoka Heritage Foundation and The District Municipality of Muskoka
Muskoka Heritage Trust Properties	2006	Muskoka Heritage Foundation/Trust
ANSI	1997-2006	Ontario Ministry of Natural Resources
Water Virtual Flow - Seamless Provincial Data Set	2005	Ontario Ministry of Natural Resources
Surficial Geology of Southern Ontario	1950-2003	Ministry of Northern Development and Mines
Natural Heritage Information Centre Element Occurrences	1993-2006	Ontario Ministry of Natural Resources
Species Observation, Locally Tracked	1998-2006	Ontario Ministry of Natural Resources
Aquatic Feeding Area	1997-2006	Ontario Ministry of Natural Resources
Nesting Site	1997-2006	Ontario Ministry of Natural Resources
Wintering Area	1997-2006	Ontario Ministry of Natural Resources
Spawning Area	1997-2006	Ontario Ministry of Natural Resources
Fish Habitat Type	1996	Ontario Ministry of Natural Resources
Pit or Quarry	1977-2006	Ontario Ministry of Natural Resources
Utility Line	1977-2006	Ontario Ministry of Natural Resources
Railway	1977-2005	Ontario Ministry of Natural Resources
Road Segment	1977-2006	Ontario Ministry of Natural Resources
Trail Segment	1997-2006	Ontario Ministry of Natural Resources
Watershed, Tertiary	2002-2005	Ontario Ministry of Natural Resources
Watershed, Quaternary	2002-2005	Ontario Ministry of Natural Resources
Municipal Boundaries 2005	2005	District Municipality of Muskoka
Municipal Boundaries 2005	2005	District Municipality of Muskoka
Federal Land, Indian Reserve - PARRY SOUND OMNR District	1997-1998	Ontario Ministry of Natural Resources

Appendix C: Methodology flowcharts

Goal: Identify terrestrial ecological systems and protected areas

<u>Terrestrial Ecological Systems:</u>



Landform:

Select the following from "Quaternary Geology":

Geol. Deposition	Material Description	LF_name
Bedrock	undifferentiated igneous and metamorphic rock, exposed at surface or covered by a discontinuous, thin layer of drift	Bedrock
Glaciofluvial ice-contact deposits	gravel and sand, minor till, includes esker, kame, end moraine, ice-marginal delta and subaqueous fan deposits	Glaciofluvial1
Glaciofluvial outwash deposits	gravel and sand, includes proglacial river and deltaic deposits	Glaciofluvial2
Glaciolacustrine deposits	sand, gravelly sand and gravel, nearshore and beach deposits	Glaciolacustrine1
Glaciolacustrine deposits	silt and clay, minor sand, basin and quiet water deposits	Glaciolacustrine2
Lacustrine deposits	gravel, sand, silt and clay, deposited on modern flood plains (Inventory: sand, gravelly sand and gravel, nearshore and beach deposits or sild and clay, basin and quiet water deposits)	Lacustrine
Organic deposits	peat, muck and marl	Organic
Till	undifferentiated, predominantly sand to silty sand matrix, high content of clasts, often low in matrix carbonate content	Till

Vegetation:

FRI forested areas:

NWR Combinations	NER Combinations	SCR Combinations (2002)	SCR Combinations (1999)	Shield Combinations
	Red Pine	Red Pine	Red Pine	Red and White Pine Mixed
Red and White Pine	Red and White Pine mixed	White Pine and Red White mixed	White Pine & White Pine mixed	
Jack Pine Upland	Jack Pine Upland	Jack Pine Upland	Jack Pine	Jack Pine Upland*
Lowland Conifer - Ce and La	Lowland Conifer Mixed	Lowland Conifer Mixed	Lowland Conifer Mixed	Lowland Conifer Mixed
Black Spruce Lowland	Black Spruce Lowland	Lowland Black Spruce	Lowland Black Spruce	Lowland Black Spruce
Black Spruce Upland				Upland Black Spruce
	Black Spruce Mixed			Mixed Spruce/Pine
	Jack Pine Black Spruce mixed	Jack Pine Black Spruce mixed		
		Spruce and Pine Mixed	Spruce and Pine Mixed	
		Spruce and Balsam Fir Mixed		
		Hemlock	Hemlock	Hemlock
Poplar Upland	Poplar	Poplar Upland	Poplar Upland	Aspen
White Birch	White Birch			White Birch
		Yellow Birch	Yellow Birch	Yellow Birch
		Oak & Oak/Pine	Oak & Oak/Pine	Oak & Oak/Pine
Other Hardwood	Tolerant Hardwoods - upland & lowland			Tolerant Hardwoods
		Upland Hardwood	Upland Hardwood	
		Lowland Hardwood	Lowland Hardwood	
		Midtolerant Hardwood	Midtolerant Hardwood	Midtolerant Hardwoods
Intolerant Hardwood Mix	Intolerant Hardwoods	Poplar and White Birch Upland	Poplar and White Birch Upland	Intolerant Hardwoods
Conifer Mixedwood		Upland Hardwood & Conifer		Upland Hardwood & Conifer Mixed
	Remaining Mixedwood (with Pine, Sb)	Upland Mixedwood	Upland Mixedwood	

SQL for the following from "Landcover 2000" forested areas:

Forested Types:

MRWIP Codes	Description	Landcover SQL Syntax
Mixed	Mixed Forest	([Code] = 12)
Coniferous	Coniferous Forest	([Code] = 13)
Deciduous	Deciduous Forest	([Code] = 11)
Sparse	Sparse Forest	([Code] = 10 or [Code] = 8 or [Code] = 7)

Non-forested and wetland areas:

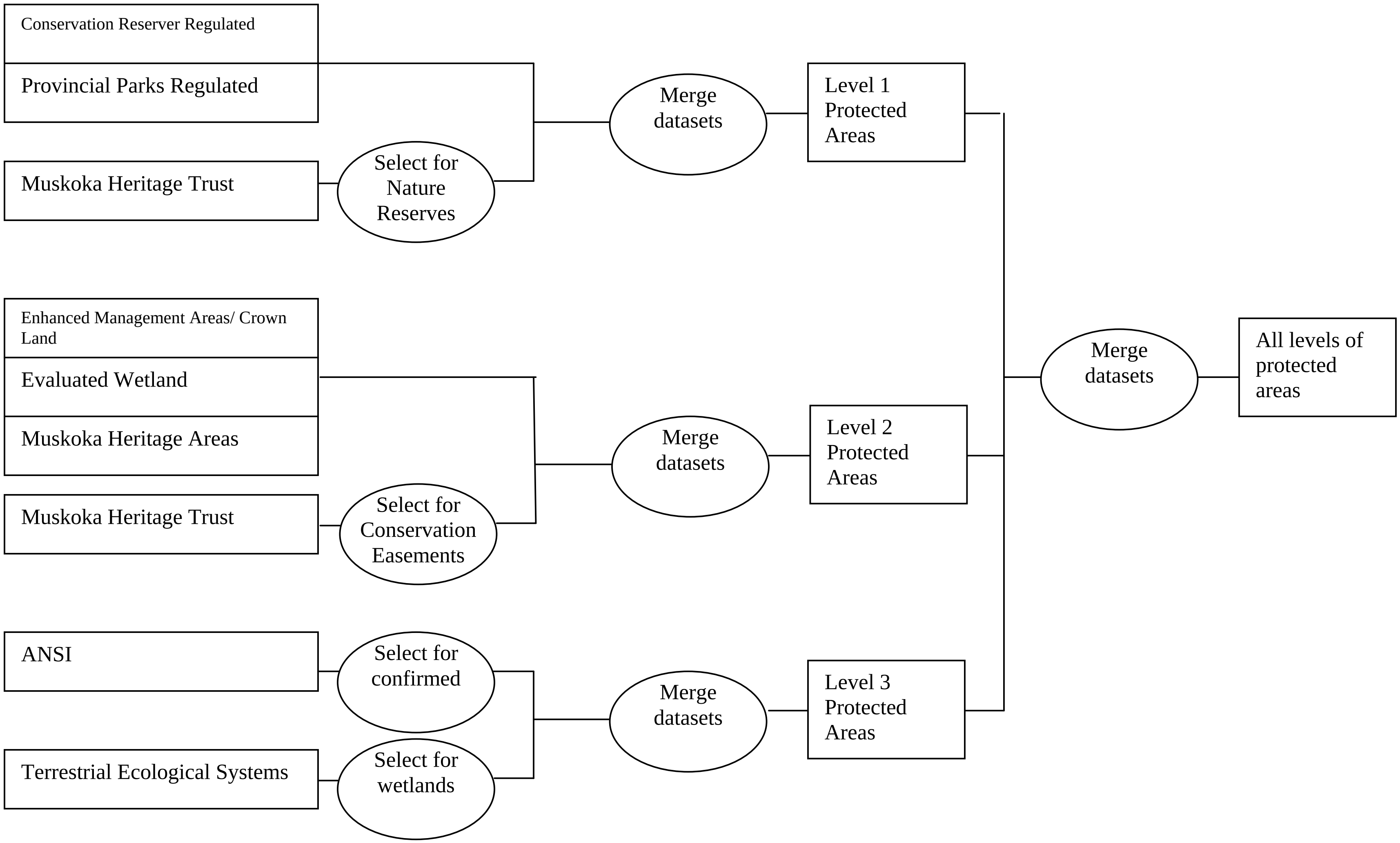
FRI:

MRWIP Codes	Description	FRI SQL syntax
SBOG	Conifer Swamp/Fen/Bog	([Mnrcode] = 310) or ([Type] = 50)
OWET	Open Marsh/Fen/Bog	([Mnrcode] = 311) or ([Mnrcode] = 77) or ([Type] = 52)
BRSH	Brush and Alder	([Mnrcode] = 312) or ([Type] = 54)
ROCK	Rock	([Mnrcode] = 313) or (([Mnrcode] = 62) and ([Type] = 56)) or ([Type] = 56)
WATER	Water	([Mnrcode] = 64) or ([Mnrcode] = 152) or ([Mnrcode] = 102) or ([Mnrcode] = 265) or ([Type] = 70) or ([Type] = 71)
DAL	Developed Agricultural Land	([Mnrcode] = 315) or ([Type] = 60)
UCL	Unclassified	([Mnrcode] = 317) OR ([Mnrcode] = 333) OR ([Mnrcode] = 302) or ([Mnrcode] = 309) or ([Type] = 66) or ([Type] = 80)
GRS	Grass and Meadow	([Mnrcode] = 316) OR ([Type] = 63)
UCL	No Data	All others

Landcover 2000:

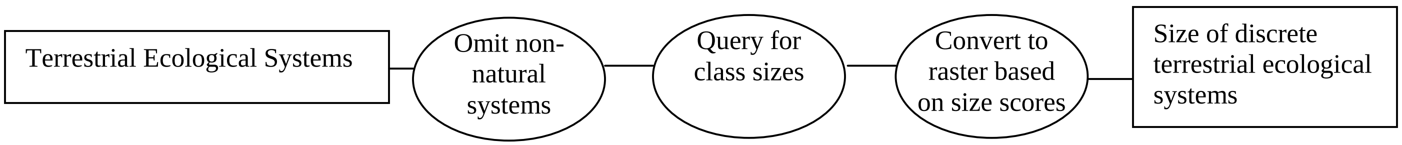
MRWIP Codes	Description	Landcover SQL Syntax
Marsh	Marsh	([Code] = 15 or [Code] = 16 or [Code] = 17)
Swamp	Swamp	([Code] = 18 or [Code] = 19)
Fen	Fen, open or treed	([Code] = 20 or [Code] = 21)
Bog	Bog, open or treed	([Code] = 22 or [Code] = 23)
DAL	Agriculture, pasture, fields, cropland	([Code] = 25 or [Code] = 27)
Bedrock	Exposed bedrock	([Code] = 5)
Tailings	Mines and mine tailings	([Code] = 4)
Settlement	Settlement/Infrastructure	([Code] = 3)
Water	Water, deep or shallow	([Code] = 1 or [Code] = 2)
UCL	Other-unknown, Other-cloud/shadow	([Code] = 28 or [Code] = 29)

Existing Protection:



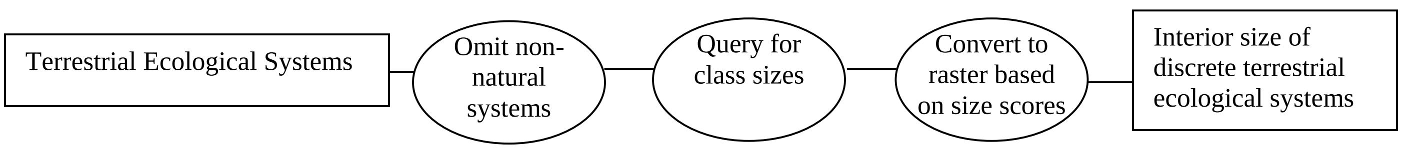
Goal: Identify areas of high terrestrial ecological importance

Size of discrete terrestrial ecological systems:

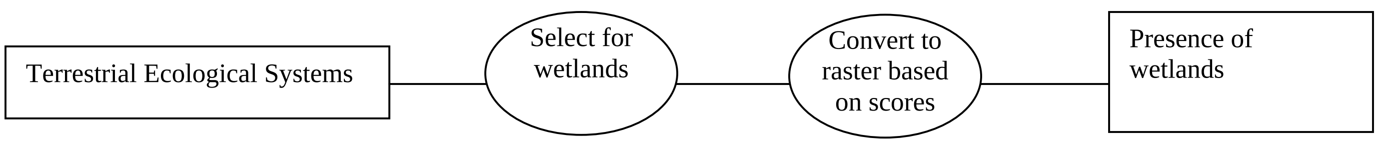


Old growth forests:

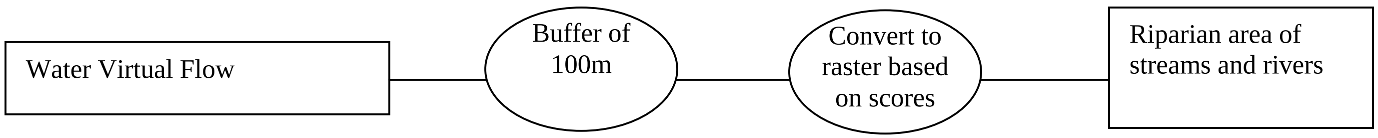
Interior size of size terrestrial ecological systems:



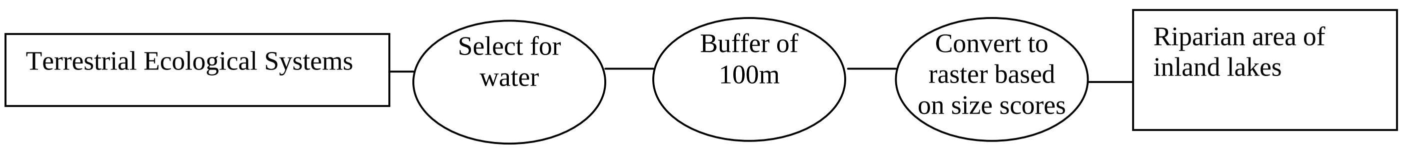
Presence of wetlands:



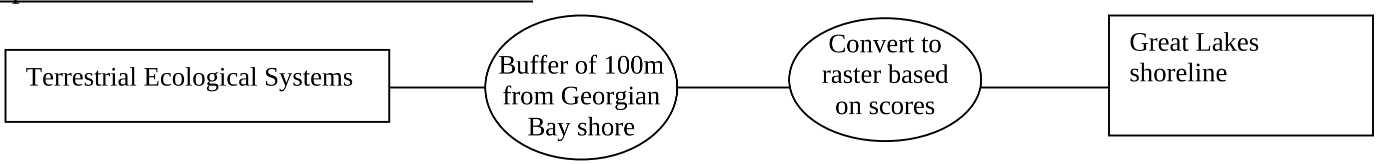
Riparian area of streams and rivers:



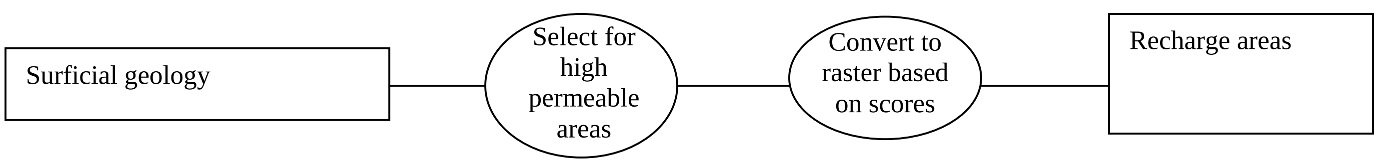
Riparian area of inland lakes:



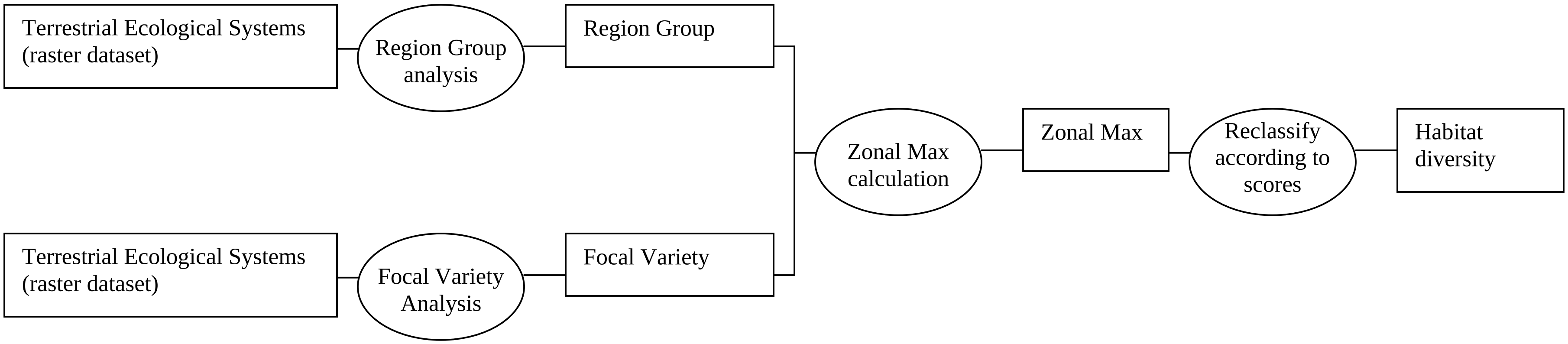
Riparian area of the Great Lakes shoreline:



Highly permeable areas:



Habitat diversity:



Raster calculation for REGIONGROUP:

Output = regiongroup ([terrestrial ecological systems], #, EIGHT, WITHIN)

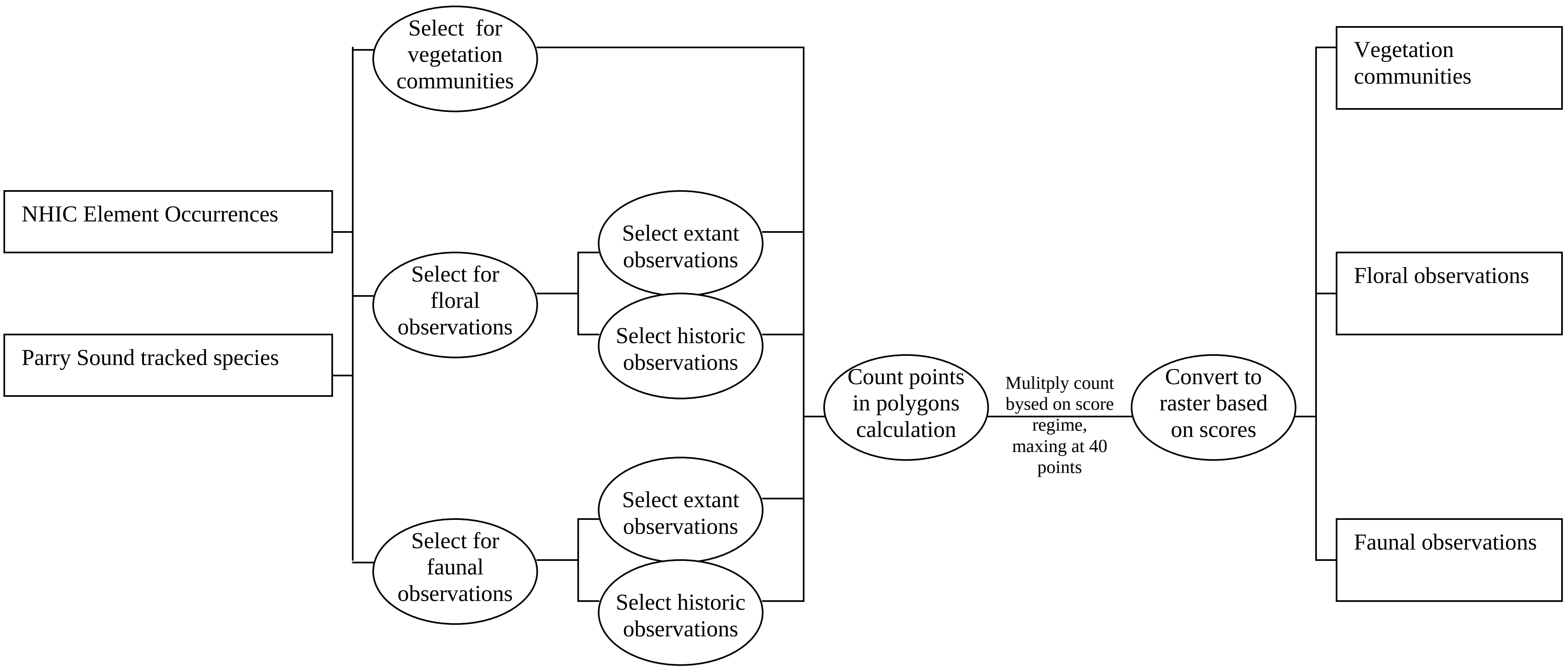
Raster calculation for FOCALVARIETY:

Output = focalvariety ([terrestrial ecological systems], rectangle, 5, 5, data)

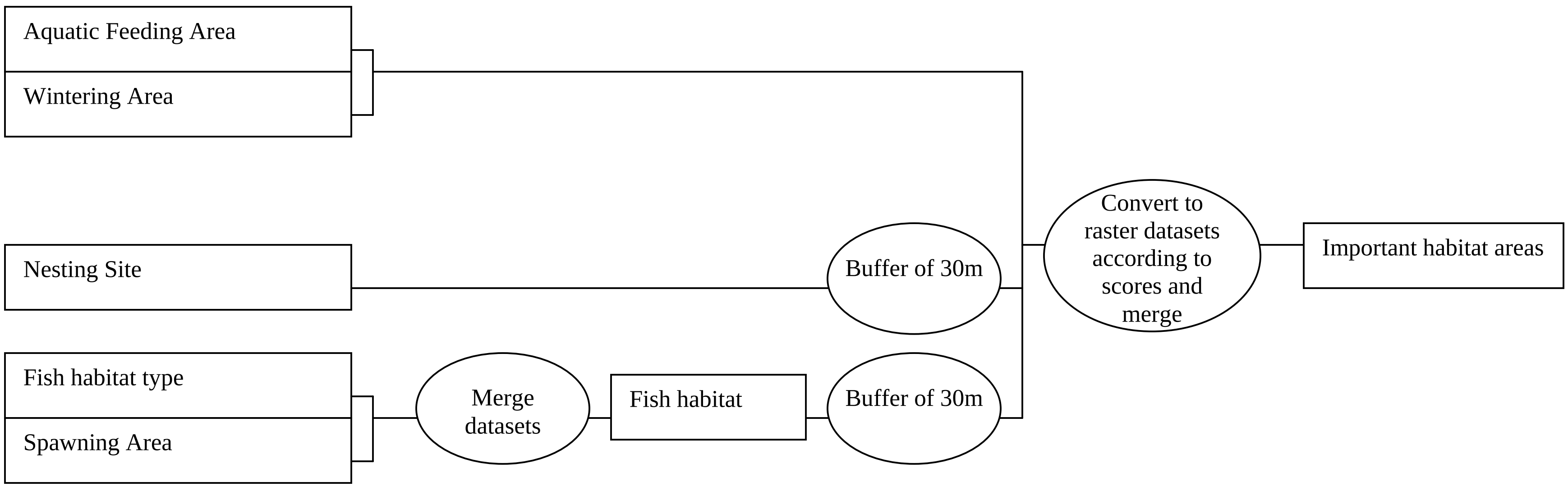
Raster calculation for ZONALMAX:

Output = zonalmax ([REGION output], {FOCALVARIETY output], data)

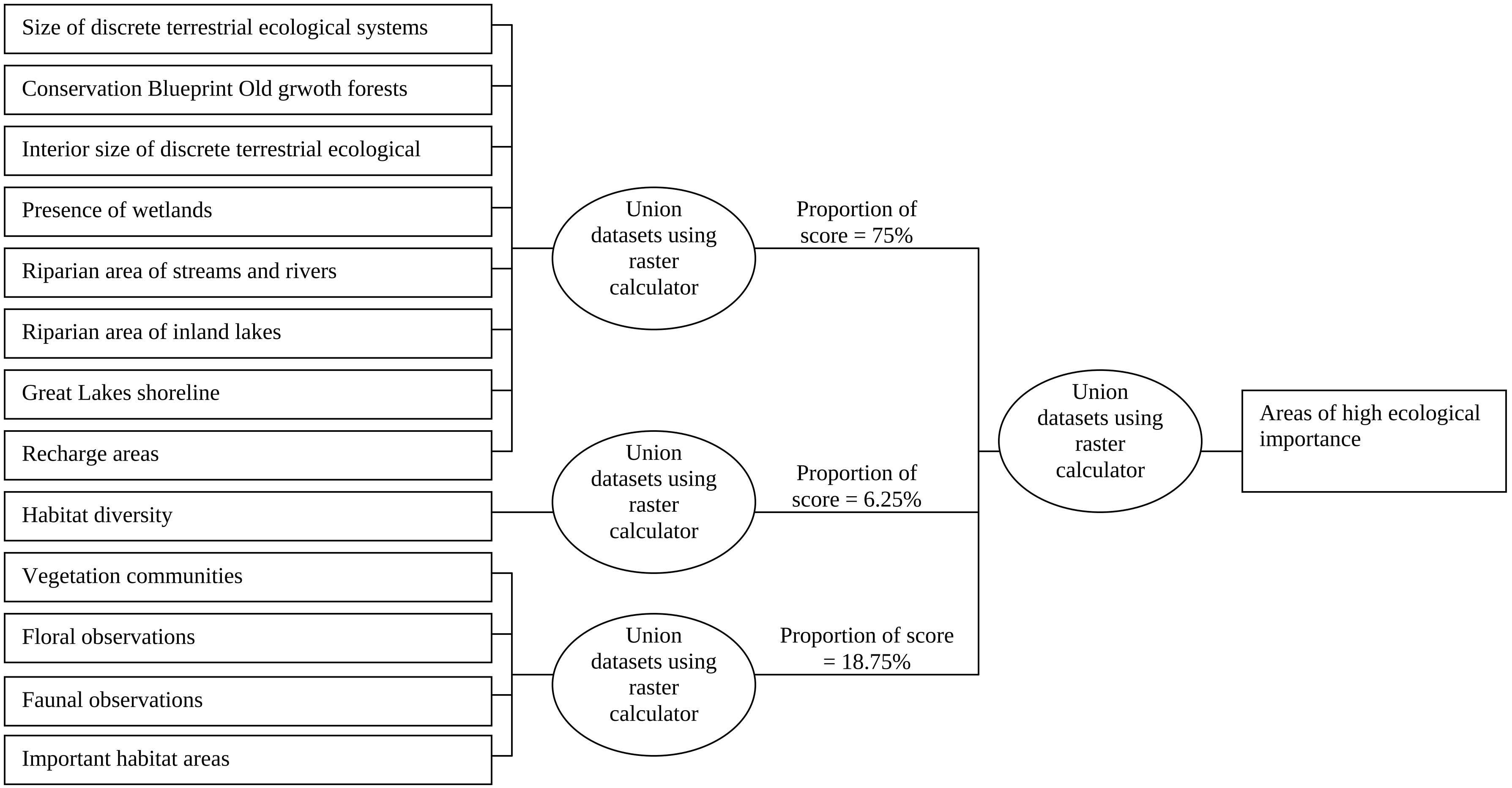
Element occurrences:



<u>Habitat Areas:</u>

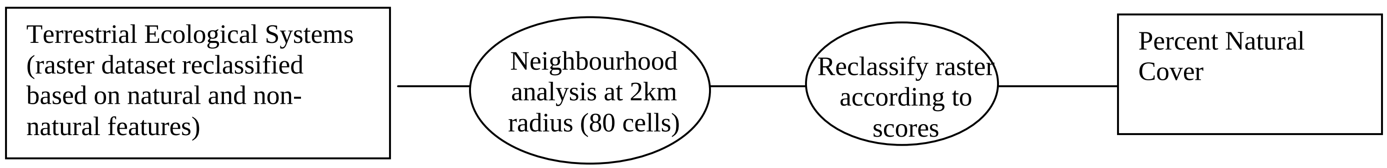


Final scored dataset for important terrestrial ecological areas:

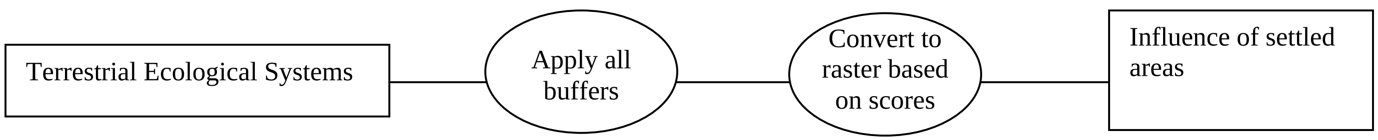


Goal: Identify condition/quality of terrestrial ecological systems

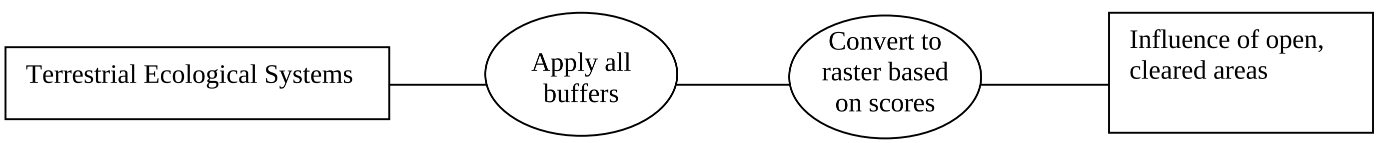
Percentage Natural Cover:



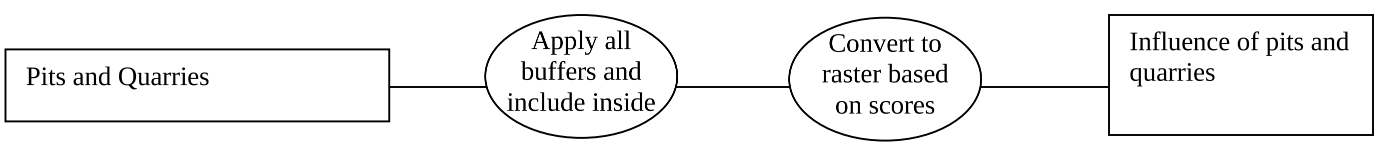
Influence of settled areas:



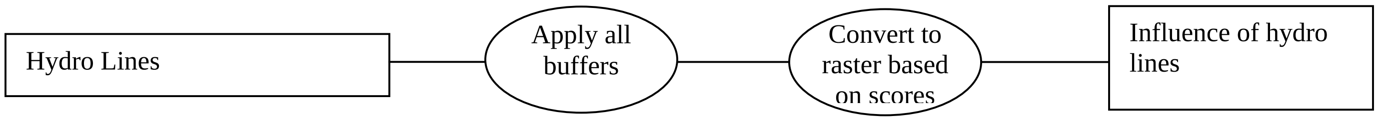
Influence of open, cleared areas:



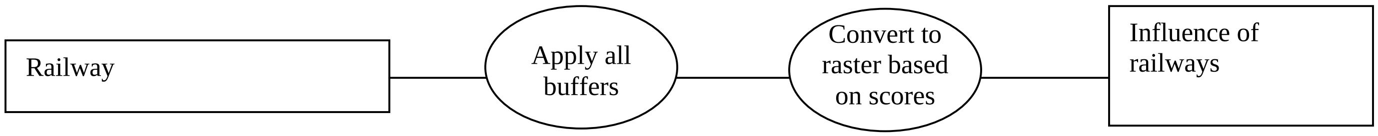
Influence of pits and quarries:



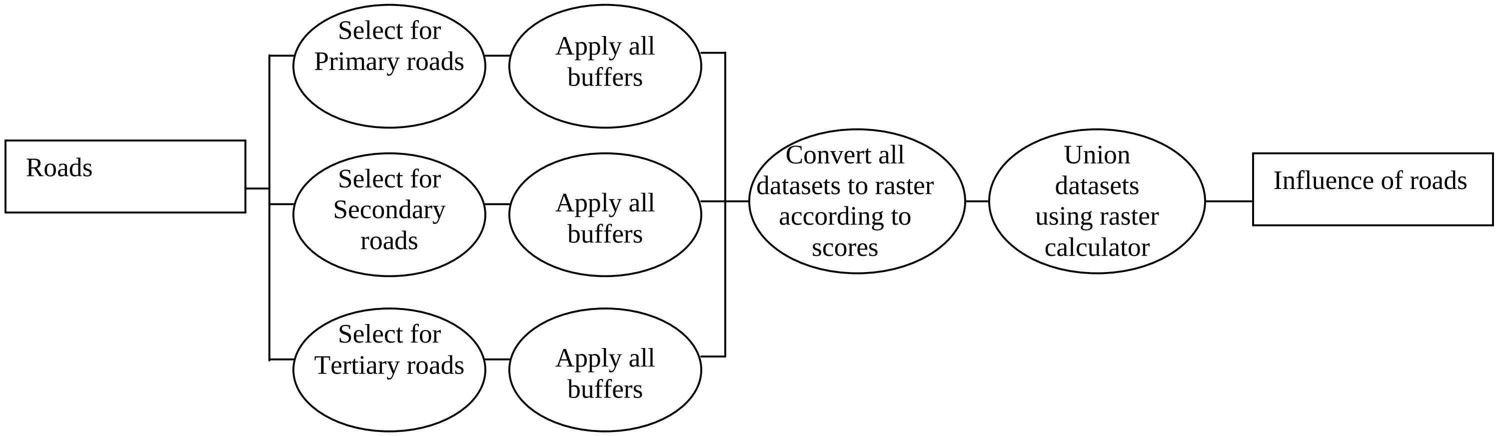
Influence of hydro lines:



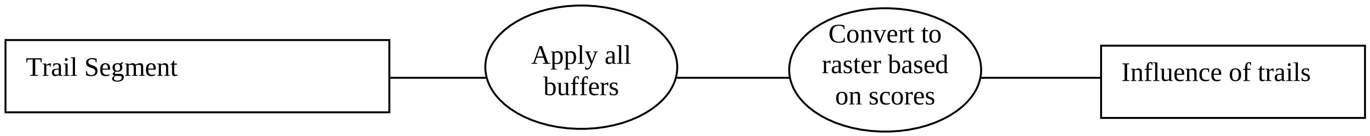
Influence of railways:



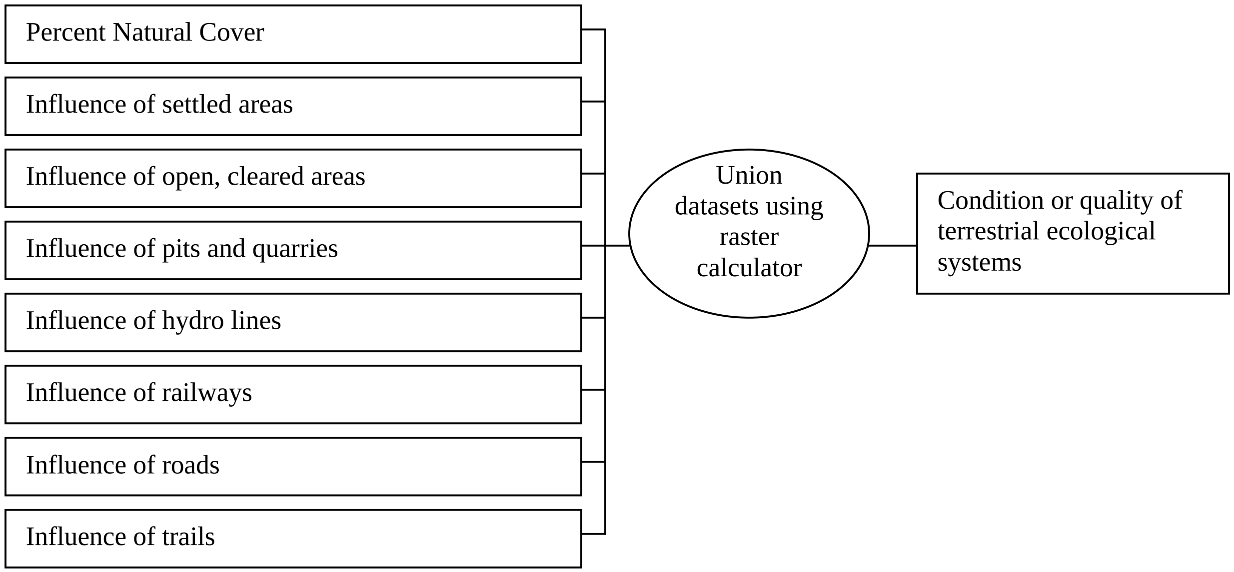
Influence of roads:



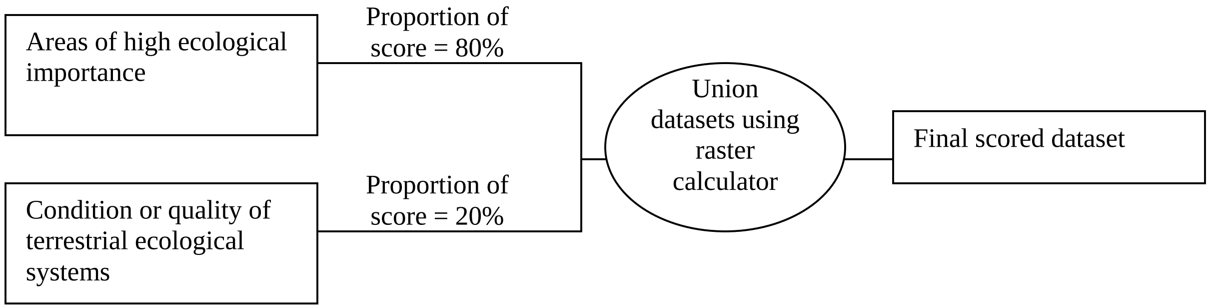
Influence of trails:



Final scored dataset for condition of terrestrial ecological areas:



Final scored values (the combination of ecological importance and condition datasets):



Appendix D: Unique Terrestrial Ecological Systems descriptions.

Update: This table has been updated to include all of the unique terrestrial ecological systems found in the entire Area of Interest (tertiary watersheds 2EB and 2EC on Shield)

Ecosystem	Landcover	Landform
Asp\Bedrock	Aspen	Undifferentiated igneous and metamorphic rock, exposed at surface or covered by a discontinuous, thin layer of drift
Asp\Glaciofluvial2	Aspen	Gravel and sand, includes proglacial river and deltaic deposits
Asp\Glaciolacustrine1	Aspen	Sand, gravelly sand and gravel, nearshore and beach deposits
Asp\Glaciolacustrine2	Aspen	Silt and clay, minor sand, basin and quiet water deposits
Asp\Organic	Aspen	Peat, muck and marl
Asp\Till	Aspen	Undifferentiated, predominantly sand to silty sand matrix, high content of clasts, often low in matrix carbonate content
Asp\Unknown	Aspen	Unknown/undefined/unclassified landform type
Bw/Bedrock	White Birch	Undifferentiated igneous and metamorphic rock, exposed at surface or covered by a discontinuous, thin layer of drift
Bw/Bedrock2	White Birch	Undifferentiated carbonate and clastic sedimentary rock, exposed at surface or covered by a discontinuous, thin layer of drift
Bw/Glaciofluvial1	White Birch	Gravel and sand, minor till, includes esker, kame, end moraine, ice-marginal delta and subaqueous fan deposits
Bw/Glaciofluvial2	White Birch	Gravel and sand, includes proglacial river and deltaic deposits
Bw/Glaciolacustrine1	White Birch	Sand, gravelly sand and gravel, nearshore and beach deposits
Bw/Glaciolacustrine2	White Birch	Silt and clay, minor sand, basin and quiet water deposits
Bw/Organic	White Birch	Peat, muck and marl
Bw/Till1	White Birch	Undifferentiated, predominantly sand to silty sand matrix, high content of clasts, often low in matrix carbonate content
Bw/Till2	White Birch	Undifferentiated, predominantly sand matrix, extremely stony, bouldery and high in total matrix carbonate, often associated with stratified sediments
Bw/Till3	White Birch	Undifferentiated, predominantly sandy silt to silt matrix, commonly rich in clasts, often high in total matrix carbonate content
Bw/Unknown	White Birch	Unknown/undefined/unclassified landform type
By\Bedrock	Yellow Birch	Undifferentiated igneous and metamorphic rock, exposed at surface or covered by a discontinuous, thin layer of drift
By\Glaciofluvial1	Yellow Birch	Gravel and sand, minor till, includes esker, kame, end moraine, ice-marginal delta and subaqueous fan deposits

Ecosystem	Landcover	Landform
By\Glaciofluvial2	Yellow Birch	Gravel and sand, includes proglacial river and deltaic deposits
By\Glaciolacustrine1	Yellow Birch	Sand, gravelly sand and gravel, nearshore and beach deposits
By\Glaciolacustrine2	Yellow Birch	Silt and clay, minor sand, basin and quiet water deposits
By\Organic	Yellow Birch	Peat, muck and marl
By\Till	Yellow Birch	Undifferentiated, predominantly sand to silty sand matrix, high content of clasts, often low in matrix carbonate content
By\Unknown	Coniferous species	Unknown/undefined/unclassified landform type
Coniferous/Bedrock	Coniferous species	Undifferentiated igneous and metamorphic rock, exposed at surface or covered by a discontinuous, thin layer of drift
Coniferous/Bedrock2	Coniferous species	Undifferentiated carbonate and clastic sedimentary rock, exposed at surface or covered by a discontinuous, thin layer of drift
Coniferous/Glaciofluvial1	Coniferous species	Gravel and sand, minor till, includes esker, kame, end moraine, ice-marginal delta and subaqueous fan deposits
Coniferous/Glaciofluvial2	Coniferous species	Gravel and sand, includes proglacial river and deltaic deposits
Coniferous/Glaciolacustrine1	Coniferous species	Sand, gravelly sand and gravel, nearshore and beach deposits
Coniferous/Glaciolacustrine2	Coniferous species	Silt and clay, minor sand, basin and quiet water deposits
Coniferous/Organic	Coniferous species	Peat, muck and marl
Coniferous/Till1	Coniferous species	Undifferentiated, predominantly sand to silty sand matrix, high content of clasts, often low in matrix carbonate content
Coniferous/Till2	Coniferous species	Undifferentiated, predominantly sand matrix, extremely stony, bouldery and high in total matrix carbonate, often associated with stratified sediments
Coniferous/Unknown	Coniferous species	Unknown/undefined/unclassified landform type
DAL	Developed Agricultural Land,	but also includes other open areas, such as cropland, pasture and golf courses
Deciduous/Bedrock	Deciduous species	Undifferentiated igneous and metamorphic rock, exposed at surface or covered by a discontinuous, thin layer of drift
Deciduous/Bedrock2	Deciduous species	Undifferentiated carbonate and clastic sedimentary rock, exposed at surface or covered by a discontinuous, thin layer of drift
Deciduous/Glaciofluvial1	Deciduous species	Gravel and sand, minor till, includes esker, kame, end moraine, ice-marginal delta and subaqueous fan deposits
Deciduous/Glaciofluvial2	Deciduous species	Gravel and sand, includes proglacial river and deltaic deposits

Ecosystem	Landcover	Landform
Deciduous/Glaciolacustrine1	Deciduous species	Sand, gravelly sand and gravel, nearshore and beach deposits
Deciduous/Glaciolacustrine2	Deciduous species	Silt and clay, minor sand, basin and quiet water deposits
Deciduous/Organic	Deciduous species	Peat, muck and marl
Deciduous/Till1	Deciduous species	Undifferentiated, predominantly sand to silty sand matrix, high content of clasts, often low in matrix carbonate content
Deciduous/Till2	Deciduous species	Undifferentiated, predominantly sand matrix, extremely stony, bouldery and high in total matrix carbonate, often associated with stratified sediments
Deciduous/Till3	Deciduous species	Undifferentiated, predominantly sandy silt to silt matrix, commonly rich in clasts, often high in total matrix carbonate content
Deciduous/Unknown	Deciduous species	Unknown/undefined/unclassified landform type
GRS	Grass and meadow	
HdConU/Bedrock	Upland hardwood	Undifferentiated igneous and metamorphic rock, exposed at surface or covered by a discontinuous, thin layer of drift
HdConU/Bedrock2	Upland hardwood	Undifferentiated carbonate and clastic sedimentary rock, exposed at surface or covered by a discontinuous, thin layer of drift
HdConU/Glaciofluvial1	Upland hardwood	Gravel and sand, minor till, includes esker, kame, end moraine, ice-marginal delta and subaqueous fan deposits
HdConU/Glaciofluvial2	Upland hardwood	Gravel and sand, includes proglacial river and deltaic deposits
HdConU/Glaciolacustrine1	Upland hardwood	Sand, gravelly sand and gravel, nearshore and beach deposits
HdConU/Glaciolacustrine2	Upland hardwood	Silt and clay, minor sand, basin and quiet water deposits
HdConU/Organic	Upland hardwood	Peat, muck and marl
HdConU/Till1	Upland hardwood	Undifferentiated, predominantly sand to silty sand matrix, high content of clasts, often low in matrix carbonate content
HdConU/Till2	Upland hardwood	Undifferentiated, predominantly sand matrix, extremely stony, bouldery and high in total matrix carbonate, often associated with stratified sediments
HdConU/Till3	Upland hardwood	Undifferentiated, predominantly sandy silt to silt matrix, commonly rich in clasts, often high in total matrix carbonate content
HdConU/Unknown	Upland hardwood	Unknown/undefined/unclassified landform type
He\Bedrock	Hemlock	Undifferentiated igneous and metamorphic rock, exposed at surface or covered by a discontinuous, thin layer of drift

Ecosystem	Landcover	Landform
He\Glaciofluvial1	Hemlock	Gravel and sand, minor till, includes esker, kame, end moraine, ice-marginal delta and subaqueous fan deposits
He\Glaciofluvial2	Hemlock	Gravel and sand, includes proglacial river and deltaic deposits
He\Glaciolacustrine1	Hemlock	Sand, gravelly sand and gravel, nearshore and beach deposits
He\Glaciolacustrine2	Hemlock	Silt and clay, minor sand, basin and quiet water deposits
He\Organic	Hemlock	Peat, muck and marl
He\Till	Hemlock	Undifferentiated, predominantly sand to silty sand matrix, high content of clasts, often low in matrix carbonate content
He\Unknown	Hemlock	Unknown/undefined/unclassified landform type
IntHd/Bedrock	Intolerant hardwood	Undifferentiated igneous and metamorphic rock, exposed at surface or covered by a discontinuous, thin layer of drift
IntHd/Bedrock2	Intolerant hardwood	Undifferentiated carbonate and clastic sedimentary rock, exposed at surface or covered by a discontinuous, thin layer of drift
IntHd/Glaciofluvial1	Intolerant hardwood	Gravel and sand, minor till, includes esker, kame, end moraine, ice-marginal delta and subaqueous fan deposits
IntHd/Glaciofluvial2	Intolerant hardwood	Gravel and sand, includes proglacial river and deltaic deposits
IntHd/Glaciolacustrine1	Intolerant hardwood	Sand, gravelly sand and gravel, nearshore and beach deposits
IntHd/Glaciolacustrine2	Intolerant hardwood	Silt and clay, minor sand, basin and quiet water deposits
IntHd/Organic	Intolerant hardwood	Peat, muck and marl
IntHd/Till1	Intolerant hardwood	Undifferentiated, predominantly sand to silty sand matrix, high content of clasts, often low in matrix carbonate content
IntHd/Till2	Intolerant hardwood	Undifferentiated, predominantly sand matrix, extremely stony, bouldery and high in total matrix carbonate, often associated with stratified sediments
IntHd/Till3	Intolerant hardwood	Undifferentiated, predominantly sandy silt to silt matrix, commonly rich in clasts, often high in total matrix carbonate content
IntHd/Unknown	Intolerant hardwood	Unknown/undefined/unclassified landform type
MidHd\Bedrock	Mid-tolerant hardwood	Undifferentiated igneous and metamorphic rock, exposed at surface or covered by a discontinuous, thin layer of drift
MidHd\Glaciofluvial1	Mid-tolerant hardwood	Gravel and sand, minor till, includes esker, kame, end moraine, ice-marginal delta and subaqueous fan deposits

Ecosystem	Landcover	Landform
MidHd\Glaciofluvial2	Mid-tolerant hardwood	Gravel and sand, includes proglacial river and deltaic deposits
MidHd\Glaciolacustrine1	Mid-tolerant hardwood	Sand, gravelly sand and gravel, nearshore and beach deposits
MidHd\Glaciolacustrine2	Mid-tolerant hardwood	Silt and clay, minor sand, basin and quiet water deposits
MidHd\Organic	Mid-tolerant hardwood	Peat, muck and marl
MidHd\Till	Mid-tolerant hardwood	Undifferentiated, predominantly sand to silty sand matrix, high content of clasts, often low in matrix carbonate content
MidHd\Unknown	Mid-tolerant hardwood	Unknown/undefined/unclassified landform type
Mixed/Bedrock	Mixed coniferous and deciduous species	Undifferentiated igneous and metamorphic rock, exposed at surface or covered by a discontinuous, thin layer of drift
Mixed/Bedrock2	Mixed coniferous and deciduous species	Undifferentiated carbonate and clastic sedimentary rock, exposed at surface or covered by a discontinuous, thin layer of drift
Mixed/Glaciofluvial1	Mixed coniferous and deciduous species	Gravel and sand, minor till, includes esker, kame, end moraine, ice-marginal delta and subaqueous fan deposits
Mixed/Glaciofluvial2	Mixed coniferous and deciduous species	Gravel and sand, includes proglacial river and deltaic deposits
Mixed/Glaciolacustrine1	Mixed coniferous and deciduous species	Sand, gravelly sand and gravel, nearshore and beach deposits
Mixed/Glaciolacustrine2	Mixed coniferous and deciduous species	Silt and clay, minor sand, basin and quiet water deposits
Mixed/Organic	Mixed coniferous and deciduous species	Peat, muck and marl
Mixed/Till1	Mixed coniferous and deciduous species	Undifferentiated, predominantly sand to silty sand matrix, high content of clasts, often low in matrix carbonate content
Mixed/Till2	Mixed coniferous and deciduous species	Undifferentiated, predominantly sand matrix, extremely stony, bouldery and high in total matrix carbonate, often associated with stratified sediments
Mixed/Till3	Mixed coniferous and deciduous species	Undifferentiated, predominantly sandy silt to silt matrix, commonly rich in clasts, often high in total matrix carbonate content
Mixed/Unknown	Mixed coniferous and deciduous species	Unknown/undefined/unclassified landform type

Ecosystem	Landcover	Landform
OCLow/Bedrock	Lowland conifer mix	Undifferentiated igneous and metamorphic rock, exposed at surface or covered by a discontinuous, thin layer of drift
OCLow/Bedrock2	Lowland conifer mix	Undifferentiated carbonate and clastic sedimentary rock, exposed at surface or covered by a discontinuous, thin layer of drift
OCLow/Glaciofluvial1	Lowland conifer mix	Gravel and sand, minor till, includes esker, kame, end moraine, ice-marginal delta and subaqueous fan deposits
OCLow/Glaciofluvial2	Lowland conifer mix	Gravel and sand, includes proglacial river and deltaic deposits
OCLow/Glaciolacustrine1	Lowland conifer mix	Sand, gravelly sand and gravel, nearshore and beach deposits
OCLow/Glaciolacustrine2	Lowland conifer mix	Silt and clay, minor sand, basin and quiet water deposits
OCLow/Organic	Lowland conifer mix	Peat, muck and marl
OCLow/Till1	Lowland conifer mix	Undifferentiated, predominantly sand to silty sand matrix, high content of clasts, often low in matrix carbonate content
OCLow/Till2	Lowland conifer mix	Undifferentiated, predominantly sand matrix, extremely stony, bouldery and high in total matrix carbonate, often associated with stratified sediments
OCLow/Till3	Lowland conifer mix	Undifferentiated, predominantly sandy silt to silt matrix, commonly rich in clasts, often high in total matrix carbonate content
OCLow/Unknown	Lowland conifer mix	Unknown/undefined/unclassified landform type
OPine/Bedrock	Oak dominated	Undifferentiated igneous and metamorphic rock, exposed at surface or covered by a discontinuous, thin layer of drift
Opine/Glaciofluvial1	Oak dominated	Gravel and sand, minor till, includes esker, kame, end moraine, ice-marginal delta and subaqueous fan deposits
OPine/Glaciofluvial2	Oak dominated	Gravel and sand, includes proglacial river and deltaic deposits
OPine/Glaciolacustrine1	Oak dominated	Sand, gravelly sand and gravel, nearshore and beach deposits
OPine/Glaciolacustrine2	Oak dominated	Silt and clay, minor sand, basin and quiet water deposits
OPine/Organic	Oak dominated	Peat, muck and marl
OPine/Till1	Oak dominated	Undifferentiated, predominantly sand to silty sand matrix, high content of clasts, often low in matrix carbonate content
OPine/Unknown	Oak dominated	Unknown/undefined/unclassified landform type
Pj\Bedrock	Jack pine	Undifferentiated igneous and metamorphic rock, exposed at surface or covered by a discontinuous, thin layer of drift

Ecosystem	Landcover	Landform
Pj\Glaciofluvial2	Jack pine	Gravel and sand, includes proglacial river and deltaic deposits
Pj\Glaciolacustrine1	Jack pine	Sand, gravelly sand and gravel, nearshore and beach deposits
Pj\Organic	Jack pine	Peat, muck and marl
Pj\Till	Jack pine	Undifferentiated, predominantly sand to silty sand matrix, high content of clasts, often low in matrix carbonate content
PWR/Bedrock	Red and white pine mix	Undifferentiated igneous and metamorphic rock, exposed at surface or covered by a discontinuous, thin layer of drift
PWR/Bedrock2	Red and white pine mix	Undifferentiated carbonate and clastic sedimentary rock, exposed at surface or covered by a discontinuous, thin layer of drift
PWR/Glaciofluvial1	Red and white pine mix	Gravel and sand, minor till, includes esker, kame, end moraine, ice-marginal delta and subaqueous fan deposits
PWR/Glaciofluvial2	Red and white pine mix	Gravel and sand, includes proglacial river and deltaic deposits
PWR/Glaciolacustrine1	Red and white pine mix	Sand, gravelly sand and gravel, nearshore and beach deposits
PWR/Glaciolacustrine2	Red and white pine mix	Silt and clay, minor sand, basin and quiet water deposits
PWR/Organic	Red and white pine mix	Peat, muck and marl
PWR/Till1	Red and white pine mix	Undifferentiated, predominantly sand to silty sand matrix, high content of clasts, often low in matrix carbonate content
PWR/Unknown	Red and white pine mix	Unknown/undefined/unclassified landform type
Rock	Exposed bedrock, lacking vegetation cover	
SbLow/Bedrock	Lowland black spruce	Undifferentiated igneous and metamorphic rock, exposed at surface or covered by a discontinuous, thin layer of drift
SbLow/Bedrock2	Lowland black spruce	Undifferentiated carbonate and clastic sedimentary rock, exposed at surface or covered by a discontinuous, thin layer of drift
SbLow/Glaciofluvial2	Lowland black spruce	Gravel and sand, includes proglacial river and deltaic deposits
SbLow/Glaciolacustrine1	Lowland black spruce	Sand, gravelly sand and gravel, nearshore and beach deposits
SbLow/Glaciolacustrine2	Lowland black spruce	Silt and clay, minor sand, basin and quiet water deposits
SbLow/Organic	Lowland black spruce	Peat, muck and marl
SbLow/Till1	Lowland black spruce	Undifferentiated, predominantly sand to silty sand matrix, high content of clasts, often low in matrix carbonate content

Ecosystem	Landcover	Landform
SbLow/Till2	Lowland black spruce	Undifferentiated, predominantly sand matrix, extremely stony, bouldery and high in total matrix carbonate, often associated with stratified sediments
SbLow/Till3	Lowland black spruce	Undifferentiated, predominantly sandy silt to silt matrix, commonly rich in clasts, often high in total matrix carbonate content
SbLow/Unknown	Lowland black spruce	Unknown/undefined/unclassified landform type
SbP/Bedrock	Jack pine and black spruce	Undifferentiated igneous and metamorphic rock, exposed at surface or covered by a discontinuous, thin layer of drift
SbP/Bedrock2	Jack pine and black spruce	Undifferentiated carbonate and clastic sedimentary rock, exposed at surface or covered by a discontinuous, thin layer of drift
SbP/Glaciofluvial1	Jack pine and black spruce	Gravel and sand, minor till, includes esker, kame, end moraine, ice-marginal delta and subaqueous fan deposits
SbP/Glaciofluvial2	Jack pine and black spruce	Gravel and sand, includes proglacial river and deltaic deposits
SbP/Glaciolacustrine1	Jack pine and black spruce	Sand, gravelly sand and gravel, nearshore and beach deposits
SbP/Glaciolacustrine2	Jack pine and black spruce	Silt and clay, minor sand, basin and quiet water deposits
SbP/Organic	Jack pine and black spruce	Peat, muck and marl
SbP/Till1	Jack pine and black spruce	Undifferentiated, predominantly sand to silty sand matrix, high content of clasts, often low in matrix carbonate content
SbP/Till2	Jack pine and black spruce	Undifferentiated, predominantly sand matrix, extremely stony, bouldery and high in total matrix carbonate, often associated with stratified sediments
SbP/Till3	Jack pine and black spruce	Undifferentiated, predominantly sandy silt to silt matrix, commonly rich in clasts, often high in total matrix carbonate content
SbP/Unknown	Jack pine and black spruce	Unknown/undefined/unclassified landform type
SbUp/Bedrock	Jack pine and black spruce	Undifferentiated igneous and metamorphic rock, exposed at surface or covered by a discontinuous, thin layer of drift
Settlement	Clearings for human settlement and economic activity	
Sparse/Bedrock	Patchy or sparse forest	Undifferentiated igneous and metamorphic rock, exposed at surface or covered by a discontinuous, thin layer of drift
Sparse/Bedrock2	Patchy or sparse forest	Undifferentiated carbonate and clastic sedimentary rock, exposed at surface or covered by a discontinuous, thin layer of drift

Ecosystem	Landcover	Landform
Sparse/Glaciofluvial1	Patchy or sparse forest	Gravel and sand, minor till, includes esker, kame, end moraine, ice-marginal delta and subaqueous fan deposits
Sparse/Glaciofluvial2	Patchy or sparse forest	Gravel and sand, includes proglacial river and deltaic deposits
Sparse/Glaciolacustrine1	Patchy or sparse forest	Sand, gravelly sand and gravel, nearshore and beach deposits
Sparse/Glaciolacustrine2	Patchy or sparse forest	Silt and clay, minor sand, basin and quiet water deposits
Sparse/Organic	Patchy or sparse forest	Peat, muck and marl
Sparse/Till1	Patchy or sparse forest	Undifferentiated, predominantly sand to silty sand matrix, high content of clasts, often low in matrix carbonate content
Sparse/Till2	Patchy or sparse forest	Undifferentiated, predominantly sand matrix, extremely stony, bouldery and high in total matrix carbonate, often associated with stratified sediments
Sparse/Till3	Patchy or sparse forest	Undifferentiated, predominantly sandy silt to silt matrix, commonly rich in clasts, often high in total matrix carbonate content
Sparse/Unknown	Patchy or sparse forest	Unknown/undefined/unclassified landform type
Tailings	Mine tailings, or could also be pits and quarries	
TolHd/Bedrock	Tolerant hardwood	Undifferentiated igneous and metamorphic rock, exposed at surface or covered by a discontinuous, thin layer of drift
TolHd/Bedrock2	Tolerant hardwood	Undifferentiated carbonate and clastic sedimentary rock, exposed at surface or covered by a discontinuous, thin layer of drift
TolHd/Glaciofluvial1	Tolerant hardwood	Gravel and sand, minor till, includes esker, kame, end moraine, ice-marginal delta and subaqueous fan deposits
TolHd/Glaciofluvial2	Tolerant hardwood	Gravel and sand, includes proglacial river and deltaic deposits
TolHd/Glaciolacustrine1	Tolerant hardwood	Sand, gravelly sand and gravel, nearshore and beach deposits
TolHd/Glaciolacustrine2	Tolerant hardwood	Silt and clay, minor sand, basin and quiet water deposits
TolHd/Organic	Tolerant hardwood	Peat, muck and marl
TolHd/Till1	Tolerant hardwood	Undifferentiated, predominantly sand to silty sand matrix, high content of clasts, often low in matrix carbonate content
TolHd/Till2	Tolerant hardwood	Undifferentiated, predominantly sand matrix, extremely stony, bouldery and high in total matrix carbonate, often associated with stratified sediments
TolHd/Till3	Tolerant hardwood	Undifferentiated, predominantly sandy silt to silt matrix, commonly rich in clasts, often high in total matrix carbonate content

Ecosystem	Landcover	Landform
TolHd/Unknown	Tolerant hardwood	Unknown/undefined/unclassified landform type
UCL	Unclassified, unknown or cloud an shadow	
Water	Inland lakes, dams and or/ponds	
Wetland	Wetlands	

Appendix E: Ontario Wetland Evaluation System, Northern Manual.

The description is the Introduction from the following publication:

Ontario Ministry of Natural Resources. 1993. Ontario wetland evaluation system: northern manual: covering Hills site regions 2, 3, 4 and 5: NEST technical manual TM-001. First Edition. Revised December 2002.

INTRODUCTION TO THE EVALUATION SYSTEM

Wetlands are land types that are commonly referred to as swamps, fens, mires, marshes, bogs, sloughs and peatlands. They occur intermittently across the landscape along lakes, rivers and streams, and in other areas where the water table is close to the surface. They vary in size from a fraction of a hectare to many thousands of hectares.

As areas where land and water come together, wetlands provide unique and specialized habitat for a great variety of species that can live nowhere else. If wetlands small and large cannot survive in reasonable abundance across the landscape, their dependent species will decrease in number and eventually disappear. The survival of wetlands helps to preserve ecological processes and functions that secure and protect the quality of the biosphere in which humans and other organisms together must dwell.

Although the evaluation system is based on scientific criteria, it was developed primarily to serve the needs of Ontario's planning process. The evaluation system recognizes the role that wetlands play in maintaining critical ecosystem functions, providing social benefits, moderating storm flows, improving water quality, and protecting rare species. The system provides a way of rating wetlands relative to each other and also provides information about why one wetland is more important than another. The evaluation system can also be used to carry out a preliminary or "first cut" biophysical inventory of a wetland.

The evaluation manual for northern wetlands is derived from the evaluation process that has been used in southern Ontario since the early 1980's (Environment Canada and Ministry of Natural Resources 1984). Most of the components of the two systems are the same but important differences do exist. These differences reflect true differences in conditions between northern and southern Ontario and permit northern wetlands to be compared among themselves. Figure 1 shows the boundary for application of the two manuals. In the event that a particular wetland is located very close to the boundary, the evaluator should consult with the appropriate MNR regional specialist.

Pressures on northern wetlands are, in many areas, quite different from pressures in southern Ontario. Although urban development (including recreational developments) and drainage for agriculture are a concern in the more southern, settled parts of the north, pressures from activities such as forestry, mining, hydro-electric development, and peat extraction are significantly different from those in southern Ontario. In addition, many northern wetlands are found on Crown land, a situation very different from that in the south. Nevertheless, as a tool to be used primarily in the land use planning process, the evaluation system is likely to be applied most frequently in areas where wetlands are under development pressures. Such areas include, but are not limited to, most of Hills Site Region 5, the Greater Claybelt, the Lake Superior shoreline and the Lake of the Woods area.

Wetlands in northern Ontario are still abundant even in the more settled areas. Although the system is designed to be applicable to all freshwater wetlands located within Site Regions 2, 3, 4 and 5 as defined by Hills (1959, 1961), it is unlikely that this detailed version will be used in the more remote parts of the province. A screening system for these remote areas will be designed to identify wetlands that have the potential to be provincially significant will be developed. This system will assist in setting priorities for full evaluation of wetlands that may be threatened by development.

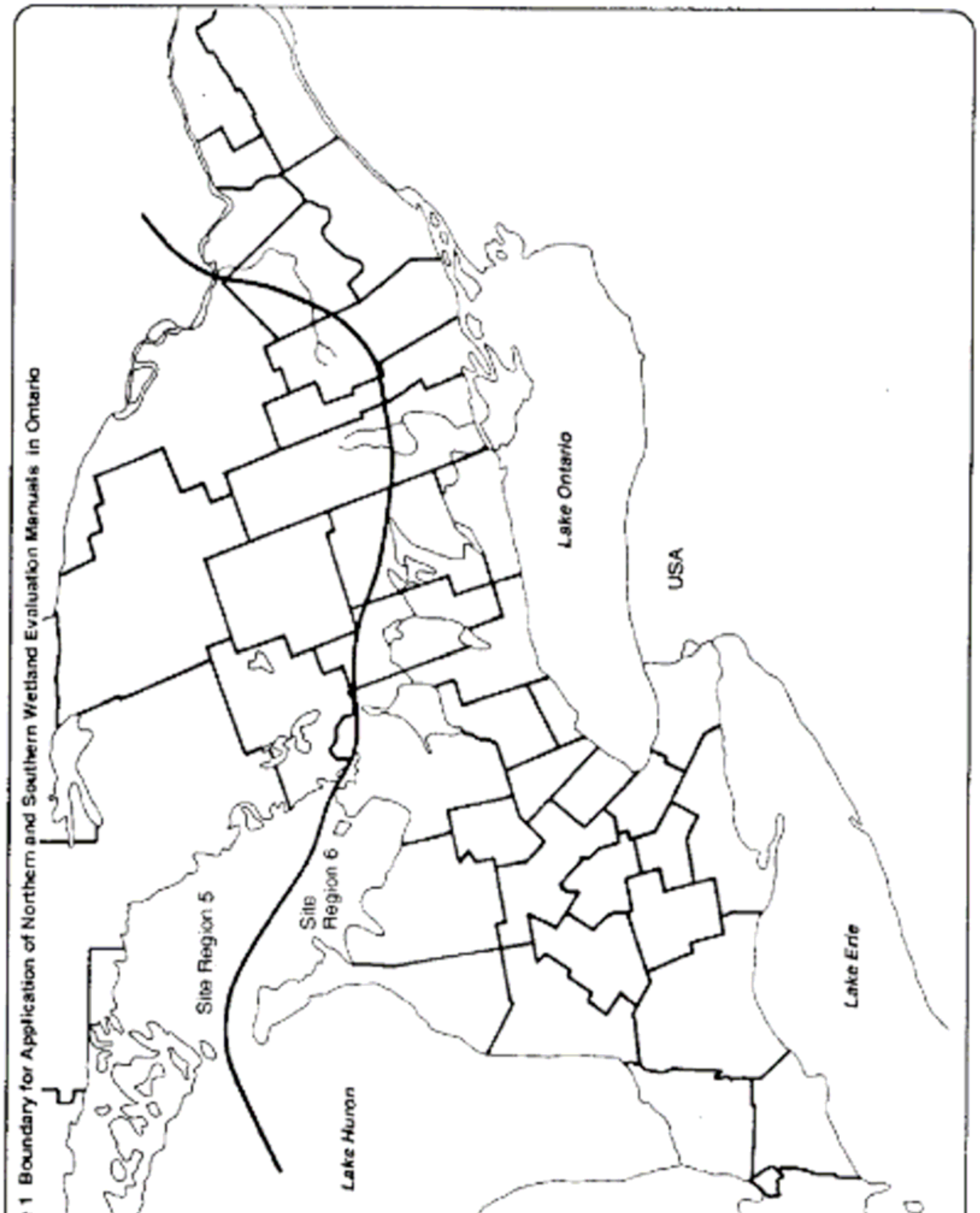


Figure 1 Boundary for Application of Northern and Southern Wetland Evaluation Manuals in Ontario

Since this evaluation system is designed to identify and measure recognized values of wetlands, it should provide a mechanism or framework through which conflicting claims about wetland values and uses can be resolved. The application of this system provides knowledge of the different kinds of wetland functions, which is then available for examination and review by any interested person, agency or group. Nevertheless, the evaluation is not a complete biophysical inventory and certain information, particularly about the presence of rare species and about hydrological values, may be lacking even after the evaluation is completed. If this is determined to be the case, and an alternate use for the wetland is proposed, more information should be obtained. Decisions about future uses of a wetland must have a rational basis.

The evaluation system does not evaluate vulnerability of wetlands to various sorts of developments and pressures. The system is a tool that allows planners to consider the relative value of different wetlands through the examination and ranking of a number of wetland functions. However, it is marketplace forces together with political and planning processes, including wetlands policy of government, that determine the future of any particular wetland. The assessment of vulnerability is considered to be presumptive and outside the scope of this evaluation.

Likewise, the evaluation system does not suggest the kinds of management that would be best for a wetland. However, the information gathered through the application of this evaluation system can provide the basis for considering management options and alternatives.

The results of evaluations made under this system may be used at three levels:

1. By a municipality, or county government as part of the municipal planning process where often there is need for knowledge or information about the value of a particular wetland in relation to other nearby wetlands;

2. By Conservation Authorities as part of an overall watershed management plan, or by MNR Areas in relation to the development of wildlife, fisheries, timber, shoreline and other management plans; and

3. By the province as an aid to broad land use planning. In this regard, the wetland evaluation system serves as an essential cornerstone of the provincial Wetlands Policy Statement under the Planning Act. As well, the evaluation system may prove of value in identifying nationally important wetland features.

Rationale for Wetland Features Included in the Evaluation

A system of evaluation for wetlands must be concerned with the definition, identification and measurement of wetland functions. The wetland is then evaluated based upon the perceived values of characteristics, activities, or expressions of the wetland or its parts that function to maintain ecosystem processes, or that have some utility or amenity value to a segment of society. While these two kinds of values are perceived as being different, humans cannot separate their utility needs or desires from the orderly functioning of healthy ecosystems. Wetland values recognized in this evaluation system include both ecosystem and human utility values:

1. Ecosystem values. These include the many roles that wetlands play in the functioning of natural ecological processes. Such ecosystem values occur in the wetland itself, in the wetland's immediate vicinity, or downstream. They include specific characteristics such as primary production, watershed protection, preservation of biodiversity, maintenance of three dimensional vegetation systems necessary for much of animal life, the maintenance of conditions essential for symbioses, natural cycles (such as carbon, nitrogen, water), provision of species to support food chains, and similar characteristics that provide for higher (or more inclusive) levels of organization in the terrestrial and aquatic landscape. Ecosystem functions at higher levels are discussed by Rowe (1961, 1990a, p. 244); Odum (1971); de Groot (1986) and others.

2. Human utility values. These include the social and economic values that wetlands provide to people. Such values include the benefits provided by wetlands in flood attenuation, recreation, production of economically valuable products, improvement of water quality, educational benefits and the like.

Wetland values recognized in the evaluation system are many and varied with respect to their fundamental nature. Thus, the evaluation includes, among other things, values which derive from an expression, an activity, an amount, a distance, a timing, a direct benefit to humans, the presence of a species or ecological circumstance and the like. The rationale for inclusion of each value is provided so that the reasons for selecting and weighting the values in relation to others within the system are as clear as possible. The values defined are intended to be mutually exclusive, or nearly so.

The kinds of information to be gathered, or attributes to be measured, by this system were determined based on a number of considerations. These are:

1. The needed information could be secured without time-consuming scientific research;

2. Needed information could be obtained after a minimum training period by individuals already having the required expertise in wetland ecology, flora and fauna;

3. Information related to each wetland value could be meaningfully graduated into a scale of numbers ranging from little or no value to "full value";

4. Consultation with many professionals in the fields of biology, ecology, hydrology and agriculture eliminated dubious or excessively controversial values.

The evaluation system considers only the positive values of wetlands. Hence, it will be the presence of positive values that will determine which wetlands have more value than others. Expertise Required to Apply this Evaluation System Wetland evaluations using this system should be carried out only by persons who have been approved by the Ministry of Natural Resources as having the necessary qualifications including the following minimum expertise:

1. Adequate knowledge and experience with wetland ecology to be able to identify correctly all wetland types, their characteristic species and features.

2. Adequate knowledge of flora/fauna to the extent of being able to identify most wetland species, species of immediately adjacent upland areas and significant or rare species. Associated skills in the use taxonomic keys are also necessary.

3. Knowledge of aerial photograph interpretation, sufficient to interpret wetland vegetation and boundaries;

4. General knowledge of natural history and wildlife, and

5. Some understanding of hydrological processes.

Persons will be required by the Ministry to take a wetlands evaluation course and/or to demonstrate that they have the necessary understanding of the system, including the ability to identify appropriate plant and animal species, to gain the necessary certification.

While it is desirable for evaluators to be able to identify rare species (particularly plant species) that may be present in a wetland, it is recognized that an adequate evaluation can be conducted by evaluators with moderate plant identification skills. It is recommended that an investigation separate from the evaluation be conducted by appropriate technical experts if rare species are suspected to be present.

How the Scoring System Works

In this evaluation, wetland values are grouped into four principal components. These are Biological, Social, Hydrological, and Special Features. Each component is evaluated individually and separately from the others. Each component is further subdivided into subcomponents, and some subcomponents are further subdivided into attributes and some into subattributes.

The method used for assessing the value of a component, subcomponent, attribute or subattribute is numerical. Thus, relative value is assessed by ascribing point totals to predefined values. The scores are then totalled to provide a measure of value at the subcomponent and component levels. The total number of points for each of the four major components is capped at 250 points. An individual wetland can score a maximum of 1000 points.

The values that are assessed and the scores assigned derive from the judgement of a large number of people with many years of experience in wetland science and evaluation. This system parallels the evaluation system for southern Ontario which was developed in the early 1980's (Environment Canada and Ministry of Natural Resources 1984). At that time a Canada/Ontario Steering Committee on Wetland Evaluation (which included both government and non-government experts) carried out numerous reviews of and adjustments to scores, and made final decisions on weighting. Experience in use of the 1984 edition resulted in suggestions for improvements to the scoring for the southern system. Many of these were implemented by the Southern Ontario Wetland Evaluation Review Committee for the southern system and were carried over into the northern system by the Northern Wetlands Working Group and the Provincial Wetland Working Group. Thus, experience and calculated judgement of dozens of people about the relative importance of the accepted variables is the basis for the credibility of the scores. The validity of the system as a whole stems from the long process carried out with deliberation and attention to detail over many years.

Within each component, subcomponent, attribute and/or subattribute, values have been weighted to reflect their importance relative to each other. The judgement of the Northern Wetlands Working Group and the Provincial Wetlands Working Group, with assistance from a large number of reviewers, is the basis for the relative weighting. Some values are widely considered to be of major importance (e.g., breeding habitat for an endangered species) and many points (250) are allotted to them. At the other end of the scale are "minor" values, given only a few points.

The large number of points that can be accumulated in each of the four components means that the system provides a relatively sensitive point spread among subcomponents and attributes. The employment of high scores for some values also permits "minor" values (ones to which only a few points are allotted) to be easily included in the evaluation system.

Definition of Wetlands and Wetland Areas

In this evaluation system wetlands are defined as:

"*Lands that are seasonally or permanently flooded by shallow water as well as lands where the water table is close to the surface; in either case the presence of abundant water has caused the formation of hydric soils and has favoured the dominance of either hydrophytic or water tolerant plants*".

The term wetland is a general one and includes specific land types commonly called marshes, bogs, swamps and fens. Wetlands may be relatively simple or highly complex and diverse biologically and ecologically. Within a single wetland area (i.e. contiguous wetland) one may find very different ecological circumstances as for example, an open water marsh, a spring fed swamp forest, a floating lakeside fen, an open channel of river, and the open water edge of a lake. Despite these profound ecological differences, the entire area is considered as a single wetland. It is to be identified and evaluated as a single unit. Areas of upland where typical upland species are dominant are not to be included in the wetland area.
The idea of a wetland complex [see detailed definition under Wetland Complexes below] is an extension of the above concept of a single contiguous wetland. In a wetland complex, major functional discontinuities (such as uplands or open water lakes) may subdivide the area into a number of distinctive wetland units, but the entire wetland area is evaluated as a single unit.

Agricultural Lands

It should be clearly understood that if an area no longer meets the definition of a wetland, in terms of water, soil, and vegetation characteristics, then it should be not be considered to be a wetland. Conversely, land which is under agricultural use, but which has retained the characteristics of a wetland, is still considered to be one. Cattle pasturing or grazing, e.g., in a wooded swamp, is an example of an existing agricultural use that, while it may result in some degradation in the quality of the wetland, will usually allow the wetland to persist over time. In contrast, planting of crops or tillage tends to destroy wetland values. See Section (d) under

Wetland Size and Boundaries below for a discussion of wetland boundaries in agricultural areas.

Appendix F: Ducks Unlimited Canada Wetland Mapping

The description is from the following publication:

Hogg, A., P. Beckerson and S. Strobl. 2003. Developing mapping and evaluation models for wetland conservation in central Ontario. Ontario Ministry of Natural Resrouces & Ducks Unlimited. 5pp.

Developing mapping and evaluation methods for wetland conservation in central Ontario

Introduction

Approximately 50 % of the land in central Ontario is privately owned. Between 1981-1996, in some parts of this area, population growth was 35 - 400 % greater than the provincial average. Such increases in population density are putting pressure on numerous natural heritage features in the region, including wetlands. Wetlands are extremely valuable ecosystems, comprising approximately 20 % of the landscape in this part of the province. However, fewer than one percent of them have been evaluated by the Northern Ontario Provincial Wetland Evaluation System (OWES). An evaluated wetland is considered to be either a Provincially Significant Wetland (PSW) or an insignificant wetland, based on the overall score it receives. In central Ontario, municipalities require an Environmental Impact Statement before development can be permitted in or within 120 metres of a PSW. Unfortunately, the cost of OWES field-based surveys is high, averaging $1000 for every 50 acres of wetland.

Researchers at the University of Waterloo used a regression analysis to demonstrate that only a few of the 28 variables evaluated in the OWES contribute substantially to the final wetland score (Chisholm *et al.* 1997). They also showed that the scores for these variables can be determined without site visits. Furthermore, they suggested that the regression equations could serve as a Rapid Assessment Technique (RAT) and provide a preliminary screening tool to determine priority wetlands that require field evaluation, especially where development may be proposed. However, this RAT has not yet been widely applied.

The objectives of this proposed project are:

1) To more accurately map wetlands, especially emergent marsh communities in shallow areas of water bodies and forested swamps, using existing GIS and information derived from current remote sensing imagery, and

2) To automate the RAT in GIS to provide an indication of the potential significance of any wetland complex if it were to be evaluated by the OWES.

The District Municipality of Muskoka (DMM) was chosen as a pilot area to develop the wetland mapping and evaluation procedures for the following reasons:

- They demonstrated leadership in their wetland protection policies, over and above provincial requirements.
- OMNR- Bracebridge District has already evaluated a relatively large number of wetlands (24) in the DMM upon which the RAT modeling could be based.
- We could access several thousands of field based terrestrial and wetland ecosite survey points (through the Nature Conservancy of Canada’s Georgian Bay Coast project) to verify our wetland mapping procedure.
- Naturalists have contributed a large number of records of rare species sightings to the provincial Conservation Data Centre (Natural Heritage Information Centre).

In this poster we report our progress on automating the N1A Rapid Assessment Technique model (Chisholm *et al.* 1997[1]). This model requires inputs for 5 variables. It is based on the regression of 28 variables from 50 existing OMNR Northern OWES evaluations and had an adjusted R_2 of 0.691.

1 Chisholm, S., C. Davies, G. Mulamoottil, and D. Capatos. 1997. Predictive models for identifying potentially valuable wetlands. Cdn. Water Res. J. 22(3): 249-267.

To map wetlands, we:

- Used all known spatial wetland data to identify new wetlands.
- Used remotely sensed imagery to determine wetland type: swamp or marsh.
- Visually validated a sample of mapped wetlands with available aerial photography and existing field data.
- Modeled all wetlands into one final layer.

Step 1

- We used 65 community polygons within the existing evaluated wetland layer to “train” Landsat TM Imagery to spectrally identify other swamp and marsh pixels.
- We refined boundaries using a 1:50,000, air photo interpreted, quaternary geology “peat/muck” layer and topographic index of potential wetness derived using upslope contributing area and local slope.

Step2

- We classified wetlands that were previously derived from interpretation of 1:30,000 early spring 1983-84 air photos to swamp and marsh using signatures derived from Step 1.

Step 3

- Some open water areas previously derived from interpretation of 1:30,000 early spring 1983-84 air photos are often miss-classified and may actually be areas of shallow water with emergent marsh in summer conditions.
- Presence of pre-leaf trees in deciduous swamps would also have been difficult to identify from the 1983-84 spring air photography.
- Therefore we used Normalized Difference Vegetation Index (NDVI) derived from a summer TM image (cookie cut to open water polygons) to flag water areas incorrectly mapped as water.
- We assumed flagged areas were marsh; we delineated “hardwood” and “thicket” swamps in a later mapping step.

Step 4

- We used the radar property of corner reflection combined with other slope and hydrological vector data sets to identify new swamps.

Technology Transfer

- Partners and funding have been assembled to transfer the wetland mapping and evaluation methodology to municipalities in Haliburton County and Algoma District.
- This method can also be applied to forest management planning on Crown Land in the Area of the Undertaking in Ontario to ensure wetland values are adequately assessed.

Technical Steering Committee members

Wasyl Bakowsky (NHIC, OMNR), Paula Beckerson (PGSC, OMNR), Rosita Ben-Oliel (NHIC, OMNR), Judi Brouse (DMM), Graham Good (DMM), Paul Heaven (Consultant on Contract to Haliburton County), Adam Hogg (PGSC, OMNR), James Holland (DUC), Jarmo Jalava (NCC), Gerald Kroes (Tembec), Jan Mcdonnell (OMNR), Richard Mussakowski, (OMNR), Brian Naylor (OMNR), Brian Potter (OMNR), Paul Sampson (OMNR), Silvia Strobl (DUC)

Appendix G: Water Resources Information Project (WRIP)

The description is from the following publication:

Ontario Ministry of Natural Resources. 2002. Water Resources Information Project: A Guide to the Provincial Watershed Project. November 2002. Queen's Printer for Ontario. 20pp.

1.0 Introduction

1.1 Water Resources Information Project

The Water Resources Information Project (WRIP) was initiated in March 2000 by the Ontario Water Directors. WRIP is a co-operative project with participation from the Ontario Ministries of Natural Resources, Environment & Energy, Municipal Affairs and Housing, Agriculture & Food, Northern Development & Mines and Conservation Ontario.[1] The vision of WRIP is "*an integrated, standardized, water information program for Ontario as the foundation for effective knowledge-based water management decisions bringing the right information to people when they need it*." In general, the project has been designed to review the current state of water information in Ontario and to develop a strategy to ensure information is readily available to support effective water management. In particular, one component of WRIP has been the collection, improvement, and standardization of data. This document closely examines three core digital data sets, which have been created or improved within the mandate of the Provincial Watershed Project (PWP).

1.2 Background: Provincial Watershed Project

The PWP was initiated by the Ontario Ministry of Natural Resources (MNR) in October 1998 in response to the need for digital watersheds of second-order (Strahler) streams to support the Forest Management Planning (FMP) process. Ontario's Forest Management Planning Manual, which guides the FMP process, stipulates:

"The current value for the amount of productive forest area within second-order stream watersheds which has been clear-cut or burned, and the change in that value since the last plan was prepared, must be presented in Table FMP-6 and described in the plan text. In addition to the overall assessment of each type of disturbance within second-order stream watersheds, any suggested alterations to harvest activities within particular watersheds (e.g., reducing or deferring clear-cuts in an already heavily disturbed second-order stream watershed) in order to stabilize water yields must be discussed in the plan text."[2]

The initial area of the undertaking for the PWP generally corresponded to the Canadian Shield, where forests were being managed in 1998, as shown in Figure 1. Although the final objective was the derivation of digital second-order (Strahler) stream watersheds, the process required the refinement of both hydrology and elevation base data. The second-order (Strahler) stream watersheds were completed in 1999 and final improvements to the hydrology and elevation base data sets were made during 2002 as part of WRIP.

Figure 1: Area of the Undertaking

1.3 Benefiting from Partnership: Conservation Ontario

During the spring of 1999, the focus of the PWP shifted to southern Ontario. Due to the anthropogenic influence on the hydrology in this region, special knowledge was required to improve the data. A partnership was quickly formed between the Conservation Authorities (CA's) and the MNR, which became a mutually beneficial collaboration whereby the CA's provided local knowledge and the MNR provided digital data, GIS expertise, software, and hardware. The project initiated a new data sharing agreement and facilitated the development of a standard hydrology and elevation model base across southern Ontario.

1 Wilcox, I., 2001. Water Resources Information Project: Conservation Ontario report. The Queens printer for Ontario.

2 Ontario Ministry of Natural Resources, 1996. Forest management planning manual for Ontario's crown forests. The Queens printer for Ontario.

1.4 NRVIS – Natural Resources and Values Information System

NRVIS is a GIS that stores and manages the MNR's digital land-related information. It provides the ability to store, maintain and access approximately 150 Concrete Classes organizing over 690 different geographic feature types. NRVIS was developed out of the Ontario Base Mapping (OBM) program and tiling system. One of its main functions was to seamlessly append more than 10,000 OBM tiles into 26 MNR district data sets. If internal access to the MNR intranet is available more information can be found about NRVIS at http://mnronline.mnr.gov.on.ca/spectrasites/nrvis/nrvishome.cfm

NRVIS stores data in the Universal Transverse Mercator (UTM) projection and uses the North American Datum (NAD) 1983 adjusted from North American Datum of 1927 (NAD27) using the National Transformation Version 2 (NTv2) specifications. Figure 2 shows the four UTM zones that cover Ontario. The data stored in NRVIS has been mapped at a scale of 1:10,000 in southern Ontario and 1:20,000 in northern Ontario (Figure 3) and were derived from aerial photogrammetry acquired at 1:30,000 and 1:50,000 scales, respectively. Table 1 provides accuracy and mapping specifications for the data within NRVIS.

Figure 2: UTM zones across Ontario

Figure 3: Distribution of map scales

Table 1: Accuracy and specifications for data within NRVIS[3]

	Southern Ontario	Northern Ontario
Nominal Scale of Photogrammetry	1:30,000	1:50,000
Nominal Scale of Mapping	1:10,000	1:20,000
Absolute Positional Accuracy	5 metre	10 metre
Absolute Vertical Accuracy (contours & DTM)	2.5 metre	5 metre
Contour Interval	5 metre	10 metre
DTM Elevation Point Spacing (max)	60 metre	100 metre
Spot Elevation Point (vertical accuracy)	1.25 metre	2.5 metre

3 Ontario Ministry of Natural Resources, 1996. Ontario digital topographic database: A guide for users. The Queens printer
for Ontario.

1.5 LIO - Land Information Ontario

The Government of Ontario has established Land Information Ontario (LIO) to orchestrate the collection and management of land information in the Province of Ontario. In 1997, following an internal "mapping review", the Province of Ontario established the Land Information Transition Project (LITP). The objective was to consult with stakeholders and provide recommendations on how to achieve more effective and efficient management of Ontario's Land Information assets. During this period the Government of Ontario began to consult extensively with industries, local governments and groups concerned about land information management. These stakeholders unanimously agreed that a common framework to manage land information was essential. The recommendations arising from LITP led to the creation of the Land Information Ontario project, an exciting three year initiative to restructure the management and use of Ontario's land information infrastructure led by the Ontario Ministry of Natural Resources. The Natural Resources and Values Information System is currently a major part of Land Information Ontario. The relationship between NRVIS and LIO is outlined in Figure 4. More information about LIO can be found at www.lio.mnr.gov.on.ca/lioweb/default.asp.

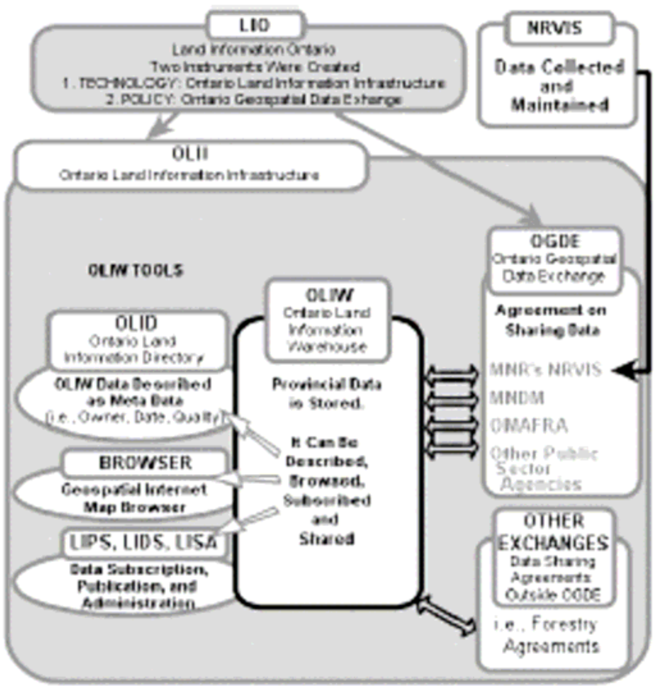


Figure 4: The structure of LIO and NRVIS

Appendix H: NHIC Element Occurrences

Data provided by the Natural Heritage Information Centre, Ontario Ministry of Natural Resources, September 12th, 2006, http://nhic.mnr.gov.on.ca/MNR/nhic/about.cfm

The NHIC was established in 1993 as a joint venture between the Ontario Ministry of Natural Resources (MNR) and three partners:

The Nature Conservancy of Canada,

Natural Heritage League

and The Nature Conservancy

The NHIC is part of the Ontario OMNR Fish and Wildlife Branch. The NHIC contributes to OMNR's role in protecting the genetic, species and ecosystem diversity of Ontario.

The Mission

- To acquire, maintain, update, and make available data on the province's rare species, vegetation communities, and natural areas.

The Goal

  - To generate a permanent and dynamic atlas and data bank on the character, distribution and conservation status of natural areas, critical flora and fauna, communities and special features in Ontario.

The Objectives

  - To assemble and organize information on endangered species and spaces from all available sources, such as atlas projects, naturalist groups, universities, museums, and inventory/monitoring programs by public and private sector agencies and organizations.
  - To make information on rare species and spaces more accessible for ecologically-sound land use planning, and in support of biodiversity conservation programs.
  - To track priority species, ecological communities and sites to guide biodiversity conservation activities by public and private sector conservation organizations.
  - To maintain a central repository of natural heritage data and information in Ontario.

COSEWIC Status

Endangered (E):
A wildlife species facing imminent extirpation or extinction.

Extirpated (XT):
A wildlife species no longer existing in the wild in Canada, but occurring elsewhere.

Extinct (X) :
A wildlife species that no longer exists.

Data Deficient (DD) :
A wildlife species for which there is inadequate information to make a direct, or indirect, assessment of its risk of extinction.

Not At Risk (NAR) :
A wildlife species that has been evaluated and found to be not at risk of extinction given the current circumstances.

Special Concern (SC) :
A wildlife species that may become a threatened or an endangered species because of a combination of biological characteristics and identified threats.

Threatened (T) :
A wildlife species likely to become endangered if limiting factors are not reversed.

MNR Status (MNR)

Extinct:
A species that no longer exists anywhere.

Extirpated:
A species that no longer exists in the wild in Ontario but still occurs elsewhere.

Endangered (Regulated):
A species facing imminent extinction or extirpation in Ontario which has been regulated under Ontario's Endangered Species Act (ESA).

Endangered (Not Regulated):
A species facing imminent extinction or extirpation in Ontario which is a candidate for regulation under Ontario's ESA.

Threatened:
A species that is at risk of becoming endangered in Ontario if limiting factors are not reversed.

Special Concern:

(formerly Vulnerable) A species with characteristics that make it sensitive to human activities or natural events.

Not at Risk:
A species that has been evaluated and found to be not at risk.

Data Deficient:
(formerly Indeterminate) A species for which there is insufficient information for a provincial status recommendation

Appendix I: Fish Habitat Type Descriptions

Summarized by:

Stephen Scholten
Bracebridge Area Fisheries Biologist
Ontario Ministry of Natural Resources

Originally received on September 12th, 2006.

MNR Fish Habitat Type Mapping Descriptions

Type 1

Habitats are rare or highly sensitive to the potential impacts of development or limit fish productivity either directly or indirectly in a specified water body or portion of a water body. Where these habitats are limiting, productivity would be expected to diminish of they are harmed.

Examples of Type 1 habitats include:

- spawning, nursery, rearing, shelter, refuge and highly productive food supply areas of fish species important to local commercial, recreational or subsistence fishing activities,
- constricted migration routes (including pathways that connect a wetland hydrologically to a lake or river, and flood plain pathways that may be seasonally important),
- groundwater discharge areas including headwaters, springs and seepage areas,
- habitat types that are in short supply within a watershed (e.g. macrophyte beds where aquatic vegetation is limiting; spawning/nursery habitats provided by seasonally flooded wetlands; submerged shoals and reefs used as primary feeding areas; deep pools in rivers/streams used as adult holding areas.

Type 2

Habitats that are moderately sensitive to the potential impacts of development and although important to fish populations, do not limit the productivity of fish either directly or indirectly. These habitats are usually abundant and another habitat component is the limiting factor in fish production.

Examples of Type 2 habitats include:

- seasonally flowing streams or seasonally inundated lands not used as spawning or nursery areas,
- feeding areas,
- open water areas
- areas of abundant nursery or feeding habitat (e.g. areas of sparse vegetation in water bodies where there is heavy plant growth,
- littoral areas composed of sand, silt, detritus, bedrock and/or boulders that are not used as spawning or nursery habitats for important fish species,
- water bodies supporting fish species that are not important to commercial , recreational or subsistence fishing activities,
- pool-riffle-run complexes that occur frequently along much of a watercourse.

Type 3

Habitats that are marginal or highly degraded, and currently do not contribute directly to fish productivity, based on fish community management objectives. Type 3 habitats can often be improved significantly, thereby providing a net gain of productive capacity.

- A water body or portion that fish do not utilize due to physical or chemical barriers (e.g. severe water pollution),
- Water body or portion that has been highly altered physically (e.g. channelized streams, sheet piling retaining wall, concrete walls,
- In-water substrate that is heavily silted or degraded (e.g. areas fronting old mill sites filled with slab-wood lumber,
- Drained or filled wetlands.

Disclaimer:

Habitat type mapping is based on the best available information and may be incomplete or inaccurate for various reasons, such as:

- Historical data collected prior to establishment of, or under different standards,
- Time of year data collected (e.g. vegetation not a maximum extent, not at peak time of bass nesting, etc.),
- Habitat within a polygon may not be homogeneous,
- Change in habitat over time (extent of vegetation, erosion),
- Change in fish species present,

Habitat type mapping is based primarily on substrate and vegetation type and not the direct observation of use by fish.

Polygon boundaries should not be assumed to be precise.

Appendix J: Glossary

	Definition Notes	Source
ANSI, Areas of Natural and Scientific Interest:	Publicly or privately owned areas of land and associated water, identified on the basis of earth or life science features, that have important natural heritage, scientific or educational values.	Ontario Provincial Parks: Planning and Management Policies, 1992 Update
Biodiversity/ biological diversity:	The variability among living organisms from all sources including, inter alia, terrestrial, marine and other aquatic ecosystems and the ecological complexes of which they are part; this includes diversity within species, between species and of ecosystems.	Ontario Biodiversity Strategy (2005)
Bog:	They are precipitation dominated with no groundwater seepage. Bogs are dominated by peat-accumulation of dead, decaying mosses -- covered by sphagnum moss, evergreen trees (primarily black spruce) and characteristic shrubs. Bogs form in deep depressions left by the glaciers, there are no drainage holes for water to escape so all water is stagnant creating anaerobic conditions and high acidity from decaying moss. Bogs, in contrast to other wetland types, host few animals due to conditions of low oxygen and high acidity. Bogs contain specialized flora, able to cope with the harsh conditions.	Adopt-a-Pond Wetland Conservation Programme (2006)
Clastic:	Geological term: Denotes rocks composed of broken pieces of other rocks.	Algoma Headwaters Signature Site Strategy
Coastal wetlands:	(a) Any wetland that is located on one of the Great Lakes or their connecting channels (Lake St. Clair, St Mary's, St. Clair, Detroit, Niagara and St. Lawrence Rivers); or (b) Any other wetland that is on a tributary to any of the above-specified water bodies and lies, either wholly or in part, downstream of a line located 2km upstream of the 1:100 year floodline (plus wave run-up) of the large water body to which the tributary is connected.	Provincial Policy Statement (MMAH 2005)
Conservation:	Maintenance of the Earth's resources in a manner that maintains ecosystem, species and genetic diversity and the evolutionary and other processes that shaped them. Conservation may or may not involve the use of resources; that is, certain areas, species or populations may be excluded from human use as part of an overall landscape/waterscape conservation approach while in other areas the sustainable use of biological resources is permitted.	Ontario Biodiversity Strategy (2005)
Conserved:	The identification, protection, use and/or management of cultural heritage and archaeological resources in such a way that their heritage values, attributes and integrity are retained. This may be addressed through a conservation plan or heritage impact assessment.	Provincial Policy Statement (MMAH 2005)
Conservation Organization:	A non-government conservation body including a land trust, conservancy or similar not-for-profit agency governed by a charter or articles of incorporation or letters patent, and with by-laws and objectives that support the protection of the natural environment. Such an organization must have registered charitable status.	Niagara Escarpment Plan (NEP, NEC 2005)
Conservation reserve:	A new form of protected area in Ontario regulated under the Public Lands Act. They complement provincial parks in protecting representative landscapes and ecosystems across the province, while allowing a range of existing uses (such as wildlife viewing, hunting, fishing, hiking, boating) to continue. Commercial uses such as forestry, mining, hydro development or aggregate extraction are not permitted in CRs. Management direction for CRs is provided by Statements of Conservation Interest or Resource Management Plans.	Temagami Integrated Planning, Background Information Document (OMNR 2005)
Corridor/ Linkage:	A physical or biological link, connecting two areas of habitat and differing from the habitat on either side. For the Muskoka River Watershed Inventory Project, linkages were sites that scored very high, high, or medium indicating their capability for supporting and maintaining ecological and evolutionary processes, as well as being of high quality or condition. These sites are generally in proximity to significant core areas and used to connect core areas and other priority sites, as well as linking to already protected areas.	Dictionary of Natural Resource Management (Dunster and Dunster 1996); Muskoka River Watershed Inventory Project

Crown land:	All land held by the Province of Ontario (including lands under water) that has never been granted to any individual or group. This also includes lands that have been re-acquired by the Province.	Algoma Headwaters Signature Site Strategy
Cumulative effect:	The effect on the environment as a result of the incremental impacts of development when considered in conjunction with other past, present and possible future actions, occurring over a period of time and area.	Niagara Escarpment Plan (NEP, NEC 2005)
Data deficient:	A species for which there is insufficient information for a provincial status recommendation.	Natural Heritage Information Centre (2006)
Deer wintering sites (Deeryards):	An area where deer concentrate during the winter months.	Niagara Escarpment Plan (NEP, NEC 2005)
Diversity:	See Biodiversity.	
Easement:	A negotiated interest in the land of another which allows the easement holder specified uses or rights without actual ownership of the land.	Niagara Escarpment Plan (NEP, NEC 2005)
Easement agreement:	When reference is made to the Ontario Heritage Act means an easement agreement under Section 37 of the Ontario Heritage Act guaranteeing the maintenance and protection of designated heritage property.	Niagara Escarpment Plan (NEP, NEC 2005)
Ecological(ly):	The sum total of all the natural and cultural conditions which influence and act upon all life forms, including humans.	Niagara Escarpment Plan (NEP, NEC 2005)
Ecological approach:	Resource planning and management activities that assure consideration of the relationship among and between all organisms, including humans, and their environment.	Ontario Biodiversity Strategy (2005)
Ecological function:	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.	Provincial Policy Statement (MMAH 2005)
Ecological integrity:	The quality of a natural, unmanaged or managed ecosystem in which the natural ecological processes are sustained, with genetic, species, and ecosystem diversity assured for the future.	Ontario Biodiversity Strategy (2005)
Ecoregion/ Ecodistrict:	Ecoregion: A large ecological landscape unit that captures major subdivisions of Ontario, primarily identified by sub-continental climatic regimes. Ecoregions identify broad abiotic factors such as temperature and precipitation that influence patterns of primary productivity, biotic distribution, and solid development. Within Ontario there are 14 different ecoregions, ranging from the Hudson Bay Lowlands to the Carolinian Forest. Their size ranges from hundreds to tens of thousands of square kilometers. Ecodistrict: An ecological landscape unit defined by subregional patterns of landforms, physiography, and topography. These physical factors result in modifications of local climate, abiotic landscape complexity and configuration, distribution of dominant surficial and soil materials, vegetation distribution and productivity. Ontario's 14 ecoregions are subdivided into 71 ecodistricts. Ecodistricts are usually several thousand square kilometers in size.	Temagami Integrated Planning, Background Information Document (OMNR 2005)
Ecosite:	A site-specific ecological landscape unit comprised of relatively uniform geology, parent materials, soils, topography, and hydrology, occupied by consistent complexes of dominant overstory and understorey vegetation. Ecosites range from less than one hectare to hundreds of hectares in size.	Temagami Integrated Planning, Background Information Document (OMNR 2005)
Ecosystem:	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.	Conservation Blueprint for Biodiversity (2005)

Ecosystem approach:	An ecosystem approach to management is as much a philosophy as it is a set of planning and management tools. It aims to understand the interrelationships that may exist between the elements associated with the social, economic and natural environments that are considered when evaluating projects. Furthermore, it encourages people to: consider the elements of ecosystem composition, environment; ensure that human actions and disturbance mimic natural processes to the greatest extent possible; recognize the wide range of resource values, and; use ecological classifications to map ecosystems.	A Class Environmental Assessment for Provincial Parks and Conservation Reserves
Ecosystem health:	The condition of an ecosystem, through its structure and functions, that permits the maintenance of biological diversity, biotic integrity and biological processes over time.	Ontario Biodiversity Strategy (2005)
Ecozone:	An area of the earth's surface that represents a large ecological zone and has characteristic landforms and climate. Each ecozone is distinguished from others by it's unique mosaic of plants, wildlife, climate, landforms, and human activities. In this strategy we briefly describe the three ecozones and the Great Lakes as the four "ecological regions" that comprise Ontario.	Ontario Biodiversity Strategy (2005)
Element Occurrence (EO):	An area of land and/or water in which a species or natural community is, or was, present.	Natural Heritage Information Centre (2006)
Endangered species:	Species that are threatened with immediate extinction or extirpation if the factors threatening them continue to operate. Included are species whose numbers have been reduced to a critical level or whose habitats have been so drastically reduced that they are deemed to be in immediate danger of extinction.	Ontario Biodiversity Strategy (2005)
Environmental monitoring:	The long term and repeated measurement of selected properties or characteristics of the environment and of the activities believed to be responsible for changes in the environment. The most significant properties or characteristics are often referred to as indicators. Monitoring may be carried out on a very broad, even global scale or on a restricted, local scale.	Niagara Escarpment Plan (NEP, NEC 2005)
Extinct species:	A species that no longer exists anywhere.	Natural Heritage Information Centre (2006)
Extirpated species:	Species that are no longer found in the wild in the portion of their natural range that is within Ontario but that still exist elsewhere in the world.	Ontario Biodiversity Strategy (2005)
Fen:	Fens, like bogs, are primarily found in Northern Ontario. However, unlike bogs, fens are fed by groundwater and precipitation. Their pH conditions are not acidic but rather alkaline or neutral. Peat also accumulates in these wetlands but instead, like a bucket with a slow leak drains out acidic water created by decaying moss and peat. Fens look like meadows with sedges, grasses and low shrubs as typical vegetation.	Adopt-a-Pond Wetland Conservation Programme (2006)
Fish habitat:	As defined in the Fisheries Act, means spawning grounds and nursery, rearing, food supply, and migration areas on which fish depend directly or indirectly in order to carry out their life processes.	Provincial Policy Statement (MMAH 2005)
Forest Management Plan:	A document containing pertinent information and prescriptions by which forest policy, aims, and objectives are translated into a continuity of specific treatments on a forest management unit for a specified period of years.	Algoma Headwaters Signature Site Strategy
Geomorphology:	A study of the physical features of the earth's surface and their relation to its geological structures.	Ontario Provincial Parks: Planning and Management Policies, 1992 Update
Gneiss:	Geological term: A metamorphic rock with a banded or foliated structure, typically coarse-grained and containing quartz, feldspar, and mica.	Algoma Headwaters Signature Site Strategy
Granite:	Geological term: A very hard, crystalline, igneous rock containing quartz, mica, and feldspar.	Algoma Headwaters Signature Site Strategy
Habitat:	The place or type of site where an organism or population naturally occurs. Species may require different habitats for different uses throughout their lifecycle.	Ontario Biodiversity Strategy (2005)
Indicator/ surrogate:	For the Muskoka River Watershed Inventory, an indicator or surrogate is a spatial representation of a project objective, thus providing a mappable entity that can be manipulated and analyzed using GIS.	Muskoka River Watershed Inventory Project

Interior habitat:	Habitat located in portions of a patch which are relatively stable and uninfluenced by changing climatic conditions and other variables (noise, wind, sunlight, temperature, moisture) associated with edge conditions.	Dictionary of Natural Resource Management (Dunster and Dunster 1996)
Intrinsic value:	Valued for its own sake, not for what they lead to or produce.	Ontario Biodiversity Strategy (2005)
Intrusion:	Geological term: The action of forcing a body of igneous rock between or through existing formations, without reaching the surface.	Algoma Headwaters Signature Site Strategy
Landscapes:	Complexes of terrestrial ecosystems in geographically defined areas.	Ontario Biodiversity Strategy (2005)
Linkages:	See Corridors/Linkages:	
Maintenance:	Generally, the regular, routine actions, taken to retard the natural deterioration of a resource (or fixture, chattel and/or equipment). These actions are intended to keep the resource from premature loss due to failure, decline, wear or change attributable to normal use or the effect of the natural environment.	A Class Environmental Assessment for Provincial Parks and Conservation Reserves
Management plan:	A document that identifies management objectives and implementation priorities for a defined area, over a period of time (e.g., 20 years). Management plans are based on an understanding of the natural, social, cultural and economic values of the area, usually obtained through detailed inventories. The plans are prepared though a multi-stage public consultation process.	A Class Environmental Assessment for Provincial Parks and Conservation Reserves
Marsh:	A marsh is a treeless wetland dominated by soft-stemmed emergent (cattails, reeds, rushes and sedges) and submergent plants. They are shallow (2m in depth) and permanent or semi-permanent (small marshes may dry completely in the summer). Marshes are dominated by surface water with high productivity from nutrients and minerals in runoff. Marshes are found along lakeshores, ponds, streams, riparian and riverine areas. Marshes are the most productive wetlands habitat.	Adopt-a-Pond Wetland Conservation Programme (2006)
Microclimate:	The climate of a small, local area.	Ontario Provincial Parks: Planning and Management Policies, 1992 Update
Mitigation:	Avoiding, eliminating, offsetting or reducing to an acceptable level the potential effects of a project. It can also include rehabilitation, restoration, or enhancement where feasible. The means by which projects can be modified to minimize or eliminate potential negative effects. This can include off-site measures that achieve the same objective.	A Class Environmental Assessment for Provincial Parks and Conservation Reserves
Municipality:	A city, county, region, town, village and township.	Niagara Escarpment Plan (NEP, NEC 2005)
Muskeg:	A term used for peatlands (bogs and fens) by the Ontario Forest Resource Inventory.	Conservation Blueprint for Biodiversity (2005)
Natural heritage:	Collective term used to describe features of the natural landscape (e.g, botany, zoology, geology, geomorphology worthy of preservation.	Ontario Provincial Parks: Planning and Management Policies, 1992 Update
Natural heritage features and areas:	Features and areas, including significant wetlands, significant coastal wetlands, fish habitat, significant woodlands south and east of the Shield, significant habitat of endangered species and threatened species, significant wildlife habitat, and significant areas of natural and scientific interest, which are important for their environmental and social values as a legacy of the natural landscapes of an area.	Provincial Policy Statement (MMAH 2005)
Natural heritage system:	A system made up of natural heritage features and areas, linked by natural corridors which are necessary to maintain biological and geological diversity, natural functions, viable populations of indigenous species and ecosystems. These systems can include lands that have been restored and areas with potential to be restored to a natural state.	Provincial Policy Statement (MMAH 2005)
Natural Values Resources and Information System (NRVIS):	Ontario governments' Geographical Information System platform for storing, maintaining and managing tabular and spatial geographic information according to province-wide standards.	Conservation Blueprint for Biodiversity (2005)

Negative impacts:	(a) Degradation to the quality and quantity of water, sensitive surface water features and sensitive ground water features, and their related hydrologic functions, due to single, multiple or successive development or site altercation activities. (b) In regard to fish habitat, the harmful alteration, disruption or destruction of fish habitat, except where, in conjunction with the appropriate authorities, it has been authorized under the Fisheries Act, using the guiding principle of no net loss of productive capacity; and (c) In regard to other natural features or ecological functions for which an area is identified due to single, multiple or successive development or site alteration activities.	Provincial Policy Statement (MMAH 2005)
Not-at-risk species:	A species that has been evaluated and found to be not at risk.	Natural Heritage Information Centre (2006)
Official plan:	A document approved by an approval authority in accordance with the Planning Act, containing objectives and policies established primarily to provide guidance for the physical development of a municipality or a part thereof, while having regard to relevant social, economic and environmental matters.	Niagara Escarpment Plan (NEP, NEC 2005)
Old growth forest:	There are many criteria that can define old-growth, including the age of large, old trees for the species and site, the tree size and spacing, the number of canopy layers or gaps, accumulation of downed woody debris, and many other indicators of old-growth forests. As a result, the age defining old-growth can be different for each type of species or forest stand. In Ontario, old-growth is defined by OMNR (Ontario Ministry of Natural Resources) within the framework of the provincial Ecological Land Classification (Uhlig, P., A. Harris, G. Craig, C. Bowling, B. Chambers, B. Naylor and G. Beemer. 2001. Old growth forest definitions for Ontario. Ont. Min. Nat. Res., Queen's Printer for Ontario, Toronto, ON. 27pp.).	Old growth forest definitions for Ontario (2001)
Patented land (private land):	A grant from the crown which conveys free hold interest in public lands to an individual or group.	Algoma Headwaters Signature Site Strategy
Policy:	A statement of direction developed for the purpose of guiding present and future actions and decisions.	Algoma Headwaters Signature Site Strategy
Preservation:	The maintenance of natural or cultural heritage features in their current or original form, and the maintenance of the natural environment to allow natural processes to continue undisturbed by human intervention.	Niagara Escarpment Plan (NEP, NEC 2005)
Protected area:	Geographically defined areas that are designed or regulated and managed to achieve specific protection objectives.	Ontario Biodiversity Strategy (2005)
Protection:	A commitment to protect individuals, a subpopulation, or ecosystems (or parts thereof) from adverse impacts that may result in their loss.	Ontario Biodiversity Strategy (2005)
Provincial Park:	A protected area regulated under the Provincial Parks Act. Provincial parks are established to ensure that features representing the most significant aspect of Ontario's natural and cultural history are protected - now, and for future generations. Ontario's system of parks strives to meet four key objectives: protection, heritage appreciation, recreation, and tourism.	Temagami Integrated Planning, Background Information Document (OMNR 2005)
Provincially Significant Wetland:	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.	Conservation Blueprint for Biodiversity (2005)
Rare species:	Small populations of species that are not currently endangered, threatened or of special concern but may be at risk. These species are usually localized within restricted geographical areas or habitats, or are thinly scattered over a more extensive range. Rarity can be defined locally, regionally, provincially/territorially, nationally or globally.	Ontario Biodiversity Strategy (2005)
Recovery:	An action that is necessary to reduce or eliminate the threats that cause a species to be listed as threatened, endangered, or extirpated.	Ontario Biodiversity Strategy (2005)
Resilience:	The ability of an ecosystem to recover and maintain the desired condition of diversity, integrity, and ecological processes following disturbances.	Ontario Biodiversity Strategy (2005)

Research:	Research includes measuring, monitoring, and testing and means an undertaking that is carried out for the purposes of or consists of research. For MNR this can consist of projects such as lake surveys, wildlife population and habitat studies, inventories, and other studies, surveys or inventories including measuring, monitoring and testing that is carried out for the purpose of or consists of research.	A Class Environmental Assessment for Provincial Parks and Conservation Reserves
Resource:	Generally, a value, feature, attribute, or physical component; and available renewable or non-renewable supply that can be drawn on when needed, be it animal, vegetable, mineral, etc.	A Class Environmental Assessment for Provincial Parks and Conservation Reserves
Restoration:	The return of species, population or ecosystem to its state prior to disturbance.	Ontario Biodiversity Strategy (2005)
Roads (forestry):	Primary road: A road constructed, maintained and used as part of the main all-weather road system which provides access to the management unit as a whole. Primary roads are essentially permanent roads, regularly maintained, with a life in excess of 15 years. Secondary road: A road which is essentially a branch off a primary road, providing access to areas of operations within a management unit. These roads are not considered permanent and are not normally maintained beyond the five to 15 year period of their use. Tertiary road: A road which is built for short-term use (i.e. up to five years) for harvest and subsequent renewal operations. Tertiary roads may be un-surfaced or thinly surfaced and are not maintained beyond the period of their use. They are often reforested.	Algoma Headwaters Signature Site Strategy
Score:	For the Muskoka River Watershed Inventory, score means values that have been assigned to indicators in order to evaluate their influence on ecological and evolutionary processes.	Muskoka River Watershed Inventory Project
Significant core area:	An area of land that has vital attributes necessary for the survival of one or more species, or ecosystem functions, and that is considered an essential component of a broader management plan. For the Muskoka River Watershed Inventory, significant core areas are the highest scored sites. High scored sites indicate that the site had values indicating that it was capable of supporting and maintaining ecological and evolutionary processes, as well as values indicating high quality or condition.	Dictionary of Natural Resource Management (Dunster and Dunster 1996); Muskoka River Watershed Inventory Project
Species at risk:	Wild plant or animal threatened by, or vulnerable to extirpation in Ontario or extinction. Species at Risk are assigned a designation to represent the degree of imperilment: extinct; extirpated, endangered (regulated), endangered (not regulated), threatened, special concern, not at risk, data deficient.	Ontario Biodiversity Strategy (2005)
Special concern species:	A species that is particularly sensitive to human activities or natural events but is not and endangered and/or threatened species.	Ontario Biodiversity Strategy (2005)
Stewardship:	Managing property on someone else's behalf. Private stewardship involves landowners protecting significant natural resources on their lands for the benefit of society.	Ontario Provincial Parks: Planning and Management Policies, 1992 Update
Stream/ watercourse:	Feature having defined bed and banks, though which water flows at least part of the year.	Niagara Escarpment Plan (NEP, NEC 2005)
Substrate:	An underlying layer of rock or soil beneath the surface.	Ontario Provincial Parks: Planning and Management Policies, 1992 Update
Swamp:	Swamps are treed wetlands dominated by woody stemmed plants. Swamps are typically woodland areas that have flooded with water in the spring by river/stream overflow. Some swamps dry completely by late summer. The dominant tree species found in association with a swamp are red maple, elm, alder and willow. Swamps are found along rivers, streams and lakes.	Adopt-a-Pond Wetland Conservation Programme (2006)
Threatened species:	Species that are likely to become endangered if the natural and/or human pressures limiting them are not reversed.	Ontario Biodiversity Strategy (2005)

Topography:	The natural or artificial features of a land surface.	Ontario Provincial Parks: Planning and Management Policies, 1992 Update
Utility corridors:	Land alienations in the form of patents, leases or easements for the purposes of roads, railways, transmission lines, pipelines, etc.	Ontario Provincial Parks: Planning and Management Policies, 1992 Update
Watershed:	An area that is drained by a river and its tributaries.	Provincial Policy Statement (MMAH 2005)
Wetlands:	Lands that are seasonally or permanently covered by shallow water, as well as lands where the water table is close to or at the surface. In either case, the presence of abundant water has caused the formation of hydric soils and has favoured the dominance of either hydrophytic or water tolerant plants. The four major types of wetlands are swamps, marshes, bogs, and fens.	Provincial Policy Statement (MMAH 2005)