The Watershed Inventory Project
Aquatic Ecosystem Assessment
Technical Report

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Executive Summary

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

This report focuses on the aquatic component of the Watershed Inventory Project and is a companion report to the terrestrial report completed in 2007. In 2005, the Watershed Inventory Project (the Inventory) was initiated. The Inventory was undertaken collaboratively by the Muskoka Heritage Foundation, Muskoka Watershed Council, District Municipality of Muskoka, and Ontario Ministry of Natural Resources. In 2007 Fisheries and Oceans Canada joined the collaborative for the development of the aquatic component. The purpose of the Inventory is to identify ecologically significant areas using the best available datasets as well as to identify where there is a lack of existing protection for significant areas on both Crown and private land. It also identifies whether or not these significant areas are connected across the landscape. The Inventory uses a transparent, ecology-based methodology produced by the Nature Conservancy of Canada and the Ontario Ministry of Natural Resources who are leaders in defining and conserving significant areas based on best available ecological principles.

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

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

This report provides information on the methodology and rationale behind the criteria, indicators and scores used for the Inventory, as summarized below. It is a supplement to the Aquatic Inventory Final Report.

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

1. Identify unique terrestrial ecosystems
2. Identify areas of high ecological importance

3. Identify stresses on ecosystems and process

To meet these goals, five criteria were considered:

1. representation
2. ecological function
3. diversity
4. special features; and
5. condition

In a GIS (geographic information system) environment, the five criteria were applied using the best available data to represent the objectives of the Inventory. The criteria were based on ecological principles of ecosystem health, which included:

1. Representing some portion of each distinct aquatic ecological system types
2. Representing features that support ecological function
3. The significance of diversity
4. The importance of special features; and
5. Considering the stresses on ecosystem health

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

1. Natural areas that exhibit high degrees of integrity and resiliency
2. Wetlands
3. Riparian areas
4. Recharge areas
5. Habitat diversity
6. Species occurrences
7. Wildlife habitat; and
8. Condition or quality of natural areas

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

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.

The project was initiated with a one-day workshop that brought together many of the resource people identified below in addition to input from Bill Crins (Ontario Parks), Arunas Liskaukas (Upper Great Lakes Management Unit), Eric McIntyre and Steve Sandstrom of the Ontario Ministry of Natural Resources, Andrew Paterson of the Ontario Ministry of the Environment (Dorset Environmental Science Centre), Andrew Promaine of Parks Canada (Georgian Bay Islands National Park), Dan Thompson of Fisheries and Oceans Canada, Bev Wicks of the Muskoka Heritage Foundation Natural Heritage Committee, and Norman Yan, Professor at York University. We are grateful to Randy French and Jasmine Chabot for facilitating the session.

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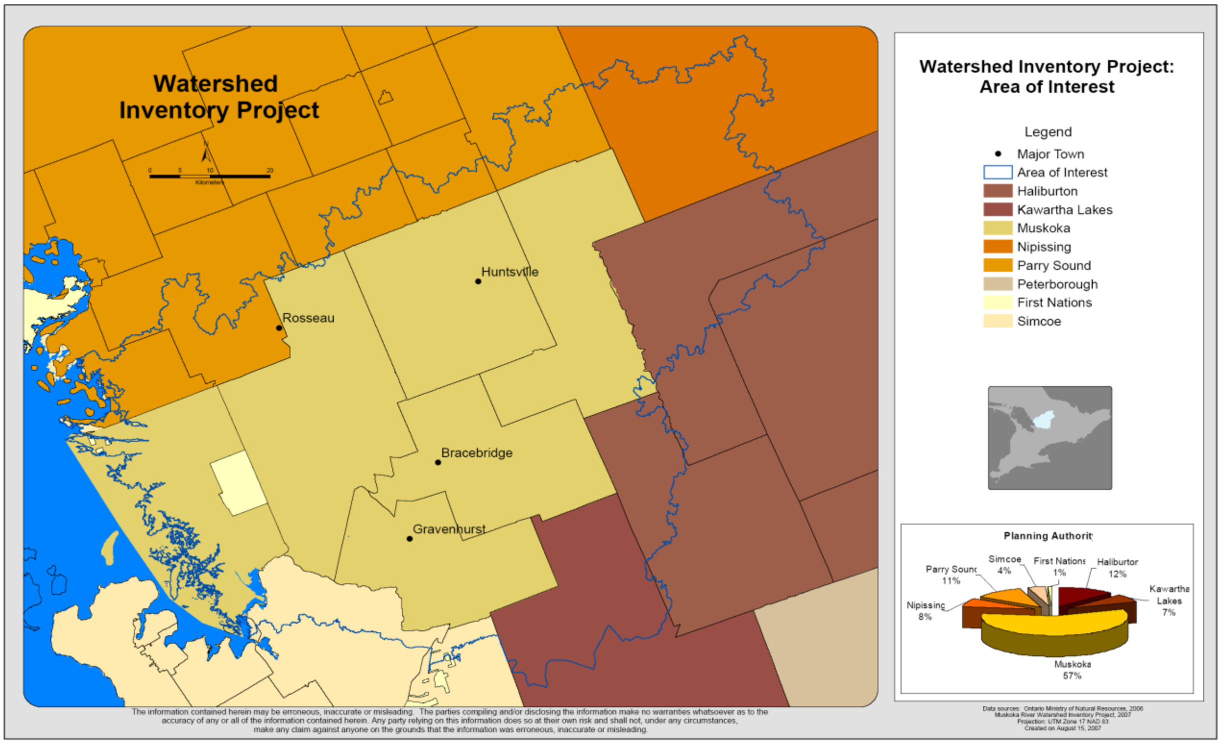


Figure 1: Area of the Muskoka Watershed Inventory Project (in blue) representing the Muskoka and Black-Severn River tertiary watersheds that fall on the Canadian Shield.

The Muskoka Watershed Inventory Project (WIP) was an initiative to provide a strategic level of understanding of the natural systems within the Muskoka and Black-Severn River watersheds that fall upon the Canadian Shield (Area of Interest, AOI; Figure 1). In 2005, the collaborative members of the WIP began a landscape analysis of terrestrial natural ecosystems within the AOI. The terrestrial component of the WIP assessed the quality and quantity of natural areas that, if protected or restored, would conserve and sustain *terrestrial* ecological systems within the AOI. Funding support for the terrestrial component was acquired from the Ontario Trillium Foundation. The WIP collaborative members were represented on the technical committee and included biologists, resource and urban planners, and stewardship coordinators from different levels of government and non-government agencies. The WIP terrestrial component collaborative was the Ontario Ministry of Natural Resources, the Muskoka Heritage Foundation, Muskoka Watershed Council and The District Municipality of Muskoka.

The intention of the WIP collaborative was to complete a comprehensive assessment considering both terrestrial and aquatic ecosystems for the Muskoka region. Recognizing that an assessment of such a proportion would be ambitious, especially since the two diverse ecosystem types would potentially require very different variables and expertise to analyse, the collaborative group divided the assessment into a terrestrial component and an aquatic component. The WIP terrestrial component identified some semi-aquatic significant areas (such as wetlands), however other important aquatic areas were not identified as significant (such as shorelines) and further confirmed the initial thought that an aquatic focused analysis was necessary in order to complete a comprehensive inventory of the Muskoka area. Other observations in the literature validated the thoughts of the WIP collaborative. Mandrak (1998) assessed the terrestrial classification system used in Ontario to protect aquatic biodiversity throughout the province and found weak correspondence of terrestrial classification regions with terrestrial watersheds and fish faunal zones. Analysis on the potential of indicator species to represent biodiversity showed that terrestrial indicator species may not adequately address the needs of aquatic species (Lawler et al 2003). The weak correspondence suggested a low potential for the current terrestrial classification system to inform about the conservation of fresh water biodiversity (Wichert et al 2004).

The need to consider aquatic biodiversity was intuitive, especially for Muskoka where water and shorelines are highly valuable ecologically and economically. The Muskoka region is a popular location for cottagers with properties located on shorelines and recreational activities that rely on water resources. A study completed by the District Municipality of Muskoka (Muskoka 2005) found that 96% of second homeowners had waterfront properties in the District of Muskoka. Not surprisingly, as the population within and around the Muskoka region increases, so will the development pressures on aquatic natural systems. There was an opportunity to try to understand our aquatic landscape and make more informed decisions at the regional and local levels (Nadeau and Rains 2007).

Many animal species rely on both terrestrial and aquatic natural areas for survival and contribute to the regulation of ecological systems. Studies on reptile and amphibian species show a great diversity of habitat use on both terrestrial and aquatic landscapes (Arvisais et al 2004; Davic and Welsh 2004; Ficetola et al 2004). Contribution by animal species to ecosystems has been demonstrated by salamanders that provide direct and indirect biotic control of species diversity. They connect energy and matter between aquatic and terrestrial landscapes during seasonal migrations and emergences (Davic and Walsh 2004; Regester et al 2006; Compton et al 2007).

There was much more literature and media attention on the plight of native terrestrial species and their rapidly declining population status compared to aquatic species. However, freshwater species are disappearing faster than terrestrial species. Future extinction rate for freshwater fauna was five times more than terrestrial species and three times more than marine fauna and has been compared to the level of extinction for tropical rainforest communities (Riccardi and Rusmussen 1999).

Identifying significant natural areas to conserve and maintain aquatic ecological systems was crucial to protecting biodiversity and preserving water quality and quantity for communities. Combined with the identified significant areas of the terrestrial analysis, significant aquatic areas completed a comprehensive, logical network of areas that should be protected. The network of priority sites allowed the collaborative members to focus on maintaining and building healthy communities and sustainable wildlife populations in Muskoka.

The aquatic component of the WIP began in 2007 with funding from The Ontario Trillium Foundation. The aquatic component collaborative group was the Ontario Ministry of Natural Resources, the Muskoka Heritage Foundation and Trust, 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 provided a solid base for present and future natural heritage work of the collaborative members. The completed terrestrial component of the WIP was being used by each of the collaborative groups to further their individual mandates. The aquatic assessment was another tool to identify significant areas linked to aquatic resources. The outcome of the aquatic assessment verified what the terrestrial WIP had already identified as significant and enhanced the connection of Muskoka’s natural heritage across the landscape. Similar to the terrestrial reporting, the aquatic WIP included the following products:

1. A gap analysis of unprotected aquatic ecological systems;
2. A gap analysis of biological data and site inventories;
3. A map portraying the significant natural areas and connecting corridors; and
4. Identification of significant degraded sites and areas within the watersheds that require remediation.

This report documents the methodology and datasets used for the aquatic component of the WIP. The final aquatic analysis for the watersheds in the Muskoka region required extensive discussion by the WIP collaborative group to determine appropriate buffer distances and score values for each indicator at the regional watershed scale. The WIP collaborative depended heavily on the completed terrestrial component to guide the aquatic assessment. The terrestrial methodology provided lessons learned, but also the two assessments were comparable and would potentially be combined into one rational dataset or map.

Although, it is not necessary to read the terrestrial technical and final reports in order 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 WIP analysis 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 2004). 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 requirements for healthy, functioning freshwater ecological systems needed to be developed in order to adequately address aquatic components. The GLCB collaborative initiated the development of an aquatic ecosystem classification (AEC) to be used for assessing the significance of aquatic systems. The AEC was a hierarchical classification framework that used many variables including drainage patterns, life history requirements, and biological characteristics of fish. Just as the units for the terrestrial analysis was based on vegetation and landform associations, the basic units for the aquatic analysis used this recently created aquatic classification system (Wichert et al 2004; Higgins et al 2005).

Indicators 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.

Methodology Approach

Table 1: The goals of the Watershed Inventory Project, and the criteria, objectives and indicators used to achieve the 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 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 system 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

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. The first goal was to categorize unique aquatic ecological systems across the landscape and identify systems that were not under existing protection. The second goal was to identify areas of high ecological importance for aquatic ecological systems, and the third goal was 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.

In a GIS environment, the assessment of natural systems required using surrogates, or indicators, to characterize the objectives (Margules and Pressey 2000; Noss 2002). The indicator was a digital representation of the objective that could be mapped, manipulated, and analyzed in a GIS environment and used to evaluate the objectives of the WIP. For some objectives, indicators were obvious, such as using a dataset of fish habitat to identify important fish habitat, while other indicators required manipulation in order to achieve the objective, such as selecting specific sizes of natural areas to represent areas that exhibit degrees of ecological integrity and resiliency. In addition, some indicators required specific expertise and knowledge of the local environment, such as the development of a list of invasive species for lakes in the area of interest. There were indicators that were used in both the terrestrial and aquatic assessments, highlighting the reality that terrestrial and aquatic systems were intricately connected to each other (Rothley et al 2005).

This report is organized by following Table 1 across each row. The goal is outlined, followed by the criterion with respect to that goal, description of the objectives and details of the indicators representing those objectives.

Goal: Identify aquatic ecological systems and protected areas

Criterion:

1. Representation

Objective:

(a) Identify all aquatic ecological systems within the watershed and their protection status

Indicator:

(i) Aquatic Ecological Systems

Identifying unique ecosystems has contributed a great deal to the understanding of the world we live in. Classifying ecological systems uses our knowledge that ecosystems are made up of living and non-living components and their interactions. In the WIP terrestrial component, classifying terrestrial ecosystems at a landscape scale followed methods that had been used for decades by experts in the field of terrestrial ecology and biology. For the aquatic landscape, classification of ecosystems has traditionally focused on fish assemblages and, on a landscape scale, was a relatively recent endeavour compared to classification of terrestrial ecosystems (Henson and Brodribb 2004).

The terrestrial component of the WIP classified ecosystems based on the most fundamental definition of an ecosystem: the interaction of non-living and living components in a given area. Using geological landform information (the non-living component) and the vegetation response upon those landform variables (the interaction of the living component), classifying unique terrestrial ecosystems was relatively simple and logical. Applying those fundamental concepts to classify aquatic ecosystems required slightly more creative thinking when looking at the landscape through an aquatic perspective. What makes up a unique *aquatic* ecosystem at a landscape scale? More importantly for the WIP, what makes a unique aquatic ecosystem in *Muskoka*?

The methodology was guided by the Aquatic Ecosystem Classification system created for the Great Lakes Aquatic Conservation Blueprint for Biodiversity (GLCB) by the Ontario Ministry of Natural Resources and Nature Conservancy of Canada. The partnership between these two well-recognized agencies in the conservation and resource management fields ensured that the aquatic classifications were scientifically sound and used the most current information available. The aquatic classifications were defined based on the literature discussing the biological relationships of aquatic processes across different temporal and spatial scales (Wichert et al 2004). Using the GLCB method as a guide, the WIP technical committee further refined the aquatic ecosystem classifications based on careful consideration of variables that affected aquatic systems for the Muskoka area of interest.

The Muskoka area is fortunate to have many wetlands, lakes and ponds, as well as an extensive network of rivers and streams. Thus, we began by separating aquatic ecosystems into wetland, lake and stream types. The GLCB also recognized coastal ecosystem types. Although the area of interest contained the Georgian Bay coast, the WIP committee did not categorize for coastal systems because we considered the Georgian Bay coast in our area of interest as one distinctive ecosystem with unique indicators for assessing its significance and thus would require a separate analysis altogether. However, the WIP did include the coastal area when defining stream, lake and wetland systems, consequently taking much of the coastal area into consideration.

The three ecosystem types were further categorized based on unique features indicating the important ecological processes they supported. As well, the collaborative group refined the classification to specific parameters at the regional Muskoka level. The refinement ensured that the WIP systems reflected the unique characteristics of features for our area of interest and that the assessment was meaningful for the collaborative group.

When creating aquatic ecosystem units useful and relevant to stakeholders in the Muskoka area, knowledge and scrutiny by local experts of the categories and GIS routines contributed to more refined aquatic ecosystem units. In addition, the WIP classification were further developed and strengthened with information that was available for Muskoka ecosystems, but were not available at the time of the GLCB classification. For example, depth/thermal regime was known for many of the lakes in the WIP area of interest, whereas these data were not available on a larger great lakes basin scale of the GLCB analysis. However, the GLCB science team did recognize that thermal regime was a key variable for classifying aquatic ecosystems. Another strength afforded to the WIP aquatic classification was the information gathered as a result of the terrestrial component of the WIP. For instance, the terrestrial ecosystem amalgamation identified many more lakes (and ponds) and wetland areas than the GLCB assessment or any existing stand-alone dataset.

Stream Ecosystems

There were over 6,000 km of rivers and streams in the area of interest. Stream information was taken from stream network data produced from the Water Resources Information Project (WRIP) (OMNR 2002). The project was a cooperative initiative of the Ontario Ministries of Natural Resources, Environment and Energy, Municipal Affairs and Housing, Agriculture and Food, Northern Development and Mines and Conservation Ontario. The WRIP was one of the datasets created within the mandate of the Provincial Watershed Project (PWP) (OMNR 2002) which was initiated in response to the need for digital watersheds of second-order streams to support Forest Management Planning.

In the past, research on lotic systems has focused on the stream or river exclusively. Research now shows the significance of complex interactions between aquatic systems and the areas beyond the riparian zone (Johnson and Gage 1997; Bailey et al 2007). Thus, stream ecosystems included the stream itself as well as its drainage area, consequently capturing the entire area of interest.

Using flow information, available contour and DEM (digital elevation modeling) information (and elevation spot heights) from the Natural Resources Values Information System (NRVIS), drainage area was delineated for each stream segment on which the stream categories were determined. Each delineated watershed was distinguished from one another by applying a set of categories. These classifiers were mentioned in the literature as important factors for recognizing unique ecosystem processes that occur within each delineated watershed boundary (McRae 1998). Stream ecosystems were classified using (i) geological permeability, (ii) gradient, (iii) water storage potential (the proportion of wetland and lake area within the stream's drainage area) and (iv) its position within the context of the larger tertiary watershed. The following describes these categories.

(i) Geological Permeability (Figure 2)

Permeability allowed classification to take into account streams in a geological context (the enduring, landform features) (Eyquem 2007). 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 (Wichert et al 2004; Dahm et al 1998; Detenbeck et al 2003), as well as exchange of oxygen (Malcolm et al 2005). Each delineated drainage area was classified using permeability information from the Ministry of Northern Development and Mines surficial geology data.

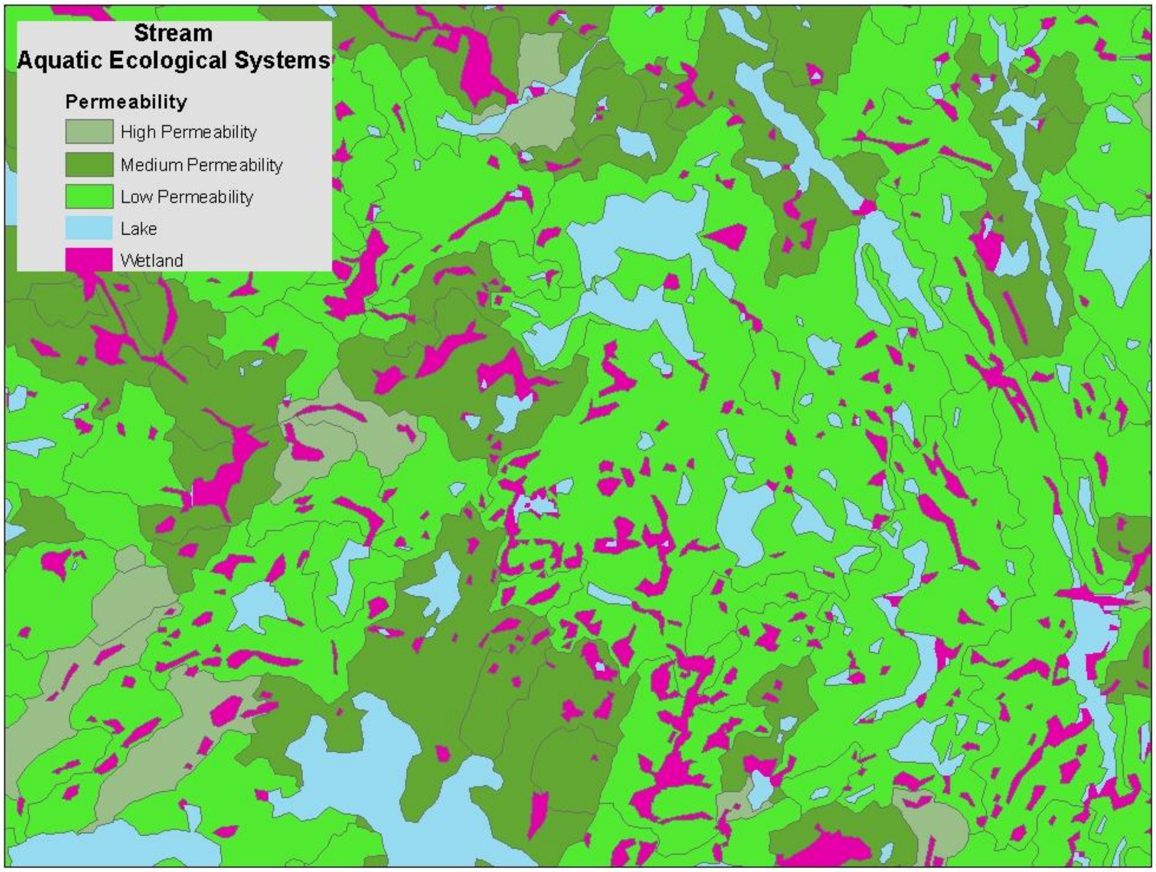


Figure 2: An area example of the geological permeability classifier for stream aquatic ecological systems (AES). Stream AES are depicted in green.

(ii) Gradient (Figure 3)

Gradient was an important factor for stream ecosystems as a means of delivering oxygen (Malcolm et al 2005) and indicated the likely presence of pools and riffles, as well as substrate size and composition (Hawkins et al 1993; Wichert et al 2004).

Gradient was calculated in the GLCB by using the elevation data of the stream segment, not of the drainage area. The calculation was the difference in elevation at the upstream and downstream ends of the stream segment and divided by its length. The WIP drainage areas were classified into gradient classes using the results of the GLCB, essentially classifying the delineated drainage area by overlaying them with the GLCB mapping.

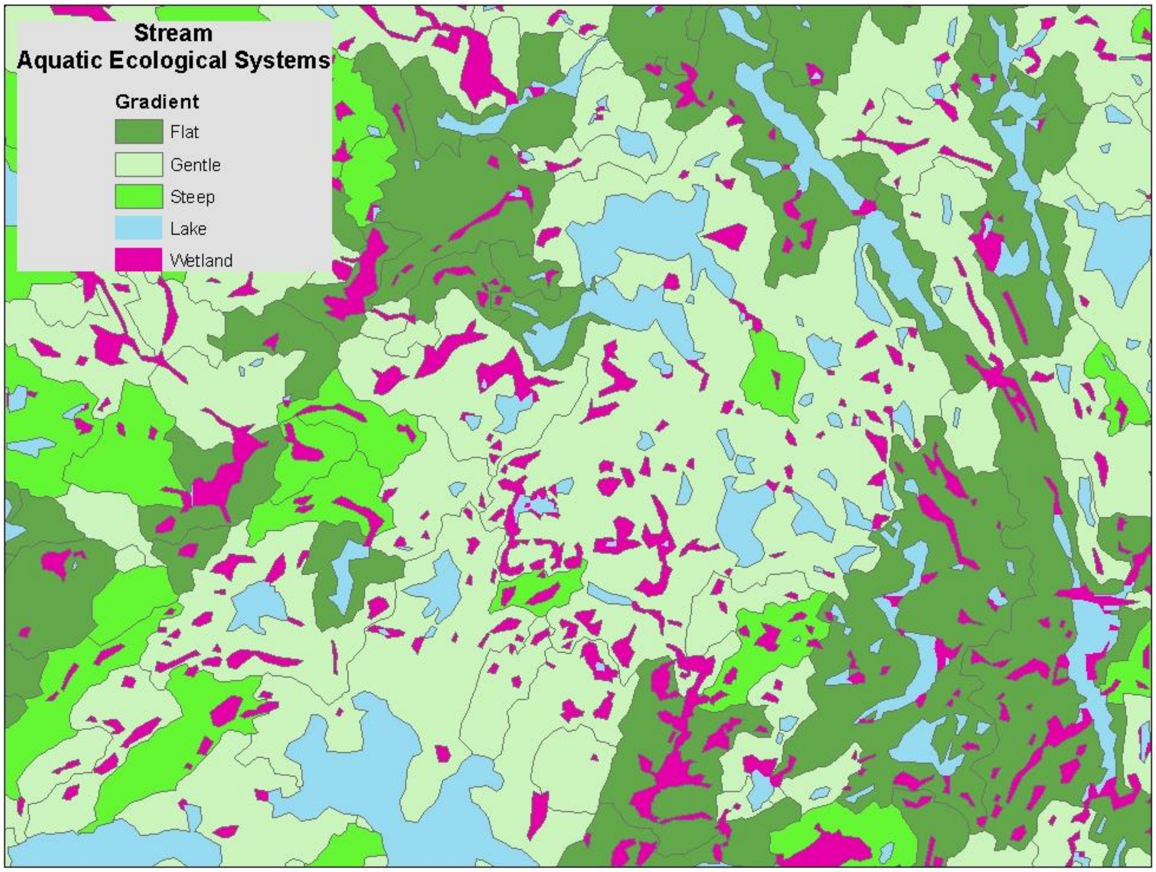


Figure 3: An area example of the gradient classifier for stream aquatic ecological systems (AES). Stream AES are depicted in green.

(iii) Water Storage Potential (Figure 4)

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 that was especially important considering recent climatic uncertainties.

Wetlands, inland lakes and ponds were essential components of a catchment's water storage and water quality potential. The proportion of wetland and lake/pond was calculated for each drainage unit or stream catchment. The calculation used wetland and inland lake information derived from the Terrestrial Component of the WIP.

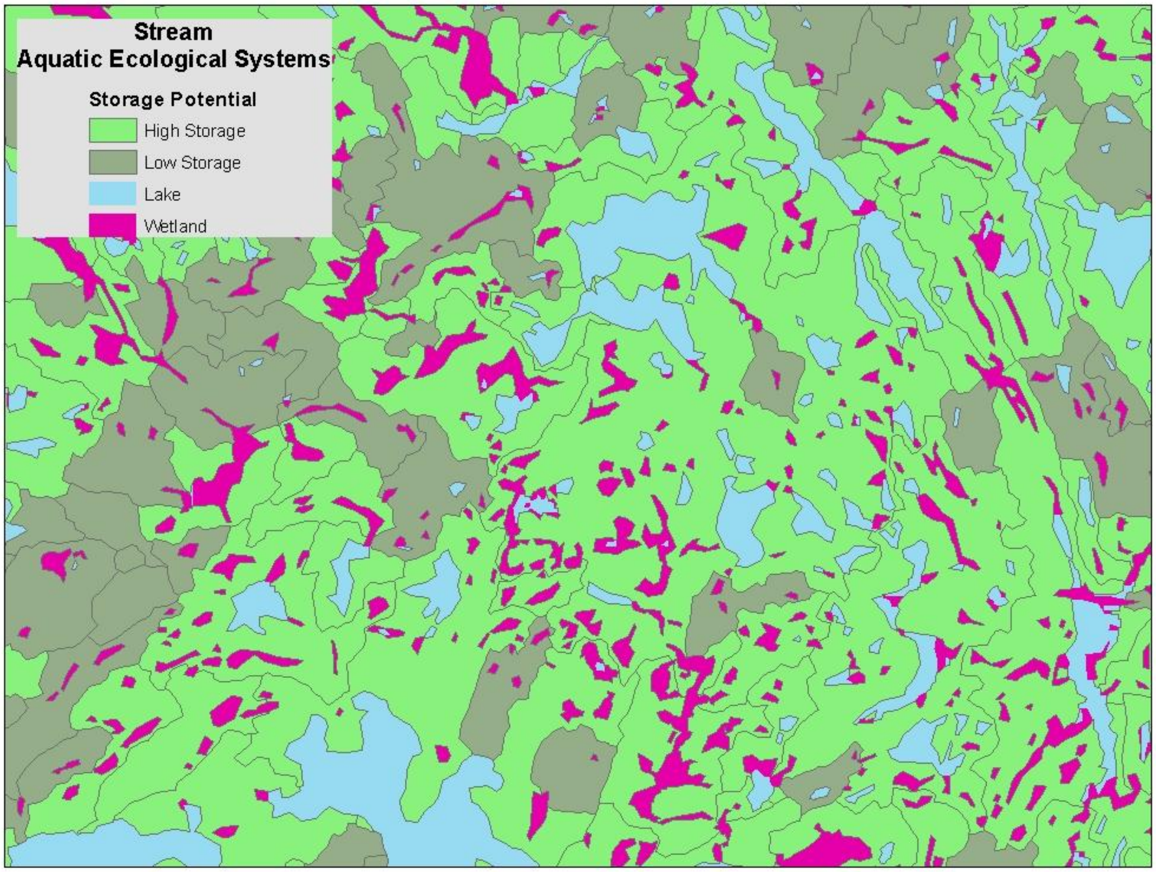


Figure 4: An area example of the storage potential classifier for stream aquatic ecological systems (AES). Stream AES are depicted in green.

(iv) Watershed Position (Figure 5)

The position of streams within the bigger 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 (Freeman et al 2007; Wipfli 2007), as well as provide unique habitat requirements for residents and migrants that contribute to biological integrity of the entire river network (Meyer et al 2007; Robinson et al 1995).

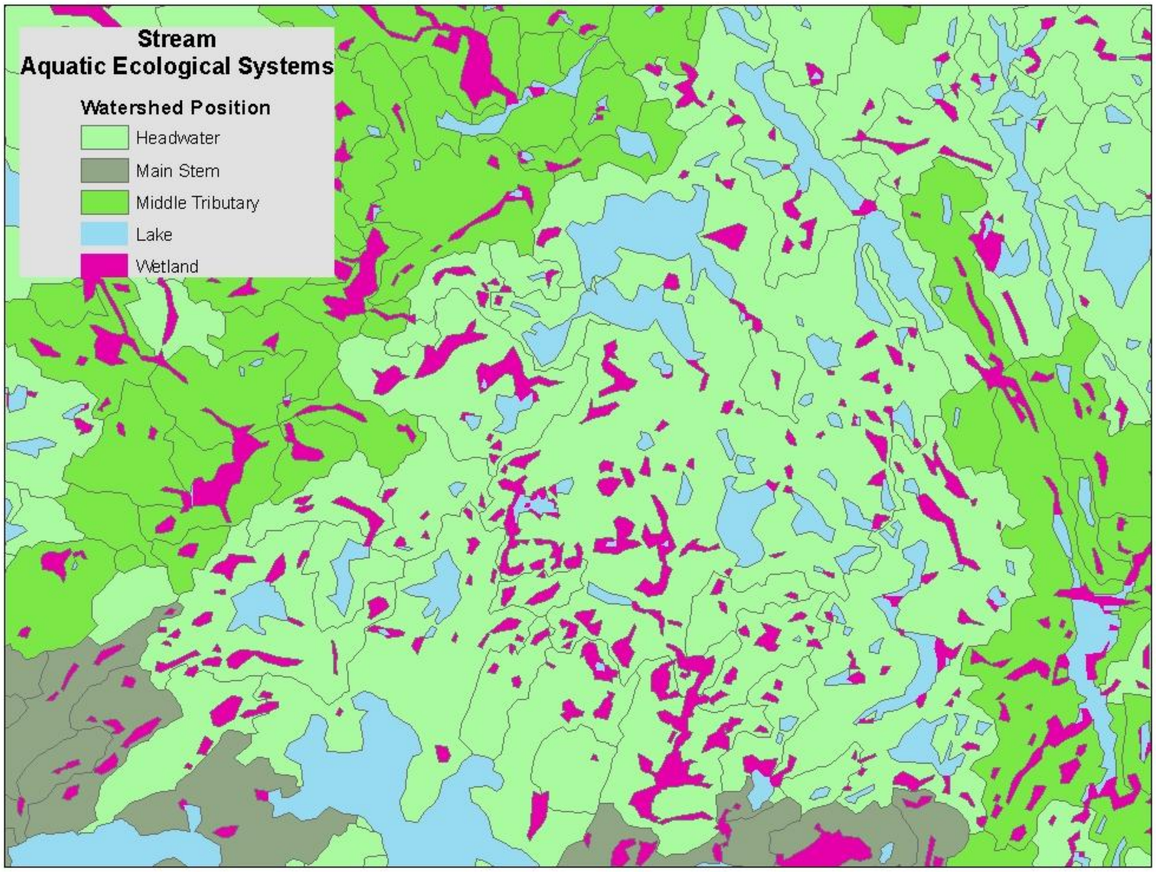


Figure 5: An area example of the watershed position classifier for stream aquatic ecological systems (AES). Stream AES are depicted in green.

Lake Ecosystems

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 (Poff et al 2002). There were meaningful variables that accounted for unique inland lake processes and influence species richness and productivity of freshwater species (Wichert et al 2004).

The WIP technical committee made a few alterations to the lake system classification created by the GLCB in order to refine the systems for Muskoka and used local information and expertise available. Firstly, the connectivity category was removed as a classifier for lakes. During the analysis for connectivity, it was identified that on a surficial level, all lakes were connected by water flow or through connections with wetland areas.

In addition, the shape category was removed. Using the shape index formula from the GLCB calculations, all lakes (except ponds) were identified as being irregularly shaped, thus the shape classifier was not meaningful for distinguishing unique lake systems within the area of interest.

The WIP committee added two categories to the lake classifications. The GLCB aquatic ecosystem classification method used the best available data to classify systems at a Great Lakes basin scale. As a result, there were data available for some areas, but not others, and thus could not be used for an assessment of such a scale. However, it was encouraged by the GLCB aquatic classification authors and experts to use those data available at a more regional scale.

Factors used to classify lake systems for WIP were (i) size, (ii) geological permeability, (iii) thermal regime and (iv) presence of glacial relict species. The following describes these categories.

(i) Size (Figure 6)

Specific habitat functions were related to size of, and connections between, lake systems (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). Size for lake systems were grouped into four unique classes: large, medium, small and ponds. Size range for each class was based on the GLCB classifications, with the exception of ponds. The technical committee decided to add a fourth class to represent the large number of water polygons created during the terrestrial ecosystem assessment that had an area less than 8 ha. Ponds were important at a regional scale for supporting biodiversity (Davies et al 2004) and were included in the assessment with some adjustment in the classification depending on the appropriateness of the classifier for ponds. The adjustments are mentioned in the category descriptions below. Pond size range was based on figures used by both the District Municipality of Muskoka and the Ministry of Natural Resources to identify ponds for planning purposes.

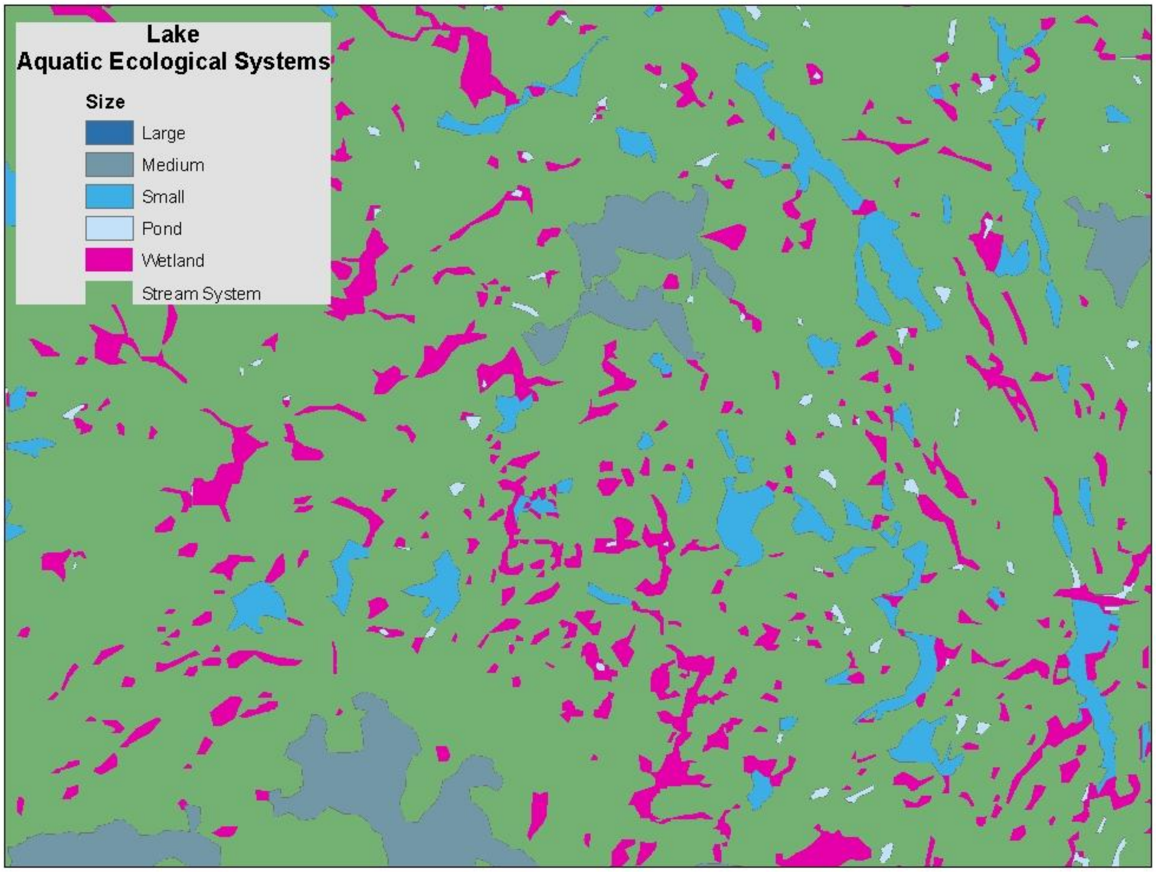


Figure 6: An area example of the size classifier for lake aquatic ecological systems (AES). Lake AES are depicted in shades of blue.

(ii) Geological Permeability (Figure 7)

Surficial geology represented the complexity of drainage for lake systems, identified movement and holding capacity of water. Permeability associated with surficial geology information also contributed to the exchange processes between surface water and ground water (Wichert et al 2004; Dahm et al 1998). Similar to the stream ecosystem classification, surficial geology information was used to categorize lakes into permeability classes.

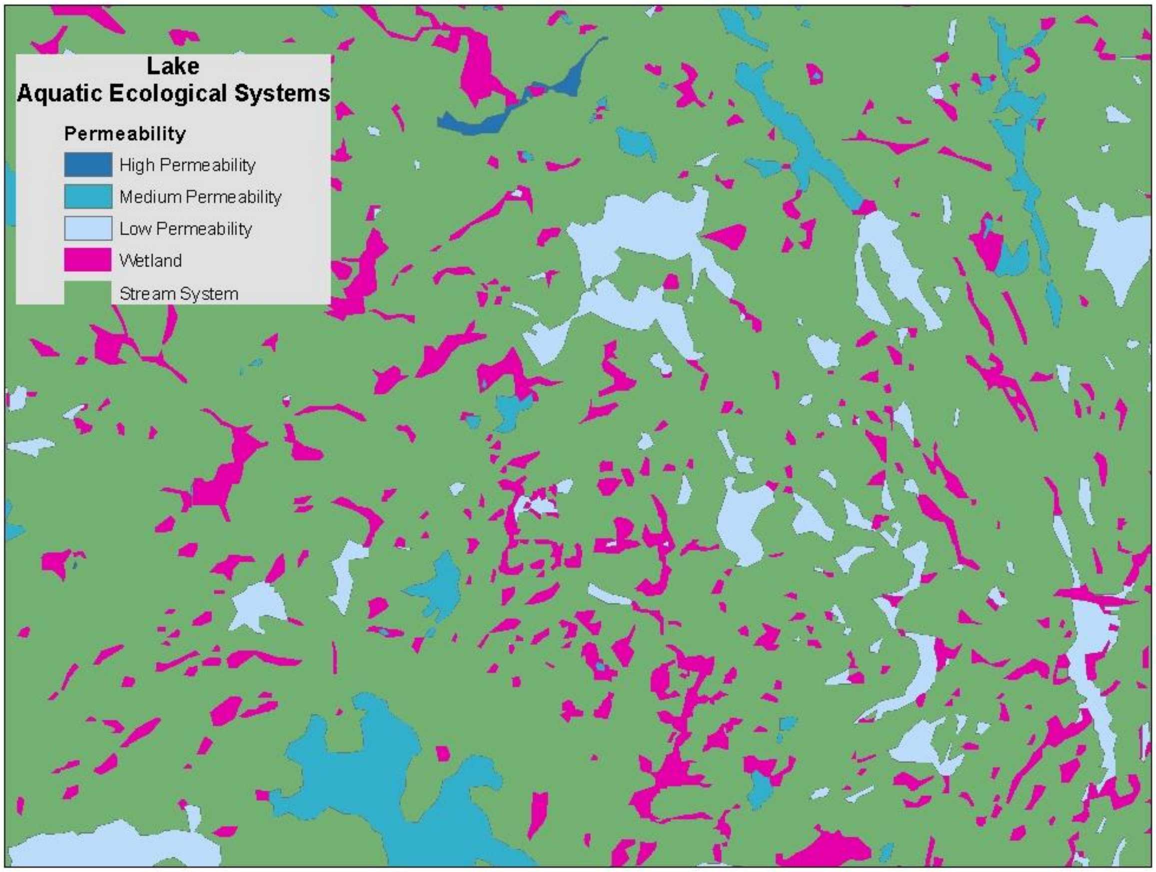


Figure 7: An area example of the geological permeability classifier for lake aquatic ecological systems (AES). Lake AES are depicted in shades of blue.

(iii)Thermal Regime (Figure 8)

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 classification.

Thermal regime was identified using the Aquatic Resource Area database available through the Parry Sound District MNR. Most of the large, medium and small lakes were classed into warm, cool or cold water. What the thermal regime field could not identify, available depth information along with local fisheries expertise and knowledge were used to class lakes into a thermal class. Many of the ponds that could not be classed using these methods were identified as warm water given that they were small and likely shallow water bodies. Those lake polygons that could not be classified using these datasets were labelled as “Unknown”.

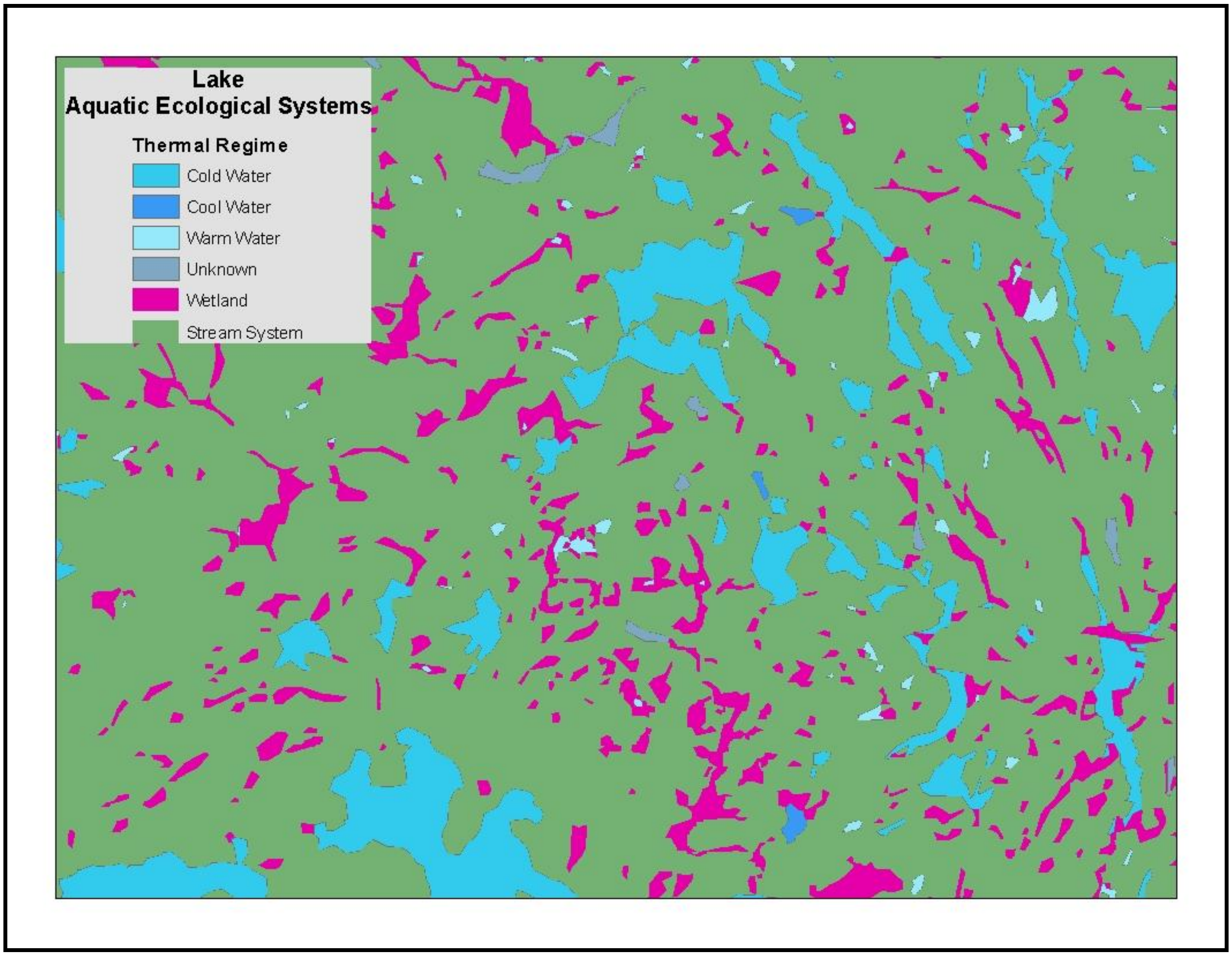


Figure 8: An area example of the thermal regime classifier for lake aquatic ecological systems (AES). Lake AES are depicted in shades of blue.

(iv) Glacial Relict Species (Figure 9)

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 class the lakes in the area of interest: the presence of glacial relict species. In relatively recent glacial history, the area of interest 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; Wilson and Mandrak 2004; Yan and Pawson 1997, 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; Dadswell 1974). Ponds were not classified using glacial relict species because it was likely that ponds did not support or contain relict species.

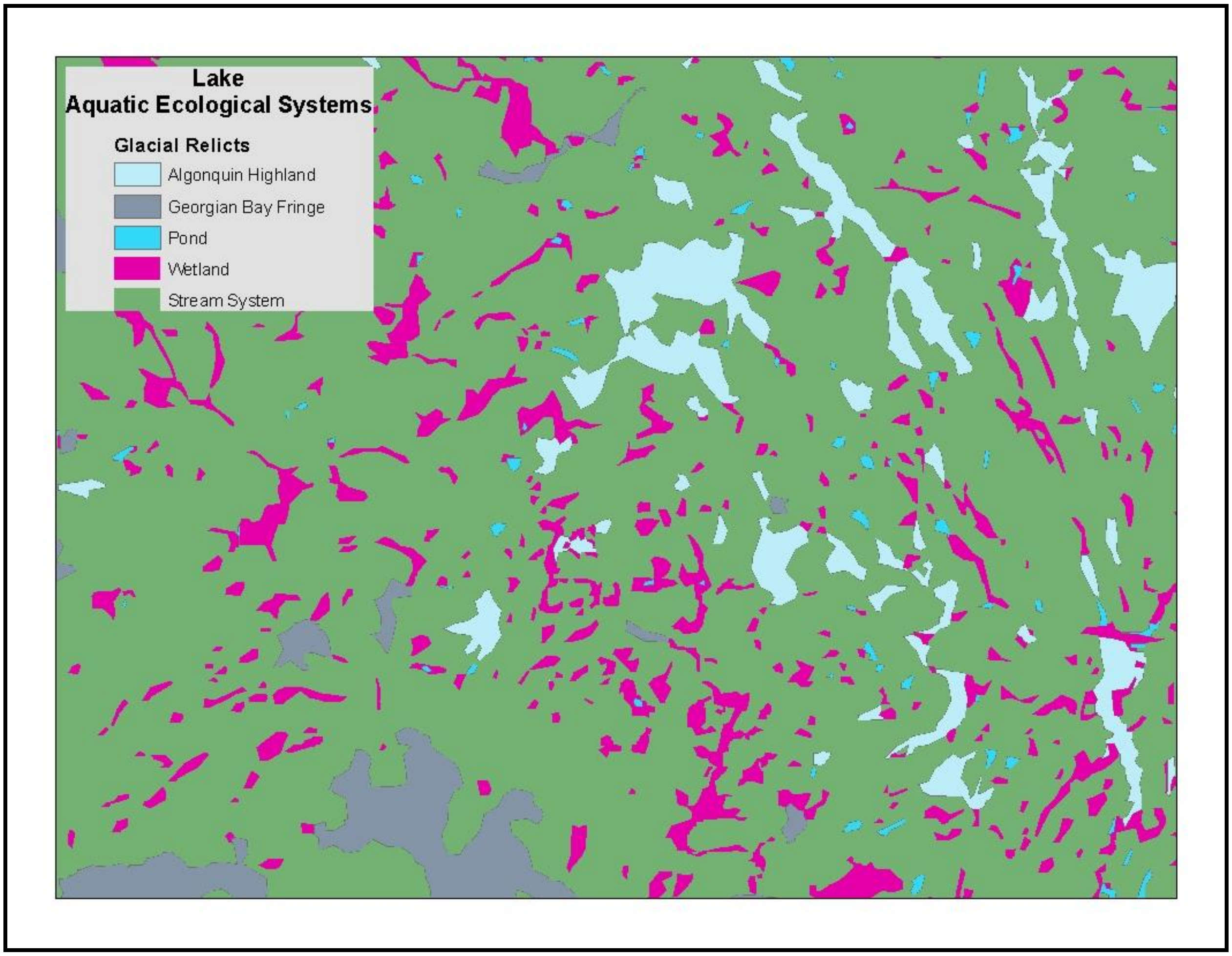


Figure 9: An area example of the glacial relict species classifier for lake aquatic ecological systems (AES). Lake AES are depicted in shades of blue.

Wetland Ecosystems

Over two thirds of wetlands in Southern Ontario (south of the Canadian Shield) have disappeared mostly due to land-use conversions for development purposes (Environment Canada). The Muskoka area was fortunate enough to still have a large portion of wetlands covering the landscape and these wetlands have contributed greatly to the high water quality and quantity that people and wildlife in this area benefit from. Wetlands were lands that were seasonally or permanently covered by shallow water and have unique characteristics, such as hydric soils and water tolerant plants (MMAH 2005). These wetland conditions support a diversity of ecosystem functions for people and wildlife and are a crucial part of a functioning aquatic landscape (Compton et al 2007).

Variables used to distinguish wetland ecosystems were (i) wetland type and (ii) size. Similar to lakes, connectivity was a variable used to classify wetlands for the GLCB, but taken out of the WIP because almost all of our wetlands were connected to either another wetland or to a lake or stream/river, thus the connectivity classifier was not a useful category for our area of interest.

(i) Wetland Type (Figure 10)

The northern Ontario Wetland Evaluation System 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. The datasets used were from the Natural Resource Values Information System, Ducks Unlimited Rapid Assessment Technique, Forest Resource Inventories and Landcover 2000 satellite imagery. Those wetland polygons that could not be classified using these datasets were labelled as “Unclassified”.

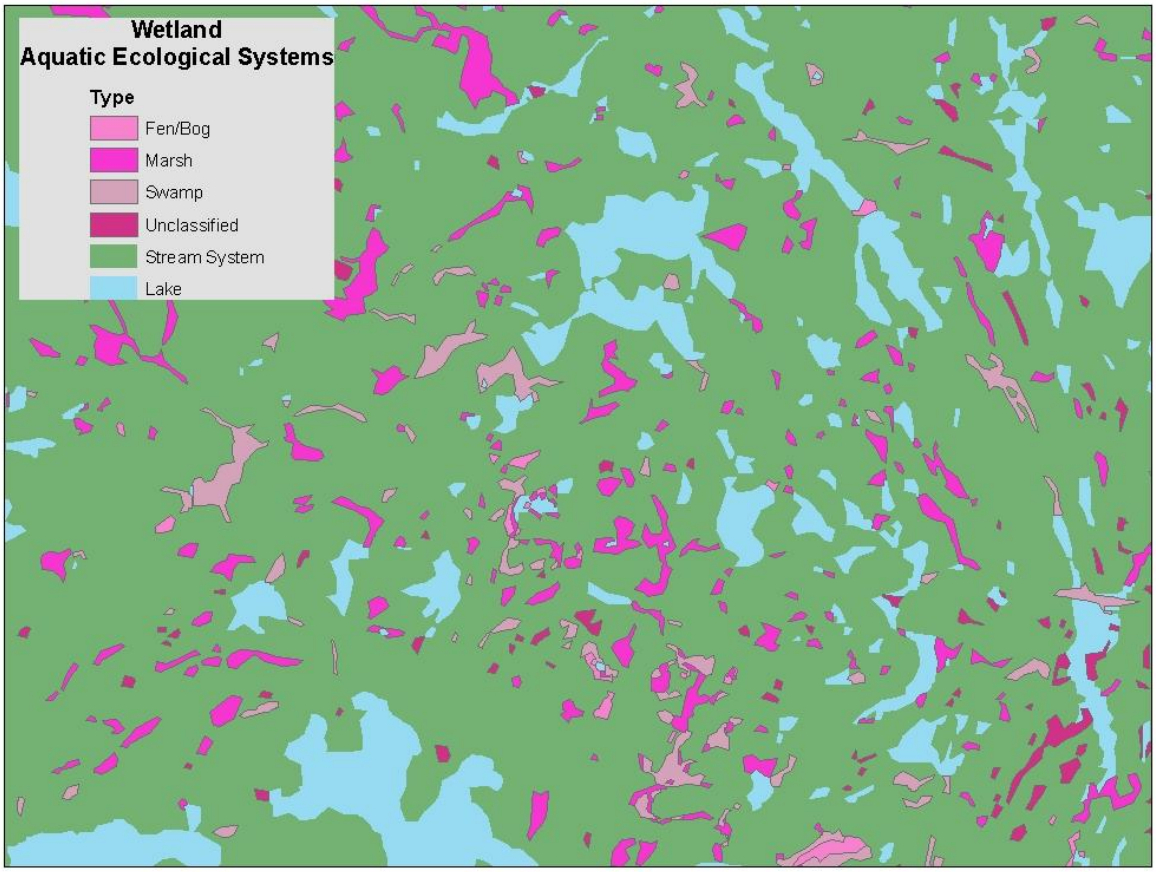


Figure 10: An area example of the wetland type classifier for wetland aquatic ecological systems (AES). Wetland AES are depicted in shades of pink.

(ii) Size (Figure 11)

The WIP 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 (Environment Canada 2004).

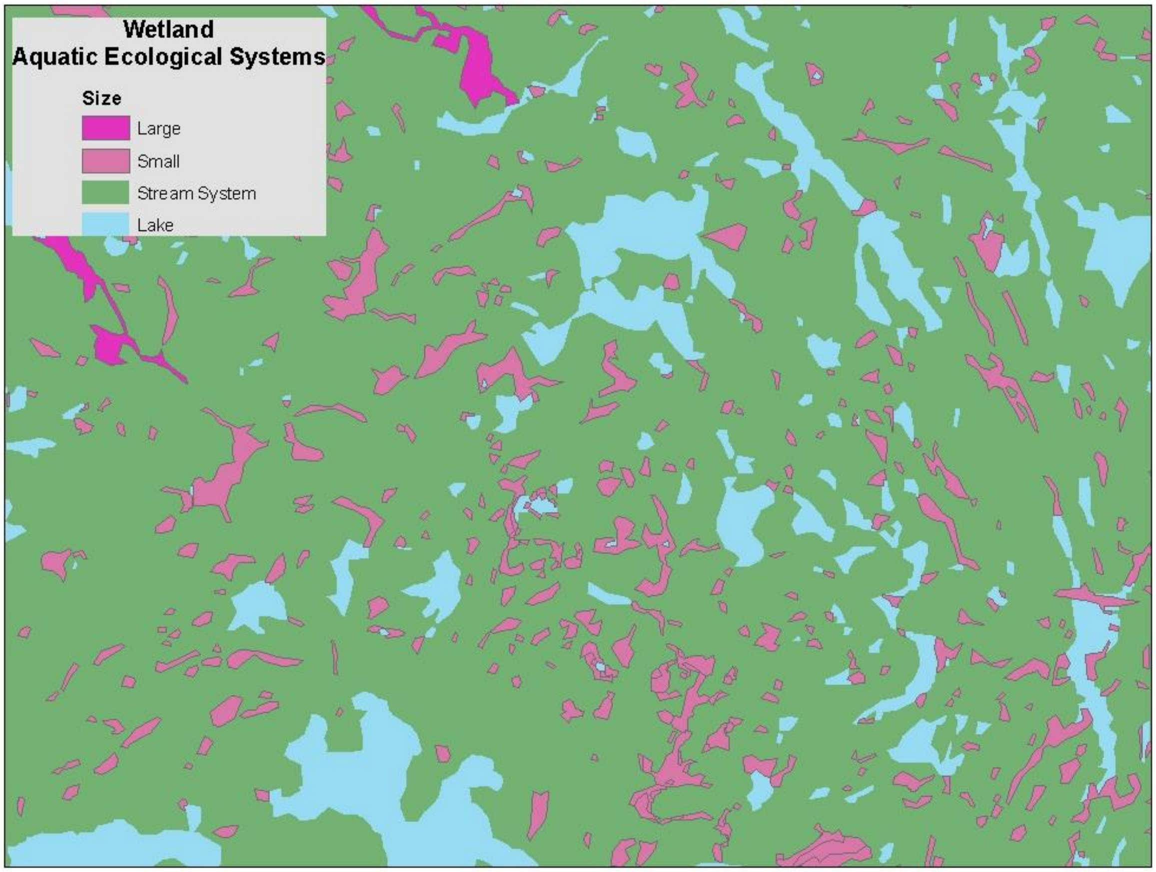


Figure 11: An area example of the size classifier for wetland aquatic ecological systems (AES). Wetland AES are depicted in shades of pink.

Amalgamating Aquatic Systems

Each aquatic ecosystem type was created separately by applying the classifiers described in the previous section. The unique aquatic ecosystem types were amalgamated for scoring purposes and for the final statistical analysis. Based on the number of categories and the corresponding classifiers there was a total of 54 possible stream types (Table 2), 96 possible lake types (Table 3) and eight possible wetland types (Table 4) for the area of interest.

Table 2: Categories and classification scheme for creating stream aquatic ecological systems.

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

Permeability	3
Gradient	3
Storage	2
Position	3
Total Possible Stream Types	**54**

Table 3: Categories and classification scheme for creating lake aquatic ecological systems.

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 $\leq$2.34
	Low Permeability	$\leq$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
	Georgian Bay Fringe	<350 m

Size	4
Permeability	3
Thermal	4
Glacial	2
Total Possible Lake Types	**96**

Table 4: Categories and classification scheme for creating wetland aquatic ecological systems.

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

Type	4
Size	2
Total Possible Wetland Types	**8**

Indicator:

(ii) Existing protected areas (Figure 12)

Existing protected areas within the area of interest provide different levels of protection for a variety of values. One of the many challenges was to determine whether existing protected lands adequately represents important ecological processes and unique features. In an assessment that looked at terrestrial systems, it was relatively straightforward to evaluate how protected areas safeguard terrestrial features and ecosystem processes. Protecting a large tract of a diverse forested area, for instance, would ensure that those ecological and evolutionary functions were sheltered from negative land use practices. For aquatic systems and its fluid nature, protecting a large lake, for example, might not necessarily sustain its ecological and evolutionary functions because the lake would be significantly affected by terrestrial and aquatic activities surrounding and upstream from the protected lake. It was also important to note that many of the existing protected areas have been terrestrially-based, in other words, the creation of most existing protected areas did not consider specific aquatic ecosystem characteristics. There were many portions of the WIP area of interest that were under various levels of protection. As mentioned earlier, many of these areas had protection applied by assessing the landscape from a terrestrial perspective. These particular lands were divided into three divisions, portraying the levels of protection afforded to these areas.

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

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

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

- Crown Land (including lake bottoms)
- Provincially Significant Wetlands
- Muskoka Heritage Areas
- Muskoka Heritage Trust Conservation Easements

Level 3:
These areas were protected from incompatible land-use decisions related to development and site alteration through zoning and official plans of municipalities. Only ANSIs (Areas of Natural and Scientific Interests) and significant evaluated wetlands were protected through the Provincial Policy Statement’s Planning Act.

- ANSIs (confirmed)
- All other wetlands

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

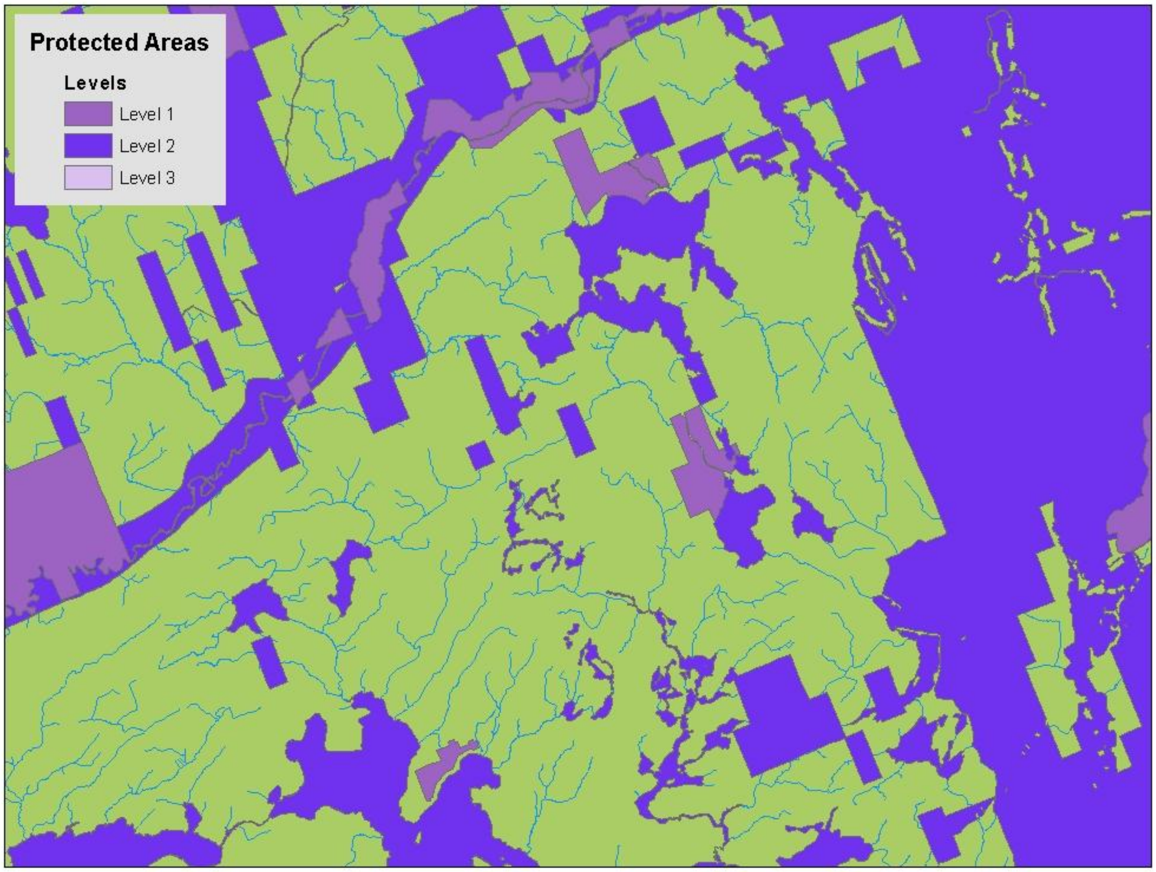


Figure 12: An example of the different levels of protected areas found within the WIP area of interest.

Assessing Significance of Ecosystems

There was significant research in aquatic sciences at the time of WIP development. A great deal of the research was related to chemistry, movement of water and fisheries. In contrast to research related to terrestrial ecosystems, there was little reported on the influence of landscape scale biodiversity on aquatic ecosystems. However, there was awareness of several threats to aquatic resources including algal toxins that affect taste and odour, pesticides, endocrine disrupting substances, nutrients, acidification, municipal wastewater effluents, urban runoff, landfills and waste disposal, agricultural and forestry land-use impacts, influence of dams and road crossings and impacts of climate change.

The WIP terrestrial component used buffer area sizes and defined relative influence values that were based on terrestrially-related studies. For aquatic ecosystems, there were studies indicating a variety of the influences on freshwater ecosystems, however, determining the intensity or extent of those features required additional discussion and relied more on local understanding and expertise. There was no best indicator for this type of analysis, thus in order to provide for systematic conservation planning and develop an assessment based on defensible and transparent indicators, decisions needed to be based on our best knowledge, particularly in the face of lacking empirical information (Margules and Pressey 2000).

Goal: Identify areas of high aquatic ecological importance

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

Criterion:

2. 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 weighted ecological function criterion at 40% of the total score based on the GLCB framework.

Objective:

(a) Identify natural areas that exhibit a high degree of integrity and resiliency

Indicator:

(i) Size of discrete aquatic ecological units (Figure 13)

The size of natural areas was an important indicator of the sustainability of natural areas. Aquatic ecosystems are diverse in size and communities have evolved to survive in the unique niches they provide. Although a variety of sizes of aquatic ecosystems were important across the landscape for connectivity and movement of water and species, it was important to maintain large sized aquatic systems. Generally, larger lakes had more capacity to buffer against changes or disturbances in the surrounding landscape and airscape (development and climatic factors) as well as having a greater ability to handle recreational pressures (fishing). Larger wetlands tend to sustain more biodiversity than smaller wetlands (Wichert et al 2004). Loss of large unique areas changes the ability of aquatic ecosystems to maintain a functioning aquatic landscape (Chambers et al 1999).

Methodology:

The scoring regime was applied to each AES polygon in the amalgamated aquatic ecosystem dataset (streams, lakes and wetlands). Similar to the GLCB methodology, a grouping function was used in GIS to amalgamate similar system types that were adjacent to each other, thus providing them with a higher score.

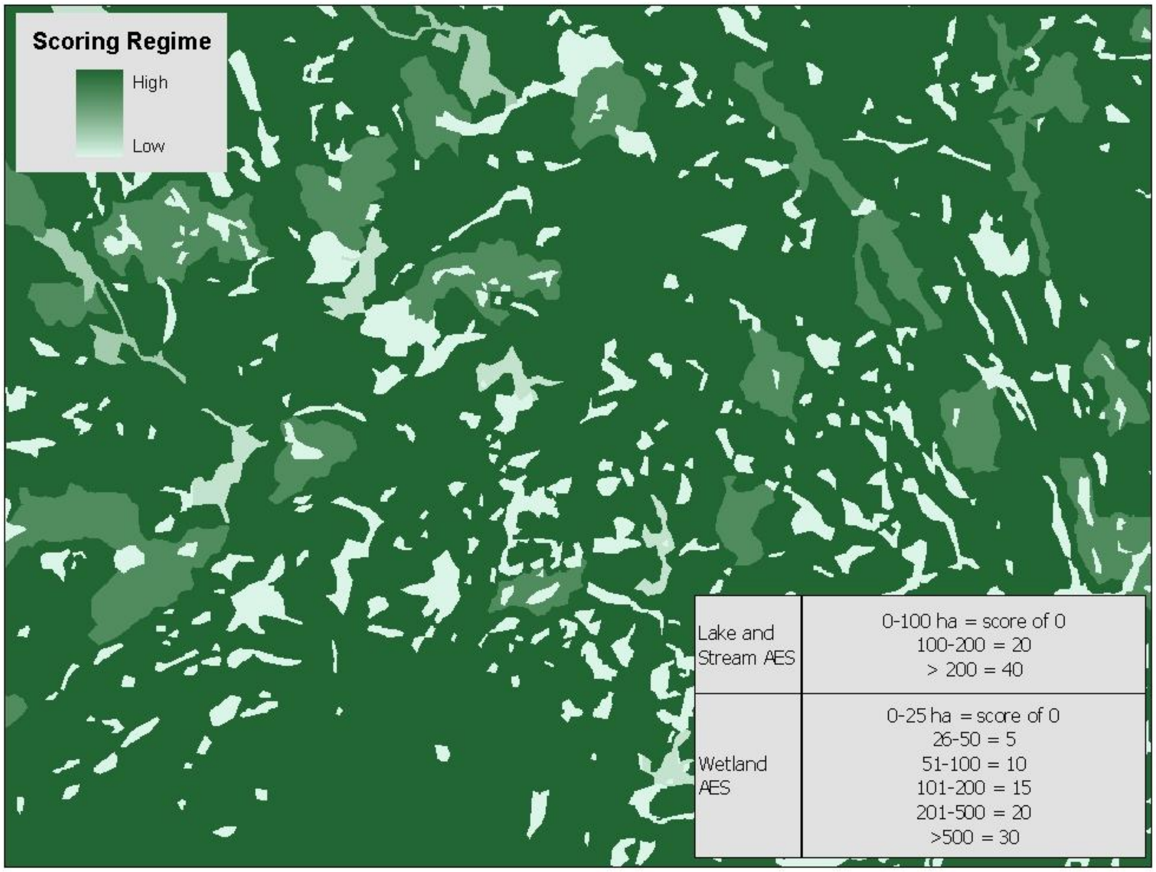


Figure 13: An example screenshot for size of discrete aquatic ecological systems.

Objective:

(b) Identify riparian areas

Indicator:

(i) Riparian area of streams/rivers, inland lakes, and Great Lakes shoreline (Figure 14)

In general, riparian areas provided connectivity between terrestrial and aquatic systems. These areas were the interface between land and water that experiences frequent changes in water level, extreme events such as floods and droughts (Naiman et al 1998) 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, Bunn et al 1999). Riparian areas were 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; Polyakov et al 2005; Chambers et al 1999), as well as assisted in regulating water temperature (Caisie 2006).

In the Muskoka region, riparian areas were incredibly important for the simple fact that the area of interest contained a large number of lakes and an extensive network of rivers and streams. As a result, much of the aquatic landscape was part of a riparian area and thus activities affecting our watersheds have an impact on economic, environmental and human health of communities. The area of interest also contained part of the Eastern Georgian Bay coast which experiences the unique near-ocean geomorphological processes of large waterbodies, such as waves and currents, winds and weather (Riffell et al 2003; Wei et al 2004; Henson et al 2005).

Methodology:

The indicator for riparian areas was a buffered distance of 300 meters from the shoreline of lakes and rivers/streams. A larger buffer area of 1,000 meters was used for the Georgian Bay Coast to account for the unique riparian area of large waterbodies. The buffer distance amount was suggested by the GLCB methodology (Wichert et al 2005). This buffer distance for the aquatic assessment was different from the terrestrial analysis because this assessment was analyzing the effects of riparian areas on water resources, thus larger buffer sizes indicated the importance of riparian areas for aquatic ecosystems.

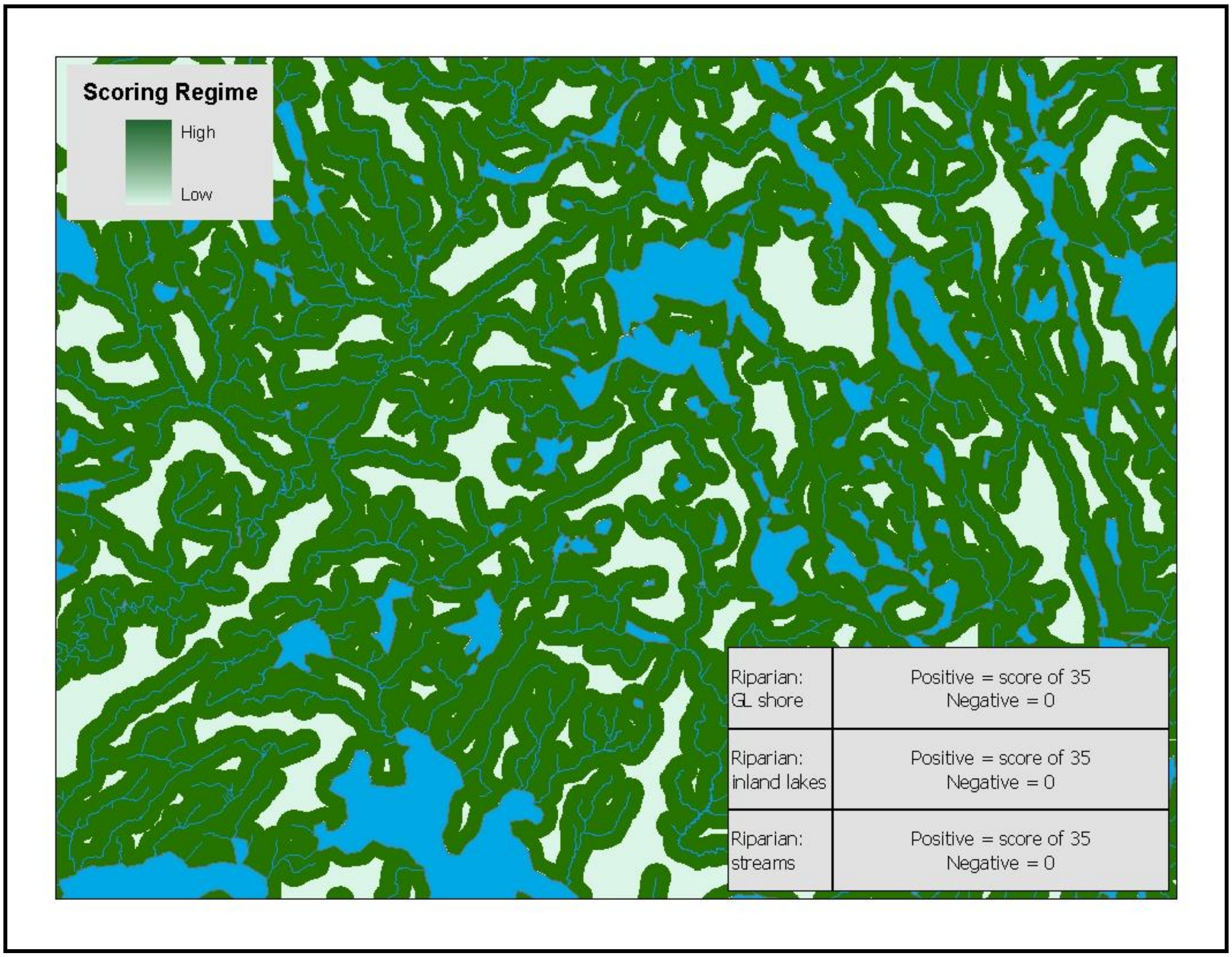


Figure 14: An example screenshot of riparian areas.

Objective:

(c) Identify recharge areas (Figure 15)

Indicator:

(i) Highly permeable areas

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 was extremely 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. Identifying potential recharge (or discharge) area was an important part of assessing for the ecological function of the landscape.

Methodology:

Recharge areas were identified using surficial geology data of permeable surfaces (MNDM). Most of these identified locations were not confirmed as being actual recharge or discharge areas, however at the time of the WIP assessment there was no specific dataset available for recharge areas. Surficial geology data for permeable substrate and local knowledge were the best available information to assess for recharge areas. The WIP committee recognized that these data were a gap that needs to be filled for future assessments.

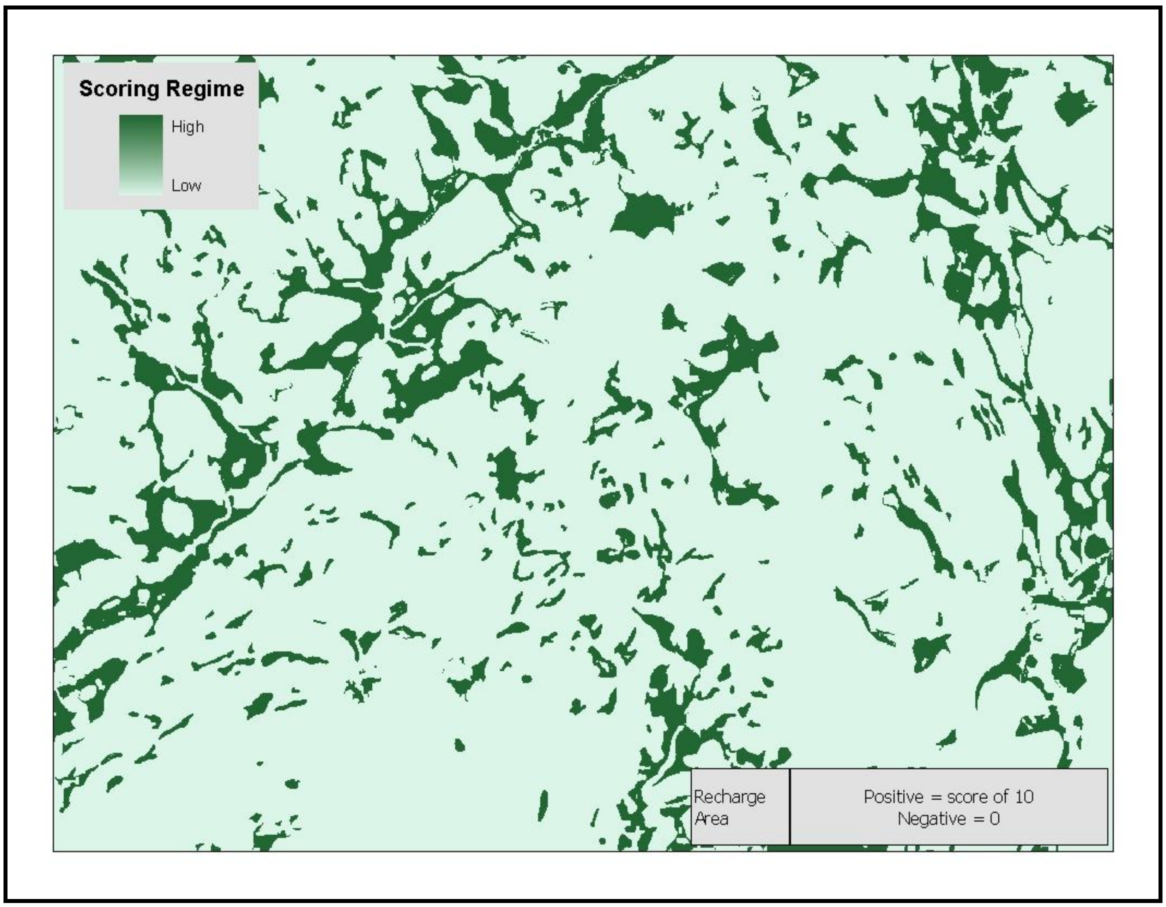


Figure 15: An example screenshot for size of discrete aquatic ecological systems.

Criterion:

3. Diversity

Diversity of the aquatic ecological landscape was 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) and contribute to the stability of ecosystem processes (Naeem 1998; Thebault and Loreau 2005). Diversity was worth 2% of the total score.

Objective:

(a) Identify system diversity

Indicator:

(i) Diversity of Aquatic Ecological Units (Figure 16)

Similar to terrestrial landscapes, a diverse aquatic landscape was associated with high species richness and created complex habitat relationships at different spatial scales (Davies et al 2004; Verberk et al 2008).

At a landscape-level analysis, diversity was identified by determining the number of aquatic ecological systems surrounding each discrete ecosystem. Another method of evaluating diversity was to analyze species richness, however, this method was much more meaningful at site-specific scales (Crins and Kor 2000) and where comprehensive datasets are readily available.

The aquatic ecological system types (stream, lake and wetland) were amalgamated into one layer and were used to analyze ecosystem diversity. Each discrete aquatic ecosystem was scored based on the number of different aquatic ecosystems surrounding it. For example, if one unique ecological system had four other different ecological systems adjacent to its border, the central ecological system received a higher score than if it had only two different systems surrounding it.

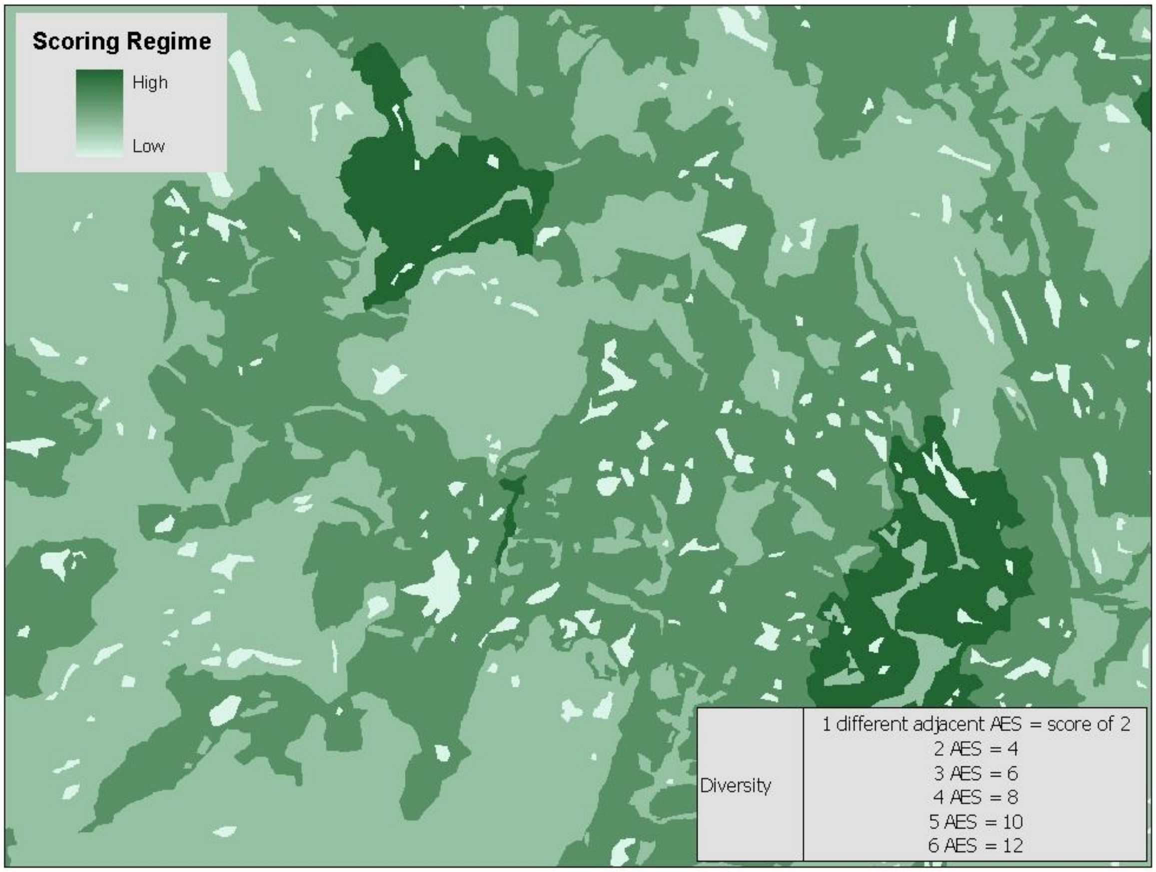


Figure 16: An example screenshot for diversity scores.

Criterion:

4. 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 was usually incomplete because it relied 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 assessment in order to capture those special features and enhance specific sites that were known to be significant. Special Features was worth 20% of the total score.

Objective:

(a) Identify species element occurrences, vegetation communities and other significant wildlife habitat

Indicator:

(i) Species occurrences and vegetation communities occurrences (Figure 17)

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 goal of assessing for ecologically important areas.

Element occurrence (EO) data from the Natural Heritage Information Centre (NHIC) and locally-collected information from the Parry Sound District Ministry of Natural Resource in the area of interest was used to identify observations of species and vegetation communities. Some of these observations were of species-at-risk and some were locally common species that had been tracked for a variety of reasons (such as being globally rare or for research purposes). Available data for locally-tracked species, regardless of status, were included in the assessment because even common species were important to ecological processes (Lyons et al 2005) and to ensure the assessment captured species unique to the aquatic landscape of the area of interest.

Methodology:

Observations were in the form of point data. Each ecosystem was assessed based on the presence or absence of a particular species within the available databases. The number of each present species within a discrete aquatic ecological system determined the score for this indicator (each species not each observation thus if an AES had three Fox snake observations, the count would be one for supporting that species); the higher the number of present species in the polygon (regardless of species status), the higher the polygon was scored. The assessment also considered the locational accuracy of these observations and only included those within a recorded accuracy of one to two meters. Although species status was not considered, the assessment did split the observations by isolating for specific aquatic flora/fauna. Aquatic species and community presence were given a higher score consideration since this assessment focused on aquatic ecosystem features.

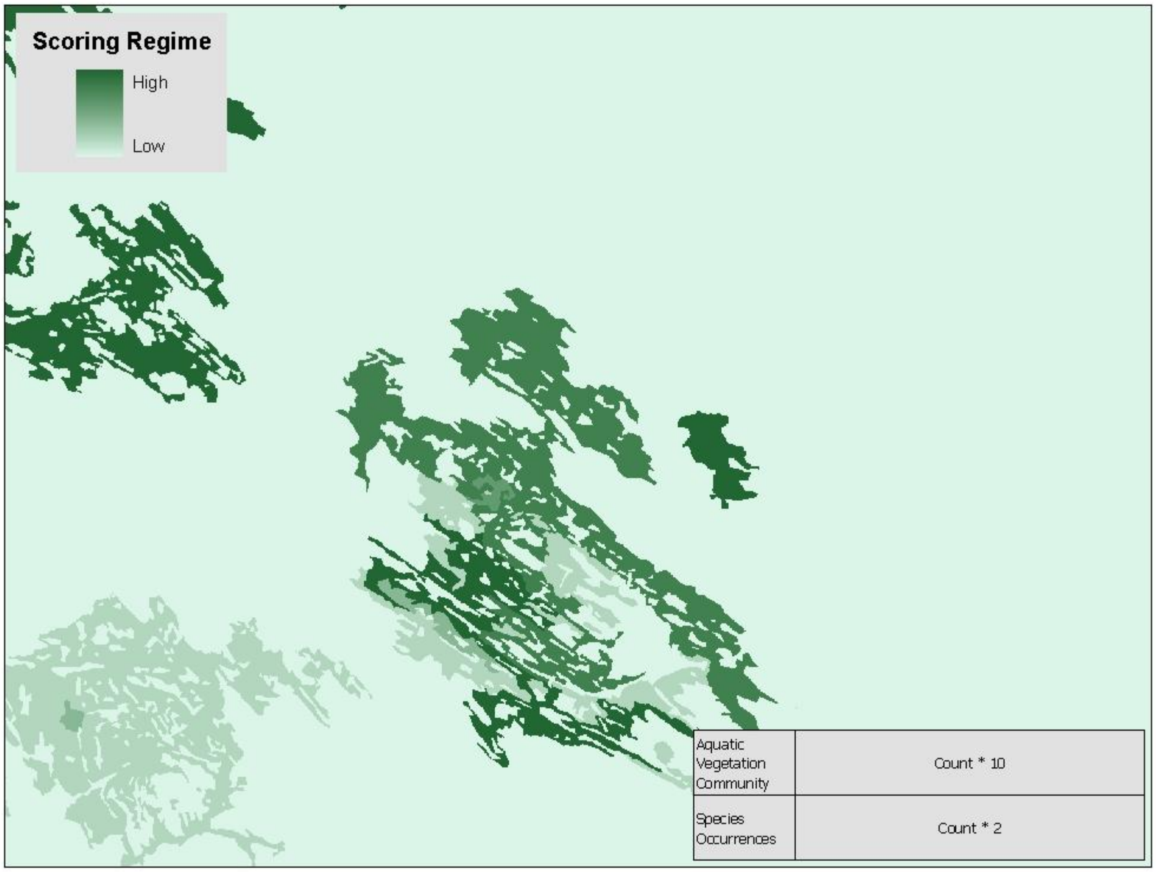


Figure 17: An example screenshot for species occurrences, vegetation communities and other significant wildlife habitat scores.

Indicator:

(ii) Important habitat areas (Figure 18)

The Canadian Shield is a relatively young ecological district in terms of species evolution. Many of the observed species have evolved to use very specific conditions available in the area of interest for reproductive success and long-term survival, thus continued existence depends on sustaining the ecological function and condition of these specific areas known to be used by wildlife (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).

In previous criteria, the WIP assessment took into account some broad critical habitat features, such as riparian areas, however, the area of interest did have particular sites known to be used by wildlife for specific life history needs and thus we can ensure that these critical areas did not slip through the cracks of the broader criteria. The available information for the area of interest included moose aquatic feeding sites, fish habitat type (including spawning areas and specialized habitat, see Table 5), bird nesting sites and deer wintering areas.

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

Table 5 specifies species that would indicate specialized fish habitat. The aquatic systems these species were found in were scored as important habitat areas since their presence indicated important specialized habitat.

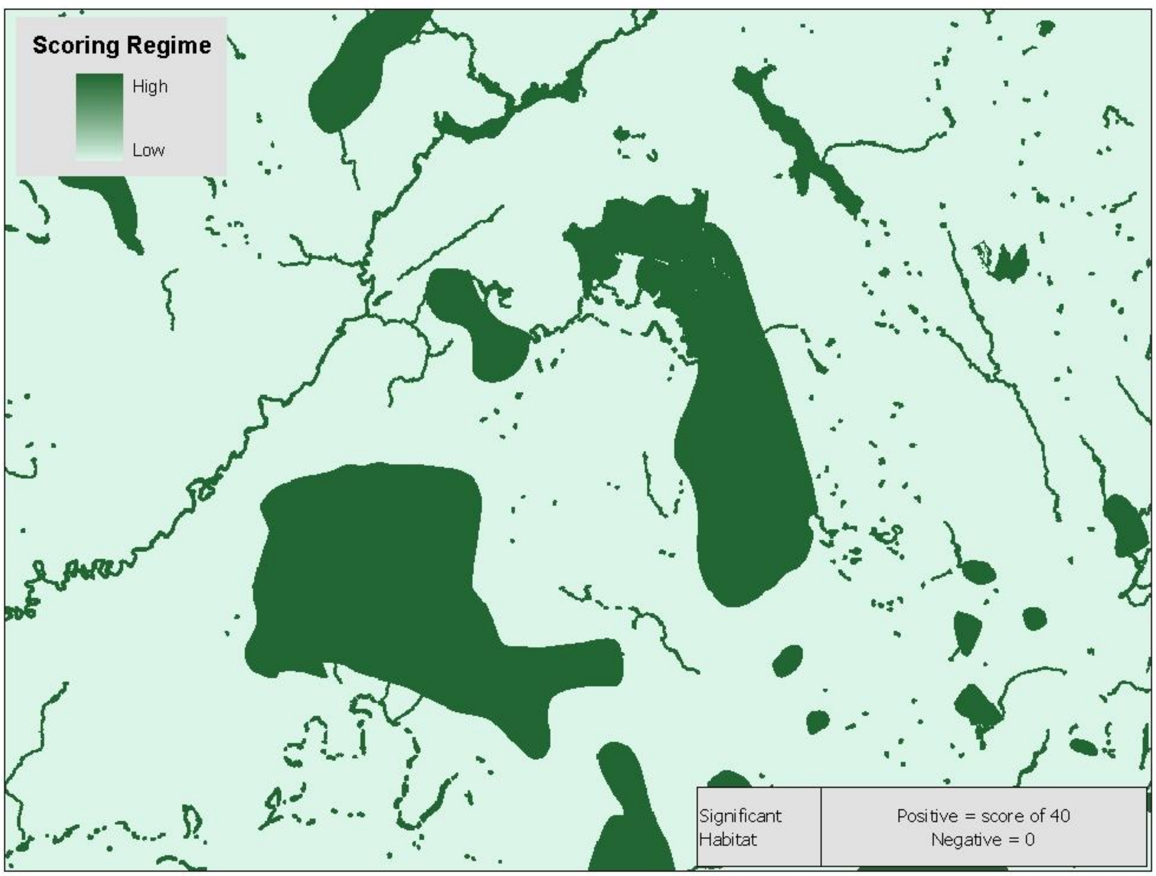


Figure 18: An example screenshot for important wildlife habitat scores.

Goal: Identify stresses on aquatic ecological systems and processes

The Inventory defined three specific goals that guided the production of the final products. The previous two sections describe the first goal, which was to categorize unique ecological systems across the landscape and identify systems that were not under existing protection. The second goal identified areas of high ecological importance without considering the relative or actual condition of these areas. 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 provide protection of the highest quality sites, but also 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.

The WIP collaborative group recognized that stress on ecological systems was different from threats. Threats were considered to be *future* risks to ecological systems, whereas the Inventory evaluated *current* stresses or pressures.

Similar to the terrestrial assessment, evaluating threats to aquatic ecosystems was beyond the scope of the WIP, however one threat was worth a mention in this report. Global warming, or climate change, was known as the accelerated warming trend of the Earth's atmosphere and was mostly a result of human activities (U.S. Environmental Protection Agency 2002). There was still some uncertainty of the regional and local affects of climate change.

Criterion:

5. 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. Aquatic ecosystems are a delicate balance between biogeochemical processing and downstream transport of dissolved elements. Activities occurring in water (such as road crossings) and on land (such as urban development) can easily disrupt the balance 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.

Objective:

(a) Identify condition/quality of watershed

Indicator:

(i) Invasive species (Figure 19)

Invasive species tend to tolerate degraded systems well. Thus the presence of invasive species could indicate water quality. Invasive species can out-compete native species for resources and with the fluid nature of aquatic ecosystems, can spread efficiently if there are no barriers (Strecker and Arnott 2005; Kennard et al 2004). Depending on the sensitivity of the aquatic ecosystem, presence of invasive species can dramatically change the native aquatic communities and affect species diversity and biological integrity of the ecosystem (Yan and Pawson 1997; Kennard et al 2005).

Invasive species information was limited for the terrestrial portion of the aquatic ecosystems. However, there were some data of invasive species available for lakes through the Aquatic Resource Area database from the Ministry of Natural Resources as well as from recent scientific studies done by the Dorset Environmental Science Centre (Norm Yan, pers. Comm.). Several water bodies have been identified as containing aquatic invasive species such as the spiny water flea (Table 5).

Table 5: List of invasive and indicator species for the lake systems in the Muskoka area (K. Eggers, S. Scholten and B. Steinberg, pers. comm. July 26, 2008).

Species	Status
Alewife	Invasive
Black crappie	Invasive
Blacknose dace	Indicator
Brook trout	Indicator
Brown trout	Invasive
Common carp	Invasive
Eurasion water-milfoil	Invasive
Grass pickeral	Specialized habitat
Iowa darter	Indicator
Lake trout	Indicator
Lake whitefish	Indicator
Muskellunge	Specialized habitat
Ninspine stickleback	Invasive
Northern pike	Invasive
Pumpkinseed	Invasive
Rock bass	Invasive
Sculpin family	Indicator
Spiny water flea	Invasive
Walleye	Specialized habitat

Methodology:

Similar to the presence/absence methodology for species occurrences, every time an ecosystem was listed as containing an identified invasive species, the ecosystem received a negative score. The more identified invasive species an ecosystem had (for each species, not the number of observations), the lower its score.

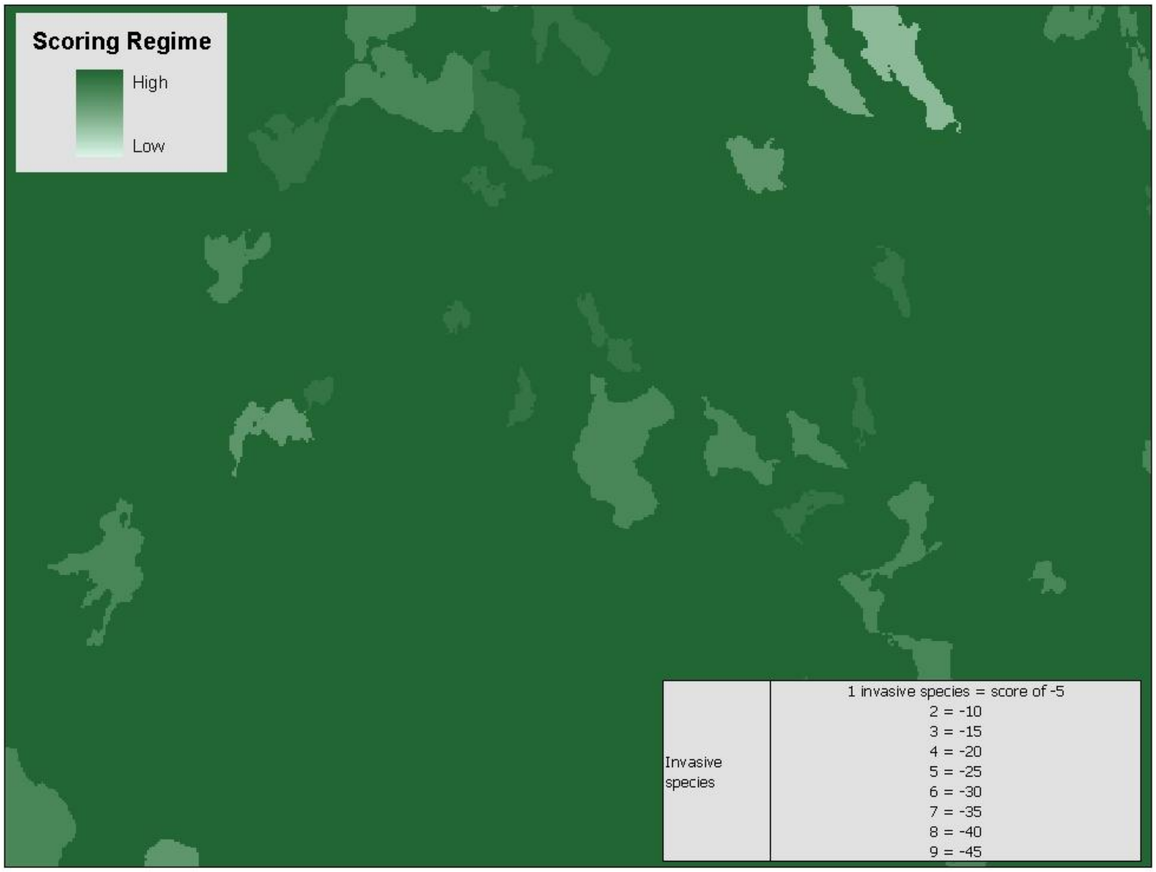


Figure 19: An example screenshot for invasive species scores.

Indicator:

(ii) Indicator species (Figure 20)

In contrast to invasive species indicating a degraded or degrading system, indicator species can signify a functioning natural system. Thus, indicator species for WIP meant indicating the quality of a water body to support sensitive aquatic species, such as Lake trout. The list of indicators species was determined by local fisheries biologists at the provincial and federal government levels (Table 5).

Methodology:

The presence/absence of indicator species was applied to score aquatic ecosystems. Each time an ecosystem contained an indicator species, the ecosystem received a positive score (for each species, not the number of observations). The higher the number of indicator species, the higher the score for the ecological system.

Table 5 also specifies species that would indicate specialized fish habitat. These species were not included as an indicator species, but the aquatic systems they were found in were scored as important habitat areas since their presence indicated specialized habitat (sees Special Features objective section).

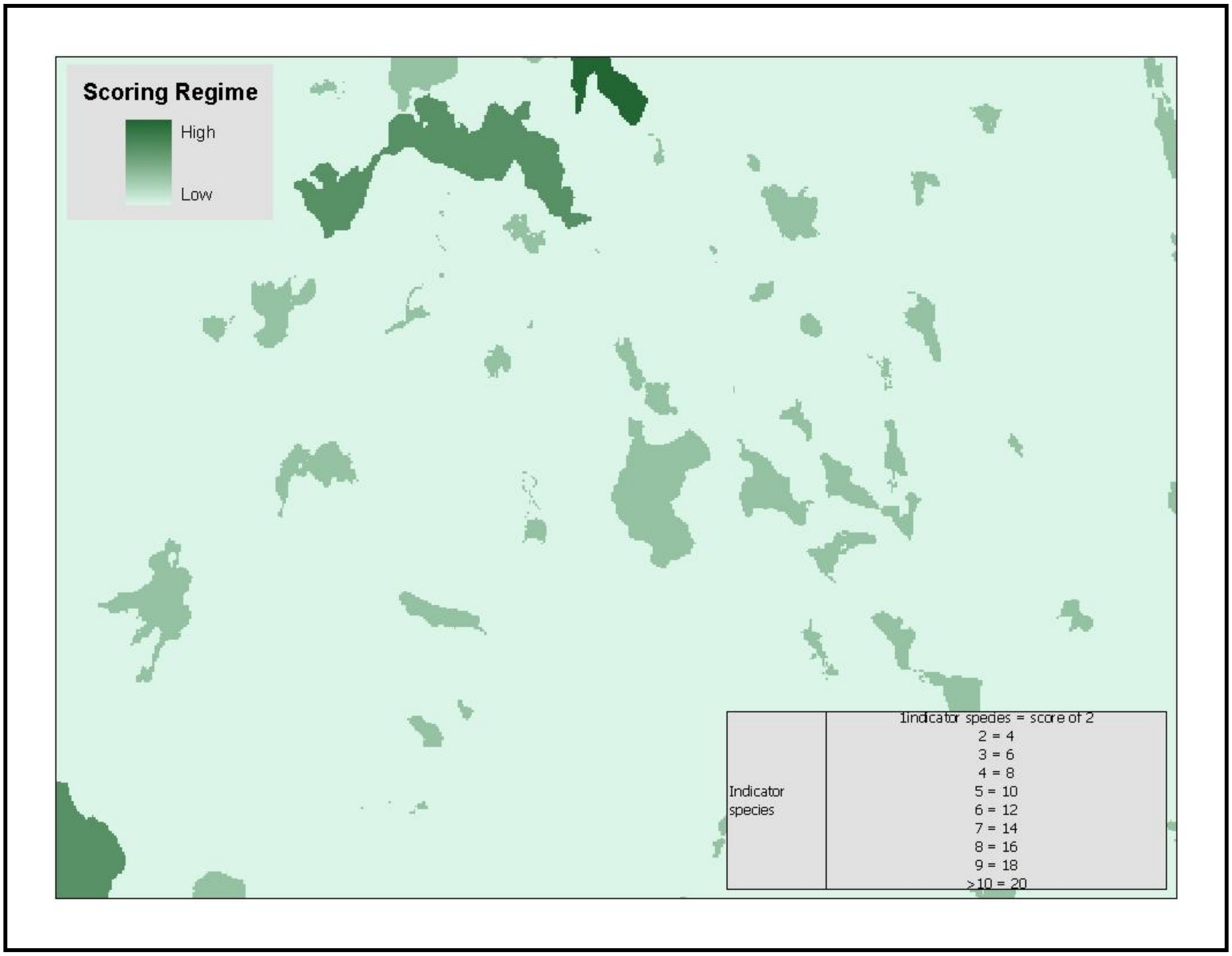


Figure 20: An example screenshot for indicator species scores.

Indicator:

(iii) Road and railway crossings (Figure 21)

The effects of roads on terrestrial and aquatic communities have been studied relatively well. Ecological effects include mortality both from road and crossing construction and collision with vehicles, modification of animal behaviour, alteration of the chemical and physical landscape, the spread of exotic species, as well as promoting an increase in hunting and fishing by humans (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).

Methodology:

Using the road, trail and railway datasets, a GIS routine was run to identify every location those linear features crossed a stream/river. Each intersection created a point location within the aquatic ecosystems. The number of points within each ecosystem polygon (thus the number of crossings within each discrete aquatic ecosystem) determined the score for each system. The number of crossings were grouped into five range classes to account for the large range of numbers and scored accordingly. The higher the number of road crossings, the lower the score for that system.

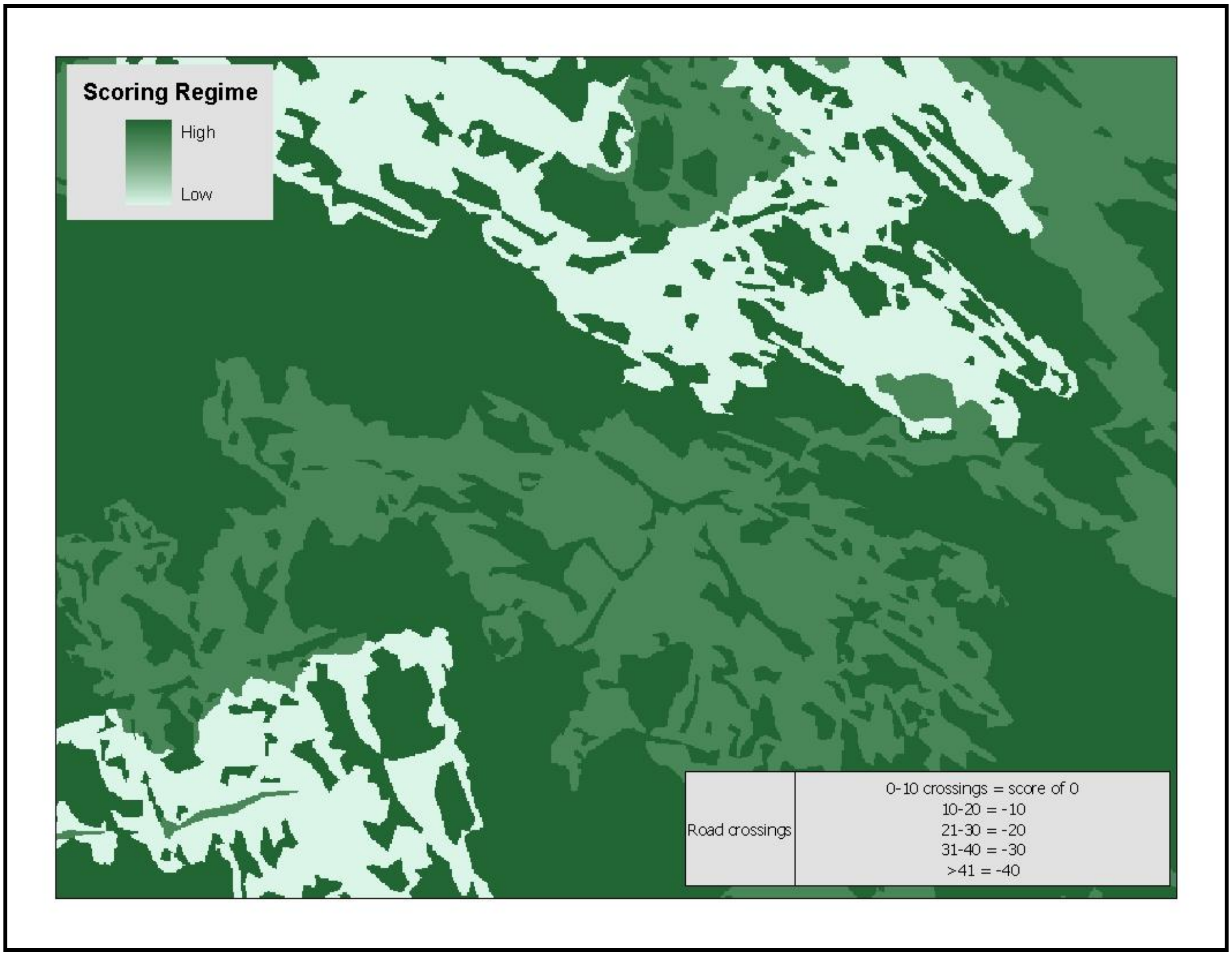


Figure 21: An example screenshot for road and railway crossing scores.

Indicator:

(iv) Influence of roads (Figure 22)

Roads have become a major concern because of the multiple impacts they have on wildlife and ecosystem functions. Roads contribute to habitat loss and fragmentation, increasing the impacts associated with isolation of wildlife populations (Fleury and Brown 1997; Adam and Geiss 1983; Rosenberg et al 1999; Vos et al 2001), increased opportunity for predation (edge effects), easy access and movement for exotic and invasive species (accidental or intentional activities of anglers) (Gelbard and Belnap 2003; Watkins et al 2003), increased concentrations of nutrients and sediments in water (Houlahan and Findlay 2004) and killing/injuring wildlife and altering physical conditions beneath and adjacent to roads (Findlay and Bourdages 2000; Tromulak and Fissell 2000).

The dataset used for influence of roads at a landscape level was similar to the dataset used for terrestrial assessment since it included forestry roads, as well as some private and municipal roads.

Methodology:

The influence of roads was scored in two ways. First, distance was a factor in the scoring. Several buffer distances were placed on the roads to represent the relative intensity of impacts and each buffer area was scored accordingly. Also, whether the road was considered a primary, secondary or tertiary road influenced the intensity of road use. The further away from a road and the less intense tertiary road received a higher score than areas close to a primary road (Figure 22).

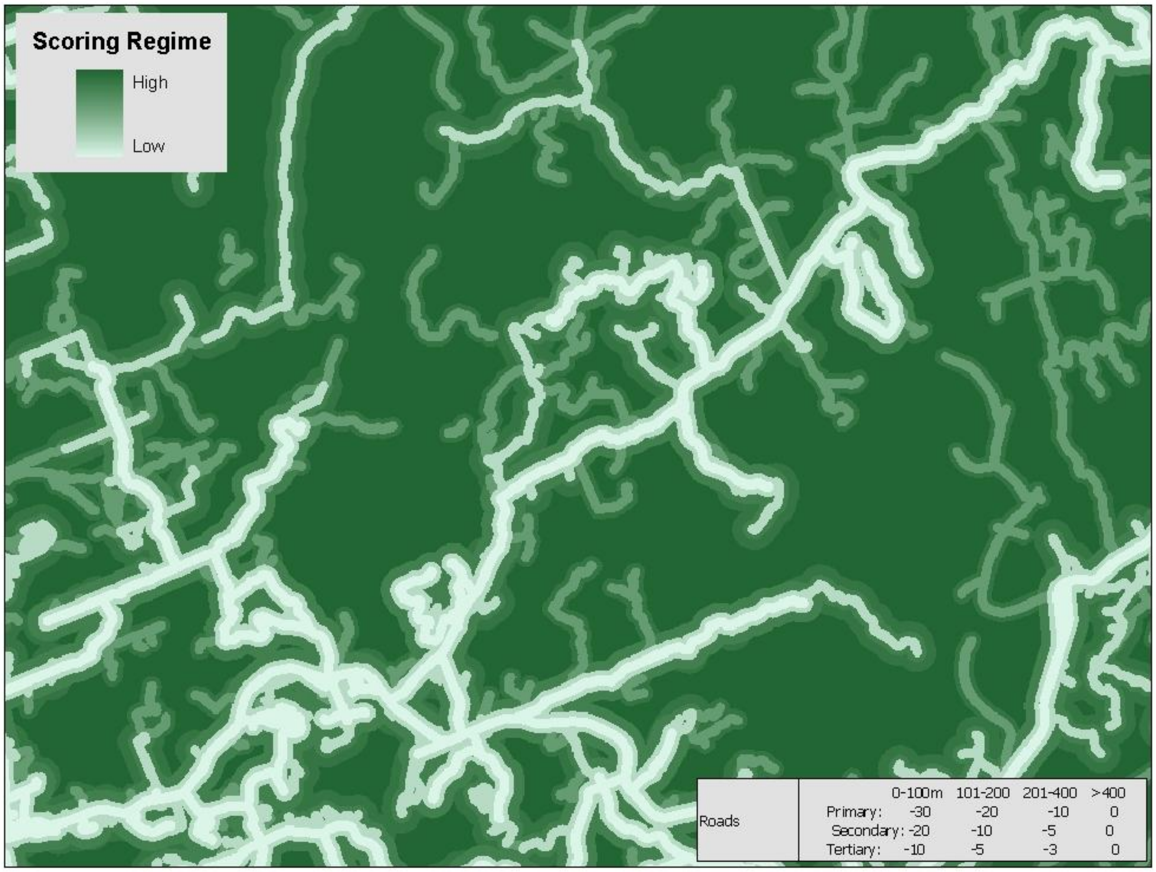


Figure 22: An example screenshot for influence of roads scores.

Indicator:

(v) Percentage natural cover (Figure 23)

The terrestrial component of the Watershed Inventory Project identified a large percentage of natural cover. Compared to areas off the Canadian Shield in southern Ontario, the WIP area of interest was 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 the 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 (Saab 1999; Fenton and Frego 2005; Rubbo and Kiesecker 2005).

Methodology:

The percent natural cover was calculated for each stream AES using the natural and non-natural information for the WIP terrestrial assessment. Within each stream AES the amount of natural cover was calculated and scored based on the GLCB percentage categories. The higher the percent of natural cover within each stream AES, the higher the score given to the stream AES.

Figure 23: An example screenshot for percent natural cover scores.

Indicator:

(vi) Influence of settled areas (Figure 24)

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 2007). 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).

Methodology:

Settled areas were identified from the WIP terrestrial assessment. Each settled area polygon was buffered up to 300 metres based on the buffer distances of the GLCB. For the aquatic assessment, the settled area polygon itself was also scored. The closer the buffered areas were to the settled area, the lower the score the buffered area received.

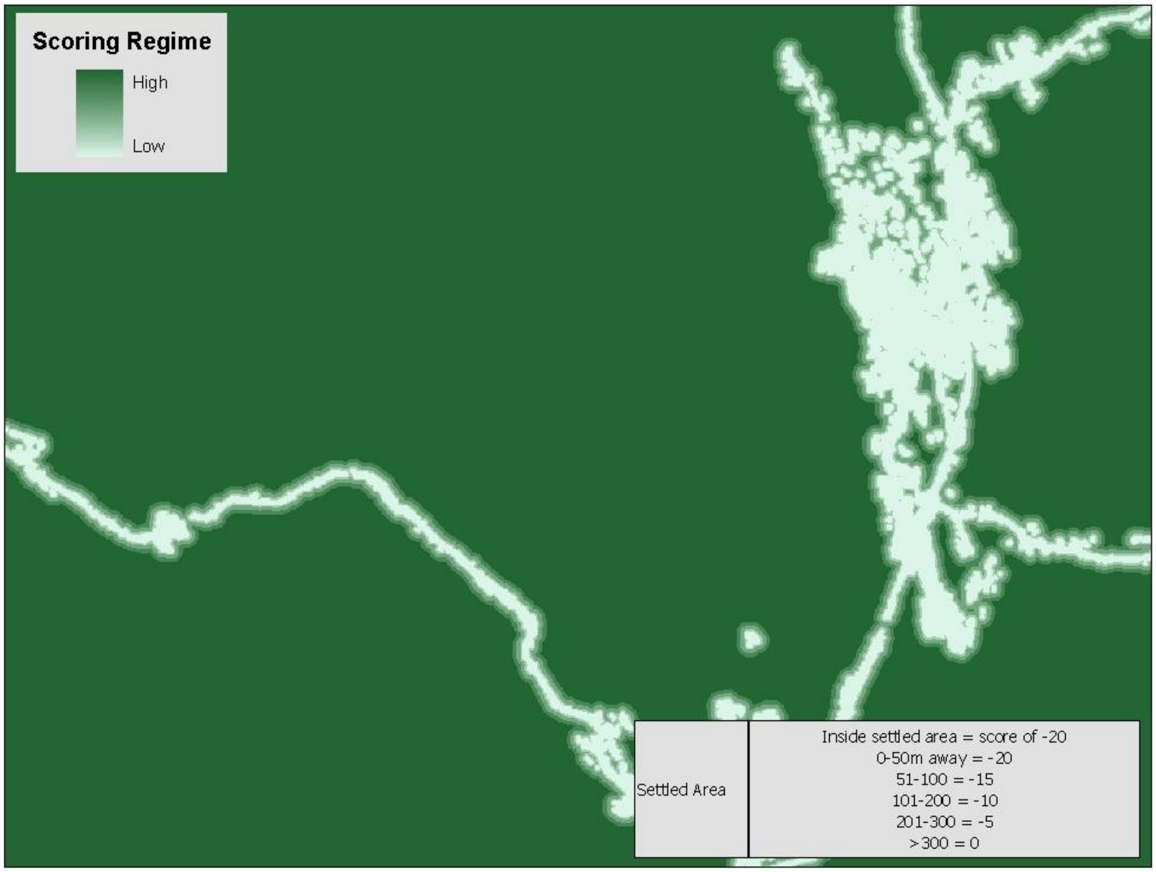


Figure 24: An example screenshot for the influence of settled areas scores.

Indicator:

(vii) Water quality (Figure 25)

General water quality for public use was also a criterion of condition for WIP. In Muskoka, there were 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. Those lakes not over-threshold met the criteria for high water quality for recreational purposes.

Methodology:

The District Municipality of Muskoka listed lakes that were over-threshold. Lakes over-threshold received a negative score. There were some larger lakes with more than one sampling station (i.e. multiple bays). The WIP lakes were not partitioned in that way, thus if one lake had both over-threshold and not over-threshold classifications, the entire lake received a negative score accordingly.

Figure 25: An example screenshot for water quality scores.

Indicator:

(viii) Influence of pits and quarries (Figure 26)

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 (Neel and Ellstrand 2001; Michalski et al 1987; Cooke and Johnson 2002; UNEP 2000). 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), thus the landscape is altered permanently.

Methodology:

Active and abandoned pits and quarries for Crown land from the provincial database were used for the assessment. This was the same dataset used for the terrestrial assessment and at the time of the aquatic assessment, the database had not been updated with private land pits and quarries. Buffer distances were placed on the pits and quarries. The further away from the pit or quarry, the more positive the WIP score.

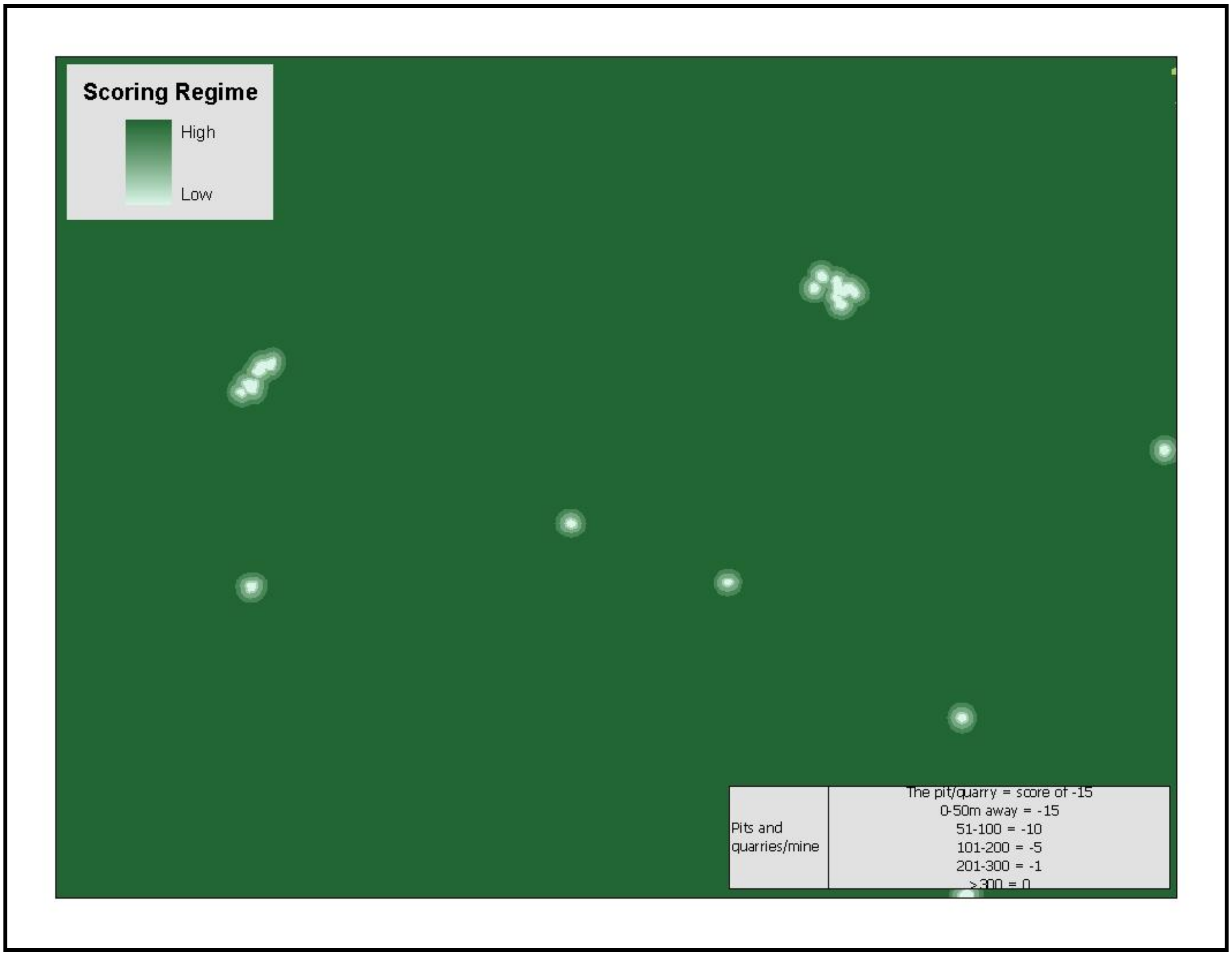


Figure 26: An example screenshot for influence of pits and quarries scores.

Indicator:

(ix) Influence of railways (Figure 27)

Railways have similar impacts on the landscape as other linear features, such as roads. Railways contribute to landscape fragmentation, create barriers to wildlife movement (Ito et al 2005) and potentially contaminate waterbodies (i.e. derailment spills).

Methodology:

Similar to roads, railway lines were buffered. The closer the buffer was to the railway, the lower the score assigned to the buffer.

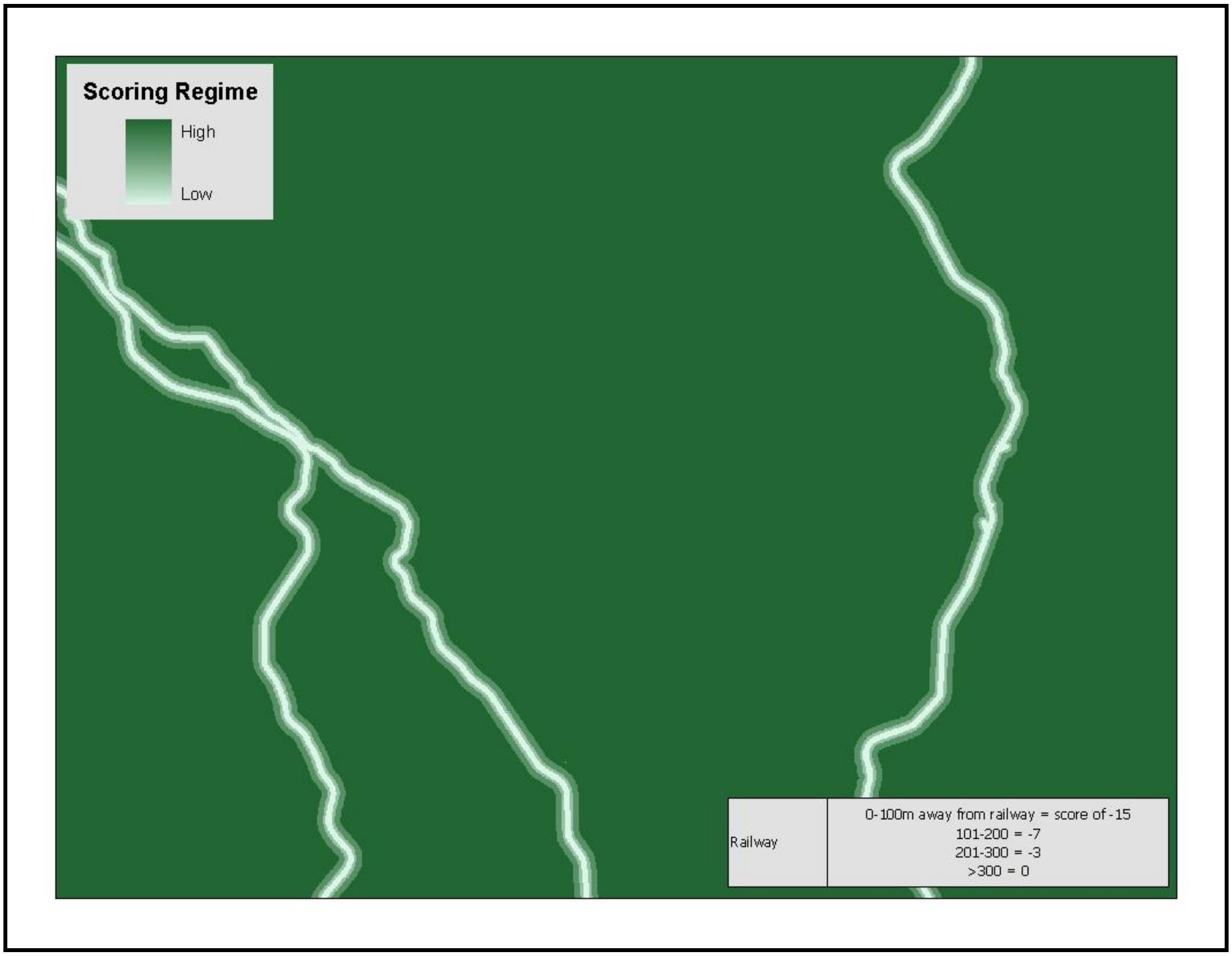


Figure 27: An example screenshot for influence of railways scores.

Indicator:

(x) Influence of open cleared areas (Figure 28)

Open cleared areas for the WIP assessment were areas that have been cleared for non-natural land-use. These open cleared areas included areas that have been cleared for agriculture and other uses that were not included in settled areas (such as 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 (Dunster and Dunster 1996) that negatively impact water quality and aquatic ecosystem processes (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).

Methodology:

Open cleared areas were identified from the WIP terrestrial assessment. Each polygon was buffered up to 300 metres based on the buffer distances of the GLCB. For the aquatic assessment, the open cleared polygon itself was also scored. The closer the buffered areas were to the settled area, the lower the score the buffered area received.

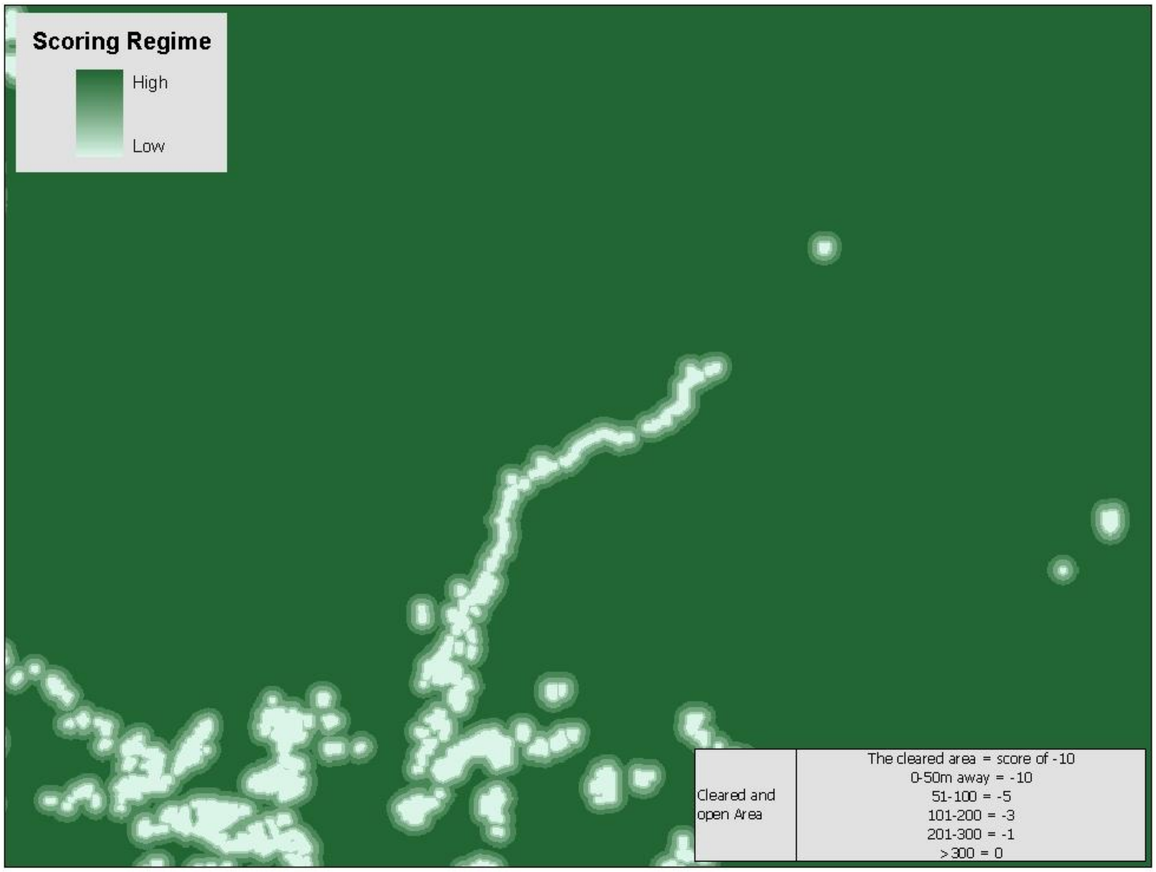


Figure 28: An example screenshot for influence of open cleared areas scores.

Indicator:

(xi) Influence of trails (Figure 29)

Trails were not considered to negatively impact the landscape as roads do, however, they do play a role in fragmenting natural areas (Blumstein et al 2005; Creel et al 2002). Heavy use of trails also leads to compaction of soil, altering the thermal regime and movement of water (Trombulak and Frissell 2000).

Methodology:

Trails for the WIP assessment included paths for hiking, backpacking, hiking, horseback riding or snowmobiling. Trails were treated similar to tertiary roads because of the low intensity of the potential impacts.

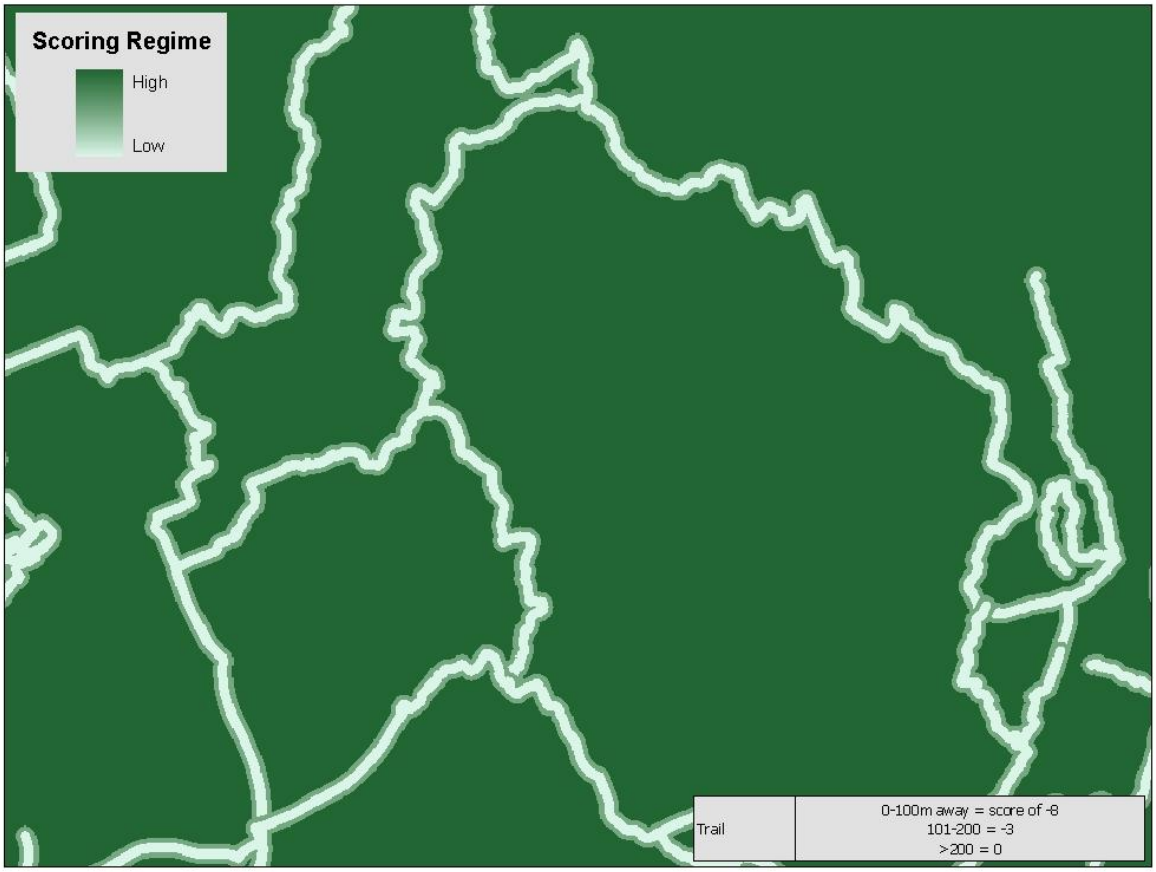


Figure 29: An example screenshot for influence of trails scores.

Indicator:

(xii) Influence of dams (Figure 30)

Dams can have major impacts on aquatic ecosystems. Dams fragment the aquatic landscape by preventing and/or diverting the flow of water. Some of the 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.

Methodology:

The dam's indicator was derived from the water-structure database from the province (NRVIS). Each dam structure was buffered up to 300 metres based on buffer areas of the GLCB framework. The closer the buffered area to the structure, the lower the score it received.

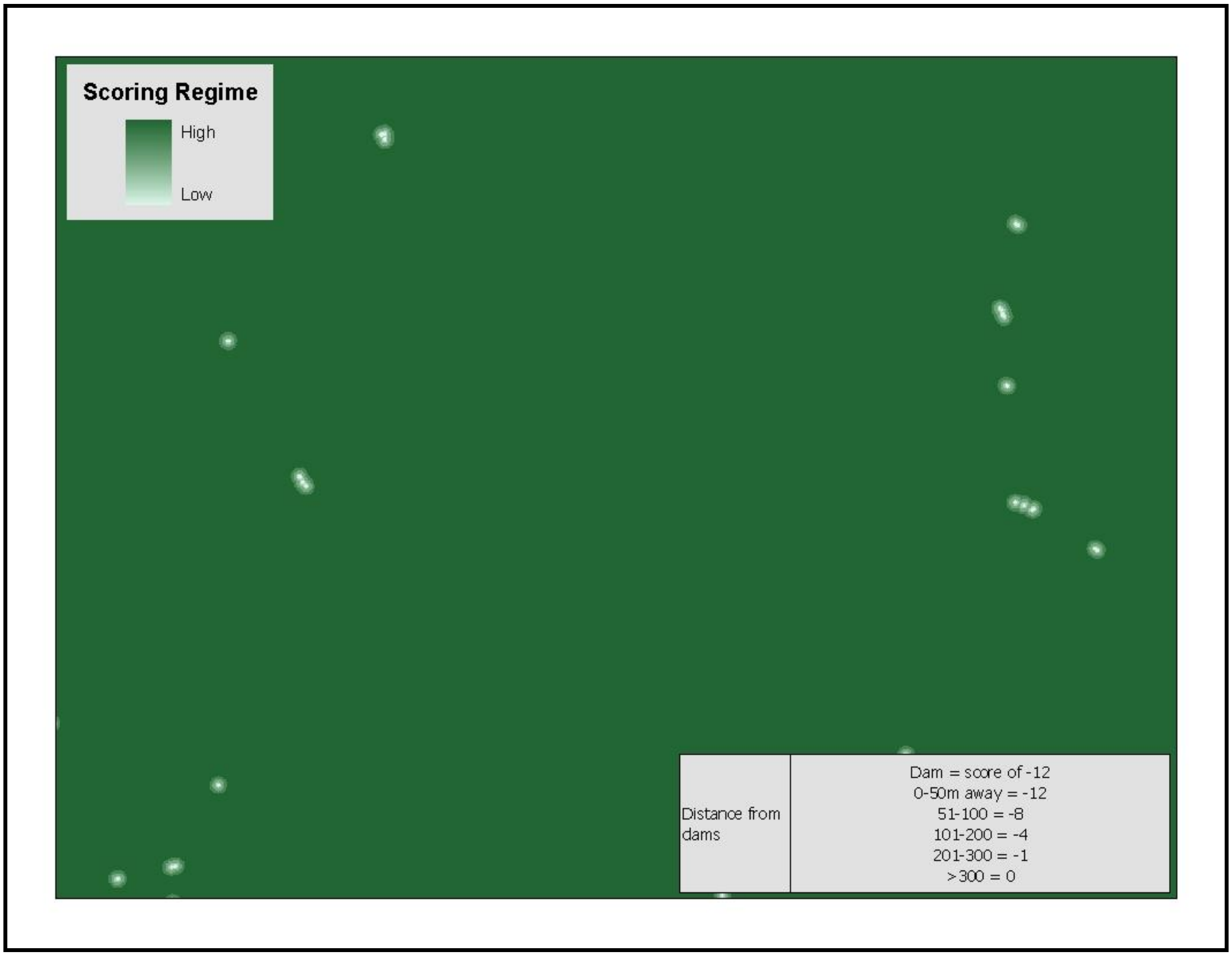


Figure 30: An example screenshot for influence of dams scores.

Scores

The Watershed Inventory Project strived to meet three goals. The first goal was to classify unique aquatic ecological systems across the landscape and identify systems that were not under existing protection. The second goal identified areas of high ecological importance for aquatic ecological systems, and the third goal identified the stresses upon aquatic ecological systems and processes.

The first goal was met by categorizing aquatic ecological systems within the area of interest and assessing their protection status. The aquatic ecological systems were classified into stream, lake and wetland systems (Figures 2-12).

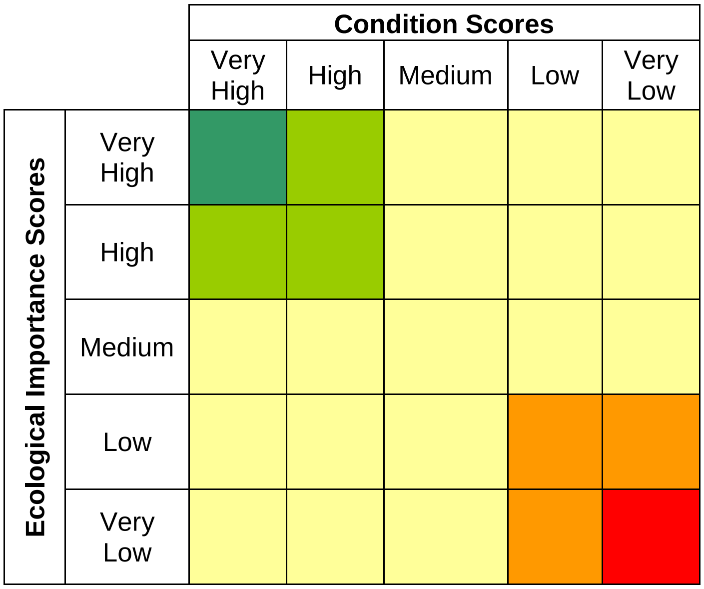
The second goal was met by identifying areas of high ecological importance. The second goal was accomplished by summing the scores from datasets that indicated ecological function, diversity and special features (figures 13-18); the resulting highest scoring areas were the most important for sustaining aquatic ecosystem processes.

The third goal was met by summing the scores of the condition indicators (figures 19-30). The lowest scored areas were under a high degree of stress, or of low condition or quality.

Parallel to the terrestrial WIP assessment, the summed datasets of ecological importance (second goal) and condition (third goal) created a final scored dataset. The final scores show how the negative scores of condition affect the positive scores of the ecological importance dataset. The final resulting scores determined those sites that were ecological significant and also in good condition and all of the combinations in between (Figure 31). The final report describes the results of the WIP goals and final scored dataset.

The motive for scoring the two goals separately (ecological importance and condition) as well as combining the two goals, was a result of the diverse interests of the collaborative group (MNR, MHF, DMM, MWC and DFO). For example, from the overall final scored dataset:

- The Ministry of Natural Resources can assess significant sites for regulated protection on Crown land.
- The Muskoka Heritage Trust (of MHF) can focus attention on land acquisition of private land that would capture highly significant and high quality sites.
- The Muskoka Heritage Foundation can identify ecologically important sites and assess the site's condition to focus effort on appropriate areas for restoration work (high ecologically significant scored, but low condition scored sites would be the most efficient use of resources if compared to a site that was of low ecological significance).
- The District Municipality of Muskoka can use the results of the second goal to assess appropriate levels of development surrounding significant sites and to use the combined score as background information for a natural areas strategy.
- The Muskoka Watershed Council can monitor significant sites, and assess their quality or condition by comparing all three datasets and report on the changes.
- Fisheries and Oceans Canada is interested in the overall landscape affects of ecological processes and stresses on aquatic resources. DFO uses the results of the WIP to identify important aquatic habitat areas that would be affected by projects or in-water works and also the best locations where project proponents will rehabilitate to compensate for destroying fish habitat.



	Very high ecological importance and very high condition. These sites are the most ecologically important and least stressed. These sites are the best potential for protection or acquisition.	
	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 be potential for restoration to restore highly significant sites to become higher quality. As well, these sites could be potentially used 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 low condition. These sites do not appear to contribute greatly to the ecological processes of the landscape and are highly disturbed.	

Figure 31: Matrix of final WIP scores.

The Products

The Inventory achieved three main goals (Table 1). The first goal identified aquatic ecological systems and protected areas. Accomplishing the first goal allowed the completion of the first product of the Inventory:

(1) A gap analysis of unprotected aquatic ecological systems.

Product 1:

A gap analysis of unprotected aquatic ecological systems

Finding gaps in the protection of aquatic ecological systems was accomplished by the first criterion of Representation. Unique aquatic ecological systems (stream, lake and wetland types) were overlaid with the existing protected areas to identify the unprotected ecological systems.

Similar to the terrestrial WIP assessment where vegetation communities and landform types were the basic units, stream, lake and wetland ecosystem types were used as the basic *aquatic* units in the GIS environment to apply the scoring values for the aquatic assessment. The final report describes the number and variety of aquatic ecological systems found within the WIP area of interest. The WIP also reported on the proportion of each aquatic ecological system within the entire area of interest.

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

The second goal identified areas of high ecological importance and the third goal identified stresses on ecological systems and processes (Table 1). By achieving the second and third goals, the WIP produced the remaining three products:

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

Product 2:

A gap analysis of biological data and site inventories

The WIP collection of datasets was comprehensive to ensure that sites captured the significance of ecological processes and biodiversity of the Muskoka and Black-Severn watersheds on the Canadian Shield. By assessing the datasets and documenting/verifying the currency and accuracy of each, missing and inaccurate data were identified. This technical report touches on some of the inaccurate and out-of-date data used in the WIP. The final report summarized these data limitations and reported on future updates for some datasets and their sources. Many of the datasets used for the aquatic assessment were used in the terrestrial assessment and did not change dramatically from one assessment to the next (such as trails or recharge areas). Some datasets used for the aquatic assessment were used or valued differently than the terrestrial assessment because these indicators affect aquatic systems differently (such as scoring for only *aquatic* species observations). Further datasets were used only for the aquatic assessment to capture indicators that would impact aquatic systems but were not considered for the terrestrial assessment (such as over threshold lakes and road crossings). The use of GIS allows the Inventory database to be updated as new data becomes available and for future iterations.

Product 3:

A map portraying the significant natural areas and connecting corridors

The final scored grid achieved the third product of identifying significant natural areas and connecting corridors. By scoring the criteria to identify areas of high aquatic ecological importance (second goal), and combining the grid of stresses on ecological systems and processes (third goal), the WIP assessed high quality, ecologically significant natural areas (Figure 31).

The terrestrial assessment identified the highest quality significant areas and identified remaining natural areas that would contribute to and enhance the overall terrestrial ecological quality of the area of interest. Unlike southern Ontario, the area of interest has a large proportion of high quality natural landcover (forested areas and rock terrain). From an aquatic perspective, the area of interest was also unique from southern Ontario because of the vast amounts of remaining wetlands and water in the form of lakes, ponds, streams and rivers. Intuitively, aquatic ecosystems are connected simply by its fluid nature. However, the question remains as to whether the connecting streams, lakes, wetlands and their riparian areas were in good ecological condition. If these systems are not ecologically functioning across the landscape, aquatic ecosystems become isolated and not connected functionally, even if they appear to be connected physically. The WIP scoring regime identified significant, ecologically functioning natural areas and the potential linkages between them. The results are discussed in the final report.

Product 4:

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

Restoration and remediation projects are costly and require expertise in most cases to ensure efforts are used efficiently and effectively. Restoring a degraded site repairs the site's integrity, but restoring a site that would also contribute to the landscape's ecological function and biodiversity would be ideal. Traditionally, restoration efforts have focused on bringing a site back to a more natural looking state (i.e. planting vegetation or erosion control of a depleted aggregate pit). However, rarely was ecological function a forethought in the planning stages of rehabilitation (Corry et al 2008), but more likely an assumption that ecological function is restored if the site appears to be rehabilitated.

The results of the second goal identified highly significant areas. The sites were considered significant based on the most current scientific principles of landscape ecology and biological diversity. The analysis of the second goal did not include any specific stresses upon sites, thus identifying areas that were important to ecological processes regardless of condition. The third goal identified the condition, or quality of sites. By finding areas that were highly significant from the results of the second goal and determining its condition from the third goal, the most appropriate sites to focus restoration efforts can be identified, but also the reasons for the degradation can be determined. Thus, the best of efforts can be put forth to restore a site back to an ecologically functioning site.

Discussion and Limitations

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

The Great Lakes Conservation Blueprint for Biodiversity (GLCB) conservation framework was developed to inventory and identify significant natural heritage areas. One of the strengths of using the GLCB framework for the WIP was the support of a Core Science Team with expertise and experience in conservation and natural heritage planning. The GLCB also used conservation principles and terminology familiar to conservation planners across Ontario, thus developing a framework that was useful to all organizations with similar conservation mandates. The GLCB framework was adaptable and useful for further iterations and allowed data to be re-analyzed as goals and objectives change over time, and can be perfected with different datasets and values. Thus, the GLCB framework worked well for both the terrestrial and aquatic assessments at the tertiary watershed level for the Muskoka region.

The WIP attempted to gather a comprehensive list of attributes that would capture ecological units, ecological processes and their condition or quality. The WIP was based on current scientific knowledge of ecology and conservation science. However, one aspect of identifying significant areas was missing from the WIP: threats to ecological systems. Threats were considered to be *future* risks to ecological systems, whereas the WIP evaluated *current* stresses or pressures. Evaluating threats to ecological systems was beyond the scope of the WIP, however, the collaborative recognized that some of these threats would need to be addressed, or at the very least flagged, in future iterations. For example, aquatic ecosystems may be affected more so than terrestrial systems by global warming or climate change. Some impacts, such as changing water levels and thermal regimes, may occur at rates that will not allow sensitive aquatic and semi-aquatic species to adapt (Poff 2002, Allan et al 2005). Although many of the effects of climate change are occurring presently, we do not know the full impact of global warming.

In Ontario, natural heritage inventories have occurred mostly in the south, off of the Canadian Shield. Many existing site inventories for the Canadian Shield were considerably out-of-date at the time of the Inventory analysis. As well, natural heritage inventories have traditionally focused on terrestrial species and values. Aquatic values have mainly been collected for human use (water sampling or fish surveys). Fortunately, agencies in the Muskoka area have been sampling and modeling recreational water quality for years and that information was used in the WIP. Also, in the WIP area of interest, significant fish habitat values have been mapped for many waterbodies.

As well, the aquatic component had an advantage as a result of the completion of the terrestrial component of the WIP. Many datasets that were created during the terrestrial analysis were used in the aquatic assessment, such as settled areas and natural areas coverage.

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

The WIP collaborative also recognized that desktop modeling and analysis does not replace the value of site-specific, on-the-ground surveys. Furthermore, it was not in the scope of the WIP to confirm or verify the landscape modeling and analysis results with more site-specific assessments.

Considering the constraints of time and data availability the WIP relied heavily on the expertise, techniques, and created datasets of GLCB initiatives. As a result, there were datasets created by GLCB that were used directly in the Inventory (i.e. not recreated specifically for the WIP), for example, the creation of some datasets to classify the aquatic ecological systems (i.e. gradient for stream ecosystem types).

The WIP was a collaborative of five different agencies. Each collaborative member used the WIP results in different ways; hence the deliverables must be useful for all members. Maintaining strong communication between members was important to make certain that issues were addressed, technical and scientific knowledge was accepted and that the methods produced a useful project for all agencies. As a result of working together to complete the terrestrial component of the WIP, established communication and data sharing agreements were advantages for completing the aquatic component in a relatively short period of time.

The aquatic component of the WIP attempted to identify ecologically significance areas across the Muskoka River and Black-Simcoe River tertiary watersheds on the Canadian Shield through an aquatic lens. The WIP used a methodology that was developed by experts in the field of conservation science research and natural heritage planning, thus was scientifically supported and transparent. The methodology allowed flexibility for using local information and expertise to identify significant areas within our area of interest, which was important when faced with lacking regional and provincial data for this type of an assessment.

The WIP was designed to assess the landscape in two essential components: terrestrial and aquatic ecosystems. Using similar methodology for both components, the WIP was able to apply lessons learned and use datasets that were created specifically for the WIP area of interest. The result was an assessment that was specific and unique to the Muskoka area.

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