The Watershed Inventory Project
Aquatic Component
Final Report

October 2009

Acknowledgements

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

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Introduction

The development of the aquatic portion of the Watershed Inventory Project (WIP-A) was overseen by a collaborative of the Muskoka Heritage Foundation, Muskoka Watershed Council, District Municipality of Muskoka, Ontario Ministry of Natural Resources (Parry Sound District),and Fisheries and Oceans Canada (Parry Sound office). The Collaborative members identified a need to undertake a landscape level analysis of the aquatic ecological systems (ecosystems) within the watersheds that are totally or partially within the District Municipality of Muskoka in order to facilitate their planning and resource management mandates. Funding was acquired from the Ontario Trillium Foundation and the Ontario Ministry of Natural Resources.

The Muskoka River watershed is located on the Canadian Shield in central Ontario. The watershed contains over 500,000 hectares of forests, wetlands, settlement and agricultural areas. It is also comprised of 12% wetlands and 14% lakes and rivers. The Muskoka River begins in the Algonquin Highlands in Algonquin Provincial Park and travels about 210 km before it flows into Lake Huron at Georgian Bay. The Muskoka River is divided into three branches: North, South and Lower. The North branch starts in the Algonquin Highlands and passes through Rebecca Lake, Lake Vernon, Fairy Lake, and Mary Lake. The South branch has its beginnings in Algonquin Provincial Park and the Haliburton Highlands, and passes through Kawagama Lake and Lake of Bays. The Lower branch receives inflow from the North and South branches, as well as from Lakes Joseph and Rosseau, and it passes through Lake Muskoka before emptying into Georgian Bay.

The northern portion of the Black and Severn River watersheds make up the remainder of the study area. The southern boundary of the study area stops at the Canadian Shield contact line. The rationale for defining the study area by the Shield contact line was that different data sets are available for on-shield and off-shield analysis. As well, the collaborative group recognized that natural processes behave differently on the different landform types.

Private land makes up 45% of the study area. There are six upper-tier municipalities and counties covering the area. The District Municipality of Muskoka covers 57%, District of Nipissing covers 8%, District of Parry Sound makes up 11%, the County of Haliburton covers 12%, the City of Kawartha Lakes covers 7%, and the County of Simcoe covers 4%, while 1% of the land is owned by first nations. Crown land covers approximately 54% of the study area (Figures 1 and 2).

At a bird's eye-view, most of the study area appears to be covered in lakes, forest and other natural vegetation types (about 97%) (Figure 3). About 12% of the study area consists of wetlands, 14% is water in the form of lakes and ponds, and rock (barrens and outcrops) forms just over 5% of the area. Settlement areas including urban and built areas make up almost 1%, while developed agricultural areas, croplands and open fields such as golf courses form over 2% of the landcover types within the study area.

The Collaborative identified the importance of protected areas as the starting point for developing future natural areas strategies. The level of protection of natural areas within the study area varies. More than 62% of the land-base portion of the Muskoka River watershed is covered by some level of protection although those protected areas vary in their degree of protection. However, with just a few exceptions, protected natural areas were based on a gap analysis of terrestrial ecosystems and values and not on the aquatic ecosystems or values.

National Parks, Provincial Parks, Conservation Reserves, and land trust properties provide the highest level of protection in the study area (Figure 4). Level 1 protection contains about 76% provincial parks, 22% provincial conservation reserves, 1% land trust properties, and 1% National Park. These areas provide full protection of natural areas through strictly regulated planning policies and restrictions; they cover about 18.3% of the study area's natural land-base.

Level 2 protection areas include Crown land (92%), Muskoka Heritage Areas (7%), Muskoka Heritage Trust conservation easement agreements (0.01%), and Provincially Significant Wetlands (1%) (Figure 5).

These designations either fully or partially protect natural areas depending on policies and agreements with a variety of users, including private landowners, industry and/or other agencies. Level 2 protection areas cover 38.9% of the study area's natural land-base, excluding those areas in level 1 protection that also fall under level 2 categories.

Level 3 protected areas are confirmed Areas of Natural and Scientific Interest (9%) and all wetlands (91%) (Figure 6). These areas are protected from incompatible land-use decisions related to development through municipal official plan policies and comprehensive zoning bylaws. Level 3 protected areas cover about 4.8% of the study area's natural land-base.

The purpose of the Aquatic Watershed Inventory Project was to provide the collaborative members with a GIS tool that could be used to evaluate aquatic ecosystem health and assist in the ongoing analysis and management of aquatic natural areas. In particular, the objective of the Aquatic Watershed Inventory Project was to identify areas of core ecological significance that are in good condition and other areas of high quality that can enhance the core areas and can be used to develop a natural areas strategy and inform conservation and protection activities across the watershed.

Figure 1: The Watershed Inventory Project Study Area

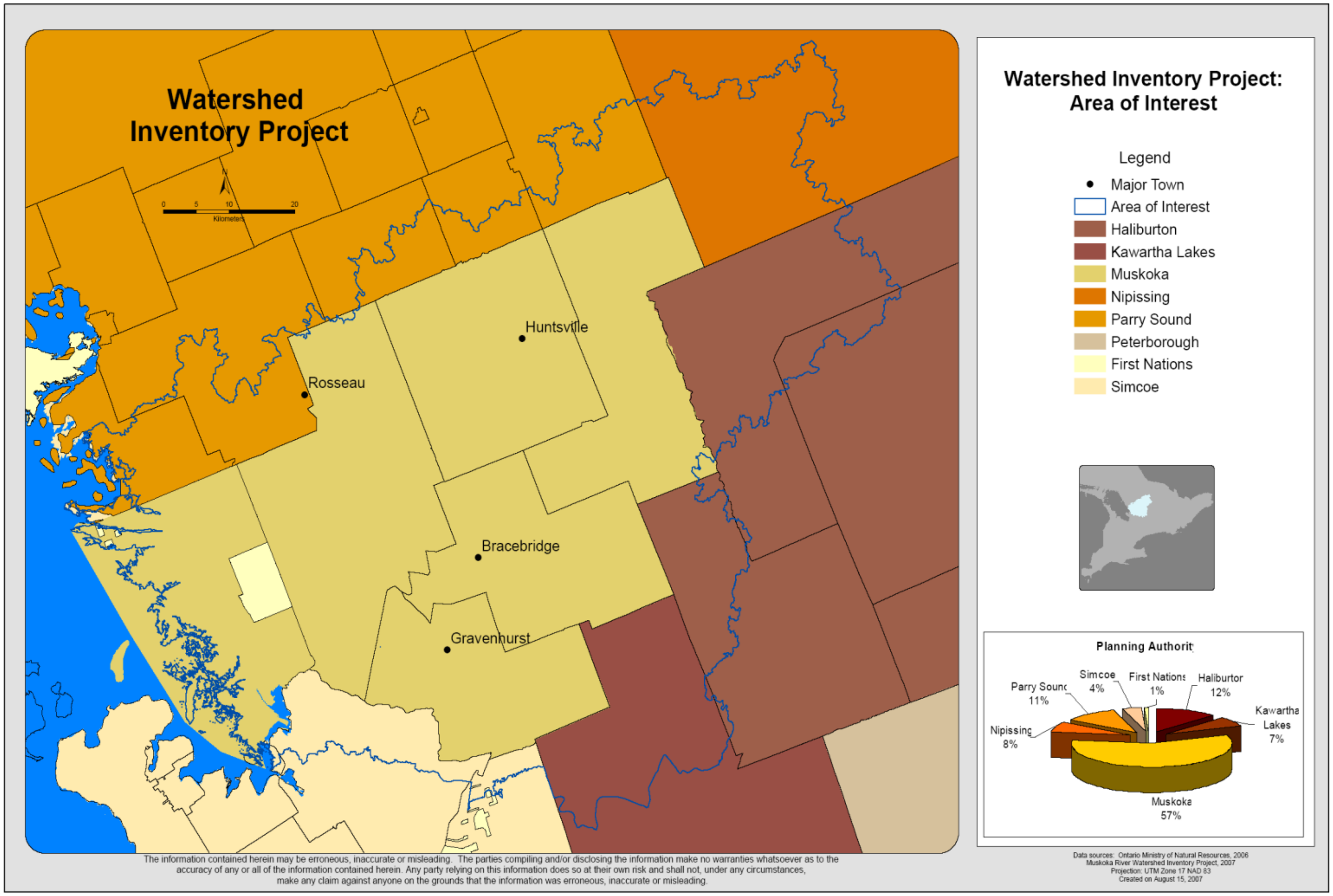


Figure 2: Land Ownership within the Study Area

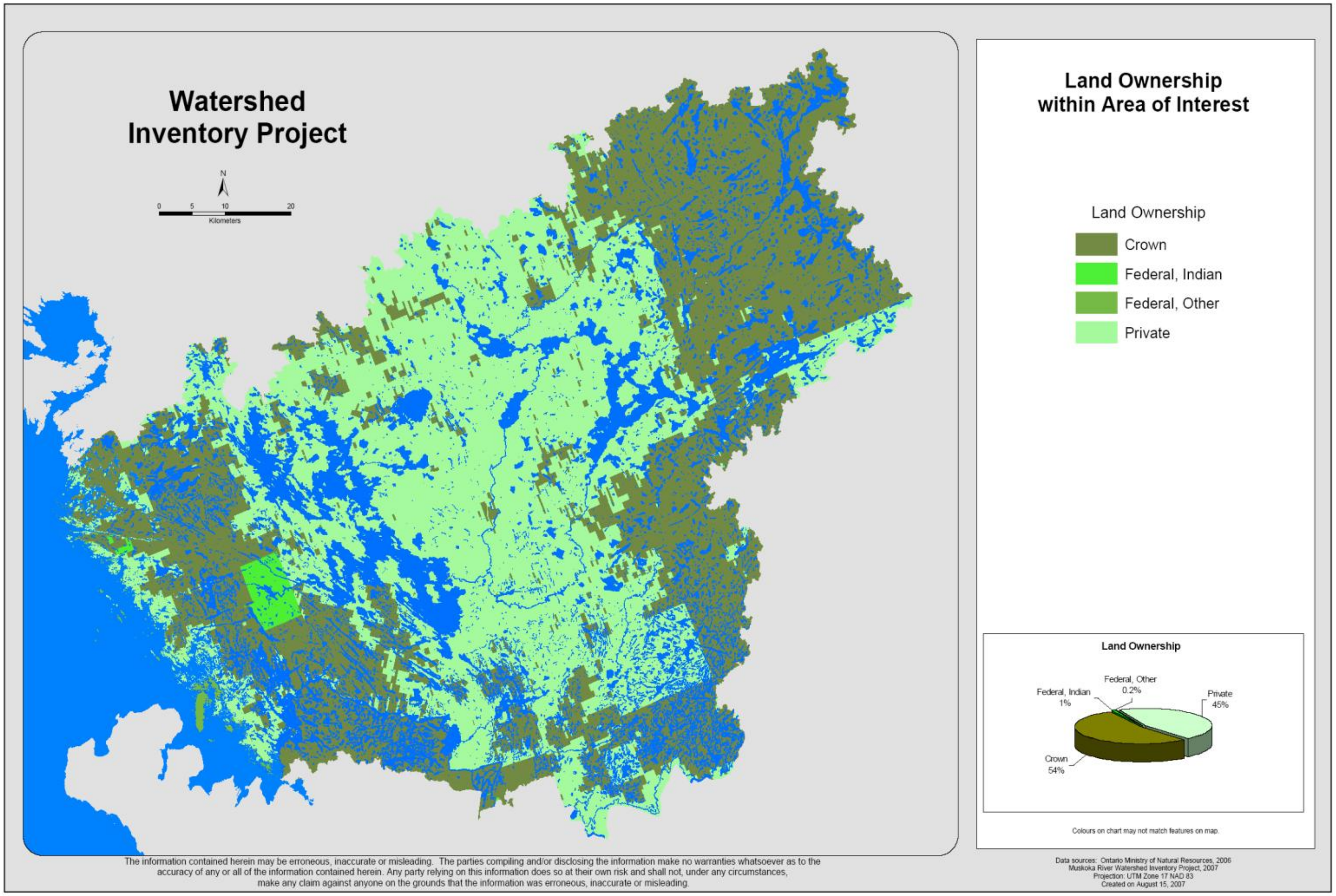


Figure 3: Landcover within the Study Area

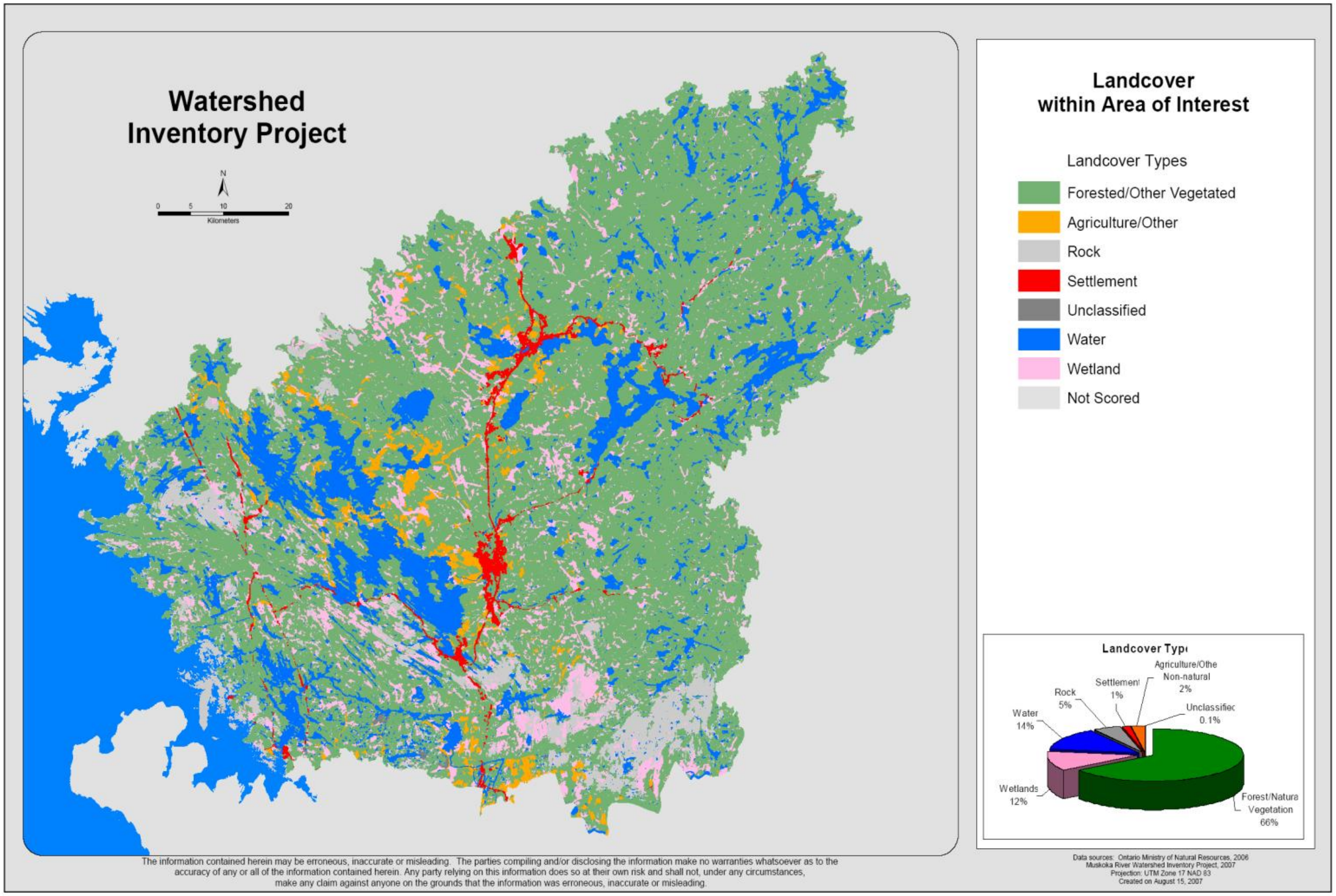


Figure 4: Level 1 Protected Areas

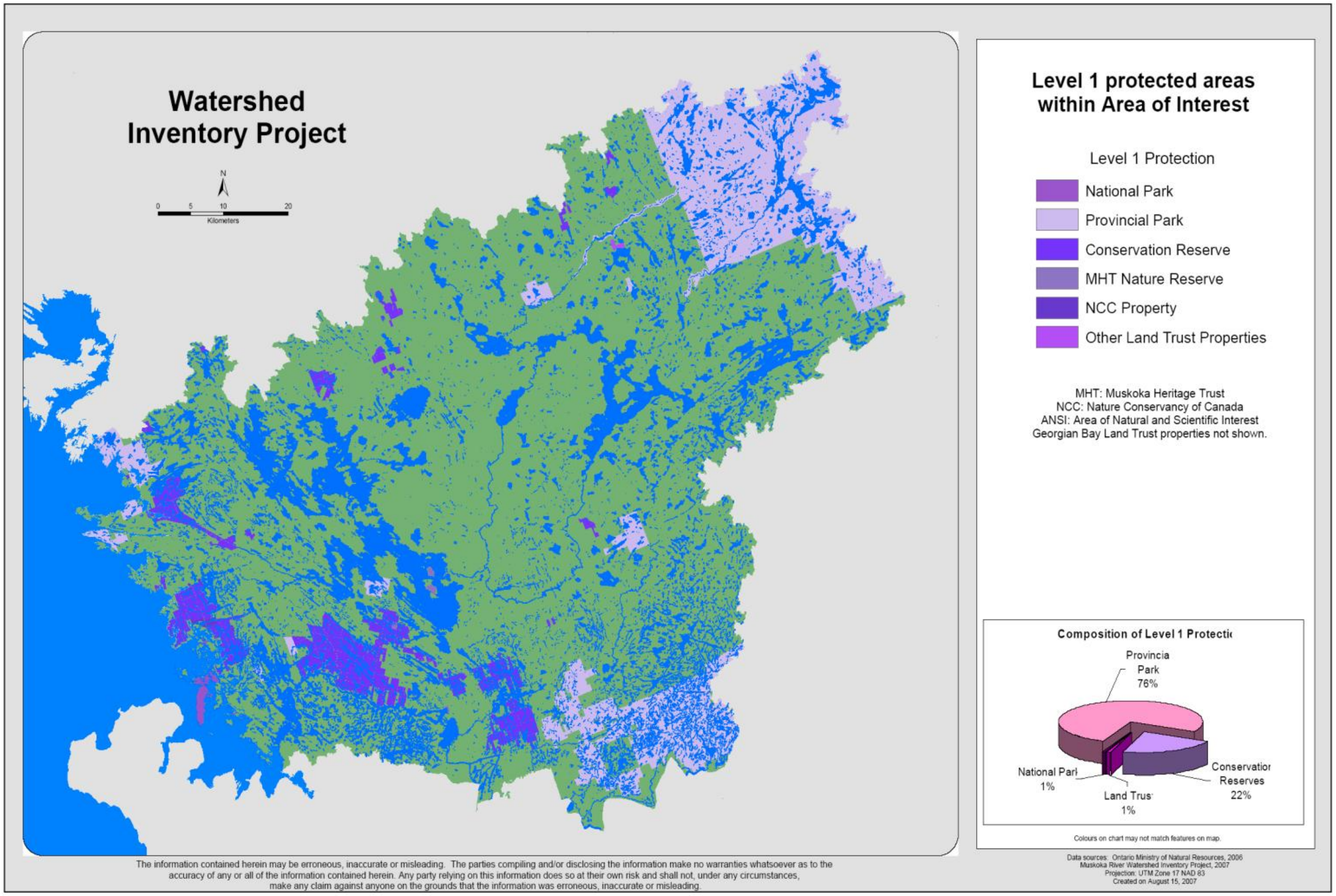


Figure 5: Level 2 Protected Areas

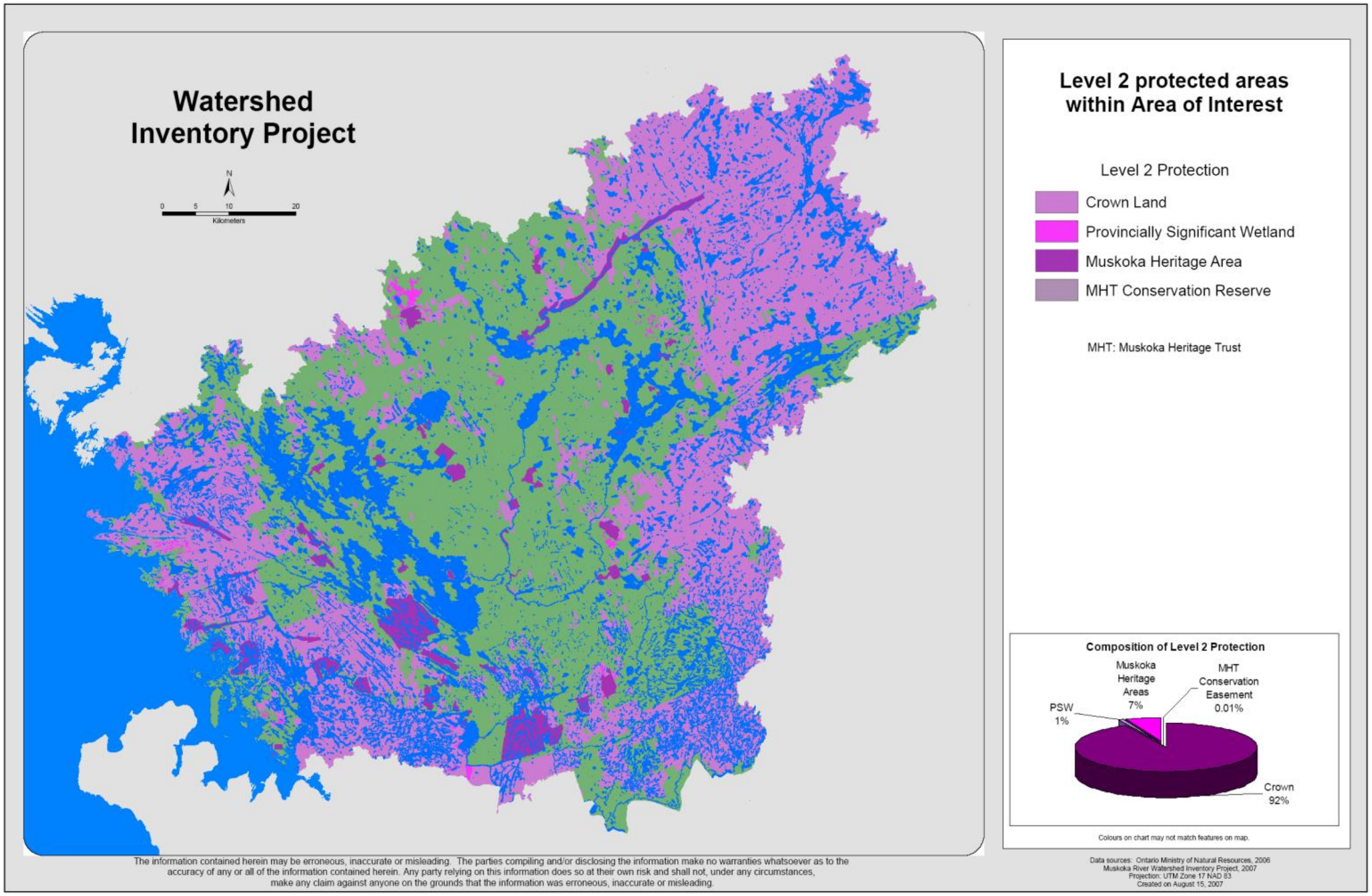
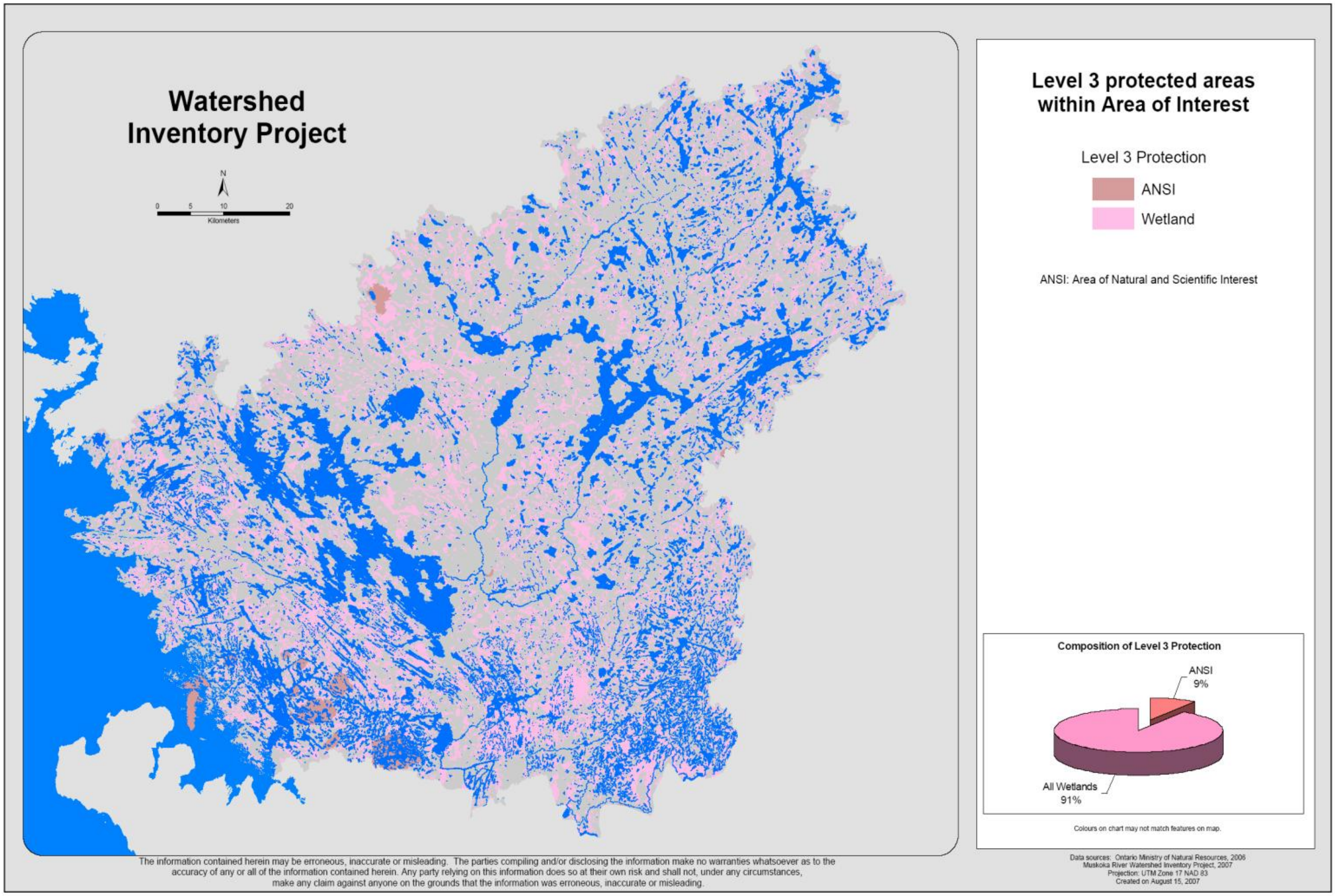


Figure 6: Level 3 Protected Areas



The Watershed Inventory Project – Aquatic Component

The aquatic component of WIP began in 2007 with funding from The Ontario Trillium Foundation. The aquatic component collaborative group was composed of the Ontario Ministry of Natural Resources, The Muskoka Heritage Trust and Foundation, the Muskoka Watershed Council, The District Municipality of Muskoka and Fisheries and Oceans Canada. The aquatic analysis technical committee included representatives from each collaborative agency with expertise in fisheries and aquatic biology, resource and urban planning and landowner stewardship. External expertise from many government, non-government, consulting and academic agencies was also sought in a series of meetings and an organized workshop focusing on an assessment of aquatic ecosystems in Muskoka. As a result, priorities and goals were determined for the aquatic WIP assessment.

The WIP-A provides a solid base for present and future natural heritage work of the collaborative members. The completed terrestrial component of the WIP is being used by each of the collaborative groups to further their individual mandates. The aquatic assessment is another tool to identify significant areas linked to aquatic resources. The outcome of the aquatic assessment verifies what the terrestrial WIP has already identified as significant and enhances the connection of Muskoka's natural heritage across the landscape. Similar to the terrestrial reporting, the aquatic WIP includes the following products:

1. A gap analysis to identify unprotected aquatic ecological systems;

2. A gap analysis to identify 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.

Although it is not necessary to read the terrestrial technical and final reports to follow the aquatic assessment, familiarity with the terrestrial methodology is recommended. As mentioned earlier, the aquatic assessment follows similar methodology as the terrestrial assessment, thus the aquatic reports revisit the terrestrial component in some instances.

Background

The terrestrial and aquatic analysis of WIP relied on scientific rationale for developing a rule-based methodology to identify significant natural areas. The WIP borrowed heavily from the expertise of leading conservation biologists and ecologists within the Ontario Ministry of Natural Resources (MNR) and the Nature Conservancy of Canada (NCC). MNR and NCC have been leaders in undertaking conservation science research and natural heritage planning for decades. Recently, MNR and NCC partnered to develop the Great Lakes Conservation Blueprint for Biodiversity (GLCB) for both terrestrial and aquatic ecological systems (Henson and Brodribb 2004; Henson et al 2005; Wichert et al 2005). The GLCB produced a portfolio of significant natural areas that, if protected, would conserve biodiversity. The WIP adopted the values-based methodology created for the GLCB analysis to identify significant natural areas. The WIP collaborative further refined the GLCB methodology and used up-to-date datasets and local information to develop an analysis specific to the Muskoka region and to reflect the goals of the WIP collaborative members.

Aquatic Ecological Classification

The Core Science Team contributing to the Great Lakes Conservation Blueprint for Biodiversity (GLCB) identified significant natural areas on terrestrial and aquatic landscapes separately, realizing that using one methodology to assess both landscapes would not sufficiently reflect either natural system. Until recently, conservation effort has been based on terrestrial representation. Direct management of freshwater biodiversity exists through protection of resources that have been exploited (such as fish regulations) (Mandrak 1998; Wichert et al 2004; Lawler et al 2003). A classification system focusing on the requirements for healthy, functioning freshwater ecological systems needed to be developed in order to adequately address aquatic components. GLCB collaborative initiated the development of an aquatic ecosystem classification (AEC) to be used for assessing the significance of aquatic systems. The AEC is a hierarchical classification framework that uses many variables including drainage patterns and life history requirements and biological characteristics of fishes. Just as the units for the terrestrial analysis was based on vegetation and landform associations, the basic units for the aquatic analysis uses this recently created aquatic classification system (Wichert et al 2004).

Indictors of Ecological Importance and Condition

Once the aquatic ecosystems were classified, assessing the quality of natural areas through an aquatic lens required using surrogates or indicators that informed on important watershed processes and the ecological condition of those aquatic ecosystems. The GLCB methodology assigned numerical scores to a suite of indicators. The scores were assigned according to their ecological value to convey the relative ecological influence of a particular indicator. For example, roads were known to have a negative effect on ecological systems and thus scored low, while areas with a high percentage of natural cover were scored high. Also, scores were adjusted according to the relative importance of a particular criterion in relation to other criterion and was represented by a percentage of the overall score. For instance, the “ecological function” criteria represented 40% of the overall score of an ecological system, and “diversity” represented 2% of the overall score (Henson and Brodribb 2004; Henson et al 2005).

The indicators used in the GLCB assessment were carefully considered and discussed for their appropriateness for the WIP assessment. Some indicators for assessing ecological value and condition of aquatic ecosystems were similar to the terrestrial assessment, such as size of natural areas and the influence of roads. Other indicators were specific to aquatic ecosystems, such as aquatic invasive species and the influence of roads crossing rivers and streams. The end products were datasets that placed a numerical value on all of the natural areas within the area of interest. Table 1 presents the goals, criteria, objectives and indicators for the aquatic component of the Watershed Inventory Project. The WIP defined three specific goals that guided the production of the final products.

1. To categorize unique aquatic ecological systems across the landscape and identify systems that were not under existing protection;

2. To identify areas of high ecological importance for aquatic ecological systems; and

3. To identify the stresses upon aquatic ecological systems and processes.

Each goal consisted of a comprehensive list of criteria. Under each criterion, specific objectives were captured by using indicators.

Table 1: The goals of the Watershed Inventory Project: Aquatic Component and the Criteria, Objectives, and Indicators of these Goals.

Goal	Criterion	Objective	Indicator
Identify aquatic ecosystem units and protected areas	1. Representation	(a) Identify all aquatic ecosystem units within the watershed and their protection status	(i) Aquatic Ecological Units (from Aquatic Ecosystem Classification) (ii) Existing protected areas
Identify areas of high aquatic ecological importance	2. Ecological Function (40%)	(a) Identify natural areas that exhibit a high degree of integrity and resiliency	(i) Size of discrete Aquatic Ecological Units
		(b) Identify riparian areas	(i) Riparian areas of stream/rivers, inland lakes, and Great Lakes shoreline
		(c) Identify recharge areas	(i) Recharge Areas (Highly permeable areas)
	3. Diversity (2%)	(a) Identify habitat diversity	(i) Diversity of Aquatic Ecological Units
	4. Special Features (20%)	(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 aquatic ecosystems and processes	5. Condition (38%)	(a) Identify condition/quality of watershed	(i) Invasive species (ii) Indicator species (iii) Road and railway crossings (iv) Influence of roads (v) Percentage natural cover (vi) Influence of settled areas (vii) Water quality (viii) Influence of pits and quarries (ix) Influence of railways (x) Influence of open cleared areas (such as agricultural lands and golf courses) (xi) Influence of trails (xii) Influence of dams

GIS Analysis Results and Maps

A Geographical Information System (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, for example, roads or lakes, along with their attributes, such as road names or area measurements. As more and more data are collected digitally worldwide, GIS provides the ability to store, maintain, retrieve, update, and display large amounts of information.

GIS relates different datasets and has the ability to define relationships, such as finding the percentage of roads within a defined proximity of a major lake. Many organizations now use GIS in their applications, including land-use planning, natural resource management, real estate, and emergency planning.

For the WIP-A, data were collected from a variety of sources. The Ontario Ministry of Natural Resources provided most data on landscape features. Other data were more specific to the Muskoka River watershed, such as wetland data from Ducks Unlimited Canada, forestry data from Westwind Forest Stewardship, Bancroft and Parry Sound MNR Districts, and Algonquin Provincial Park. Additional protected areas datasets were obtained from The District Municipality of Muskoka, Muskoka Heritage Foundation, Nature Conservancy of Canada, and Georgian Bay Land Trust. The Ministry of Northern Development and Mines provided quaternary and surficial geological information.

The following are the final summary results and maps for the Muskoka Watershed Inventory Project. For more detailed information on technical methodology and scientific justification of criteria, objectives and indicators, please refer to the Muskoka Watershed Inventory Project Technical Report (Tran 2009).

Goals of the Muskoka Watershed Inventory Project

Goal 1: Identify aquatic ecosystems and protected areas.

Three different categories of aquatic ecosystems were identified: lake systems, stream systems, and wetland systems. Each category of aquatic ecosystem was then further defined by a set of specific criteria developed by the technical team associated with the Great Lakes Conservation Blueprint and further refined for use in Muskoka by the technical coordinating committee with the assistance of several local experts.

LAKE SYSTEMS

The significance of lake ecosystems is apparent to the residents and visitors of the Muskoka region. Freshwater ecosystems are essential to the biodiversity and productivity of the watershed, as well as providing goods and services to humans. Table 2 identifies the criteria used to define lake ecosystem types.

Table 2: Categories and Classification Scheme for Creating Lake Aquatic Ecosystems.

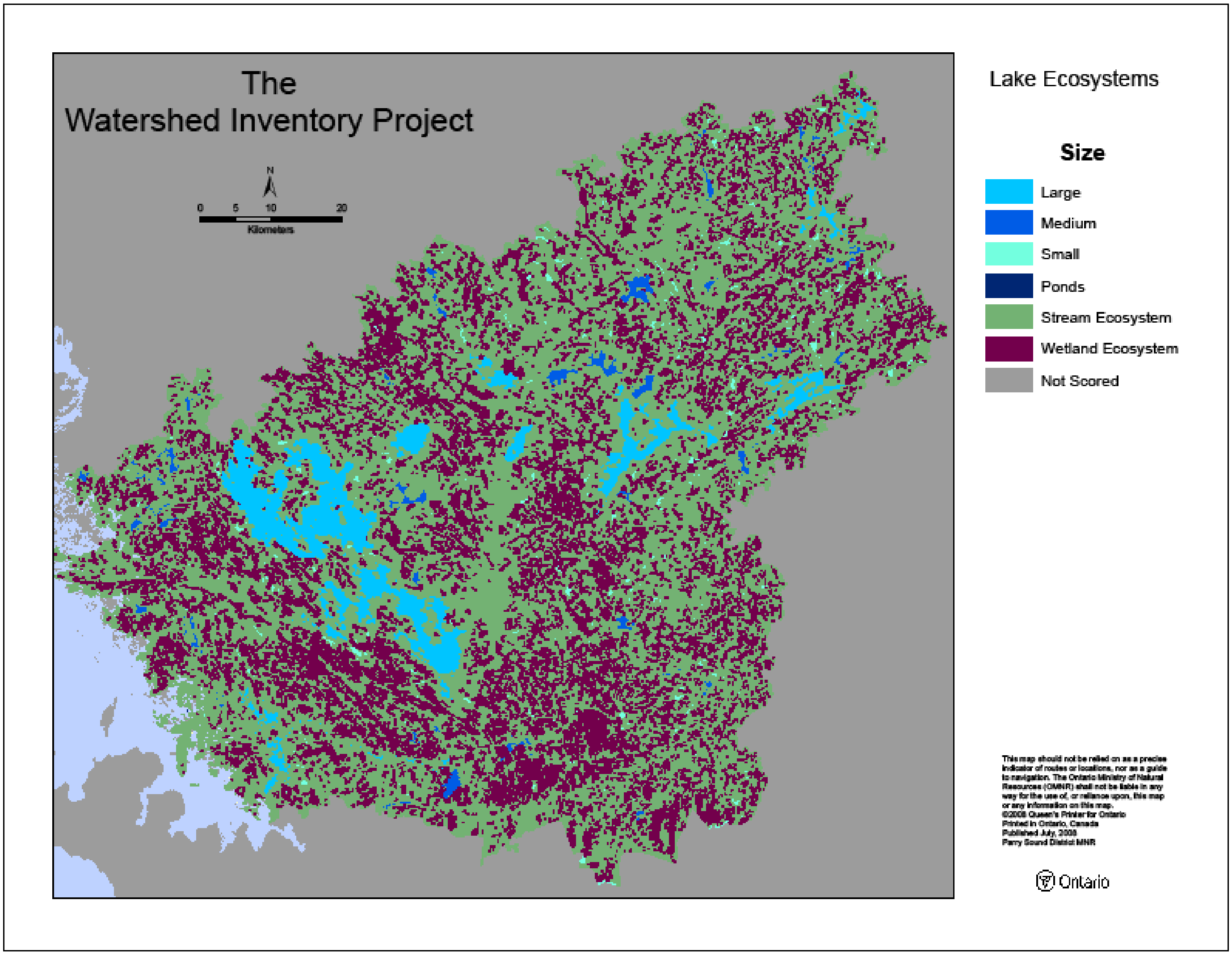
Category	Class	Interval
Size	Pond	8 ha or less
	Small	8 ha to 200 ha
	Medium	200 ha to 1,000 ha
	Large	Greater than 1,000 ha
Permeability	High Permeability	>2.34
	Medium Permeability	>1.67 to <2.34
	Low Permeability	<1.67
Depth/Thermal regime	Warm Water	<4 m
	Cool Water	4 m to 9 m
	Cold Water	>9 m
	Unknown Thermal	
Glacial Relict species	Algonquin Highland	>350 m above sea level
	Georgian Bay Fringe	<350 m above sea level

Although there are 96 potential combinations of lake ecosystems in the watershed, 38 lake ecosystems are actually present.

Size

Size (as defined in Table 2 and illustrated in Figure 7) and the connections between lake systems were related to specific habitat functions (Bendel and McNicol 1982…From Wichert et al 2004). Size of lakes was also associated with water chemistry, resilience to perturbations and species communities (Quinlan et al 2003…from Wichert et al 2004).

Figure 7: Size classifier for defining Lake Ecosystems



Geological Permeability

Surficial geology represented the complexity of drainage for lake systems, identified movement, and the holding capacity for water. Permeability associated with surficial geology information also contributed to the exchange processes between surface water and ground water (Wichert et al 2004). Similar to the stream ecosystem classification, surficial geology information was used to categorize lakes into permeability classes.

Figure 8: Geological Permeability classifier for Lake Ecosystems

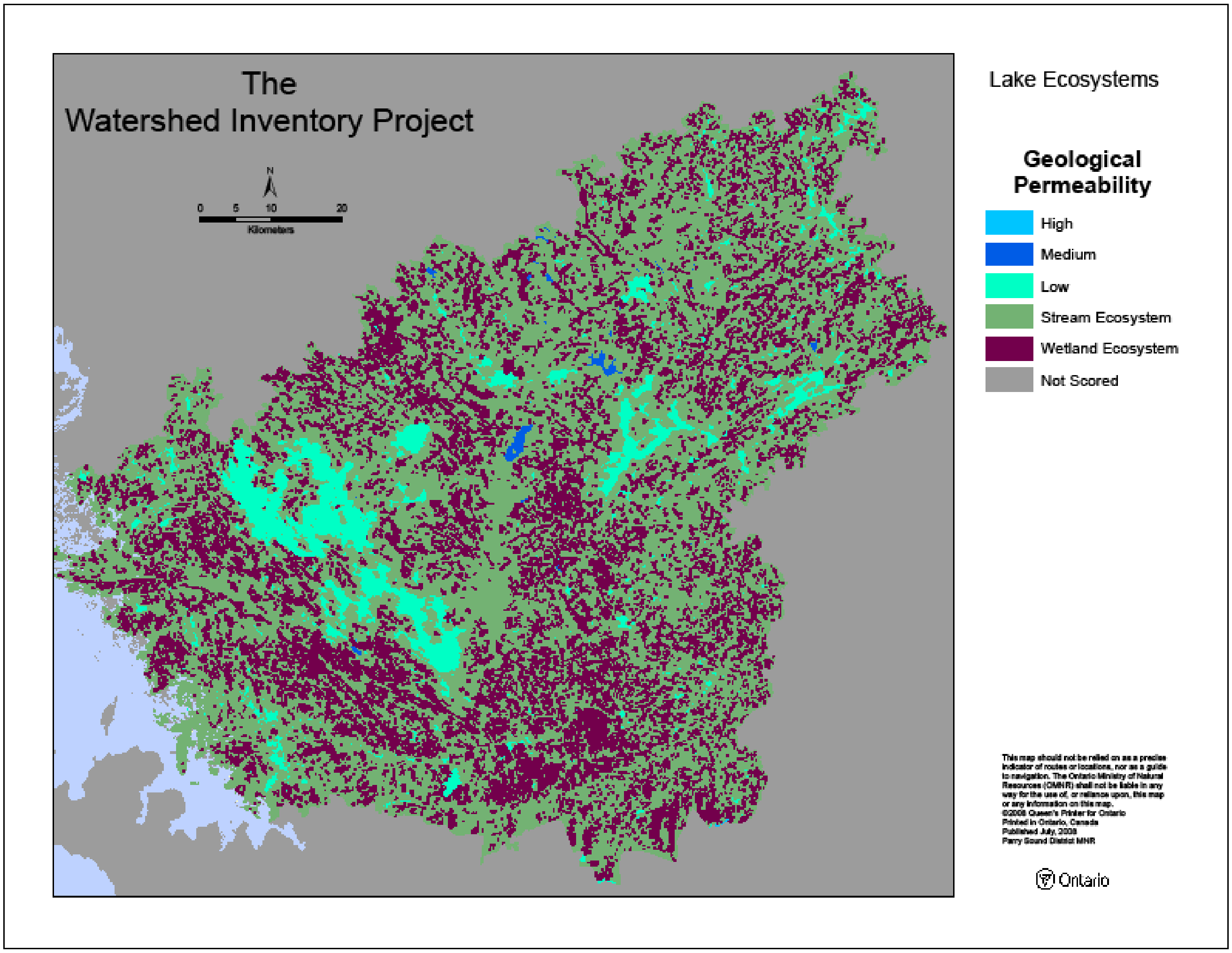
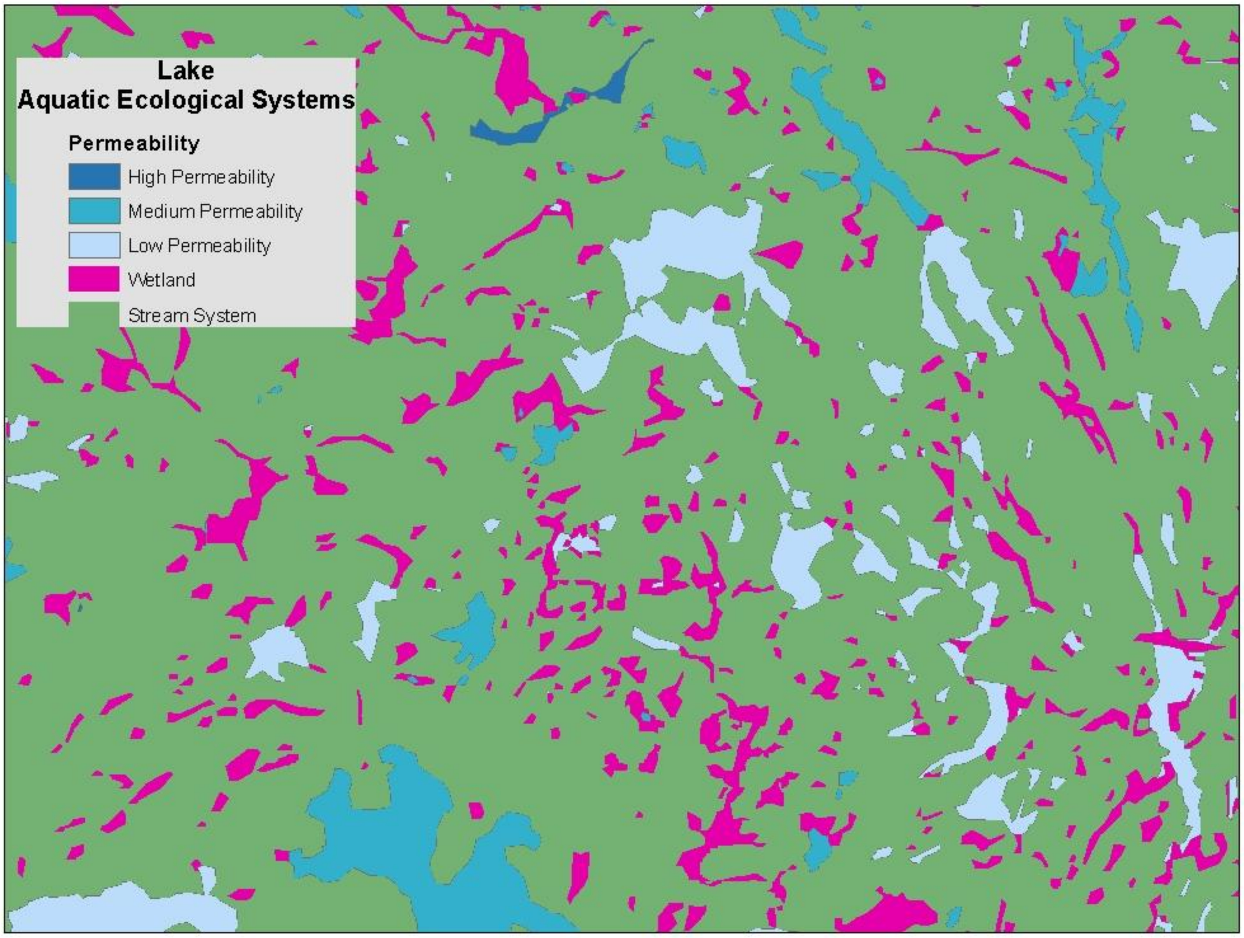


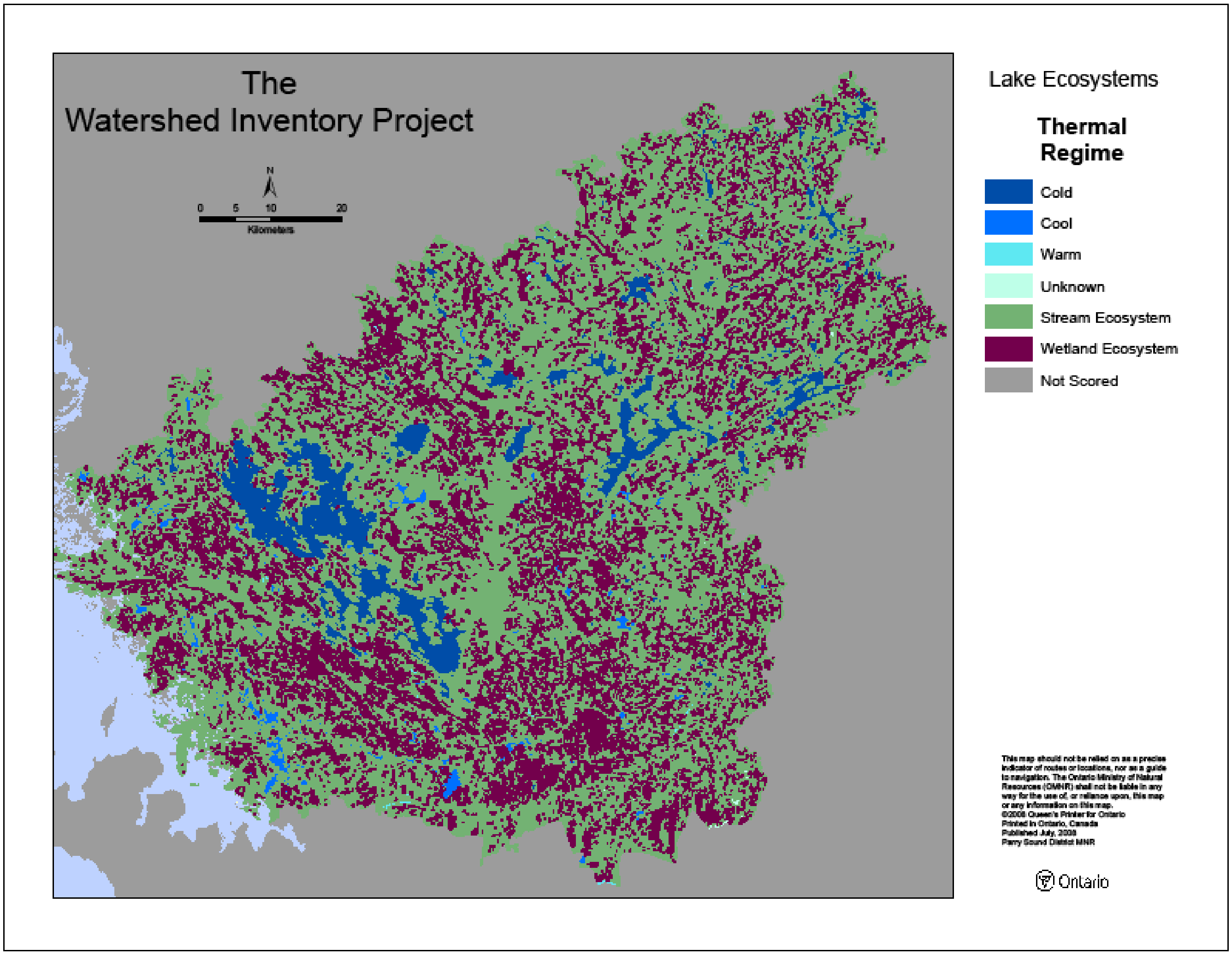
Figure 9: Detailed view of Geological Permeability



Water Thermal Regime

The GLCB aquatic classification method recognized that a key variable for lake classification was depth or thermal regime, which at the time of the GLCB aquatic ecosystem development was only available for a relatively small number of lakes. The Muskoka region did have thermal regime information for many of the lakes within the area of interest and thus it was used for the WIP-A classification.

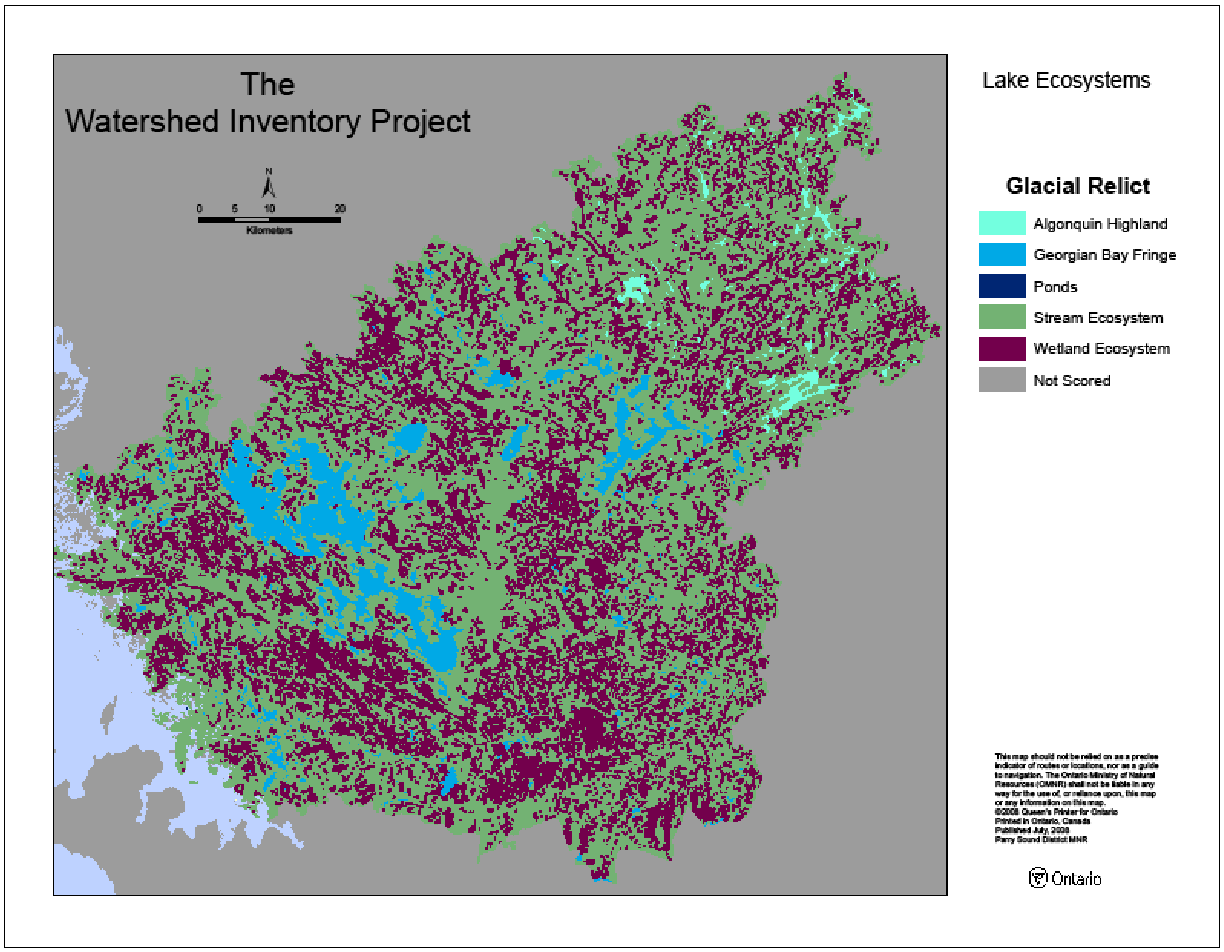
Figure 10: Water Thermal Regime classifier for Lake Ecosystems



Glacial Relict Species

As a result of discussions with local and provincial experts in the field of aquatic sciences from all levels of government and non-government agencies and academia, an additional category was used to classify the lakes in the area of interest: the presence of glacial relict species. In relatively recent glacial history, the study area was partly covered by Glacial Lake Algonquin, a proglacial lake, creating two separate physiographic regions: the Georgian Bay Fringe and the Algonquin Highlands (Bajc 1991). The Georgian Bay Fringe was inundated with water, while the Algonquin Highlands stood above the level of the lake and was unaffected by glacial lake processes. As well, the Georgian Bay Fringe was populated with glacial lake species that were not able to move further upstream as a result of the glacial barrier. Many of the present day lakes may still contain relict glacial species, including samples found in Harp Lake (east of Huntsville) during studies in 1993 (Wichert et al 2004; N. Yan personal communication). The glacial relict category was classified by separating the area of interest by elevation to capture the area inundated by the glacial lake. The elevation of 350 m was used as the demarcation line interpreted from the literature (Bajc 1991). Ponds were not classified using glacial relict species because it was likely that ponds did not support or contain relict species.

Figure 11: Glacial Relict classifier for Lake Ecosystems



STREAM SYSTEMS

There are over 6,000 km of rivers and streams in the study area. Stream information was taken from stream network data produced from the Water Resources Information Project (WRIP) (MNR 2002). In the past, research on lotic systems has focused on the stream or river exclusively. There are complex interactions between aquatic systems and the areas beyond the riparian zone. Thus, stream ecosystems included the stream itself as well as its drainage area, consequently capturing the entire area of interest. Table 3 identifies the criteria used to define stream ecosystem types.

Table 3: Categories and Classification Scheme for Creating Stream Aquatic Ecosystems.

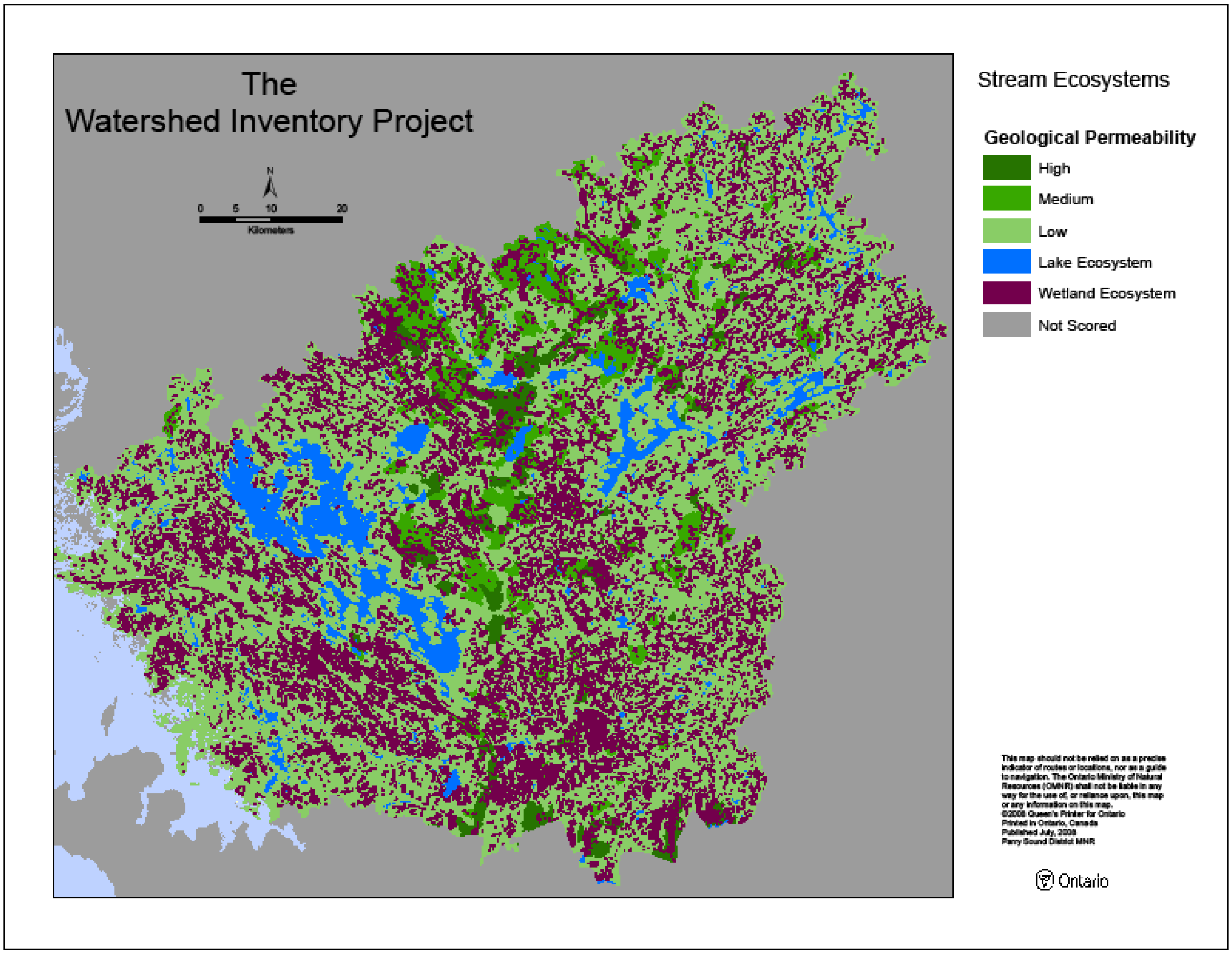
Category	Class	Interval
Permeability	High Permeability	>2.34
	Medium Permeability	>1.67 to <=2.34
	Low Permeability	<=1.67
Gradient	Flat	<=0.20%
	Gentle	>0.20 to <=2.0%
	Steep	>2.0%
Water storage potential: lake and wetland area in catchment	High Storage	>10% of catchment
	Low Storage	<=10% of catchment
Watershed position	Headwater	<=100 upstream 1st order streams
	Middle	>100-1,000 upstream 1st order streams
	Main stem	>1,000 upstream 1st order streams

There are potentially 54 stream ecosystems based on this classification system of which 53 distinct stream ecosystems are actually found in the study area.

Geological Permeability

Permeability allowed classification to take into account streams in a geological context (the enduring, landform features). Geological information provided an indication of the contribution of precipitation to the groundwater or surface water components of the hydrological cycle including control of nutrient fluxes between uplands and the aquatic system and for upstream/downstream processes in lotic ecosystems, as well as exchange of oxygen (Wichert et al 2004).

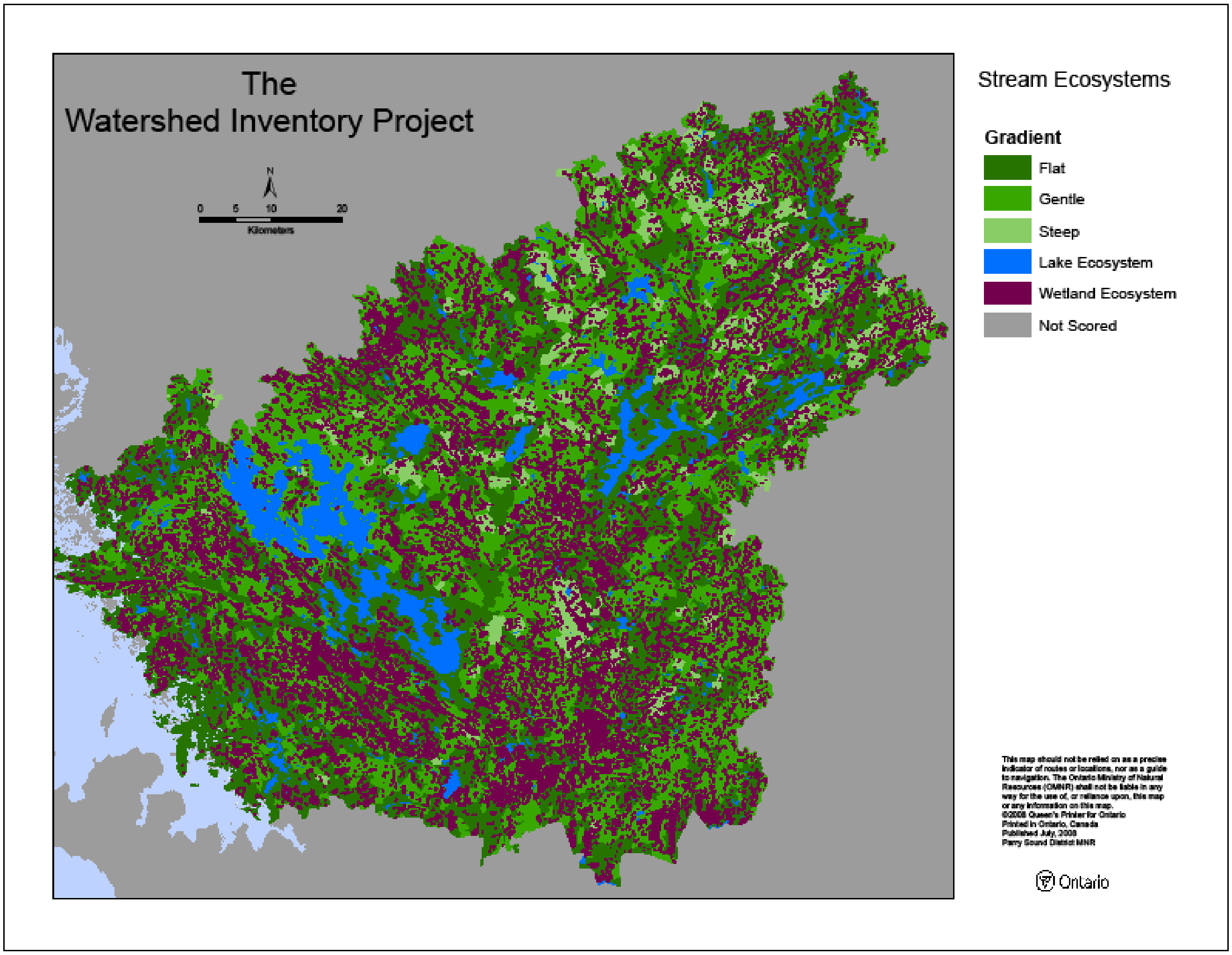
Figure 12: Geological Permeability classifier for defining Stream Ecosystems



Stream Gradient

Gradient was an important factor for stream ecosystems as a means of delivering oxygen and indicated the likely presence of pools and riffles, as well as substrate size and composition (Wichert et al 2004).

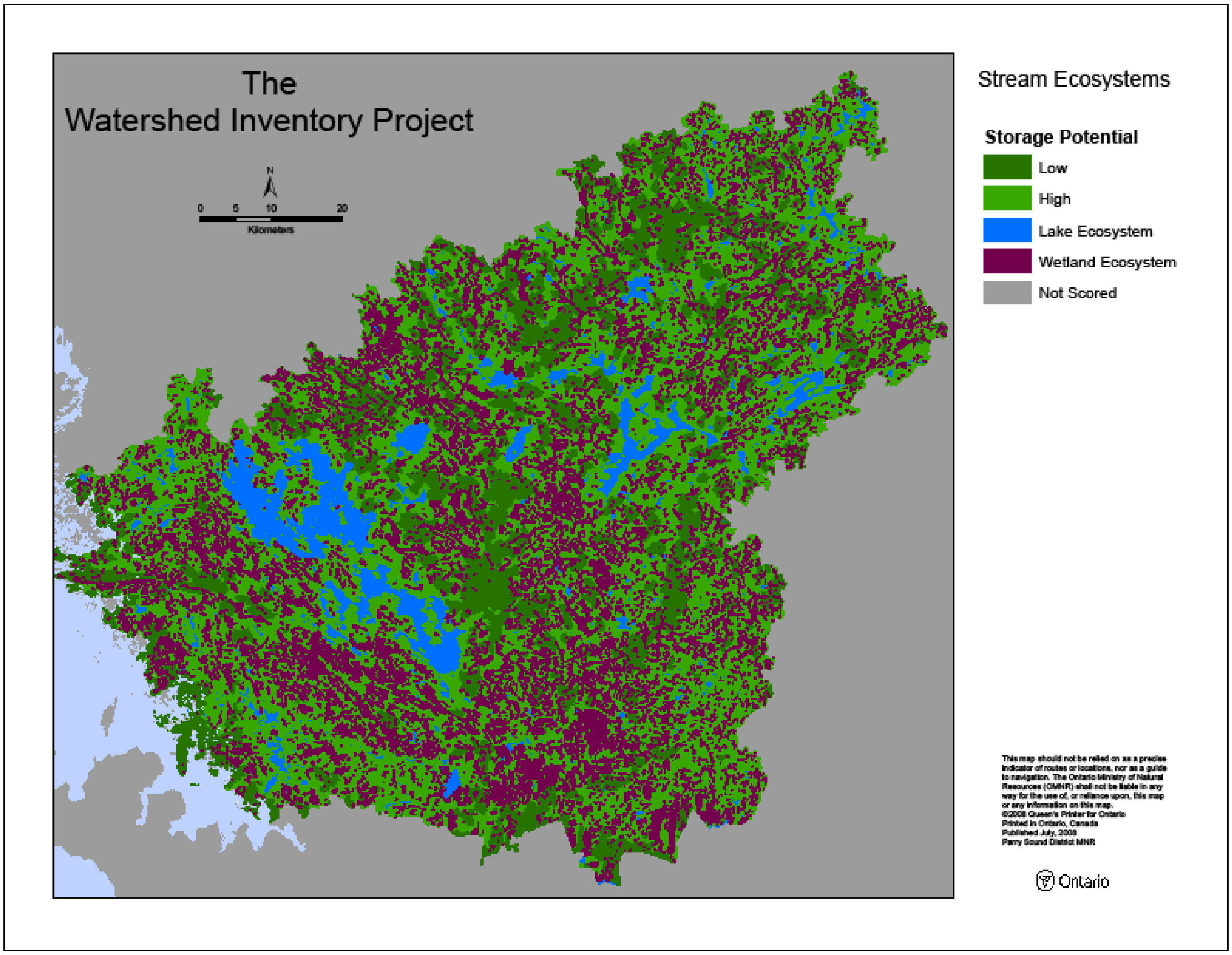
Figure 13: Gradient classifier for defining Stream Ecosystems



Water Storage Potential

A catchment’s natural capacity to store water was an important variable to consider when classifying ecosystems. A catchment’s storage potential safeguards against future low water conditions and provides a dependable source of clean and abundant water supply that was especially important considering recent climatic uncertainties.

Figure 14: Water Storage Potential classifier for defining Stream Ecosystems



Watershed Position

The position of streams within the greater watershed context was an important factor when classifying stream ecosystems. Headwater streams influence downstream supply, transport and fate of water and solutes in watersheds (Alexander et al 2007). In addition, the position of streams provides hydrological connectivity important to transferring energy across the landscape. Stream position also provides unique habitat requirements for residents and migrants that contribute to biological integrity of the entire river network.

Figure 15: Watershed Position classifier for defining Stream Ecosystems

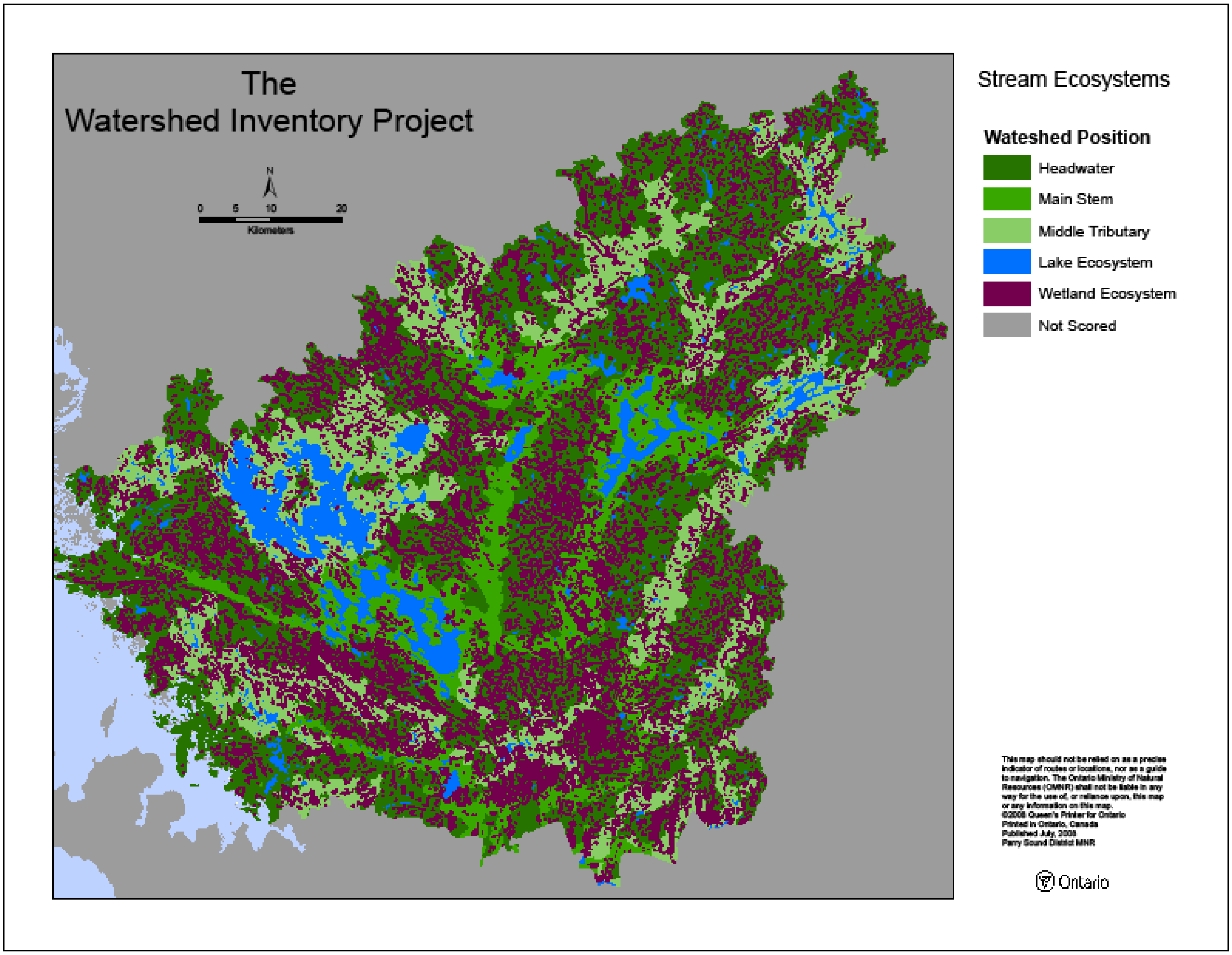
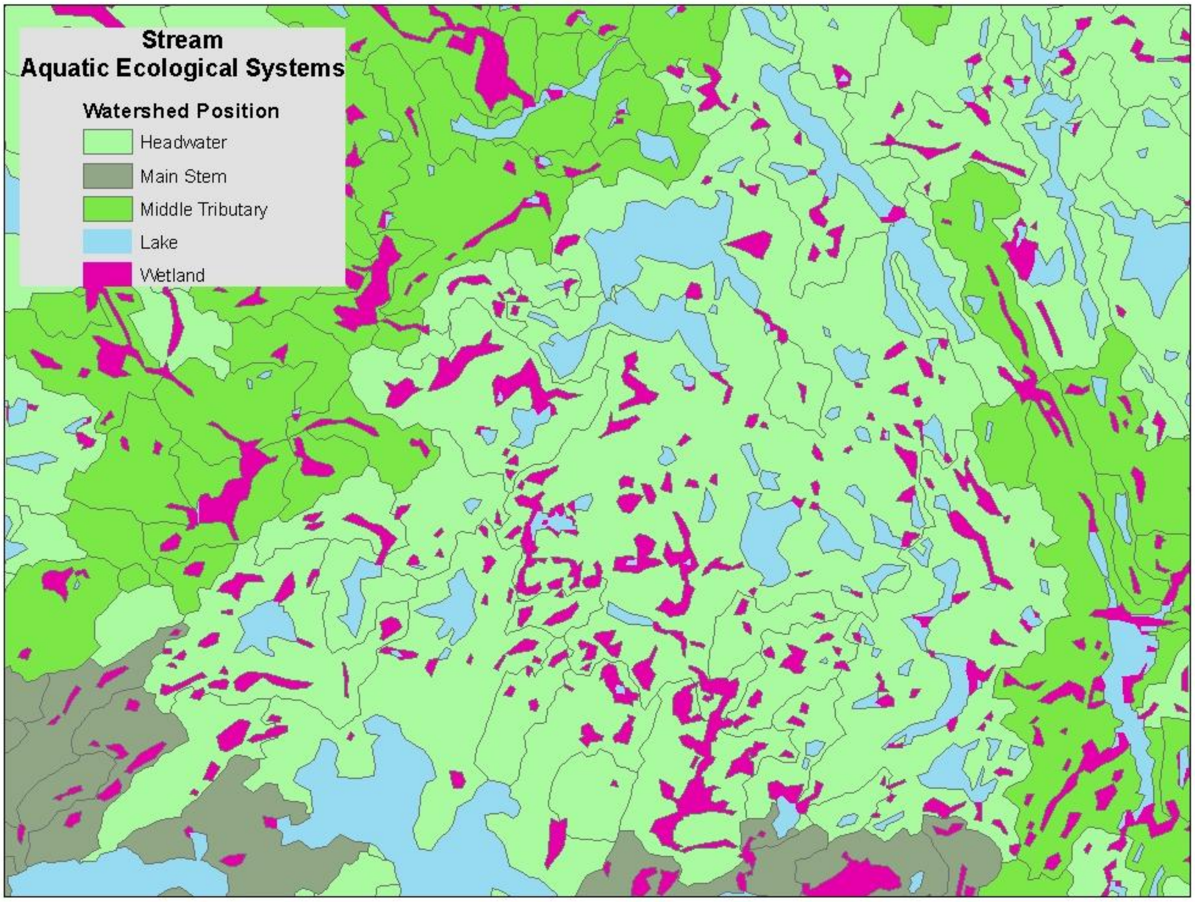


Figure 16: Detailed Watershed Position classifier



WETLAND SYSTEMS

Muskoka is fortunate to still benefit from a natural landscape that is dotted with wetlands. These wetlands have contributed greatly to the high water quality and quantity that provide the people and wildlife of the area with many benefits.

Wetlands are 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 water tolerant plants (MMAH 2005). Wetlands support a diversity of ecosystem functions that benefit both people and wildlife and are a crucial part of a functioning aquatic landscape. Table 4 identifies the criteria used to define wetland ecosystem types.

Table 4: Categories and Classification Scheme for Creating Wetland Aquatic Ecosystems.

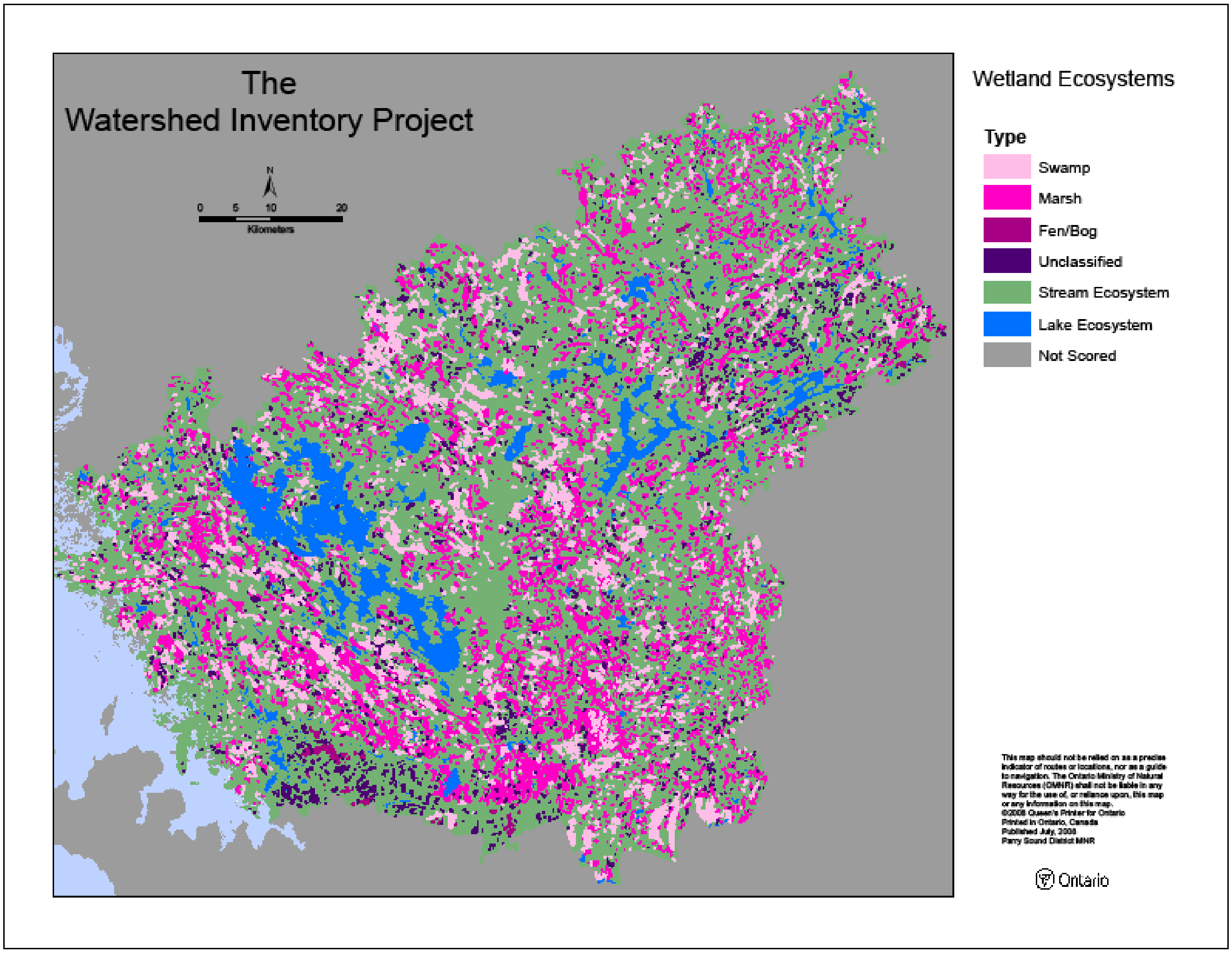
Category	Class	Interval
Type	Swamp	
	Marsh	
	Fen/Bog	
	Unclassified	
Size	Small	<=100 ha
	Large	>100 ha

There are potentially 8 wetland ecosystems based on this classification system of which 7 distinct wetland ecosystems can be found in the study area.

Type

The Ontario Wetland Evaluation System: Northern Manual classifies wetlands into four types – bog, fen, swamp and marsh. Each wetland polygon was identified as one of the four wetland types based on classifications labelled in datasets used during the WIP terrestrial component.

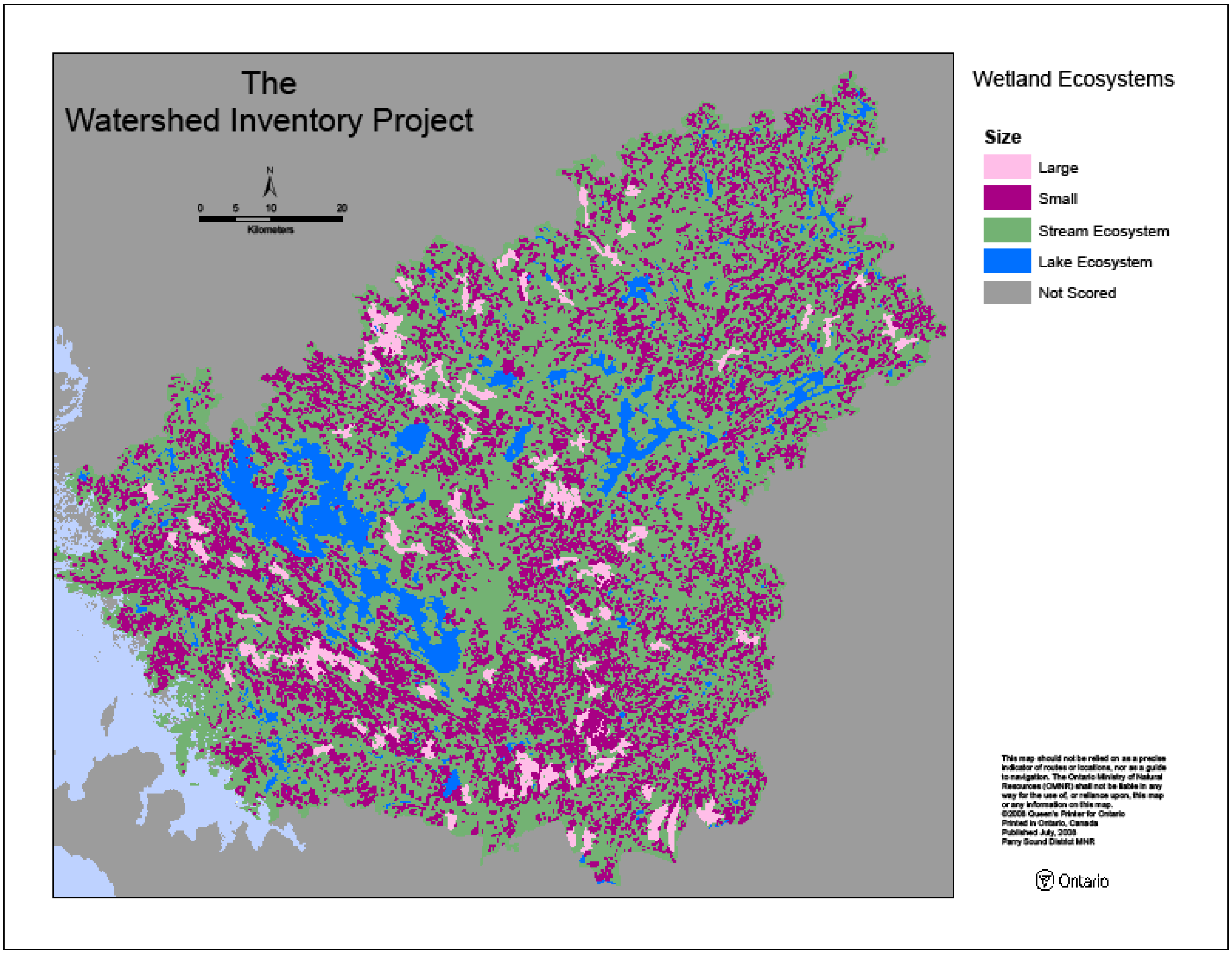
Figure 17: Type of Wetland classifier for defining Wetland Ecosystems



Size

The WIP-A sized all wetland types in the area of interest. Size range categories were based on observed wildlife uses on various sized wetlands. For example, large wetlands (greater than 100 ha) can support a variety of waterfowl, while smaller wetlands provide more limited habitat.

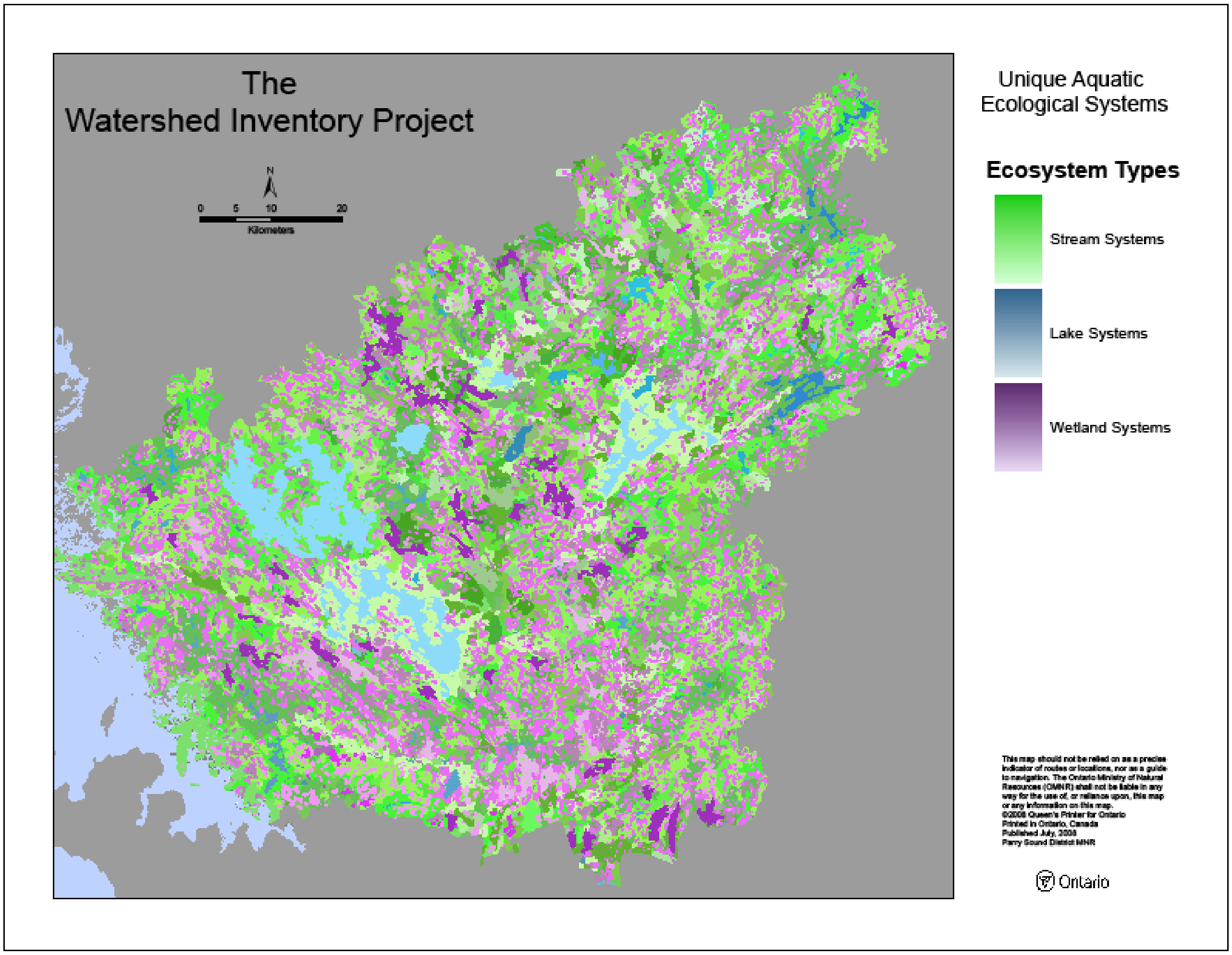
Figure 18: Size classifier for defining Wetland Ecosystems



UNIQUE AQUATIC ECOSYSTEMS

Figure 19 shows all the unique ecosystems within the study area. There are 38 lake systems which occupy approximately 13.2% of the landscape. The single largest lake ecosystem is the Georgian Bay Fringe, Cold Water, Low Permeability, Large. It represents 4.6% of the landscape. There are 53 stream ecosystems within the area of interest and occupy 75.6% of the landscape. The single largest stream ecosystem is Headwater, High Storage, Gentle, Low Permeability. It represents 21.4% of the landscape. There are 7 wetland ecosystems within the area of interest and they occupy about 11.2% of the landscape. The single largest wetland ecosystem is Marsh, Small representing about 4.6% of the landscape.

Figure 19: Unique Aquatic Ecological Systems within the Study Area



Unique Aquatic Ecosystems and Level of Protection

Table 5 identifies the existing level of protection for each ecosystem type. Some, like the Lake System: Algonquin Highland, Cold Water, Low Permeability, Large are well protected (53%) while others have little or no protection at all. Most protection appears to be through Crown land policy and it is important to note that little area is under Level 1 protection. Figure 20 illustrates the areas of protection by level.

Table 5: Unique Aquatic Ecosystems and their Representation in Protected Areas.

	Total Within Study Area	Percent of Study Area	Within Level 1 Protection	Within Level 2 Protection	Within Level 3 Protection	Proportion not within protection
Aquatic Ecological System	**Area (ha)**	**Percentage**				
Lake System: Algonquin Highland, Cold Water, High Permeability, Small	67	0.01%	0.3%	19.2%	0.0%	0.0%
Lake System: Algonquin Highland, Cold Water, Low Permeability, Large	5,834	0.8%	0.0%	52.3%	0.0%	3.0%
Lake System: Algonquin Highland, Cold Water, Low Permeability, Medium	3,502	0.5%	0.0%	37.0%	0.0%	1.4%
Lake System: Algonquin Highland, Cold Water, Low Permeability, Small	5,912	0.8%	0.0%	48.3%	0.0%	7.8%
Lake System: Algonquin Highland, Cold Water, Medium Permeability, Small	1,147	0.1%	0.1%	76.1%	0.0%	13.2%
Lake System: Algonquin Highland, Cool Water, Low Permeability, Small	537	0.1%	0.2%	81.2%	0.0%	2.5%
Lake System: Algonquin Highland, Cool Water, Medium Permeability, Small	33	0.004%	3.0%	96.8%	0.0%	3.2%
Lake System: Algonquin Highland, Unknown Thermal, High Permeability, Small	49	0.01%	0.4%	21.4%	0.0%	0.0%
Lake System: Algonquin Highland, Unknown Thermal, Low Permeability, Small	1,831	0.2%	0.0%	20.0%	0.0%	18.2%
Lake System: Algonquin Highland, Unknown Thermal, Medium Permeability, Small	84	0.01%	0.0%	0.0%	0.0%	66.6%
Lake System: Algonquin Highland, Warm Water, Low Permeability, Small	924	0.1%	0.1%	80.8%	0.0%	10.1%
Lake System: Algonquin Highland, Warm Water, Medium Permeability, Small	64	0.01%	1.5%	98.2%	0.0%	1.8%
Lake System: Georgian Bay Fringe, Cold Water, Low Permeability, Large	35,298	4.6%	0.0%	94.7%	0.01%	5.2%
Lake System: Georgian Bay Fringe, Cold Water, Low Permeability, Medium	4,036	0.5%	0.02%	88.2%	0.0%	11.8%
Lake System: Georgian Bay Fringe, Cold Water, Low Permeability, Small	3,815	0.5%	0.0%	76.7%	0.0%	14.6%
Lake System: Georgian Bay Fringe, Cold Water, Medium Permeability, Large	1,090	0.1%	0.1%	96.8%	0.0%	3.2%
Lake System: Georgian Bay Fringe, Cold Water, Medium Permeability, Medium	1,082	0.1%	0.1%	93.9%	0.0%	6.1%
Lake System: Georgian Bay Fringe, Cold Water, Medium Permeability, Small	588	0.1%	0.1%	50.4%	0.0%	37.0%
Lake System: Georgian Bay Fringe, Cool Water, High Permeability, Small	29	0.004%	0.0%	0.0%	0.0%	100.0%

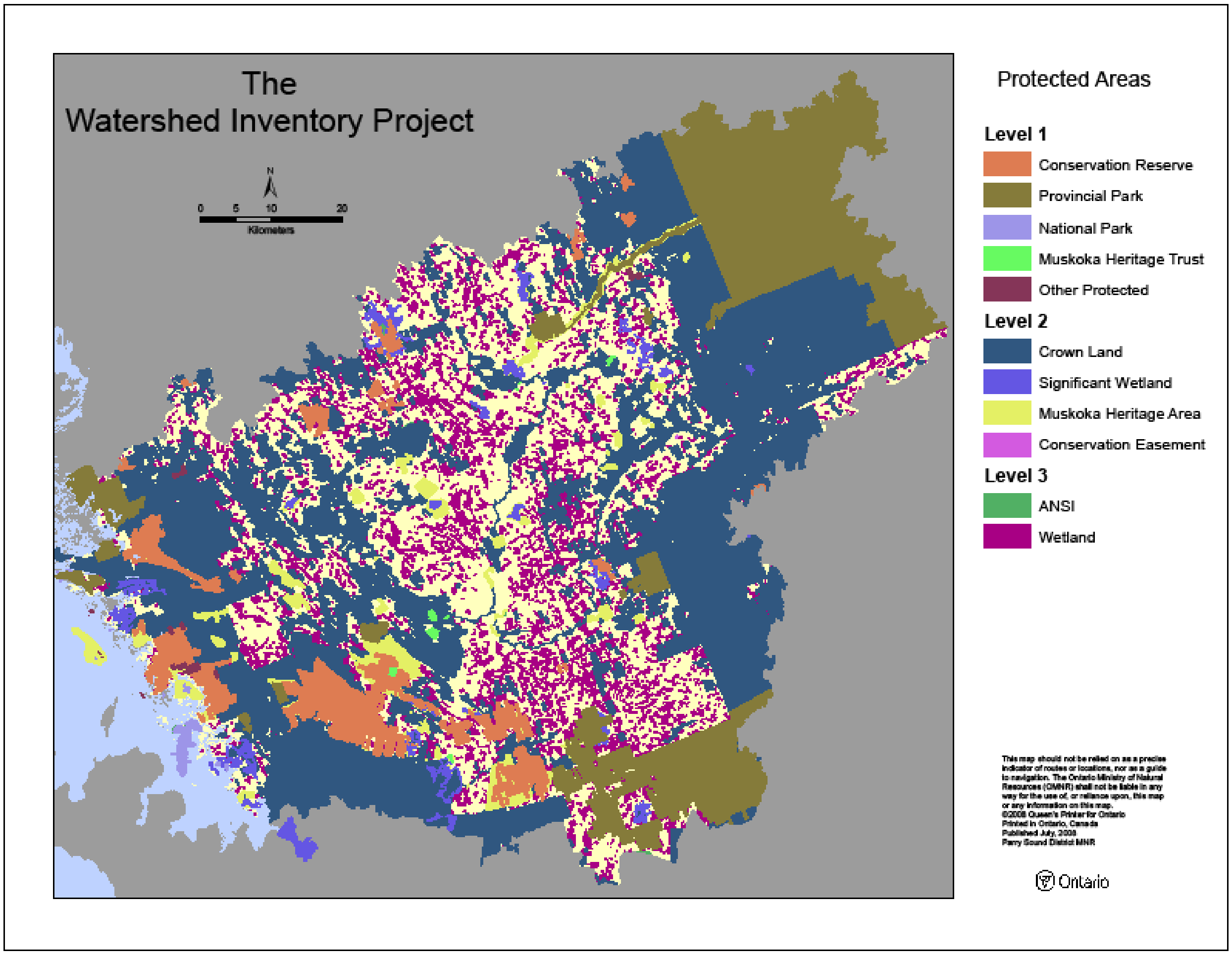
	Total Within Study Area	Percent of Study Area	Within Level 1 Protection	Within Level 2 Protection	Within Level 3 Protection	Proportion not within protection
Aquatic Ecological System	**Area (ha)**	**Percentage**				
Lake System: Georgian Bay Fringe, Cool Water, Low Permeability, Large	4,608	0.6%	0.0%	93.7%	0.1%	5.1%
Lake System: Georgian Bay Fringe, Cool Water, Low Permeability, Medium	7,316	1.0%	0.0%	81.3%	0.0%	12.4%
Lake System: Georgian Bay Fringe, Cool Water, Low Permeability, Small	7,862	1.0%	0.0%	59.3%	0.001%	26.3%
Lake System: Georgian Bay Fringe, Cool Water, Medium Permeability, Small	276	0.04%	0.2%	57.5%	0.0%	42.5%
Lake System: Georgian Bay Fringe, Unknown Thermal, High Permeability, Small	241	0.03%	0.2%	50.2%	0.0%	7.0%
Lake System: Georgian Bay Fringe, Unknown Thermal, Low Permeability, Small	3,443	0.4%	0.0%	44.0%	0.0%	29.7%
Lake System: Georgian Bay Fringe, Unknown Thermal, Medium Permeability, Small	130	0.02%	0.2%	21.1%	0.0%	70.3%
Lake System: Georgian Bay Fringe, Warm Water, High Permeability, Small	65	0.01%	1.1%	70.0%	0.0%	30.0%
Lake System: Georgian Bay Fringe, Warm Water, Low Permeability, Medium	268	0.03%	0.4%	100.0%	0.0%	0.0%
Lake System: Georgian Bay Fringe, Warm Water, Low Permeability, Small	3,076	0.4%	0.0%	58.7%	0.0%	30.4%
Lake System: Georgian Bay Fringe, Warm Water, Medium Permeability, Small	145	0.02%	0.4%	63.4%	0.0%	36.6%
Lake System: Pond, Cold Water, Low Permeability	375	0.05%	0.2%	57.5%	0.0%	27.1%
Lake System: Pond, Cold Water, Medium Permeability	62	0.01%	0.8%	47.9%	0.0%	52.1%
Lake System: Pond, Cool Water, High Permeability	31	0.004%	1.3%	40.4%	0.0%	59.6%
Lake System: Pond, Cool Water, Low Permeability	1,536	0.2%	0.0%	47.9%	0.0%	20.2%
Lake System: Pond, Cool Water, Medium Permeability	27	0.004%	2.7%	73.4%	0.0%	20.6%
Lake System: Pond, Warm Water, High Permeability	273	0.04%	0.1%	29.4%	0.0%	30.6%
Lake System: Pond, Warm Water, Low Permeability	5,813	0.8%	0.0%	42.3%	0.0%	25.0%
Lake System: Pond, Warm Water, Medium Permeability	319	0.04%	0.1%	32.1%	0.0%	48.0%
Stream System: Headwater, High Storage, Flat, High Permeability	3,152	0.4%	0.0%	13.6%	0.0%	64.7%
Stream System: Headwater, High Storage, Flat, Low Permeability	91,905	12.0%	0.0%	39.7%	0.003%	37.8%
Stream System: Headwater, High Storage, Flat, Medium Permeability	9,084	1.2%	0.0%	25.0%	0.0%	64.6%
Stream System: Headwater, High Storage, Gentle, High Permeability	5,730	0.7%	0.0%	22.9%	0.0%	67.3%

	Total Within Study Area	Percent of Study Area	Within Level 1 Protection	Within Level 2 Protection	Within Level 3 Protection	Proportion not within protection
Aquatic Ecological System	**Area (ha)**	**Percentage**				
Stream System: Headwater, High Storage, Gentle, Low Permeability	164,468	21.4%	0.0%	36.6%	0.1%	40.8%
Stream System: Headwater, High Storage, Gentle, Medium Permeability	14,621	1.9%	0.0%	14.1%	0.5%	77.8%
Stream System: Headwater, High Storage, Steep, High Permeability	1,655	0.2%	0.0%	0.03%	0.0%	83.0%
Stream System: Headwater, High Storage, Steep, Low Permeability	15,898	2.1%	0.0%	30.4%	0.0%	31.2%
Stream System: Headwater, High Storage, Steep, Medium Permeability	2,866	0.4%	0.0%	32.4%	0.0%	57.6%
Stream System: Headwater, Low Storage, Flat, High Permeability	618	0.1%	0.1%	74.4%	0.0%	25.6%
Stream System: Headwater, Low Storage, Flat, Low Permeability	22,035	2.9%	0.0%	37.9%	0.1%	38.9%
Stream System: Headwater, Low Storage, Flat, Medium Permeability	2,210	0.3%	0.0%	27.8%	0.0%	66.9%
Stream System: Headwater, Low Storage, Gentle, High Permeability	2,737	0.4%	0.0%	40.0%	0.0%	60.0%
Stream System: Headwater, Low Storage, Gentle, Low Permeability	28,122	3.7%	0.0%	34.6%	0.05%	50.6%
Stream System: Headwater, Low Storage, Gentle, Medium Permeability	5,821	0.8%	0.0%	11.7%	0.0%	86.4%
Stream System: Headwater, Low Storage, Steep, High Permeability	1,119	0.1%	0.0%	1.8%	0.1%	78.0%
Stream System: Headwater, Low Storage, Steep, Low Permeability	7,219	0.9%	0.0%	45.4%	0.0%	33.2%
Stream System: Headwater, Low Storage, Steep, Medium Permeability	1,116	0.1%	0.0%	24.9%	0.0%	75.1%
Stream System: Main Stem, High Storage, Flat, High Permeability	1,868	0.2%	0.0%	42.2%	0.0%	57.8%
Stream System: Main Stem, High Storage, Flat, Low Permeability	38,410	5.0%	0.0%	15.5%	0.1%	79.5%
Stream System: Main Stem, High Storage, Flat, Medium Permeability	1,239	0.2%	0.0%	1.6%	0.0%	98.4%
Stream System: Main Stem, High Storage, Gentle, High Permeability	1,047	0.1%	0.0%	5.4%	0.0%	94.6%
Stream System: Main Stem, High Storage, Gentle, Low Permeability	5,084	0.7%	0.0%	16.3%	0.0%	80.1%
Stream System: Main Stem, High Storage, Gentle, Medium Permeability	1,018	0.1%	0.0%	12.2%	0.0%	87.8%
Stream System: Main Stem, High Storage, Steep, High Permeability	116	0.02%	0.0%	0.001%	0.0%	100.0%
Stream System: Main Stem, High Storage, Steep, Low Permeability	3,028	0.4%	0.0%	3.3%	0.0%	96.7%
Stream System: Main Stem, High Storage, Steep, Medium Permeability	394	0.1%	0.0%	5.2%	0.0%	94.8%
Stream System: Main Stem, Low Storage, Flat, High Permeability	1,294	0.2%	0.0%	8.6%	0.0%	91.4%
Stream System: Main Stem, Low Storage, Flat, Low Permeability	10,086	1.3%	0.0%	17.9%	0.2%	71.8%
Stream System: Main Stem, Low Storage, Flat, Medium Permeability	2,286	0.3%	0.0%	6.8%	0.0%	93.2%
Stream System: Main Stem, Low Storage, Gentle, High Permeability	1,327	0.2%	0.0%	5.5%	0.0%	94.4%
Stream System: Main Stem, Low Storage, Gentle, Low Permeability	2,566	0.3%	0.0%	11.8%	0.0%	85.4%
Stream System: Main Stem, Low Storage, Gentle, Medium Permeability	1,010	0.1%	0.0%	16.7%	0.0%	82.5%
Stream System: Main Stem, Low Storage, Steep, High Permeability	1,615	0.2%	0.0%	6.1%	0.0%	93.9%

	Total Within Study Area	Percent of Study Area	Within Level 1 Protection	Within Level 2 Protection	Within Level 3 Protection	Proportion not within protection
Aquatic Ecological System	**Area (ha)**	**Percentage**				
Stream System: Main Stem, Low Storage, Steep, Low Permeability	567	0.1%	0.0%	0.4%	0.0%	99.6%
Stream System: Middle Tributary, High Storage, Flat, High Permeability	1,863	0.2%	0.0%	23.5%	0.0%	42.6%
Stream System: Middle Tributary, High Storage, Flat, Low Permeability	53,479	7.0%	0.0%	36.3%	0.03%	34.3%
Stream System: Middle Tributary, High Storage, Flat, Medium Permeability	4,932	0.6%	0.0%	23.5%	0.0%	74.9%
Stream System: Middle Tributary, High Storage, Gentle, High Permeability	217	0.03%	0.2%	41.9%	0.0%	33.8%
Stream System: Middle Tributary, High Storage, Gentle, Low Permeability	34,342	4.5%	0.0%	23.9%	0.0%	62.1%
Stream System: Middle Tributary, High Storage, Gentle, Medium Permeability	2,362	0.3%	0.0%	34.1%	0.0%	58.6%
Stream System: Middle Tributary, High Storage, Steep, High Permeability	150	0.02%	0.1%	10.5%	0.0%	89.5%
Stream System: Middle Tributary, High Storage, Steep, Low Permeability	1,098	0.1%	0.0%	18.8%	0.0%	71.8%
Stream System: Middle Tributary, High Storage, Steep, Medium Permeability	460	0.1%	0.1%	68.3%	0.0%	31.7%
Stream System: Middle Tributary, Low Storage, Flat, High Permeability	1,182	0.2%	0.0%	8.6%	0.0%	70.6%
Stream System: Middle Tributary, Low Storage, Flat, Low Permeability	8,849	1.2%	0.0%	36.2%	0.0%	46.9%
Stream System: Middle Tributary, Low Storage, Flat, Medium Permeability	3,800	0.5%	0.0%	46.4%	0.0%	50.0%
Stream System: Middle Tributary, Low Storage, Gentle, High Permeability	958	0.1%	0.0%	34.7%	0.0%	64.4%
Stream System: Middle Tributary, Low Storage, Gentle, Low Permeability	10,018	1.3%	0.0%	37.3%	0.0%	55.8%
Stream System: Middle Tributary, Low Storage, Gentle, Medium Permeability	2,256	0.3%	0.0%	27.0%	0.0%	65.9%
Stream System: Middle Tributary, Low Storage, Steep, High Permeability	228	0.03%	0.1%	19.0%	0.0%	80.5%
Stream System: Middle Tributary, Low Storage, Steep, Low Permeability	1,253	0.2%	0.0%	29.9%	0.0%	43.8%
Stream System: Middle Tributary, Low Storage, Steep, Medium Permeability	233	0.03%	0.0%	2.5%	0.0%	97.5%
Wetland System: Fen/Bog, Large	142	0.02%	0.7%	100.0%	0.0%	0.0%
Wetland System: Fen/Bog, Small	2,418	0.3%	0.0%	58.2%	25.04%	0.0%
Wetland System: Marsh, Large	7,847	1.0%	0.0%	36.6%	33.5%	0.0%
Wetland System: Marsh, Small	35,382	4.6%	0.0%	31.6%	45.9%	0.0%
Wetland System: Swamp, Large	10,377	1.3%	0.0%	32.6%	51.16%	0.0%

	Total Within Study Area	Percent of Study Area	Within Level 1 Protection	Within Level 2 Protection	Within Level 3 Protection	Proportion not within protection
Aquatic Ecological System	**Area (ha)**	**Percentage**				
Wetland System: Swamp, Small	21,908	2.8%	0.0%	36.2%	42.0%	0.0%
Wetland System: Unclassified, Small	7,865	1.0%	0.0%	46.2%	39.0%	0.0%
Total:	**768,739**	**100%**	**0.00005%**	**37.7%**	**4.86%**	**39.2%**

Figure 20: All levels of protected areas



Goal 2: Identify areas of high potential for sustaining ecological processes.

The second goal was to identify areas of high ecological importance. Based on the most current ecological principles and concepts, as well as local expertise, 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 WIP study area 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, regardless of the land uses within the buffer that might impair these processes.

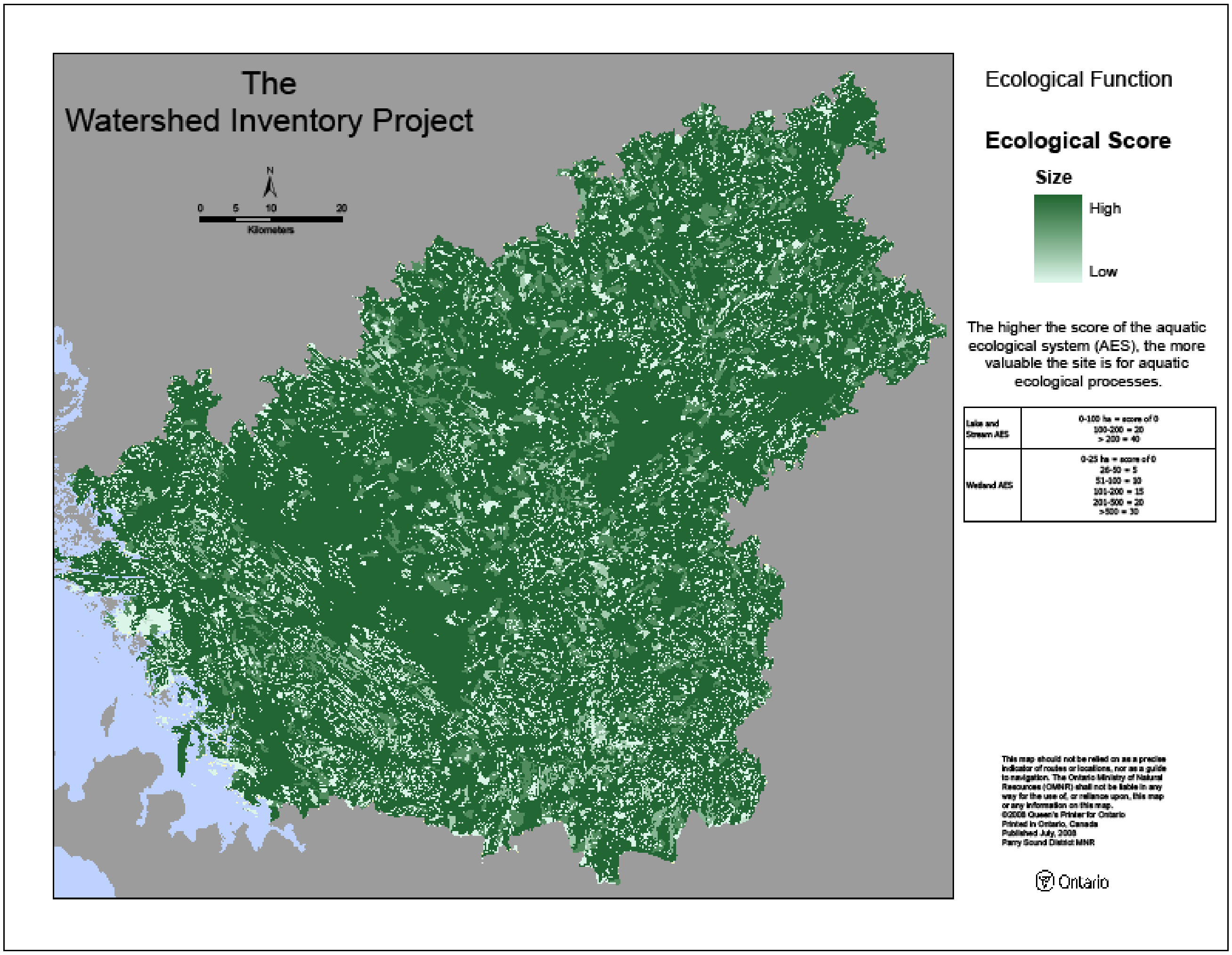
ECOLOGICAL FUNCTION

The ecological function criterion assessed the biotic and abiotic components involved with maintaining ecological and evolutionary processes related to aquatic ecosystems. The ecological function criterion was weighted heavily compared to the other criteria to capture the important characteristics that ensure a functioning aquatic landscape. The WIP-A weighted Ecological Function criterion at 40% of the total score based on the GLCB framework.

Size of discrete aquatic ecological units (Figure 21)

The size of natural areas was an important indicator of the sustainability of natural areas. Although aquatic ecosystems are diverse in size and communities have evolved to survive in the unique niches they provide, larger systems have more capacity to buffer against changes or disturbances such as development and climatic factors in the surrounding landscape and airscape. Large systems also have a greater ability to handle recreational pressures (fishing) and are therefore more valuable. Larger wetlands tend to sustain more biodiversity than smaller wetlands (Wichert et al 2005). Loss of large unique areas changes the ability of aquatic ecosystems to maintain a functioning aquatic landscape (Chambers et al 1999).

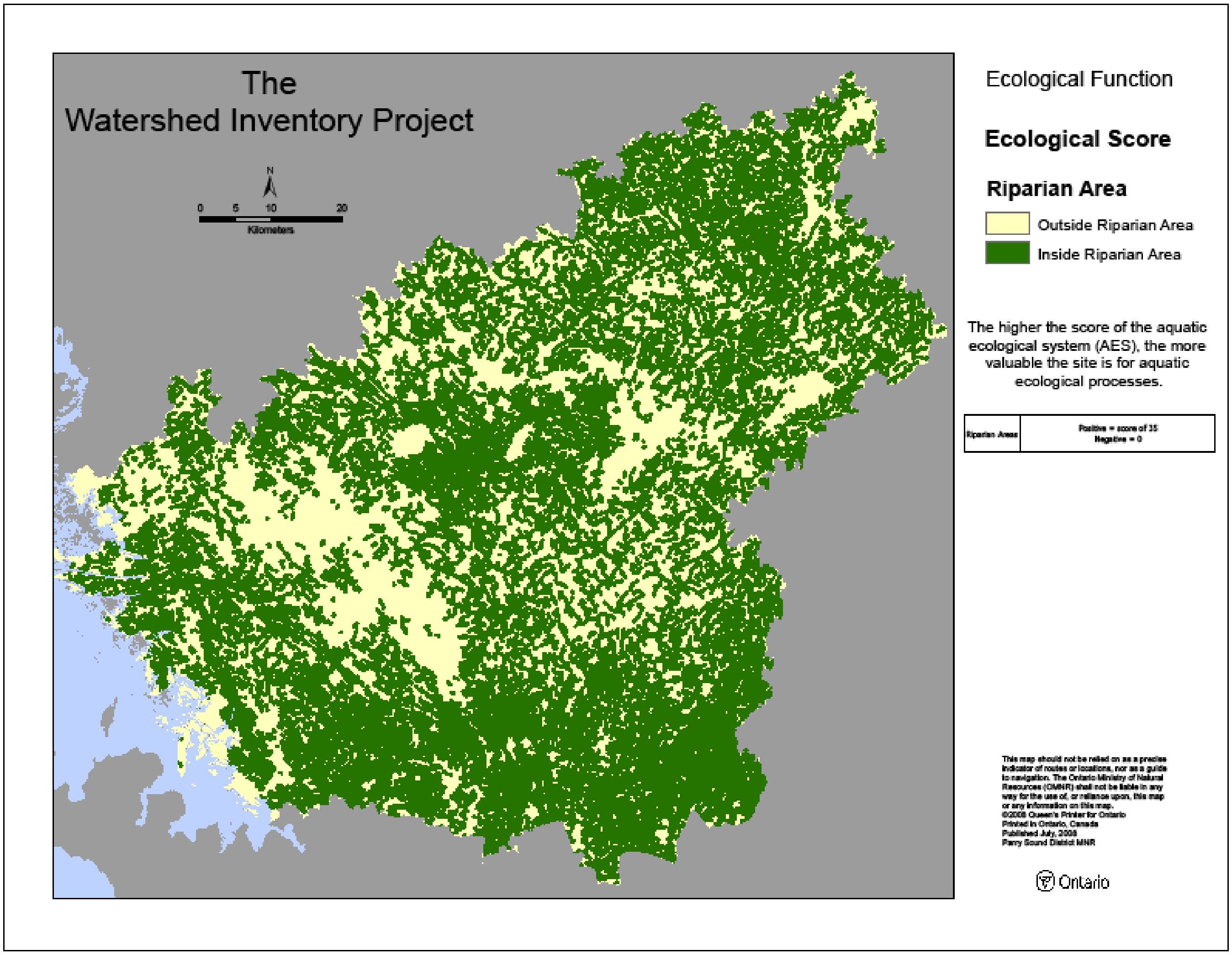
Figure 21: Size of discrete Aquatic Ecosystems



Riparian area of streams/rivers, inland lakes, and Great Lakes shoreline (Figure 22)

The riparian area is the land area immediately adjacent to a waterbody and provides connectivity between terrestrial and aquatic systems. As the interface between land and water, this area experiences frequent changes in water level, extreme events such as floods and droughts and provide unique characteristics for permanent and temporary habitat and critical migration corridors for plant and animal species (Monkkonen and Reuanen 1999; Stauffer et al 2000; Spackman and Hughes 1995; Keddy and Fraser 2000). Riparian areas are instrumental in nutrient cycling processes (Dodds and Oakes 2006; Nadeau and Rains 2007), filtering pollutants, noise, light and invasive species from reaching the water (Castelle et al 1994; Chambers et al 1999), as well as assisting in regulating water temperature (Caissie et al 2006).

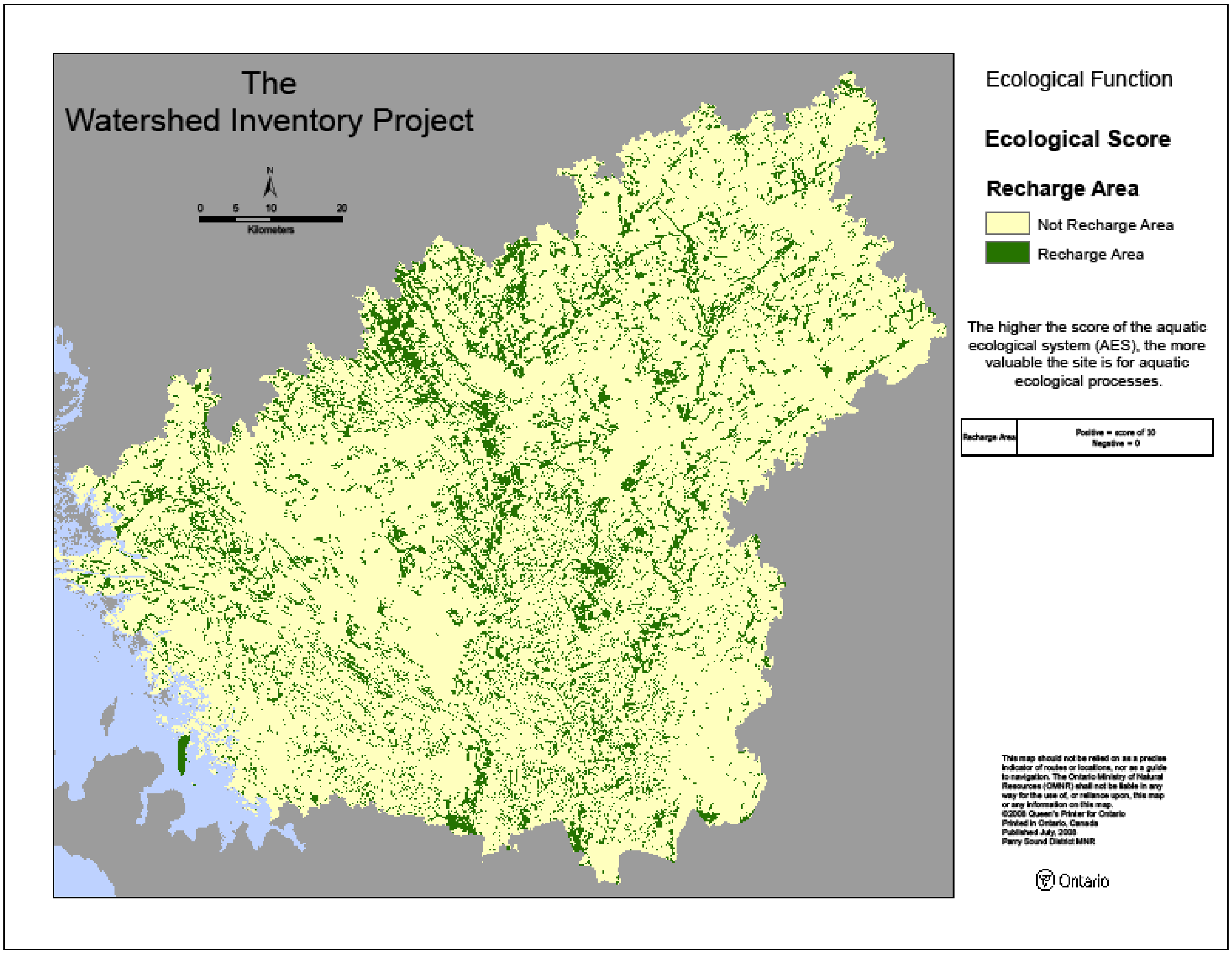
Figure 22: Riparian areas of streams, lakes and the Georgian Bay Coast



Recharge areas (Figure 23)

Highly permeable areas or locations of porous layers of soil, sand and other substrate allow water from rain or snowmelt to infiltrate slowly below the surface and replenish the groundwater supply. Groundwater is important, especially for rural residents of Muskoka, as a source of drinking water and essential to the hydrological cycle that is critical for all life on Earth.

Figure 23: Highly permeable areas that are potential recharge areas

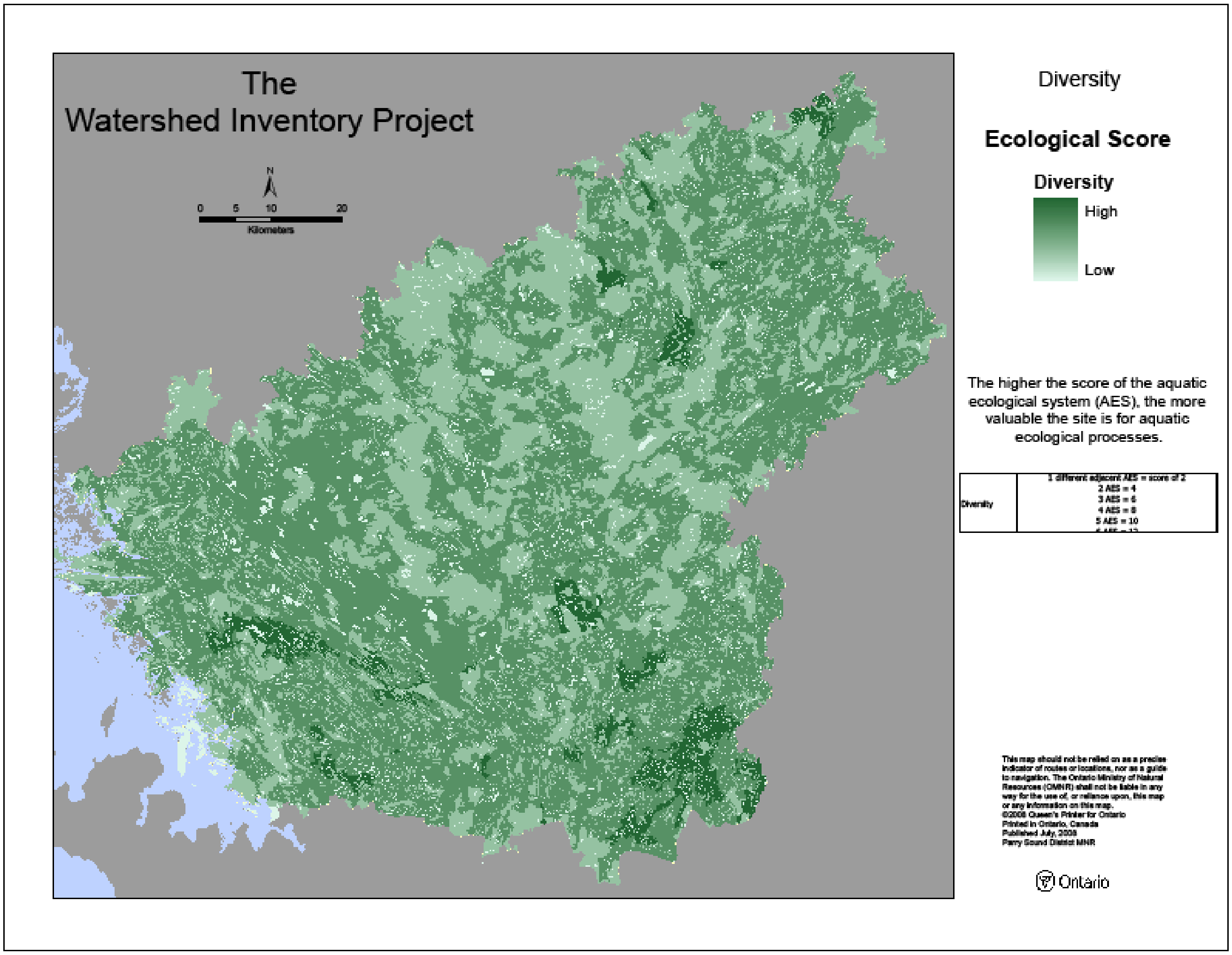


DIVERSITY

Diversity of the aquatic ecological landscape 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 have been extensively investigated (Lyons et al 2005; Allison 1999; Naeem 1998). Biodiversity contributes to the stability of ecosystem processes (Naeem 1998; Thebault and Loreau 2005). Diversity was worth 2% of the total score.

Similar to terrestrial landscapes, a diverse aquatic landscape is associated with high species richness and creates complex habitat relationships at different spatial scales. At a landscape-level analysis, diversity was evaluated by determining the number of aquatic ecological systems surrounding each discrete ecosystem (Figure 24).

Figure 24: Ecosystem diversity

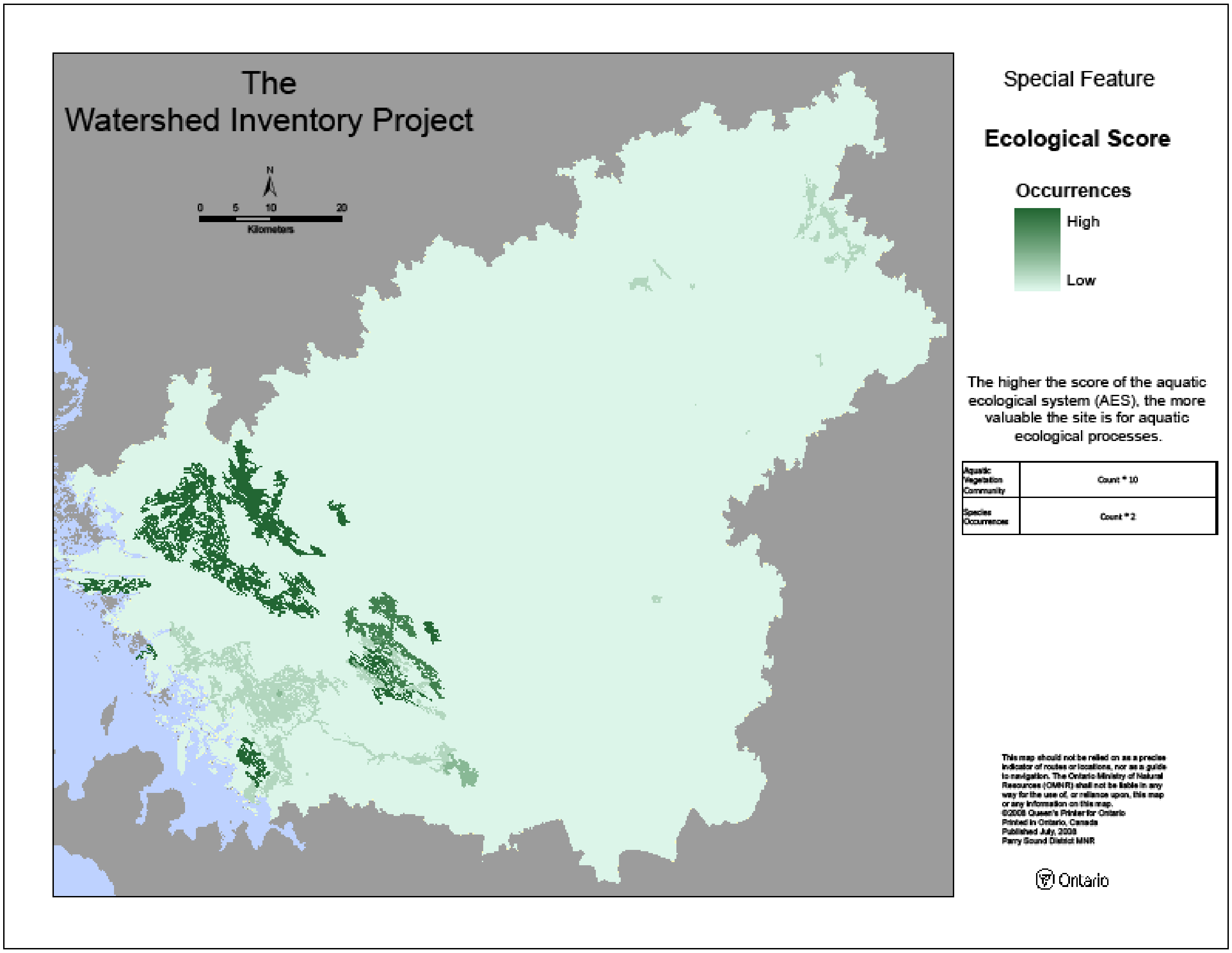


SPECIAL FEATURES

The special features criterion assessed known and/or observed significant features of ecological importance that might have otherwise been missed by the previous criteria. The special features criterion allowed the consideration of known species observations, specific critical wildlife habitat sites and unique aquatic vegetation communities. The data available for this criterion is usually incomplete because it relies on observational data at site specific scales and not necessarily from comprehensive surveys which require considerable effort and resources to complete at regional scales (Crins and Kor 2000). However, the available information was still meaningful for the WIP-A assessment in order to enhance specific sites where these features were known to occur. Special Features was worth 20% of the total score.

Ecologically functioning areas should support flora and fauna. The observation of individuals or populations in an area indicated that the site contains ecological processes or features that were supporting, or had supported, these occurrences. Although the observations do not necessarily indicate that the site was healthy and fully functioning, it did indicate that the area was or had historically been used by flora and/or fauna and needed to be considered in the WIP-A goal of assessing for ecologically important areas.

Figure 25: Species and vegetation community occurrences

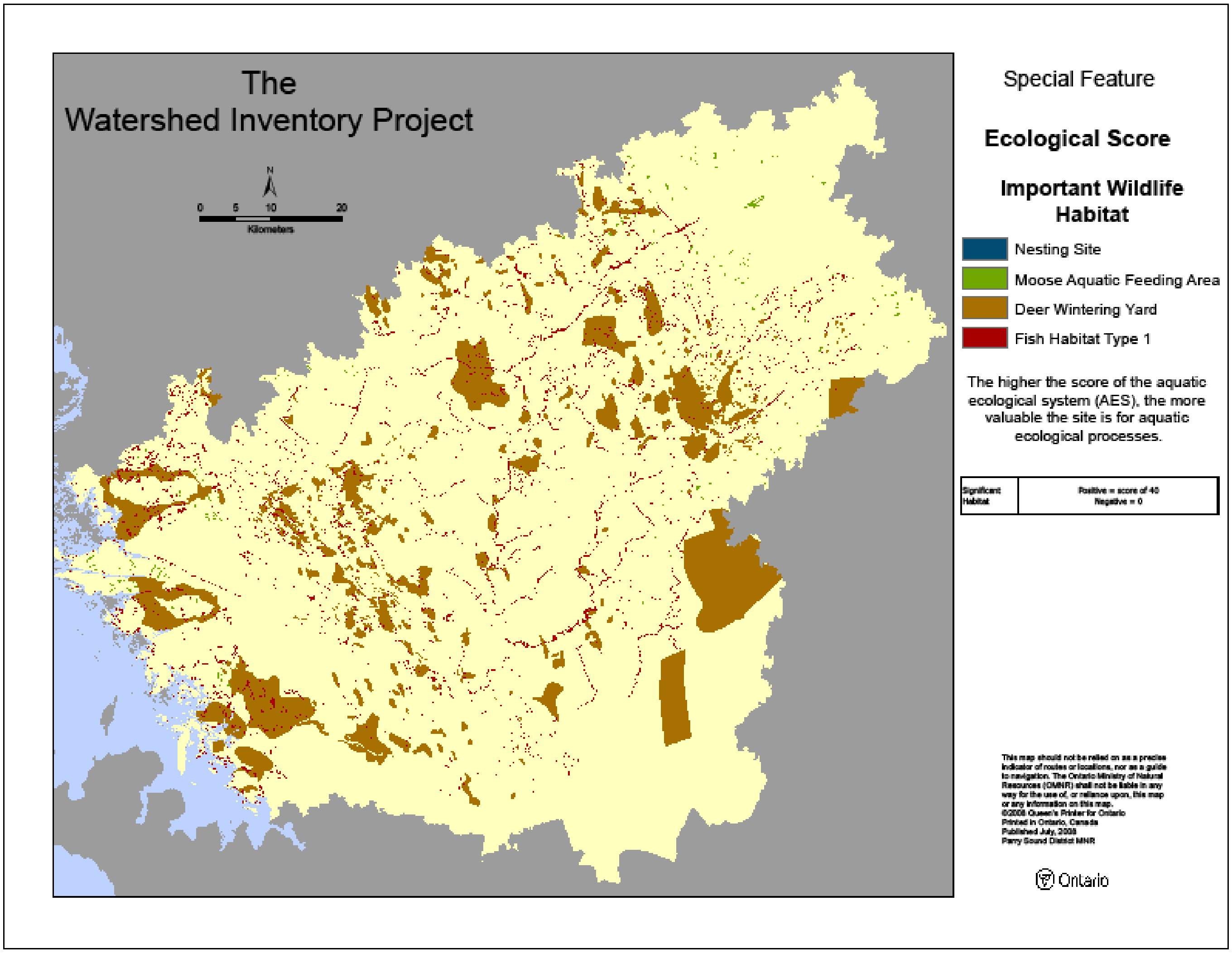


IMPORTANT HABITAT

The Canadian Shield is relatively young in terms of species evolution. Many of the observed species have evolved to use very specific conditions available in the study area for reproductive success and long-term survival, thus continued existence depends on sustaining the ecological function and condition of these specific areas (Hagen and Hodges 2006; Leon-de-La Luz and Breceda 2006; Semlitsch 2002). Flora and fauna also have a role in the maintenance and continued existence of ecosystems by contributing to ecosystem stability, connecting energy and matter within aquatic ecosystems, as well as between aquatic and terrestrial landscapes (Davic and Welsh 2004).

The available information for the study area included moose aquatic feeding areas, type 1 fish habitat, including spawning areas and other essential habitat, bird nesting sites and deer wintering areas (Figure 26).

Figure 26: Important habitat areas



ECOLOGICAL SCORING

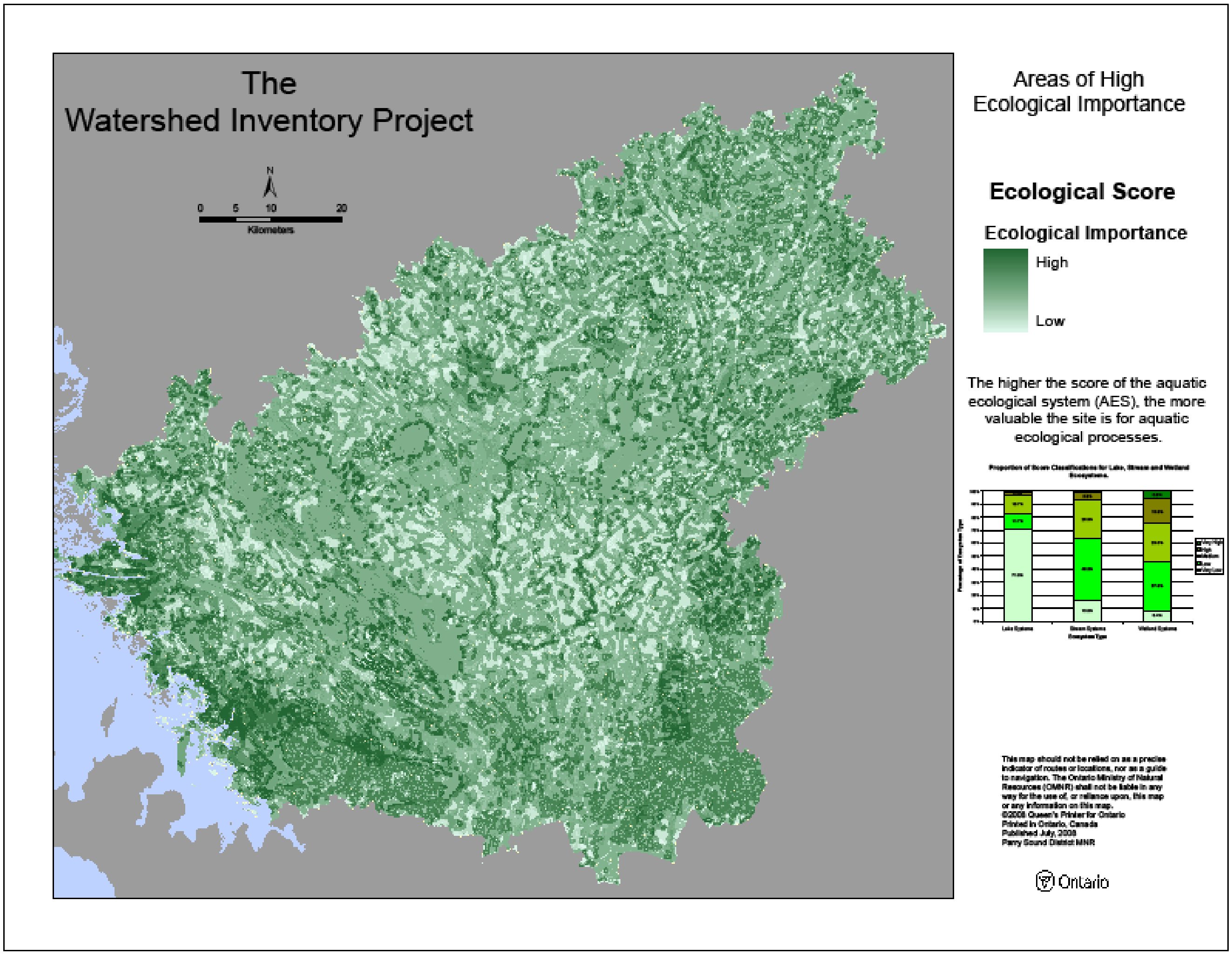
Figure 27 shows ecologically important areas based on the indicators in Table 1 and as described above in figures 21 to 26. The higher the ecological score the more valuable the site for ecological functions, maintaining diversity, and supporting special features such as species occurrence and critical habitat.

Final scores were classified into five classes:

1. Very High – Areas with the best potential for sustaining ecological processes
2. High – Areas with good potential for sustaining ecological processes
3. Medium – Areas with some potential for sustaining ecological processes
4. Low – Areas with limited potential for sustaining ecological processes
5. Very Low – Areas with very limited potential for sustaining ecological processes

Classification of scores was accomplished using a statistical formula that divides the values into classes by looking for groups and patterns that are found in the data, thus minimizing the variation in classes. The breaks between each class are identified where there is a statistical difference in the scores from one class to the next (Jenks 1967).

Figure 27: Areas of high ecological importance



Goal 3: Identify stresses on aquatic ecosystem processes.

Based on the most current ecological principles and concepts and local expertise, ecological systems were evaluated for their ability to support and maintain ecological processes when impacted by different stressors. The motive for this goal was to evaluate the condition of ecosystems in order to identify the highest quality sites, but also to assess the need for attention to degraded sites. Identifying significant ecological systems required an evaluation of the pressures found on aquatic systems across the landscape.

CONDITION

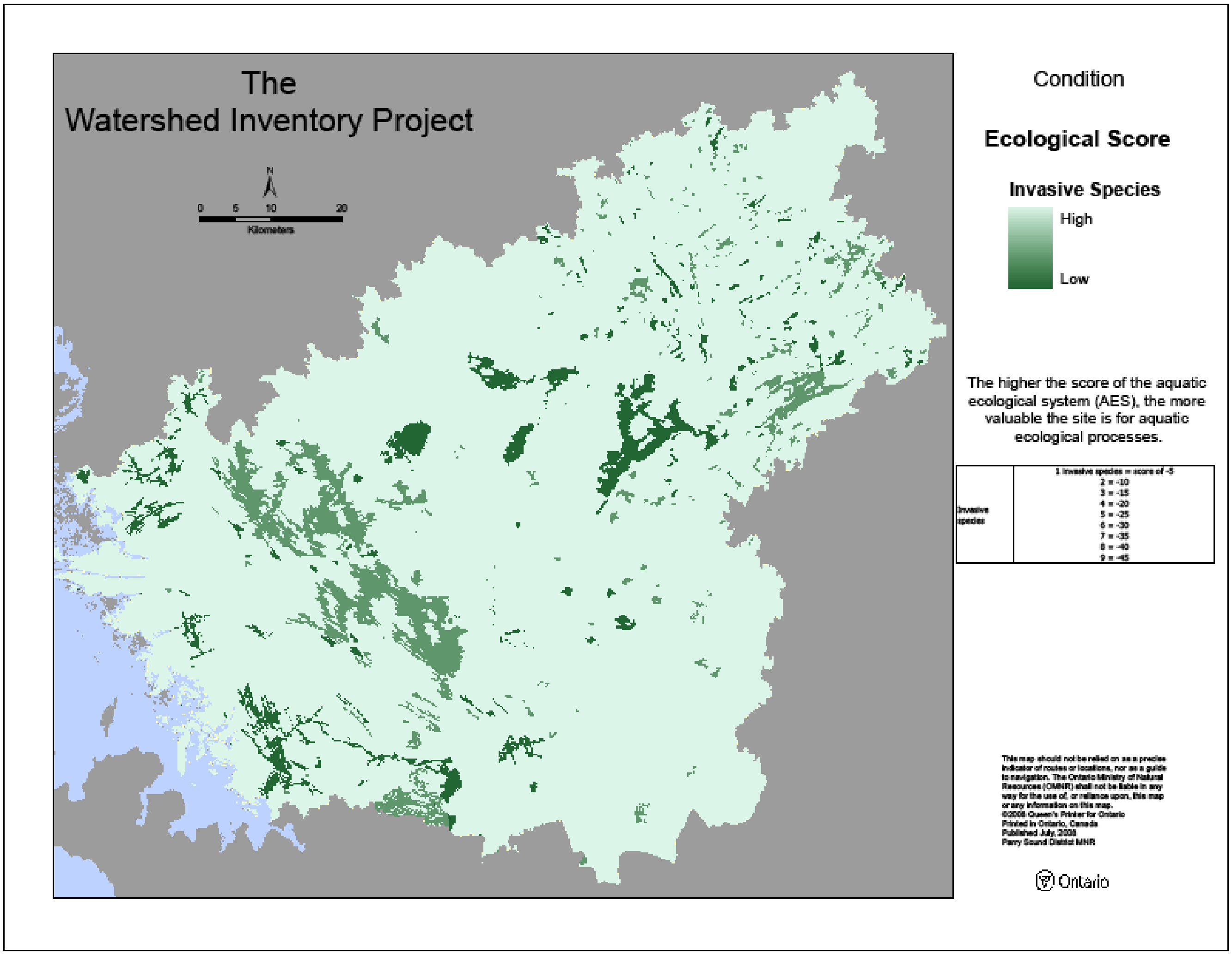
Similar to the ecological importance component of the analysis, condition used indicators that assessed how activities across the landscape put stress on aquatic systems. The indicators provide an understanding of the balance between biogeochemical processes and downstream transport of dissolved elements. Activities occurring in water such as road crossings and on land such as urban development can easily disrupt aquatic ecosystems and consequently ecosystem structure and function (Nadeau and Rains 2007).

The condition criterion achieved the third goal of identifying stresses on ecological systems and processes. When combined with the ecological importance components of the WIP, the condition criterion represented 38% of the total combined score based on the GLCB framework.

Invasive species (Figure 28)

Invasive species can dominate ecosystem processes and significantly impact biodiversity resulting in a degraded system. Thus the presence of invasive species could indicate impacted ecosystem function. The spread of the *Bythotrephes* (spiny water flea) was used as an indicator of the impact of invasive species (Yan and Pawson 1997; Kennard et al 2005).

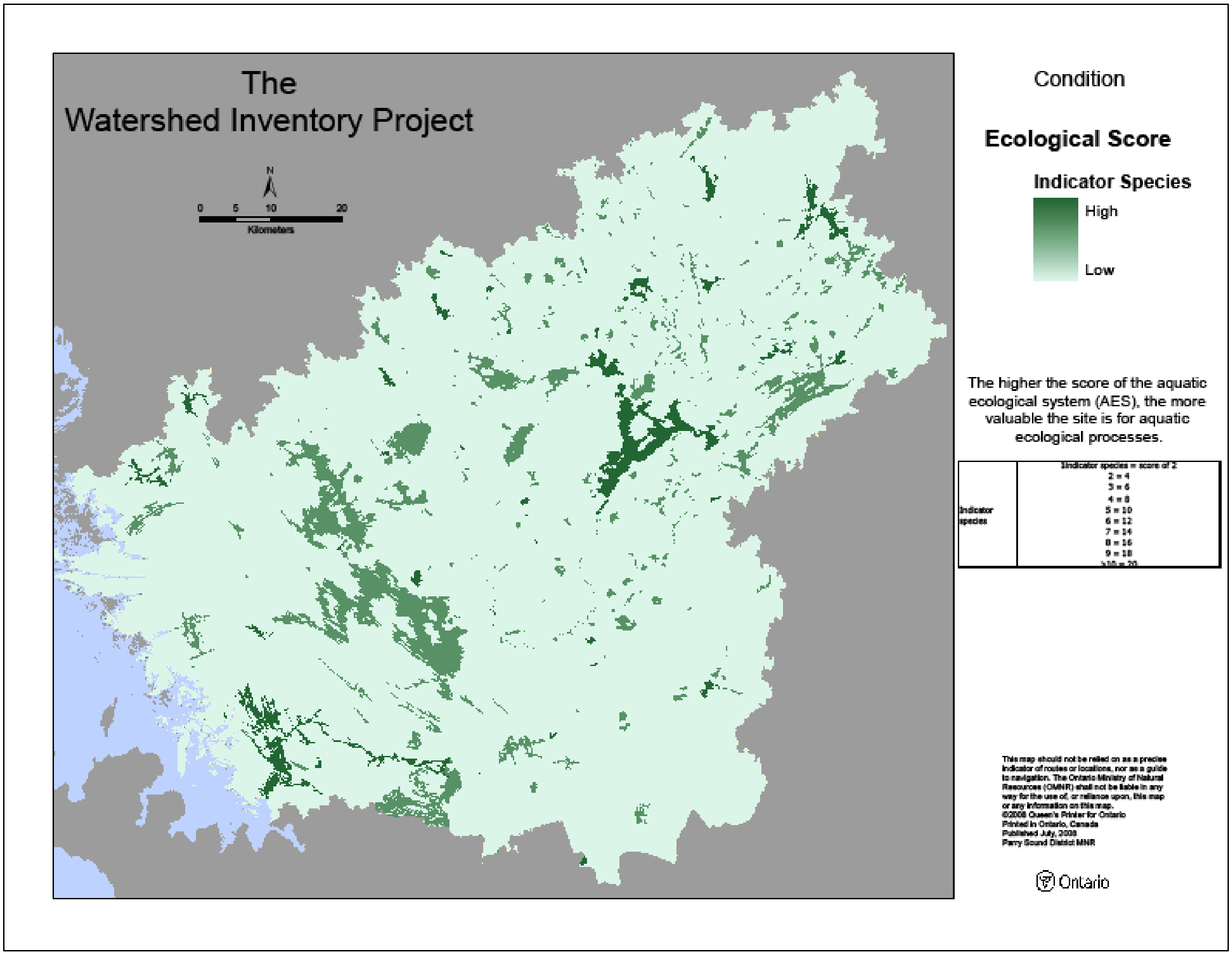
Figure 28: Invasive species occurrences



Indicator species (Figure 29)

In contrast to invasive species indicating a degraded or degrading system, indicator species can signify a functioning natural system. Thus, indicator species for WIP-A reflect the ability of a waterbody to support sensitive aquatic species such as lake trout. The list of indicator species was determined by local fisheries biologists at the provincial and federal government levels.

Figure 29: Indicator species occurrences



Road and railway crossings (Figures 30, 31, and 32)

The effects of roads and railways on terrestrial and aquatic communities have been studied relatively well. Ecological effects include wildlife mortality, both from road and crossing construction and collision with vehicles, modification of animal behaviour, alteration of the chemical and physical landscape, and the spreading of exotic species (Trombulak and Frissell 2000). Roads crossing waterbodies can impact aquatic systems directly by increasing sedimentation, preventing fish passage and increasing velocity of stream flows (Trombulak and Frissell 2000).

Perhaps the most significant impact is habitat fragmentation. As a result of fragmenting the landscape, roads and railways increase the impacts associated with isolation of wildlife populations (Fleury and Brown 1997; Adam and Geiss 1983; Rosenberg et al 1999; Vos et al 2001), increase the opportunity for predation (edge effects), easy access and movement for exotic and invasive terrestrial species(i.e roadside ditches) and aquatic species (i.e. accidental or intentional activities of anglers) (Gelbard and Belnap 2003; Watkins et al 2003), increased concentrations of nutrients and sediments in water, killing/injuring wildlife, and altering physical conditions beneath and adjacent to roads (Findlay and Bourdages 2000; Trombulak and Fissell 2000).

Railways have similar impacts on the landscape as other linear features, such as roads and, in addition, offer the additional risk of potentially contaminating waterbodies (i.e. derailment spills).

Figure 30: Road and railway crossings

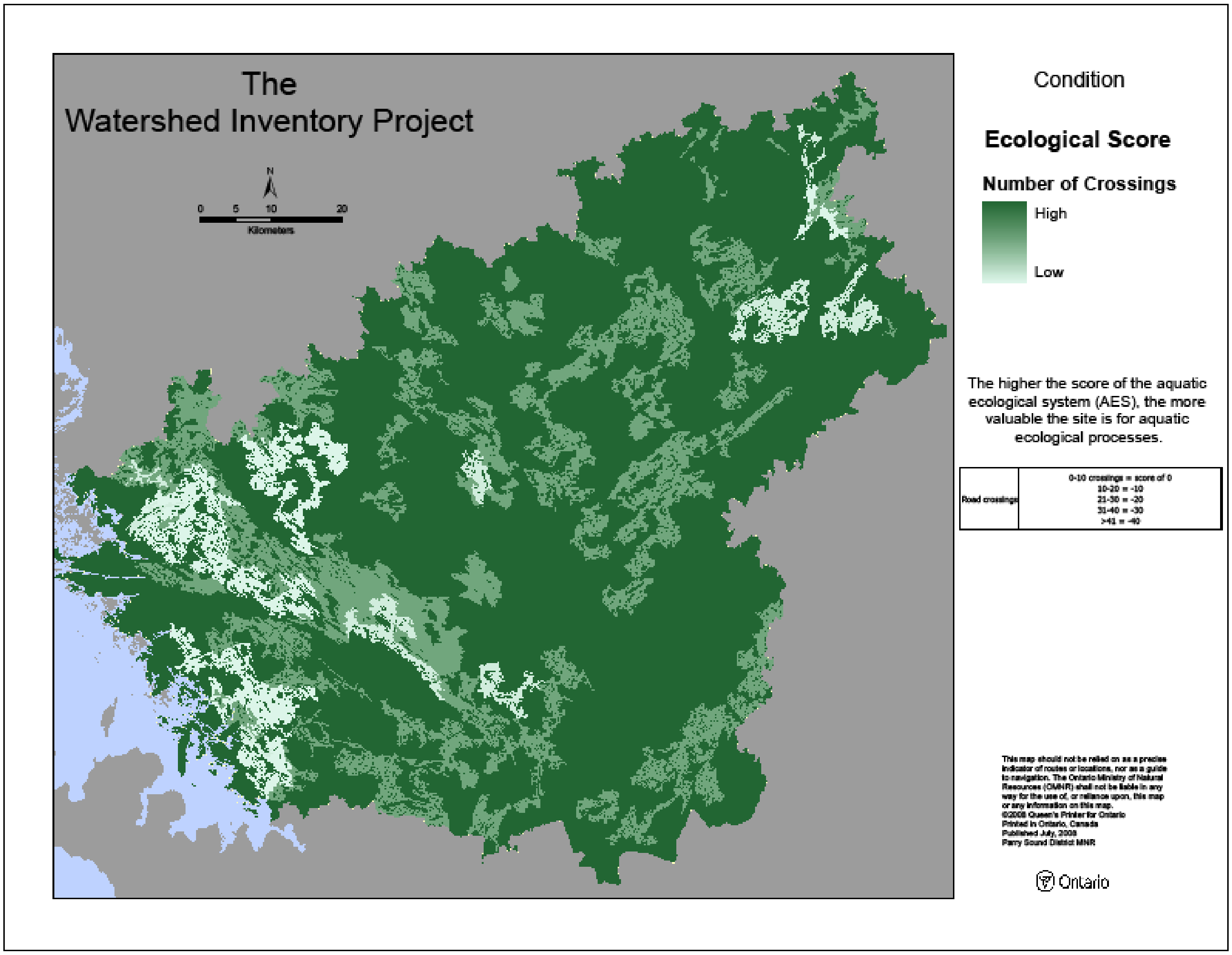


Figure 31: Influence of roads

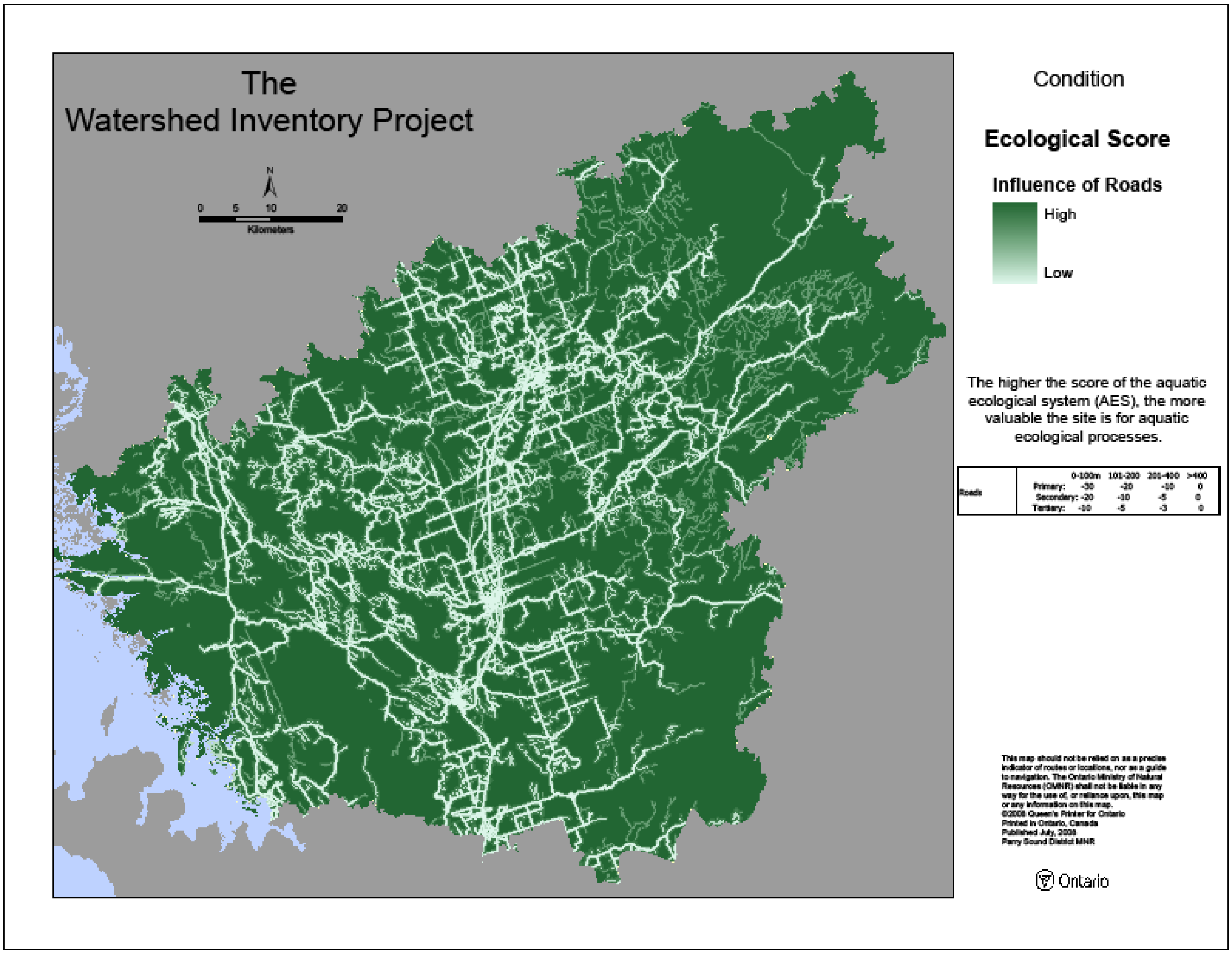
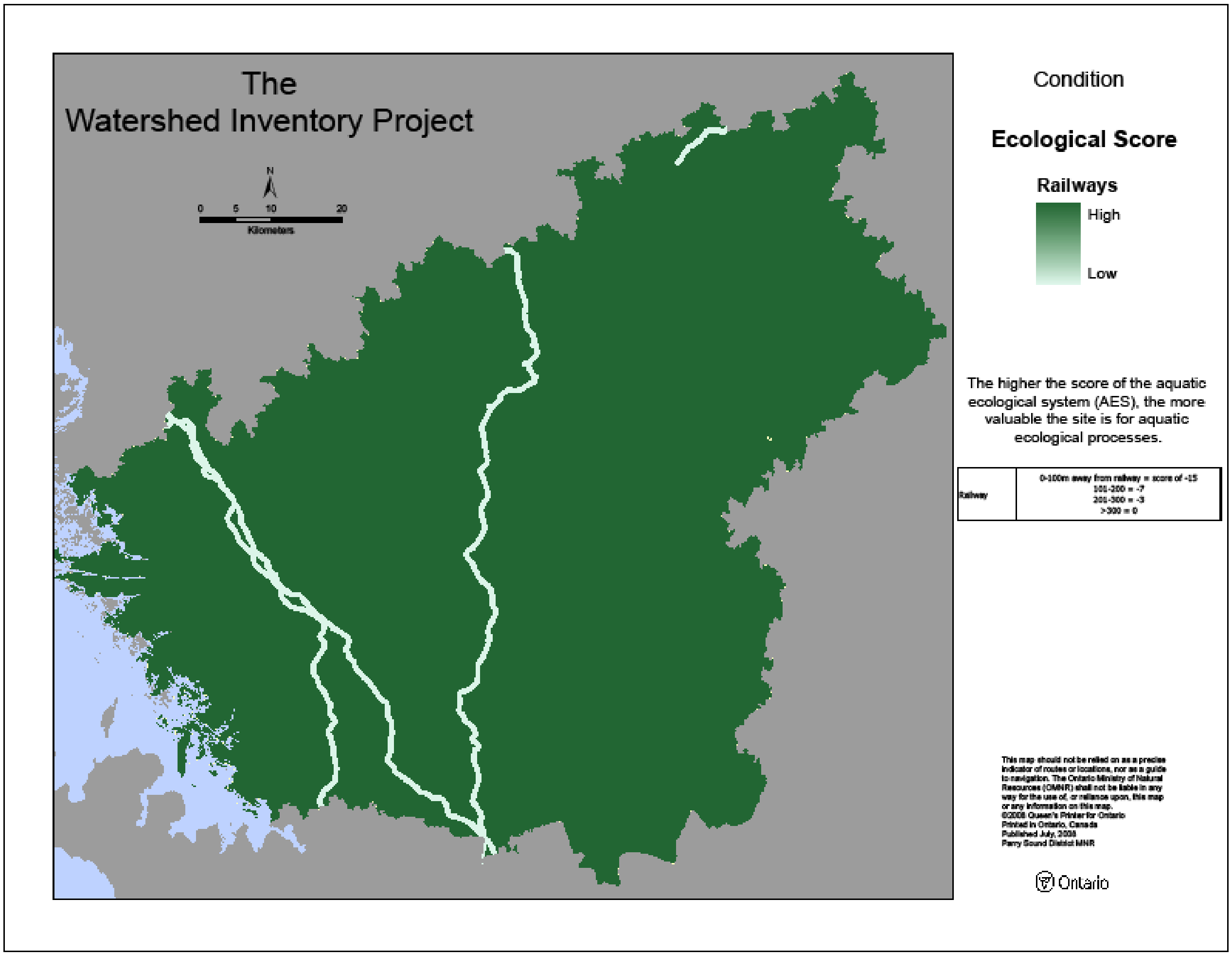


Figure 32: Influence of railways

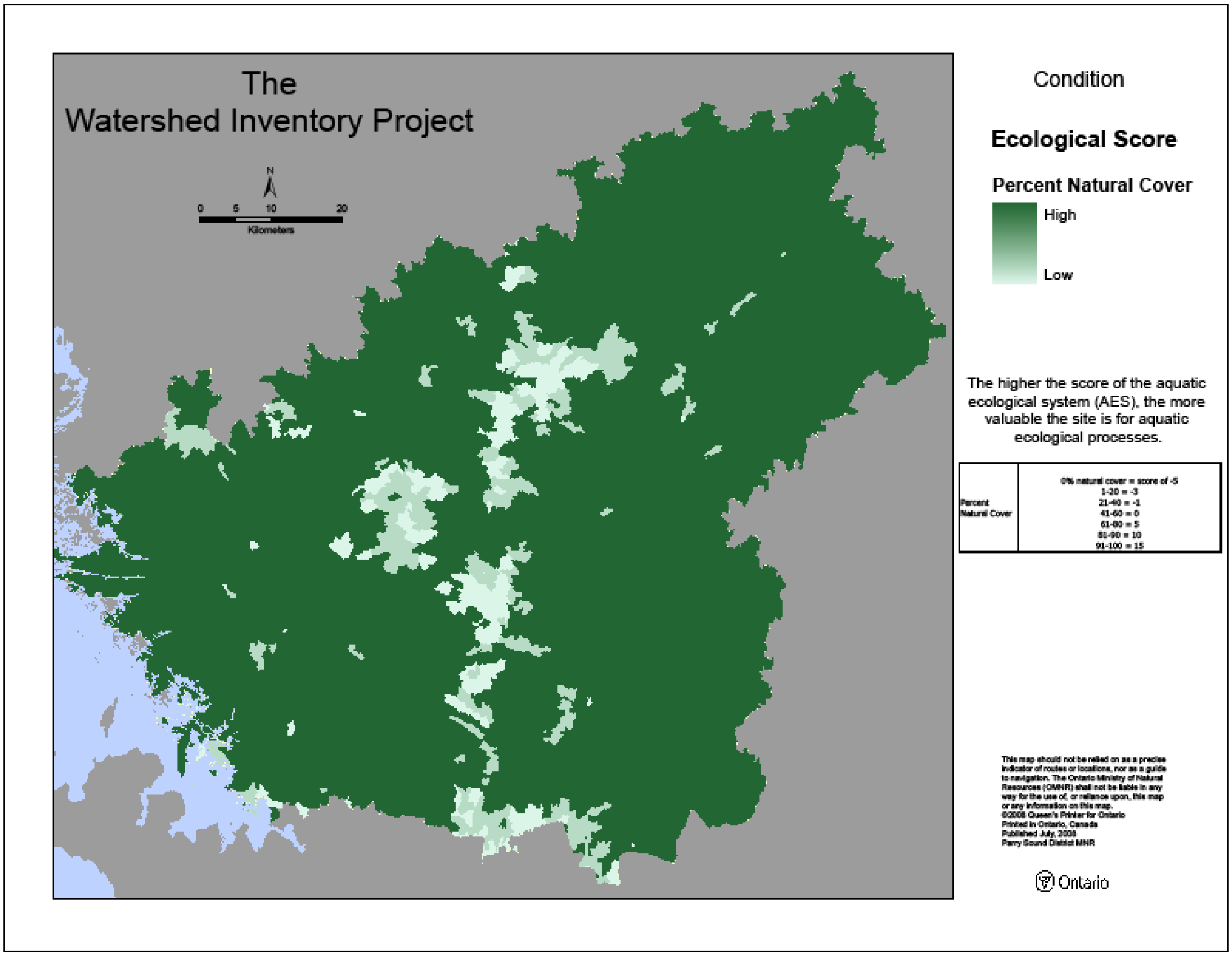


Percentage natural cover (Figure 33)

The terrestrial component of the Watershed Inventory Project (Tran 2007) identified a large percentage of natural cover. Compared to areas off the Canadian Shield in Southern Ontario, the WIP study area is still relatively connected with natural cover across the landscape (McMurtry et al 2002).

Lack of natural cover negatively impacts the landscape at all scales. Natural cover intercepts overland water-flow and increases the amount of water infiltrating into recharge areas. Lack of vegetative cover increases potential for soil erosion and decreases the volume of groundwater recharge (Johnson and Heaven 1999). Although natural cover contributes to functioning systems and species survival at micro- and macro-scales (i.e. regulating water temperature, providing shelter from wind), continuous natural cover at a landscape scale was the best predictor of species occurrences and survival success (Fenton and Frego 2005; Rubbo and Kiesecker 2005).

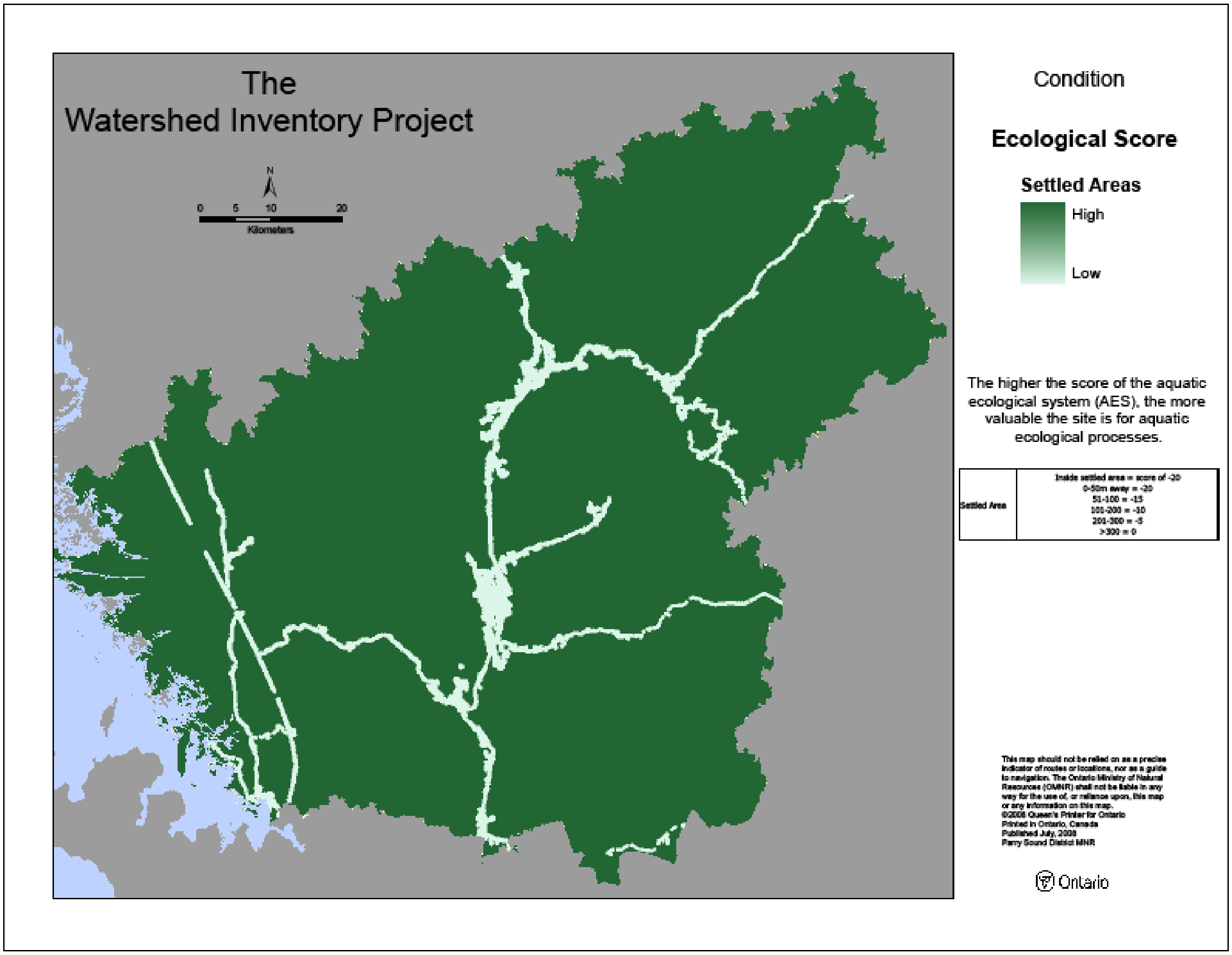
Figure 33: Percentage natural cover



Influence of settled areas (Figure 34)

Settled and developed areas have a large impact on the aquatic landscape. Developed areas have high proportions of impervious areas that increase runoff and peak flows (Olivera and Defee 2007). Impervious structures, such as roads and parking lots, also easily deliver contaminants into waterbodies (Woodcock and Huryn 2006). Some settled areas do have natural features such as wetlands, however studies have shown that in an urbanized landscape natural areas have lower species richness and more predation than rural natural areas (Rubbo and Kiesecker 2005).

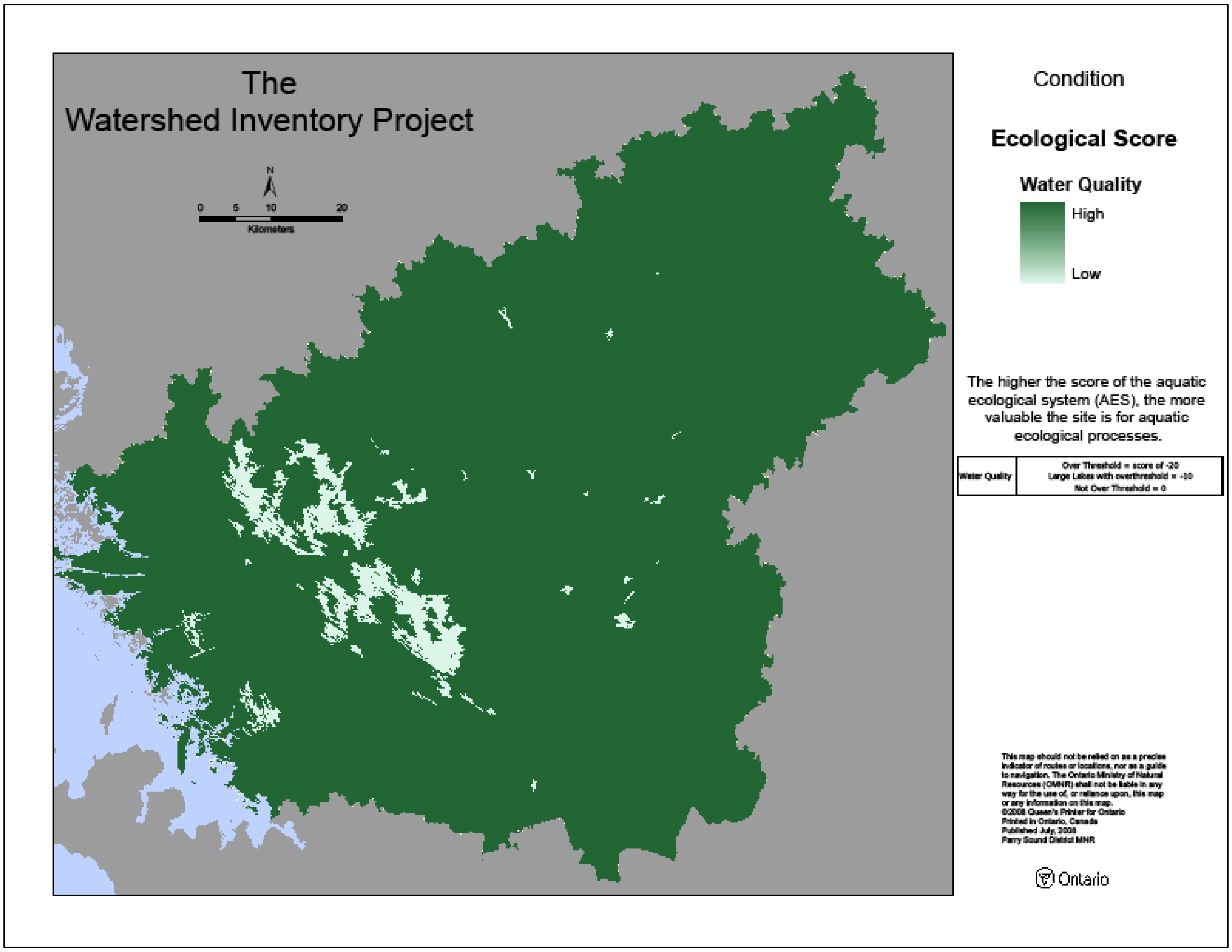
Figure 34: Influence of settled areas



Water Quality (Figure 35)

General water quality for recreational use was also a criterion of condition for WIP. In Muskoka, there are municipal government programs committed to monitoring the recreational water quality of many lakes. Lakes were classified based on their sensitivity to phosphorus inputs and determined acceptable if phosphorus concentrations did not exceed modeled and measured thresholds (Gartner Lee 2005). Those lakes not over threshold met the criteria for high water quality for recreational purposes.

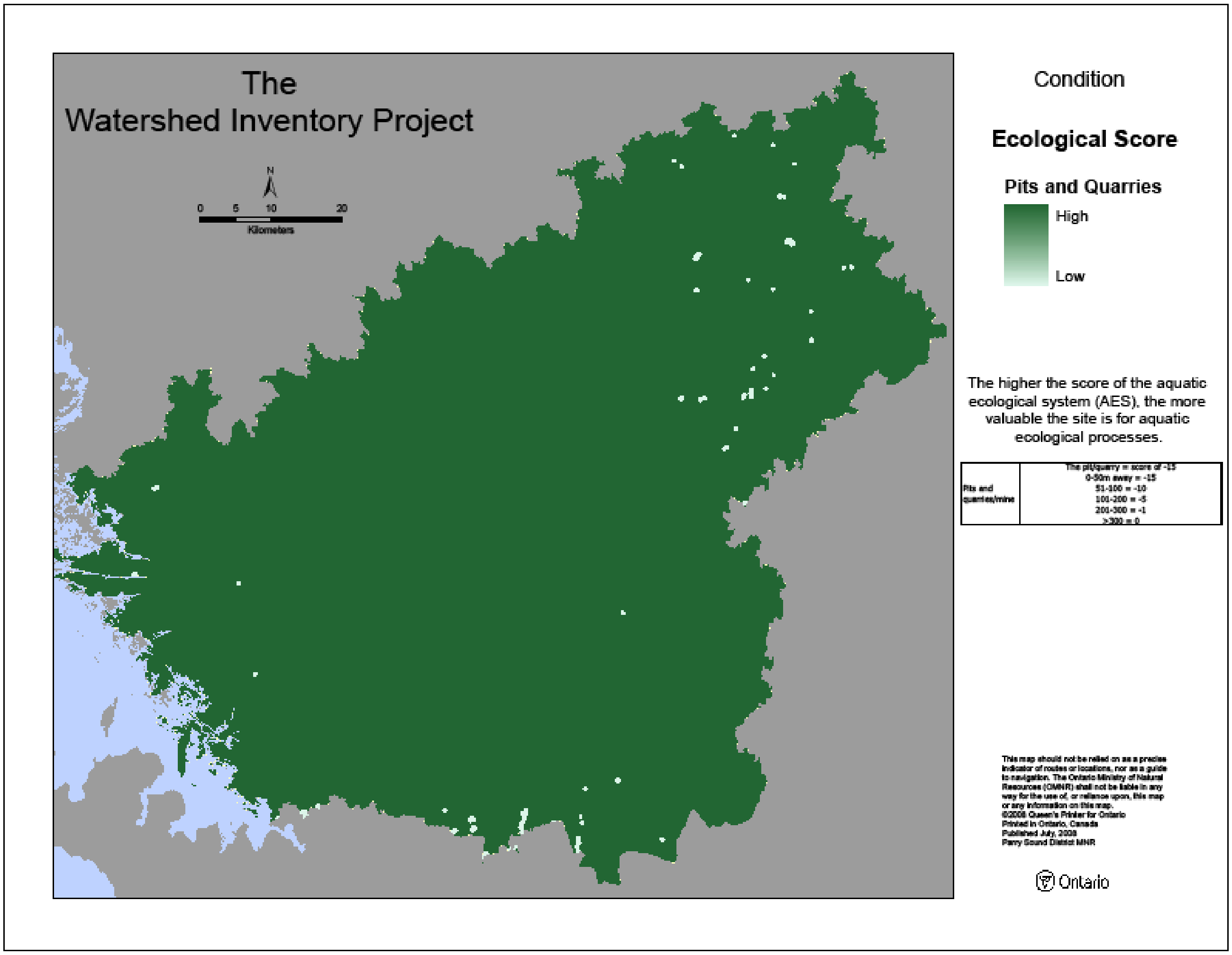
Figure 35: Water quality



Influence of pits and quarries (Figure 36)

Pits and quarries can have direct and indirect impacts on aquatic ecosystems. Habitat fragmentation and destruction, as well as soil erosion and compaction impacts local hydrology patterns (Michalski et al 1987). Pits and quarries in Ontario must be rehabilitated after extraction is finished, however, few efforts attempt to restore ecological function of the particular site (Corry et al 2008), and thus the landscape is altered permanently.

Figure 36: Influence of pits and quarries

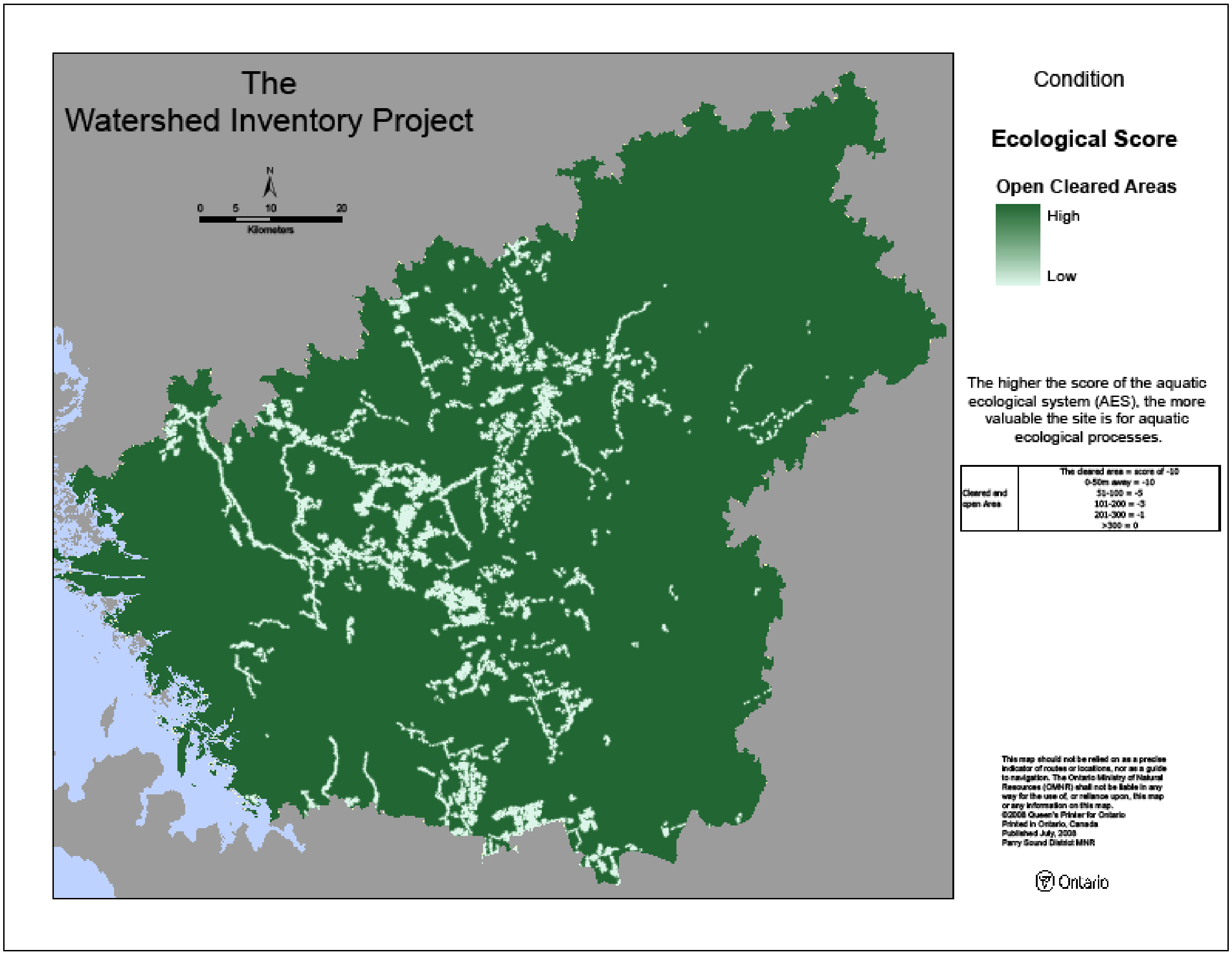


Influence of cleared areas (Figure 37)

Open cleared areas for the WIP-A assessment were areas that have been cleared for non-natural land-use such as agriculture and golf courses.

Non-natural open areas can be intensively managed. Agricultural practices and golf courses operations, for example, regularly apply fertilizers, pest-control treatments and tillage that negatively impact water quality, cause erosion and impair aquatic ecosystem processes (Dunster and Dunster 1996; Houlahan and Findlay 2004; Bernot et al 2006). Clearing of natural areas also impacts at a landscape level by weakening terrestrial and aquatic linkages (England and Rosemond 2004).

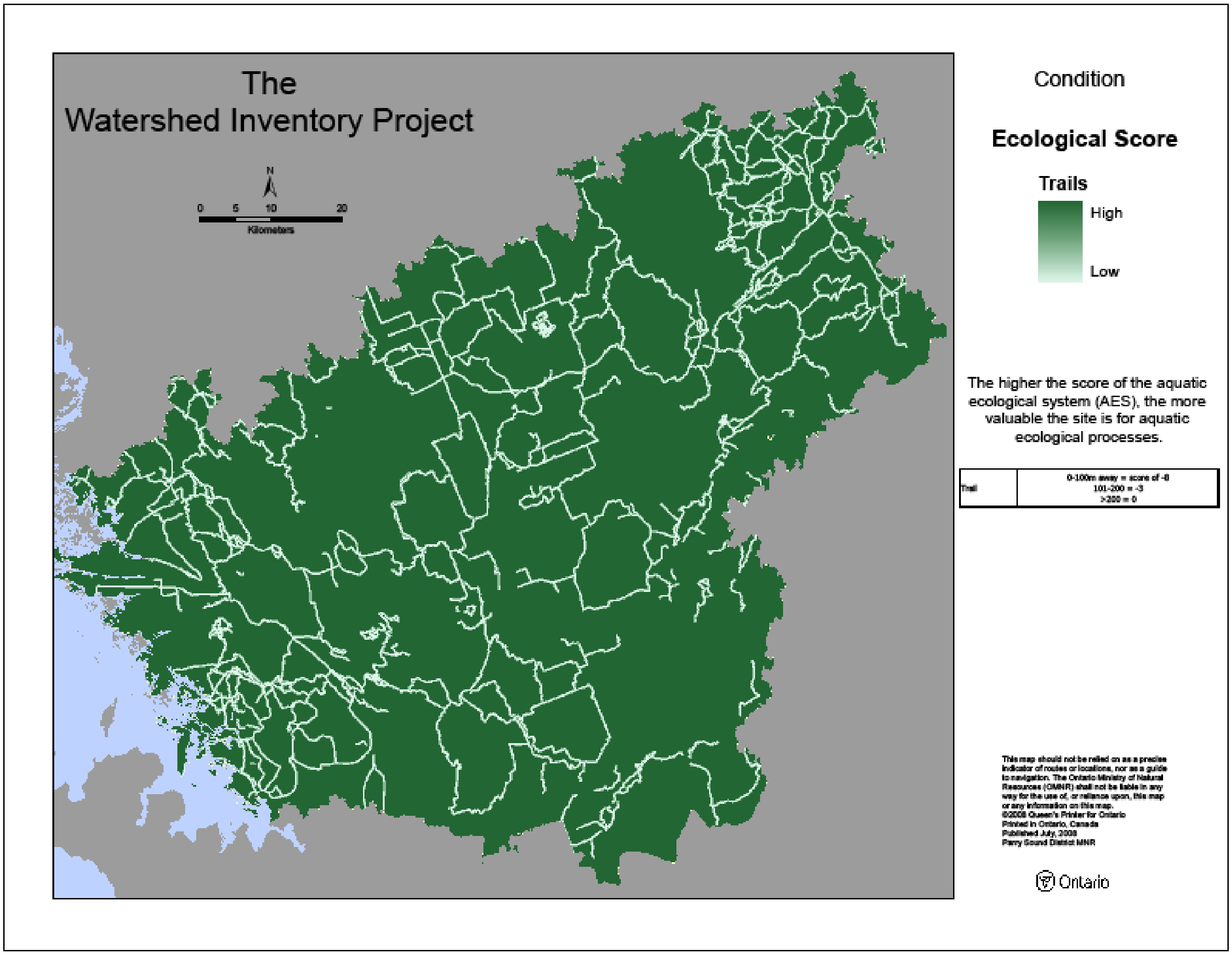
Figure 37: Influence of open, cleared areas



Influence of trails (Figure 38)

Trails were not considered to negatively impact the landscape as much as roads, however, they do play a role in fragmenting natural areas (Blumstein et al 2005; Creel et al 2002). Heavy use of trails, especially by motorized vehicles such as ATVs, can lead to soil compaction, alteration of the thermal regime and movement of water (Trombulak and Frissell 2000).

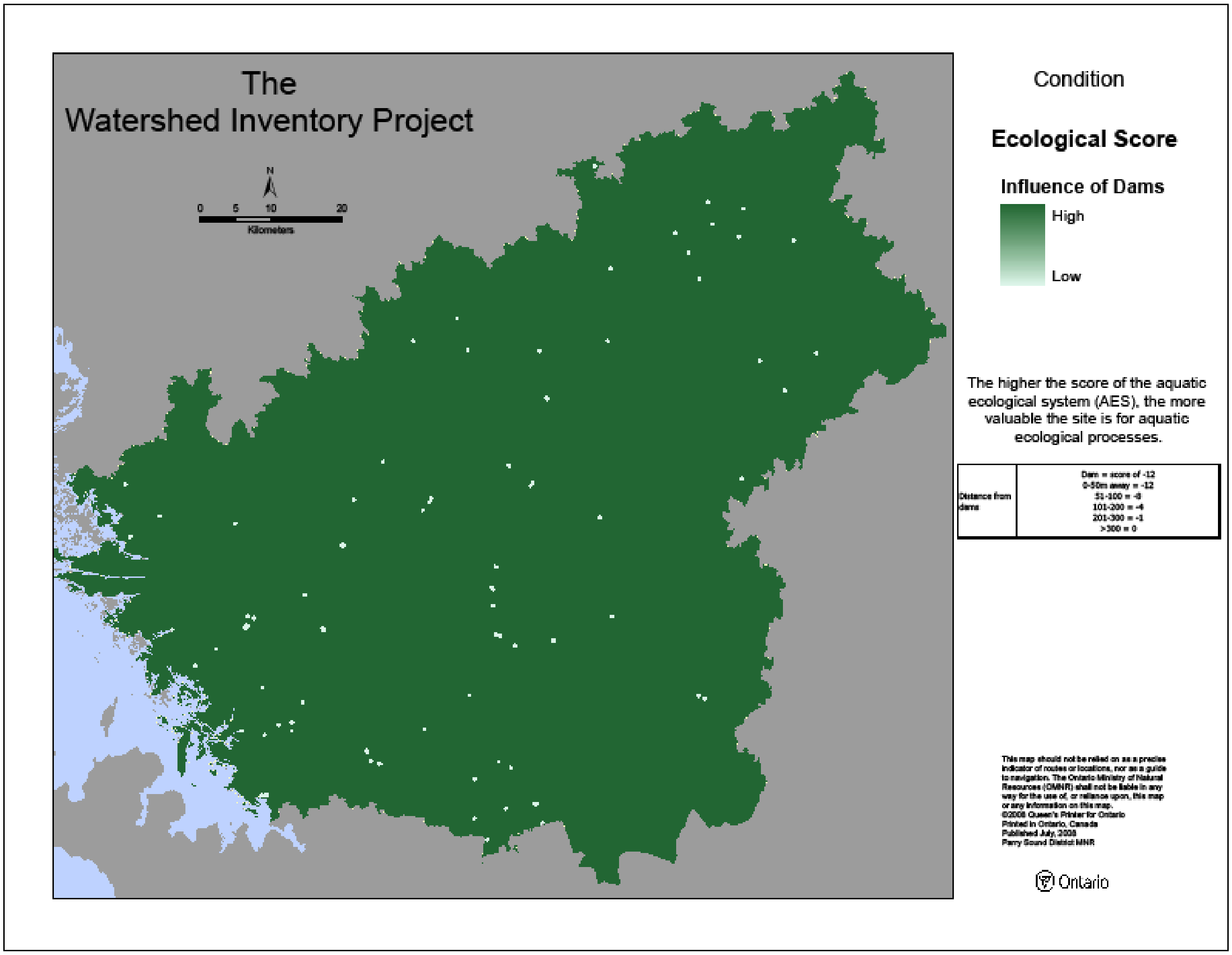
Figure 38: Influence of trails



Influence of dams (Figure 39)

Dams can have major impacts on aquatic ecosystems. Dams fragment the aquatic landscape by preventing and/or diverting the flow of water. Other impacts include creating barriers to fish movement (Poff et al 1997; Morita and Yamamoto 2009), isolating floodplains (Poff et al 1997) and decreasing biodiversity in ecosystems downstream.

Figure 39: Influence of dams



CONDITION SCORING

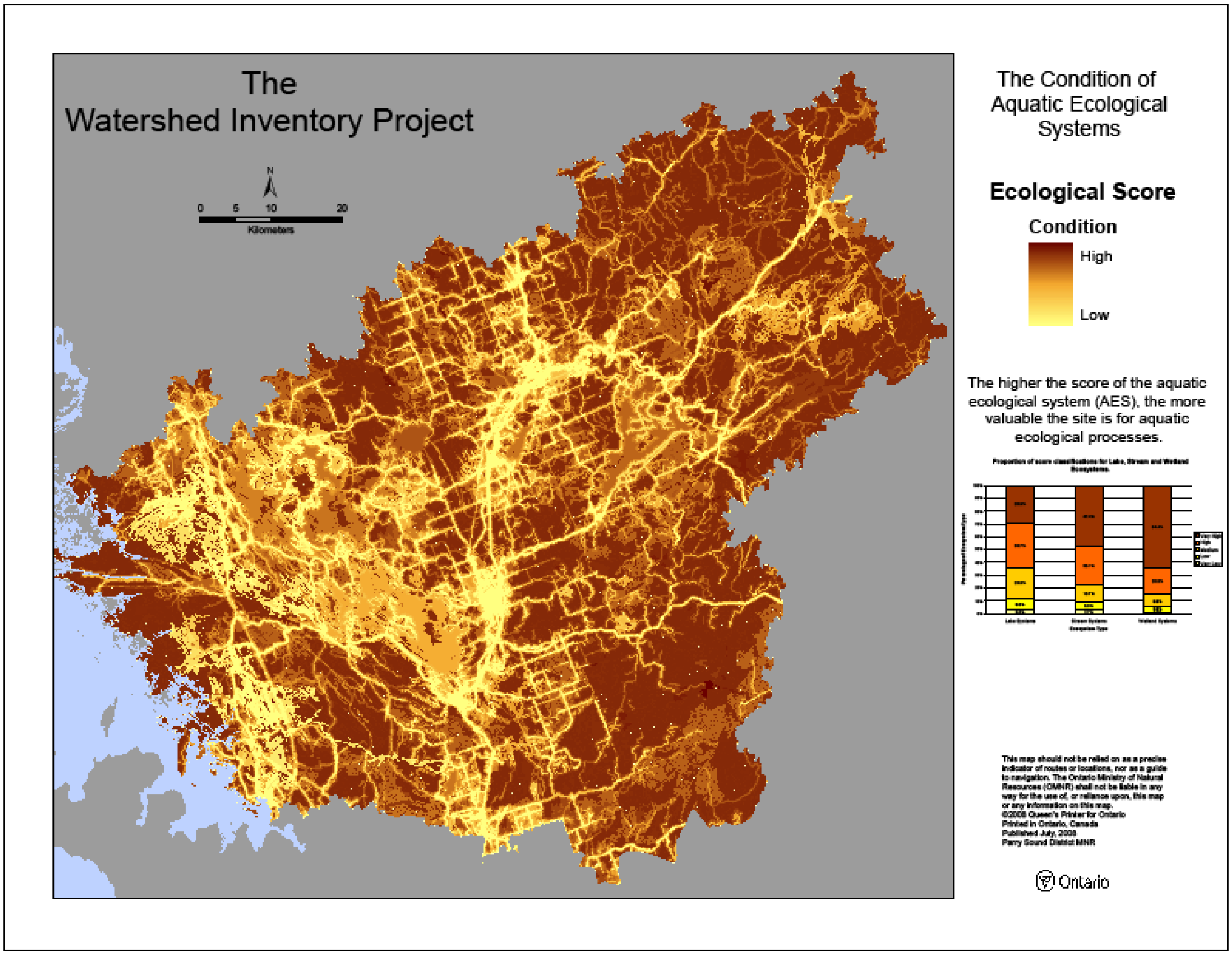
Figure 40 shows the ecological condition of areas based on the indicators in Table 1 and as described above in figures 28 to 39. The lower the condition score the more stressed or degraded the site.

Final scores were classified into five classes:

1. Very High – Areas with no or very little stress impacting the site
2. High – Areas with limited stress impacting the site
3. Medium – Areas with moderate stress impacting the site
4. Low – Areas with significant stress impacting the site
5. Very Low – Areas that are highly degraded

Classification of scores was accomplished using a statistical formula that divides the values into classes by looking for groups and patterns that are found in the data, thus minimizing the variation in classes. The breaks between each class are identified where there is a statistical difference in the scores from one class to the next (Jenks 1967).

Figure 40: Condition of aquatic ecosystems



Muskoka Watershed Inventory Project Products

After identifying the unique aquatic ecosystems in the study area, sites with the highest potential to sustain natural processes, and areas with the best ecological condition, the following products were created:

1. A gap analysis to identify unprotected aquatic ecological systems;
2. A gap analysis to identify areas where additional biological data are required;
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.

Product 1: A gap analysis of unprotected aquatic ecological systems

Finding gaps in the protection of aquatic ecological systems was accomplished by overlaying the unique aquatic ecological systems (stream, lake and wetland types) with the existing protected areas to identify the unprotected ecological systems. Table 6 and Figure 41 identify and map those aquatic ecosystems with less than 10% of the total amount of area present in the watershed protected. Figure 41 illustrates that many of these ecosystems are located within the more developed central portion of the watershed.

Many of the ecosystems that scored low to very low for ecological significance due to their proximity to roads, settlement areas, and other non-natural features are also under protected and vulnerable. These areas could be improved through restoration and remediation efforts and protected through private land stewardship or the land trust.

Figure 41: Aquatic ecosystems with less than 10% protection

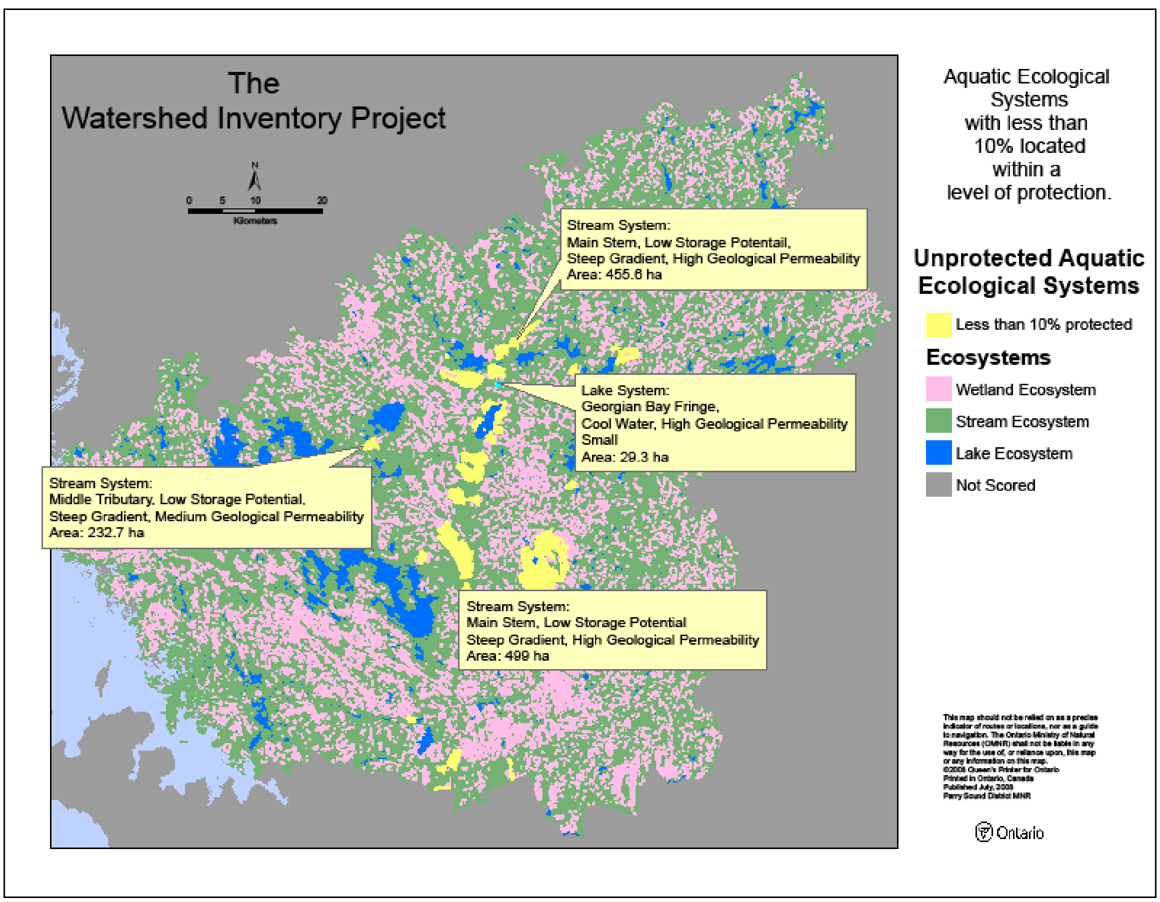


Table 6: List of Ecosystems with less than 10% by Area Located within Protection (see Figure 41).

Aquatic Ecological System	Total Within Area of Interest (ha)	Within Level 1 Protection	Within Level 2 Protection	Within Level 3 Protection	Proportion not within protection
Lake System: Georgian Bay Fringe, Cool Water, High Permeability, Small	29.3022	0.0%	0.0%	0.0%	100.0%
Stream System: Main Stem, High Storage, Steep, High Permeability	116.3332	0.0%	0.001%	0.0%	100.0%
Stream System: Main Stem, Low Storage, Steep, Low Permeability	567.4129	0.0%	0.4%	0.0%	99.6%
Stream System: Main Stem, High Storage, Flat, Medium Permeability	1238.9356	0.0%	1.6%	0.0%	98.4%
Stream System: Middle Tributary, Low Storage, Steep, Medium Permeability	232.7540	0.0%	2.5%	0.0%	97.5%
Stream System: Main Stem, High Storage, Steep, Low Permeability	3028.1130	0.0%	3.3%	0.0%	96.7%
Stream System: Main Stem, High Storage, Steep, Medium Permeability	394.4501	0.0%	5.2%	0.0%	94.8%
Stream System: Main Stem, High Storage, Gentle, High Permeability	1046.9184	0.0%	5.4%	0.0%	94.6%
Stream System: Main Stem, Low Storage, Gentle, High Permeability	1326.6367	0.00%	5.5%	0.0%	94.4%
Stream System: Main Stem, Low Storage, Steep, High Permeability	1615.4178	0.0%	6.1%	0.0%	93.9%
Stream System: Main Stem, Low Storage, Flat, Medium Permeability	2286.4087	0.0%	6.8%	0.0%	93.2%
Stream System: Main Stem, Low Storage, Flat, High Permeability	1293.8648	0.0%	8.6%	0.0%	91.4%

Product 2: A gap analysis of biological data and site inventories

There were several limitations to the datasets used in the WIP-A that should be addressed. As datasets are updated, they should be incorporated into the WIP to provide resource managers with a more complete and comprehensive analysis of watershed features.

Since the first Ontario effort to systematically record natural areas was undertaken in the late 1960s, Ontario has dedicated significant resources to the surveying of life and earth science features. This has resulted in a comprehensive system of protected areas and parks and includes provincial parks, conservation reserves, and Areas of Natural and Scientific Interest. However, the Conservation Blueprint project and others have recognized that survey and monitoring protocols have not been consistent or undertaken on a routine basis. For example, forest resource inventories vary greatly from one MNR district to the next. Before these data can be used to undertake a landscape level analysis, such as WIP, considerable time and resources are required to standardize these datasets.

The WIP found most data to be out-of-date or evolving for Muskoka, for example, new aggregate information became available half way through the process and updated Forest Resource Inventory (FRI) mapping is scheduled to be released in fall 2009 which will provide better forest information on Crown land. For natural area planning to occur at a meaningful level, current and accurate data are required. Updating and maintaining datasets will be critical to keep tools such as WIP current and useful. Muskoka is beginning to experience increased development pressure. Lessons learned from southern Ontario indicate that maintenance of natural systems is considerably less expensive than restoring damaged ecosystems. In undertaking the WIP it became evident that many datasets were outdated or they were only available for portions of Southern Ontario that were off the Canadian Shield. As development pressures increase northward into communities on the Canadian Shield, the need for updated information in this area will grow.

Even given the shortcomings of these datasets, the data were still useful at a strategic level in undertaking the initial analysis of ecosystems for the watershed as a whole. The WIP used all available datasets; however, the weighting of specific datasets that were known to be older or imprecise was reduced so as to not skew results.

In attempting to compile a list of available datasets, several agencies whose data were unavailable or out-of-date were contacted. Several of these agencies now recognize the need to concentrate effort in this area, which should result in better data in the future. In general, there appears to be an increasing effort to update information and develop protocols to keep surveys and data management consistent across the province.

Table 7 summarizes data gaps found during the WIP. Notes on the future availability of these data are provided.

Table 7: Summary of Data Gaps and Information for Addressing Them.

Data/Information Gaps	Description	Notes
Unclassified/Unknown data in landcover mapping	Incomplete or non-surveyed areas from FRI datasets and landcover satellite mapping that were undefined or covered in cloud and shadow. The use of both FRI and Landcover 2000 datasets was to classify as much of the landscape as possible. Unclassified or unknown data covers less than 1% of the landcover mapping within the study area.	If resources are available, these areas should be investigated, either through site-specific surveys, or using future updated satellite landcover mapping techniques. The latest technology in high resolution satellite imagery is currently being discussed for the province, including areas where no coverage presently exists. Contacts for these data: Ontario Ministry of Natural Resources (MNR), Parry Sound District.
Soils and Agriculture mapping	Current datasets on soils and agricultural use within the study area is lacking. The Inventory used surficial geology from the Ministry of Northern Development and Mines, which was a collection of data and surveys dating from 1950 to 2003. Agricultural areas were identified using out-dated surveys from FRI and satellite photo interpretation from Landcover 2000, which may not be accurate.	Updated field surveys and mapping methodology is currently planned by the Ontario Ministry of Agriculture, Food and Rural Affairs (OMAFRA) for 2007/08, which will encompass the Muskoka River watershed. Contact for these data: OMAFRA. Other updated information for soils and geological data is being completed by the Ministry of Northern Development and Mines (MNDM). Contact for these data: MNDM.
MNR resource databases	Some data are out-dated and databases are somewhat inconsistent between MNR districts of Parry Sound, Algonquin Provincial Park and Bancroft. The Inventory used all datasets from all three areas, where available, and dedicated time to retrieve and organize necessary information. Also, forest stands calculated for old growth forests were taken from FRI data and should be updated for future iterations of the Inventory. This may be possible with the release of the electronic Forest Resource Inventory in fall 2009.	Within the next five years, new and updated Forest Management Plans are slated for completion. Effort is being made to organize and update FRI data into a more consistent format across the province. Contacts for these data: Each MNR District.
Pits and Quarries	The best dataset available at the time of the WIP analysis for location of pits and quarries was the provincial database (from NRVIS). The database does not include pits and quarries on private land.	At the time of the project analysis, effort was being made by the MNR to update pits and quarries information on Crown land in the Parry Sound MNR district with on-the-ground surveys. Pits and quarries on private land were not yet released digitally. Contacts for these data: Parry Sound MNR District and District Municipality of Muskoka.
Roads	There were two separate datasets available for the Inventory. A provincial database includes information on most roads at a more strategic level, and includes roads on Crown land (forestry access roads). The Ontario Roads Network database is complete and more accurate at a site-specific level, with more consistent road information within urban and settled areas; however it is missing data on roads that are not within urban areas. Since the Inventory assessed the watershed at a	Presently, there is discussion to combine the Ontario Roads Network with the provincial roads database by MNR districts, especially for use in Forest Management Plans. Contacts for these data: GIS specialists from each MNR District.

Data/Information Gaps	Description	Notes
	strategic level, the provincial roads data were used for analyses.	
Recharge areas	The Inventory looked at some elements of the watershed that would represent the interface between terrestrial and aquatic areas. There was no comprehensive dataset for the Muskoka River watershed on location of recharge areas. Instead, the Inventory used highly permeable areas from surficial geology data to indicate possible recharge areas.	As mentioned for other datasets, there will be updates for soils data from OMAFRA and MNDM. These updates may still not be able to identify locations of actual recharge areas. Resources and partnerships need to be developed if these areas are to be identified within the Muskoka River watershed. Environment Canada will be releasing a Water Use and Supply Project report in 2006/07. Although the Muskoka River watershed may not be within the scope of the project, the methodology and results may be of interest for future iterations of the Inventory. Contact for Water Use and Supply Project: Environment Canada.
Natural Heritage Information Centre Species Occurrence database	The Inventory used NHIC database for assessing species and vegetation community occurrences. The database follows strict standards used by an international network of conservation data centres. However, there were a few issues about the database for the Inventory to discuss, including the positional accuracy of observations. Some records were old and taken before GPS (geographic positioning system) units were used widely for field inventories. The Inventory used the Conservation Blueprint method for scoring historical and more current observations (high scores for more current data), thus taking into account some questionable positional accuracy of historical data. Whether extant or historical, all data were considered to have value.	The NHIC is constantly confirming and updating observations. There is current effort being made to improve the accuracy of observations and to move inaccurate point data into polygons. Contact: Natural Heritage Information Centre in Peterborough, or the Parry Sound District MNR.
Settlement and built areas	The Inventory used a combination of FRI and landcover satellite mapping data to identify areas of settlement. As mentioned, FRI data for settled areas may be out of date and satellite mapping may not accurately capture the boundaries of settled areas.	Updated and accurate data of built and settled areas within the District Municipality of Muskoka were completed in 2006. However, the data were not available in time for use in the Inventory analyses. Future iterations of the Inventory will consider this local information. Assessment of the dataset will be necessary to ensure that data are appropriate for use at this strategic level, especially if they are not available for the entire watershed. Contacts for these data: District Municipality of Muskoka.

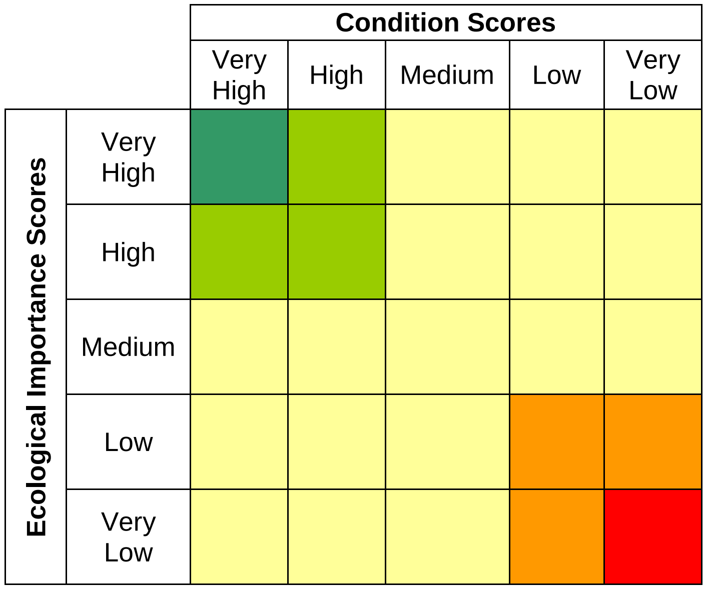
Data/Information Gaps	Description	Notes
Peer-reviewed literature and research	There was a lack of current peer-reviewed literature related to ecological processes as it occurs on the Canadian Shield. Although much literature has been published on landscape-scale ecological interactions and planning, more specific scientific support for unique processes occurring on the Canadian Shield in central/northern Ontario would be useful.	More effort to encourage and initiate research and monitoring projects within the Muskoka River watershed would help address the gaps in information and literature. As well, projects and information must be shared or made known to communities, agencies and organizations within the watershed to ensure that efforts are not being duplicated, that resources are used efficiently, and that local knowledge is considered.
Fisheries data	The Inventory used available data from the MNR. Although there was data available on some coldwater fishery lakes there was no comprehensive data set available.	Efforts to acquire and understand fish distribution, stresses and alteration to habitat is required to fully understand the impact of human activity on fish and their habitat.
Invasive species	The inventory used current work being undertaken by Dr. Norman Yan on aquatic invasive species. There was no comprehensive data set available.	More research is required to understand the migration of invasive species as development and human actions occur.

Product 3: A map portraying the significant natural areas and connecting systems

The WIP produced a model that identifies areas with the potential for sustaining ecological processes as well as areas in poor condition and subject to ecological stressors. When the two datasets are combined, the result of the final analysis shows how some stressors affect ecologically important areas. The result is an indication of where the least stressed and most ecologically significant areas are located within the study area.

Figure 43 is the final scored watershed dataset, which combines the ecological significance scores with the condition scores. As with previous scored datasets, the final scores are classified into five classes: very high, high, medium, low, and very low using a statistical formula to minimize the variation in each classification group (Jenks 1967). Figure 42 is a matrix that describes these five classifications. As noted in the matrix, the higher the score classification, the higher the ecological significance and the better the quality or condition of that site.

Figure 42: Matrix of the final WIP scores



	Very high ecological importance and very high condition. These sites are the most ecologically important and least stressed. These sites should be the top priority for protection or acquisition and they should form the core of a natural areas strategy that will support and sustain the ecosystems of Muskoka.	
	High ecological importance and high condition.	Some of these sites have the potential to increase the value of other sites either by increasing the size of an adjacent significant area or by connecting significant areas to other valuable sites. These sites could have potential for restoration to restore highly significant sites to a higher quality. As well, these sites have potential for creating ecologically significant sites, i.e. creating a wetland, in a relatively undisturbed area.
	Medium ecological importance and medium condition.	
	Low ecological importance and low condition.	
	Very low ecological importance and very poor condition. These sites do not appear to contribute greatly to the ecological processes of the landscape and are highly disturbed.	

For the Muskoka Watershed Inventory Project, significant natural core areas were identified as the sites that scored very high for the final combined score (Figure 44). These areas scored very high for maintaining and sustaining important ecological processes, as well as for having scores that indicated high quality or condition.

Significant natural linkage areas were identified as those areas that scored high and medium for the combined scores. These areas have a value in connecting or enlarging the natural core areas. If conserved or restored to a better condition, where necessary, these areas could form the basis of a linked, healthy, functioning and continuous natural system.

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 study area has a large proportion of high quality natural land cover. 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 study area can be described as “islands of green within a sea of green”. The WIP has identified the highest quality significant areas and identified remaining natural areas that would contribute to and enhance the overall aquatic ecological quality of the area.

Linkage areas connect core sites to each other and to other highly scored sites. For the WIP, linkage areas were identified as high and medium scored sites. Figure 44 shows core areas and linkages, where linkage priority 1 areas were the ‘high’ scored sites and linkage priority 2 areas were the ‘medium’ scored sites.

Figure 43: Ecological importance and condition scores combined

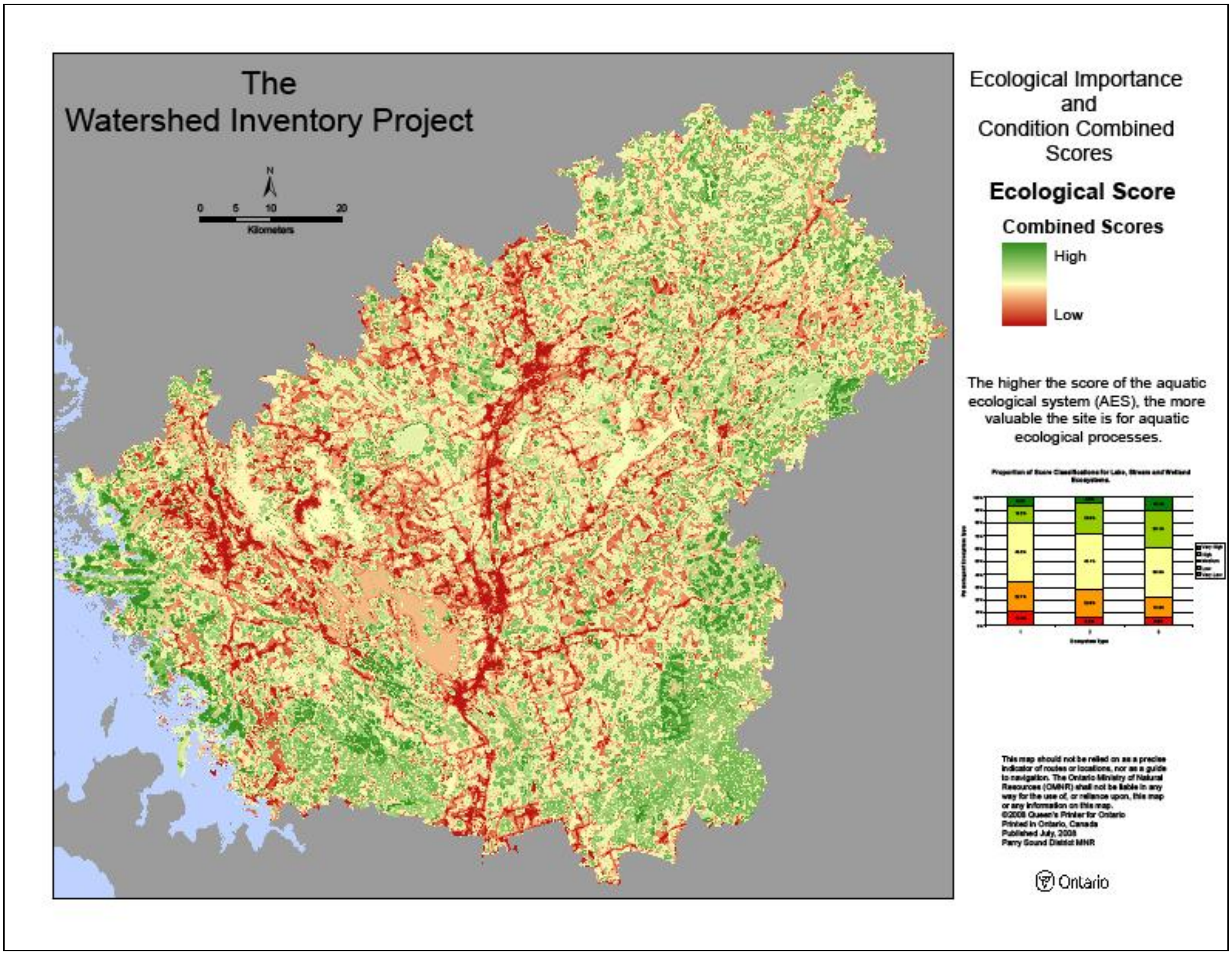
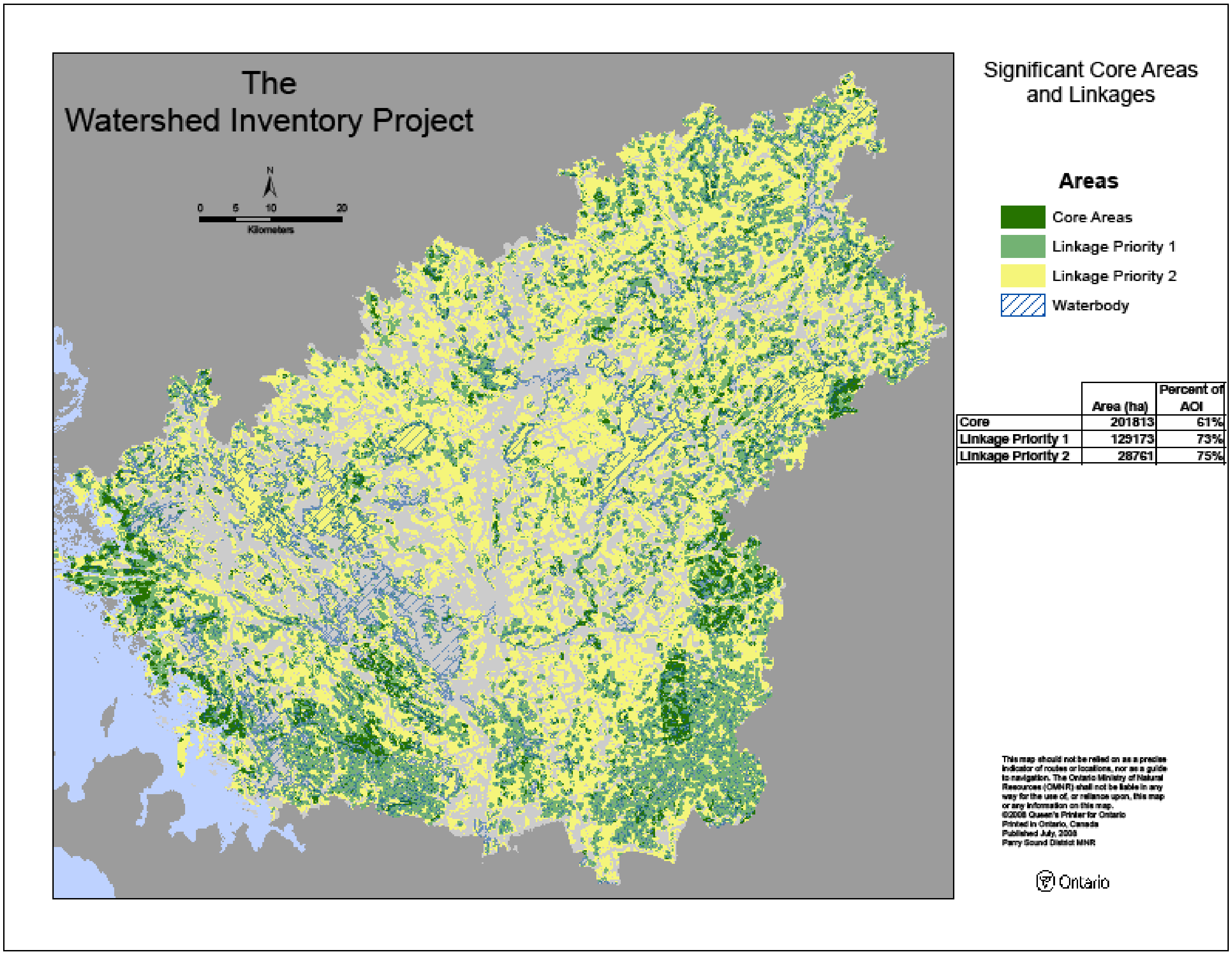


Figure 44: Core areas and potential linkages based on the combined scores of ecological importance and condition



(Core Areas = Very High Score, Linkages = High Score and Medium Score).

Product 4: Identification of significant degraded sites and areas that may require remediation.

Figure 40 shows the condition scores within the watershed. Many of these areas are urban and settled areas. By focusing future development in these areas, areas with higher ecological value can be maintained.

In some situations, it may be important to remediate degraded areas in order to enhance nearby areas of higher ecological value. For instance, a 'low' scored site may be suitable for a constructed wetland that would enhance a 'medium' or 'high' scored area. However, sites must be investigated to evaluate how reversible the stressors or impacts are to ensure that resources are used efficiently and in a cost-effective manner. Improved stormwater management both in redeveloped sites and when green field development is proposed is critical to slowly improving aquatic systems in existing developed areas and ensuring new areas meet the highest possible standard of development.

Figure 43 describes the influence of condition scores on the scores for ecological importance. The 'very high' scored sites indicate that the area is ecologically important and not greatly stressed. The 'very low' scored sites indicate that the areas have very limited ecological value and are greatly stressed. The scores in between may have potential for restoration or remediation efforts. For instance, an area could score very high in ecological importance, but very low in condition. The condition of this area could be improved, thus increasing the condition score and raising the overall value of the area.

Not all ecosystems are represented within protected areas. Current conservation science and ecological principles suggest that protecting the whole suite of ecosystems found within an area is important. Ecologists believe that it is one of the best strategies for ensuring the conservation of ecological processes and intricate species interactions for the long term.

Many of the ecosystems that are not represented in protected areas also scored low to very low for ecological significance. Some of these sites scored low because of their proximity to roads, settlement areas, and other non-natural features. As size of the system is a significant factor in scoring, restoration and remediation of these sites in order to connect existing natural areas may increase their ecological significance. Organizations undertaking restoration projects may need to consider restoring these areas of low condition, as well as restoring areas to connect these systems to prevent further fragmentation and isolation.

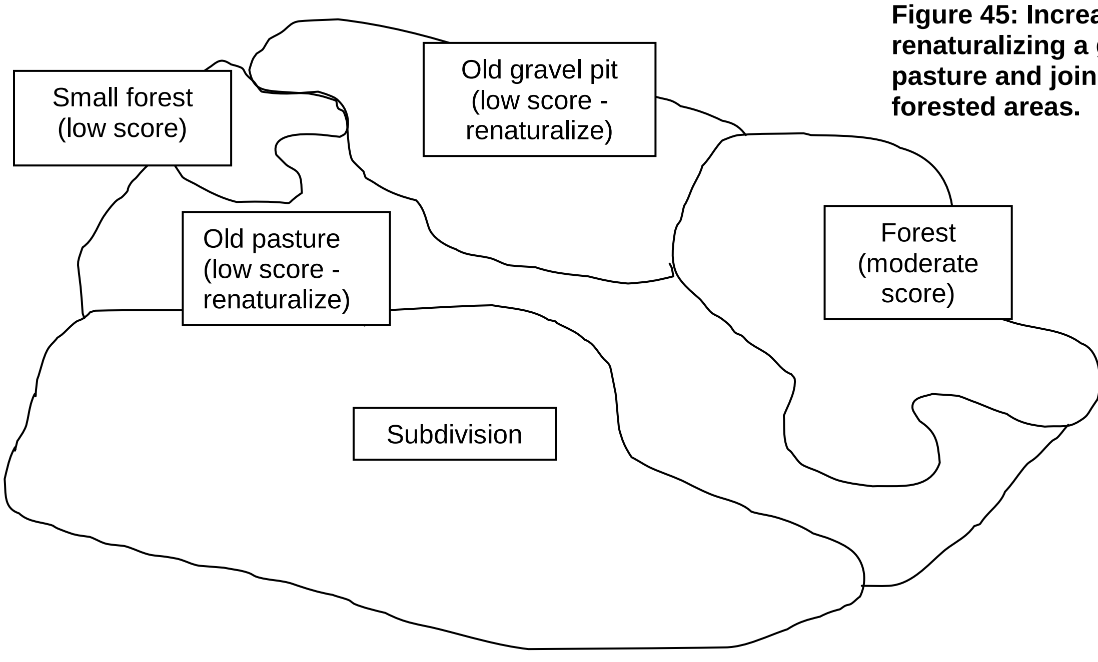


Figure 45: Increase overall score by renaturalizing a gravel pit and pasture and joining two smaller forested areas.

Recommendations and Next Steps

The Watershed Inventory Project was a systematic, landscape-scale analysis of ecological significance and condition of the aquatic ecosystems within the study area. Although the methodology developed through the Great Lakes Conservation Blueprint was used in the analysis, this project is the first time such an analysis has been undertaken on a regional basis as background documentation for local and regional planning and conservation efforts.

The methodology used can be replicated and enhanced as new data become available. In order to continue to be relevant and useful, methods for identifying significant areas need to be iterative and incorporate new data and technology as they become available. In recognition of this fact, the Collaborative have commenced the development of a regional biological database in conjunction with local consultants, The District Municipality of Muskoka, the Ministry of Natural Resources and other interested parties. The Watershed Inventory Project is also being automated so that regular updates are easily possible.

The Watershed Inventory is a living and evolving analysis of the ecosystems within the study area. The project fostered discussion, created new and strengthened previous relationships, and provided a better visualization of the concept of large-scale ecological planning that crosses private and public lands, and political borders. The WIP strived to collect the best-available data and scientific support for measuring and modeling the present and future integrity of terrestrial and aquatic natural areas. The products produced provide guidance and direction for collaborative members to further the resource management and planning mandates of each agency represented.

Table 8 provides a detailed list of recommendations for the Watershed Inventory Project. In summary, it is recommended that Collaborative members:

1. Develop and implement a natural areas strategy based on protecting and enhancing areas that scored very high for ecological importance and very high for condition, and that includes as a goal representation of all ecosystems within protected areas.

2. Work together to develop and maintain standardized datasets.

3. Work with appropriate agencies to ensure that Muskoka-based datasets are updated on a regular and ongoing basis.

4. Remediate areas of very low to low ecological significance where:
    a. They would add to the value of an adjacent site of higher ecological significance.
    b. Remediation would result in the restoration of an area with high ecological importance but is currently in poor condition.

The diversity of expertise of the WIP collaborative group will assist in ensuring that the results of the WIP project are interpreted using a variety of strategies to protect and restore significant natural areas. Collaborative members represent agencies that are active in ensuring the conservation of unique features within the study area. The results of the WIP provide many opportunities for attaining the conservation objectives of each collaborative member.

Table 8: Strategies and Recommendations for the Watershed Inventory Project

Strategy	Recommendations
Planning and Policy	**Develop a Natural Heritage Strategy** - Natural heritage system planning is increasingly important for ensuring that significant areas are shielded from incompatible land-use. Natural heritage systems are defined in the Provincial Policy Statement (PPS) as systems "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." The WIP model was developed with natural features, ecological function, and long term ecological processes as high priority factors in identifying significant natural areas and connecting corridors. Thus, the WIP identified significant natural areas and connecting corridors that should be considered in the development of planning policies and any future natural heritage planning strategies.
Resource Management	**Protect areas of high ecological importance on Crown land from incompatible uses** - Appropriate management of natural resources is in the best interest of all stakeholders. Resource management plans are developed based on current scientific data and local information. The WIP model was developed using the most current concepts in ecology and conservation science of natural ecosystems; thus, WIP findings should be considered in the development of future resource management plans. As well, land-use planning on Crown land can identify highly valuable areas when considering land dispositions, aggregate and logging activities, and other Crown land uses.
Land Securement	**Acquire private land areas of high ecological importance** - The priority for land trusts is to focus effort on securement of properties found to comprise highly significant sites. As well, quality sites that have been identified as potential linkages to significant areas should be considered for purchase or easements.
Restoration and Remediation	**Restore or remediate appropriate sites** - Selection of appropriate sites for restoration should focus on areas that are degraded, but not isolated from other significant sites. Restoring an area should ensure that upgrading that degraded site will improve the connectedness of the entire landscape. Agencies should work with partners to increase the ecological values of lower quality sites that will provide potential linkages to significant and/or protected areas.
Enhanced Protection	**Enhance protection of unique sites** - Although high scored areas are considered significant, there are low scored sites that need to be considered significant as well. Many rare to uncommon aquatic ecosystems within the Muskoka River watershed identified in the analysis as low quality sites. There are many reasons for their low scores, including their size and their proximity to non-natural features. However, the fact that they are uncommon systems within the watershed should flag them as being significant and prevent them from becoming further isolated and disturbed through enhanced protection.

Strategy	Recommendations
Research and Data Collection	**Improve datasets and encourage research projects** - There are many opportunities within the Muskoka River watershed for research efforts. During the WIP process, it became evident that peer-reviewed scientific studies specific to the Muskoka River watershed, or similar regions were lacking. Most literature concentrated on Southern Ontario. As well, many of the various datasets used in the WIP were collected and assessed using protocols developed for areas in Southern Ontario, off the Canadian Shield. There should be continued support of wetland evaluations within Muskoka. As well, partnerships should be developed with First Nations, non-profit organizations such as cottage associations and nature groups, and other agencies, including universities and colleges for new inventories, and innovative projects and studies specific to the interactions within the study area.
Monitoring and Evaluation	**Continue to monitor and evaluate natural areas** - The study area is considered a naturally intact area, compared to other areas in Southern Ontario. Thus, the opportunity exists to monitor our healthy, functioning natural areas and evaluate them against other areas within the watershed and across the province.
Stewardship and Community Engagement	**Develop education and stewardship programs that engage the community** - The results of the WIP should be shared with municipalities and the community, increasing local awareness of natural heritage values within the watershed. Information from the WIP should be used in presentations, reports and plans to inform and support communities.
Information Sharing	**Continue to share information** - The collaborative group should continue working together to create a database to monitor identified significant natural areas, and share this important information with other interested agencies of similar conservation mandates, especially if it leads to the enhancement of current data and knowledge of the study area.
Data Quality	**Work toward improving the quality of data** -The quality of data greatly influences the results of the analyses. The WIP identified some issues related to data accuracy and currency (Table 7). Presently, there is significant lag time between data collection and GIS useable digital datasets, but also a lag time between updating local information into provincial databases. As well, one dataset can be used for several different purposes. As a consequence, there are many versions of similar datasets, all of which were updated at different times for different purposes. It is the responsibility of the data custodians to ensure that data are managed appropriately and issues with the data are communicated to the user.

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