Credit Valley Conservation

June 2011

Towards a Natural Heritage System for the Credit River Watershed:

Summary report on watershed characterization and Landscape Scale Analysis

CVC
CREDIT VALLEY CONSERVATION

ABSTRACT

Credit Valley Conservation (CVC) is building upon its considerable natural heritage expertise and data to identify a science based, integrated, Natural Heritage System for the Credit River Watershed. This project is congruent with the object of Conservation Authorities (CAs) in Ontario under Section 20 of the *Conservation Authorities Act*, to "*establish and undertake, in the area over which it has jurisdiction, a program designed to further the conservation, restoration, development and management of natural resources other than gas, oil, coal and minerals."* The Ontario government recognizes the importance of a natural heritage systems approach to the protection of water and natural resources in a number of pieces of legislation including the *Provincial Policy Statement*. A number of municipalities within CVC boundaries have also completed or are in the process of completing Official Plan updates relating to Natural Heritage Systems planning.

The primary goals for the Credit River Watershed Natural Heritage System are: to protect, restore, or enhance the ecological integrity of the Credit River Watershed's natural features, functions and systems; and to protect or enhance the quantity and quality of surface and ground water for environmental and human uses. A watershed is recognized by the province of Ontario as the "*ecologically meaningful scale for planning"* to protect, improve, or restore the quality and quantify of water; hence the CVC focus on the watershed as the scale for Natural Heritage System planning.

A Natural Heritage System is defined by the Province of Ontario as *"a system made up of natural heritage features and areas, linked by natural corridors which are necessary to maintain biological and geological diversity, natural functions, viable populations of indigenous species and ecosystems. These systems can include lands that have been restored and areas with the potential to be restored to a natural state"*.

A watershed Natural Heritage System can be used as a planning tool; for watershed securement, stewardship and restoration programs; for identification of natural heritage data gaps and to guide species or community inventories. Municipal planning authorities can utilize the system to review their existing natural heritage systems policies and strategies at the municipal scale to enhance the protection of natural heritage features and functions in their area of jurisdiction over the long term.

The Terrestrial Ecosystem Enhancement Model (TEEM) project was initiated in CVC to develop a Natural Heritage System for the Credit River Watershed. The term 'Credit River Watershed' is used in this document as a convenient term to refer to the entire CVC jurisdiction.
The project Phases are as follows:

Phase 1: Characterize existing conditions in the watershed; assess the relative importance of existing natural areas in GIS using a Landscape Scale Analysis;
Phase 2: Plan integration of water and terrestrial functions in the Landscape Scale Analysis; consult with stakeholders;
Phase 3: Develop criteria, GIS methodology, and mapping for a watershed Natural Heritage System and consult with stakeholders;
Phase 4: Finalize the Natural Heritage System, identifying lands for stewardship, protection or restoration following assessments of impacts of increased development or other land uses and climate change. Develop recommended model policies following stakeholder consultation and review of existing policies.
Post Phase 4, engage municipal planning authorities to emphasize the effectiveness of existing natural heritage related policies and provide information in updating existing natural heritage system protection strategies in the context of watershed health.

This abbreviated summary report which includes characterization of the watershed and an assessment of its existing features and functions through a Landscape Scale Analysis constitutes the culmination of the first two Phases of the TEEM project. The full technical report (CVC 2011) with accompanying Appendices can be found on the CVC website at
http://www.creditvalleyca.ca/bulletin/resources.htm#natural

The watershed characterization and assessment of existing conditions through a Landscape Scale Analysis were undertaken through the following steps:

1. ***Review of background information***
    a. Baseline information on the Credit River Watershed was gathered and summarized
    b. Relevant scientific and grey literature related to natural heritage systems planning was reviewed
    c. Available data on watershed land cover, land use and the size and configuration of natural areas in the watershed were gathered and summarized
2. ***Development of Criteria and Thresholds***
    a. Broad criteria for the Landscape Scale Analysis (LSA) were developed based on current science, common practice and/or technical peer review, and the best available data
3. ***Execution of the Landscape Scale Analysis***
    a. The LSA was conducted using GIS (Geographic Information System) mapping
    b. The scale and resolution of analysis were identified
    c. The analysis was conducted using Ecological Land Classification (ELC) mapping, a method for classifying vegetation communities that has been developed by the province of Ontario.
    d. The finest scale of ELC mapping was the ELC community series, created for the entire watershed through a combination of air photo interpretation and field data.

e. ELC community series were aggregated into habitat patches, defined as areas of contiguous natural and semi-natural cover within the watershed
f. Nine criteria were used in the LSA: **1) woodlands, 2) wetlands, 3) successional habitats** such as meadows, **4) valleylands or riparian areas**, **5) high habitat diversity**, **6) uncommon vegetation communities**, **7) ecological proximity**, **8) regional linkages**, and **9) provincial linkages**.
g. Thresholds were developed for the above criteria using results of the review conducted in Step 1. Thresholds for criteria were based on well established scientific principles, federal or provincial guidelines, best practices, professional judgment of technical committees or external peer reviewers, and CVC data.
h. Habitat patches were scored using the above nine criteria with respect to their relative importance in contributing to ecosystem function within the watershed.
i. Habitat patches were given a score of zero or one for each criterion.
j. Scores were summed for each individual habitat patch. Habitat patches received scores ranging from zero (relatively small contribution to ecosystem functioning) to nine (extremely high contribution to ecosystem functioning).
k. A separate analysis of the Aquatic System in the watershed identified aquatic features contributing strongly to ecosystem function at the watershed scale. These included permanent and intermittent streams, lakes, and online ponds.

4. ***Post analysis data summarization***
   a. The results of the LSA were used to create ‘functional groups’, where habitat patches scoring 0-9, were clustered into groups, based on their relative importance to ecosystem function within the watershed.
   b. Functional groups were determined by examining the relationship between habitat patch scores and other independently designated significant natural heritage features in the watershed, including Areas of Natural and Scientific Interest, Environmentally Significant Areas, Provincially Significant Wetlands, known habitats for Species at Risk, and existing data on species richness within habitat patches.
   c. Habitat patches scoring 7, 8 or 9 were designated ‘Core ecofunction habitats’ for the watershed; habitat patches receiving scores of 4, 5, or 6 were termed ‘Highly Supporting ecofunction habitats’; those scoring 1, 2, or 3 were termed ‘Supporting ecofunction habitats’, and those receiving a score of 0 were termed ‘Contributing ecofunction habitats’.
   d. These functional groups can be used to prioritize future protection, stewardship and restoration efforts. Core ecofunction habitats are

considered to be very high importance in terms of ecosystem function at the landscape scale. Contributing ecofunction habitats provide contribute less to overall function on the landscape, but at the site level may be locally significant.

The Landscape Scale Analysis represents the first step in developing a Natural Heritage System for the Credit River Watershed by assessing existing key natural terrestrial and aquatic areas in the watershed that should be included within a Natural Heritage System. Future work (Phase 3) will focus on developing criteria, GIS methodology and mapping of a Natural Heritage System for the Credit River Watershed that will improve the healthy functioning of the watershed's ecosystems particularly through improving functional linkages among natural areas and identifying opportunities for stewardship, restoration, protection, or securement.

The Credit River Watershed Natural Heritage System will include lands that are in a natural or semi-natural state as well as areas under compatible uses or "*lands with the potential to be restored to a natural state"*, as defined by the *Provincial Policy Statement*, and aquatic features. Areas under compatible uses include agricultural lands. Areas with potential to be restored to a natural state could include successional lands such as cultural meadows to enhance linkages among natural areas. The Natural Heritage System is not intended to limit existing uses on lands within the system, and recommended model policies in Phase 4 of the project will reflect this intention.

The development of the Credit River Watershed Natural Heritage System does not limit the ability of planning authorities within the watershed to consider other systems based approaches but provides an alternative based on maintaining water quality and quantity and healthy ecological functioning of the Credit River Watershed. In this regard, CVC continues to be committed to further working with planning authorities to develop compatible and consistent 'municipal level' natural heritage systems that best fit their needs while enhancing watershed health.

TABLE OF CONTENTS

LIST OF FIGURES

LIST OF TABLES

1.0 BACKGROUND

The Credit River winds its way from Orangeville in the north, through fertile farmland, diverse marshes, swamps and forests, over the Niagara Escarpment, past the large cities of Brampton and Mississauga, finally emptying into Lake Ontario, a source of freshwater for millions of people.

Our health depends on the health of our lands, air and water. Natural areas contain diverse plants and wildlife which have the intrinsic right to exist. As part of their healthy functioning, these areas provide services from which we all benefit and without which we cannot exist, such as clean air, pure and abundant water, biodiversity for food, fuel, research, medicine and engineering design, flood control, cycling of gases and nutrients, pollination, and natural pest control.

Recognizing the linkages between healthy waters, lands, and biodiversity, the Credit Valley Conservation (CVC) Board of Directors approved the Terms of Reference for developing a watershed scale Natural Heritage System in 2006 through creation of a project called the *Terrestrial Ecosystem Enhancement Model,* or TEEM. The purpose of this project is to establish a Natural Heritage System for the Credit River Watershed that will protect biodiversity and ecosystem functions of the watershed in perpetuity (CVC 2006b). In the context of this study, the term 'Credit River Watershed' is used for convenience to indicate the area of jurisdiction of Credit Valley Conservation and includes the lands drained by the Credit River and creeks that flow directly into Lake Ontario, as well as the Lake Ontario Shoreline and the area extending 6km into Lake Ontario.

The watershed is an integrated system of human and natural resources that needs to be managed in a holistic and balanced way to achieve a healthy and sustainable environment. In this regard, the Province of Ontario provides direction regarding the development of sustainable natural systems. As defined under the *Provincial Policy Statement* (PPS), a Natural Heritage System means *"a system made up of natural heritage features and areas, linked by natural corridors which are necessary to maintain biological and geological diversity, natural functions, viable populations of indigenous species and ecosystems. These systems can include lands that have been restored and areas with the potential to be restored to a natural state"* (OMMAH 2005a). Lands *"with the potential to be restored to a natural state"* means lands that currently do not hold natural cover but have the capacity to be restored or rehabilitated to a natural state. These may include agricultural lands and manicured open space such as parks and golf courses, as well as semi-natural (human modified or cultural) lands such as cultural meadows, cultural thickets and cultural savannahs. Agricultural lands or manicured open spaces in a Natural Heritage System that have no or limited natural cover can still perform natural functions such as infiltration, groundwater recharge, and provision of habitat for species movement, feeding, or migration.

In human-modified environments such as the Credit River Watershed, remaining natural features are often not large enough or diverse enough, or lack sufficient connectivity to meet the daily, seasonal and long term life cycle requirements of species. When species survival is compromised, ecosystems lose the ability to function well. Land use change from rural to urban and the impacts of climate change result in significant impacts to natural areas and increased human dependence on dwindling natural features and functions. A Natural Heritage System that improves the functioning of natural features through improvements to their size, connectivity, and hydrological functioning will help mitigate to some extent the impacts of land uses and climate change in the watershed. A watershed approach can help ensure that the hydrologic functioning of the system is maintained, restored or enhanced.

The Natural Heritage System for the Credit River Watershed is not intended to prevent existing uses from continuing, and recommended model policies for the system will reflect this intention. The purpose of the project is to develop an efficient, cost-effective system which has a greater likelihood of sustaining and improving biodiversity and ecosystem function for the watershed over the long term through a combination of stewardship, restoration, securement and policy.

2.0 PROJECT PHASES AND TIMELINES

The TEEM project is divided into four phases (CVC 2006a):

Phase 1
Review literature and relevant natural heritage studies; establish Technical and Municipal Advisory Committees; characterize existing conditions in the watershed and assess existing natural and semi-natural features in the watershed with regards to their relative importance in sustaining ecosystem function using a Landscape Scale Analysis.

Phase 2
Identify and fill data gaps; plan integration of water and land functions in Landscape Scale Analysis; finalize Landscape Scale Analysis; communicate assessment of existing features and functions to stakeholders and invite stakeholder input.

Phase 3
Develop Natural Heritage System for the Credit River Watershed; consult with stakeholders.

Phase 4
Finalize Natural Heritage System for the Credit River Watershed. Assess impacts of increased development and other land uses, and climate change. Identify key natural areas providing connectivity across watershed boundaries.
Develop recommended model policies and strategies for the Credit River Watershed Natural Heritage System. Hold stakeholder workshops on recommended model policies and strategies and provide opportunities for public input on model policies and strategies.

Ongoing following phase 4
Engage municipalities in discussions to best determine how a healthy watershed can be maintained (for example through policy review and/or strategy development) under municipal mandates for ensuring sustainable social, economic, and environmental systems. Monitor and refine the Natural Heritage System at appropriate time intervals, and update as required to integrate with provincial policies, Official Plans, and new science.

This abbreviated summary report which includes characterization of the watershed and an assessment of its existing features and functions through a Landscape Scale Analysis constitutes the culmination of the first two Phases of the TEEM project. The full technical report (CVC 2011) with accompanying Appendices can be found on the CVC website at
http://www.creditvalleyca.ca/bulletin/resources.htm#natural

3.0 SYSTEMS APPROACH TO NATURAL HERITAGE PLANNING IN ONTARIO

Environmental planning in Ontario in the 1970s focused on the identification of natural features of high biodiversity or species habitat value, hydrological value, or aesthetic or distinctive landform characteristics. As the science of landscape ecology and conservation biology progressed, studies showed that landscape level planning is necessary to maintain biodiversity and ecosystem functions over the long term in addition to identification of individual features, because the spatial configuration of natural features can have important effects on biodiversity and the health of ecosystems (Forman and Godron 1986, Forman 1995).

This systems approach, recognizing that the health of individual natural heritage features depends upon their placement within a functioning system, gained rapid acceptance. In 1991, OMNR released a framework for protection of natural heritage, outlining key principles for natural heritage protection that emphasized the protection of natural heritage systems. In 1996, the *Provincial Policy Statement* was released to provide direction on matters of provincial interest related to land use planning and development. The 2005 version of this document contains natural heritage policies that provide protection for key natural heritage features while stressing that the functions of natural features be maintained or enhanced using a natural heritage systems approach (OMMAH 2005a). The 1999 *Natural Heritage Reference Manual* updated in 2010 (OMNR 2010), intended for use in policy development, provided guidance on developing natural heritage systems, while reinforcing the importance of a systems approach in protection of individual features: "*A natural heritage system approach is a useful method for the protection of specific natural heritage features and areas because it reinforces an understanding that individual areas and features have strong ecological ties to other physical features and areas in the overall landscape*"**.**

The policy direction provided by the provincial government has resulted in the development of several natural heritage systems in Ontario that utilize a systems approach, based on sound, scientifically defensible landscape ecology and conservation biology principles. These Natural Heritage Systems frequently identify cores and corridors, where cores represent large tracts of forests, wetlands, and semi-natural or rural areas, and linkages or corridors represent smaller natural, semi-natural, or rural areas that knit the cores into a larger, functioning system.

4.0 PLANNING AND POLICY CONTEXT FOR NATURAL HERITAGE SYSTEMS DEVELOPMENT

There is a strong established provincial framework for the development of Natural Heritage Systems in Ontario. Section 2.1.2 of the *Provincial Policy Statement (PPS)*, a policy document under the *Planning Act* states: *"The diversity and connectivity of natural features in an area, and the long-term ecological function and biodiversity of natural heritage systems, should be maintained, restored or, where possible, improved, recognizing linkages between and among natural heritage features and areas, surface water features and ground water features."*

Natural heritage protection is also mentioned in section 2.2 of the *Provincial Policy Statement* on Water, particularly policies 2.2.1a, 2.2.1c and 2.2.1e:

"Planning authorities shall protect, improve or restore the quality and quantity of water by:

a) using the watershed as the ecologically meaningful scale for planning;

c) identifying surface water features, ground water features, hydrologic functions and natural heritage features and areas which are necessary for the ecological and hydrological integrity of the watershed;…

e) *maintaining linkages and related functions among surface water features, ground water features, hydrologic functions and natural heritage features and areas;"*

The *Conservation Authorities Act* is the enabling provincial legislation that provides the legal basis for the creation of Conservation Authorities (CAs) in Ontario. Generally, the Conservation Authorities Act directs CAs to perform a number of functions regarding watershed planning and management including the prevention, elimination, or reduction of loss of life and property from flooding and erosion, as well as the protection and restoration of natural resources. Section 20 of the Conservation Authorities Act outlines the objects of the CAs which includes undertaking programs designed to further the conservation, restoration and management of natural resources, and Section 28 of the *Conservation Authorities Act* empowers CAs to make regulations in the area under its jurisdiction. Through regulations updated in 2006, CAs regulate interference with wetlands and watercourses as well as development in or adjacent to natural heritage features such as river or stream valleys, Great Lakes and large inland lakes shorelines, watercourses, hazardous lands and wetlands.

There are a number of other provincial and federal Acts and strategies that additionally protect species, features, or functions that would form part of a natural heritage system. In the Province of Ontario, the *Greenbelt Plan 2005* refers to a Natural Heritage System of core areas and connecting corridors (OMMAH 2005b). The Greenbelt Plan includes land within, and builds upon the Niagara Escarpment Plan and the Oak Ridges Moraine Conservation Plan, complementing other provincial level initiatives such as the Parkway Belt West Plan and Rouge North Management Plan. The Credit River Watershed contains lands that fall within the *Niagara Escarpment Plan area*, *Oak Ridges Moraine Conservation Plan* area, Parkway Belt West Plan area and Protected Countryside area of the Greenbelt Plan.

The *Places to Grow – Growth Plan for the Greater Golden Horseshoe*, implemented through the *Places to Grow Act 2005* (Government of Ontario includes the direction to *"protect, conserve, enhance and wisely use the valuable natural resources of land, air and water for current and future generations"* and also states that "*Planning authorities are encouraged to identify natural heritage features and areas that complement, link or enhance natural systems*".

A commitment to the conservation of biodiversity has been identified as a key focus for the Ontario Ministry of Natural Resources (OMNR). Ontario's *Biodiversity Strategy* (OMNR 2005, recently updated in 2011) notes that *"A broad vision of the landscape is needed to provide a context for biodiversity conservation. Biodiversity conservation must be built into all aspects of land use planning."*

The *Federal Fisheries Act* protects all fish habitat, including that of threatened and endangered fish species. The Federal *Species at Risk Act (SARA;* Government of Canada) provides protection on federal lands for species that are Endangered or Threatened. The *Endangered Species Act* in Ontario provides protection for species that are Endangered or Threatened, and their habitat (Government of Ontario). These species are identified in the *Species at Risk in Ontario (SARO)* list. Ontario's *Clean Water Act* (Government of Ontario) relates to protection or regulation of lands within watersheds that provide drinking water.

Finally, a number of municipal Official Plans or Strategies recognize the importance of Natural Heritage Systems and the need for creating, maintaining and enhancing resilient, healthy ecosystems (e.g. Regional Municipality of Peel 2005, North-South Environmental Inc 2009, Region of Peel draft *Climate Change Strategy*, 2011).

5.0 GUIDING PRINCIPLES, GOALS AND OBJECTIVES FOR THE CREDIT RIVER WATERSHED NATURAL HERITAGE SYSTEM

Guiding principles for the development of the Credit River Watershed Natural Heritage System provide a context for the goals and objectives for the system. Some of the key guiding principles include the following: 1) Protection and enhancement of existing natural heritage features and functions shall take priority over restoration; 2) A systems perspective to natural features and functions shall be maintained, recognizing that the health of individual features depends on their placement within a functioning watershed system; and 3) A preventive, proactive and integrative approach shall be taken that applies the Precautionary Principle to watershed management based on adaptive environmental management. The Precautionary Principle recognizes that the absence of full scientific certainty shall not be used as a reason to postpone decisions where there is a risk of serious or irreversible harm.

The goals and objectives for the Credit River Watershed Natural Heritage System arise from the CVC vision of *"An environmentally healthy watershed supporting native biodiversity and self-sustaining natural features and functions for present and future generations"*. Goals and objectives from CVC's Strategic Plan (CVC 2006b) related specifically to the maintenance of biodiversity and healthy ecosystem functioning were adopted for the development of a watershed Natural Heritage System:

5.1 PRIMARY GOALS FOR THE CREDIT RIVER WATERSHED NATURAL HERITAGE SYSTEM

Terrestrial and aquatic species, communities and ecosystems:
To protect, restore, or enhance the ecological integrity of the Credit River Watershed's natural features, functions and systems.

Water quality and quantity
To protect or enhance the quantity and quality of surface and ground water for environmental and human uses;

5.2 PRIMARY OBJECTIVES

Terrestrial and aquatic species, communities and ecosystems:

a. Protect, restore or enhance integrity of watershed ecosystems, through an integrated network of core areas, connections, and linkages;
b. Protect, restore or enhance native terrestrial and aquatic plant and animal species, community diversity and productivity;

c. Ensure that the complete range of representative and significant natural features and functions distributed within the watershed are protected in perpetuity
d. Protect, restore or enhance natural ecosystems to sustain watershed functions, human uses, and build resilience to stresses such as climate change; and
e. Promote sustainable resource management of aquatic and terrestrial systems and areas within the watershed for plant, animal and human needs.

Water Quality and Quantity:

a. Preserve, maintain or re-establish the natural hydrological cycle;
b. Maintain, enhance or restore natural stream processes to achieve a balance of flow and sediment transport;
c. Maintain and restore groundwater levels and baseflows (groundwater discharge to streams) to sustain watershed functions and human uses and build resilience to stresses such as climate change;
d. Minimize risk to human life and property due to flooding and erosion;
e. Maintain or enhance water and sediment quality to achieve ecological integrity;
f. Protect drinking water sources;
g. Protect and restore surface water quality with respect to conventional and toxic pollutants to ensure protection of ecosystem functions and water supply;
h. Protect, restore and enhance groundwater quality to support watershed functions;
i. Improve water quality in streams, the Credit River, and Lake Ontario to meet standards for body contact recreation and provide for sustainable fishing opportunities and the safe consumption of fish; and
j. Improve water aesthetics including odour, turbidity and clarity.

5.3 SECONDARY GOALS FOR THE CREDIT RIVER WATERSHED NATURAL HERITAGE SYSTEM

Natural Hazards:

To protect public safety and minimize property damage from natural hazards including flooding, drought, erosion, sedimentation, wetlands and dynamic beach processes; and

Social and Economic:

To promote the health and sustainability of watershed communities through effective watershed management.

5.4 SECONDARY OBJECTIVES

Natural Hazards:

a. Protect potentially hazardous river or stream valleys, flood plains and Lake Ontario shoreline; and
b. Protect watercourses (including their meander belt) and wetlands.

Social and Economic:

a. Promote the community benefits of the watershed's natural areas and system (recreational, educational, cultural, psychological, tourism, economic);
b. Recognize the contribution of agricultural lands and the urban forest to the health of the watershed's natural areas and to the well being of watershed communities; and
c. Provide appreciation and compatible recreational opportunities on protected land.

6.0 LANDSCAPE SCALE ANALYSIS AS A METHOD FOR ASSESSING THE CONTRIBUTION OF EXISTING NATURAL FEATURES TO WATERSHED FUNCTIONING

A Landscape Scale Analysis (LSA) is a desktop analysis conducted using spatial data contained in a Geographic Information System, or GIS. The LSA can be defined as a tool for characterization and assessment of ecosystem features and functions at the landscape scale, using GIS mapping, a systems approach, and well-established ecological principles to ensure integration of the features and functions within the region of interest with those in the broader landscape.

The systems approach of the Landscape Scale Analysis identifies natural features that are important for maintaining biodiversity and healthy ecosystem function in a region of interest. For example, larger and more compactly shaped natural patches in the landscape tend to hold and maintain more species than smaller, irregularly shaped patches; a greater area of the landscape containing streamside natural vegetation has been linked to improved conditions for aquatic life; and more connected patches allow species to move, preserving genetic diversity and ecosystem resilience in the landscape over time (Forman and Godron 1986, Forman 1995). A Landscape Scale Analysis can be conducted at various scales, including regional, watershed, municipal or sub-municipal.

It is important to recognize what a Landscape Scale Analysis can and cannot do. It is a science based analysis capable of identifying and prioritizing for protection a set of natural habitat. The analysis uses existing, well-established principles of landscape ecology and conservation biology to determine site quality at the landscape scale. It can identify a broad suite of functions that a particular habitat patch supports, or is capable of supporting. A Landscape Scale Analysis can identify local connections that allow species to move among natural habitats, improving the resilience of the system; and it can identify corridors that connect the system to larger, bioregional natural systems. A Landscape Scale Analysis is a key first step in identifying a Natural Heritage System for an area of interest.

There are a few things the Landscape Scale Analysis cannot do. First, an LSA cannot determine the site level ecological integrity of the natural habitats in the analysis. For example, it cannot specifically identify woodlands that contain a high proportion of native plant species. The Landscape Scale Analysis is limited to data that is available across the region of interest. Second, because the analysis uses GIS data from air photo interpretation at a relatively coarse scale (1:10,000) and a percentage of field verification, a certain degree of error is inherent in the analysis such that field measurements may not correspond exactly to measurements made on the map. Therefore mapping requires constant updating in order to remain accurate. Credit Valley Conservation has recently updated its ELC mapping in 2008 based on 2007 aerial photography. Hence mapping errors are minimized during the Landscape Scale Analysis.

In general the strengths of landscape scale analyses far outweigh their weaknesses. Consequently this level of analysis and accuracy is generally considered acceptable for implementation into municipal Official Plans. Spatial analyses have been used extensively in designing significant features or systems in Ontario (e.g. Lower Trent Conservation 2001, NHIC 2002, OMMAH 2002, Rowsell 2003, OMMAH 2004a, Dougan and Associates 2009, UTRCA 2003, City of Mississauga 2005, Henson et al. 2005, Regional Municipality of Peel 2005, Region of Waterloo 2006, Cataraqui Region Conservation Authority 2006, City of London 2006, UTRCA and County of Oxford 2006, Land Ethic Group 2006, Toronto and Region Conservation Authority 2007, Beacon Environmental and LSRCA 2007, North-South Environmental Inc. 2009, North-South Environmental Inc. et al. 2009). This level of accuracy is also sufficient to drive stewardship, securement, and restoration strategies.

A watershed scale Landscape Scale Analysis is part of a hierarchical framework for protecting features and functions in a watershed. Subwatershed or smaller scale subregional studies help to refine the watershed scale analyses by identifying locally important features and functions as steps in identifying local Natural Heritage Systems. Credit Valley Conservation has completed a number of subwatershed studies that summarize high quality sites at the subwatershed scale (e.g., CVC 2003a, 2003b, 2007c).

7.0 OVERVIEW OF THE CREDIT RIVER WATERSHED

Natural heritage systems planning for the watershed requires an understanding of the Credit River watershed's past, its existing biotic and abiotic resources, and current stresses.

7.1 PRE-SETTLEMENT CONDITIONS

The past land cover of the Credit River Watershed provides a historical perspective on current-day vegetation communities. Based on detailed surveyor records dating from 1806, around the time of European settlement, the region was composed primarily of deciduous forest (CVC and University of Guelph 2003). Other communities included marsh, swamp, and a few pockets of savannah. The pre-settlement vegetation of the Credit River Watershed consisted approximately of 65% upland forest, 21.7% lowland forest and swamp, 7% non-forest wetland and aquatic (watercourse and water bodies) and 1% early successional habitats (CVC and University of Guelph 2003).

A study of wetland extent in the broader southern Ontario landscape has shown that more than 76% of south Ontario wetland area has been lost following European settlement, primarily through early conversion of land for agriculture (Ducks Unlimited Canada 2010), and that wetland losses continue to occur. Forest cover has similarly been lost across southern Ontario. It is estimated that about 90% of southern Ontario's land base was forested prior to European settlement (Larson et al. 1999).

7.2 PRESENT LAND COVER AND LAND USE

The Credit River Watershed encompasses approximately 980 square kilometres of land in southern Ontario, Canada (CVC 2007a).

The Watershed is presently composed of 34% natural area (including aquatic), 37% agricultural land use or manicured open space, and 29% urban area (CVC 2011). Land cover is shown in Figure A1 in Appendix A (Figures with the prefix 'A' refer to maps; these are all found in Appendix A).

Approximately 6% of the Watershed is classified as wetlands (e.g. marshes and swamps, Figure 1), while 21% of the watershed is covered by woodlands (e.g. upland forests, swamps, plantations, and cultural or human modified woodlands; CVC 2011). Successional areas, such as meadows and thickets, occupy 10% of the watershed.

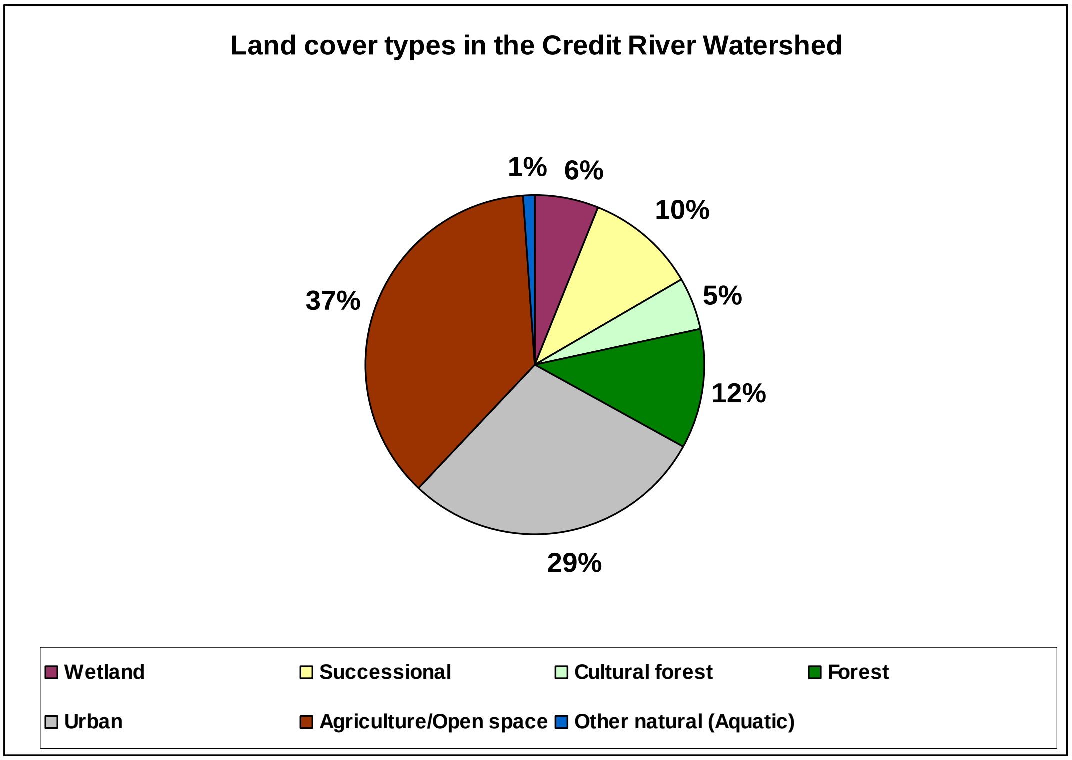
The Credit River flows southeast for nearly 100 kilometres from its headwaters in Orangeville to its drainage point at Lake Ontario. There are 20 subwatersheds within the main watershed boundaries which together contain almost 1500 kilometres of streams and creeks that empty into the Credit River (Figure A2). In addition to the Credit River and its tributaries, there are 14 creeks located within the City of Mississauga that drain directly into Lake Ontario.

Agricultural and urban areas play a supporting role in maintaining watershed biodiversity and ecosystem function. Farm lands or hedgerows in rural areas may function as linkages or movement corridors among natural areas for some species. Hay fields are an important source of food for many species including declining grassland species (Bird Studies Canada et al. 2004). Agricultural lands and some urban areas are pervious and permit the infiltration of water, contributing to maintenance of watershed hydrology. Most landowners demonstrate a strong environmental ethic and care for their land in ways that benefit and enhance existing natural areas.

The urban forest, which includes street trees, shrubs, ground vegetation and forest remnants found within a city, provides habitat for a number of plant and wildlife species including migratory species. It plays an important role in filtering and absorbing storm water runoff to improve in stream conditions for aquatic life, and in contributing to the health and well being of human residents (McNeil and Vava 2006). Unlike most developed areas, agriculture and open space lands retain the potential for restoration or stewardship to enhance ecological function.

Agricultural and urban areas cannot provide the same level of ecological function that natural areas provide. However, they play a supportive role in natural heritage systems and agricultural lands in particular have been recognized by the province of Ontario as playing their part in natural heritage protection (OMMAH 2005a).

Figure 1. Land cover types in the Credit River Watershed showing percent cover of natural and cultural communities in relation to total watershed area.



7.3 PHYSIOGRAPHIC ZONES

Though encompassing as many as 12 distinct physiographic regions (CVC 2007a), the Credit River watershed can be divided into three main physiographic zones based on physiographic regions and the boundaries of individual subwatersheds (Figure A1).

The Upper physiographic zone lies above the escarpment and is characterized by hilly moraines, glacial spillways, and permeable loamy soils (CVC 2007a). This zone contains most of the headwaters of the Credit River. Agricultural land use dominates portions of the upper watershed, though it also consists of several large wetland complexes and a protected moraine (The Oak Ridges Moraine) that is shared with the Middle zone. As part of Ontario's Source Protection Program, significant groundwater recharge areas have been delineated across watershed regions, these areas being considered vulnerable from a water quality and quantity perspective. Within the watershed, High Recharge Areas as defined under this program are heavily concentrated in the Upper Watershed zone, where coarse-grained moraine sediments lie at ground surface.

The major urban centres in the Upper Watershed include Orangeville, Erin, Alton, Caledon Village, and Hillsburgh (Figure A3). These towns are experiencing growth pressures due to their location in (Alton and Caledon Village) or near the Greater Toronto Area.

The Middle physiographic zone contains the Niagara Escarpment, a region of steep slopes, rocky outcrops, and thin soil (CVC 2007a). These topographic factors, along with limited urbanization and the implementation of protective legislation, have resulted in the middle watershed containing the greatest proportion of natural cover in the watershed. The Escarpment area is heavily forested with upland forest and swamps. Many tributaries of the Credit River in this zone develop in massive headwater complexes that cover approximately 40% of the Escarpment plateau. East of the Escarpment, the Credit River cuts through clay till plains and is characterized by steep-walled valleys with floodplains of varying widths.

Urban areas in the Middle watershed include Inglewood, Cheltenham, Terra Cotta, Ballinafad, Acton, Georgetown and Norval, all of which lie within the Greater Toronto Area (GTA) except for Ballinafad which lies near the GTA. Consequently these towns, like those in the Upper Watershed, are experiencing growth pressures.

The Lower physiographic zone is highly urbanized, containing over 85% of the human population of the watershed. The ground surface topography of this zone is relatively flat with a gentle slope south towards Lake Ontario (CVC 2007a). Surficial soils in this zone have low infiltration rates compared to the rest of the watershed, although the Lake Iroquois Plain area in this zone has areas of higher permeability due to sandy soils. In general, runoff is greater in this zone and infiltration significantly lower than in other parts of the watershed. This zone is highly urbanized, with 87% of the watershed's 750,000 inhabitants living there, and natural cover is low, with few woodlands and wetlands remaining.

This zone contains most of the City of Mississauga, the western portion of the City of Brampton and the eastern part of the City of Oakville (Figure A3).

7.4 NATURAL HERITAGE FEATURES AND AREAS

The Credit River Watershed contains several natural features and areas, most of which are protected under provincial or municipal legislation.

Areas within the *Greenbelt Plan* Area such as the Niagara Escarpment and the Oak Ridges Moraine form natural physiographic linkages across the broader landscape of southern Ontario. Sixty four percent of the Credit River Watershed's total area is covered under the Greenbelt Plan (Figure A4). The Lake Ontario shoreline is also considered a provincial corridor, as it permits east-west plant and wildlife movement beyond the watershed's boundaries and links southern Ontario to the north-eastern United States.

The Credit River Watershed contains 23 Provincial Areas of Natural and Scientific Interest (ANSIs) as well as several regional Life Science ANSIs (Figure A5). Life Science ANSIs are provincially or regionally important natural areas containing representative features which have been identified as having provincial value relating to protection, natural heritage, scientific study, or education (OMNR 1999).

Environmentally Significant (or Sensitive) Areas (ESAs), covering approximately 10% of the Credit River Watershed (Figure A5) are identified as areas that are: 1) of importance to ecological structure and function, and/or 2) of value to society by virtue of their geological features, or the presence of native plants or animals (Ecologistics Ltd. 1979 and refined/endorsed by CVC and regional governments since).

Several potential significant woodlands have been identified in the Credit River Watershed. As criteria for these differ across the watershed, they have not been mapped in this report. A number of Provincially Significant Wetlands are found in the Credit River Watershed and several others are under evaluation (Figure A6).

Valleylands form a key natural feature of watersheds and as such play an important habitat and linkage role for a watershed Natural Heritage System. Valleylands including the Credit River and its main branches are important corridors at the watershed scale.

Lakes, rivers, streams, ponds, and many wetlands provide fish habitat, while intermittent streams and seasonally flooded areas may provide temporary habitat for some fish species.

The Credit River Watershed also provides habitat for Species at Risk, rare vegetation communities, and potential Significant Wildlife Habitat.

7.5 STRESSES AFFECTING THE CREDIT RIVER WATERSHED'S ECOSYSTEMS AND IMPLICATIONS FOR A WATERSHED NATURAL HERITAGE SYSTEM

There are a number of stresses that affect the watershed's features that may impact their healthy functioning. Stresses on the Credit River Watershed include climate change, habitat loss and degradation, unsustainable development, aggregate extraction, water taking, pollution, fragmentation and barriers to species movement, disease, pests, and invasive species, unsustainable agricultural practices, and recreation. Stresses are often interlinked and their impacts can be cumulative – for example, unsustainable development is associated with increased levels of water taking, pollution, fragmentation, and disease, pests and invasive species.

Developing a Natural Heritage System can help lessen the impacts of these stresses on the watershed's ecosystems. However the area of the system is likely to be constrained by competing land uses and socioeconomic imperatives. A more holistic approach that includes managing the land use matrix (urban, agricultural) in which the system is embedded will be necessary to maintain long term watershed health.

8.0 CREDIT RIVER WATERSHED LANDSCAPE SCALE ANALYSIS METHODOLOGY

For the purposes of this Landscape Scale Analysis, the Credit River Watershed (including watersheds of streams draining into Lake Ontario within the CVC jurisdiction) was defined as the landscape, as the watershed constitutes a connected hydrologic system that is strongly linked to other ecological features and functions (e.g. valley lands, wetlands). It was also recognized that some species and ecosystem functions cross watershed boundaries, and the analysis attempted to take this into account to the extent possible. Design of the Credit River Watershed Natural Heritage System will take into account the need for system connectivity to neighboring watershed systems such as the Humber, Grand and Nottawasaga.

The Credit River Watershed Landscape Scale Analysis involved assessing natural and semi-natural features of the watershed with respect to the ecological functions they provide. The Analysis was conducted through the following steps:

1. Review of existing criteria, thresholds and guidelines used in Landscape Scale Analyses
2. Execution of Landscape Scale Analysis for the Credit River Watershed using Geographic Information System (GIS) mapping
3. Post-analysis clustering of habitat patches and data summarization

The following sections describe in greater detail the steps followed in the Landscape Scale Analysis.

9.0 REVIEW OF EXISTING CRITERIA, THRESHOLDS, AND GUIDELINES

Important steps in natural heritage planning are to identify natural and semi-natural features within the study area and to assess their ecological importance (OMNR 1999, 2010). Features that rank high in functional importance based on sound landscape ecology and conservation biology principles can later be used to identify priority areas for inclusion in natural heritage system. In general, larger natural features are better than smaller ones; features near streams are preferred over those farther away from streams; features with greater habitat diversity are generally preferred over lower habitat diversity; features that are connected locally and to regional wildlife corridors are preferred over isolated features.

Criteria used or considered in previous natural heritage planning studies to assess important or significant natural heritage features are as follows:

- **Patch area** (e.g., woodland or wetland area; Lower Trent Conservation 2001, UTRCA 2003, City of Hamilton 2004, OMMAH 2004a, City of Mississauga 2005, Dougan and Associates 2005, Henson et al. 2005, Regional Municipality of Peel 2005, Region of Waterloo 2006, Beacon Environmental and LSRCA 2007, North-South Environmental Inc. 2009, North-South Environmental Inc. et al. 2009)
- **Forest interior or shape** (Lower Trent Conservation 2001, UTRCA 2003, City of Hamilton 2004, Dougan and Associates 2005, Henson et al. 2005, Cataraqui Region Conservation Authority 2006, TRCA 2007)
- **Slope** (Dougan and Associates 2005)
- **Matrix influence or matrix quality** (a local proximity analysis that utilizes natural cover within a 2km radius; Henson et al. 2005, TRCA 2007)
- **Proximity to another natural heritage feature** (Lower Trent Conservation 2001, UTRCA 2003, OMMAH 2004b, Dougan and Associates 2005, Cataraqui Region Conservation Authority 2006, Beacon Environmental and LSRCA 2007, North-South Environmental Inc. et al. 2009)
- **Areas of potential sensitive groundwater recharge or discharge** (Dougan and Associates 2003, UTRCA 2003, OMMAH 2004a, Dougan and Associates 2005)
- **Riparian zone, valleyland, and/or floodplain** (Lower Trent Conservation 2001, Dougan and Associates 2003, UTRCA 2003, City of Hamilton 2004, City of Mississauga 2005, Dougan and Associates 2005, Henson et al. 2005, Cataraqui Region Conservation Authority 2006, The Land Ethic Group 2006, Beacon Environmental and LSRCA 2007, North-South Environmental Inc. 2009, North-South Environmental Inc. et al. 2009)

- **Corridors for species movement** (UTRCA 2003, OMMAH 2004b, Henson et al. 2005, North-South Environmental Inc. 2009, North-South Environmental Inc. et al. 2009)
- **Diversity of vegetation communities** (Dougan and Associates 2003, 2005, Henson et al. 2005, North-South Environmental Inc. et al. 2009)
- **Roadlessness; distance from roads** (Henson et al. 2005)

Criteria used in the Landscape Scale Analysis for the Credit River Watershed included the more commonly used criteria above for which data were available at the watershed scale.

The total amount of natural cover in a landscape has a strong influence on biodiversity and ecological functions such as species movement and reproduction, although responses differ among species (Environmental Law Institute 2003 and references therein). Research shows that the total amount of suitable habitat in an area is an important explanatory variable of species distribution or abundance (Askins and Philbrick 1987, Andrén 1994, Forman 1995, Fahrig 2002, Austen et al. 2001, Lee et al. 2002). As natural cover in a landscape declines, the configuration of natural cover or the placement of natural areas relative to each other gains in importance (Andrén 1994).

Based on a scientific review, Environment Canada has provided some minimum guidelines for natural cover in watersheds (Environment Canada 2004):

- At least 30% of a watershed should be in forest cover;
- The proportion of a watershed that is forest cover 100m or further from the forest edge should be greater than 10%; the proportion of forest cover 200m or further from the forest edge should be greater than five percent;
- Greater than 10% of each major watershed should be in wetland habitat; greater than six percent of each subwatershed should be in wetland habitat;
- Wetlands of a variety of sizes, types and hydroperiods should be maintained across a landscape;
- A minimum of 75% of stream length should be naturally vegetated;
- Streams should have a minimum 30m wide naturally vegetated adjacent-lands area on both sides, greater depending on site-specific conditions; and
- Corridors designed to facilitate species movement should be a minimum of 50m to 100m in width.

The extent of existing natural cover in the Credit River Watershed and scientific recommendations for natural cover together informed the development of thresholds that were used in the Landscape Scale Analysis.

Section 10.3 below describes the specific criteria and thresholds used in the Credit River Watershed Landscape Scale Analysis.

10.0 EXECUTION OF LANDSCAPE SCALE ANALYSIS

10.1 SCALE AND RESOLUTION

The Landscape Scale Analysis was conducted at the scale of the CVC jurisdiction (i.e. watershed scale) using Ecological Land Classification (ELC) data. Ecological Land Classification is a standard, hierarchical framework developed by the province of Ontario to describe ecological communities based on abiotic and biotic factors such as climate topography, soils, and vegetation. The ELC classification for southern Ontario (Lee et al. 1998) is the current accepted standard for this region and is used in the region by most Conservation Authorities, municipalities, and OMNR.

The most detailed ELC base layer for the Credit River Watershed Landscape Scale Analysis was the community series and land use layer, at a scale of 1:10,000. The community series scale is the finest scale that can be determined through air photo interpretation. The CVC ELC layer used for this analysis and mapping was last updated in 2008. However, the ELC layer is constantly being updated, thereby enabling the Landscape Scale Analysis to be updated from time to time. The comprehensive and complete Ecological Land Classification mapping available for the entire Credit River Watershed represents a rich and detailed data source that, combined with biophysical data for the watershed, provides a strong and scientific foundation for Natural Heritage System planning.

Individual **ELC community series** were aggregated into four different types of **communities**: Forest, Wetland, Successional, and Cultural Forest, with a fifth community, Woodland, which crossed categories and included forest, cultural forest, and treed wetlands (Table 1). In turn, communities were aggregated into **habitat patches**, which were defined as natural or semi-natural areas separated from other habitat patches by a different land use type or a 30m gap on a 1:10,000 scale air photo (CVC 1998; Figure 2). Examples of natural ELC communities are deciduous forests and coniferous swamps; examples of semi-natural or cultural communities are cultural meadows, cultural thickets, and cultural woodlands (see Glossary for definition of ELC community series used in the Landscape Scale Analysis).

All habitat patches in the watershed larger than 0.5ha in size (minimum mapping unit size) were included in the Landscape Scale Analysis (Figure A7). Habitat patches were defined as the primary unit for landscape analysis because the majority of wildlife species in the Credit River Watershed depend on more than one habitat or community type (CVC 2002a, 2002b, 2002c) to carry out their life cycles. For example, the Leopard Frog (*Rana pipiens*) breeds in ponds or wetlands but disperses to adjoining meadows and other open habitats for the summer. The Sharp-shinned Hawk (*Accipiter striatus*) hunts at woodland edges and in meadows but prefers to nest in dense coniferous or mixed forest. Communities that are connected within the same habitat patch permit species to complete their life cycles more easily relative to communities that are separated by gaps such as roads, urbanized areas, or agriculture.

Table 1: Community types of the Credit River Watershed based on ELC community series or class1, 2, 3 (Lee et al. 1998; see Glossary for definitions).

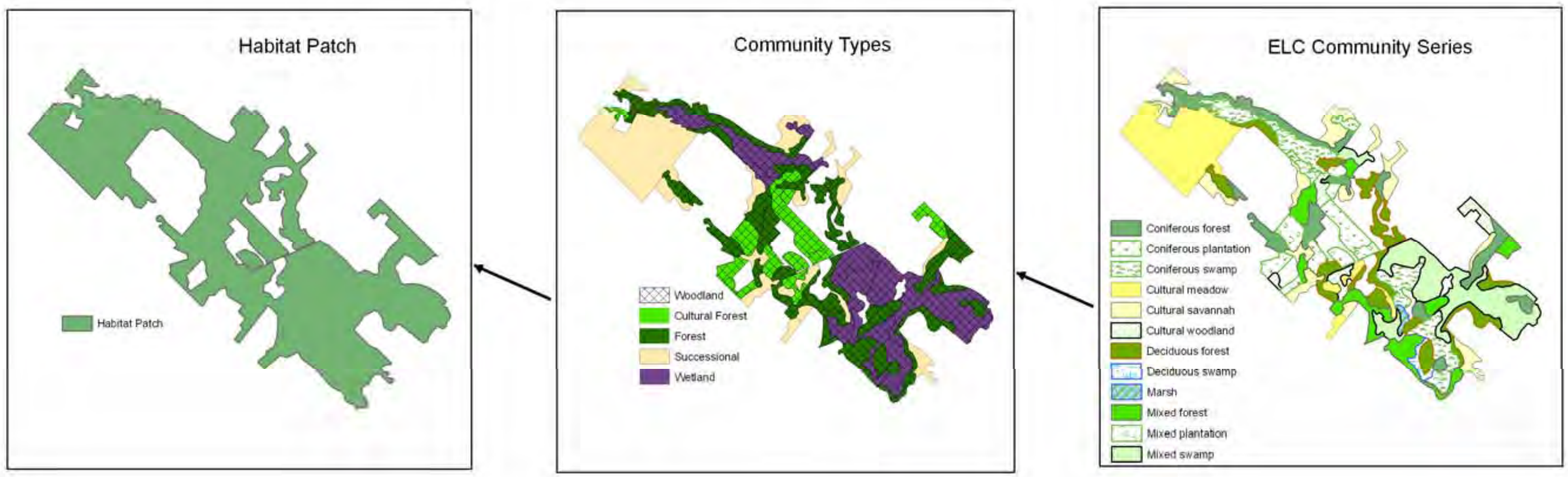
Habitat patch[2]	Community type	ELC (Ecological Land Classification) series
Habitat patch	**Forest**	Coniferous forest (FOC) Deciduous forest (FOD) Mixed forest (FOM)
	Wetland	Coniferous swamp (SWC) Deciduous swamp (SWD) Mixed swamp (SWM) Marsh or Bog/Fen[1] (MA or BO/FE) Thicket swamp (SWT)
	Successional	Cultural savannah (CUS) Cultural thicket (CUT) Cultural meadow (CUM)
	Cultural Forest	Coniferous plantation (CUP3) Deciduous plantation (CUP1) Mixed plantation (CUP2) Cultural woodland (CUW)
	Woodland[3]	Coniferous forest (FOC) Deciduous forest (FOD) Mixed forest (FOM) Coniferous swamp (SWC) Deciduous swamp (SWD) Mixed swamp (SWM) Coniferous plantation (CUP3) Deciduous plantation (CUP1) Mixed plantation (CUP2) Cultural woodland (CUW)

[1]Marshes and bogs/fens are ELC community classes. However, air photo interpretation does not permit distinction of these categories, or classification of these wetlands to the community series layer. Therefore, non-forested wetland communities were classified as marshes in this analysis. For the sake of brevity and to minimize confusion, all the above ELC units are referred to as ELC community series in the text.

[2] The ELC categories of Beach/Bar (BB) and Bluff (BL) were also included in the delineation of a habitat patch, but because they were small in size (generally <=2ha), they were not analyzed in the landscape characterization except as they contributed to the area of a habitat patch.

[3] A fifth community type, namely **Woodland**, was created for part of the analysis involving the importance of wooded areas for species habitat based on the PPS definition. This patch was composed of a combination of other patch components with significant tree cover: coniferous/deciduous/mixed forest, coniferous/deciduous/mixed swamp, coniferous/deciduous/mixed plantation, and cultural woodland.

Figure 2: Schematic showing scales of analysis in landscape characterization: ELC community series, community, and habitat patch scales. ELC community series are clustered into communities, which in turn are merged into habitat patches that represent most natural or semi-natural features in the Credit watershed. Areas outside a habitat patch may be agricultural, urban or aquatic.



10.2 SCORING METHODOLOGY

Habitat patches in the watershed were assessed for their relative importance in ecosystem functioning in the Credit River Watershed based on nine specific criteria and thresholds.

The following criteria were used for the Landscape Scale Analysis:
Habitat patches containing key natural heritage features: **A) Woodlands**, **B) Wetlands, C) Successional habitats** such as meadows, and **D) Valleylands or riparian areas**; habitat patches contributing to diversity: containing **E) High habitat diversity** or **F) Uncommon vegetation communities** at watershed scale; and habitat patches contributing to connectivity: **G) Ecological proximity**, **H) Regional linkages**, or **I) Provincial linkages**.

Thresholds for the above criteria were developed in two ways: 1) Available federal or Ontario provincial guidelines for natural heritage protection provided policy or planning context for protection of specific natural features and functions; 2) Where federal or provincial guidelines were not available, the analysis of existing conditions in the watershed, best practices, or technical committee or peer reviewers' expert opinion were used to identify high functioning habitat patches. In all cases, the best available science guided the development of criteria and thresholds in the context of existing natural cover in the watershed.

The assessment included a simple scoring system wherein a habitat patch received a score of one if it met the threshold for a criterion and a score of zero if it did not. Habitat patches were given a score of zero or one, based on whether they satisfied each of the above criteria and established thresholds. A habitat patch receiving a score of one for a specific criterion was considered to be a high functioning patch with respect to that criterion. A score of zero does not imply that the habitat patch is not providing any ecosystem function; it simply suggests that the patch contributes to a lesser degree to ecosystem function at the watershed scale relative to other habitat patches. All nine criteria received equal weighting because there was little ecological justification for specific relative weightings for the different criteria.

Scores for individual habitat patches were then added across criteria. Habitat patches received scores ranging from 0 (relatively small contribution to watershed ecosystem functioning) to 9 (extremely high contribution to watershed functioning). The overall score for a patch represented the quality of the patch at the watershed scale.

10.3 CRITERIA AND THRESHOLDS USED IN THE CREDIT RIVER WATERSHED LANDSCAPE SCALE ANALYSIS

This section describes existing conditions in the Credit River Watershed and uses these conditions as a guide for development of the criteria and thresholds used in the Landscape Scale Analysis.

Table 2 provides a summary of the criteria and thresholds used in the Landscape Scale Analysis for the Credit River Watershed. The subsections below describe in more detail the criteria and thresholds used in the analysis. Appendix B, available on the CVC website at http://www.creditvalleyca.ca/bulletin/resources.htm#natural provides details of the GIS methodology used in the Landscape Scale Analysis.

Table 2: Criteria and thresholds used to identify habitat patches (features) of particular importance with respect to ecosystem function in the Credit River Watershed.

#	Criteria	Threshold values for defining high functioning habitat patches, Credit River Watershed
A.	Woodlands	All habitat patches containing woodlands >=2ha in Lower Watershed and woodlands >=4ha in Middle and Upper Watersheds
B.	Wetlands	All habitat patches containing wetlands >0.5ha
C.	Successional habitat	All habitat patches containing >=10ha successional habitat
D.	Valleylands and riparian areas	All habitat patches containing or directly adjacent to watercourses or their crest of slope *or* All habitat patches within or intersecting the greater of: Lake Ontario Flood Hazard, Lake Ontario Erosion Hazard, Lake Ontario Dynamic Beach Hazard, *or* 30m from the Lake Ontario shoreline
E.	Habitat diversity	All habitat patches with ELC community series diversity within top quartile (i.e., top 25% of patches)
F.	Uncommon vegetation communities	All habitat patches containing locally rare ELC community series (community series <=5% area of all natural)
G.	Ecological proximity	All habitat patches with matrix quality within top quartile (i.e., top 25% of patches)
H.	Regional linkage	All habitat patches within or intersecting 500m on each side of the Credit River up to 5km from the Lake Ontario shoreline and 300m on each side of the Credit River beyond 5km from the shoreline *or* All habitat patches within or intersecting the greater of 100m on each side of main tributaries of the Credit River
I.	Provincial linkage	All habitat patches overlapping or intersecting areas classified as Escarpment Natural Area and Escarpment Protection Area within the Niagara Escarpment Plan Area *or* All habitat patches overlapping or intersecting Natural Core or Natural Linkage Areas of the Oak Ridges Moraine Plan area *or* All habitat patches overlapping or intersecting the Greenbelt Natural Heritage System *or* All habitat patches <=2km of the L. Ontario shoreline

10.3.1 A. Woodlands

Woodlands contribute to the wellbeing of humans and biodiversity in general. Forests and woodlands (which include other types of treed habitats such as plantations or swamps) are storehouses of biodiversity and play a strong role in nutrient, water and energy cycling (Daily 1997).

The importance of a woodland patch is a function of the percentage of vegetation cover in the area (OMNR 2010). The OMNR suggests that woodlands 20ha and larger are significant as a size criterion when total woodland cover in a watershed is between 15% and 30% (OMNR 2010). Thresholds such as 16ha in rural and 4ha in urban areas are being recommended for use in municipal natural heritage planning (North-South Environmental et al. 2009).

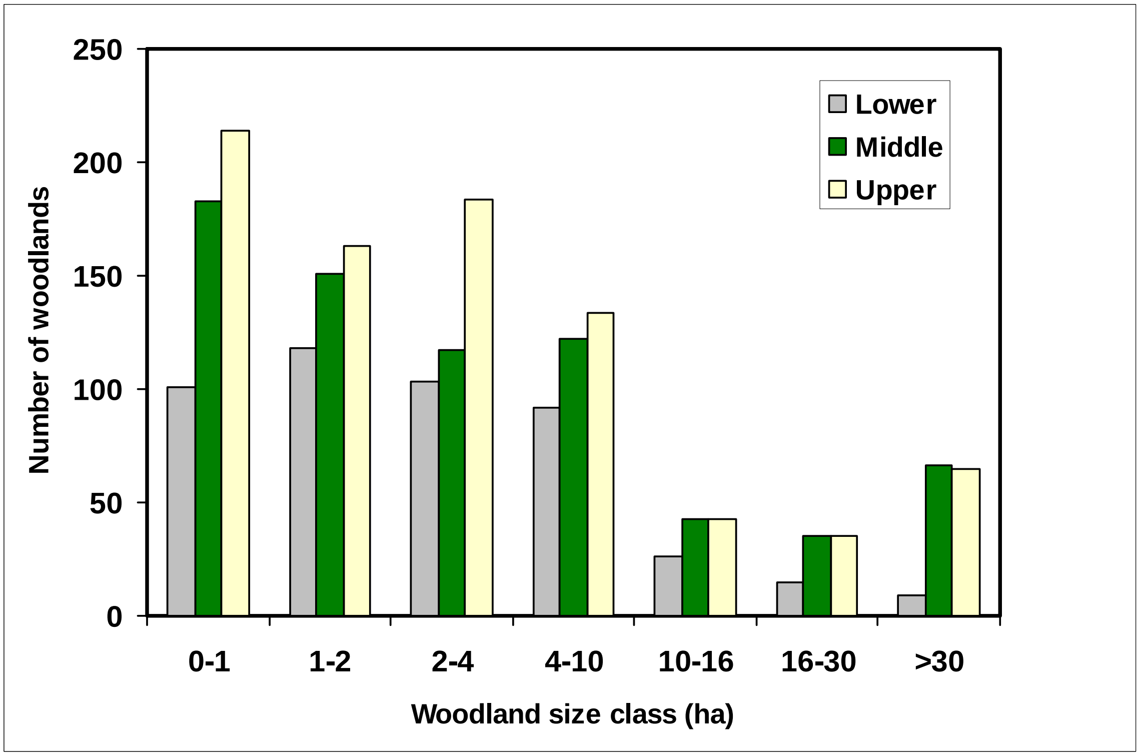
Currently, the Credit River Watershed has 21% woodland cover (including supporting semi-natural cover such as plantations or cultural woodlands), below federal guidelines of at least 30% forest cover (Environment Canada 2004; Figure A8).

Other provincial guidelines for thresholds for significant woodlands are 0.5ha or 4ha (under the Oak Ridges Moraine Conservation Plan; OMMAH 2004a). For the Greenbelt Natural Heritage System in the Protected Countryside, draft technical papers have identified 0.5ha, 1ha, 4ha, or 10ha as being significant woodlands (Greenbelt Natural Heritage System, OMNR 2008), depending on woodland functions and the geographic location in the Greenbelt.

There are 2001 woodlands in the Credit River Watershed. The size of individual woodlands ranges from less than 0.5 hectare to 581ha (Figure 3). The median size of woodlands is 2.2ha (i.e. half of all woodlands are above and half are below this size), a consequence of extensive fragmentation following European settlement. Only 17% of all woodlands are above 10ha.

Larger woodlands play a key role in maintaining biodiversity as they contain a sufficiently large area interior from the edge. Habitat edges are associated with increased levels of light, sound, wind and other abiotic effects that deter ecological function and species presence or movement depending upon the species and intensity of the effect (Ries et al. 2004, Hilty et al. 2006). Edges are also associated with increased levels of nest predation, particularly when surrounding forest cover is low and edges are hard (Hartley and Hunter 1998, Batáry and Báldi 2004, Hilty et al. 2006). Large habitat fragments have been identified as important for maintaining forest-breeding birds in Ontario (Burke and Nol 1998).

Figure 3. Distribution of woodland size classes in the Credit River Watershed by physiographic zone.



Forests in the Lower Watershed are small in size but disproportionately important from a terrestrial, hydrologic and social perspective. In the Credit River Watershed, these are the last remaining natural forests within the Iroquois Plain, South Slope and Peel Plain physiographic regions. They are also the last remnants of the Carolinian Ecozone in the watershed, an Ecozone rich in wildlife and home to about one-third of Canada's species at risk. Woodlands in the Lower Watershed, particularly those within a few kilometers of Lake Ontario, provide critical resting and feeding areas for species making the long and energy consuming migration across or around Lake Ontario. Woodlands in highly impervious subwatersheds (such as those in the Lower Watershed zone) gain hydrological importance for contributing to the hydrologic cycle in these subwatersheds through their role in interception, infiltration, and evapotranspiration (CVC 2007b, CWP 2005). Finally, woodlands in the Lower Watershed play an important social role in providing equitable access to green space for public wellbeing and recreation, education, localized shade and cooling effects, and some mitigation of noise, dust and pollutants.

In this analysis, woodlands are defined as any treed area with greater than 35% tree cover (OMMAH 2005a); these include forests, swamps, plantations, and cultural woodlands.

Based on the woodland analysis for the Credit River Watershed, impacts of loss, and minimum guidelines for woodland cover, it was determined that a reasonable threshold for identifying important woodlands was >=4ha for the Middle and Upper Watersheds and >=2ha for the Lower Watershed. Woodlands of these sizes are important in contributing to provision of habitat and linkages within their respective zones.

For the Landscape Scale Analysis, woodlands >=2ha in the Lower Watershed and >=4ha in the Middle and Upper Watershed were considered to be high functioning relative to other woodlands in those zones (Table 2). The selection of a lower threshold for the Lower Watershed additionally reflects the study objectives of ensuring adequate ecosystem representation across physiographic regions of the watershed.

10.3.2 B. Wetlands

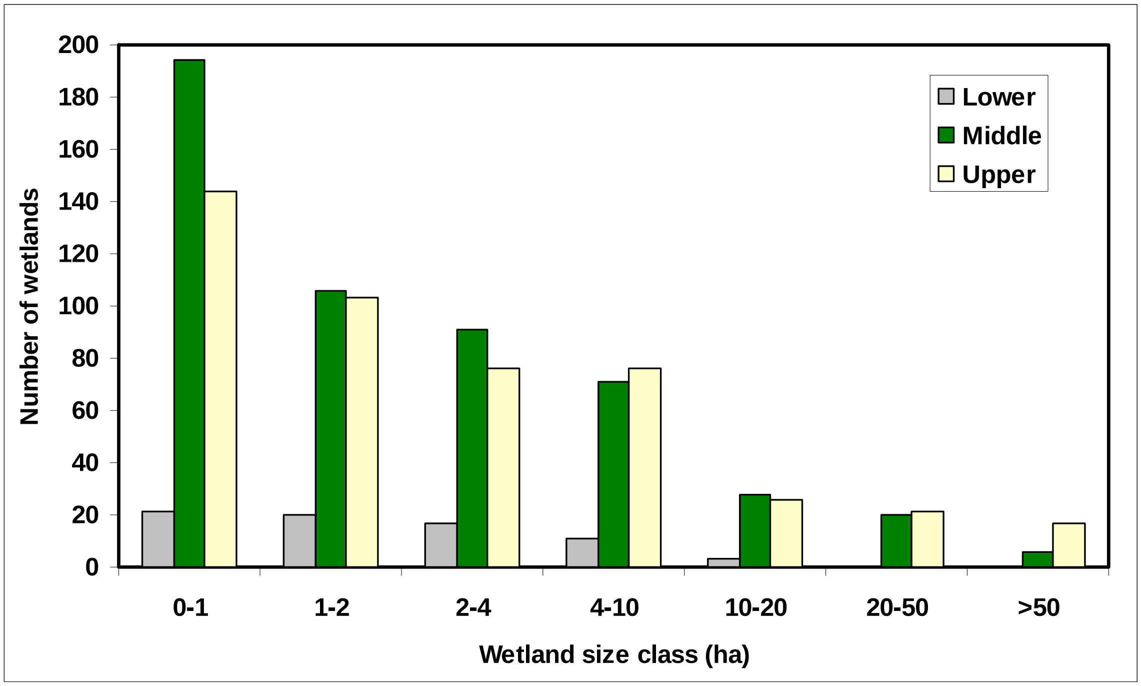
Wetlands, including swamps and marshes, are critical to the hydrologic health of a region (Mitsch and Gosselink 2007, Forman 1995, Daily 1997). Acting as natural sponges, wetlands absorb water, releasing it slowly across the landscape. By providing essential habitat for a number of species such as migratory waterfowl, amphibians, reptiles, fish, and insects, wetlands support complex food webs. Wetlands improve water quality by trapping sediments, removing or retaining excess nutrients, immobilizing or degrading contaminants, and removing bacteria. Wetlands also create soil through decomposition of rich organic matter.

Large wetlands are associated with greater species richness of birds, mammals, herptiles and plants (Findlay and Houlahan 1997). However, wetlands of all sizes and hydroperiods are considered to be important for species habitat (Semlitsch and Bodie 1998, Mitsch and Gosselink 2007). In the Credit River Watershed, over three-quarters of all amphibian, reptile, bird and mammal species depend on wetland habitat for some part of their life cycle (CVC *unpublished data)*.

Wetlands occupy only 6% of the Credit River Watershed's area and are unevenly distributed across subwatersheds with some subwatersheds containing much less than 6% wetland cover (Figure A9).

There are 1051 wetlands in the Credit River Watershed, the majority of them rather small and under 4ha in size (Figure 4). The size of individual wetlands ranges from less than 0.5 hectare to 246ha. The median size of wetlands is 1.7ha (i.e., half of all wetlands are above and half are below this size). Over half (56%) of all wetlands are less than 2ha in size.

Figure 4. Distribution of wetland size classes in the Credit River Watershed by physiographic zone.



Due to their considerable ecological importance and low coverage in the watershed, as well as the need for conservation of a variety of wetland hydroperiod types, all wetlands >=0.5ha were considered to be high functioning in the Landscape Scale Analysis (Table 2). Wetlands >=0.5ha represent 93% of all wetlands in the watershed.

10.3.3 C. Successional habitat

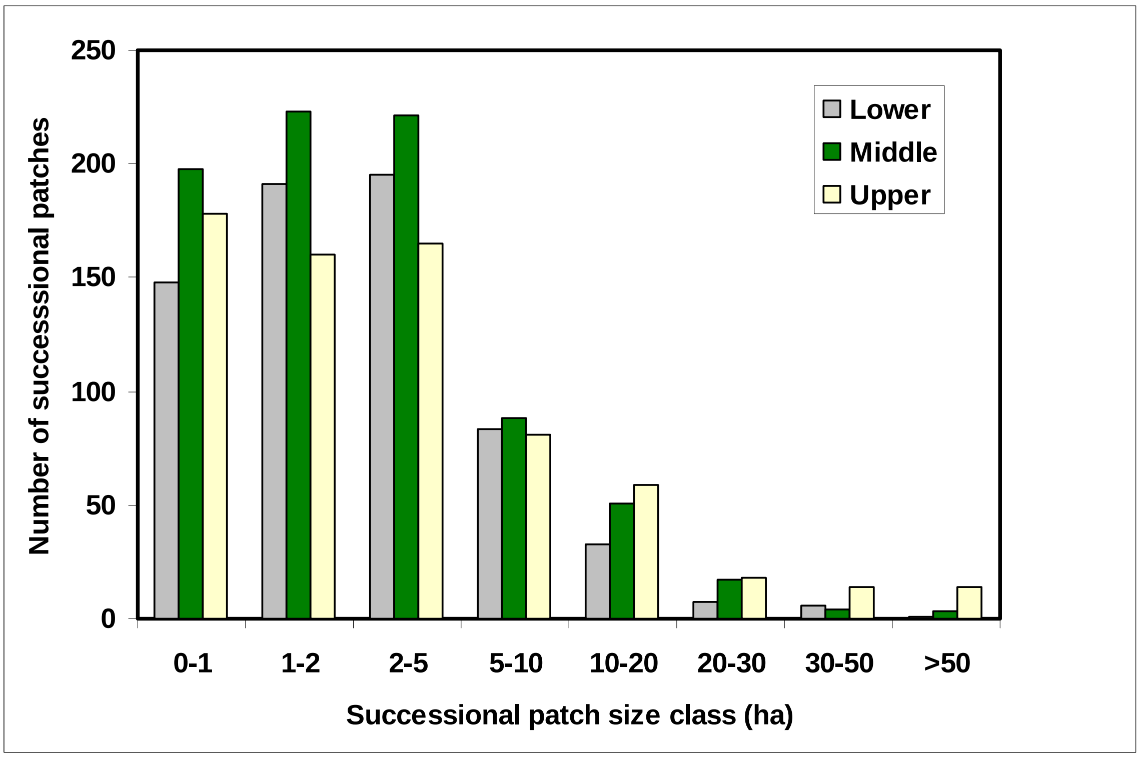
Successional or historically human modified habitats such as cultural meadows, thickets, and savannahs contribute to maintaining watershed biodiversity. They are productive habitats rich in flowering plants and insect species that are commonly used by species that inhabit adjoining forest or wetland areas for feeding or movement (CVC 2002a, 2002b, 2002c). Early successional forests act as effective carbon sinks – storehouses for greenhouse gases – as carbon uptake is rapid in the fast growing species of these habitats. Successional meadow habitats are important for grassland and prairie bird and mammal species (OMNR 2000).

Successional habitat, particularly meadow habitat, is considered significant for wildlife if it is large enough in size, approximately 10 hectares or larger (Bay 1996, OMNR 2000). These types of open habitats provide sufficient area for raptor winter feeding and roosting areas, and for the sustainable reproduction of some common grassland species (OMNR 2000).

There are 2158 successional area patches in the Credit River Watershed; over three-quarters of them are rather small and under 5ha in size (Figure 5). The size of individual successional areas ranges from less than 0.5 hectare to 143ha. The median size of successional areas is 1.9ha (i.e. half of all successional areas are above and half are below this size). In the Credit River Watershed, cultural meadows, cultural savannahs or cultural thickets greater than 10ha in area represent less than 10% of all successional area in the watershed.

For the purposes of the Landscape Scale Analysis, all successional areas >=10ha in size were considered to be high functioning successional habitat as they support or can potentially support a variety of successional or open country species (Table 2).

Figure 5. Distribution of successional habitat size classes in the Credit River Watershed by physiographic zone.



10.3.4 D. Valleylands and riparian areas

Terrestrial natural areas adjoining streams (riparian zones) are transitional areas between aquatic and upland terrestrial systems. These critical interfaces between terrestrial and aquatic environments provide important ecosystem functions related to water quality improvement, flow moderation, sediment and erosion control, bank stabilization, terrestrial, fish and aquatic habitat, moderation of stream temperatures, organic and inorganic inputs to watercourses, riparian biodiversity, plant and wildlife movement, and gene flow (Environmental Law Institute 2003, Naiman and Decamps 1997).

In comprehensive reviews of riparian buffer widths for various ecosystem functions 30m or 100 feet was the most commonly recommended buffer width for detrital input, temperature and microclimate regulation, bank stabilization and nutrient or pollutant removal (Environmental Law Institute 2003) and water quality and aquatic habitat (Chase et al. 1995). The Credit River Fisheries Management Plan recommends that 90% of streambanks of all tributaries be restored with natural vegetation (MNR and CVC 2002).

For the purposes of the Landscape Scale Analysis, all habitat patches containing or directly adjacent to watercourses or their crest of slope were scored as high functioning in terms of their contribution to water quality and aquatic habitat and were given a score of one. In addition, all habitat patches within or intersecting the greater of the Lake Ontario Flood Hazard, Lake Ontario Erosion Hazard, Lake Ontario Dynamic Beach Hazard, or 30m from the edge of Lake Ontario were also considered high functioning in terms of contributing to water quality and aquatic habitat (Table 2).

10.3.5 E. Habitat diversity

The majority of all amphibian, reptile, bird, and mammal species in the Credit watershed depend upon more than one ELC community series for completion of their life cycle (CVC 2002a, 2002b, 2002c and *unpublished* data). More diverse habitats are linked to greater biodiversity and ecosystem function (OMNR 1999, 2000 and references therein). Greater biodiversity in an area allows complex food webs to be sustained even when some species are lost, giving the natural system greater resilience and ability to recover from disturbance. Maintaining a range of diversity in species and habitats gains increasing importance under conditions of climate change, where impacts on individual species are unknown.

In the Credit River Watershed, the only data on diversity that are available across the entire Credit River Watershed are data on ELC community series within habitat patches. ELC community series represent distinct ecological communities containing distinct species of plants, therefore is reasonable to assume that areas with a high diversity of plant communities are likely to support a high diversity of plants and wildlife.

To identify high diversity areas in the Credit watershed, the number of different ELC community series of all types in each habitat patch was tallied. To avoid double counting, a community series was counted only once even if it occurred multiple times within a habitat patch. The majority (61%) of habitat patches in the Credit River Watershed contain only one type of ELC community series (e.g. deciduous forest); 22% of habitat patches contain 2 to 3 ELC community series; and only 18% of habitat patches contain high diversity (4 or more different ELC community series types).

For the purposes of the Landscape Scale Analysis, habitat patches containing four or more different ELC community series types (top 18% of habitat patches) were considered high functioning in terms of maintaining species diversity over the long term and were given a score of one while all other patches were given a score of zero under this *Habitat diversity* criterion.

10.3.6 F. Uncommon vegetation communities

To maintain the range of biodiversity in a region, there must be adequate representation of both uncommon and common natural habitats in a protected area system. ELC community series represent the finest level of vegetation community data available across the watershed. Common ELC community series are well represented by virtue of the frequency of their occurrence in the watershed. Uncommon ELC community series contribute to the overall diversity of habitats, species, and genes in the watershed.

For the purposes of this analysis, uncommon ELC community series were defined as those natural (i.e. not cultural) ELC community series representing less than 5% of the total natural and semi-natural area combined within the watershed boundary. This approach is consistent with standard CVC subwatershed analysis methodology which identifies uncommon or “locally rare” vegetation communities (CVC 1998). Under this criterion, ELC community series with less than 5% representation in the watershed are deciduous swamp, mixed swamp, thicket swamp, marsh, bog, fen, treed bog, beach/bar, and bluff.

Rare ELC vegetation types and the specific habitat of Species at Risk should also be included in a Natural Heritage System but due to incomplete knowledge of the location of these elements, their protection must be accomplished through wording that affords protection of these habitats as and when they are identified.

10.3.7 G. Ecological proximity

Natural areas that are closer together have a greater degree of species persistence because they favour persistence and movement of species and genes over the short and long term (Forman and Godron 1986, Forman 1995). The quality of the matrix, or area surrounding a habitat patch, has a strong influence on the ability of particular species to move from one habitat patch to another. For some species, an urban or agricultural matrix is relatively impermeable, that is, it prevents movement between neighbouring habitat patches. For other species, an urban matrix may impede movement, but an agricultural matrix may allow limited movement en route to an adjacent habitat patch. In general, habitat patches with a matrix containing a high percent of natural area are likely to support a greater degree of species and genetic movement than those surrounded to a high degree by urbanization or agriculture (Henson et al. 2005, Lindenmayer and Franklin 2002, TRCA 2007). In general, matrix quality has been calculated based on the percent of natural, agricultural, or urban area found within 2km of a natural area (Dunford and Freemark 2004, Henson et al. 2005, TRCA 2007). Matrix quality or ecological proximity may be viewed as one aspect of connectivity as it can help sustain metapopulations or genetic diversity in the landscape.

For the Landscape Scale Analysis, matrix quality for a habitat patch was calculated for a 2km external buffer around the patch based upon the method identified by the Toronto and Region Conservation Authority: (percent natural area*(1) + percent agricultural/open space area*(0) + percent urban area*(-1)). This formula recognizes the relative order of permeability of various land covers, with natural being most permeable, agriculture or open space such as parks being relatively neutral (permeable for some species and impermeable for others), and urban being relatively impermeable (difficult to pass through) compared to natural and agricultural land cover. The values for matrix quality range from -1 to +1, where -1 represents a patch completely surrounded by urban land cover, while +1 represents a patch completely surrounded by natural land cover. A patch surrounded completely by agriculture would have a matrix quality score of 0, which is intermediate between that for a completely urban and a completely natural matrix.

In the Credit watershed, matrix quality for habitat patches ranged from -0.81 to 0.71. Habitat patches lying in the top 25% of patches in terms of matrix quality (quality >=0.32) tended to be those with an average of 52% natural cover surrounding the patch within a 2km radius. These top quartile patches had natural cover ranging from 37% to 81% surrounding them within a radius of 2km.

For the purposes of this analysis, any habitat patch with matrix quality equal to or greater than the 75th percentile value was considered to be high functioning with respect to the *Ecological proximity* criterion (Table 2).

10.3.8 H. Regional linkage: Credit River and its main tributaries

Credit River

The Credit River comprises a natural north-south regional corridor that links the Lake Ontario shoreline and Carolinian zone with the Niagara Escarpment, Greenbelt, and the Oak Ridges Moraine farther to the north (Figure A2). The Credit River also provides an important cross-watershed linkage to natural areas in the Nottawasaga Valley Conservation Authority near Orangeville. The main tributaries of the Credit and their riparian areas serve as important subwatershed corridors that can support species, material and energy flows across subwatersheds and from one part of the watershed to another (Figure A2).

In general, wider riverine corridors favour movement of wildlife; and corridors containing water are more significant for wildlife than similar corridors without water (Wenger 1999, OMNR 2000, Environmental Law Institute 2003). Valley lands form the 'backbone' of a watershed and should be assessed as an integral part of a planning authority's Natural Heritage System (OMNR 1999, 2010).

For the purposes of this analysis, the Credit River corridor regional linkage was defined as the following:

- All habitat patches within or intersecting 500m on each side of the Credit River up to 5km from the Lake Ontario shoreline; *and*
- All habitat patches within or intersecting 300m on each side of the Credit River above 5km from the Lake Ontario shoreline (Table 2).

The Credit River consists of 6^{th} and 7^{th} order streams and generally represents the widest aquatic corridor in the CVC jurisdiction. The regional corridor width of 500m narrowing to 300m on each side of the Credit River was selected based on the following considerations: 1) a wider corridor at the mouth of the Credit River allows migrants which are found at higher densities along the Lake Ontario shoreline to be funneled into the valleylands of the Credit River in Mississauga. These valleylands form the widest and most naturally vegetated north-south corridor in the City of Mississauga; 2) a minimum corridor width of 300m on each side of the Credit provides for some interior or non-edge habitat that may provide some relief from predation and other edge effects as migratory species move up through the valleylands of the Credit. In general, interior habitat is the habitat found 100m inwards from a natural area (OMNR 2010).

Main tributaries of the Credit River

The main tributaries of each subwatershed and their riparian areas form a hydrological and terrestrial network that links all the subwatersheds of the Credit River Watershed. Subwatershed corridors permit energy, material, species and gene flow among subwatersheds of the Credit River. These streams, generally 4^{th} or 5^{th} order or larger in size, have commonly been used in past subwatershed studies to form the backbone of local Natural Heritage Systems (CVC 2003a, 2003b, 2007c). In urban areas, stream orders can change due to land use changes that alter stream hydrology. However, a visual examination ensured that the main tributaries selected through this methodology corresponded to a major catchment area of the Credit River (e.g. a subwatershed).

An extensive review of publications on recommended corridor/buffer widths found that 75 percent of values extended up to 100m on each side (for a total corridor width of 200m; Environmental Law Institute 2003). The 100m buffer widths were recommended to cover a range of ecological functions including shading and micro-climate for aquatic life; stabilization of stream banks and prevention of erosion; provision of organic matter and woody debris; regulation of sediment, nutrients and contaminants; flood attenuation and storage, and wildlife habitat (Environmental Law Institute 2003).

For the purposes of this analysis, subwatershed corridors were defined as the following:

- All habitat patches within or intersecting 100m on each side of all main tributaries of the Credit River (Table 2)

10.3.9 I. Provincial linkage: Niagara Escarpment, Oak Ridges Moraine, Greenbelt Natural Heritage System, and Lake Ontario shoreline

The Niagara Escarpment, Oak Ridges Moraine, Greenbelt Natural Heritage System and the Lake Ontario shoreline comprise the major provincial corridors in the Credit River Watershed, as they connect regions with distinct soils, climate, and vegetation and link the watershed to regional as well as provincial protected areas systems.

Provincial connectivity promotes large scale species movement in and beyond a landscape, permitting adaptation, gene flow or evolution. The linkages between and among areas of provincial importance permits the migration of species across large areas of the province over space and time and contributes to the ecological and hydrological integrity of both provincial protected areas and the natural features in the watershed.

The Lake Ontario shoreline is considered under the Lake Ontario Biodiversity Conservation Strategy as an important provincial corridor (Lake Ontario Biodiversity Conservation Strategy Working Group 2009). Natural features within 2km of the Great Lakes shorelines appear to provide critical habitat during land and shore bird and butterfly migration (OMNR 2000, Ewert et al. 2006, Bonter et al. 2009, Strobl 2010). Natural features close to Lake Ontario promote north-south movement of species and east-west movement among shoreline areas and tributaries of Lake Ontario (this includes movements of non-migratory species). The shoreline of Lake Ontario also provides a linkage to natural areas in Quebec and farther south in the United States, from which species have the potential to move in response to climate change.

For the purposes of this analysis, the following habitat patches were selected as contributing to provincial connectivity (Table 2):

- All habitat patches overlapping with areas designated as *Escarpment Natural Area* and *Escarpment Protected Area* within the Niagara Escarpment Plan Area;
- All habitat patches overlapping with natural features within the *Natural Core Areas*, *Natural Linkage Areas*, or *Countryside Area* within the Oak Ridges Moraine Plan Conservation Plan Area;
- All habitat patches overlapping with areas classified as "*Greenbelt Natural Heritage System*" within the Greenbelt Plan Area; and
- All habitat patches lying within 2km of the Lake Ontario shoreline.

11.0 ASSESSMENT OF THE AQUATIC SYSTEM OF THE CREDIT RIVER WATERSHED

The aquatic system of the Credit River Watershed includes watercourses, lakes and ponds (CVC 1998). In addition, almost all wetlands in the watershed are hydrologically connected to streams or lakes and play an important role in the functioning of the aquatic system. In combination with adjoining lands (valleylands and riparian zones), the aquatic system carries out many significant functions, including such as habitat for species, storage, release and conveyance of water and sediment for terrestrial and aquatic functions, nutrient cycling, erosion and sedimentation (OMNR 1999, 2010). Water is also a critical resource for terrestrial species.

Smaller features such as headwater drainage features or swales can be difficult to map at the 1:10,000 scale due to difficulty in detection through air photo interpretation with some exceptions such as features on agricultural lands in the Peel Plain. Nevertheless these features as a whole contribute significantly to the healthy functioning of aquatic systems (Meyer et al. 2007, Nadeau and Rains 2007). Assessment of the functional importance of specific headwater streams is generally conducted during smaller-scale studies (e.g. Environmental Impact Study). An interim set of scientific guidelines has been developed for assessing headwater features (TRCA and CVC 2009) and is currently being updated.

For the purposes of this analysis, aquatic features that were deemed important for ecosystem function at the watershed scale included permanent and intermittent streams, lakes and on-line ponds (see Glossary for definitions). These features are mapped in Figure A10.

12.0 RESULTS OF THE LANDSCAPE SCALE ANALYSIS FOR THE CREDIT RIVER WATERSHED

All habitat patches in the Credit River Watershed were mapped along with their scores (Figure A11).

Table 3 provides statistics on the number and area of habitat patches scoring between 0 and 9, and their contribution as a percent of total watershed area.

12.1 POST-ANALYSIS CLUSTERING OF HABITAT PATCHES

Following the Landscape Scale Analysis, habitat patches were clustered into broad categories or functional groups based on a separate clustering analysis. Habitat patch were clustered in this manner to aid in prioritization for activities such as restoration, stewardship, or land securement.

Habitat patches that scored 7, 8 or 9 based on the assessment criteria were termed 'Core ecofunction habitats' of the Credit watershed because they were of very high importance in terms of ecosystem function in the watershed; habitats receiving scores of 4, 5, or 6 were termed 'Highly Supporting ecofunction habitats'; those scoring 1, 2, or 3 were termed 'Supporting ecofunction habitats', and those receiving a score of 0 were termed 'Contributing ecofunction habitats' (Figure A12). Clustering of habitat patches into these categories was determined through a separate data analysis process that compared patch scores with average species numbers, presence of protected areas, and average numbers of species of conservation concern (CVC draft list). Species numbers from CVC's *Natural Areas Inventory* were strongly correlated with patch scores, thus validating the scoring methodology as a surrogate for capturing actual or potential biodiversity at a site. The term ecofunction is used as an abbreviation for ecological function, and has been used elsewhere in similar contexts. Habitat patches that have been classified as Core ecofunction support or have the capacity to support a high number of ecological functions, based on this analysis.

Table 3: Number of habitat patches scoring 9, 8, 7, 6, 5, 4, 3, 2, 1, and 0, their area, and area as percent of watershed area.

Habitat patch category	Habitat patch score	Number of habitat patches	Area of habitat patches (ha)	Percent of watershed area
Core ecofunction	**9**	22	5951	6.3%
	8	72	9180	9.7%
	7	71	5259	5.5%
Highly supporting ecofunction	**6**	80	2992	3.2%
	5	86	1623	1.7%
	4	172	1871	2%
Supporting ecofunction	**3**	234	1298	1.4%
	2	302	1431	1.5%
	1	344	1104	1.2%
Contributing ecofunction	**0**	403	774	0.8%

As additional data are obtained from the *Natural Areas Inventory*, they will be used to explore further relationships between landscape variables and site level data.

Habitat patches scoring 7-9 are termed Core ecofunction patches. Occupying 21.5% of watershed area, these patches represent the highest quality patches in the watershed from a landscape perspective and on average contain over 200 species in each patch. These core patches are important for maintaining biodiversity and ecosystem function over the long term in the watershed, and should constitute a major component of the watershed Natural Heritage System. Patches scoring 4-6 are termed Highly Supporting ecofunction patches. Occupying 6.9% of watershed area, many of these patches contain ESAs, ANSIs, and PSWs and contribute to the ecological integrity of the Core patches. Patches scoring 1-3 are termed Supporting ecofunction patches and occupy 4.1% of total watershed area. Patches scoring 0 are termed Contributing ecofunction patches and occupy 0.8% of watershed area.

While Supporting and Contributing ecofunction patches account for a smaller percent of watershed area, they are most frequently found in the Lower Watershed, where natural cover is low due to the presence of urban and agricultural land uses. These patches are unique in that they are the last remaining natural areas on three specific physiographic regions of the watershed, namely the Peel Plain, Lake Iroquois Plain, and the South Slope. These patches play an important role in that they maintain or hold the potential to maintain some elements of Carolinian zone biodiversity. They also continue to provide some localized ecosystem functions that are of value due to the overall lack of natural cover in this zone (e.g. air purification, mitigation of heat island effect). Their social value is high as they are surrounded by urbanization and provide local and accessible opportunities for education, recreation, and enjoyment.

Patches with low scores in the LSA may hold potential to form a linkage or stepping stone habitat in a Natural Heritage System, or to be restored to natural cover, thereby increasing their capacity to provide some additional functionality to the system as a whole. The contribution of urban natural spaces to local ecological functions may be enhanced through development of localized Natural Heritage Systems identifying areas for protection and enhancement at a smaller scale.

12.2 LANDSCAPE SCALE ANALYSIS RESULTS AND EXISTING PROTECTED AREAS

The habitat patches in the Credit River Watershed contain features and areas that receive some level of protection under existing legislation and those that do not currently receive protection. Features and areas that may have some level of protection include ESAs, ANSIs, PSWs, other wetlands, Greenbelt Natural Heritage System, portions of the Niagara Escarpment and Oak Ridges Moraine and regional or area municipal greenlands systems.

Figure A13 shows Core, Highly Supporting, Supporting, and Contributing ecofunction habitat patches from the Landscape Scale Analysis overlaid with the protected areas listed above as well as provincial, CVC, or NGO properties managed primarily for conservation. A significant number of the Core ecofunction patches from the Landscape Scale Analysis overlap with existing protected areas – nearly 22,000ha or 23% of watershed area. This is likely an underestimate because other protected areas (e.g. Peel's Greenlands System, Mississauga's Natural Areas System, Caledon's Environmental Policy Areas, protected areas within the Region of Halton, and others were not included due to differences in the definitions and level of 'protected' within and among the different systems. Also not included in the overlap calculation were hazard lands regulated by Conservation Authorities. The high degree of overlap indicates that some Core ecofunction habitat patches as identified by the Landscape Scale Analysis are already protected through some form of legislation, policy or ownership, but others should be a focus for protection. The overlap also suggests that the Landscape Scale Analysis methodology is a relatively robust method for identifying important natural and semi-natural features on the landscape as it has identified important areas in terms of ecological function that have also been identified under other studies (e.g. ANSIs). Overlays can be conducted in future for any individual municipalities because each municipality would have a protected areas GIS layer that is consistent for its jurisdiction.

The Landscape Scale Analysis for the Credit River Watershed is based upon sound scientific criteria and principles. Landscape Scale Analyses by their nature are scalable – they can be applied to any area of interest, depending on study goals and objectives – and they can cross municipal or watershed boundaries as long as data are available. For example, the criteria used for the watershed Landscape Scale Analysis can also be used to assess habitat patches in urban areas, using criteria and thresholds that are more applicable to the generally lower natural cover in these areas. Credit Valley Conservation is currently working with the City of Mississauga and associated Conservation Authorities (Toronto and Region Conservation Authority, Halton Region Conservation Authority) to conduct a Landscape Scale Analysis of the natural and semi-natural features within the City boundary. The Analysis offers opportunities to enhance the City's existing Natural Areas System by identifying semi-natural areas that with appropriate restoration or enhancement can contribute strongly to the ecological functioning of the City's ecosystems. The Analysis also assesses Open Space (e.g. parks) and Agriculture areas for their relative ability to improve ecological functioning of the City's natural ecosystems. These types of analyses can further help municipalities identify priority areas for restoration or stewardship activities (in the context of existing uses where applicable).

13.0 FUTURE WORK

This report represents an abbreviated summary of the Phase 1 and 2 of the TEEM project and includes watershed characterization and watershed Landscape Scale Analysis. The Landscape Scale Analysis will inform the process of identifying a Natural Heritage System for the Credit River Watershed and can be used by municipalities to compare their existing or potential protected areas systems with natural areas important for watershed function. The results of the Landscape Scale Analysis have been communicated to stakeholders through four consultation sessions (Wianecki 2009) and to the public through numerous presentations.

Phase 3 of the TEEM project is ongoing and involves development of a Credit River Watershed Natural Heritage System. Following technical review of the Landscape Scale Analysis, it was recommended that the Natural Heritage System be designed by identifying natural heritage features as specified in the *Provincial Policy Statement* and the Natural Heritage Reference Manual (OMNR 2010). Therefore, the watershed's Natural Heritage System will consist of core natural features (not habitat patches) linked by corridors. The Natural Heritage System will be overlaid with the Landscape Scale Analysis results as part of an ecological assessment to determine whether the key features identified through the LSA are captured within the system.

Phase 4 of the TEEM project has also been initiated with a project to review existing natural heritage policies in southern Ontario and beyond and a second project to review incentive programs relevant to southern Ontario.

Stakeholder input will continue to be sought at key points during each phase of Natural Heritage System development. Outreach throughout the process will keep the general public informed of this CVC initiative.

Following development of the Credit River Watershed Natural Heritage System, CVC will engage municipal planning authorities to emphasize the effectiveness of existing natural heritage related policies and provide technical information to assist in updating existing Natural Heritage System protection strategies in the context of watershed health.

14.0 REFERENCES

Andrén, H. 1994. Effects of habitat fragmentation on birds and mammals in landscapes with different proportions of suitable habitat: A review. Oikos 71(3):355-366.

Askins, R.A. and M.J. Philbrick. 1987. Effect of changes in regional forest abundance on the decline and recovery of a forest bird community. *Wilson Bulletin* 99:7-21.

Austen, M.J.W., C.M. Francis, D.M. Burke and M.S. Bradstreet. 2001. Landscape context and fragmentation effects on forest birds in southern Ontario. *Condor* 103:704-714.

Bay, M.D. 1996. Breeding Birds in Early Successional Oldfields: the Effect of Area on Community Structure. Proceedings of the Oklahoma Academy of Science 76:67-73.

Beacon Environmental and LSRCA (Lake Simcoe Region Conservation Authority). 2007. Natural Heritage System for the Lake Simcoe Watershed. Prepared for the Lake Simcoe Region Conservation Authority and the Lake Simcoe Environmental Management Strategy. 142 p. plus appendices.

Bird Studies Canada, Federation of Ontario Naturalists, Canadian Wildlife Service, Ontario Ministry of Natural Resources, and Ontario Field Ornithologists. 2004. Ontario Breeding Bird Atlas Database. Port Rowan, Ontario: Bird Studies Canada.

Bonter, D.N., S.A. Gauthreaux, and T.N. Donovan. 2009. Characteristics of important stopover locations for migrating birds: remote sensing with radar in the Great Lakes Basin. *Conservation Biology* 23:440-448.

Burke, D.M. and E. Nol. 2000. Landscape and fragment size effects on reproductive success of forest-breeding birds in Ontario. *Ecological Applications* 10:1749-1761.

Cataraqui Region Conservation Authority. 2006. Central Cataraqui Region Natural Heritage Study. Final draft report June 2006. Available online at http://www.cataraquiregion.on.ca/management/ccrnaturalheritagestudyjune2006.pdf Accessed 29 January 2009.

Chase, V., L. Deming, and F. Latawiec. 1995 revised 1997. Buffers for wetlands and surface waters. A guidebook for New Hampshire municipalities. University of New Hampshire Cooperative Extension. 82p.

City of Hamilton. 2005. Discussion Paper #4a: Review of Significant Woodland Criteria Technical Discussion Paper. 17p.

City of London. 2006. City of London: Guideline Document for the Evaluation of Ecologically Significant Woodlands. City of London. London. 12p.

City of Mississauga. 2005. Mississauga Plan. Available online at http://www.mississauga.ca/portal/residents/mississaugaplan Accessed 27 January 2009.

CVC (Credit Valley Conservation).1998. Credit Watershed Natural Heritage Project detailed methodology: identifying, mapping, and collecting field data at watershed and subwatershed scales. Version 3, April 1998. 137p.

CVC (Credit Valley Conservation). 2002a. Birds of the Credit River Watershed.

CVC (Credit Valley Conservation). 2002b. Mammals of the Credit River Watershed.

CVC (Credit Valley Conservation). 2002c. Reptiles and amphibians of the Credit River Watershed.

CVC (Credit Valley Conservation) and University of Guelph. 2003. Mapping pre-settlement vegetation from surveyors' records.

CVC (Credit Valley Conservation). 2006a. Terrestrial Ecosystem Enhancement Model (TEEM). Background document and terms of reference. February 2006.

CVC (Credit Valley Conservation). 2006b. Credit Valley Conservation Strategic Plan 2006.

CVC (Credit Valley Conservation). 2007a. Interim Watershed Characterization Report for the Credit River Watershed. 28 February 2007.

CVC (Credit Valley Conservation). 2007b. Credit River Water Management Strategy Update – Making it Work. May 2007. Available online at http://www.creditvalleyca.ca/bulletin/downloads/CRWMSU-detailedreport.pdf accessed 26 Nov 2008).

Credit Valley Conservation. 2011. Towards a Natural Heritage System for the Credit River Watershed. Phases 1 & 2: Watershed characterization and Landscape Scale Analysis. Final technical report, February 2011 plus Appendices A and B. Available online at http://www.creditvalleyca.ca/bulletin/resources.htm#natural

CWP (Centre for Watershed Protection). 2005. Urban watershed forestry manual: methods for increasing forest cover in a watershed. 94p. plus appendices.

Daily, G.C. (Ed.), 1997. Nature's Services: Societal Dependence on Natural Ecosystems. Island Press, Washington, DC.

Dougan and Associates. 2005. Region of Waterloo Environmentally Sensitive Landscapes (ESLs) Study Discussion Paper. Final Report August 2005. 66p.

Dougan and Associates 2009. Guelph Natural Heritage Strategy. Phase 2: Terrestrial Inventory & Natural Heritage System. Volume 1. Final report March 2009. 102p.

Ducks Unlimited Canada. 2010. Southern Ontario wetland conversion analysis. Final report March 2010. Ducks Unlimited Canada. 51p.

Dunford, W. and K. Freemark. 2004. Matrix matters: effects of surrounding land uses on forest birds near Ottawa, Canada. *Landscape Ecology* 20:497-511.

Ecologistics Limited. 1979. Credit River Watershed Environmentally Significant Areas. 207p.

Environment Canada. 2004. How much habitat is enough? A framework for guiding habitat rehabilitation in Great Lakes Areas of Concern. 2nd edition. Canadian Wildlife Service. 88p.

Environmental Law Institute. 2003. Conservation thresholds for land use planners. Environmental Law Institute, Washington, DC. 64p.

Ewert, D.N., G.J. Soulliere, R.D. Macleod, M.C. Shieldcastle, P.G. Rodewald, E. Fujimura, J. Shieldcastle, and R.J. Gates. 2006. Migratory bird stopover site attributes in the western Lake Erie basin. Final report to The George Gund Foundation.

Fahrig, L. 2002. Effect of habitat fragmentation on the extinction threshold: a synthesis. *Ecological Applications* 12:346-353.

Findlay, C.S. and J. Houlahan. 1997. Anthropogenic correlates of species richness in southeastern Ontario wetlands. *Conservation Biology* 11:1000-1009.

Forman, R.T.T. 1995. Land mosaics: the ecology of landscapes and regions. Cambridge University Press, Cambridge, England. 632p.

Forman, R.T.T. and M. Godron. 1986. Landscape ecology. Wiley, New York.

Government of Canada. *Species at Risk Act.* Available online at http://laws.justice.gc.ca/en/s-15.3/text.html Accessed 31 January 2009.

Government of Ontario. *Clean Water Act.* Available online at http://www.e-laws.gov.on.ca/html/statutes/english/elaws_statutes_06c22_e.htm Accessed 29 January 2009.

Government of Ontario. *Conservation Authorities Act.* Available online at http://www.e-laws.gov.on.ca/html/statutes/english/elaws_statutes_90c27_e.htm Accessed 31 January 2009.

Government of Ontario. *Endangered Species Act.* Available online at http://www.e-laws.gov.on.ca/html/statutes/english/elaws_statutes_07e06_e.htm Accessed 31 January 2009.

Government of Ontario. *Places to Grow Act.* Available online at http://www.e-laws.gov.on.ca/html/statutes/english/elaws_statutes_05p13_e.htm Accessed 31 January 2009.

Government of Ontario. *Planning Act.* Available online at http://www.e-laws.gov.on.ca/html/statutes/english/elaws_statutes_90p13_e.htm Accessed 31 January 2009.

Hartley, M.J. and M.L. Hunter, Jr. 1998. A meta-analysis of forest cover, edge effects, and artificial nest predation rates. *Conservation Biology* 12:465-469.

Henson, B.L., K.E. Brodribb, and J.L. Riley. 2005. Great Lakes Conservation Blueprint for terrestrial biodiversity. Volume 1. Nature Conservancy of Canada. 156p.

Hilty, J.A., W.Z. Lidicker Jr., and A.M. Merenlender. 2006. Corridor ecology. The science and practice of linking landscapes for biodiversity conservation. Island Press. 323p.

Lake Ontario Biodiversity Conservation Strategy Working Group. 2009. The beautiful lake. A binational biodiversity conservation strategy for Lake Ontario. Final report April 2009 updated July 2009.

Larson, B.M, J.L. Riley, E.A. Snell and H.G. Godschalk. 1999. The woodland heritage of southern Ontario: a study of ecological change, distribution and significance. Federation of Ontario Naturalists, Don Mills, Ontario. 262 p.

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

Lee, M., L. Fahrig, K. Freemark, and D.J. Currie. 2002. Importance of patch scale vs landscape scale on selected forest birds. *Oikos* 96:110-118.

Lindenmayer, D.B. and J.F. Franklin. 2002. Conserving forest biodiversity: A comprehensive multiscaled approach. Island Press, Washington, DC. 368p.

Lower Trent Conservation. 2001. Natural Heritage Report: Municipality of Campbellford/Seymour/Percy/Hastings, City of Quinte West, and City of Belleville. 33p. plus appendices.

McNeil, J. and C. Vava. 2006. Oakville's urban forest: our solution to our pollution. Town of Oakville, Parks and Open Space Department, Forestry Section.

Meyer, J.L., D.L. Strayer, J.B. Wallace, S.L. Eggert, G.S. Helfman, and N.E. Leonard. 2007. The contribution of headwater streams to biodiversity in river networks. *Journal of the American Water Resources Association* 43:86-103.

Mitsch, W.J. and J.G. Gosselink. 2000. The value of wetlands: importance of scale and landscape setting. *Ecological Economics* 35:25-33.

MPIR (Ministry for Public Infrastructure and Renewal, now renamed Ministry of Energy and Infrastructure). 2006. Places to Grow. Growth Plan for the Greater Golden Horseshoe. Queen's Printer for Ontario.

Nadeau, T-L. and M.C. Rains. 2007. Hydrological connectivity between headwater streams and downstream waters: how science can inform policy. *Journal of the American Water Resources Association* 43:118-133.

Naiman, R.J. and H. Decamps. 1997. The ecology of interfaces: Riparian zones. *Annual Review of Ecology and Systematics* 28:621-658.

NHIC (Natural Heritage Information Centre). 2002. Big Picture 2002. Available online at http://nhic.mnr.gov.on.ca/MNR/nhic/projects/BP/bigpict_2002_main.cfm Accessed 29 January 2009.

North-South Environmental Inc. 2009. Natural Heritage System definition and implementation. Sustainable Halton Report 3.02. Final Draft April 2009. 62p.

North-South Environmental Inc., Dougan and Associates, and Sorensen Gravely Lowes. 2009. Peel-Caledon Significant Woodlands and Significant Wildlife Habitat Study. Final Report June 2009. Ontario: Region of Peel and Town of Caledon. Available online at http://www.region.peel.on.ca/planning/officialplan/woodlands-and-wetlands-discussion-paper.htm accessed 15 January 2009.

OMMAH (Ontario Ministry of Municipal Affairs and Housing). 2002. Oak Ridges Moraine Conservation Plan. Queen's Printer for Ontario. 82p.

OMMAH (Ontario Ministry of Municipal Affairs and Housing). 2004a. Oak Ridges Moraine Conservation Plan Technical Papers Series. 7. Identification and protection of Significant Woodlands. Available online at http://www.mah.gov.on.ca/AssetFactory.aspx?did=4892 Accessed 28 January 2009.

OMMAH (Ontario Ministry of Municipal Affairs and Housing). 2004b. Oak Ridges Moraine Conservation Plan Technical Papers Series. 3. Supporting connectivity. Available online at http://www.mah.gov.on.ca/AssetFactory.aspx?did=4888 Accessed 28 January 2009.

OMMAH (Ontario Ministry of Municipal Affairs and Housing). 2005a. Provincial Policy Statement. Queen's Printer for Ontario. 37p. Available online at http://www.mah.gov.on.ca/Page1485.aspx Accessed 21 June 2010.

OMMAH (Ontario Ministry of Municipal Affairs and Housing). 2005b. Greenbelt Plan. Queen's Printer for Ontario. 57p. Available online at http://www.mah.gov.on.ca/Page189.aspx#greenbelt Accessed 28 January 2009.

OMNR (Ontario Ministry of Natural Resources).1988. Implementation Strategy: Areas of Natural and Scientific Interest.

OMNR (Ontario Ministry of Natural Resources). 1999. Natural Heritage Reference Manual. For Policy 2.3 of the Provincial Policy Statement - Ontario Ministry of Natural Resources – June 1999. Available online at http://www.mnr.gov.on.ca/249080.pdf Accessed 14 April 2009.

OMNR (Ontario Ministry of Natural Resources). 2000. Significant Wildlife Habitat Technical Guide. 151p.

OMNR (Ontario Ministry of Natural Resources). 2005. *Ontario Biodiversity Strategy*. Available online at http://www.obs-sbo.ca/ Accessed 31 January 2009.

OMNR (Ontario Ministry of Natural Resources). 2008. Technical paper 2: Technical definitions and criteria for Significant Woodlands in the Natural Heritage System of the Protected Countryside Area of the Greenbelt Plan (2005). Draft September 16, 2008.

OMNR (Ontario Ministry of Natural Resources). 2010. Natural Heritage Reference Manual for Natural Heritage Policies of the Provincial Policy Statement, 2005. Second edition. Toronto: Queen's Printer for Ontario. 248p.

OMNR (Ministry of Natural Resources) and CVC (Credit Valley Conservation). 2002. A cooperative management planning initiative for the Credit River Fishery. Queen's Printer for Ontario. 180p.

Region of Waterloo. 2006. Region of Waterloo Official Plan. September 2006 consolidation. Chapter 4, Natural Habitat Network. 56p.

Regional Municipality of Peel. 2005. Region of Peel Official Plan Office Consolidation November 2005.

Ries, L., R.J. Fletcher Jr., J. Battin, and T.D. Sisk. 2004. Ecological responses to habitat edges: mechanisms, models, and variability explained. *Annual Review of Ecology and Systematics* 35:491-522.

Rowsell, M. 2003. Woodland Valuation System: methods and rationale for assigning woodland value at the patch scale for consideration in planning and conservation in Eastern Ontario. Version 2.0. Eastern Ontario Model Forest. 80p.

Semlitsch, R.D. and J.R. Bodie. 1998. Are small, isolated wetlands expendable? *Conservation Biology* 12:1129-1133.

Strobl, E.E. 2010. Vegetation characterization for the Lake Ontario stopover project. A thesis submitted in partial fulfillment of the requirements for the degree of Masters of Science in Environmental Science at The Rochester Institute of Technology. 84p.

The Land Ethic Group. 2006. Natural Heritage Strategy for the Raisin Region Conservation Authority. Final version January 2006. Available online at http://www.rrca.on.ca/watershed-planning/national-heritage-strategy.html Accessed 29 January 2009.

TRCA (Toronto and Region Conservation Authority). 2007. Terrestrial Natural Heritage System Strategy. 65p. Available online at http://www.trca.on.ca/dotAsset/26746.pdf Accessed 30 May 2011.

TRCA (Toronto and Region Conservation Authority) and CVC (Credit Valley Conservation). 2009. Evaluation, Classification and Management of Headwater Drainage Features: Interim Guidelines Updated March 2009.

UTRCA (Upper Thames River Conservation Authority). 2003. The Middlesex Natural Heritage Study: A Natural Heritage Study to identify significant woodland patches in Middlesex County. July 2003. Available online at http://www.thamesriver.on.ca/MNHS/images/MNHS_Report_S1-3.pdf Accessed 29 January 2009.

UTRCA (Upper Thames River Conservation Authority) and County of Oxford. 2006. Oxford Natural Heritage Study. Available online at http://www.thamesriver.on.ca/ONHS/ONHS.htm Accessed 29 January 2009.

Wenger, S. 1999. A review of the scientific literature on riparian buffer width, extent, and vegetation. Institute of Ecology, University of Georgia. 59p.

Wianecki, K. 2009. Towards a Natural Heritage System for the Credit River Watershed – Compendium report from a series of focused dialogues across the watershed. 38p.

15.0 GLOSSARY

Agricultural Areas: These are lands that are utilized for food production and other products such as Christmas tree plantations, nurseries, and so forth. Agricultural areas are divided into two sub-categories: Intensive Agricultural and Non-intensive Agricultural. CVC 1998.

Aquatic system: The aquatic system includes shallow or deep standing or flowing waters with little or no emergent vegetation (Lee et al. 1998). The aquatic system mapped in CVC includes watercourses (stream orders 1 and higher), lakes and ponds (CVC 1998).

Community: A community is defined as a contiguous, relatively homogeneous area, boundaries delineated by a patch of a different type or by a 30mm gap on a 1:10,000 air photo (CVC 1998).

Community series: See *ELC community series*

Community type: A group of similar vegetation stands that share common characteristics of vegetation, structure, and soils (Lee et al. 1998).

Coniferous Swamps (Community Series): Wetland communities with greater than 75 percent coniferous canopy cover. CVC 1998.

Coniferous Forest or Plantation (Community Series): A community with greater than 75% coniferous composition. CVC 1998.

Cultural communities (Community Class; also referred to as semi-natural in the text): Open and treed areas where previous land use practices have significantly influenced the resulting substrate and vegetation. Tree canopy cover is less than 60% and contains a higher percentage of non-native species than natural communities. CVC 1998.

Cultural Forest: A cultural forest is defined as a cultural community with >35% tree cover; this includes coniferous plantation, deciduous plantation, mixed plantation; and cultural woodland. The definition of plantation excludes areas that are managed for the production of fruits, nuts, Christmas trees or nursery stock (CVC 1998).

Cultural Meadow (Community Series): Cultural Community where tree cover is less than 25% as a result of human disturbance. Graminoids and forbs dominate the area. CVC 1998.

Cultural Thicket (Community Series): Cultural Communities that have greater than 25% shrub species and tree cover is less than 25% as a result of human disturbance. CVC 1998.

Cultural Savannah (Community Series): Cultural Communities where tree cover is between 25% and 35%. Vegetation is stratified with scattered or clumped trees and dominated by graminoids and forbs. CVC 1998.

Cultural Woodland (Community Series): Cultural Communities where tree cover is between 35% and 60%. Vegetation is stratified with scattered or clumped trees and dominated by graminoids and forbs. CVC 1998.

Deciduous Forest or Plantation (Community Series): A community with greater than 75% deciduous composition. CVC 1998.

Deciduous Swamps (Community Series): Wetland community with greater than 75 percent deciduous canopy cover. CVC 1998.

Ecofunction: Serves as an abbreviation for 'ecological function'. This term is adopted by CVC to refer to relative habitat patch quality in terms of its ecological function at the landscape scale within the CVC jurisdiction based on the Landscape Scale Analysis. For example, a Core ecofunction habitat patch is a feature that provides or has the capacity to provide a high number of ecological functions relative to other patches in the watershed.

Ecological functions: The natural processes, products or services that living and non-living environments provide or perform within or between species, ecosystems and landscapes, including hydrological functions and biological, physical, chemical and socio-economic interactions (OMMAH 2002, OMMAH 2005a).

Ecosystem: An ecosystem consists of a dynamic set of living organisms (plants, animals, and microorganisms) together with the non-living components of their environment, related processes, and humans (OMNR 1999).

ELC community series: An ELC community series is a relatively homogeneous area identified by the type of cover (open, treed, or shrub) as well as plant form (deciduous, coniferous, or mixed) that is characteristic of the area. It is a unit that is normally visible and consistently recognizable on an air-photo or a combination of maps, air-photo interpretation and other remote sensing techniques. Community Series are the lowest level in the ELC classification that can be identified without a site visit (Lee et al. 1998).

Forest (Community Class): A complex ecosystem with greater than 60% canopy cover comprised of continuous grouping of trees, shrubs and ground vegetation and immediate environmental conditions on which they depend. CVC 1998.

Habitat patch: A habitat patch is defined as a contiguous area, boundaries delineated by another land use type or a 30m gap on a 1:10,000 scale air photo (CVC 1998). It includes natural and semi-natural communities.

Intermittent streams: Water flows for an extended period of time because of a connection with seasonally high groundwater tables; or seasonally extended contributions from wetlands or other surface storage areas. CVC 1998.

Lake: An extensive body of water lying in a depression that is 2 ha. in size or greater. A lake can be completely enclosed by land or can have either or both an in-flowing or out-flowing stream. A lake can also be created by interrupting the normal flow of a watercourse with a dam. CVC 1998.

Landscape: A mosaic where the mix of local ecosystems or land uses is repeated in similar form over a kilometres-wide area (Forman 1995).

Marsh (Community Class): Open wetland areas where tree and shrub coverage is less than 25%. CVC 1998.

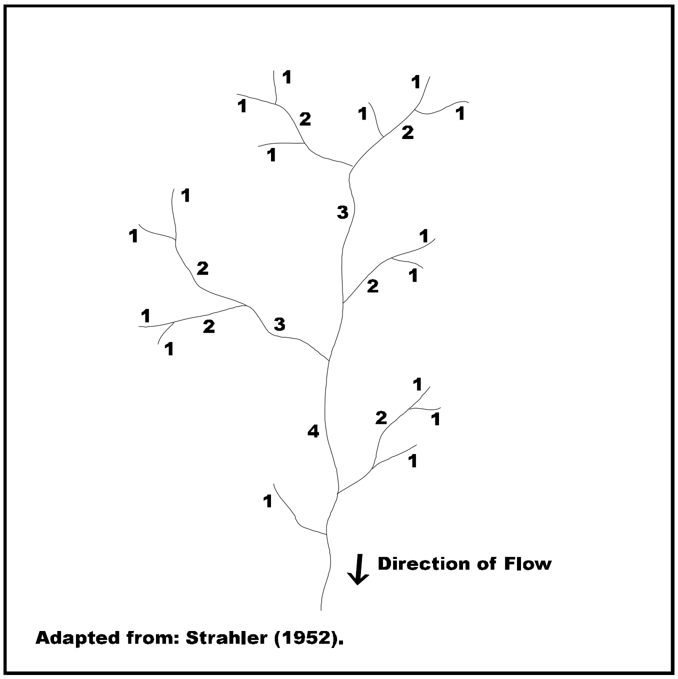
Mixed Forest or Plantation (Community Series): A community with a mixture of deciduous and coniferous trees with neither less than 25% of the total tree cover. CVC 1998.

Mixed Swamps (Community Series): Wetland communities with a mixture of deciduous and coniferous trees with neither less than 25% of the total canopy cover. CVC 1998.

On-line pond: A pond with a stream flowing into and/or out of the pond.

Semi-natural: Modified by human influence but retaining many natural features (Merriam-Webster dictionary, www.merriam-webster.com Accessed 25 Nov 2010). The term "semi-natural" is intended to convey the same meaning to non-technical users as "cultural" in the context of communities as defined under the Ecological Land Classification (Lee et al. 1998).

Stream order: A hierarchical classification system for dendritic streams to indicate their stream size and flow characteristics (see figure below).
Stream Ordering



Successional area: Successional areas are defined as areas that have experienced human influence in the past and that are succeeding or have the potential to succeed to a natural state.

Swamp (Community Class): Treed wetland areas where tree or shrub cover is greater than 25%. CVC 1998.

Thicket Swamps (Community Series): A wetland community that is dominated by shrub species. CVC 1998.

Urban Areas: Urban related uses including continuous ribbon development. Interpreted from air photos by number of roof tops, and groupings of 5 or more residential units equaling 2 or more hectares (i.e. the presence of pavement, buildings and structures). Single rural residential lots are not included as Urban Area unless part of a group of 5 or more units (OMAF, 1982). CVC 1998.

Watercourse: A watercourse is constituted when there is sufficient continuous or intermittent flow of water to form and maintain a defined channel of a permanent, yet dynamic nature. Therefore, ephemeral streams or swales will not be defined as watercourses (CVC 1998).

Wetlands: Lands that are seasonally or permanently covered by shallow water, as well as lands where the water table is close to or at the surface. In either case the presence of abundant water has caused the formation of hydric soils and has favoured the dominance of either hydrophytic plants or water tolerant plants.

Woodlands: The Provincial Policy Statement (OMMAH 2005a) defines woodlands as follows: "Woodlands means treed areas that provide environmental and economic benefits such as erosion prevention, water retention, provision of habitat, recreation and the sustainable harvest of woodland products. Woodlands include treed areas, woodlots, or forested areas and vary in their level of significance".

APPENDIX A (SUMMARY REPORT)
MAP FIGURES

Maps in Appendix A contain the best available data at the time of analysis.

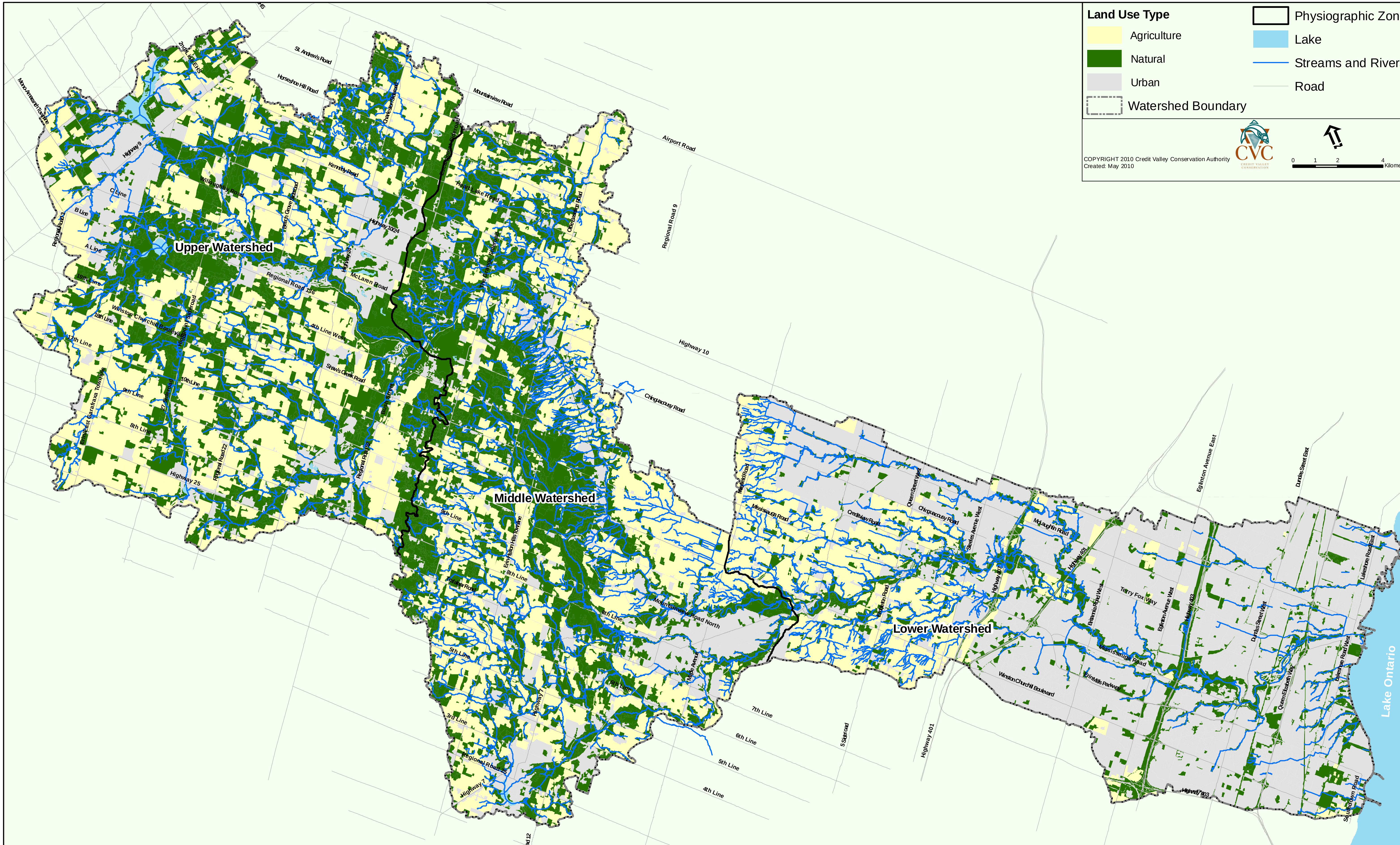


Figure A1: Land use and land cover within the Credit River Watershed and its physiographic zones

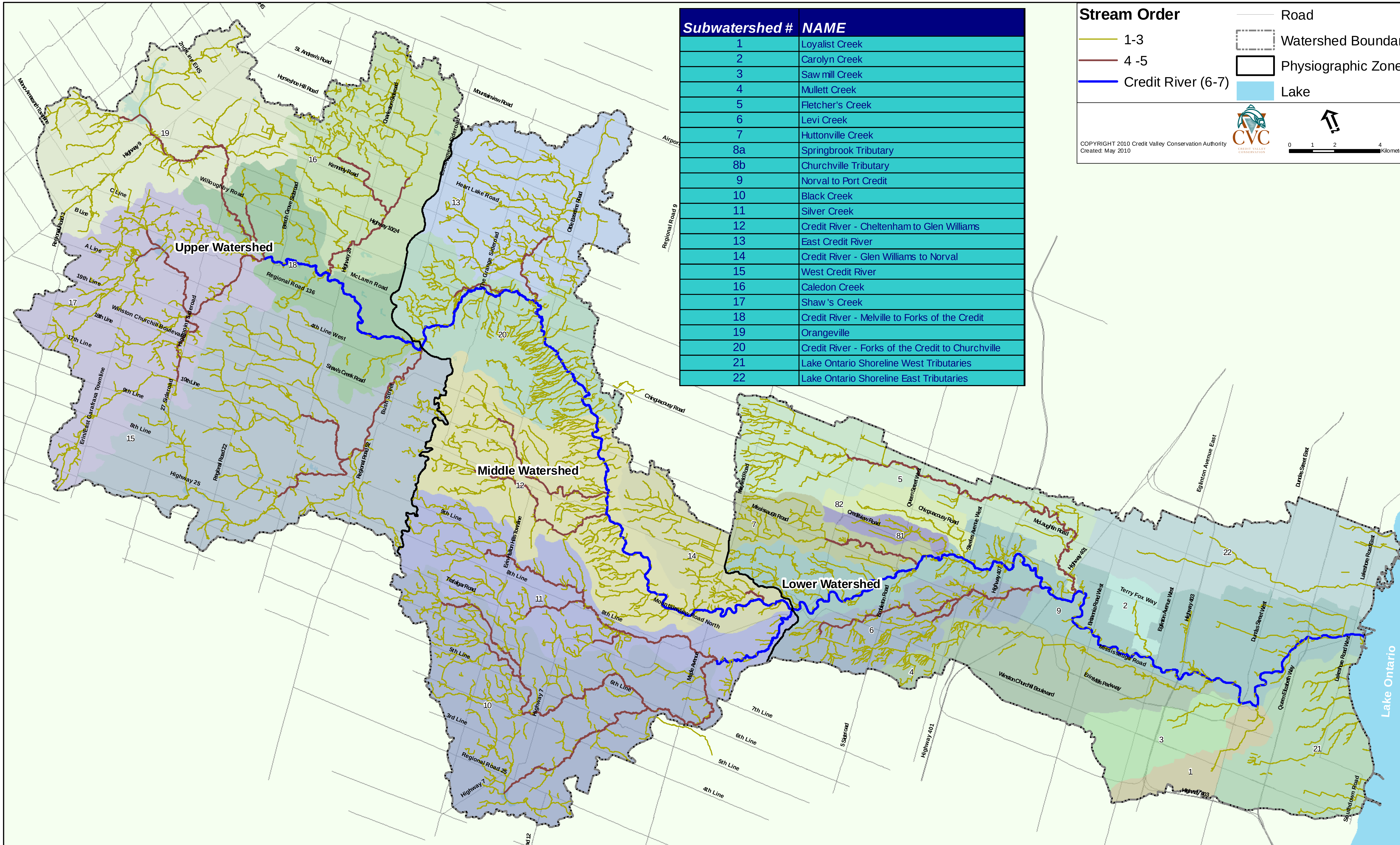


Figure A2: Subwatersheds and streams of the Credit River Watershed, including the Credit River and its main tributaries

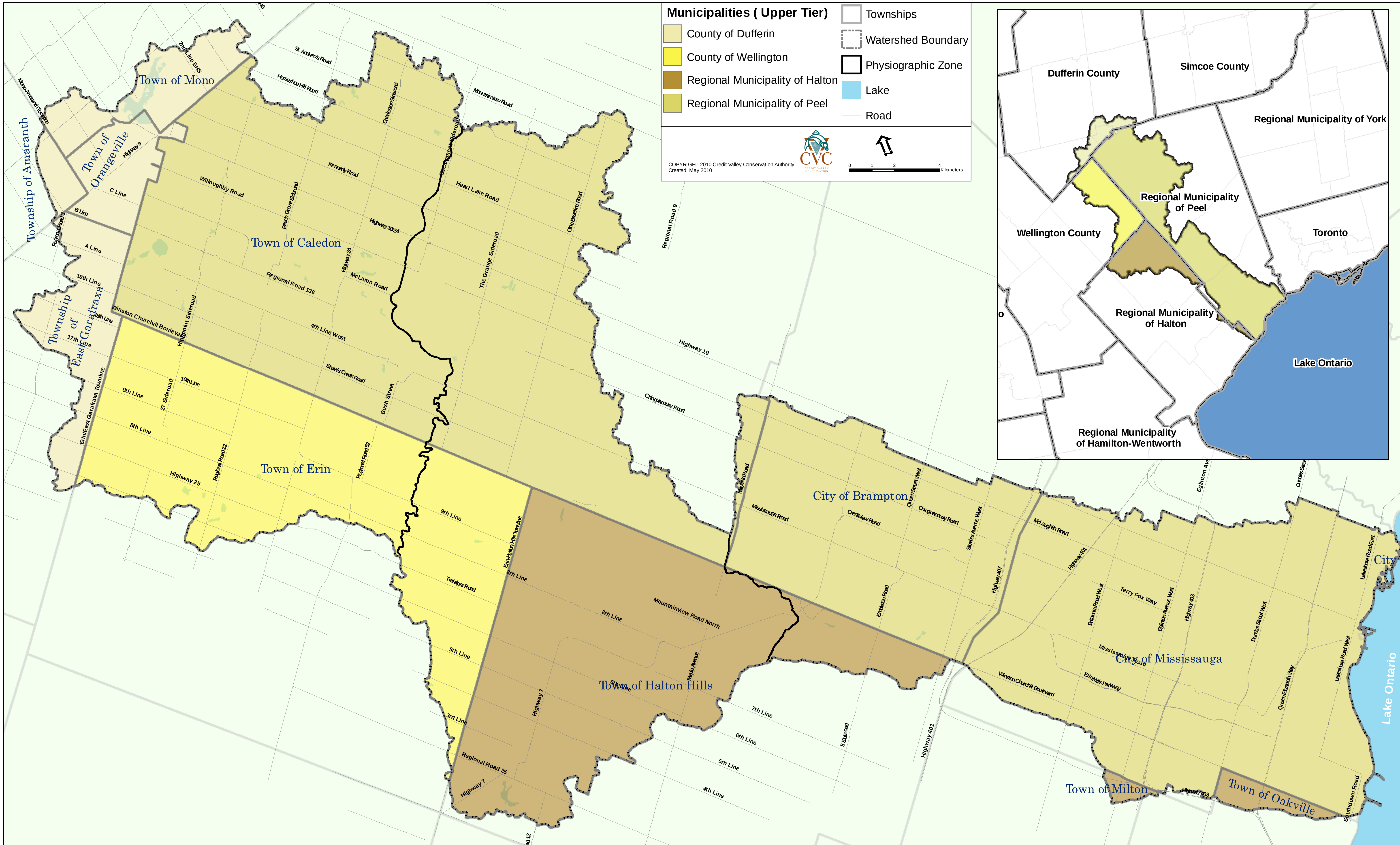


Figure A3: Municipalities within the Credit River Watershed

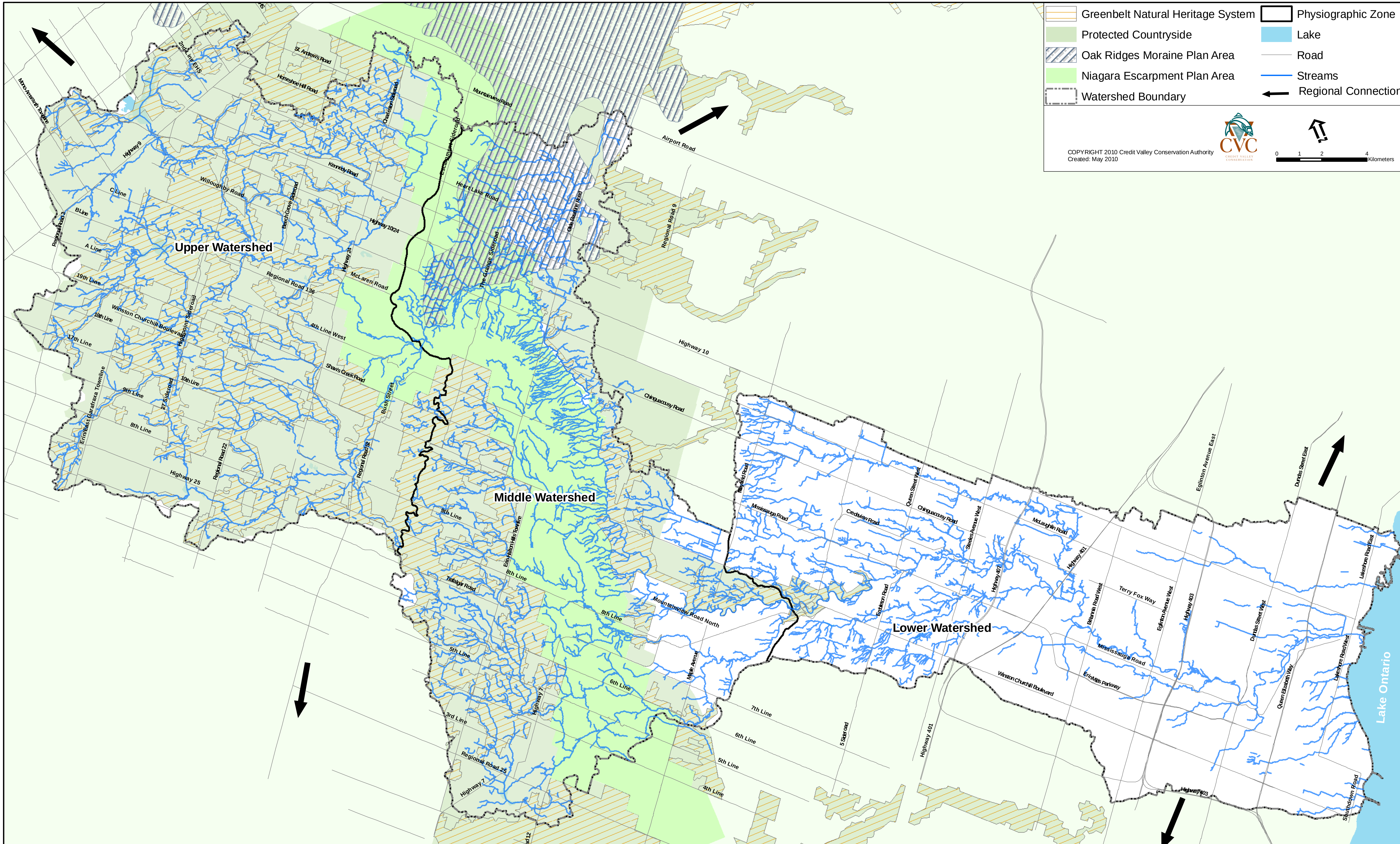


Figure A4: Greenbelt Plan areas within the Credit River Watershed: Niagara Escarpment Plan Area, Oak Ridges Moraine Plan Area, Greenbelt Natural Heritage System and Greenbelt Protected Countryside

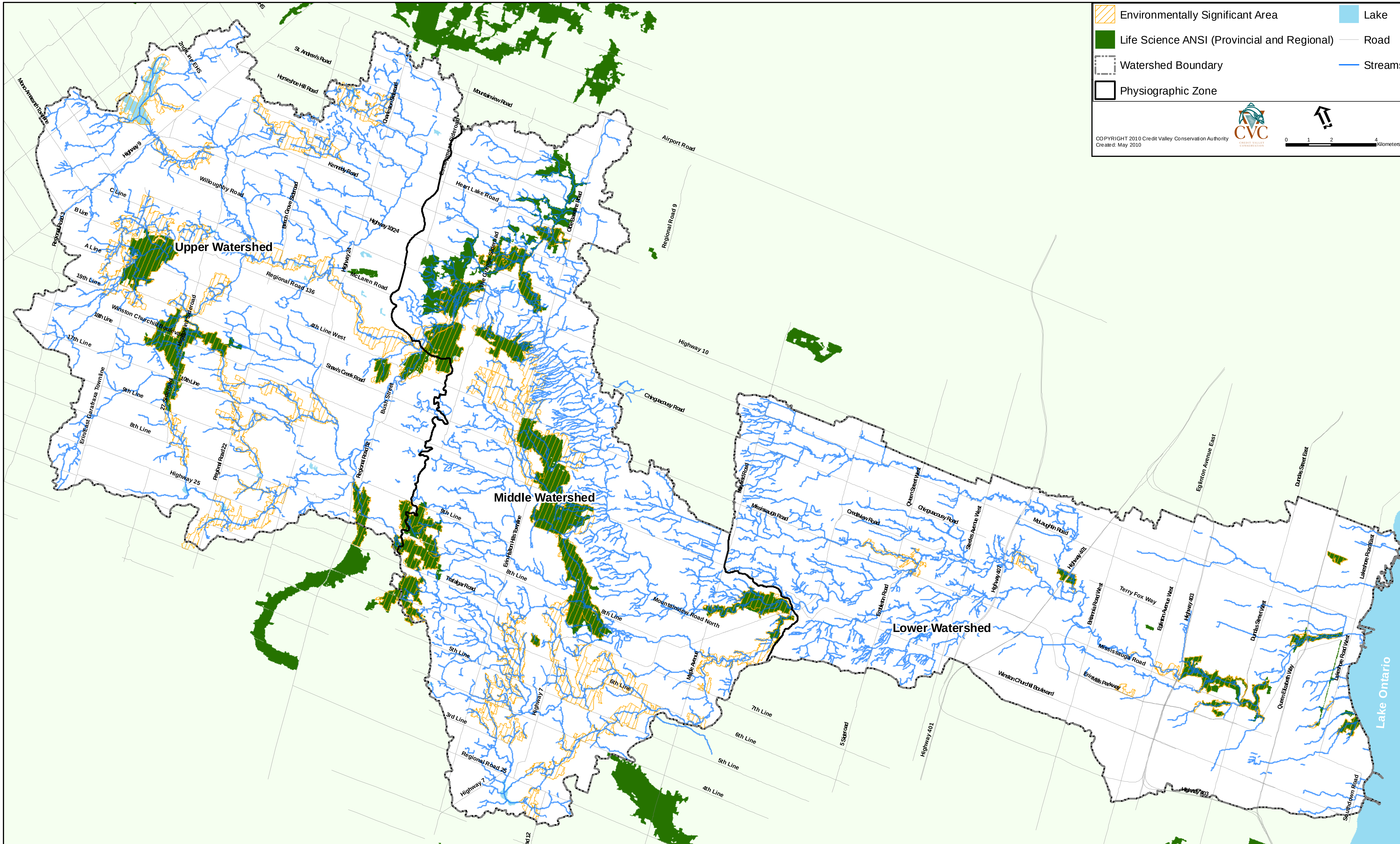


Figure A5: Provincial and Regional Life Science Areas of Natural and Scientific Interest (ANSIs) and Environmentally Significant Areas (ESAs) within the Credit River Watershed

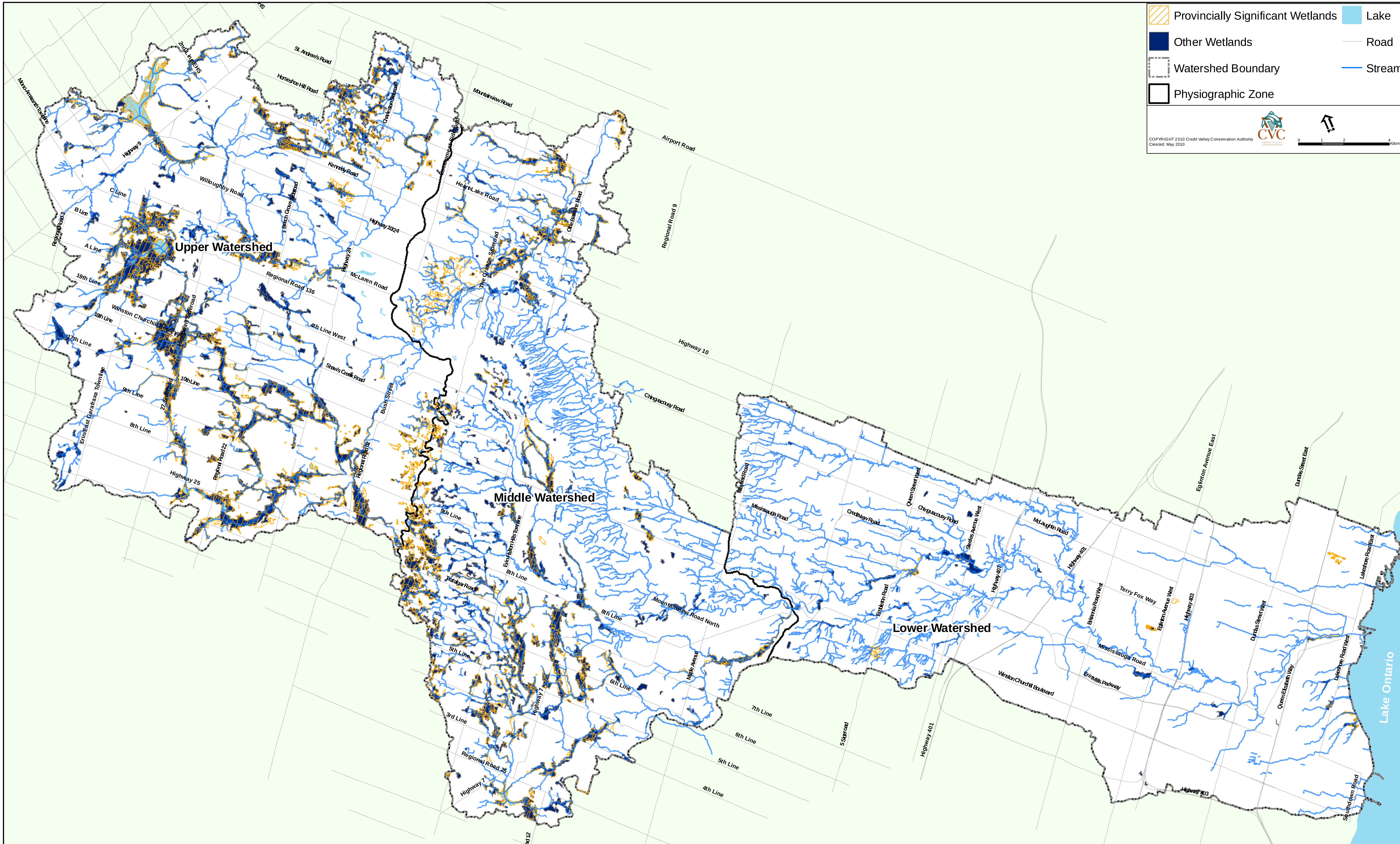


Figure A6: Provincially significant wetlands and other wetlands of the Credit River Watershed

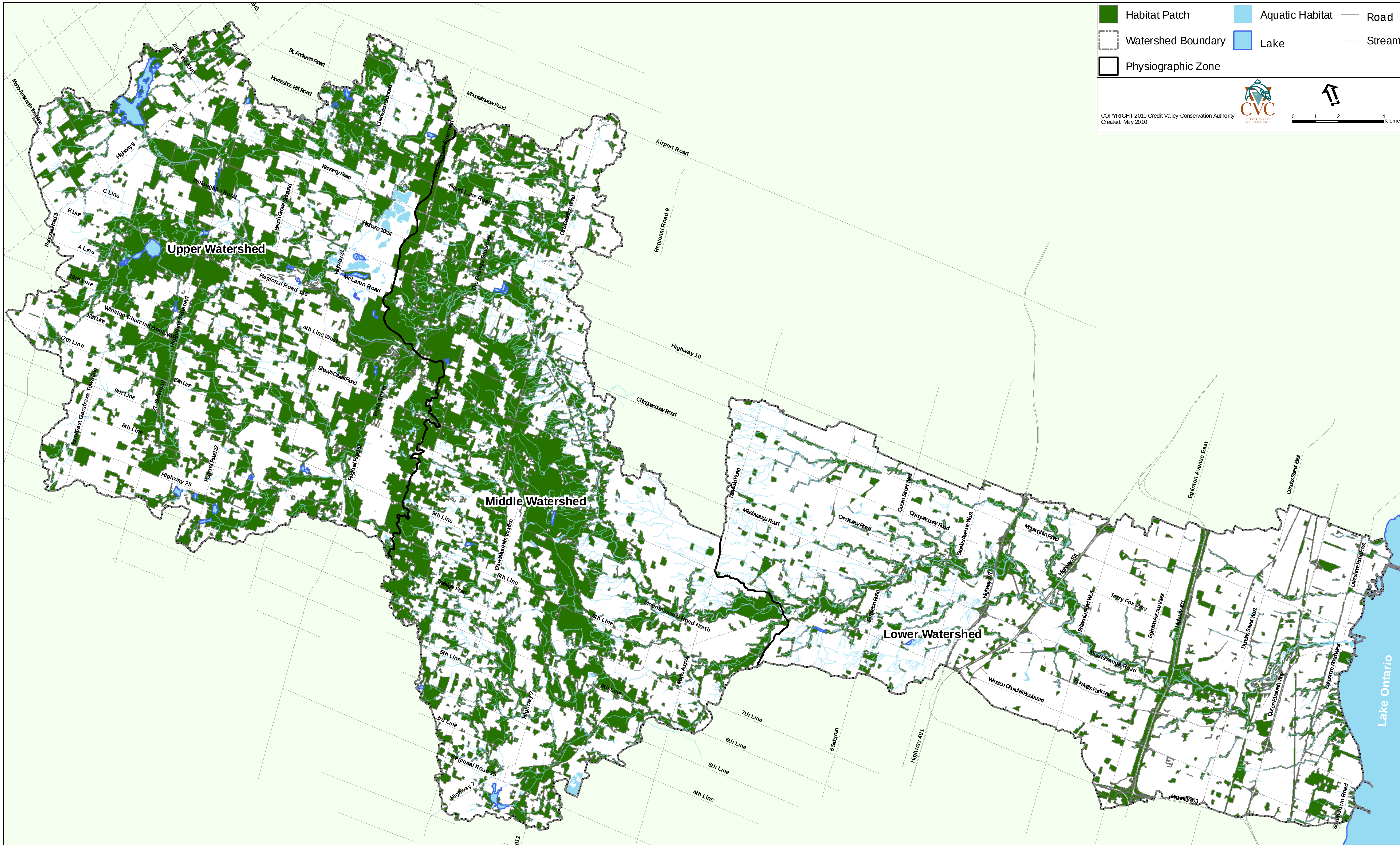


Figure A7: Habitat patches within the Credit River Watershed

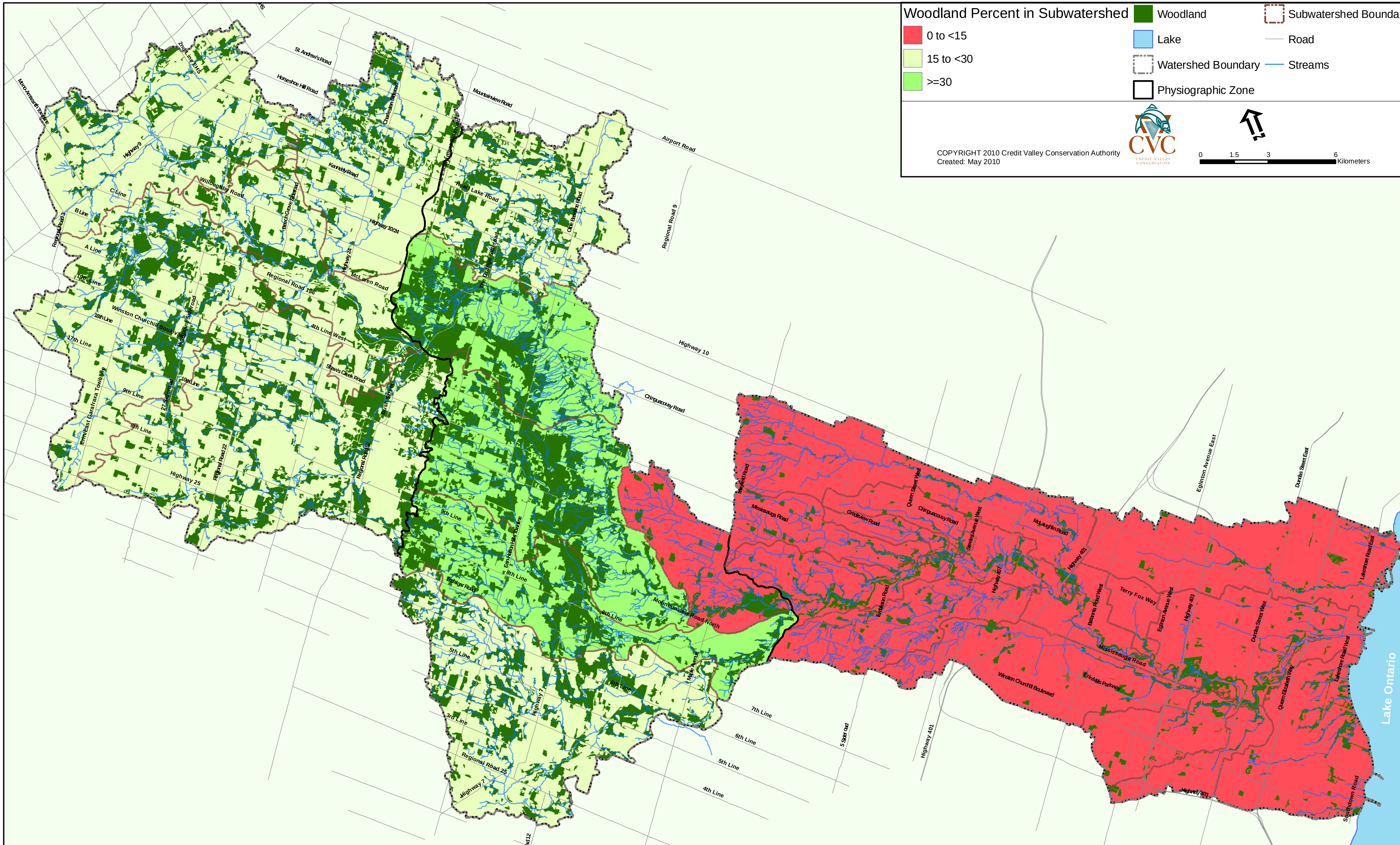


Figure A8: Percent woodland cover by subwatershed, Credit River Watershed

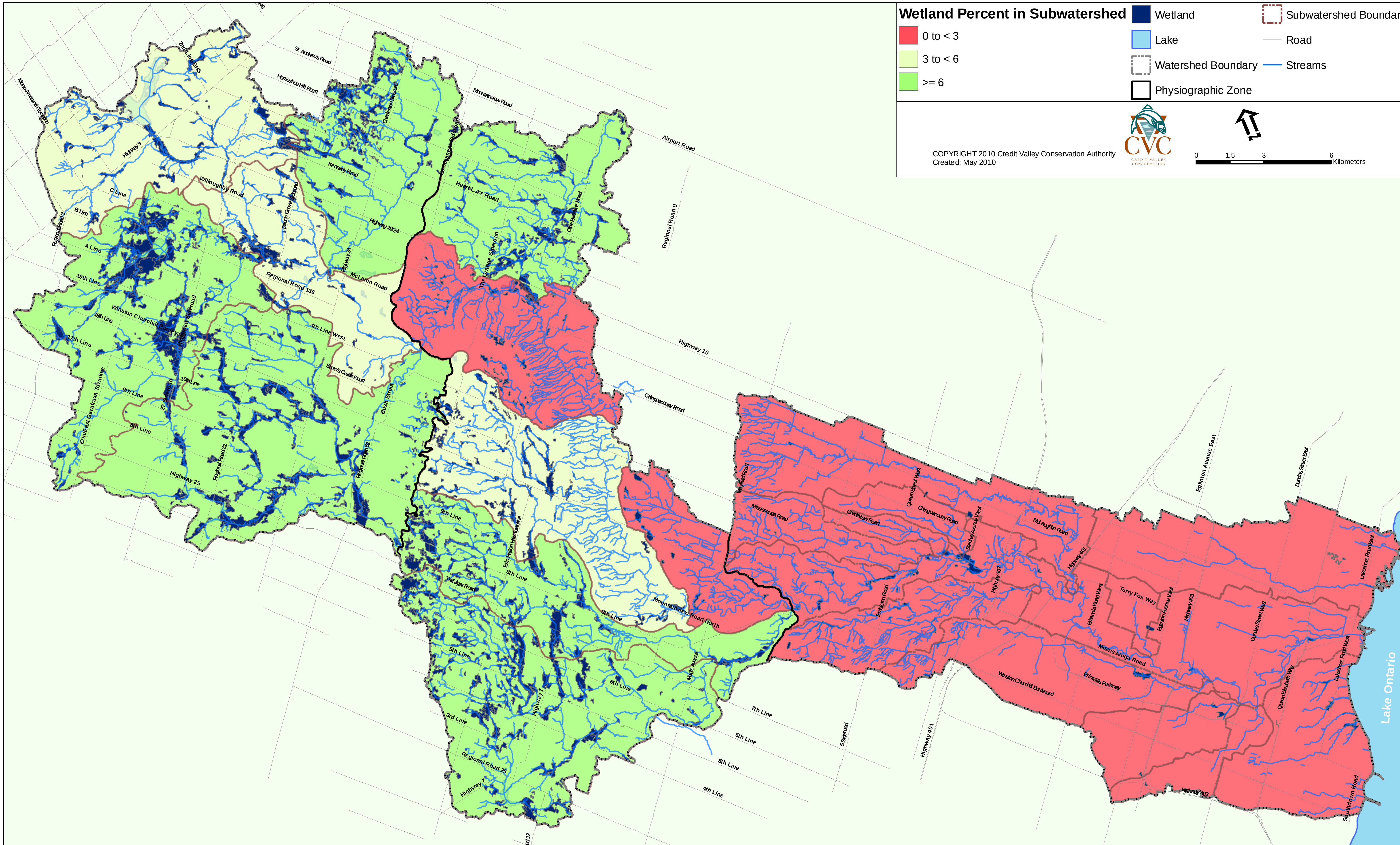


Figure A9: Percent wetland cover by subwatershed, Credit River Watershed

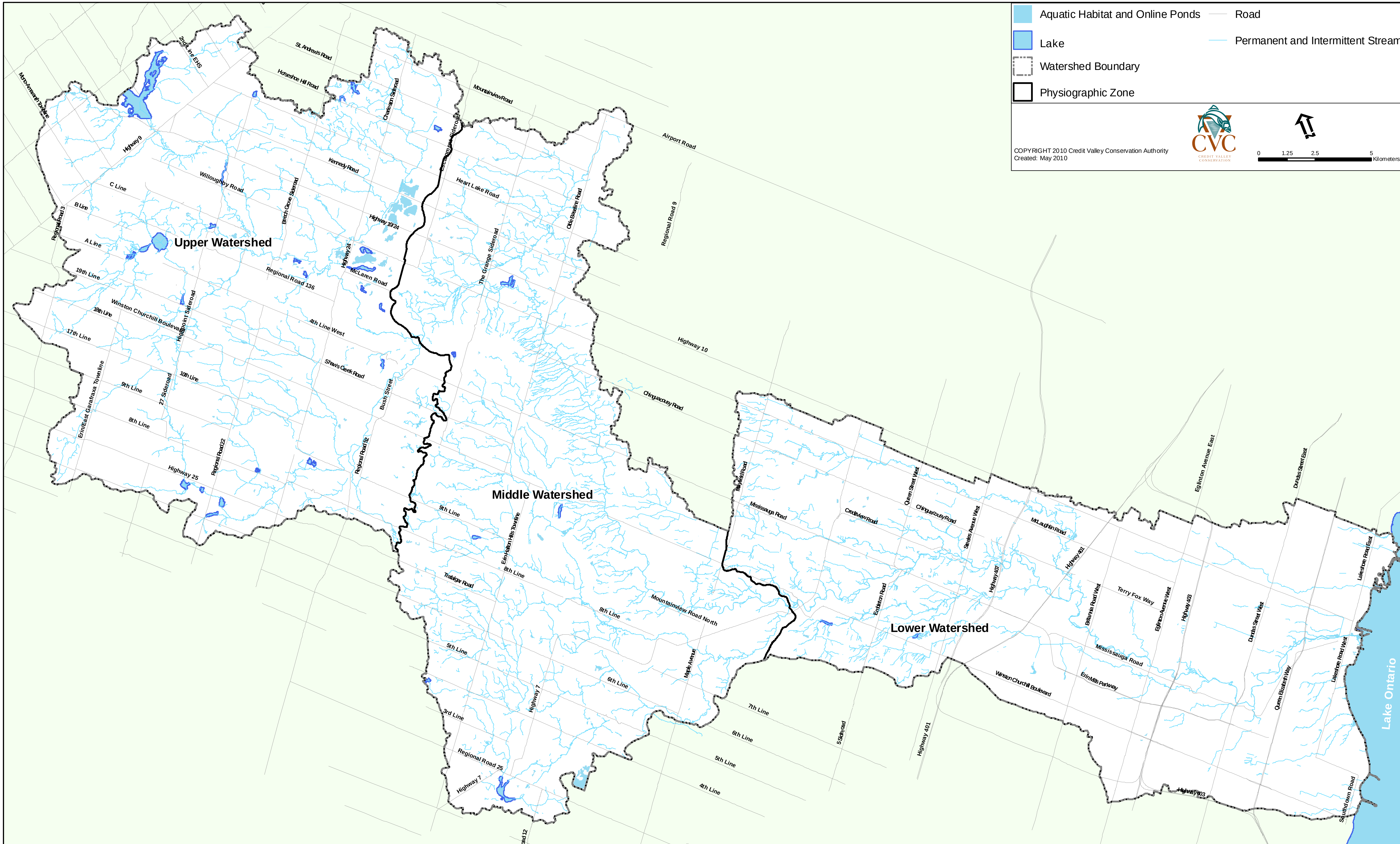


Figure A10: Aquatic features important for ecosystem functioning at the landscape scale of the Credit River Watershed

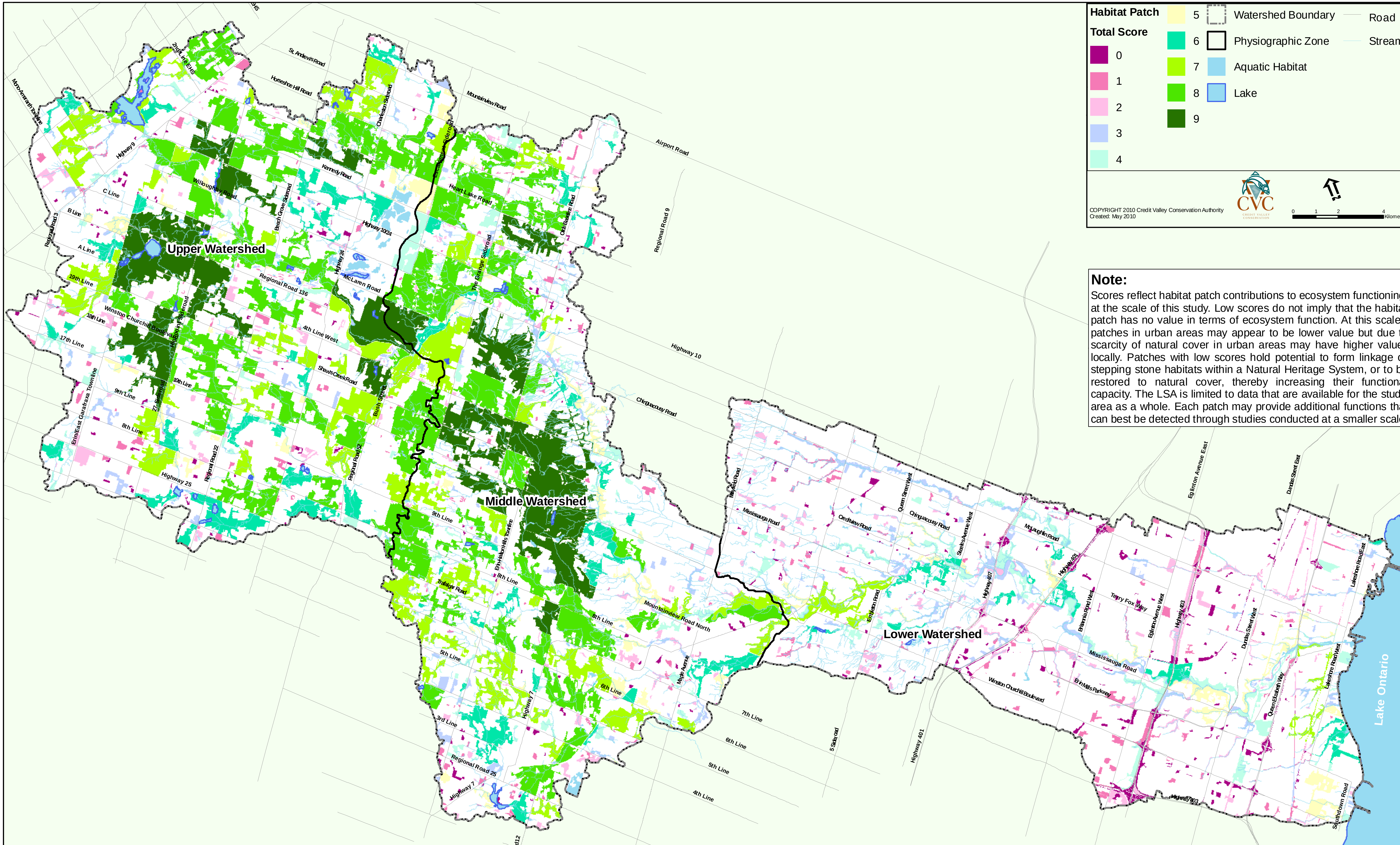


Figure A11: Results of watershed Landscape Scale Analysis - patch scores for each habitat patch in the Credit River Watershed

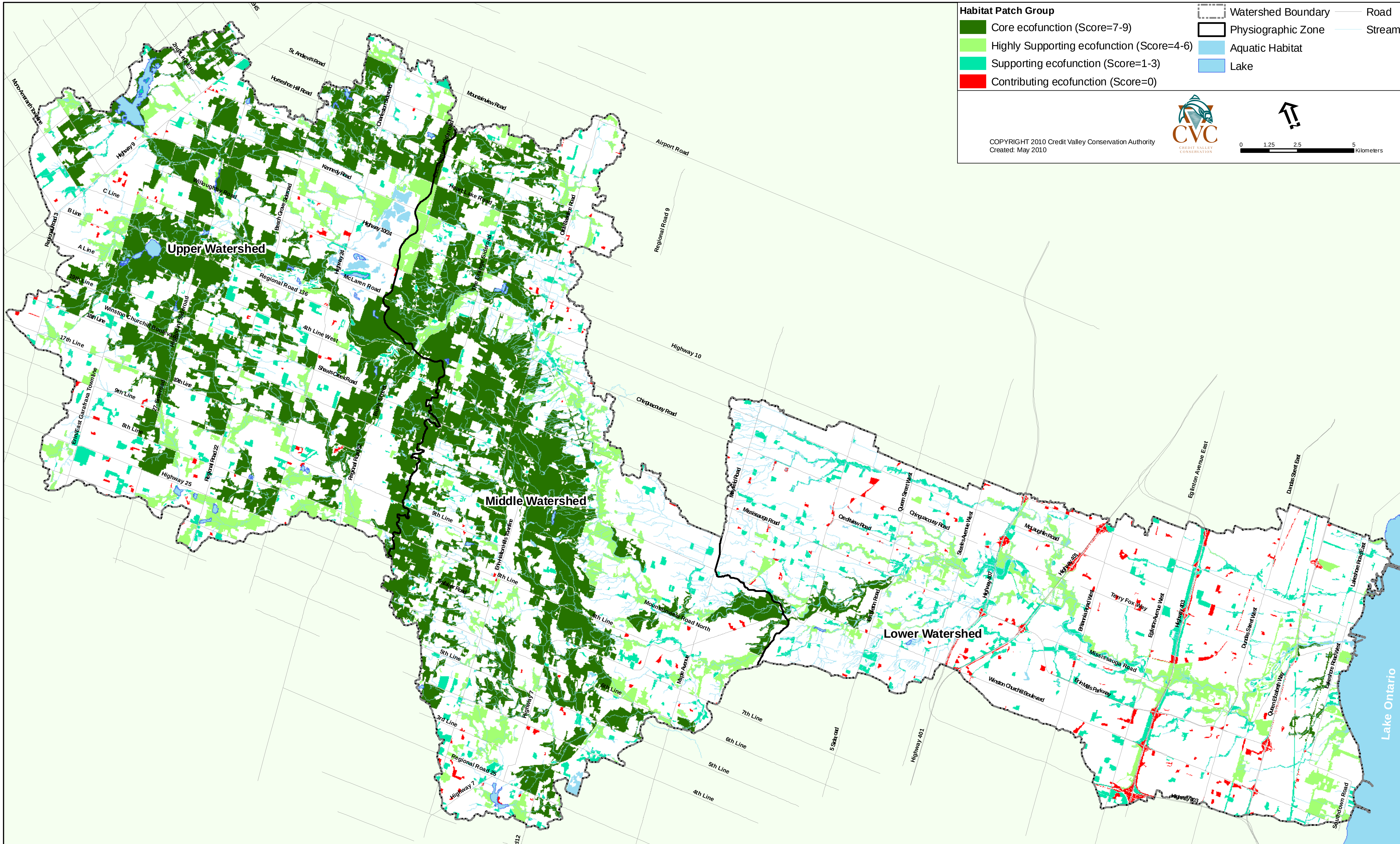


Figure A12: Core ecofunction, Highly Supporting ecofunction, Supporting ecofunction, and Contributing ecofunction habitat patches, Credit River Watershed

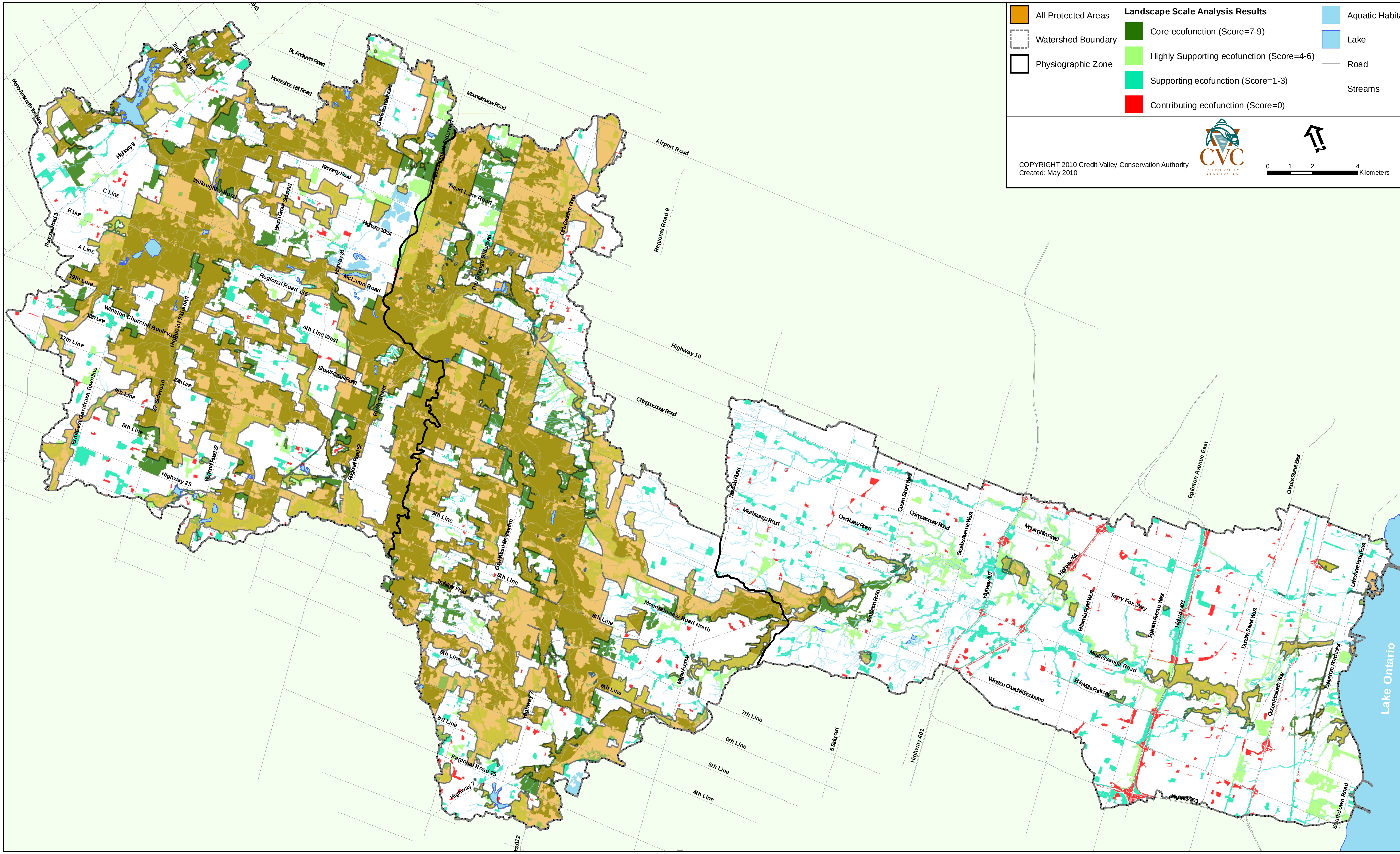


Figure A13: Landscape Scale Analysis results overlaid with all protected areas combined (ESAs, Provincial and Regional Life Science ANSIs, Provincially Significant Wetlands, areas designated as *Escarpment Natural and Escarpment Protected* under the Niagara Escarpment Plan, *Natural Core and Natural Linkage* areas under the Oak Ridges Moraine, the Greenbelt Natural Heritage System, and properties managed for conservation)