

# Credit Valley Conservation

Terrestrial Ecosystem Enhancement Model



Landscape Scale Analysis of the City of Mississauga:  
Natural and Semi-natural Habitats and Opportunities for Enhancement

Final Technical Report - 2012



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Credit River Watershed aerial photo: CVC 2007

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## **Executive Summary**

The City of Mississauga is a heavily urbanized municipality within southern Ontario, experiencing rapid population growth. The City's increasing population size is anticipated to decrease the overall number of remaining natural areas within the urban boundary, as well as increase the impacts on existing natural space. Given these current pressures, it is important to understand the value of existing natural areas across the landscape. Understanding the ecological importance of natural areas will assist urban planning and conservation efforts to maximize the overall ecosystem integrity of natural areas, and sustain the services these areas provide to urban residents.

Mississauga is located within the rare Carolinian zone, providing habitat for many unique species with distributions ranging from southern Ontario to the Carolinas. This zone is the most wildlife species rich area in Canada, and is home to approximately one third of Canada's Species at Risk. The City is situated along the Lake Ontario Shoreline, an important natural provincial corridor which provides a critical east-west connection for aquatic and terrestrial species. The Credit River Valley is a significant natural feature within the City, linking the City to the Niagara Escarpment and the Oak Ridges Moraine to the north. These provincial and regional corridors allow for species movement across the landscape, and improve the resilience of important ecological features within these corridors. Mississauga also contains several other significant features, such as provincially designated Life Science Areas of Natural and Scientific Interest (ANSIs) and Provincially Significant Wetlands (PSWs), important Migratory Bird Habitat and Significant Wildlife Habitat, habitat for several provincially and federally designated Species at Risk, and habitat for species of conservation concern. Natural areas within Mississauga provide life sustaining services that are critical for the well being of local residents, such as water purification, flood moderation and control, climate regulation and clean air. These natural areas maintain biodiversity and genetic resources, and provide space for recreation and educational activities.

Given that ecosystems function on broad scales, it is important to understand the relative contribution of individual natural areas to ecosystem integrity across the landscape. This technical report documents the methods and results of a Landscape Scale Analysis (LSA) for the City of Mississauga, assessing the City's natural and semi-natural areas for their relative importance in contributing to ecosystem function within the City. In addition, an Enhancement Opportunity Analysis was conducted to identify additional opportunities for restoration and stewardship activities within non-natural agricultural and open space areas in Mississauga. The results of these analyses provide a greater understanding of how natural areas across the City of Mississauga function as a whole, and provides context for future land-use planning and conservation initiatives.

These analyses were undertaken through a partnership with City of Mississauga staff, to better understand the natural features at the urban scale, and apply that understanding to natural heritage protection and management. In addition, this study was undertaken in partnership with the Region of Peel, the Ontario Ministry of Natural Resources, Conservation Halton and Toronto and Region Conservation Authority. These

partnerships ensured sharing of data and technical expertise and the creation of a dataset that covered the entire City area.

The Landscape Scale Analysis of the City of Mississauga's natural and cultural (or semi-natural e.g. plantation, cultural meadow) habitats was undertaken through the following steps:

- 1. Review of background information**
  - a. Summary of baseline information regarding the natural heritage of the City of Mississauga.
  - b. Review of relevant scientific literature.
  - c. Summary of available data on land cover, land use and the size and configuration of natural areas in the City.
- 2. Development of Criteria and Thresholds**
  - a. Criteria for the Landscape Scale Analyses were adapted from the Landscape Scale Analysis for the Credit River Watershed (CVC 2011)
  - b. The nine Criteria used in the LSA were: **(1) woodlands, (2) wetlands, (3) successional habitats** such as meadows, and **(4) valleylands or riparian areas, (5) high habitat diversity** or **(6) uncommon vegetation communities, (7) ecological proximity, (8) sub-regional connectivity, and (9) regional and provincial connectivity.**
  - c. Thresholds were adopted for assessment of ecosystem function at the urban scale, using results of the review conducted in Step 1. Thresholds for the criteria were based on well established scientific principles, federal or provincial guidelines, best practices, professional judgment of technical committee or external peer reviewers, and CVC data.
- 3. Execution of the Landscape Scale Analysis**
  - a. The LSA was conducted using GIS (Geographic Information System) mapping of urban, agriculture and natural areas derived through standardized procedures.
  - b. The LSA was conducted on habitat patches, defined as areas of contiguous natural and semi-natural land within the City of Mississauga.
  - c. Habitat patches were scored using the above nine criteria with respect to their relative importance in contributing to ecosystem function within the City.
  - d. Habitat patches were given a score of zero or one for each criterion.
  - e. 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).
- 4. Post-analysis Data Summarization**
  - a. The results of the LSA conducted in Step 3 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 Mississauga.

- b. Functional groups were determined by examining the relationship between habitat patch scores and other independently designated significant natural heritage features in Mississauga, including Areas of Natural and Scientific Interest, Environmentally Significant Areas, Provincially Significant Wetlands, known habitats of Species at Risk, and Natural Areas identified in Mississauga's Natural Areas System.
- c. Habitat patches scoring 6, 7, 8 or 9 were designated 'Core ecofunction habitats' for the City of Mississauga; habitat patches receiving scores of 2, 3, 4, or 5 were termed 'Highly Supporting ecofunction habitats'; those scoring 1 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 or catchment level may be locally significant.

The Mississauga LSA utilized criteria originally developed to evaluate the Landscape of the Credit River Watershed, through CVC's Terrestrial Ecosystem Enhancement Model (TEEM) Program. The watershed-scale Landscape Scale Analysis has recently been completed, and CVC is in the process of developing a watershed-wide Natural Heritage System to identify lands for restoration, protection and stewardship. This Landscape Scale Analysis for the city of Mississauga has been scaled to reflect ecosystem function within the urban context, and the analysis covers the entire City of Mississauga jurisdiction.

**The Landscape Scale Analysis represents a technical assessment of natural areas within Mississauga. The mapping presented in this analysis is not a Natural Heritage System.**

The Landscape Scale Analysis results were overlaid with a map of the City of Mississauga. Results of the LSA were also overlaid with other lands that are protected from development to some degree, including provincial and regional Life Science Areas of Natural and Scientific Interest (ANSIs), Environmentally Sensitive Areas (ESAs), Provincially Significant Wetlands (PSWs), the City of Mississauga Natural Areas System, the Region of Peel Greenlands system, all City of Mississauga, CVC and TRCA property, and all hazard lands.

The Landscape Scale Analysis complements the existing Mississauga Natural Areas Survey (NAS). The NAS uses intensive on the ground field surveys and ranks natural areas based on a combination of measures related to ecosystem function (primarily area) and biodiversity (flora and fauna). The NAS has categorized lands in Mississauga into natural areas, linkages, residential woodlands and special management areas, which form Mississauga's Natural Areas System. The NAS identifies the species and features

contained within individual areas during detailed surveys, providing valuable data on the ecological condition of natural areas at a site level that a Landscape Scale Analysis cannot provide. The Landscape Scale Analysis scores natural areas based on connectivity and ecological function at local, subregional and regional/provincial scales, identifying natural and semi-natural areas that provide important ecosystem functions and services. This analysis represents a functional analysis of natural areas within the City using surrogates based on the best available science in landscape ecology and conservation biology (e.g. size and connectivity). The LSA can thereby identify opportunities for growing Mississauga's Natural Areas System beyond its existing natural protected areas, increasing connectivity of the Natural Areas System to maintain a healthy city in the face of increased urbanization and intensification.

Natural Areas Survey mapping was used to detect gaps in protection of natural habitats within the City. NAS data were overlaid on the LSA results to determine areas of potential natural cover not captured within the Natural Areas System. Conversely, the NAS data was able to highlight natural habitats with high biodiversity or site integrity that were not defined as high functioning by the Landscape Scale Analysis. Both areas of high biodiversity or site integrity and high ecosystem function potential at the landscape scale should be targeted for securement, protection, stewardship or restoration activity.

In conjunction with the Landscape Scale Analysis, aquatic features contributing strongly to ecosystem function within Mississauga were identified and mapped. These included permanent and intermittent watercourses, lakes, and online ponds. Aquatic and terrestrial features should be integrated when implementing the results of the LSA in protection, securement, restoration and stewardship efforts.

A second phase of the landscape assessment for Mississauga involved an Enhancement Opportunity Analysis to identify areas that could be managed or restored to improve the healthy functioning of remaining natural areas within the City. These enhancement areas consist of agriculture or open space (sometimes considered 'vacant land') that could be strategically restored to support existing uses but also to build the resilience of adjoining natural areas. For example, a park next to a natural area could include native flower plantings to support local fauna, strategic tree planting to improve the shape of the adjoining natural area, or swales to enhance the infiltration of rainwater in the area. This analysis is a tool to prioritize existing agriculture and open space areas within the City to identify the highest priority areas for natural function enhancements.

Enhancement Opportunity Analysis methodology for identifying enhancement opportunities was conducted through the following steps:

- 1. Identification of land-use type for Enhancement**
  - a. Ecological Land Classification categories of agriculture and open space (e.g. parks and mowed grass) were identified as the best available land-use for enhancement of natural and semi-natural areas within Mississauga.
- 2. Development of Criteria and Thresholds**

- a. Eight criteria were identified which are anticipated to enhance existing natural and semi-natural areas within Mississauga, namely: Enhancement opportunity areas adjacent to high functioning **(1) woodlands, (2) wetlands, and (3) valleylands or riparian areas, (4) high habitat diversity or (5) uncommon vegetation communities**; and enhancement areas contributing to **(6) ecological proximity, (7) subregional linkages, or (8) regional/provincial linkages.**
- 3. Execution of the Enhancement Opportunity Analysis**
  - a. Agriculture and open space patches (termed Enhancement Opportunity Patches) were scored with respect to their proximity to features contributing to ecosystem function within the City. Enhancement Opportunity Patches were given a score of zero or one for each criterion.
  - b. Scores for individual Enhancement Opportunity Patches were then added across criteria. Agriculture or open space patches could receive scores ranging from zero (relatively low priority for stewardship or restoration activities) to eight (high priority for stewardship or restoration activities).
- 4. Post-analysis Data Summarization**
  - a. The results of the LSA conducted in Step 3 were used to create ‘functional groups’, where habitat patches scoring 0-8, were clustered into groups, based on their relative priority for enhancement within Mississauga.
  - b. Enhancement Opportunity Patches were clustered into functional groups by visually examining the contribution of the patches to increased natural area and enhancement of the key corridors throughout the City of Mississauga, including the Lake Ontario shoreline and Credit River corridor.
  - c. Enhancement Opportunity Patches that scored 5, 6, 7, or 8 based on the assessment criteria were considered ‘High priority’ patches within the City of Mississauga because they adjoined areas of high importance in terms of ecosystem function; habitats receiving scores of 2, 3 or 4 were termed ‘Medium priority’ patches, and those receiving a score of 0 or 1 were considered ‘Low priority’ patches.

The Enhancement Opportunity Analysis results were overlaid with the LSA results, as well as City of Mississauga and Conservation Authority owned properties, to assist with prioritization of enhancement initiatives. Both the Landscape Scale Analysis and the Enhancement Opportunity Analysis represent broad-scale scientific assessments of the existing landscape. These analyses first assess the relative importance of existing natural and semi-natural features on the landscape for ecosystem function at the city scale, and next identify priority areas for enhancement, stewardship or restoration. These assessments score the relative contribution of natural areas, semi-natural and enhancement areas to overall existing and potential ecosystem function within Mississauga at the landscape scale. These landscape analyses should be viewed as part of a nested hierarchy of analyses, wherein more detailed subwatershed and site level studies

serve to identify opportunities to maintain and enhance ecosystem functions at a finer scale.

The Landscape Scale Analysis represents one of the first steps in developing a Natural Heritage Strategy for the City of Mississauga. These results can be used to develop a strategy that will improve the healthy functioning of the City's ecosystems, particularly through improving functional linkages among natural areas. Additional work is needed to develop such a strategy, including integrating the results presented here with other Natural Heritage studies, including the City of Mississauga's Natural Areas Survey, the Region of Peel's Greenlands System, subwatershed studies, and CVC's Lake Ontario Integrated Shoreline Strategy. Key connections between existing natural areas and bottlenecks within the major urban corridors need to be identified. An urban Natural Heritage Strategy should integrate connectivity with other regional and provincial Natural Heritage Systems, to ensure long-term healthy ecosystem functioning.

This Landscape Scale Analysis can identify opportunities for prioritizing stewardship activity, land securement, restoration for improvement of biodiversity and function, and protection through policy or incentives. In this regard, CVC continues to be committed to further working with the City to develop a municipal level Natural Heritage System Strategy that improves the self-sustainability of natural features and functions within the urban context.

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## **1.0 Background**

Natural areas within Mississauga provide critical ecosystem services for the well being of local residents. Examples include water purification, flood moderation and control, climate moderation, and clean air. Further, natural ecosystems provide habitat for native plants and animals, and provide a variety of recreational, cultural and educational values to local residents. Ecosystem processes are connected between natural areas, and function across multiple levels, ranging from global to regional to site level. Within urban settings, such as the City of Mississauga, natural areas have become increasingly fragmented. This fragmentation restricts the ability of the remaining natural areas to provide a full suite of ecosystem services to City residents.

To increase our understanding of the natural areas within Mississauga, a Landscape Scale Analysis was undertaken to study the relative contribution of natural areas within the City to ecosystem integrity across the urban landscape. This analysis is one component of a comprehensive Lake Ontario Watersheds Restoration Plan, outlined by Credit Valley Conservation and the City of Mississauga. Recognizing the connection between ecosystem integrity and public health, this plan was developed through a draft discussion document (CVC 2006a), and involves three components:

1. *Landscape Scale Analysis of natural areas and features and an assessment of existing data sets, studies, etc. to establish broad base line conditions. This work, while having some immediate utility, will form the basis for establishing watershed priorities and the future work plan;*
2. *Lake Ontario Watershed studies with the goal of improving ecological services provided by natural areas at a more local scale;*
3. *Lake Ontario Shoreline Plan to better understand the shoreline ecosystem, respond to the knowledge gaps and make recommendation for future management.*

*- CVC 2006a*

A Landscape Scale Analysis is the characterization and analysis of ecosystem features and functions at the landscape scale, using GIS mapping, to ensure integration of the features and functions within an area of interest with those in the broader landscape. The landscape scale analysis also evaluates the features and functions within a given area, and evaluates the relative importance of each area, using a science based, systems approach. An outcome of the Landscape Scale Analysis is the characterization of the existing natural and semi-natural cover providing biodiversity and ecosystem services to the City of Mississauga. This analysis will aid in the future development of a Natural Heritage Strategy and for identification of enhancement opportunities within the City.

The goal of the Mississauga Landscape Scale Analysis is to provide a tool to inform initiatives to enhance and restore biodiversity and strengthen ecosystem function in the City of Mississauga over the long term. The Landscape Scale Analysis supports the City's stated goal of promoting an ecosystem approach to planning (City of Mississauga 2005).

### **1.1 The importance of ecosystems to human survival, health, and well-being**

An ecosystem consists of a dynamic set of living organisms (plants, animals, and microorganisms) together with the non-living components of their environment, related ecological processes, and humans (OMNR 1999). The flows of energy and materials through ecosystems are termed ecosystem functions and support life at all levels. Biodiversity has a positive relationship with ecosystem functioning (Kareiva 1994; Hooper et al. 2005; Duffy 2009; Haddad et al. 2009; Hargrave 2009; Srivastava and Bell 2009). Examples of ecosystem functions include provision of habitat for survival or movement; photosynthesis; nutrient and sediment cycling and transport; soil formation; and regulation of gases, water, disturbances, and climate.

Ecosystems also provide critical goods and services to meet human needs; specifically producing products and providing functions that are of direct or indirect benefit to human populations (Costanza et al. 1997; Daily 1997). Ecosystem services are properties that directly affect human health or well being, such as flood control, groundwater recharge, climate moderation, production of oxygen, provision of food, medicine and raw materials, genetic resources, pollination services, seed dispersal, waste management, erosion and sedimentation control, natural pest control, decomposition, recreation, aesthetic, spiritual, and scientific services (Table 1; Kareiva 1994; Costanza et al. 1997; Daily 1997; Daily et al. 2000; de Groot et al. 2002; Hooper et al. 2005).

Ecosystem goods and services have been valued at \$33 trillion globally (Costanza et al. 1997), although technological fixes for most ecosystem services do not exist, making some ecological services provided by natural areas irreplaceable. Nevertheless, there are many ecological services that have direct, measurable economic benefits. Technological replacements for the provision of clean, safe drinking water in one watershed (Catskill watershed, New York) were estimated at US\$6-8 billion, leading municipalities to purchase the entire watershed to perform this ecosystem service for the considerably lower price of US\$1-1.5 billion (Chichilnisky and Heal 1998). Pollinators provide measureable economic benefits for the agricultural sector. The estimated value of pollination services by native and domesticated pollinators in the Credit River Watershed is estimated to be \$4 million per year (The Pembina Institute and CVC 2009). Research has shown that forest habitat within 1-2km of a farm can strongly stabilize and enhance pollination services, thus serving as insurance for farmers in the region (Kremen 2005). Provision of clean drinking water and pollination services are just two of the many examples of measureable economic benefits that are provided by natural areas. It has been estimated that the Credit River Watershed receives \$371 million in natural capital, which includes \$187 million in services from wetlands and \$141 million in services from forests (The Pembina Institute and CVC 2009).

In urban settings, the added socio-economic benefits of natural spaces are significant (Table 1). Urban property values are enhanced by local greenspace and the presence of biodiversity (Conway et al 2010; Farmer et al 2011). Natural areas in urban environments provide a wide range ecosystem services to local residents, including air filtration, micro

climate regulation, noise reduction, rainwater drainage and sewage treatment (Dwyer et al 1992; Bolund and Hunhammar 1999). Lands in permanent vegetative cover have been estimated to reduce the cost of filtering sediment in municipal drinking water by \$5.60 per hectare per year, and phosphorus reduction costs by \$23.30 per hectare per year (Olewiler 2004). Urban areas are capable of supporting a range of biodiversity (Fernández-Juricic 2000; Mörtberg and Wallentinus 2000; Mörtberg 2001; Alvey 2006; Sandstrom et al. 2006; Environment Canada 2007), particularly in remnant natural habitats, such as Rattray Marsh in Mississauga.

Urban natural areas also provide a variety of recreational and cultural values to local residents. Annual expenditure by Canadians on nature related activities has been estimated at \$11 billion (Federal Provincial Task Force on the Importance of Nature to Canadians 1999). Urban natural areas provide the most accessible outdoor recreation opportunities to a large percentage of the population (The Pembina Institute and CVC 2009). Locally, the Credit River fishery has an estimated total annual value of \$1.2 million dollars, with the Erindale Park to Highway 403 section being the most popular and valuable destination overall, with over 13,000 angler days per year and valued at \$345,893 annually (CVC and DSS Management Consultants Inc. 2008). In addition, urban natural space provides environmental educational opportunities for people of all ages, and increases local residents' connection to nature (Dunnett et al 2002).

Research suggests that natural areas provide health benefits such as increased self-esteem, decreased aggression, increased overall health and a sense of well being (Kuo and Sullivan 2001; Maas et al. 2006; Velarde et al. 2007). Retail areas with a greater proportion of trees are perceived as being of greater quality to consumers, resulting in a general willingness to spend time in a store and buy products (Wolf 2005). Proximity of residential properties to high quality open space, valleylands or waterfront can significantly enhance their property values; estimated to be up to \$12 000 in waterfront areas in the City of Hamilton (Zegarac and Muir 1998).

Two of the major factors threatening the provision of essential ecosystem goods and services in Mississauga are urban intensification and climate change (CVC 2006b; The Pembina Institute and CVC 2009). Both are likely to cause declines in water quality and quantity, increase water and air pollution, changes to relative biodiversity, and soil compaction. Intensification will additionally cause increased imperviousness and increased recreational pressure on remaining natural areas within the City. The ability of remaining natural areas to provide ecosystem goods and services to City residents decreases with increasing impacts. All inhabitants of the municipality depend on the life-support goods and services provided by ecosystems, such as clean air, pure and abundant water, climate regulation, pest control, and pollination. There is growing recognition among scientists, policy makers and the public that healthy ecosystems provide the foundation for social and economic development (Millennium Ecosystem Assessment 2005). In cases where the value and costs of replacement ecosystem services are unknown, the precautionary principle must apply. For future generations to be able to enjoy the same ecosystem services, it is important that we develop a system of healthy,

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connected, and genetically diverse natural areas and linkages that allows biodiversity, and the associated provision of ecosystem services, to continue over the long term.

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**Table 1.** Goods and services provided by ecosystems (from de Groot et al. 2002)

No.	Ecosystem goods and services	Examples
<b><i>Regulation functions</i></b>		
1.	Climate regulation	Mitigation of urban heat island effect; cooling through evapotranspiration
2.	Gas regulation (e.g. oxygen /carbon dioxide balance, ozone layer)	Provision of oxygen, removal of carbon dioxide Maintenance of good air quality UVB protection by ozone, preventing disease
3.	Water regulation	Maintenance of water cycle (evapotranspiration and rainfall); moderation of flooding intensity
4.	Disturbance regulation	Storm protection (e.g. coastal marshes) Flood moderation (wetlands, stream sides, and forests)
5.	Nutrient regulation	Maintenance of healthy soils and productive ecosystems
6.	Soil retention	Prevention of erosion and siltation Maintenance of arable land
7.	Soil formation (e.g. leaf litter decomposition)	Maintenance of woodland and wetland productivity and species that support agriculture and natural systems
8.	Waste treatment	Pollution control/detoxification Noise abatement Filtering of dust and other particulates
9.	Pollination	Pollination of wild plants Pollination of crops
10.	Biological control	Control of pests and invasive species (e.g. mosquitoes) Control of diseases and pests (e.g. spruce budworm)
<b><i>Habitat functions</i></b>		
11.	Refugium function	Living space for wild plants and animals
12.	Nursery function	Habitat for reproduction of species (e.g. for fisheries)
13.	Movement function	Movement corridors for migratory or resident species
<b><i>Production functions</i></b>		
14.	Fresh water (filtering and storage)	Provision of water for consumption and irrigation
15.	Food	Provision of existing and novel food items (e.g. fish, mushrooms, nuts, berries)
16.	Raw materials	Provision of materials for building or manufacturing, biofuels and energy, fertilizer
17.	Genetic resources	Genetic resources for research and development of foods, textiles, fuels, medicines, raw materials
18.	Medicinal resources	Resources for pharmaceuticals, health care products
19.	Ornamental resources	Resources for crafts, art, gardening, worship, or souvenirs
<b><i>Information/Social functions</i></b>		
20.	Science and education	Use of natural areas for school or public education Scientific knowledge
21.	Human health and well being	Livable neighborhoods and cities Sense of place Aesthetics Recreation
22.	Recreation	Walking, biking, canoeing, fishing, bird watching
23.	Cultural, artistic, religious, historic	Use of nature in art, books, painting, etc. (inspiration) Religious significance Historic significance (e.g. heritage forests)

## **1.2 What is a Landscape Scale Analysis?**

Scientific disciplines including landscape ecology and conservation biology have shown that landscape level planning is necessary to maintain biodiversity and ecosystem functions over the long term. A Landscape Scale Analysis (LSA) is founded in principles of landscape ecology, which has demonstrated that the spatial configuration of natural areas can have important effects on biodiversity and ecosystem function (Forman and Gordon 1986; Forman 1995; McGarigal and Marks 1995; McGarigal and McComb 1995; Ritters et al. 1995; Hargis et al. 1998; Leitao and Ahern 2002). For example, larger and more compactly shaped natural patches in the landscape tend to contain more species; a greater area of the landscape containing streamside natural vegetation has been linked to improved flood control; and more connected patches allow species to move, preserving genetic diversity and ecosystem services in the landscape over time. This type of Landscape Scale Analysis is also known as a terrestrial Landscape Scale Analysis because it is focused on terrestrial habitats.

The City of Mississauga Landscape Scale Analysis involved the characterization of extent and spatial configuration of Mississauga's natural areas through the following steps:

1. Identify the **scale and the resolution of measurement** (these are often dictated by study goals and data availability);
2. Gather background data on the area of interest to provide appropriate context;
3. Identify **features that contribute highly to ecosystem function at the scale of interest through well-established landscape ecology and conservation biology principles**. For example, the presence of woodlands adjacent to streams is linked to improved water quality, water temperature and aquatic habitat.
4. **Score existing natural and semi-natural features** for their relative importance in contributing to watershed ecosystem function, using existing guidelines, best practices, and expert opinion to develop criteria and thresholds.
5. **Identify aquatic features** within the City that are important for ecosystem function.
6. **Aggregate scores for the natural and semi-natural features** in the City and **identify habitat patches and aquatic features providing relative levels of ecological function**.
7. **Overlay existing protected area designations on the Landscape Scale Analysis** to determine gaps and opportunities for securement, restoration, protection, or stewardship – for example, ANSI, ESA or PSW designations and Mississauga's Natural Areas Survey.

It is important to know what a Landscape Scale Analysis can and cannot do. It is a science based analysis capable of identifying and prioritizing a set of natural habitats that provide or have the potential to ensure the healthy functioning of an area of interest. Consideration of large areas (on the scale of species movements) and long time frames (to allow for adaptation and evolution) are critical for planning and implementing the conservation of biodiversity and ecosystem functions. An analysis at a city scale can help identify which areas within Mississauga are significant for maintaining or improving

ecosystem functions. A Landscape Scale Analysis can be integrative, identifying features that are important for land and water related functions. Further, it 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, regional natural systems.

There are a few things the Landscape Scale Analysis cannot do. First, an LSA cannot determine the composition or level of 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, or meadows that support viable populations of grassland birds. However, the analysis does identify high quality sites, that is, areas that have the potential to provide multiple ecological functions by virtue of their placement in the landscape. The Landscape Scale Analysis also contains data consistent across the City, and offers a credible, science based substitute for more detailed site level information which is lacking at a broader scale. The Landscape Scale Analysis uses criteria (or measures) that have been proven to be related to ecological integrity (for example, larger patches are more likely to have less disturbed area and contain more diversity), adjacent land uses or land use history may have modified the structure and composition of specific natural or semi-natural areas. Ecological integrity itself is best determined through detailed site level studies, such as the Natural Areas Survey (City of Mississauga 2010) or the Natural Areas Inventory (currently being undertaken by CVC). The analysis uses existing, well-established principles of landscape ecology or conservation biology to determine the functions that a particular habitat supports, or is capable of supporting.

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. In urbanizing areas, land use changes are constantly occurring. Therefore mapping requires constant updating in order to remain accurate, and at any point in time the analysis may include lands that are currently under development or that are slated for development.

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 designating significant features or systems in Ontario (Lower Trent Conservation 2001; NHIC 2002; Gartner-Lee Ltd. 2002; OMMAH 2002; Rowsell 2003; CVC 2004; OMMAH 2004a-c; NVCA 2004; UTRCA 2003; City of Hamilton 2005, 2006; City of Mississauga 2005; Henson et al. 2005; Regional Municipality of Peel 2005; Wichert et al. 2005; Wiersma and Urban 2005; Region of Waterloo 2006; Cataraqui Region Conservation Authority 2006; City of London 2006; UTRCA and County of Oxford 2006; The Land Ethic Group 2006; Toronto and Region Conservation Authority 2007; Beacon Environmental and LSRCA 2007; Dougan and Associates 2009; North-

South Environmental Inc. et al. 2009). This level of accuracy is also sufficient to drive stewardship, securement, and restoration strategies.

This Landscape Scale Analysis is part of a hierarchical framework for protecting features and functions across the City. Subwatershed or smaller scale studies can help to refine our understanding of ecosystem function within Mississauga, by identifying locally important features and functions. Credit Valley Conservation is currently completing studies for the Sheridan and Cooksville Creek Watersheds (Background Reports: CVC 2008a, 2008b), Fletchers Creek Subwatershed (CVC in progress), and in addition a Lake Ontario Integrated Shoreline Study (LOISS; CVC in progress). Toronto and Region Conservation Authority has produced detailed studies of the Etobicoke and Mimico Creek Watersheds (TRCA 2006). Although coverage for subwatershed studies is not complete within the City of Mississauga, site or catchment level initiatives assist with providing guidance for specific protection, restoration, or stewardship activities.

### **1.3 How is a Landscape Scale Analysis used to guide protection, securement, restoration and stewardship?**

A Landscape Scale Analysis can be used in several ways. A primary use of the LSA is to identify for protection a Natural Heritage System, defined in the *Provincial Policy Statement* (OMMAH 2005) 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.*

*- Provincial Policy Statement, 2005*

It is now recognized that protecting natural features such as forests or wetlands alone is insufficient to maintain the ecosystem functions they provide. Over half of all species in the Credit River Watershed are dependent on more than one type of habitat (CVC 2002a, 2002b, 2002c and unpublished data). Maintaining a diversity of natural features, and connections (corridors or linkages) among these features, is critical for ensuring the long term survival of biodiversity and ecosystem function in a landscape.

A second important use of the Landscape Scale Analysis is to identify priority areas for conservation, which broadly encompasses land securement, protection through policy, restoration or stewardship. A Landscape Scale Analysis may identify particular natural features as priority areas worthy of protection based on their attributes (e.g. large size, proximity to a stream or other natural features, role as linkage or stepping stone habitat, or presence of interior habitat supporting area sensitive species). These priority areas then become prime targets for acquisition, restoration, or stewardship. These priority areas can be overlaid on a map showing securement, restoration and stewardship opportunities

based on other criteria (such as land ownership, or landowner willingness) to develop a conservation strategy for the landscape.

The Mississauga Landscape Scale Analysis can also inform other ongoing studies and initiatives (Table 2) including:

- Development of a Natural Heritage Strategy for the City of Mississauga
- Identification of priority lands for protection through land securement or policy
- Identification of agricultural (e.g. farm fields) or open space (e.g. park land) to be considered for protection or restoration in subwatershed studies
- Inform municipal-level strategies, including the Credit River Parks Strategy and Naturalization Plan
- Identification of additional areas to expand Mississauga's Natural Areas System
- Identification of priority sites for field surveys under the Natural Areas Inventory
- Identification of priority protection or restoration areas for the Lake Ontario Integrated Shoreline Study (LOISS), or component subwatershed studies, based on a City-wide perspective

Finally, a Landscape Scale Analysis may be used to guide planning and development within the study boundary, by identifying those natural habitats that provide or have the potential to provide multiple ecosystem services at a landscape scale. Development may be directed away from these key habitats or if this is not possible, development can be planned in such a way as to optimize the ability of the site in question to continue to contribute to the functioning of the overall ecosystem to some degree.

A Landscape Scale Analysis works best when it is used as part of a hierarchy of studies at the landscape, local, and site scales (e.g. watershed, subwatershed, and site scale). Province wide initiatives, including the Greenbelt Plan and the Oak Ridges Moraine Plan, allow for study and protection of ecologically significant features at the provincial scale. The Landscape Scale Analysis identifies natural habitats important for ecosystem functioning of a large scale system. Within the CVC jurisdiction, this analysis has also been conducted at the overall watershed scale (CVC 2011), and at the urban scale (this report). A subwatershed study identifies natural habitats important for ecosystem functioning at the local scale, and these may include additional habitats not identified at the landscape scale that are nevertheless important for the health of the ecosystem and provision of ecosystem services (e.g. improvement of water quality, flood control) at the local scale. Finally, a site level study can determine where and how restoration on a particular site can occur, or how the land use on the site can minimize or mitigate disturbance to the ecosystem functions provided by the site.

**Table 2.** Relationship of landscape and site level initiatives in southern Ontario and the Credit River Watershed relevant to the City of Mississauga.

	<b>Landscape level planning for improvement of biological function</b>	<b>Component identification for improvement of biological function</b>	<b>Site level studies for identifying or monitoring areas of important biological function</b>
<i><b>Large scale, bioregional or Provincial</b></i>	Big Picture Ontario Great Lakes Conservation Blueprints for Terrestrial Biodiversity and Aquatic Biodiversity Ontario Greenbelt Niagara Escarpment Oak Ridges Moraine Great Lakes/IJC/LAMP Ontario Natural Spaces Niagara Escarpment, Oak Ridges Moraine, Algonquin to Adirondack Heritage Project (NOAH)	World Biosphere sites Provincial Parks Provincially significant Areas of Natural and Scientific Interest (ANSIs) Provincially Significant Wetlands (PSWs)	Environmental Impact Assessments (EAs) Environmental Impact Studies (EISs) Natural Heritage Evaluations (NHEs)
<i><b>Watershed or regional</b></i>	CVC Watershed Plan Credit River Water Management Strategy Update (CRWMSU) Credit River Fish Management Plan (CRFMP) CVC Greenlands Securement Strategy CVC Terrestrial Ecosystem Enhancement Model (TEEM) CVC Lake Ontario Integrated Shoreline Strategy (LOISS) CVC Integrated Watershed Restoration Strategy (IWRs) CVC Landscape Scale Analysis for City of Mississauga TRCA Target Natural Heritage System Strategy (TNHSS) TRCA Region of Peel Urban Forest Strategy Halton Region Natural Heritage System Regional and Municipal Official Plans Subwatershed plans	Regionally significant Areas of Natural and Scientific Interest (ANSIs) Environmentally Sensitive Areas (ESAs) Significant valleylands, wildlife habitat, and woodlands Fish habitat Habitat of species at risk Mississauga Natural Areas Survey (NAS) Regional and Municipal Official Plans	CVC ELC site inventories and monitoring sites CVC Natural Areas Inventory Mississauga Natural Areas Survey (NAS) TRCA monitoring and site surveys Halton Region Natural Areas Inventory Property Management Plans (CVC and Municipal) Niagara Escarpment Commission monitoring sites Community monitoring sites Voluntary landowner interest

#### **1.4 Overview: City of Mississauga**

The City of Mississauga is composed of just less than 30,000 ha within southern Ontario. Mississauga is highly urbanized, and home to more than 668,000 people (Statistics Canada 2006). The population has grown by a rate of approximately 9% between 2001 and 2006 (Statistics Canada 2006). According to the Ministry of Energy and Infrastructure (MEI) *Places to Grow - Growth Plan for the Greater Golden Horseshoe* (MPIR 2006), the Region of Peel is predicted to grow by almost 60% by 2031 (over its 2001 population). Currently, rapid population growth is straining its infrastructure and natural resources, and increasing recreation pressure within the remaining natural areas.

The City is composed of portions of five watersheds, including: Sixteen Mile Creek, Credit River, Etobicoke Creek, Mimico Creek and the Humber River watersheds, which fall under the jurisdiction the Toronto Region Conservation Authority, Credit Valley Conservation and Conservation Halton. The two major rivers which run through Mississauga and drain into Lake Ontario are the Credit River and Etobicoke Creek. These rivers serve as important corridors for species movement and connectivity within the City. In addition, 14 creeks originate within Mississauga and empty directly into Lake Ontario, including Birchwood Creek, Cawthra Creek, Cooksville Creek, and Sheridan Creek. Many of these creeks and tributaries have been channelized and have lost significant riparian area, and water quality is generally poor (CVC 2006b). The City borders Lake Ontario and contains an important provincial corridor, the Lake Ontario Shoreline.

The City of Mississauga spans three physiographic regions, described by Chapman and Putnam in 1951. Mapping for these physiographic regions has been recently updated by the Ontario Geological Survey (Chapman and Putnam 2007). Physiographic regions are created when characteristic differences in glacial deposits create distinct regions with unique combinations of soils, elevation, and drainage. The major physiographic regions are listed in Table 3 and further described in the *Credit River Water Management Strategy Update* (CVC 2007a). Understanding natural cover within each of these regions will be an important consideration when examining ecosystem functioning in the City. Currently, forest cover is unevenly distributed among physiographic regions within the City of Mississauga (Table 4).

**Table 3.** Physiographic regions within the City of Mississauga (from *Credit River Water Management Strategy Update, CVC 2007a*).

Physiographic Region	Geological Characterization
Lake Iroquois Plain	Gentle slope toward Lake Ontario; thin veneer of glaciolacustrine sand and silty sand; extends 3 to 5km inland from current Lake Ontario shoreline.
South Slope	Lies at the base of the Escarpment, and encompasses portions of Palgrave and Cheltenham Moraines and part of the Trafalgar Moraine between Peel Plain and Lake Iroquois Plain. Consists of low-lying fine-grained ground moraine and knolls.
Peel Plain	Flat to undulating topography consisting of clay soils deposited when glacial melt water ponded on top of the low permeability Halton Till plain.

**Table 4.** Natural forest and wetland cover by physiographic region within the City of Mississauga in hectares (rounded to nearest whole number) and as a percentage of Physiographic region area<sup>a</sup>.

Physiographic Region	Forest cover within Physiographic Region (ha)	Forest cover as a percentage of Physiographic Region area (%)	Wetland cover within Physiographic Region (ha)	Wetland cover as a percentage of Physiographic Region area (%)
Iroquois Plain	582	6.76	59	0.68
South Slope	347	2.53	56	0.41
Peel Plain	131	1.91	24	0.35

<sup>a</sup>Numbers are not likely to be precise because of overlaying maps at different scales, namely, forest or wetland cover at 1:10,000 and physiographic regions at approximately 1:50,000; nevertheless the table allows for comparison of relative amounts of forest and wetland cover among physiographic regions.

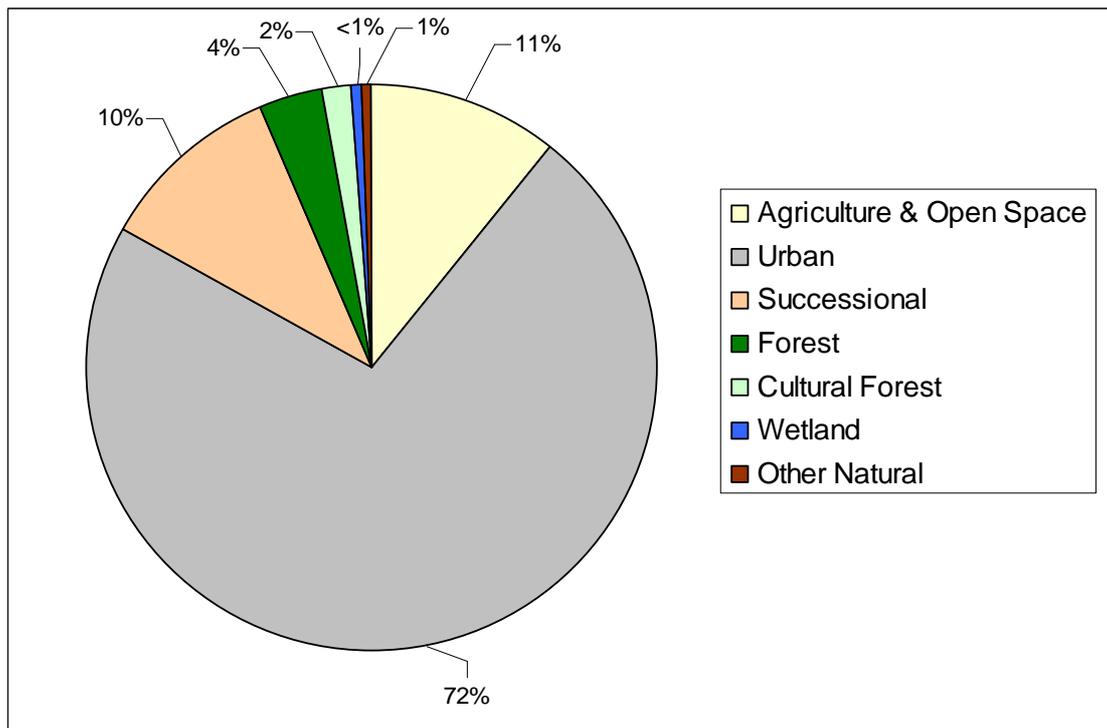
The City of Mississauga is located within the Carolinian zone, which reaches its northern limit in Canada. This zone is considered to be a rare ecosystem as it contains many “southern” species not found elsewhere within the country. There are a greater number of Species at Risk in the Carolinian zone than elsewhere in Ontario.

Currently, natural forest and wetland communities cover only 4.1% of the City’s area. Semi-natural areas, including cultural woodlands, plantations and successional areas (cultural meadow, cultural savannah, and cultural thicket) cover an additional 12.2% of Mississauga (see glossary for community definitions). The City’s Natural Areas Survey, which includes some successional communities, covers 7.1% of the urban area (City of Mississauga 2010).

An examination of land cover in the past 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. Twenty-nine different tree species were recorded, the most frequently mentioned being maple, beech, basswood, elm, pine, and hemlock. 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 2006b). Species specific data should be viewed with some caution because species identification skills may have differed among surveyors while the community type information is likely to be somewhat more reliable.

Wetland loss in southwestern Ontario has been significant. A study of wetland extent and loss has shown that approximately 72% of southwestern Ontario wetlands have been lost following European settlement, primarily through early conversion of land for agriculture (Ducks Unlimited Canada 2010). Remaining wetlands therefore gain in importance as they represent communities that have become relatively rare.



**Figure 1.** Land cover within the City of Mississauga. Urban land-use includes commercial, industrial, institutional, residential, transportation and construction areas. Other Natural includes open aquatic, beach/bar and open rock barren communities.

Despite significant amounts of habitat loss, the City still contains several important natural features (Table 5). Some of these features include: Rattray Marsh (ESA, ANSI and PSW), Lorne Park Prairie (ESA and ANSI), and Cawthra Woods (ESA, ANSI, PSW), each which have also been identified as Significant Natural Sites by the NAS

(City of Mississauga 2010). In addition, the City is also home to several interesting floral and faunal species, some of which include: Black Crowned Night Heron (*Nyctanassa violacea*), Great Horned Owl (*Bubo virginianus*), Eastern Screech Owl (*Otus asio*), Snapping Turtle (*Chelydra serpentina*), Arrow-leaved Violet (*Viola sagittata* var. *sagittata*), Bog Goldenrod (*Solidago uliginosa*) and Star Flower (*Trientalis borealis* ssp. *borealis*).

**Table 5.** Area values for Provincial and Regional Life Science ANSIs, ESAs, and Provincially Significant Wetlands within the City of Mississauga rounded to the nearest hectare<sup>a</sup>.

<b>Feature</b>	<b>Number</b>	<b>Area (ha)</b>	<b>Percent of Mississauga Area (%)</b>
Provincial Life Science ANSI	5	110	0.38
Regional Life Science ANSI	4	360	1.23
Provincially Significant Wetlands (PSWs)	107	58	0.20
Environmentally Significant Areas (ESAs)	18	520	1.78

<sup>a</sup>As ANSIs, ESAs, and PSWs sometimes overlap, numbers cannot be added to determine total area of these features within the City.

Finally, natural and cultural cover in the City of Mississauga is not evenly distributed among subcatchments (Figure A1; Appendix A contains all maps, and all figures with prefix ‘A’ refers to maps). Subcatchments are terrestrial areas in which water flows towards an individual stream or distinct river or stream branch. These are important hydrological units because the extent and distribution of natural cover within subcatchments determines to a strong degree the quality and flow rate of water draining the subcatchment. Within Mississauga, some subcatchments were delineated using sewersheds because stream paths have been modified heavily due to urbanization; nevertheless, improvements in water flow and quality remain relevant goals. Mapping of subcatchment natural and cultural cover helps target restoration efforts at a landscape scale (for example, Cooksville Creek and its neighbouring subcatchments contain very little natural and cultural cover, less than 11% of subcatchment area).

### **1.5 Landscape of Interest and Resolution of Measurement**

For the purposes of this Landscape Scale Analysis, the area included within the boundaries of the City of Mississauga was defined as the landscape. In addition, natural patches which cross the boundary of Mississauga and another municipality were also included, as they are anticipated to contribute to ecosystem functioning within the City. The Landscape Scale Analysis focused on the functional assessment of natural and semi-natural features and aquatic features within and adjoining the boundary of the City of Mississauga. It was recognized that species and ecosystem functions cross this municipal boundary, and the analysis attempted to take this into account to the extent possible.

A review of existing spatial data for the City of Mississauga was conducted to assess the best ecological and non-ecological data available for the landscape characterization. The

most detailed base layer for ecological data was the ELC (Ecological Land Classification) community series (OMNRSTU 1996; Lee et al. 1998; OMNR 1999) and land use layer, at a scale of 1:10,000. The CVC ELC layer used for the analysis was based on 2009 orthophotos, last updated in 2010 (Appendix B).

The ELC community series data formed the basis of the Landscape Scale Analysis (Figure A2, Appendix A). 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 6, Table 7, Figure 2, Figure A2, Figure A3, Appendix A). 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 20m gap on a 1:10,000 scale air photo (CVC 1998; Table 6, Table 7, Figure 2). Examples of natural areas are forests and wetlands; examples of semi-natural or cultural communities are cultural meadows, cultural thickets, and cultural woodlands. Forest, wetland, successional and cultural forest communities compose the majority of natural area within the City. Other natural communities also exist, including mapped open rock barren, bluff, bog, treed beach bar and open beach bar. These communities are generally smaller, and were grouped with other natural communities within a habitat patch (e.g. marsh, swamp) due to their very small size. In some cases they were mapped separately and included within a habitat patch as an “other natural” community. Information on other natural but rare communities such as prairies or sand barrens was not available for analysis at this scale.

A recent accuracy assessment of ELC mapping for the City of Mississauga involved a random survey of 30% of the City’s area, or 583 samples. Results showed that CVC’s ELC mapping had 90% accuracy, above the generally accepted threshold of 80%, in identifying the following classes: woodland, wetland, successional, aquatic, other natural (e.g. beach/bars), agriculture, open space, residential, commercial/industrial, and educational/institutional (CVC 2008, unpublished data).

The minimum mapping unit was set at 0.5ha, because this is generally the smallest area that can be determined with accuracy through air photo interpretation (CVC 1998). Therefore, only communities greater than or equal to 0.5ha (rounded to the nearest 10<sup>th</sup> of a hectare) were mapped (Appendix B). Landscape features smaller than 0.5ha were merged with their adjoining feature and were not used in the analysis, however some exceptions were made to include mapped wetlands smaller than 0.5ha. Habitat patches within the City of Mississauga are shown in Figure A4 (Appendix A).

Small habitat patches (<0.5ha) constitute a very small percentage of area in the City of Mississauga (10 ha in total or 0.03% of the City). Therefore, exclusion of these small habitat patches from the analysis has little effect on the Landscape Scale Analysis, although this does not necessarily mean that their protection at a local scale based on a site specific analysis is unimportant. Some features smaller than 0.5ha have been deemed significant at provincial or local scales (e.g. Provincially Significant Wetlands,

Significant Wildlife Habitat) based on field studies and should be considered when developing a Natural Heritage Strategy for the City of Mississauga.

The Landscape Scale Analysis was conducted using habitat patches as the unit for analysis (Table 6, Table 7, Figure A4, Appendix A), although data at finer scales were also incorporated into the study. Habitat patches were selected as the primary unit for landscape analysis because individual species depend on more than one habitat for their survival. For example, approximately half of all wildlife species within the Credit River Watershed are estimated to utilize more than one habitat or community type throughout their life cycle (CVC 2002a; 2002b; 2002c; 2010a). In landscapes fragmented by roads and other land uses that make the landscape relatively impermeable to movement of certain species or species groups, it is critical that areas used for breeding, feeding, movement, and reproduction are kept as contiguous as possible. In addition, habitat patches and communities are the scale at which one can most likely capture the potential for both smaller (e.g. mouse, herbaceous plants) and larger (e.g. red-tailed hawk, coyote, tree) species to survive and move or spread within the City of Mississauga.

Streams, rivers, and natural (not human created) lakes receive strong protection under several Acts. For example, the federal *Fisheries Act* prohibits watercourse alterations that would harm fish habitat, the *Planning Act* allows for minimum setbacks between watercourses and structures, and the *Conservation Authorities Act* regulates alteration to watercourses, wetlands, river or stream valleys and shorelines. Development cannot occur within these habitats; hence their physical structure is generally protected. Due to differences in planning processes, regulations and policy in protection of aquatic and terrestrial features, this analysis focuses on an assessment of *terrestrial habitats*, but identifies key aquatic features at the City wide scale. Aquatic and terrestrial function should be integrated when completing a comprehensive Natural Heritage Strategy for the City of Mississauga.

**Table 6.** Definitions used in the Landscape Scale Analysis, using Ecological Land Classification (ELC) except where indicated.

<p><b>Habitat patch:</b> A habitat patch is defined as a contiguous area, boundaries delineated by a <math>\geq 2</math>mm gap on a 1:10000 air photo (CVC 1998). It includes natural and semi-natural communities. Habitat patches were uniquely identified based on their Habitat ID. Figure 2 provides an example of the structure of a habitat patch.</p> <p><b>Community:</b> A community is defined as a contiguous, relatively homogeneous area, boundaries delineated by a patch of a different type or by a <math>\geq 2</math>mm gap on a 1:10,000 air photo (CVC 1998). A community consists of one of the following types: Forest, Wetland, Cultural Forest, or Successional. A fifth community type, Woodland, consists of a combination of Forest, Cultural Forest, and treed Wetland.</p> <p><i>Forest:</i> A Forest is defined as a terrestrial vegetation community with at least 60% tree cover (Lee et al. 1998). In this analysis, the following ELC communities were defined as Forest: coniferous forest, deciduous forest, and mixed forest.</p> <p><i>Wetland:</i> A Wetland is defined as an area of land that is saturated with water long enough to promote hydric soils or aquatic processes as indicated by poorly drained soils, hydrophytic vegetation and various kinds of biological activity that are adapted to wet environments (Lee et al. 1998). The following ELC communities were defined as Wetlands: coniferous swamp, deciduous swamp, mixed swamp; marsh; and thicket swamp.</p> <p><i>Successional:</i> A Successional patch is human disturbed land dominated by native and non-native graminoid or shrub vegetation (CVC 1998). The following ELC communities were defined as successional: cultural meadow, cultural savannah, and cultural thicket.</p> <p><i>Cultural Forest:</i> A cultural forest is defined as a cultural community with <math>&gt;35\%</math> 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).</p> <p><i>Woodland (PPS definition):</i> The Provincial Policy Statement (OMMAH 2005) 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”.</p> <p><b>ELC community series:</b> 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). Examples of community series are: deciduous forest, mixed forest, thicket swamp.</p>
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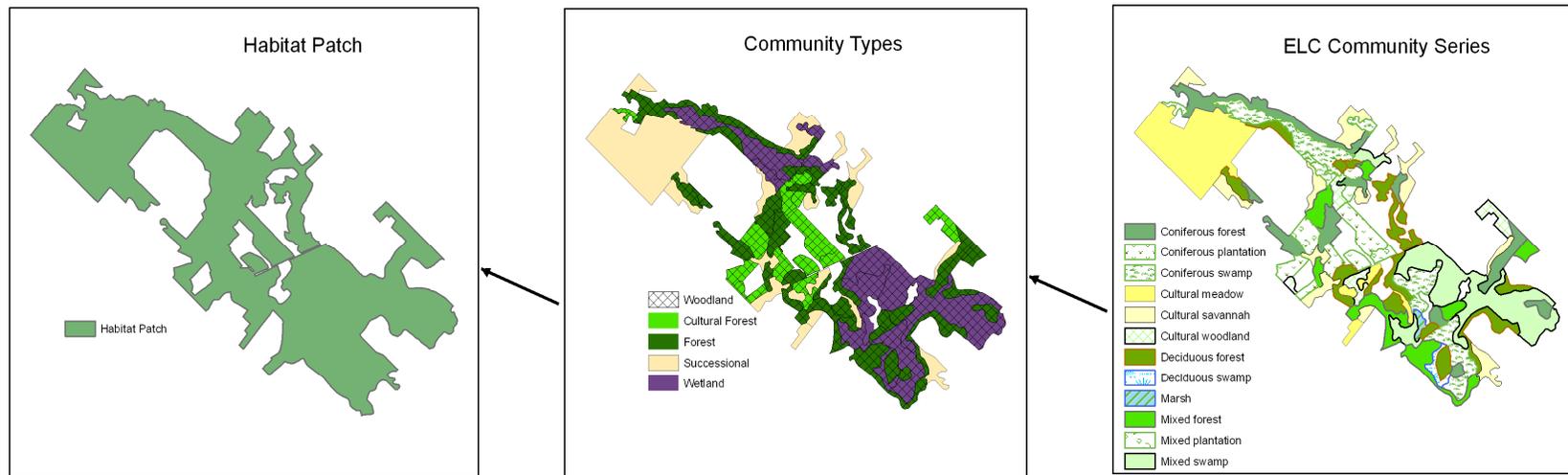
**Table 7.** Community types in the City of Mississauga based on ELC community series or class<sup>1,2,3</sup> (Lee et al. 1998).

Habitat patch <sup>2</sup>	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 <sup>1</sup> (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 <sup>3</sup>	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)

<sup>1</sup>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.

<sup>2</sup>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.

<sup>3</sup>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 units listed in the figure are clustered into communities, which in turn are merged into habitat patches that represent most natural or semi-natural features in the City of Mississauga. Areas outside a habitat patch may be agricultural, urban or aquatic. See Tables 6 and 7 and Glossary for definitions and composition of units.

## **2.0 Methodology**

### **2.1 Data preparation**

It was necessary to update existing Ecological Land Classification (ELC) mapping prior to analysis of the natural and cultural habitats of Mississauga. Updates to the base ELC mapping included the elimination of natural or cultural areas across all of Mississauga that are currently undergoing construction or that do not exist any more due to recent construction activity. These updates included recently collected site visit data from Sheridan and Cooksville Creek watersheds and information from planning applications received by CVC for the City of Mississauga.

It is important to note that natural habitats within the study area that were slated for future development but on which no construction activity was yet occurring were retained within the analysis. The reason for including these sites was that at the time of analysis, these remained natural features that provide, or have the potential to provide, valuable ecosystem functions for the City. If these areas scored high for their potential to provide landscape level ecosystem functions in our analysis, this information could help guide future development in these areas (e.g. reductions in impermeability or increases in urban canopy cover). Open space areas (see below and Glossary) that lay between Pearson airport runways were excluded from mapping and analysis because the restrictions on their maintenance precludes any restoration, stewardship or protection opportunities. However, semi-natural and open space areas on Pearson airport property that lay between buildings were mapped and included in the Landscape Scale Analysis and Enhancement Opportunity Analysis, respectively.

The ELC mapping reflects actual land use, and in cases may not correspond to the zoning or designation in the municipal Official Plan. For example, open spaces are mapped separately from their commercial, institutional or other use. In addition, areas zoned as vacant lands in the Official Plan, are generally mapped as agriculture or successional area in the ELC mapping used for this analysis.

Data from Mississauga's NAS could not be seamlessly incorporated into the Landscape Scale Analysis primarily because NAS data were prepared on a different platform (Microstation) from that of CVC data (ArcView). Merging NAS and CVC data and refining the edges of individual natural unit boundaries to create a seamless data layer would have extended the length of the project well beyond its projected timeline. However, NAS mapping was overlaid on the landscape scale analysis to enable comparison of results.

Figure A3 (Appendix A) shows the composition of habitat patches (woodland, non-forested wetland, or successional) and Figure A4 (Appendix A) shows all habitat patches (including natural and cultural habitats) used in the Landscape Scale Analysis of the City of Mississauga (see Figure 2 for relationship between *ELC Community* and *Habitat patch*).

## **2.2 Mississauga's Natural Areas Survey and the Landscape Scale Analysis**

Mississauga's Natural Areas Survey (NAS) and the Landscape Scale Analysis (LSA) are distinct but complementary studies. Throughout the City of Mississauga the NAS has identified Natural Areas (Significant Natural Sites, Natural Sites and Natural Green Space), Residential Woodlands, Special Management Areas, and Linkages (Table 8). The NAS used intensive on the ground field surveys and identified significant sites for protection based on a combination of landscape ecology measures related to ecosystem functions (primarily area) and biodiversity (flora and fauna). The NAS also identified the ecosystem functions provided by individual features during detailed surveys, providing valuable data on the ecological condition of natural areas that a Landscape Scale Analysis cannot provide. The Landscape Scale Analysis scores natural areas based on connectivity and ecological function at local, subregional and regional/provincial scales, identifying natural and semi-natural areas that provide important ecosystem functions and services. This analysis represents a functional analysis of natural areas within the City using surrogates based on the best available science in landscape ecology and conservation biology (e.g. size and connectivity). The LSA can thereby identify opportunities for growing Mississauga's Natural Areas System beyond its existing natural protected areas, increasing connectivity of the Natural Areas System to maintain a healthy city in the face of increased urbanization and intensification.

NAS mapping was used post-analysis to detect gaps in protection of natural habitats within the City. NAS data were overlaid on the LSA results to determine areas of potential natural cover not captured within the NAS. Conversely, the NAS data was able to highlight natural habitats with high biodiversity that were not defined as high functioning by the Landscape Scale Analysis. Both areas of high biodiversity and high ecosystem function potential should be targeted for securement, protection, stewardship or restoration activity.

**Table 8.** Natural Area Classification Scheme (from *Natural Areas Survey 2010 Update, City of Mississauga 2010*).

<b>Natural Area Classification</b>	<b>Description</b>
<b>Significant Natural Site</b>	<p>Significant Natural Sites must fulfill one of the following criteria:</p> <ul style="list-style-type: none"> <li>• ANSI, ESA, and other areas designated for outstanding ecological features</li> <li>• Areas with a Floristic Quality Index (FQI) of <math>\geq 40</math></li> <li>• Areas with a mean floristic coefficient of <math>\geq 4.50</math></li> <li>• Woodlands <math>\geq 10</math>ha (25 acres) in size</li> <li>• Areas that support provincially significant (S1, S2 S3) or “species at risk” listed as special concern, threatened or endangered (designated by COSEWIC or COSSARO)</li> <li>• Woodlands with the potential to provide interior conditions (i.e. no dimension of the woodland is <math>&lt; 700</math>m)</li> <li>• Woodlands that support old-growth trees (<math>\geq 100</math> years old)</li> <li>• Wetlands <math>\geq 2</math>ha (5 acres) in size regardless of rank</li> <li>• The Credit River and Etobicoke Creek valleys</li> </ul>
<b>Natural Site</b>	<p>Natural Sites must fulfill one of the following criteria:</p> <ul style="list-style-type: none"> <li>• Woodlands <math>\geq 2</math>ha (5 acres) but <math>&lt; 10</math>ha (25 acres) (defined as forests which support understory and canopy species)</li> <li>• Areas that represent uncommon vegetation associations in the City</li> <li>• Areas that support regionally significant plant (in the City of Mississauga) or animal species (CVC species of concern)</li> <li>• Areas with a Floristic Quality Index (FQI) of 25.00 to 39.99</li> <li>• Areas with a mean floristic coefficient of 3.50 to 4.49</li> <li>• Areas that include natural (i.e. not engineered) landscape features [e.g. Valley lands, watercourses, unusual (in the context of the City) landform features]</li> </ul>
<b>Natural Green Space</b>	<p>Natural Green Space includes:</p> <ul style="list-style-type: none"> <li>• Watercourses with vegetation other than mowed grass, even if they are predominantly engineered (e.g. straightened or channelized)</li> <li>• Wooded areas that are <math>&lt; 2</math>ha in size and do not fulfill any of the other criteria for Natural Site or Significant Natural Site</li> <li>• Lakes Aquitaine and Wabukayne</li> </ul>

**Residential Woodland**

These are older residential areas, generally with large lots, and almost completely in private ownership. They support trees with a mature, fairly continuous canopy, but the native understory is generally absent or degraded, usually through maintenance of residential lawns and landscaping. However, these areas still serve some functions such as: providing habitat for tolerant canopy birds, both in migration and for breeding; fixing atmospheric carbon; and facilitating groundwater recharge owing to the high portion of permeable ground cover. With approaches that involve landscaping with native species, the ecological function of these areas would be greatly increased.

**Special Management Area**

These area areas adjacent to or close to existing natural areas, and which have the potential for restoration, or which should be planned or managed specially. They are primarily identified to alert planners to the possibility of directing compatible land uses to lands adjacent to natural areas.

**Linkage**

These are areas which serve to link two or more of any of the above five classes within the City, or to natural areas outside of the City boundaries. Linkages could include:

- Stormwater management facilities including ponds and watercourses
- Designated open space
- Rights of way; and
- Greenspace along major arterial roads providing there is an adequate barrier between the linkage and the roadway

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### **2.3 Identification of features related to ecosystem function**

An important step in a Landscape Scale Analysis is to identify natural and semi-natural features within the study area and to assess their ecological importance (OMNR 1999; OMNR 2010). Features (in this study, habitat patches) that rank high in functional importance based on sound landscape ecology and conservation biology principles can later be used to identify priority areas for conservation. 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; and features that are connected locally and to regional wildlife corridors are preferred over isolated features.

The Landscape Scale Analysis is used as a tool to assess features based on their contribution to ecosystem function within the City of Mississauga. Features identified were based on well established conservation biology principles and have been used or recommended by others to varying degrees to identify Natural Heritage Systems or significant features (OMNR 1999; 2010; Lower Trent Conservation 2001; NHIC 2002;

OMMAH 2002, 2004a, 2004b, 2004c, 2005; Dougan and Associates 2003; 2005, 2009; UTRCA 2003; NVCA 2004; City of Hamilton 2005, 2006; City of Mississauga 2005; Henson et al. 2005; Regional Municipality of Peel 2005, 2008; Wichert et al. 2005; Cataraqui Region Conservation Authority 2006; City of London 2006; The Land Ethic Group 2006; Region of Waterloo 2006; Beacon Environmental and LSRCA 2007; Toronto Region Conservation Authority 2007; North-South Environmental Inc. et al. 2009).

Features used in previous natural heritage planning studies are as follows:

- Patch area
- Forest interior or shape
- Slope
- Matrix influence or matrix quality
- Proximity to another natural heritage feature
- Areas of potential sensitive groundwater recharge or discharge
- Riparian zone, valleyland, and/or floodplain
- Corridors for species movement
- Diversity of vegetation communities
- Roadlessness; distance from roads

The Landscape Scale Analysis was limited to features that were available at a reasonable level of accuracy within the 1:10,000 scale mapping (Table 8). Due to this limitation, there are a number of ecologically important features that could not be mapped or due to incomplete information at the city scale. These included old growth woodlands, rare vegetation communities, habitat of Species at Risk, Fish habitat, and Significant Wildlife Habitat, all identified by the province as important features for inclusion in a Natural Heritage System (OMNR 1999, 2000, 2010). These features should be incorporated when developing a Natural Heritage Strategy for the City of Mississauga, because they contribute to maintenance of biodiversity and improve the resilience of the system. However, because these features have not been exhaustively catalogued and require field studies for confirmation, they are best identified through finer scale studies, rather than in this Landscape Scale Analysis.

**Table 9.** Features contributing to ecosystem functioning in the City of Mississauga, along with supporting scientific literature.

<b>Feature</b>	<b>Linkage between feature and ecosystem function</b>	<b>Relevant literature linking feature and function</b>
<b>Woodlands</b>	<p>Larger woodland, wetland, or successional patches tend to support greater biodiversity than smaller patches under similar conditions; support increased groundwater recharge; possess greater potential for withstanding anthropogenic and natural disturbances; are source populations for other patches; control erosion; and sequester carbon.</p> <p>Woodlands (including forests, swamps, plantations, and cultural woodlands) provide habitat for the majority of species in Mississauga. Small urban woodlands gain disproportionate importance relative to their size because they support airborne pollution uptake, provide shelter for migratory species, provide recreation, and relieve human pressure on other, more sensitive woodlands.</p>	<p>MacArthur and Wilson 1967; Naiman et al. 1993; Castelle et al. 1994; Forman 1995; Shafer 1995; Spackman and Hughes 1995; Naiman and Decamps 1997; Semlitsch and Bodie 1998; Wilson and Imhof 1998; OMNR 1999, 2000, 2010; Trzcinski et al. 1999; Burke and Nol 2000; Gabor et al. 2001; Golet et al. 2001; Lee et al. 2001; Mortberg 2001; Gartner Lee 2002; Lee et al. 2002; Lindenmayer et al. 2002; Environmental Law Institute 2003; Rowsell 2003; Environment Canada 2004; Petit et al. 2004; Mayer et al. 2005; Crawford and Semlitsch 2007; Packett and Dunning 2009</p>
<b>Wetlands</b>	<p>Wetlands of all sizes and hydroperiods provide critical species habitat as well as nutrient removal, carbon sequestration, flow moderation, sediment control, and biogeochemical cycling.</p>	
<b>Successional habitat</b>	<p>Successional habitats including meadows, thickets, and savannahs provide species habitat, including grassland bird and top predator (raptor) hunting grounds and migratory bird stopover habitat. A number of woodland and wetland species utilize meadows, savannahs or thickets for part of their life cycle.</p>	
<b>Valleylands and riparian habitat</b>	<p>Watercourses and adjacent natural areas including valleylands provide aquatic and terrestrial habitat or support aquatic productivity downstream. Terrestrial natural areas containing or adjacent to streams are transitional areas between aquatic and upland terrestrial systems. They provide aquatic habitat, filter sediment and nutrients, shade and cool surface water, and contribute organic and inorganic matter to watercourses. Natural areas adjacent to water bodies are important because they support hydrologic functioning, biochemical cycling, species habitat, and species movement functions.</p>	
<b>Patch containing ELC community series diversity</b>	<p>Greater community diversity in a natural patch means that there are a greater number of habitats within the patch, promoting greater biodiversity.</p>	<p>Forman 1995; OMNR 1999, 2000, 2010; Ontario Nature 2004; Henson et al. 2005, OMMAH 2005</p>
<b>Patch containing uncommon vegetation communities</b>	<p>Uncommon vegetation communities maintain biodiversity within Mississauga and are identified for protection in CVC subwatershed plans. Provincial policy additionally provides protection for habitat of species at risk and rare vegetation communities.</p>	
<b>Patch</b>	<p>The matrix, or the type of landscape surrounding a patch, plays an important role in facilitating or</p>	<p>Saunders et al. 1991; Austen</p>

<b>Feature</b>	<b>Linkage between feature and ecosystem function</b>	<b>Relevant literature linking feature and function</b>
<b>contributing to ecological proximity</b>	limiting species movement across the landscape and among like or unlike natural patches. Matrix quality has commonly been identified using the percent of natural area contained within 2km of a patch (TRCA 2007, Henson et al. 2005). Natural patches with higher matrix quality (more natural area surrounding them) tend to be associated with greater biodiversity.	and Bradstreet 1996; Debinski et al. 2001; Fahrig 2001; Lee et al. 2001; Lindenmayer and Franklin 2002; Henson et al. 2005; Herrmann et al. 2005
<b>Patch contributing to sub-regional connectivity</b>	The distribution of habitat patches within fragmented urban landscapes and the presence of corridors have an important impact on species persistence. Riparian and hydro corridors are thought to provide connectivity and habitat for species within urban areas (Dougan and Associates and North-South Environmental Inc 2009).	Bastin and Thomas 1999; Jokimaki 1999; Fernandez-Juricic and Jokimaki 2001; Crooks 2001; Dougan and Associates and North-South Environmental Inc. 2009
<b>Patch contributing to regional connectivity: Credit River and main branches</b>	River valleys form the ‘backbone’ of a watershed (OMNR 1999). Natural areas along rivers and their main tributaries serve as regional movement and habitat corridors for a number of plant and wildlife species. Corridors containing water sources are considered more significant in terms of their ability to support wildlife than similar corridors without water (OMNR 2000).	Noss and Harris 1986; Waterfront Regeneration Trust 1995; OMNR 1999, 2000, 2010; Haddad 2000; Tewksbury et al. 2002; Environmental Law Institute 2003; Semlitsch and Bodie 2003; Henson et al. 2005; Levey et al. 2005; Wichert et al. 2005; Ewert et al. 2006; Lake Ontario Biodiversity Conservation Strategy Working Group 2009
<b>Patch contributing to provincial connectivity: Lake Ontario shoreline</b>	Natural areas that intersect one or more regional or provincial corridors permit species movement at larger scales, promoting genetic diversity and ecological resilience. Natural areas within the Niagara Escarpment, Oak Ridges Moraine, and Greenbelt Natural Heritage System link the Lake Ontario shoreline and the Credit River with the broad north-south corridor of the Niagara Escarpment and the east-west corridor of the Oak Ridges Moraine, permitting long range genetic movement, adaptation, and evolution. Natural areas from line of wave action of Lake Ontario up to 2km inland support migratory stopover sites for land and shore birds and shoreline dependent species.	

## **2.4 Scoring methodology**

All habitat patches greater than 0.5ha were assessed for their relative importance in ecosystem functioning within the City of Mississauga based on nine specific criteria and thresholds. 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. 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 city scale relative to other habitat patches, based on the criteria. All nine criteria received equal weighting because there was little ecological justification for specific relative weightings for the different criteria.

At the conclusion of the Landscape Scale Analysis, all habitat patches received scores that ranged from a minimum of zero (the habitat patch was not high functioning with respect to any criteria) to nine (the habitat patch was high functioning with respect to all nine criteria). The overall score represented patch quality at the municipal scale.

## **2.5 Landscape Scale Measures used in the Mississauga LSA**

High functioning habitat patches were identified using nine criteria, adapted from the Credit River Watershed Landscape Scale Analysis (CVC 2011). Criteria for identifying high functioning habitat patches 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; and (2) Where federal or provincial guidelines were not available, the analysis of existing conditions within the watershed, best practices, expert opinion, or top percentile values were used to identify high functioning habitat patches. In all cases, the best available science guided the development of criteria and thresholds. Criteria used in the Landscape Scale Analysis of the Credit River Watershed (CVC 2011) were adapted to assess ecosystem function at the urban scale (Table 9). Available federal guidelines included Environment Canada's *How Much Habitat is Enough* (Environment Canada 2004) and provincial guidelines included the *Natural Heritage Reference Manual* (OMNR 1999) and *Significant Wildlife Habitat Technical Guide* (OMNR 2000).

For features that did not have provincial or federal guidelines, threshold values were derived through available science, analysis of existing conditions within the watershed, best practices, or technical committee and peer reviewers' expert opinion. The 75<sup>th</sup> percentile (i.e. the top 25%) was used as one guideline to be combined with technical committee and peer reviewers' expert opinion where other guidelines or best practices were absent. The 75<sup>th</sup> percentile threshold was selected for several reasons: 1) there is already a precedent for using this threshold. The Ministry of Environment commonly uses the 75<sup>th</sup> percentile value for background conditions and to compare against water quality objectives; 2) the 75<sup>th</sup> percentile was felt to be a reasonable threshold for determining relative importance within a given range of values; 3) the 75<sup>th</sup> percentile has been considered a reasonable threshold in another natural heritage study (Dougan and

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Associates 2003); and 4) results from the Credit River Watershed LSA showed that the 75<sup>th</sup> percentile identified approximately one-third of the study area as high functioning for at least one criterion (CVC 2011). A minimum of 30% forest cover is recommended for watersheds and Areas of Concern (Environment Canada 2004), hence the 75<sup>th</sup> percentile appears to be a conservative threshold.

**Table 10.** Criteria and thresholds used to identify habitat patches (features) of particular importance with respect to ecosystem function in the City of Mississauga<sup>a</sup>.

#	Criterion	Scoring criteria and thresholds (if any criterion is met, habitat patch receives a score of 1 for that component; otherwise, it receives a score of 0)
A	Woodlands	All habitat patches containing woodlands $\geq 2$ ha
B	Wetlands	All habitat patches containing wetlands $\geq 0.5$ ha
C	Successional habitat	All habitat patches containing cultural meadows, cultural thickets, and/or cultural savannah $\geq 10$ ha
D	Riparian habitat and valleylands	All habitat patches that are contained within or intersect the greater of: Crest of slope <sup>b</sup> , Meander belt (none for Mississauga), Engineered flood plain, or 30m from an open watercourse, <i>or</i> All habitat patches that are contained within or intersect 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 containing two or more ELC community series types
F	Uncommon vegetation communities	All habitat patches containing locally rare natural ELC community series (where locally rare is defined as ELC community series comprising $\leq 5\%$ area of all natural) <i>or</i> All habitat patches containing locally rare natural ELC vegetation types (where locally rare is defined as ELC vegetation types comprising $\leq 5\%$ area of all natural, identified in NAS)
G	Ecological proximity	All habitat patches with matrix quality in top 25 <sup>th</sup> percentile for Mississauga
H	Sub-regional connectivity	All habitat patches within or intersecting 50m on each side of identified urban-scale corridors, including Cooksville Creek, Little Etobicoke Creek, and semi-natural right-of-way corridors (scored utilizing association with 410, 403 and Eastgate Parkway)
I	Regional and Provincial connectivity	All habitat patches $\leq 2$ km of the L. Ontario shoreline <i>or</i> All habitat patches within or intersecting 500m on each side of the Credit River and Etobicoke/Mimico Creeks up to 5km from the Lake Ontario shoreline <i>or</i> All habitat patches within or intersecting 300m on each side of the Credit River beyond 5km from the shoreline

<sup>a</sup> Details of the GIS Methodology can be found in Appendix B.

<sup>b</sup> Includes habitat patches on tablelands that are adjoining a watercourse or crest of slope.

### **2.5.1 Criteria and thresholds for the Landscape Scale Analysis**

#### **A) Woodlands**

It is now generally accepted that the bigger the natural area, the better for maintaining biodiversity and healthy, self-sustaining ecosystem function (Forman 1995; Shafer 1995; OMNR 1999, 2010; Burke and Nol 2000; Mancke and Gavin 2000; Mortberg 2001; Environment Canada 2004). The number of species a natural area can support is strongly related to its size, making this is one of the most important criteria for ensuring protection of biodiversity and the long term resilience of a natural system. Larger areas provide more habitat for the resource needs of species, tend to have a greater diversity of habitat types, and tend to have interior areas that support edge-intolerant species. Large natural areas are also somewhat more resilient to some of the negative effects of urbanization, such as domestic cat predation of birds, unsanctioned trails, invasive species, and litter.

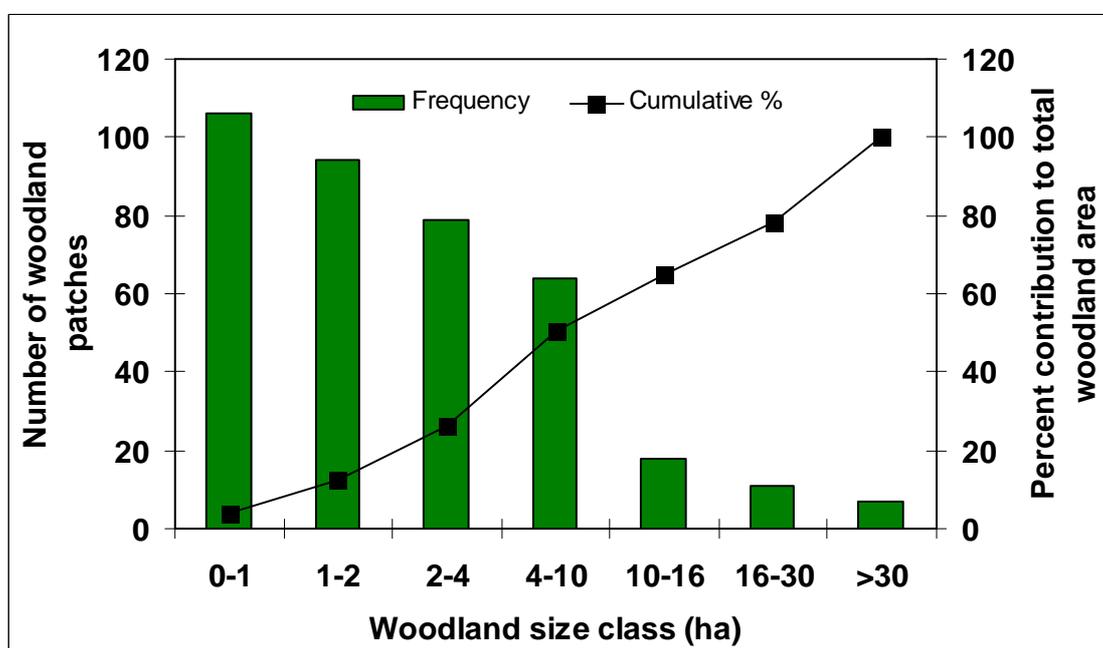
Woodlands are critically important for the well being of humans and biodiversity in general. Forests and woodlands (which include other types of treed habitats such as plantations or swamps) play a strong role in global oxygen, carbon dioxide, and water cycles; moderate climate; store and purify water; prevent erosion and sedimentation; form soil; play a strong role in nutrient cycling; reduce air pollution in urban areas; provide food, fiber, genetic and medicinal resources, pollination and biological control services, and shelter; act as refugia and nurseries for species; and provide cultural, spiritual, aesthetic, and scientific information services (Costanza et al. 1997; OMNR 1999, 2010; de Groot et al. 2002). A number of studies have supported a 20-30% threshold of forest cover for bird species persistence, or beyond which habitat configuration had little effect on species richness or abundance (Andren 1994; Fahrig 1997; Villard et al. 1999). Another study found that bird species favouring interior habitat conditions continue to increase in number from 20% to at least 35% of forest cover, depending on the scale of the analysis (Tate 1998). It is important to note that these values represent minimum targets for forest cover, and overall forest cover may need to be higher to ensure ecosystems are well-functioning and healthy at a landscape scale.

The significance of a woodland patch is dependant on the percentage of vegetation cover in the area (Riley and Mohr 1994; OMNR 1999, 2010). For example, in watersheds containing between 15% and 30% natural woodland cover 20ha is considered a minimum size for defining significant woodlands (OMNR 2010). In areas with less than 5% woodland cover 2ha woodlands are considered significant (OMNR 2010). Other provincial guidelines for thresholds for significant woodlands are 0.5ha or 4ha (under the Oak Ridges Moraine Conservation Plan; OMMAH 2002). 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 geographic location.

Within the City of Mississauga woodland cover is less than 6% and declining. The size of woodland patches ranges from less than 0.50 hectares to 71ha (Figure 3). Some areas containing large woodlands within Mississauga include Rattray Marsh, Erindale Park and

Riverwood. The median size of woodlands is 1.89ha (i.e. half of all woodlands are above and half are below this size), a consequence of extensive fragmentation due to urbanization. Less than a third of all woodland patches are above 3ha.

Based on woodland size distribution in the City of Mississauga, it is likely that smaller woodlands ranging from 1-4 ha play a role in maintaining overall biodiversity and ecosystem function within this fragmented landscape. These woodlands serve as habitat for certain species, may support sensitive species if they are embedded in a well-forested matrix, and may function as linkages in the landscape. Further, all existing woodlands contribute to overall natural cover within the urban landscape, where total natural cover is considerably below existing guidelines (Environment Canada 2004, OMNR 2010).



**Figure 3.** Distribution of woodland patch sizes within the City of Mississauga.

Forests within the City of Mississauga are small in size but disproportionately important from a terrestrial, hydrologic and social perspective. Within 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 zone within the watershed; this zone is perhaps the most wildlife rich area in Canada, and also home to about one-third of Canada’s species at risk. Woodlands in Mississauga, 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. Natural areas that support migrating species are considered Significant Wildlife Habitat (OMNR 1999, 2000, 2010). An Environment Canada study of forest breeding birds in urban areas has suggested that increasing vegetation species and height diversity, along with improving the urban tree canopy, may improve habitat for forest breeding birds and potentially provide habitat for migrating area-sensitive forest

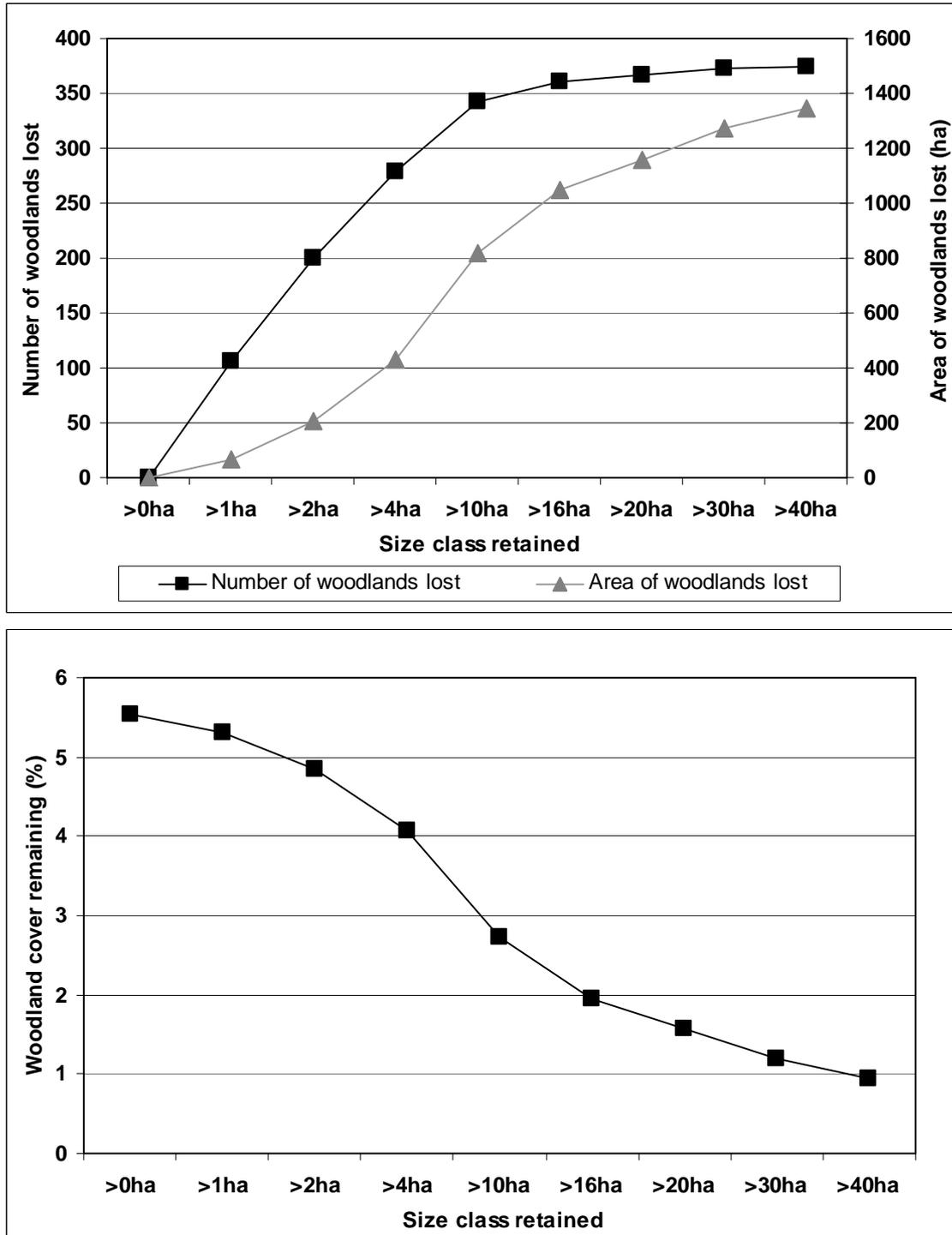
breeding birds (Environment Canada 2007). A literature review on migratory birds found that in rural and urbanizing contexts, even small woodlot patches can be of value (Dougan and Associates and North-South Environmental Inc. 2009).

Woodlands within highly impervious subwatersheds gain hydrological importance for contributing to the hydrologic cycle in these subwatersheds through their role in interception, infiltration, and evapotranspiration (CVC 2007a, CWP 2005).

Finally, woodlands within urban areas 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.

An analysis was conducted to determine an appropriate size for defining woodlands important for maintaining ecosystem functions in the City of Mississauga. The impact on percent woodland cover for the City of Mississauga was examined by successively removing all woodlands smaller than 16ha, 10ha, 4ha, and 2ha from the woodlands dataset (Figure 4). These thresholds were selected because they have been recommended or used in significant woodlands or significant natural heritage feature studies elsewhere (OMMAH 2004c; City of Mississauga 2005; OMNR 2008; North-South Environmental Inc. et al. 2009).

Total woodland cover for the City of Mississauga was 5.5%. A loss of woodlands  $\leq 4$ ha would have a strong impact on woodland function in the Mississauga, removing approximately 73% of all woodlands in the City and reducing woodland cover to 4.1%. A loss of woodlands  $\leq 2$ ha in this zone would have a smaller effect, resulting in a loss of 52% of all woodlands in the City, but a smaller impact on total cover (Figure 4). The complete loss of smaller woodlands is unlikely to occur due to the fact that the City of Mississauga incorporates protection of 2ha woodlands in its Official Plan (City of Mississauga 2005). This analysis simply serves as an exercise to determine an appropriate threshold for woodland size contributing to ecosystem functioning in Mississauga when assumptions about policy are set aside.



**Figure 4.** Impacts of woodland loss within the City of Mississauga, including: a) Number and area of woodlands lost; b) Percent woodland cover remaining when woodlands of various size categories are retained.

In addition to habitat patch size, the amount of woodland core area is an important predictor of habitat quality (Figure 5; Forman 1995; OMNR 1999; Burke and Nol 2000; Mancke and Gavin 2000; Austen et al. 2001). The core area of a community type (generally forest or woodland) is defined as the area within that community beyond a specified edge distance or internal buffer width, usually 100m (McGarigal and Marks 1995; OMNR 1999), where adverse edge effects such as wind, invasive species and predators are minimized. Deep core areas consist of the area within 200m of the edge of a community type. These core areas are particularly important for supporting many area sensitive species, such as Scarlet Tanager (*Piranga olivacea*) or Ovenbird (*Seiurus aurocapillus*) (Villard 1998; OMNR 2000).



**Figure 5.** Core area of a habitat patch (woodland, wetland or successional) represents the area contained after a 100m internal buffer has been created.

In the City of Mississauga, 100m core area is 0.11% (31.4ha) of City area, and no habitat patches contained 200m core. Core area is rare in the City of Mississauga and edge effects are likely to be dominant. Only five woodlands within the City of Mississauga contained >2ha core area (or woodland interior), and all were found in habitat patches containing protected areas, including: Rattray Marsh, Erindale Park, Cawthra Woods, Credit Meadows Park, and Meadowvale Station Woods. As interior habitat is considerably below recommended guidelines for restoration, it is recommended that all

woodland interior habitat greater than 0.5ha in the City of Mississauga should be protected (Figure A5, Appendix A). Small woodland core areas, while they likely do not support area sensitive species, can act as nodes for expansion through stewardship or restoration, enabling support of these species in the future. Core area of woodlands is essentially a redundant criterion in this analysis because all woodlands containing core area would fall within the woodland size criterion. Therefore it was not included as a criterion in the LSA. However, if a different woodland size criterion were to be used in another analysis, woodland interior would be an important consideration in determining patch quality.

Based on the above analyses and minimum guidelines for woodland cover, it was determined that a reasonable threshold for important woodlands was  $\geq 2$ ha. Woodlands of these sizes contribute to provision of habitat and linkages, and are considered to be high functioning relative to other woodlands in the City (Table 9). Habitat patches scoring a 'one' under the *Woodlands* criterion are shown in Figure A6 (Appendix A).

### ***B) Area of wetlands***

Wetlands, including swamps and marshes, are now recognized as being critical to the water balance of a region (Forman 1995; OMNR 1999, 2010; Daily et al. 2000). They reduce flooding and erosion hazards and costs, contribute to long term water supply, contribute to stabilization of shorelines, store carbon and produce oxygen, and enhance groundwater recharge and discharge (Zedler and Kercher 2005; Mitsch and Gosselink 2007; OMNR 2010). 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 (Zedler and Kercher 2005; OMNR 2010). Wetlands act as natural sponges, absorbing water and releasing it slowly across the landscape. This absorption capacity enables wetlands to regulate high water flows. 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 Houlihan 1997). However, it is now accepted that wetlands of all sizes and hydroperiods are considered to be important for species habitat (Semlitsch and Bodie 1998, OMNR 1999, Snodgrass et al. 2000, Environment Canada 2004, Burne and Griffin 2005, CWP 2007). Waterbirds in urban and urbanizing areas have been found to use a variety of wetland sizes and types (Pearce et al. 2007). More than half of amphibian, reptile, bird and mammal species in the Credit River Watershed depend upon wetland habitats for a part of their life cycle (CVC 2002a, 2002b, 2002c). Data from CVC's terrestrial monitoring program indicate that plant species richness is considerably higher in wetland plots than in forest plots in all zones of the watershed (CVC 2010a, 2010b). Wetlands of various sizes and hydroperiods contribute to ecological functioning of the overall landscape.

There is some evidence for a threshold in watershed wetland cover for two wetland functions, namely flood flow and loading of suspended solids. Studies by Johnston and colleagues (Johnston et al. 1990, Johnston 1994) found that watersheds that contained less than 10% wetland cover were more sensitive to incremental loss of wetland area than those with more than 10% wetland cover. A review by Mitsch and Gosselink (Mitsch and Gosselink 2000) concluded that the optimal amount of wetlands in temperate zone watersheds should be 3-7% for the optimization of ecosystem values such as flood control and water quality enhancement. Environment Canada has recommended that wetlands cover a minimum of 10% in a watershed and 6% within a subwatershed, or that wetland cover should be restored to original percentage of wetlands in the watershed (Environment Canada 2004). Currently wetland (marsh and swamp) communities occupy only 0.44% (130ha) of the City of Mississauga's area. Therefore all existing wetlands within Mississauga are considered important for maintaining ecosystem health and function. In the City of Mississauga, all wetlands are regulated through the *Conservation Authorities Act* (Government of Ontario).

Due to their considerable ecological importance and low coverage within the City, all wetlands  $\geq 0.5$ ha (the minimum mapped size) were considered to be high functioning in the Landscape Scale Analysis (Table 9. Habitat patches scoring a 'one' under the *Wetlands* criterion are shown in Figure A7 (Appendix A).

### ***C) Area of successional habitats***

Successional area and historically human modified habitats such as cultural meadows, thickets, and savannahs perform a support function in maintaining biodiversity. When they are found adjoining forests, successional habitats act as buffers, limiting isolation and predator effects in forests and providing a 'soft' edge that favours the movement of animals in search of food, shelter, or breeding habitat (Forman and Gordon 1986; Forman 1995). 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 species (CVC 2002a, 2002b, 2002c; Berger et al. 2003), for several North American mammal species (Fuller and DeStefano 2003), and for some species of Neotropical migrant birds (Bay 1996; Ewert et al. 2006; Packett and Dunning 2009). Grassland bird species have declined dramatically in North America over the past few decades (Askins 2000; Bird Studies Canada et al. 2004). Studies have shown that agricultural fields (e.g. hayfields, pastures, old fields) and open meadow type habitats play an important role in supporting grassland and other bird species including raptors (Herkert 1994; Beacon Environmental and LSRCA 2007), and that larger old fields supported significantly more breeding bird species, likely due to lower rates of nest predation (Bay 1996).

In addition, successional habitats provide habitat heterogeneity that complements existing woodland and wetland habitat and supports a number of open country species including wildflowers and native pollinators. Habitat heterogeneity has been identified as a strong predictor of butterfly richness in Canada (Kerr 2001).

Successional habitat, particularly meadow habitat, is considered significant for wildlife if it is large enough in size (approximately 10ha 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). Lake Simcoe Region Conservation Authority has identified large 'grasslands' (cultural meadows or cultural thickets larger than 15ha) as contributing to significant wildlife habitat (Beacon Environmental and LSRCA 2007). For the purposes of this analysis, successional habitat was defined as cultural savannah, cultural meadow or cultural thicket (see Glossary for definitions of these terms). However, the majority of successional habitat in the City is meadow habitat.

For the purposes of the Landscape Scale Analysis, all successional areas  $\geq 10$ ha in size were considered to be high functioning successional habitat (Table 9). These areas represent approximately 1465ha or 5.0% of Mississauga area. Habitat patches scoring a 'one' under the *Successional areas* criterion are shown in Figure A8 (Appendix A).

#### ***D) Valleylands and riparian areas***

Terrestrial natural areas adjoining streams (riparian zones) are transitional areas between aquatic and upland terrestrial systems. Riparian zones are defined as the stream channel between low and high water marks and the terrestrial zone from the high water mark towards upland area where vegetation may be influenced by elevated water tables or flooding and by the ability of soils to hold water (Naiman and Decamps 1997). In addition, vegetation outside the riparian zone that is not directly influenced by hydrologic conditions but contributes organic matter to the floodplain or channel may also be considered part of the riparian zone (Gregory et al. 1991). These critical interfaces between terrestrial and aquatic environments often contain concentrations of wildlife and plant biodiversity and may provide early indications of environmental change (Naiman and Decamps 1997, Semlitsch 1998, Guerry and Hunter 2002, Environmental Law Institute 2003, Environment Canada 2004, Roe and Georges 2007).

Natural and cultural areas adjacent to streams provide important ecosystem functions related to water quality improvement and flow, flood moderation, sediment and erosion control, bank stabilization, fish and aquatic habitat, moderation of stream temperatures, organic and inorganic inputs to watercourses, riparian biodiversity, plant and wildlife movement, and gene flow (Hodges and Krementz 1996; Machtans et al. 1996; Naiman and Decamps 1997; Tabacchi et al. 1998; OMNR 1999; Wenger 1999; Environmental Law Institute 2003; Environment Canada 2004; Sandin and Johnson 2004; Sweeney et al. 2004; Stanfield and Kilgour 2006; Roy et al. 2007; OMNR 2010). In addition, riparian areas are highly valued for recreation. Riparian zones cannot be mapped through air photo interpretation and need to be identified through field study. However, in the absence of detailed field data, riparian areas or buffers (or set distances from the stream edge) are frequently used as a surrogate measure to indicate the areas of the riparian zone that contribute to different ecological functions.

The amount and quality of natural cover adjacent to a stream has important ecological effects on water quality and aquatic plants and animals. The widths of riparian buffers (the areas on each side of a stream) and their associated functions have been widely studied (Castelle et al. 1994, Wenger 1999, Environmental Law Institute 2003, Lee et al. 2004, Sweeney et al. 2004, Mayer et al. 2005). Riparian buffers vary in their effectiveness in contributing to different types of ecological functions depending on their widths. Besides vegetation, parameters such as soil type, slope, and catchment conditions also play a role in determining the width of a riparian buffer that is effective in improving aquatic habitat through stream water quality and temperature (Castelle et al. 1994, Roy et al. 2005). 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). This buffer width also provides limited habitat for some stream-associated terrestrial species (Chase et al. 1995, Environmental Law Institute 2003, Crawford and Semlitsch 2007). Buffers less than 30m wide can be effective in removing pollutants; however, buffers of 30m or more are generally recommended as a reasonable minimum to cover a number of ecological functions including provision of limited habitat (Chase et al. 1995). It is important to note that a 30m buffer width is insufficient in terms of providing habitat and movement for a wider variety of species; for these corridor functions, a width of 100m is recommended (Environmental Law Institute 2003).

In a Toronto area study, stream degradation occurred when natural riparian vegetation along first to third order streams in a watershed covered less than 75% of total stream length (Steedman 1987 cited in Environment Canada 2004). Environment Canada guidelines for watershed restoration suggest 1) that 75% of stream length be naturally vegetated, and 2) that 100% of the area within a 30m buffer on streams be naturally vegetated. The Credit River Fisheries Management Plan recommends that 90% of streambanks of all tributaries be restored with natural vegetation (OMNR and CVC 2002). Natural vegetation and buffers are particularly important on first to third order (smaller) streams, as water quality downstream is strongly dependent on water quality from upstream feeder tributaries (Environment Canada 2004; see Environment Canada 2004 and OMNR and CVC 2002 for additional detail on the importance of stream orders and the River Continuum Concept). A review of vegetated buffers and a meta-analysis of their efficiency in removing nonpoint source pollution showed that buffers of 30m width on favourable slope conditions removed more than 85% of the pollutants studied (Zhang et al. 2010).

An analysis of streams within the City of Mississauga showed that approximately 76% of the total length of all streams in the City is covered in natural or semi-natural vegetation. Within a buffer zone of 30m on each side of a stream, approximately 68% of the area contained natural vegetation. Because these numbers meet or fall below the minimum recommended guidelines for watershed restoration, it is important to maintain and

enhance all natural and semi-natural riparian areas within the City of Mississauga to sustain healthy aquatic habitat.

Riparian areas around other aquatic habitats serve as a link between terrestrial and aquatic function and filter sediments from water flowing into lakes. A minimum buffer width of 30m around aquatic features is important for water quality and aquatic habitat improvement (Environmental Law Institute 2003). Natural features near lakes provide habitat for terrestrial species that utilize lakes, and serve as resting or staging areas for migratory species including birds and butterflies (OMNR 2000, Macdonald et al. 2006). Natural features within hazard lands associated with Lake Ontario, namely, Lake Ontario Flood Hazard, Erosion Hazard and Dynamic Beach Hazard – protect the shoreline from storm swells and erosion and moderate the effect of these disturbances on natural areas further inland. Under current climate change predictions of increased extreme weather events, the disturbance regulation capacity of lands adjacent to surface water is of high importance.

For the purpose of this analysis, all habitat patches containing or directly adjacent to watercourses or their crest of slope, meander belt and floodplain, or within 30m of an open watercourse 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 on each side of Lake Ontario were also considered high functioning in terms of contributing to water quality and aquatic habitat (Table 9). Habitat patches scoring a ‘one’ under the *Valleylands and Riparian areas* criteria are shown in Figure A9 (Appendix A).

#### ***E) Habitat diversity***

The vast majority of all amphibian, reptile, bird, and mammal species in the Credit River Watershed depend upon more than one ELC community series for completion of their life cycle (CVC 2002a, 2002b, 2002c and CVC unpublished data). More diverse habitats are linked to greater biodiversity and ecosystem function (OMNR 1999, 2000 and references therein). Greater biodiversity within an area allows complex relationships to be sustained even when some species are lost, giving the natural system greater resilience and ability to recover from disturbance (Loreau et al. 2001; Hooper et al. 2005). Maintaining a range of diversity in species and habitats gains increasing importance under conditions of climate change, where impacts on individual species are unknown (Thomas et al. 2004; OMNR 2007; Lavergne et al 2010).

Patch size and habitat diversity are correlated because larger patches tend to have greater diversity than smaller patches. However, certain patches, regardless of size, are likely to support particularly high diversity. For example, patches that contain a number of microhabitats, elevation or soil gradients, or unique plant assemblages, compared to others patches of similar size.

Within the City of Mississauga, some areas with high species and community diversity have been identified and are protected as Environmentally Sensitive Areas (ESAs) or as provincially significant Life Science Areas of Natural and Scientific Interest (ANSIs). However, there are likely other highly diverse areas that have not yet been identified. The most complete data measuring diversity across the entire City is the ELC community series data within habitat patches. Community series data are a reasonable surrogate for identification of areas with high species diversity. Because ELC community series represent distinct ecological communities containing distinct assemblages of plant species, it is reasonable to assume that areas with a high diversity of plant communities are likely to support a high diversity of floral and faunal species. For example, a habitat patch containing a Deciduous swamp, a Mixed forest and a Cultural meadow, will likely contain more species than a patch with a Deciduous swamp alone.

To identify high diversity areas within the City of Mississauga, the number of different ELC community series of all types within each habitat patch was tallied. To avoid double counting, a community series was counted only once even if it occurred multiple times within the habitat patch. The majority (79%) of habitat patches in Mississauga contain only one type of ELC community series (e.g. deciduous forest; Table 7); 16% of habitat patches contain 2 to 3 ELC community series; and only 5% of habitat patches contain 4 or more different ELC community series types (Table 10).

**Table 11.** Number of ELC community series per habitat patch.

Number of ELC community series per habitat patch	Number of habitat patches	Percent of habitat patches (%)
1	651	79.20
2	90	10.95
3	40	4.87
4	20	2.43
5	9	1.09
6	6	0.73
7	4	0.49
8	2	0.24

For the purposes of the Landscape Scale Analysis, habitat patches containing two or more different ELC community series types (top 21% 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 (Table 9; Figure A10, Appendix A).

***F) Uncommon vegetation communities***

To maintain the range of biodiversity within a region, there must be adequate representation of both uncommon and common natural (i.e. not extensively human modified) habitats within a protected area system. Common ELC community series are well represented by virtue of the frequency of their occurrence in the City. Uncommon ELC community series contribute to the overall diversity of habitats, species, and genes within the City of Mississauga.

Two methods were used to score uncommon vegetation communities within the City of Mississauga. Habitats patches considered to have an uncommon vegetation community contained either (i) a locally rare natural (i.e. not cultural) ELC community series, which represented less than 5% of the total natural and semi-natural area combined within the municipal boundary or (ii) locally rare natural ELC vegetation types identified through the NAS which represented less than 5% of all natural and semi-natural area. 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 within natural areas are coniferous forest, deciduous swamp, mixed swamp, thicket swamp, marsh, open beach/bar, treed beach/bar, and open rock barren. Forty-seven ELC vegetation types identified through the NAS represented less than 5% of city’s natural area. Urbanization has likely caused certain communities to become rare in the Mississauga relative to their original representation in pre-settlement times. However, a number of these communities may also be naturally rare because they exist due to a specific set of abiotic conditions.

All habitat patches containing Species at Risk habitat, provincially rare ELC vegetation types, and mature forest should be included within this category, as these features contribute to maintaining diversity within Mississauga. However, given the lack of data for these features, including only known features of this type would have skewed the results of the analysis. Therefore, rare vegetation types and the habitats of Species at Risk were not explicitly included within the Landscape Scale Analysis. These habitats receive protection under existing provincial and municipal policies (City of Mississauga 2005; OMMAH 2005; Regional Municipality of Peel 2005; City of Brampton 2008) and should be considered when developing a Natural Heritage Strategy for Mississauga.

Habitat patches scoring a 'one' under the *Uncommon vegetation communities* criteria are shown in Figure A11 (Appendix A) and represent habitats that are particularly important for providing ecosystem functions that are dependent on biodiversity.

### ***G) Ecological proximity or matrix quality***

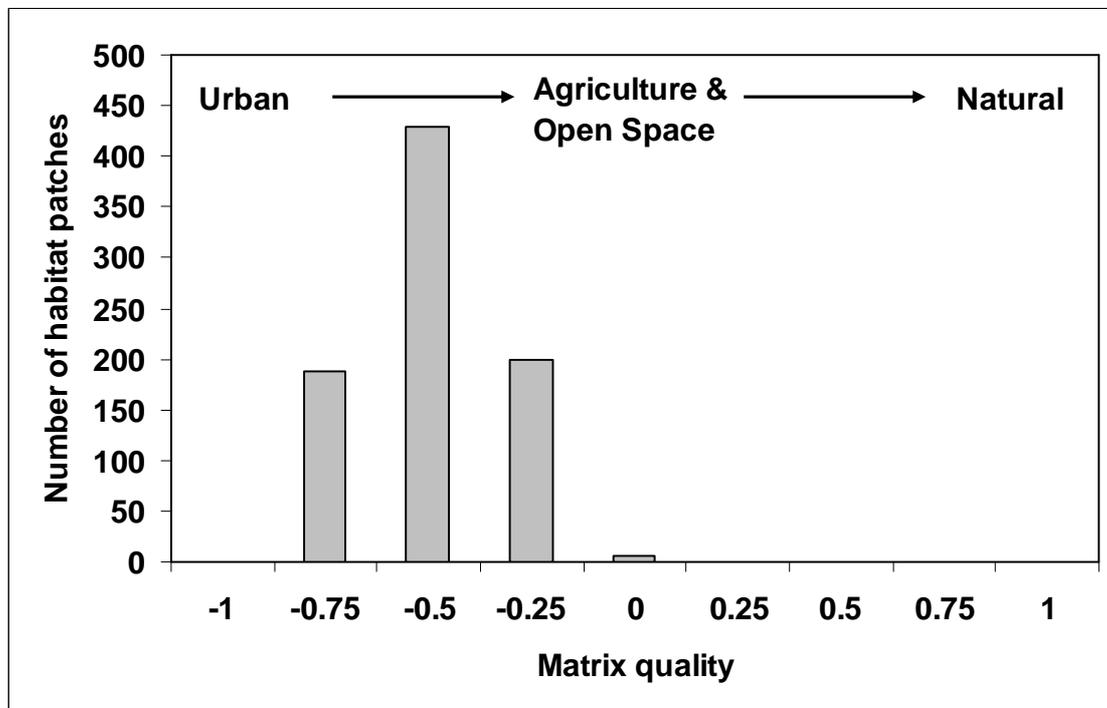
The proximity of natural areas to one another, or the quality of the land use between natural areas, can be used as a surrogate for connectivity at a local scale. Connectivity can be defined as the degree to which species can move between and among habitat patches (Hunter 1996 cited in Gutzwiller 2002). Animal species move among habitats for feeding, breeding, refuge, or migrating. Plant species reproduce and maintain themselves using seeds or vegetative structures to spread into neighbouring habitats. Connectivity is essential in allowing habitat patches to recover from disturbance by receiving genes and species from neighbouring habitat patches, and in allowing longer distance migration of genes and species to enable adaptation and evolution to occur.

The quality of the matrix, or area surrounding a habitat patch, has a strong influence on the ability of a species to move from one habitat patch to another. Natural areas that are closer together have a greater degree of species persistence because they favour movement of species and genes over the short and long term (Forman and Gordon 1986; Andren 1994; Forman 1995; OMNR 1999; Hames et al. 2001; Damschen et al. 2006). For some species, an urban or agricultural matrix 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 percentage 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 (Saunders et al. 1991; Austen and Bradstreet 1996; Lindenmayer and Franklin 2002; Dunford and Freemark 2004; Petit et al. 2004; Henson et al. 2005; TRCA 2007). In general, matrix quality has been calculated based on the percentage of natural, agricultural, or urban area found within 2km of a natural area (Dunford and Freemark 2004; Henson et al. 2005; TRCA 2007).

For the purposes of this Landscape Scale Analysis, matrix quality for a habitat patch was calculated for a 2km external buffer around each habitat patch, adapted from the methodology used by the Toronto and Region Conservation Authority: (percent natural area\*(1) + percent agricultural area\*(0) + percent neutral area\*(0) + percent urban area\*(-

1)). This formula recognizes the relative order of permeability of various land covers, with natural being most permeable, agricultural being relatively neutral (permeable for some species and impermeable for others) and urban being relatively impermeable compared to natural and agricultural land cover. Additionally, percent natural accounted for area within Lake Ontario surrounding a habitat patch. Lake Ontario was classified as having a neutral impact on terrestrial habitat because it acts as a barrier to some species, but not others (P. Prior and S. Hayes, Pers. Comm.). The values for matrix quality range from -1 to +1, where -1 represents a patch completely surrounded by urban land cover, +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 a completely urban and a completely natural matrix. For the purpose of the matrix quality analysis, “agriculture” includes agricultural land, open space, inactive aggregate areas and wet meadows, as all these land-use types are expected to have some positive and some negative impacts on ecological functioning within the City of Mississauga (Appendix B).

In Mississauga, matrix quality for habitat patches ranged from -0.82 to -0.03, with no habitat patches having a matrix quality score greater than zero. Habitat patches lying within the top 25% of patches in terms of matrix quality (quality  $\geq$  -0.38) had an average of 25% natural cover surrounding the patch within a 2km radius. These results are indicative of the strong urban influence on natural areas within Mississauga (Figure 6).



**Figure 6.** Matrix quality for individual habitat patches in the City of Mississauga, showing the range of values from urban to natural.

For the purposes of this analysis, any habitat patch with matrix quality equal to or greater than the 75<sup>th</sup> percentile value was considered to be high functioning with respect to the *Ecological proximity* criterion (Table 9) and is shown in Figure A12 (Appendix A).

#### ***H) Sub-regional connectivity***

At the municipal scale, sub-regional (Criteria H), regional and provincial connectivity (Criteria I) are each important for maintaining ecological integrity within the urban landscape. Large corridors, such as the Credit River and the Lake Ontario shoreline (described below), provide connectivity over a large scale for species movement across the region. Smaller corridors promote connectivity within the urban landscape, allowing for smaller scale species movement.

Within the City of Mississauga, extensive urbanization has resulted in loss of natural east-west connections and reduced the number of north-south connections. To improve connectivity within the City of Mississauga, sub-regional corridors were identified as any corridor which covered a third or more of the City's width or length. These sub-regional corridors included Cooksville and Little Etobicoke Creeks and the hydro corridors or highway corridors along Highways 403 and 410 (Figure A13, Appendix A). Within the urban context, river corridors provide some of the best opportunities to increase overall connectivity, as they are composed of large stretches of uninterrupted, undeveloped land. Further, it has been demonstrated that natural corridors (e.g. riparian corridors) support greater species movement than created corridors (Gilbert-Norton et al. 2010). In addition, it has been documented that hydro corridors can provide habitat for some species (Bramble and Byrnes 1983; Yahner et al 2001; Yahner et al 2002; Dougan and Associates and North-South Environmental 2009). While these corridors may not currently provide habitat or connectivity for large numbers of species, restoration appropriate to existing uses may allow for greater species movement within the City and beyond, and contribute to the resilience of the overall natural system.

For the purpose of this analysis, all habitat patches adjacent to Cooksville Creek, Little Etobicoke Creek, and Highways 403 and 410 up to a distance of 50m on each side were considered to contribute to sub-regional connectivity (Table 9). Habitat patches scoring a 'one' under the *Sub-regional connectivity* criteria are shown in Figure A14 (Appendix A).

#### ***I) Regional and provincial connectivity***

The Credit River, Etobicoke Creek, Mimico Creek and the Lake Ontario Shoreline are each important features that provide regional and provincial connectivity throughout the City of Mississauga. The Credit River and Etobicoke Creek comprise natural north-south regional corridors that link the Lake Ontario shoreline and Carolinian forest habitat with the Niagara Escarpment, Greenbelt, and the Oak Ridges Moraine (Figure A13, Appendix A). The main tributaries of the Credit River, Etobicoke Creek and Mimico Creek, 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 A13, Appendix A). Finally, the Lake Ontario Shoreline provides an

important connection for east-west species movement across the province, as well as important stopover habitat for spring and fall migratory species.

In general, wider riverine corridors favor 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). Valleylands form the 'backbone' of a watershed and should be assessed as an integral part of any Natural Heritage System (OMNR 1999, 2010). Provision for large wildlife corridors is recommended under provincial and federal guidelines (OMNR 1999; Environment Canada 2004). Corridors to support wildlife movement are recommended to be a minimum of 200m in width and include any adjoining areas of natural cover (OMNR 2000; NHIC 2002; Environmental Law Institute 2003). Wildlife movement corridors are valuable as they allow species movement at larger scales, promoting genetic diversity (OMNR 1999, 2010). An extensive review of publications on recommended riparian 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). A meta-analysis of corridor studies has found that corridors improved movement of species among patches and, as discussed above, natural corridors supported greater species movement than created corridors (Gilbert-Norton et al. 2010). Corridor width must be sufficient to permit habitat for or passage of disturbance sensitive species; to provide habitat for species during movement; and to minimize edge predation or mortality. The provincial guidelines for significant wildlife habitat recommend a minimum corridor width of 200m to allow for plant and wildlife movement at a large scale (OMNR 2000). The Region of Peel and Town of Caledon Significant Woodlands and Significant Wildlife Habitat Study recommends that natural features within major river valleys and creeks and within 500m of major river valleys near the Lake Ontario shoreline be protected to promote migratory bird movement up the Credit River corridor (North-South Environmental Inc. et al. 2009).

Natural features within 2km of the Lake Ontario shoreline (ranging from 2 to 10km distant from the shoreline) provide critical habitat during land and shore bird and butterfly migration (OMNR 2000). A study on Lake Erie found that attributes associated with migratory bird stopover sites included a diversity of natural and semi-natural habitats and proximity to the Great Lakes (Ewert et al. 2006). Another Lake Erie study found that nearly all migrant activity was concentrated within 10km of the lake's shoreline (Bonter et al. 2009). Migratory bird and butterfly species require natural or semi-natural habitats in which to rest before or after their long flights across Lake Ontario. The Lake Ontario Biodiversity Conservation Strategy (Lake Ontario Biodiversity Conservation Strategy Working Group 2009) identifies natural features from line of wave action of Lake Ontario up to 2km inland as providing migratory stopover sites for land and shore birds, dune plant assemblages, piping plover, and bank swallow

colonies. The Region of Peel and Town of Caledon Study has identified areas within 2km of the Lake Ontario shoreline for protection for migratory species (North-South Environmental Inc. et al. 2009).

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). Hence the Lake Ontario shoreline is a critical provincial corridor. The shoreline of Lake Ontario also provides a linkage to natural areas 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, regional and provincial linkages were defined as the following:

- All habitat patches  $\leq 2$ km of the Lake Ontario shoreline, *or*
- All habitat patches within or intersecting 500m on each side of the Credit River and Etobicoke/Mimico Creeks up to 5km from the Lake Ontario shoreline, *or*
- All habitat patches within or intersecting 300m on each side of the Credit River beyond 5km from the Lake Ontario shoreline (Table 9).

The Credit River consists of 6<sup>th</sup> and 7<sup>th</sup> order streams and generally represents the widest aquatic corridor in the City of Mississauga (see Glossary for Stream order classifications). 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 River provides some interior or non-edge habitat. This habitat may provide relief from predation and other edge effects as migratory birds move up through the valleylands of the Credit River. In general, interior habitat is found 100m or more inwards from the edge of a natural area (Environment Canada 2004, OMNR 2010).

Habitat patches scoring a 'one' under the *Regional and Provincial connectivity* criteria are shown in Figure A15 (Appendix A). These represent habitat patches that are particularly important for providing ecosystem functions related to provincial connectivity.

### **2.5.2 Assessment of the aquatic system of the City of Mississauga**

The aquatic system of the City of Mississauga includes watercourses, lakes, ponds and the nearshore aquatic habitat of Lake Ontario (CVC 1998). In the Ecological Land Classification system used by CVC and in this study, wetlands are considered part of the terrestrial system; however, a great number of wetlands in the City are hydrologically connected to streams or lakes and play an important role in the functioning of the aquatic system. Valleylands are often considered the "backbone" of a watershed, performing

important ecological functions because they usually contain watercourses (OMNR 2010). On-line ponds (definition, see Glossary) are associated with some negative ecosystem impacts including increase in water temperature of cold or cool water streams and impedance of sediment movement down the watercourse. Nevertheless these ponds provide habitat for some species and most importantly, form part of the stream continuum. Along with adjoining lands (valleylands and riparian zones), the aquatic system carries out many significant functions, including habitat for species, storage, release and conveyance of water and sediment, nutrient cycling, erosion and sedimentation (OMNR 1999, 2010). However, many small streams within the urban setting currently have aquatic barriers, impacting the synergy and exchange of materials between the terrestrial and aquatic systems. A large number of terrestrial species also depend directly or indirectly on water for their life-cycles (CVC 2002a, 2002b, 2002c). Ecosystem goods and services associated with the aquatic system include flood moderation, sediment deposition, water purification and supply, groundwater recharge and discharge, fisheries, and recreation.

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, Peterman et al. 2008). Assessment of the functional importance of specific headwater streams is generally conducted during smaller-scale studies (e.g. Environmental Impact Study). A draft set of scientific guidelines has been developed for assessing headwater features (TRCA and CVC 2009).

For the purposes of this analysis, aquatic features that were deemed important for ecosystem function included permanent and intermittent streams, lakes and on-line ponds (see Glossary for definitions; Figure A16, Appendix A), in addition to the aquatic habitat along the Lake Ontario shoreline (not mapped). The aquatic system should be considered when developing any Natural Heritage Strategy, as there is a need to integrate aquatic and terrestrial functions and to complement the *Fisheries Act* in protecting the other natural resources of the aquatic system.

## **2.6 Enhancement Opportunity Analysis**

The second phase of this study involved identifying areas, in addition to natural habitat identified in the LSA, which could be enhanced to improve the healthy functioning of ecosystems within the City. Given the urban setting of this analysis, the best non-natural areas which may be used to improve connectivity and the functioning of existing natural areas within the City are agriculture and manicured open space (referred to as open space; e.g. city park, cemetery, institutional grounds; Lee et al. 1998; CVC 2007b; Figure 7; Appendix C). These areas have the potential to be strategically restored or managed to improve connectivity and ecosystem function throughout the City. This analysis prioritizes agriculture and open space to identify the highest priority areas for future enhancements. Enhancement opportunities may include redevelopment or intensification to reclaim lands adjoining natural areas and restore or enhance ecosystem services. In addition, stewardship activities focused on backyards or smaller public spaces can help improve connectivity at local scales.

Prior to initiating the Landscape Scale Analysis for the City of Mississauga, open space within urban areas was not previously delineated from other types of urban land use within the ELC mapping. In 2007, Credit Valley Conservation developed an Urban Land Classification system that divides urban land uses into five distinct classes, including open space (Table 11; Figure 7; Appendix C). The Urban Land Classification system defines open space as areas dominated by low intensity human activity. Open space boundaries were delineated by land uses other than open space, or roads/streams >20m wide. Open space and agricultural areas offer potential for enhancing natural areas to which they are connected, or for performing valuable ecosystem functions following restoration.

For the purpose of this study, open space is considered separately from all other urban designations, because this land use has the potential to enhance the ecological function of the natural spaces within Mississauga. Therefore, when “urban” area is analyzed within this report, it is referring specifically to the other four classes of urban land: transportation, urban residential, commercial/industrial/institutional and construction (Table 11).

The Enhancement Opportunity Analysis was conducted on ‘enhancement patches’ consisting of agriculture and open space (Figure A17, Appendix A; Appendix B). All patches greater than 0.5ha were scored with respect to their proximity to features contributing to ecosystem function within the City based on eight criteria (Table 12; Appendix B). Enhancement patches were scored with respect to their proximity to features contributing to ecosystem function within the City. These criteria included agriculture or open space proximity to high functioning woodlands, wetlands, and valleylands or riparian areas; proximity to habitat patches containing high habitat diversity, uncommon vegetation communities or high functioning ecological proximity, and Enhancement patches contributing to sub-regional linkages, or regional/provincial linkages.

The scoring method was consistent with the Landscape Scale Analysis, wherein a habitat patch received a score of one if it met the threshold for a given criterion and a score of zero if it did not (Figure A18-A25, Appendix A). Scores for individual enhancement patches were then added across criteria, and patches received a score ranging from zero (relatively low priority for stewardship or restoration) to eight (high priority for stewardship or restoration). This analysis identifies and prioritizes agriculture and open space areas (including woodlands, wetlands and watercourses) that may be acquired, restored or enhanced to benefit the existing natural areas.

Expanding the size of current successional areas by adding adjoining open space or agricultural area was not anticipated to significantly increase ecological integrity in the City of Mississauga. Therefore, agriculture and open space adjoining high functioning successional areas (identified in the LSA) was not included as a criterion in the Enhancement Analysis. Most of the successional area within the City is cultural meadow, and is a result of human modification to the environment. Some of the existing successional area can provide important habitat and ecosystem services within the City. For example, meadows provide habitat for pollinators, grassland bird species and species of conservation concern (Bay 1996; Cadman et al 2007; Knop et al 2011). In addition, successional areas within Mississauga, included in the LSA, may be in and of themselves targets for future restoration efforts. Restoration may include tree planting to expand core forest area, or the creation of meadow habitat. Although successional areas were not formally included in this Enhancement Opportunity Analysis, a select number of successional areas could be identified for enhancement in the future, on a site-specific basis.

The scores given to the enhancement patches are not intended suggest that all areas identified will be restored or managed, as this will depend on the limitations of existing land use. Furthermore, the scores do not suggest that other areas will not be restored or managed, as this will depend on opportunities that present themselves through land use planning or stewardship. However, these results will assist CVC, the City of Mississauga and partners in developing priorities to guide future protection, restoration, stewardship, and land acquisition initiatives.

**Table 12.** Urban Land Classifications.

<b>Urban Land Classifications</b>
Transportation
Highway
Regional Road
Collector
Railways
Airport
Urban Residential
Low Density Residential
Medium Density Residential
High Density Residential
High Rise Residential
Mixed Residential
Residential Estate
Commercial / Industrial / Institutional
Commercial / Industrial
Educational / Institutional
Construction
Construction
Manicured Open Space <sup>a</sup>
Institutional Open Space
Recreational Open Space
Residential (Private) Open Space
Commercial / Industrial Open Space
Other Open Space

<sup>a</sup> Open space category was combined with agricultural land in the Enhancement Opportunity Analysis

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**Figure 7.** Examples of open space within the City of Mississauga (Photocredit: Paul Tripodo, Credit Valley Conservation).

**Table 13.** Criteria and thresholds used to identify habitat patches for enhancement opportunities within the City of Mississauga.

#	Criterion	Scoring criteria and thresholds (if any criterion is met, Enhancement patch receives a score of 1 for that component; otherwise, it receives a score of 0)
A	Woodlands	Agriculture or Manicured Open Space adjoining woodlands $\geq 2$ ha
B	Wetlands	Agriculture or Manicured Open Space adjoining wetlands $\geq 0.5$ ha
C	Riparian habitat and valleylands	Agriculture or Manicured Open Space contained within or intersecting the greater of: Crest of slope <sup>a</sup> , Meander belt (none for Mississauga), Engineered flood plain, or 30m from an open watercourse, <i>or</i> Agriculture or Manicured Open Space contained 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
D	Habitat diversity	Agriculture or Manicured Open Space adjoining habitat patches containing greater than two ELC community series types
E	Uncommon vegetation communities	Agriculture or Manicured Open Space adjoining habitat patches containing locally rare ELC community series ( $\leq 5\%$ area of all natural) <i>or</i> Agriculture or Manicured Open Space adjoining habitat patches containing locally rare ELC vegetation types ( $\leq 5\%$ area of all natural, identified in NAS)
F	Ecological proximity	Agriculture or Manicured Open Space adjoining habitat patches with matrix quality in top 25 <sup>th</sup> percentile for Mississauga
G	Sub-regional connectivity	Agriculture or Manicured Open Space within or intersecting 50m on each side of identified city-scale corridors, including Cooksville Creek, Little Etobicoke Creek, and semi-natural right-of-way corridors (scored utilizing association with 410, 403 and Eastgate Parkway)
H	Regional and Provincial connectivity	Agriculture or Manicured Open Space $\leq 2$ km of the L. Ontario shoreline <i>or</i> Agriculture or Manicured Open Space within or intersecting 500m on each side of the Credit River and Etobicoke/Mimico Creeks up to 5km from the Lake Ontario shoreline <i>or</i> Agriculture or Manicured Open Space within or intersecting 300m on each side of the Credit River beyond 5km from the shoreline

<sup>a</sup>Includes habitat patches on tablelands that are adjoining a watercourse or crest of slope.

### 3.0 Results

#### 3.1 Landscape Scale Analysis results for the City of Mississauga

Following the evaluation of each habitat patch according to the nine criteria used in the Landscape Scale Analysis, habitat patches were mapped along with their scores (Figure A26, Appendix A). No habitat patches received a score of 9 within the City of Mississauga.

As part of a clustering analysis, habitat patch scores were overlaid with ecologically significant features that were not used in the LSA. Forty percent of habitat patches scoring 6, 7, or 8 contained at least one significant feature, identified as an ESA, provincially significant Life Science ANSI, or PSW. Only 6.7% of habitat patches scoring 2, 3, 4, or 5 contained a significant feature, while no habitat patches scoring 0 or 1 contained a significant feature. All species at risk occurrences within the past 20 years were captured within habitat patches scoring 3 or more (1x1 km squares or generalized locations). Mississauga LSA habitat patch scores also displayed a significant correlation with City of Mississauga’s Natural Area’s Survey data. That is, higher habitat patch scores are more likely to overlap with natural sites or significant natural sites identified in the Natural Areas System, further validating the Landscape Scale Analysis approach.

Based on these results, habitat patches within the City were clustered into Core ecofunction, Highly Supporting ecofunction, Supporting ecofunction, and Contributing ecofunction patches (Table 13; Figure A27, Appendix A).

**Table 14.** Number of habitat patches scoring 8, 7, 6, 5, 4, 3, 2, 1, and 0, their area, and area as percent of City of Mississauga area and habitat patch area.

Habitat patch category	Habitat patch score	Number of habitat patches	Area of habitat patches (ha)	Percent of Mississauga area	Percent of habitat patch area
<b>Core ecofunction</b>	8	4	105	0.4	2.1
	7	13	571	2.0	11.4
	6	35	985	3.4	19.6
<b>Highly supporting ecofunction</b>	5	44	815	2.8	16.2
	4	65	554	1.9	11.0
	3	80	496	1.7	9.9
	2	141	561	1.9	11.2
<b>Supporting ecofunction</b>	1	244	559	1.9	11.1
<b>Contributing ecofunction</b>	0	196	374	1.3	7.5

Habitat patches scoring 6-8 are termed Core ecofunction patches. These patches occupy 5.7% of Mississauga area and represent the highest quality patches in the City from a landscape perspective. These core patches are critical to maintaining biodiversity and ecosystem function over the long term. Forty nine percent of the area of these patches overlapped with Natural Areas System Natural Sites or Significant Natural Sites (Table 14; Figure A28, Appendix A). Patches scoring 2-5 are termed Highly Supporting ecofunction patches. These patches occupy 8.3% of Mississauga and many of these patches contain ESAs, ANSIs, and PSWs and contribute to the ecological integrity of the Core patches (Table 14; Figure A29, Appendix A). Patches scoring 1 are termed Supporting ecofunction patches and occupy approximately 2% of the City, and patches scoring 0 are termed Contributing ecofunction patches and occupy 1% of Mississauga (Table 14).

These categories have been established to provide an assessment of the relative contribution that each of these natural and semi-natural areas provide to ecosystem function at the landscape scale. Core and Highly Supporting ecofunction patches are essential to provide minimum levels of connectivity at the watershed and city-scales. Nevertheless, all of these habitat patches are important when taken together. All remaining natural patches contribute to increased natural cover within the City of Mississauga, where natural cover is low. Furthermore, while Supporting and Contributing ecofunction patches account for a smaller percentage of the area within Mississauga, they comprise over 50% (440 patches) of remaining natural habitat patches. These low scores do not imply that the habitat patches have no value in terms of ecosystem function. The patches contribute to the local hydrologic cycle through infiltration, particularly in watersheds or subwatersheds with low natural cover (Figure A1, Appendix A). The patches may also support functions that can best be detected through site level study. For example, they may lie on a sensitive groundwater recharge area, or support particular species of conservation interest whether such species exist on site or utilize the site. In addition, these urban natural areas serve an important social function through enhancement of human well being, educational opportunities, and access to local green spaces.

**Table 15.** Percentage of habitat patches which intersect significant features (including ESAs, PSWs and Life Science ANSIs) and area of overlap with Natural Areas System Natural Sites and Significant Natural Sites.

Habitat patch category	% overlap with significant features	% Overlap with Natural Areas System (natural areas)
Core ecofunction (6-8)	40%	49%
Highly supporting ecofunction (2-5)	7%	34%
Supporting ecofunction (1)	0%	4%
Contributing ecofunction (0)	0%	0%

The Landscape Scale Analysis cannot capture all data useful for determining a particular site’s functions because the analysis is limited to data that are available for the study area as a whole. Patches with low scores may hold potential to form a linkage or stepping stone habitat, or to be restored to natural cover, thereby increasing their capacity to provide some additional functionality to the overall system.

Overall, seventy-six percent of habitat patches received a score for at least one criterion (Table 13). The largest number of habitat patches fall within the *Valleylands and riparian areas* criterion, reflecting past history of land use as tableland areas were the first to be converted to agriculture or urban areas (Table 15). Conversely, only 49 patches (6%) received a score for the *wetlands* criterion (Table 15), an indication of overall wetland loss within urban areas.

**Table 16.** Number and area of habitat patches contributing significantly to ecosystem function.

Criterion	Number of habitat patches	Percentage of habitat patches
A. Woodlands	160	19.5%
B. Wetlands	49	6.0%
C. Successional areas	79	9.6%
D. Valleylands and riparian areas	353	42.9%
E. Habitat diversity	171	20.8%
F. Uncommon vegetation communities	159	19.3%
G. Ecological proximity	217	26.4%
H. Sub-regional linkage	215	26.2%
I. Regional and provincial linkage	176	21.4%

### 3.1.1 Landscape Scale Analysis results and existing protected areas

The habitat patches within the Landscape Scale Analysis consist of features and areas that are protected under existing legislation and those that are not protected. Protected features and areas include species at risk habitat, ESAs, ANSIs, PSWs, other wetlands and regional greenlands systems.

Overall, a significant number of the Core ecofunction patches from the Landscape Scale Analysis overlap with existing protected areas. For example, a total of 48% (754ha) of core ecofunction patches overlapped with designated ANSI’s, ESA’s and PSW’s (Figure A29, Appendix A). Core ecofunction patches also overlap with some Conservation Authority properties (Figure A30, Appendix A), City of Mississauga property (Figure A31, Appendix A), Species at Risk habitat (not shown) and natural hazards (Figure A32, Appendix A), which are all currently offered some protection. The high degree of overlap indicates that 1) Many Core ecofunction habitat patches as identified by the Landscape Scale Analysis are already protected through some form of legislation, policy or ownership; and 2) the Landscape Scale Analysis methodology is a relatively robust

method for identifying important natural and semi-natural features on the landscape. Further analyses in developing a Natural Heritage Strategy should examine core ecofunction patches which are currently not protected, to determine if there is a gap in current habitat protection strategies.

### **3.1.2 Landscape Scale Analysis results and Mississauga's Natural Areas Survey**

The results of the Landscape Scale Analysis were compared to the City of Mississauga's Natural Areas System and corresponding Natural Areas Survey data. Landscape Scale Analysis Results were overlaid with Natural Areas, Residential Woodlands, Special Management Areas, and Linkage Areas (Figure A28, Appendix A). Forty-nine percent of core patches and 34% of highly supporting ecofunction patches overlapped with Natural Sites and Significant Natural Sites identified in the Natural Areas System.

LSA results were also overlaid with mCC, FQI and faunal species richness in Natural Areas identified in the NAS (Figure A33-A35, Appendix A). Categories of Low, Medium and High FQI and mCC are defined in the NAS and were used for comparison with the Landscape Scale Analysis Results. The total number of faunal species (birds, mammals and herptofauna) observed at each site at each NAS site was categorized into three groups: Sites containing less than 20 faunal species, sites with 21-50 faunal species, and sites with greater than 51 faunal species. These groupings allow for an approximate visualization of areas with relatively "low", "medium" and "high" faunal diversity, and were determined by examining the 33<sup>rd</sup> and 66<sup>th</sup> percentile of the total number of observations detected within a site, as well as the minimum and maximum range of faunal species diversity observed within each category of Natural Area (poor – excellent condition). NAS areas containing high Floristic Quality Index (FQI), high mean Coefficient of Conservatism (mCC) scores or a large number of faunal species tended to be associated with Core and Highly Supporting ecofunction patches identified in the LSA.

Overall, the LSA results reinforce the value of the areas identified in the NAS, as they largely overlap (Figure A28, Appendix A). Areas where the NAS and LSA do not overlap deserve special consideration. The LSA has the potential to identify sites which may be included to expand areas covered by the NAS in the future (discussed further in Section 4.2).

Conversely, because the NAS is an on the ground evaluation of an area, it has the ability to identify important ecological features which cannot be detected with a landscape approach. These features may include species at risk, rare communities, or other features of significant importance. For example, Erin Woods (CE10) received a score of 2 in the LSA, but is considered a Significant Natural Site in the NAS, containing a high mCC (mCC >4.0) and high FQI (FQI >40). Cawthra Woods (LV7) received a score of 5 in the LSA, and is considered a significant natural site in the NAS. This site contains current records 339 floral species and 80 faunal species, including several interesting records, such as the Hairy Woodpecker (*Picoides villosus*), Common Yellowthroat (*Geothlypis trichas*), Gray's Sedge (*Carex grayi*), and Bluebead Lily (*Clintonia borealis*). The

Landscape Scale Analysis scores of both Erin Woods and Cawthra Woods is partially a result of the isolation of these areas on the landscape from other habitat patches. These areas would benefit from improved connectivity to other habitat patches (including stewardship of the surrounding urban matrix), which would improve the ability of these high quality areas to sustain species over the long term. These examples highlight the importance of on the ground evaluation of sites to determine local site significance, and to assist with direction of future management, restoration and planning efforts.

In addition to significant overlap with the NAS, there is also considerable overlap of areas identified as important in the Landscape Scale Analysis with the Region of Peel's Greenlands System (Figure A36, Appendix A).

An integrated approach, where a landscape approach is applied and on the ground evaluation of sites are both considered, will assist with prioritization of future management activities and provide the best protection to natural areas within the City of Mississauga.

### **3.2 Enhancement Opportunity Analysis results for the City of Mississauga**

Enhancement opportunities for improving the health of Mississauga's ecosystems within open space and agricultural areas were assessed in the Enhancement Opportunity Analysis. Following evaluation of each enhancement patch according to the criteria used in the Enhancement analysis (Table 12), enhancement patches were mapped along with their total scores (Figure A37, Appendix A). No patch received a score of 8 within the City of Mississauga.

Scores were clustered into high, medium and low priority areas for enhancement (Table 16). The priority was determined through visual observation of the data, and examining overlap of the enhancement patches and the LSA results to provide the greatest connectivity within the City of Mississauga. High priority patches for future enhancement were considered to be patches which received a score of 5, 6 or 7. A total of 105 enhancement patches were identified as high priority, covering 627 ha within Mississauga. These patches generally contributed greatly to enhancing connectivity along major corridors within the City. Habitat patches scoring 2-4 were considered to be medium priority. These patches have the potential to enhance overall natural cover throughout the City, and tend to be connected to existing natural habitat patches or river corridors. Finally, patches scoring 0-1 were considered low priority for enhancement, and are generally small, isolated patches within the City. Future management activities directed at medium and high priority enhancement patches will contribute significantly to improving connectivity and ecosystem function within the City of Mississauga (Figure A38, Appendix A).

**Table 17.** Number and area of habitat patches providing opportunity for enhancement within the City of Mississauga.

<b>Priority</b>	<b>Enhancement Opportunity Score</b>	<b>Number of habitat patches</b>	<b>Total Area of habitat patches (ha)</b>
High	8	0	0
High	7	3	4.7
High	6	24	193.8
High	5	78	428.6
Medium	4	70	352.7
Medium	3	79	455.6
Medium	2	93	548.5
Low	1	109	464.6
Low	0	325	897.0

Finally, to assist with determining priority areas for future management, enhancement opportunity patches were overlaid with City of Mississauga and Conservation Authority owned properties (Figure A39-A40, Appendix A).

#### **4.0 Implementing results of the Mississauga Landscape Scale Analysis and Enhancement Opportunity Analysis**

##### **4.1 Prioritizing sites for future restoration and stewardship activities**

The identification of sites for future restoration and stewardship activities at the landscape scale should focus on improving the potential for natural and cultural areas to maintain biodiversity and provide ecosystem services over the short and long term. Natural and cultural areas in landscapes such as Mississauga are under stress from urbanization, diminishing the integrity of these natural areas. Given that the majority of natural and semi-natural areas within Mississauga are strongly influenced by the urban matrix, future management activities should focus on restoring ecosystem function through programs that manage or limit the negative effects of urbanization, such as increased recreational impacts within natural areas. Further, management efforts should increase the connectivity of natural areas, and should provide linkages with natural systems beyond the City of Mississauga boundaries (Figure A41, Appendix A).

The results of the Landscape Scale Analysis and Enhancement Opportunity Analysis will assist with prioritizing future restoration and stewardship activities within the City of Mississauga, and should be incorporated into the a municipal Natural Heritage Strategy. However, any increase in natural cover would benefit the Mississauga's ecosystem functioning, and ongoing stewardship and restoration efforts should be encouraged wherever possible.

The analyses presented here use entire patches of natural area, or open space and/or agricultural habitat as the unit of analysis. Site visits will be required to determine where and how management activities occur within these patches. In some cases, restoration and management activities may already have occurred, but they may not have been detected by this study due to the scale of this analysis (only identifying features 0.5ha or greater). The type of enhancement activity that occurs at each site, and the location of the activity, will depend strongly on what is feasible, and will be based on compatibility with existing land use, landowner permission, and restoration goals.

Future enhancement activities to improve overall ecosystem functioning within Mississauga may occur in either current natural habitat patches evaluated through the Landscape Scale Analysis (e.g. removal of invasive species, planting in successional areas), or within open space or agricultural areas evaluated through the Enhancement Opportunity Analysis (e.g. native species plantings within park lands). Highly Supporting ecofunction and Core ecofunction areas identified by the Landscape Scale Analysis could be considered a high priority for future management activities.

In addition, successional habitats offer further opportunities for future restoration and stewardship efforts. These areas have a history of human modification and consequently require management to increase the number of species dependent upon these open habitats. Successional areas within habitat patches scoring 1-8 are therefore identified as

candidates for future work, which could include increasing the extent of adjacent forests or wetlands over time (Figure A3 and A26, Appendix A). Restoration and stewardship activities would need to be designed in accordance with site conditions and existing uses of successional habitats, and encompass a variety of options including plantings of native species or invasive species management.

Additional existing information about natural areas within the City can assist with further prioritization of future restoration and stewardship work. For example, comparison of the Landscape Scale Analysis results with site-level information gathered by the Natural Areas Survey can assist with prioritizing sites. One future analysis could include examining Core ecofunction patches containing a high proportion of non-native species identified in the NAS, which should be considered a high priority for invasive species removal. These results could assist with developing a municipal-level invasive species strategy.

High priority and medium priority enhancement patches should also be considered a priority for future management activities. These sites may be used to expand on current natural areas or improve connectivity within Mississauga (Figure A38, Appendix A). The Urban Land Classification may be used to assist with further prioritization of these natural areas in the future (Appendix C).

Given the urban landscape of the City of Mississauga it is critical to manage the urban matrix to enhance ecosystem function within the City boundaries. Although areas within the urban matrix (e.g. lawns and boulevards) will not resemble a fully functioning ecosystem, it is possible to increase connectivity between natural areas and provide greater environmental benefits for urban residents through various enhancement initiatives. Examples of ongoing initiatives include increasing urban canopy cover, green roofs, Low Impact Development, and gardening with native species. These initiatives are particularly important, as the overall natural cover within the City remains low. Matrix management focused on important linkages, and areas adjoining high functioning natural areas, assist with decreasing the negative impacts associated with urbanization.

Enhancing urban forests has been identified as a priority by the Region of Peel's Urban Forest Strategy (TRCA 2010a), which includes an Urban Forest Study for the City of Mississauga (TRCA 2010b). The urban forest study is complementary to the analyses presented here. The LSA and Enhancement Opportunity Analysis identify priority areas that should be maintained or enhanced to improve the connectivity and function of natural areas within the City. The Urban Forest Study identifies priority areas where natural cover is low, highlighting the need for street trees and gardens to improve overall ecosystem integrity for the City and the well being of its residents. By incorporating each of these studies within a Natural Heritage Strategy for the City of Mississauga, it will be possible to outline a comprehensive plan for improving ecosystem function within Mississauga while simultaneously meeting multiple goals.

The Credit River corridor and the Lake Ontario Shoreline deserve special consideration when prioritizing future protection, restoration and stewardship efforts. These areas represent the most intact existing natural corridors within the City of Mississauga, and enhancing linkages within these areas would be of great benefit to ecosystem function within the City, and would enhance connection between Mississauga's natural areas and important provincial corridors. One data gap within this analysis was a lack of detailed mapping along the City of Mississauga's lakeshore. CVC is currently in the process of completing the *Lake Ontario Integrated Shoreline Strategy* (LOISS). This study will use detailed mapping to identify restoration initiatives along the Lake Ontario Shoreline. This detailed study is necessary to identify areas to enhance connectivity along this important provincial corridor.

Restoration activities surrounding significant corridors should focus on enhancing bottleneck areas, which are areas where the corridor narrows and movement throughout the area could be limited. Widening these bottlenecks, as well as enhancing existing natural and semi-natural areas within these corridors, will improve overall connectivity throughout the urban environment.

Wetland habitat within the City of Mississauga is also a priority for enhancement and restoration. Wetland cover within Mississauga is well below recommended guidelines (Environment Canada, 2004), with marsh and swamp communities covering 0.44% of City area. Potential wetland restoration sites have been identified through the Credit Valley Conservation Wetland Restoration Strategy (Dougan and Associates et al. 2009; Figure A42, Appendix A). Wetland creation, even if it involves a simple creation of swales or seasonal wetlands, would improve ground and surface water related services, particularly with respect to water quality and flow moderation.

Finally, several subcatchments within the City of Mississauga contain low natural cover (Table 17, Figure A1, Appendix A) and are particularly vulnerable hydrologically, in terms of groundwater recharge (lower infiltration), surface water quality and quantity (higher runoff rates), and reduced evapotranspiration (e.g. local cooling effect). Subcatchments with low natural cover should be prioritized for hydrologic retrofit activities that improve groundwater recharge and discharge and surface water functions, such as stream daylighting, natural channel design, and improving perviousness in built surfaces (Table 17). In addition, naturally vegetated streams are important for maintaining aquatic health, and several subwatersheds fall below environment Canada's guidelines for minimum vegetated stream length and do not contain natural vegetation within a 30m buffer from the stream. The Credit River Water Management Strategy update provides guidance for improving hydrologic function in the watershed, particularly in urban areas with low natural cover (CVC 2007a). Subwatersheds with low natural vegetation should be further prioritized for restoration (Table 18).

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**Table 18.** Total area and percent natural cover within each subwatershed, and total area and percent of subwatershed area available for enhancement within each subwatershed.

<b>Subwatershed/ Watershed Name<sup>1</sup></b>	<b>Natural Cover Area (ha)</b>	<b>Percentage of Natural Cover (%)</b>	<b>Enhancement Area (ha)</b>	<b>Percentage of Enhancement Area (%)</b>
Applewood Creek	38.1	9.3	51.2	12.5
Avonhead Creek	66.2	24.4	29.7	10.9
Birchwood Creek	62.8	18.9	23.2	7.0
Carolyn Creek	43.4	8.2	119.5	22.5
Cawthra Creek	9.6	4.9	34.3	17.5
Chappell Creek	68.9	39.3	5.6	3.2
Clearview Creek	24.5	48.3	12.4	24.5
Cooksville Creek	373.8	10.4	333.2	9.3
Credit River	730.2	22.8	390.6	12.2
Cumberland Creek	4.4	7.8	2.1	3.7
East Branch Lisgar	246.6	18.9	303.8	23.3
Fletcher's Creek	163.4	19.8	112.0	13.6
Joshua's Creek	28.5	23.0	69.9	56.4
Kenollie Creek	24.5	11.2	12.7	5.8
Lakeside Creek	108.7	25.8	39.4	9.4
Levi's Creek	44.1	21.3	28.9	14.0
Little Etobicoke	371.0	15.4	158.9	6.6
Lornewood Creek	79.2	19.2	16.8	4.1
Lower Etobicoke	562.0	22.7	302.2	12.2
Lower Mimico	151.2	15.3	104.4	10.6
Loyalist Creek	91.9	10.9	56.3	6.6
Mary Fix Creek	73.4	12.5	40.5	6.9
Moore Creek	11.7	51.4	0.0	0.0
Mullett Creek	319.9	11.8	232.0	8.6
Sawmill Creek	230.4	14.4	181.9	11.4
Serson Creek	30.2	11.1	20.3	7.5
Sheridan Creek	136.1	16.9	76.7	9.5
Spring Creek	281.2	33.3	82.3	9.7
Tecumseh Creek	19.5	12.8	8.3	5.4
Turtle Creek	48.1	20.9	25.4	11.1
Upper Etobicoke	203.1	15.6	146.7	11.3
Upper Mimico	21.2	5.5	41.3	10.8
West Mimico	38.2	8.1	55.7	11.8
Wolfdale Creek	62.8	9.4	37.5	5.7

<sup>1</sup>Calculations completed for only the portion of subwatershed within the City of Mississauga boundaries

**Table 19.** Percentage of stream length which is naturally vegetated<sup>1</sup> and percentage 30m buffer which contains natural vegetation, within each subwatershed.

<b>Subwatershed/Watershed Name<sup>2</sup></b>	<b>Percentage of Naturally Vegetated Stream Length (%)</b>	<b>Percentage of naturally vegetated buffer within 30m of stream (%)</b>
Applewood Creek	48.1	34.7
Avonhead Creek	57.3	49.6
Birchwood Creek	86.1	71.2
Carolyn Creek	81.2	68.8
Chappell Creek	96.9	96.0
Clearview Creek	97.1	76.7
Cooksville Creek	82.7	66.0
Credit River	81.4	73.2
East Branch Lisgar	63.6	48.0
Fletcher's Creek	72.8	63.8
Joshua's Creek	53.2	34.4
Kenollie Creek	53.1	45.9
Lakeside Creek	42.9	42.3
Levi's Creek	85.3	79.0
Little Etobicoke	94.2	78.3
Lornewood Creek	68.0	57.2
Lower Etobicoke	82.1	76.5
Lower Mimico	88.1	80.9
Loyalist Creek	79.3	61.8
Mary Fix Creek	57.9	40.4
Moore Creek	100.0	93.9
Mullett Creek	79.0	66.6
Sawmill Creek	72.2	66.0
Serson Creek	73.8	49.2
Sheridan Creek	78.6	61.3
Spring Creek	97.6	92.4
Tecumseh Creek	69.1	62.4
Turtle Creek	78.8	63.3
Upper Etobicoke	80.5	68.5
Upper Mimico	97.4	68.2
West Mimico	87.3	57.4
Wolfdale Creek	74.4	46.2

<sup>1</sup>The length of stream which is naturally vegetated was calculated in GIS by determining the total length of stream boarded by a natural habitat patch

<sup>2</sup>Calculations completed for portion of stream/river within the City of Mississauga boundaries

In summary, critical areas to focus enhancement efforts on include:

- Core ecofunction and Highly Supporting ecofunction habitat patches identified in the LSA, to improve ecosystem functioning within the patches
- Successional patches scoring 1-8 identified in the LSA
- High and Medium priority patches identified in the Enhancement Opportunity Analysis
- Areas which overlap with City of Mississauga property
- Areas which overlap with other protected areas, including CVC and TRCA owned property
- Areas along the Credit River and the Lake Ontario Shoreline, key corridors within Mississauga
- Wetland communities within patches which overlap with priority areas identified by CVC's *Wetland Restoration Strategy*
- Sites identified at subwatershed-level or site-level, including:
  - Additional Lakeshore areas identified as priority for restoration by CVC's *Lake Ontario Integrated Shoreline Strategy* (in progress)
  - Areas identified for restoration in recent subwatershed studies (e.g. Sheridan Creek and Cooksville Creek, in progress)
  - Areas in subcatchments with low natural cover (initiatives may include increasing tree cover or perviousness)
  - Sites to increasing water infiltration and surface water quality through wetland or bioswale creation and natural channel design

#### **4.2 Application of LSA to Natural Heritage Strategy Development**

This study has characterized and assessed existing natural and semi-natural habitats within the City of Mississauga. The Landscape Scale Analysis can provide a foundation for developing a Natural Heritage Strategy for the City, by providing an overall understanding of the functional importance of habitat patches within the urban boundary.

**The Landscape Scale Analysis represents a technical assessment of natural areas within Mississauga. The mapping presented in this analysis is not a Natural Heritage System.**

Developing a Natural Heritage Strategy for the City of Mississauga would involve the integration of information from the Natural Areas Survey, the Region of Peel's Greenlands System, the Region of Peel and Town of Caledon Significant Woodlands and Significant Wildlife Habitat Study (North-South Environmental Inc. et al. 2009), provincially identified features and areas, and the Landscape Scale Analysis, among others.

A natural heritage system should maintain or enhance the resilience of natural areas to sustain the range of ecological goods and services provided to local residents by natural areas (Table 1). For example, within the Landscape Scale Analysis woodlands greater than 2ha are considered 'significant', as they are anticipated to provide the greatest

ecological services at the landscape scale within the municipal boundary. However, given the total natural cover within Mississauga is low, all woodlands are currently providing ecosystem services to the City, and a net loss of overall tree cover is not advised. Further, small isolated woodlots may provide recreational, cultural and educational opportunities to neighbouring residents.

A Natural Heritage Strategy could include planning for improvement of key linkages and corridors throughout the City using the Landscape Scale Analysis to inform such planning. Regional connectivity and east-west connections could be enhanced through identification of key connections in consultation with neighbouring Municipalities and Conservation Authorities. To further enhance key connections, a bottleneck analysis examining key corridors could identify natural 'pinchpoints' (i.e. narrow segments of the corridor) where species movement may be restricted. These areas may be enhanced within a Natural Heritage System, to increase overall corridor function within the City of Mississauga.

Finally, future work in developing a Natural Heritage Strategy could incorporate data and recommendations from other related studies, including Subwatershed studies, CVC's Lake Ontario Integrated Shoreline Strategy and the Region of Peel Urban Forest Strategy (Table 2).

## **5.0 Summary**

This study assessed the existing natural features and biophysical components within Mississauga. The Landscape Scale Analysis and Enhancement Opportunity Analysis have prioritized existing natural, semi-natural, agricultural and open-space land uses that support biodiversity and ecosystem function within the City. These analyses could potentially be integrated into a Natural Heritage Strategy for the City of Mississauga, as well as inform future enhancement, protection and land securement initiatives.

This Landscape Scale Analysis presents the rationale and approach to assessing existing natural and semi-natural areas of the City for purposes of natural heritage planning, based on current science and information. As data improve and the science around these analyses advances, the Landscape Scale Analysis should be updated and improved. It is recommended that the Landscape Scale Analysis be repeated every 5 years to determine how landscape quality across the City is changing. The analysis may be refined as new data sources become available. Landscape Scale Analysis shapefiles and the analysis results will be kept as current as possible based on CVC's Ecological Land Classification updates.

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## **7.0 Glossary**

*Active Aggregate:* Areas that are currently being excavated (see aggregate extraction) (CVC 1998).

*Aggregate Extraction:* All resource extraction pits or quarries. These areas are subdivided into active and inactive aggregate extraction areas (CVC 1998).

*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).

*Areas of Natural and Scientific Interest (ANSI):* Areas of land and water containing natural landscapes or features which have been identified as having life science or earth science values related to protection, scientific study, or education (OMMAH 2005).

*Bog (Community Class):* Peatlands often covered in Sphagnum. Bogs are often raised and therefore, nutrient poor. Tree cover is less than 25% (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 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).

*Dominant Form:* The vegetation form that is considered to have the greatest influence on the community. It is usually the tallest form with the greatest amount of canopy cover and/or biomass (CVC 1998).

*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). The ELC community series classification breaks down communities into sub types such as deciduous forest, coniferous swamp, cultural meadow, cultural thicket, etc. The ELC community series characterized in this analysis include coniferous, deciduous and mixed forests; bog, coniferous swamp, deciduous swamp, fen, marsh, mixed swamp, thicket swamp; coniferous plantation, deciduous plantation, mixed plantation; cultural woodland; and cultural meadow, cultural savannah or cultural thicket.

*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 2005).

*Ecofunction:* Serves as an abbreviation for 'ecological function'. This term is used by CVC to refer to relative habitat patch quality at the landscape scale within the CVC jurisdiction based on the Landscape Scale Analysis. Habitat patch quality is related to ecological features and functions within the patch.

*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).

*Enhancement:* For the purpose of this study, Enhancement refers to any type of activity where an area is restored or improved upon, including in the ground reestablishment of natural communities (restoration), as well as management of an existing natural area (e.g. invasive species removal) or improvement of a non-natural area to benefit adjacent or nearby natural communities (e.g. light mitigation, native plant gardens). Enhancement can occur within existing natural features, as well as in agriculture and open space areas.

*Fen (Community Class):* Peatlands characterized by surface layers of poorly decomposed peat usually dominated by sedges and have low oxygen saturation and mineral supply is limited. Tree cover is less than 25% (CVC 1998).

*Fish Habitat:* is defined as the spawning grounds and nursery, rearing, food supply, and migration areas on which fish depend, directly or indirectly, in order to carry out their life functions (Federal *Fisheries Act*, 1985). This Act defines fish as shellfish, crustaceans, marine animals, any parts of shellfish, crustaceans, or marine mammals, and the eggs, sperm, spawn larvae, spat and juvenile stages of fish, shellfish, crustaceans and marine animals.

*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).

*Groundwater Discharge:* Groundwater discharge is the process of upward movement of groundwater as a result of hydraulic pressures, which results in groundwater reaching the surface. Groundwater discharge is typically noted as seepage into wetlands and watercourses. Springs are the visible discharge points at the surface (CVC 1998).

*Groundwater feature:* Refers to water-related features in the earth's subsurface, including recharge/discharge areas, water tables, aquifers and unsaturated zones that can be defined by surface and subsurface hydrogeologic investigations (OMMAH 2005).

*Groundwater Recharge:* Groundwater recharge is the process of water, usually from precipitation, moving downward through permeable soil and rock layers into an aquifer (i.e. a water bearing soil or rock formation). High recharge rates occur in areas of high permeable soils and rocks (e.g. sand and gravel and fractured bedrock) while low recharge rates may occur in low permeable soils (e.g. clays)(Gartner Lee, 1997; CVC 1998).

*Habitat patch:* A habitat patch is defined as a contiguous area, boundaries delineated by another land use type or a 20m gap on a 1:10,000 scale air photo (CVC 1998). It includes natural and semi-natural communities.

*Hazardous Lands:* Hazardous lands are property or lands that could be unsafe for development due to naturally occurring processes. Along the shorelines of the Great Lakes - St. Lawrence River System, this means the land, including that covered by water, between the international boundary, where applicable, and the furthest landward limit of the flooding hazard, erosion hazard or dynamic beach hazard limits. Along the shorelines of large inland lakes, this means the land, including that covered by water, between a defined offshore distance or depth and the furthest landward limit of the flooding hazard, erosion hazard or dynamic beach hazard limits. Along river, stream and small inland lake systems, this means the land, including that covered by water, to the furthest landward limit of the flooding hazard or erosion hazard limits (OMMAH 2005).

*Inactive Aggregate:* Areas that have been recently revegetated to an abandoned field or wetland stage (CVC 1998).

*Intensive Agriculture:* Intensive agriculture includes cultivated fields producing crops in varying degrees (e.g. corn and wheat). This includes specialty agriculture, which consists of orchards, market gardens, Christmas tree plantations, and nurseries (CVC 1998).

*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).

*Landscape Scale Analysis:* The characterization and analysis of ecosystem features and functions at the landscape scale, using GIS mapping, a systems approach, and well-established principles of landscape ecology and conservation biology, to ensure integration of the features and functions within the region of interest with those in the broader landscape.

*Manicured Open Space:* Dominated by gardens, parkland, and lawn areas. For example, cemeteries, golf courses, urban parks, ski hills, and residential/industrial open space with a minimum size of 2 hectares. Also referred to as open space (CVC 1998).

*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).

*Natural Heritage System:* A system made up of natural heritage features and areas, linked by natural corridors which are necessary to maintain biological and geological diversity, natural functions, viable populations of indigenous species and ecosystems. These systems can include lands that have been restored and areas with the potential to be restored to a natural state (OMMAH 2005).

*Non-Intensive Agriculture:* Non-intensive agriculture includes fields dominated with herbaceous vegetation and grasses with an understory of similar material in a state of decay. Includes pasture/grazing areas. Weedy hay and/or pasture cover more than 50% of the area. Associated with extensive or unconfined grazing of livestock and minimal evidence of recent cultivation (CVC 1998).

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

*Off-line pond:* A pond without any stream flow into or out of the pond.

*Permanent streams:* Contain continuously flowing water most years (e.g. baseflow conditions are supported by year round groundwater and/or wetland/surface storage areas) (CVC 1998).

*Plantation (Community Class):* A cultivated area, usually dominated by commercially valuable species. Tree species are usually even-aged, planted in linear rows and have little or no shrub or ground vegetation. In CVC methodology, plantations that are immature, and that may therefore not have 60% canopy cover, are still mapped as plantation. The definition of plantation excludes plantations that are managed for the production of fruits, nuts, Christmas trees or nursery stock (CVC 1998).

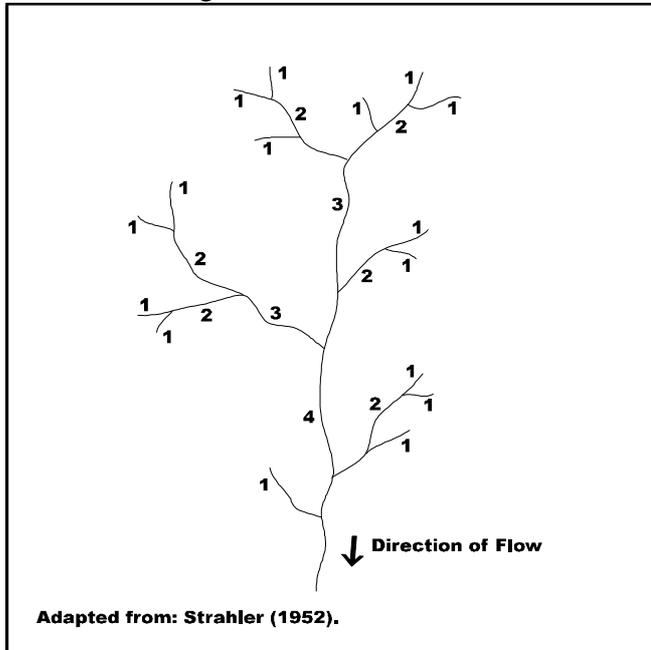
*Pond:* an area of still water between 0.5 and 2 ha. in size lying in a natural or man-made depression. Can be completely enclosed by land or can have either or both an in-flowing or out-flowing stream. A pond can also be created by interrupting the normal flow of a watercourse with a dam (CVC 1998).

*Restoration:* Restoration is the process of assisting the recovery of an ecosystem that has been degraded, damaged or destroyed (SER 2004).

*Shrub:* Woody vegetation usually consisting of a number of stems from the ground or small branches near the ground.

**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. These areas correspond to the Cultural Meadow (CUM), Cultural Savannah (CUS) and Cultural Thicket (CUT) ELC communities.

**Surface Water feature:** Refers to water-related features on the earth's surface, including headwaters, rivers, stream channels, inland lakes, seepage areas, recharge/discharge areas, springs, wetlands, and associated riparian lands that can be defined by their soil moisture, soil type, vegetation or topographic characteristics (OMMAH 2005).

**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).

**Tree:** A perennial woody species usually consisting of one stem that grows to at least 4.5 m.

**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 equalling 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).

*Watershed:* The area of land drained by a river and its tributaries (OMMAH 2005). For the purposes of this study, 'watershed' refers to the area under CVC jurisdiction.

*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. The four major types of wetlands are swamps, marshes, bogs and fens. (OMMAH 2005).

*Wet Meadows:* Lands that are periodically "soaked" or "wet", and are currently being used for agricultural purposes (i.e. grazing). These lands, by definition under the Ontario Wetland Evaluation System, are not considered to be wetlands.

*Woodlands:* 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. (OMMAH 2005).