XING: LANDSCAPE + INFRASTRUCTURE

A Guide to Landscape Connectivity in Toronto's Ravine System

credit: Vitto Riccio

Coauthored by:
Aaron Cameron
Michael Chung
Kristen Flood
Megan Ketchabaw
Jenny Kluke
Emily Osborn
Jennifer Roth
Lauren Sauve

Prepared for PL8109, Graduate Planning Studio
under the supervision of Professor Nina-Marie Lister

Project clients:
Stewart Chisholm - Evergreen Brick Works
Jeremy Guth - ARC Solutions

Stakeholder: City of Toronto - Environmental Planning

Project mentor: David Carruthers - PlanLab

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In September 2013, a group of Ryerson graduate planning students were assigned the task of creating a landscape infrastructural connectivity plan for the City of Toronto. The project, titled 'XING: Landscape + Infrastructure - Connectivity in Toronto's Ravine System', builds on a master planning and design project being undertaken by Evergreen Brick Works, ARC Solutions, the City of Toronto, and the Toronto and Rregion Conservation Authority (TRCA) that focuses on developing landscape infrastructural design solutions for long-term sustainability and resiliency.

Through a mapped study and concept plan, the project accomplishes the following:
1. Provides an understanding of the inter-related needs for landscape connectivity from ecological and social-cultural perspectives (i.e. urban and natural, human and wildlife needs for mobility, urban resilience and sustainable infrastructure);
2. Assesses and analyzes the the opportunities and constraints to "blue" and "green" infrastructures that collide, intersect, diverge and converge in the ravines; and
3. Proposes a series of designed connections in the ravine systems as key locations, and at various scales in cost, time and scope.

This manual provides a bird's eye view of the landscape infrastructure of the ravine system, and examines where and how connections can be made between and within the Humber, Don and Rouge watersheds. It is intended to provide ideas for improving connections for both humans and wildlife to ensure the ecological functions of the city's green spaces and natural systems are adequately supported. Presented within this manual are some approaches and design principles that can be used to revitalize the connections to the ravines, and to restore and protect the city's important valley lands and river corridors, within the context of urban resilience.

The ideas outlined in this manual stem from a growing body of knowledge around road ecology, which is the study of how roads and the natural environment interact. More specifically, road ecologists explore how roads act as barriers that inhibit the movement of wildlife, and they examine the ways in which the planning and design of roadways can compliment the surrounding landscape (Tepper, 2011).

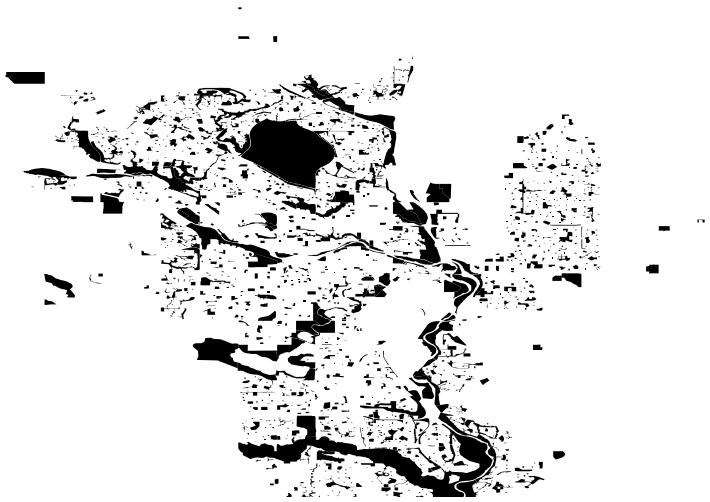
This manual is intended for use by the general public, city planners, decision makers, environmentalists, and anyone else interested in creating a more resilient and connected city.

INTRODUCTION

Toronto's ravine system is one of the largest urban ravine systems in the world, and is a defining feature of the city. Because of changing land use patterns stemming from urbanization, this system is becoming increasingly fragile. Of particular concern are the consequences of rapid urban expansion and our long history of road building. The way in which the city has been built has fragmented the natural landscape. In an attempt to provide for the city's human residents, we have overlooked the needs of the city's wildlife. Their habitats are becoming increasingly fragmented, and the number of species at risk in the Toronto area is growing every year, threatening the region's biodiversity. In addition, the fragility of the city's network of green spaces is reducing its ability to maintain its natural ecological function, which provides a number of benefits to our environment, such as flood protection, air filtration, and climate regulation. To mitigate the stress we are putting on the city's natural systems, we need to put in place a better-connected landscape that allows humans and wildlife to move more freely and in better harmony with one another. We need to find ways to better integrate the city's green infrastructure into Toronto's urban fabric. Our health, and the health of the environment depend on these connections (Lister, 2012).

Figure Ground Diagrams
These figure ground diagrams compare the ravine systems of various cities. The figure ground diagram for Toronto demonstrates significant potential for improving landscape connectivity across the city.

Toronto, Ontario
(Chung, 2013)



Calgary, Alberta
(Chung, 2013)

Los Angeles, California
(Chung, 2013)

New York, New York
(Chung, 2013)

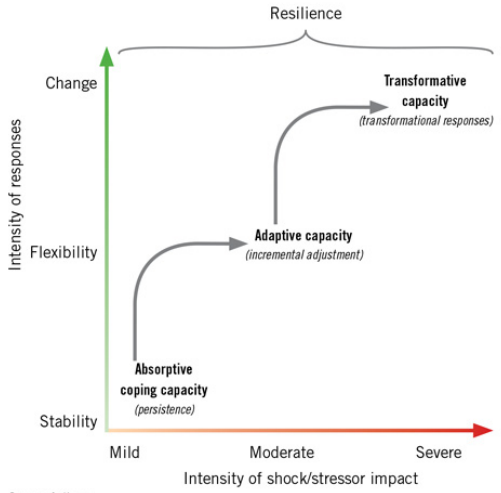
Vancouver, British Columbia
(Chung, 2013)

WHAT IS URBAN RESILIENCE?

Definition

A resilient city is one that is capable of adapting to and preparing for stresses and changes in its physical, social, and economic systems, while still being able to perform its basic functions. Resilient development means incorporating continuous learning, innovation and adaptation into our practices. It is imperative to allow a process of evolution in the way that we plan, so that our city's ability to function robustly and flexibly will be possible with an unpredictable future.

FIGURE 3.1 **RESILIENCE AS THE RESULT OF ABSORPTIVE, ADAPTIVE, AND TRANSFORMATIVE CAPACITIES**



(Source: International Food Policy Research Institute, 2013)

The City as a Resilient Ecosystem

'Resilience' is a term traditionally associated with the study of ecology. It refers to the capacity of an ecosystem to respond to a disturbance by resisting damage and recovering quickly without changing its basic structure and function (Wu & Wu, 2013). Because cities are complex ecosystems made of physical and human infrastructure, they can be viewed through the lens of resilience. What is unique to cities is that humans are capable of foresight. We are able to anticipate and plan for future stresses and change (ResilientCity.org). As such, our cities can demonstrate adaptive capabilities.

'Adaptive capacity' is a term often used interchangeably with 'resilience'. It is an idea best articulated by C.S. Holling. Applying his understanding of resilient ecological systems to urban ecosystems, a resilient city is one that can undergo change and still retain the same control on function and structure, is capable of self-organization, and expresses capacity for learning and adaptation (Holling, 1973). Therefore, a resilient city responds to change in a way that it is able to retain its basic functions while incorporating new ideas, approaches, policies, and industries. As a result, an improved system of planning emerges, showing its capacity to adapt to shocks and stresses, while maintaining a resilient ecosystem. The adaptive capacity of a city is closely related to aspects of creativity, innovation, flexibility, and diversity (Walker et al., 2002).

Nature, Parks, and Greenspace as a Source of Resilience

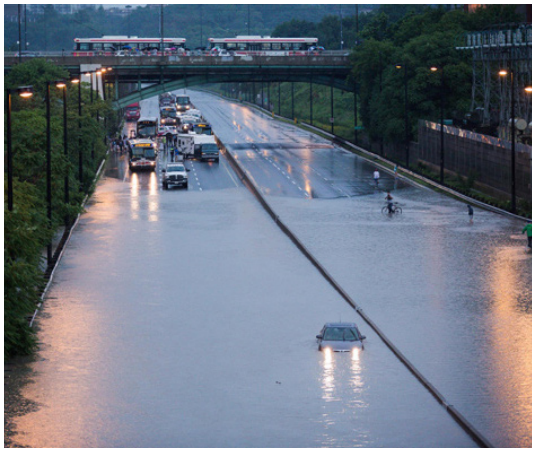
There is an increasing need to plan for and implement design approaches that improve urban resilience, as shocks and stresses associated with climate change, energy scarcity, and aging infrastructure become much more prevalent (ResilientCity.org). One way that cities can become more resilient is by better integrating natural systems and areas of environmental significance into the urban context.

This is important because humans derive many benefits from the natural environment. Natural systems provide food, clean air and clean water, support soil formation and nutrient cycling, and regulate flood, drought, and disease (Wu & Wu, 2013). Urban parks and green spaces also offer recreational and cultural opportunities. We depend on these functions of the environment for our physical and mental health. Consequently, a happy and healthy population is a more resilient one (Kofinas & Chapin, 2009).

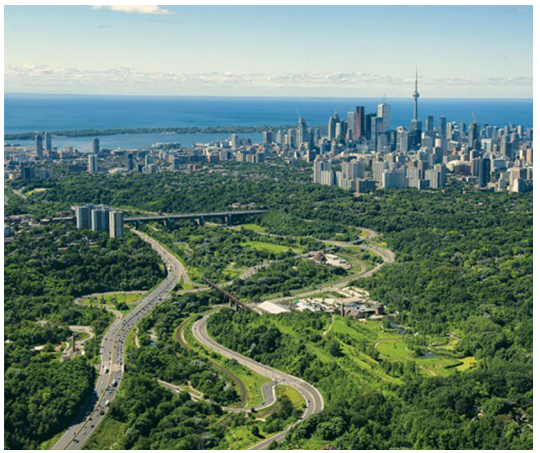
The Focus on Toronto's Ravines

Natural systems are a source of resilience, promoting access to nature and natural features is crucial for cities. This planning approach requires a shift in focus to initiatives that preserve and restore natural environments. This practice contributes to increased resilience by protecting existing biodiversity, indigenous or endangered species, and allows for the maintenance of natural ecosystem processes (Science for Environmental Policy, 2013). It also helps us achieve greater landscape connectivity and ensures that natural features are incorporated into new development projects.

The concept of urban resilience is the underlying motivation for this project's focus on strengthening human connectivity to the ravines, while taking into consideration other species that grow, live and travel through them. This manual outlines a number of strategies that can be used to help re-establish the ravines as a safe, accessible, and valuable green space in the city for both humans and wildlife.

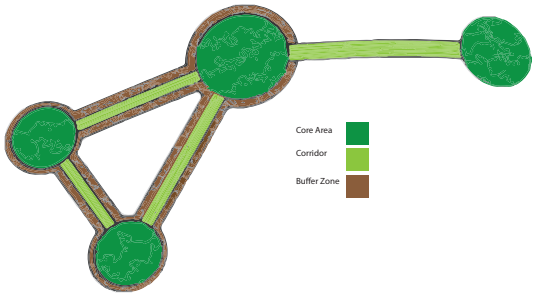


Flooding in the Don Valley, July 2013.
(Photo Source: Ryaboi, 2013)



A resilient city is one that focuses on making strong connections between its natural landscape and built form.
(Photo Source: Meeting of the Minds, 2013)

WHAT IS LANDSCAPE CONNECTIVITY?



(Cameron, 2013 as modified from Peck, 1998)

Definition

Nodes and Networks are terms that are used to describe landscape connectivity. Nodes are pieces of land where animals live and networks are the paths that connect the nodes together. Complete networks of land allow animals to move from node to node safely.

Connectivity refers to the degree to which the landscape facilitates or impedes movement between two or more locations. Whether it is a natural connection or man-made, the concept of connectivity contains both structural and functional components. Structural connectivity refers to the physical linkages between two locations, whereas functional connectivity refers to the movement of individuals among them based on their behavioural response to the composition of the landscape (Kindlemann & Burel, 2008). Connections between two locations do not always provide useful linkages. A structural connection for one species may act as a functional barrier to another species.

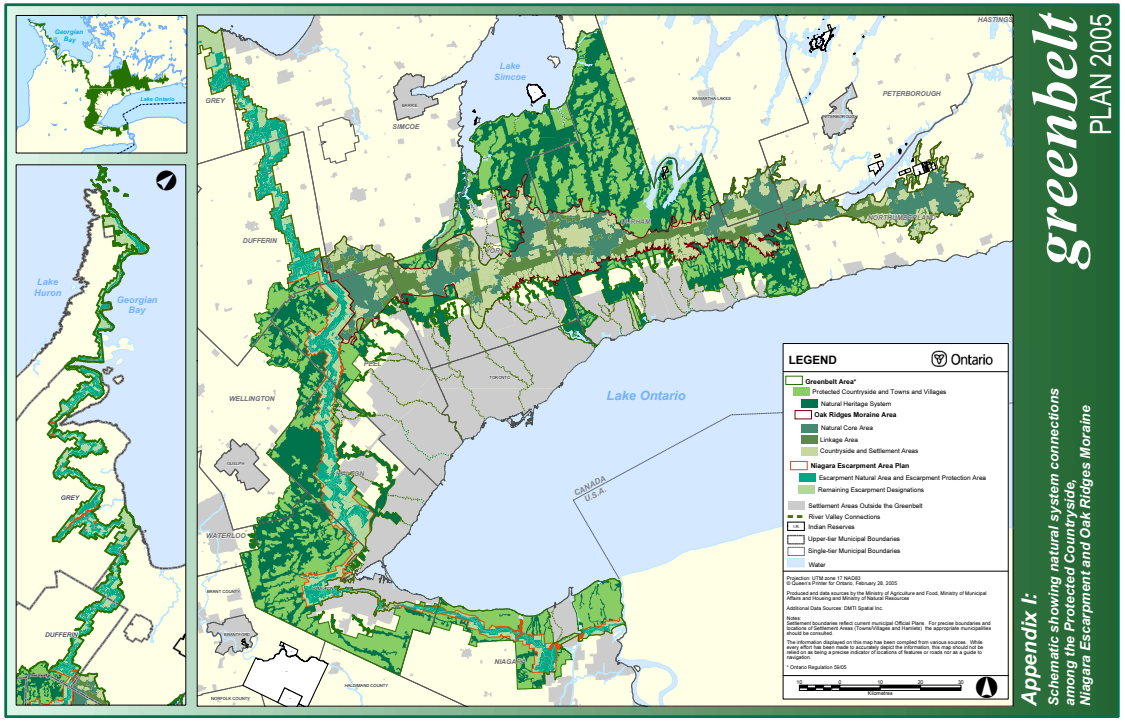
There is a need to improve overall connectivity between Toronto's green spaces and natural systems in a manner that is aware of, and respectful to, the inter-related needs of both humans and wildlife. For humans, a more connected landscape is one with improved accessibility and access to natural areas within the city. For wildlife, the degree to which landscapes are connected influences access to food, mate and hibernation locations, gene flow, local adaption, colonization probability and the potential for organisms to migrate as they cope with climate change (Ecological Society of America, 2012).

A connected landscape is one where there are corridors of connectivity between hubs of land. Hubs can take many forms. The most obvious hubs are parks, but backyards, golf courses and cemeteries also act as hubs that animals inhabit and move between. Landscape connectivity is not just about the physical relationship of green spaces; it is also about how animals move across those green spaces. Migratory patterns are specific to unique species and it is important to improve landscape connectivity along the routes that a variety of species use.

There are three types of habitat corridors: migration corridors, dispersal corridors and commuting corridors. Of these three types of corridors, commuting corridors are most relevant to Toronto's urban context. Migration corridors allow for the annual

movement of wildlife during seasonal changes. Dispersal corridors provide for the mobility needs of species that are forced to flee their habitat because of changes in the levels of available resources. Commuting corridors are for the daily back-and-forth movement of wildlife in search of mates, food and shelter (Meiklejohn, et al., n.d.). Wildlife in downtown Toronto move mostly through commuting corridors, as there are very few migratory species in the city.

It is important to look at the movements of specific species because landscape connectivity is defined as both the physical connections between green spaces and the way that animals use those connections (Taylor, 2013). Toronto is home to many migratory birds, insects and reptiles. Birds and insects do not depend on the same physical corridors for migration that large migratory species do. Green roofs and



Greenbelt Plan, 2005

Case Study

The Green Links Atlas is a project of the Douglas College Institute of Urban Ecology. The goal of the project is to increase landscape connectivity in urban environments. The project relies on regreening to accomplish its goal: "The primary activity of Green Links is to plant native vegetation in utility corridors, parks, schoolgrounds and backyards" (Douglas College Institute of Urban Ecology). The project also promotes habitat restoration through the introduction of green space whenever possible.

backyards provide habitat connections for birds and insects without the need for physical connections or the removal of barriers.

Even though Toronto has migratory corridors for birds and insects, the city still lacks commuting corridors for larger animals. Landscapes are fragmented when green space is divided by roads and built form. Much of the infrastructure humans depend on for movement inhibits the movement of wildlife. When roads cut through natural heritage areas, they need to support the movement of wildlife as well as humans. Landscape connectivity for all species can be increased through re-greening projects that increase the biodiversity and plant life in the city.

"Our expanding web of highways, cities, and intensive agriculture traps many animals and plants in islands and cul-de-sacs of habitat, held back by barriers of geography or architecture from reaching mates, food, and wider resources." - Ecological Society of America

Forging landscape connections will become even more important in the future. Climate change is affecting the availability of the resources animals depend on. It is also affecting the timing of seasonal changes. Extreme weather events are becoming more common and they may force wildlife populations to disperse quickly (Lester, 2012). Migration corridors, dispersal corridors and commuting corridors will all undergo changes or shifts in use because of climate change. Connected landscapes are not static - they must change in response to the changing movements of the species that use them.

One change that is currently underway that will improve Toronto's landscape connectivity is the inclusion of the three ravine systems in the Greenbelt Plan. The Greenbelt is a major corridor of connectivity for wildlife in the Greater Toronto Area. By incorporating the ravines into the Greenbelt Plan, they will be protected for the future. The ravines are an important north-south connection that will make the Greenbelt a connected landscape by linking it through the ravines to the waterfront.

The waterfront is a major corridor of connectivity in the city. Waterfront Toronto has

plans underway to add more parkland and connections along the water's edge over the next 5 to 10 years. These projects will improve connections between Toronto's three major rivers.

The inclusion of the ravine system in the Greenbelt Plan and the re-greening projects underway along the waterfront represent major improvements in Toronto's landscape connectivity at a broad scale. The introduction of corridors on a small scale is equally important to improving landscape connectivity, although small-scale connections are more difficult to plan for.

A rendering of the waterfront after it has undergone extensive regreening. Waterfront Toronto has plans to add parkland along the water's edge to create a more connected landscape and therefore enhance the city's biodiversity.
(Photo Source: Waterfront Toronto, 2013)

Case Study

The City of Ottawa has a Greenspace Master Plan that promotes landscape connectivity. Corridors of connectivity in Ottawa are designed to be used by many different species, including humans: "Multi-use pathways are a primary means of creating connectivity within Ottawa".4 Ottawa's approach to landscape connectivity is equally geared to humans and animals – it is as much about promoting active transportation as it is about the reconstruction of wildlife habitat. The city highlights streams and creeks as ideal opportunities for the placement of new paths. "Streams and creeks provide the best connections among natural areas, because they provide upland and riparian habitat for a diversity of plant and animal species (" Furthermore, Ottawa is an urban city and the plan recognizes the challenge of increasing landscape connections in an urban environment and the necessity of buffers between animal habitat and the built environment.

HISTORY OF THE RAVINES

Toronto's ravine system is a defining feature of the city. With over 27,000 acres of protected green space, it is one of the largest urban ravine systems in the world. The ravines contain the most diverse ecosystems within the urban boundary, and are a central natural resource for the city. Throughout their history, the ravines have been largely ignored, sometimes used as a dumping ground, or seen only as a transportation corridor for rail lines and highways. Within the last decade, the landscapes housed within the city's ravine system have been increasingly recognized as important assets that require leadership to ensure they are ecologically viable and resilient. Groups like Friends of the Don East, Toronto and Region Conservation Authority, and projects such as the Human River and Lost River Walks have led to increased awareness and interest in protecting and restoring the ravines. As well, in an effort to protect ravine lands, the City of Toronto issued the Ravine Protection Bylaw in 2002. An understanding of the ravine system's history can help to shape a better future for the region (Hardwicke, 2007; Seymour, 2000).

The ravines were formed over 12,000 years ago after the end of the ice age. Several rivers and creeks created deep ravines throughout the region, with the largest running south from the Oak Ridges Moraine to Lake Ontario. The original ravine system contained over 1200 kilometres of ravine edge, which is ten times the length of the city's waterfront. Many of these ravines have since disappeared under the city, and the remaining ravine system is currently lined with housing and other developments. As the city's population increases, and as pressure to intensify urban neighbourhoods increases, the remaining ravines – the Humber River, the Don River, Highland Creek and the Rouge River – will be under an increased amount of stress (Hardwicke, 2007; Seymour, 2000).

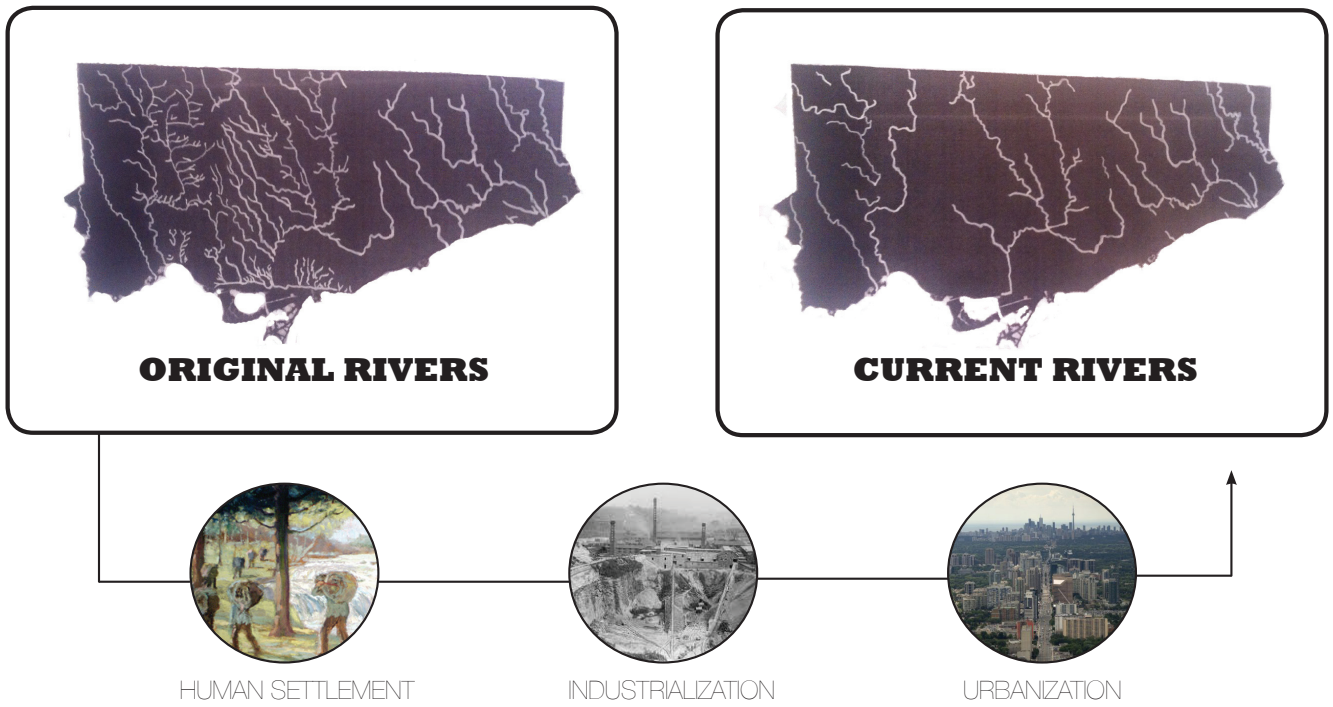
The ravines were originally used as a source of food, water and fuel. They were logged extensively and the rivers were used as a source of power for water mills. As well, bricks made out of clay from the ravines were used to build much of the city. Early photographs show that they were also a source of recreation and pleasure for settlers in the area.

As well, bricks made out of clay from the ravines were used to build much of the city. Early photographs show that they were also a source of recreation and pleasure for settlers in the area. They engaged in such activities as swimming and bathing, fishing, hiking, boating and skating. However, since the 1800s, the ravines have suffered from extensive pollution, channeling, dumping, and logging (Hardwicke, 2007; Seymour, 2000).

The ravines are now largely used for recreational activities, and offer a network of trails, parks and open spaces that

provide residents with some connection to the ravine system. Despite these recreational activities, the ravines remain disconnected from the city.

The history of Toronto's three main ravines reveals their importance in providing important connections throughout history, whether it is trade connections in the early days, or the recreational connections of the present. The issues and challenges facing each watershed necessitates the development of connections between man-made landscapes and the natural environment to ensure a resilient future for the city's ravine system.



(Photos: Hardwicke, 2007; Evergreen Brick Works, 2013; NOW Magazine, 2013; Toronto Star, 2012)

"We have bridged, fenced and bypassed the ravines to the point that many people are entirely unaware of the ravines around them. The engineering of our ravines was a modern project that reflected the Western attitude towards nature as a wild force to be subdued and civilized" (Hardwicke, 2007).

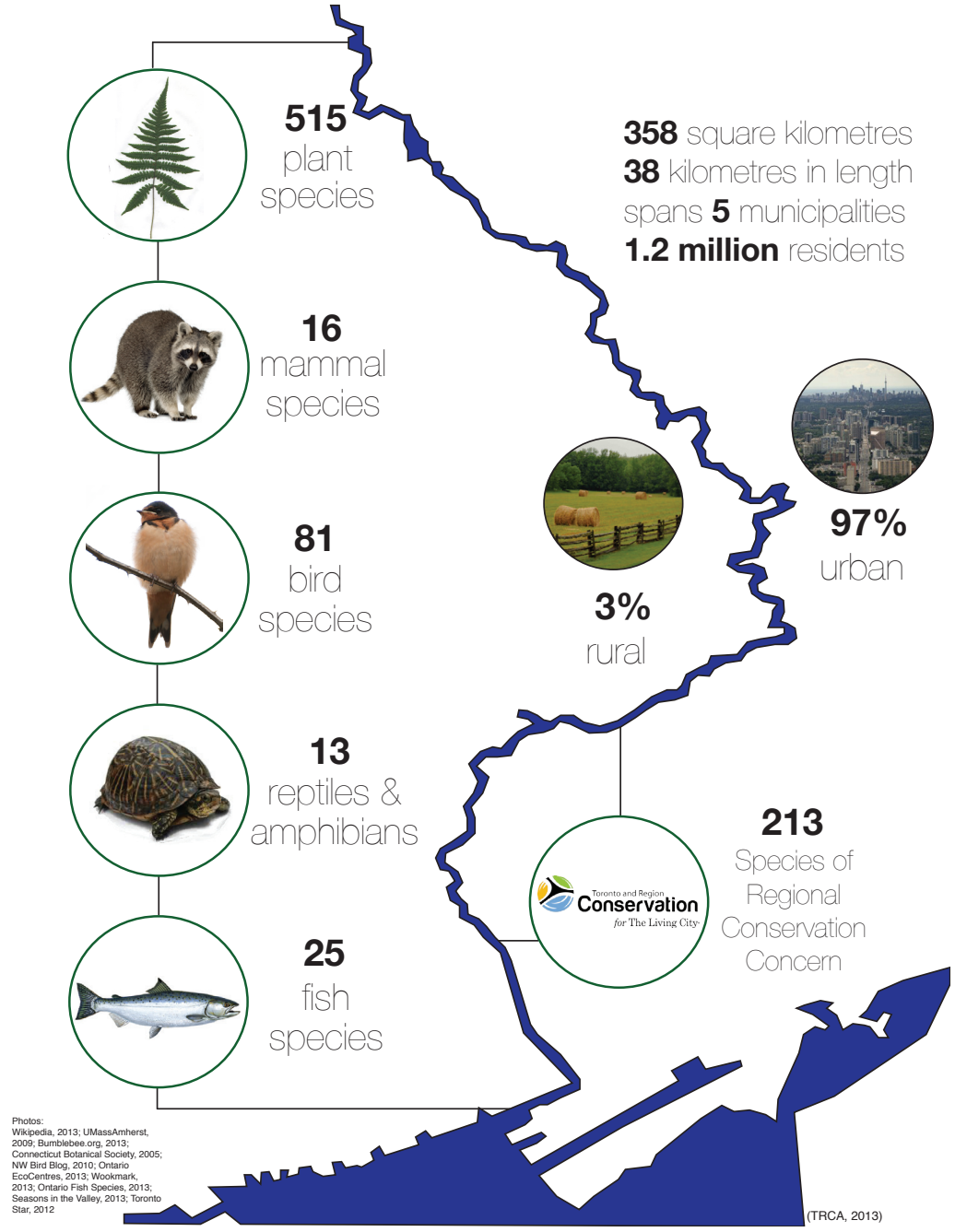
DON RIVER WATERSHED

Flowing south from the Oak Ridges Moraine to the Keating Channel, where it flows into Lake Ontario, the Don River Watershed covers approximately 36,000 hectares, and is close to 38 kilometres in length. It is home to over one million residents, and as a result, there is very little undeveloped land left within the watershed. As a result of colonization and urbanization over the last 200 years, the watershed has experienced intense pressure from human settlement. Changes in both the aquatic and terrestrial landscape within the ravine has led to significant environmental challenges. The natural areas and greenspace within the watershed provide residents within the region with important recreation uses; however, population growth over the next several decades will put added stress on this undeveloped land (TRCA, 2013).

The Don watershed served as a transportation corridor for First Nations peoples and for European explorers, traders and settlers. It's role as a corridor has played a significant role in Toronto's development. It was an important route for voyageurs in the fur trade during the 1700s, a rail corridor by the 1800s, and the site of a main expressway by the 1960s. The construction of the Don Valley Parkway has provided the city with an important transportation route, allowing for the movement of goods and people in and out of the city, however, it has created both visual and noise pollution within the valley (TRCA, 2013).

Prior to the annexation of Riverdale in 1884, the Don River formed the eastern edge of the city. Its place on the periphery resulted in it being largely ignored, and it became a place to discard the city's waste. Sewage outfalls and solid waste were relegated to the river, and the tanneries, slaughterhouses, and oil refineries in the area used the river as a dumping ground. There have been close to 150 unofficial dump sites found throughout the watershed. The history of the Don River demonstrates the environmental costs associated with urbanization (Seymour, 2000; TRCA, 2013).

The city's relationship with the Don has changed significantly over the past few centuries. Early settlers to the area relied on the river for water, lumber, clay and fish. In the late nineteenth century, the river became a polluted and disease-ridden edge to the city, and in the aftermath of Hurricane Hazel in 1954, the city began efforts to restore the watershed as an important ecological landscape within the city. The river has become a symbol of the city's health and the importance of building strong connections between people and their physical environment. Finding ways to enhance these connections and to ensure the city's ecological systems are resilient and functioning properly is an important issue that must be adequately addressed to ensure the future health of the city (Toronto Standard, 2011).



"The challenge for the future will be to protect and restore the natural heritage features of the watershed – regenerating what's been lost, and rehabilitating areas that have been abused – while trying to accommodate the competing recreational demands of a growing number of greenspace users" (TRCA, 2013).

HUMBER RIVER WATERSHED

The Humber River Watershed is the largest watershed in the Toronto region, spanning four regional municipalities and ten local municipalities. It encompasses 911 square kilometers, includes 1800 kilometres of waterway with 600 bodies of water and 750 streams, and is home to over 850,000 people. The ravine stretches from the Niagara Escarpment and the Oak Ridges Moraine down to Lake Ontario. The main branch of the river travels 100 kilometres through a number of natural habitats in both rural and urban landscapes. The watershed runs through many different landscapes, such as the rocky terrain of the Niagara Escarpment, the agricultural lands of the South Slope and Peel Plain, and the ancient Lake Iroquois shoreline. In the same vein, the land uses within the watershed vary significantly. Century farms can be found along the Peel Plain, low density residential areas can be found along the Oak Ridges Moraine, while high-density areas can be found in Brampton, Mississauga, Toronto and Vaughan (TRCA, 2013; CHRS, 2011).

Much like the Don watershed, the Humber watershed has a long history of human settlement. First Nations, followed by European explorers and settlers built their homes along

Photos: Wikipedia, 2013; UMassAmherst, 2009; Bumblebee.org, 2013; Connecticut Botanical Society, 2005; NW Bird Blog, 2010; Ontario EcoCentres, 2013; Wookmark, 2013; Ontario Fish Species, 2013; Seasons in the Valley, 2013; Toronto Star, 2012

(TRCA, 2013)

the watershed. The Humber watershed was home to the Carrying Place Trail, or Toronto Passage, which was an important transportation route that followed a long portage along the banks of the Humber River, and provided a shortcut to the upper Great Lakes. Both aboriginals and Europeans used this trail to travel inland and transport goods. It has been established as one of the oldest transportation routes in Canada, and because of its historical significance, the Federal Historic Sites and Monuments Board has identified it as being an important part of the country's history (TRCA, 2013; CHRS, 2011).

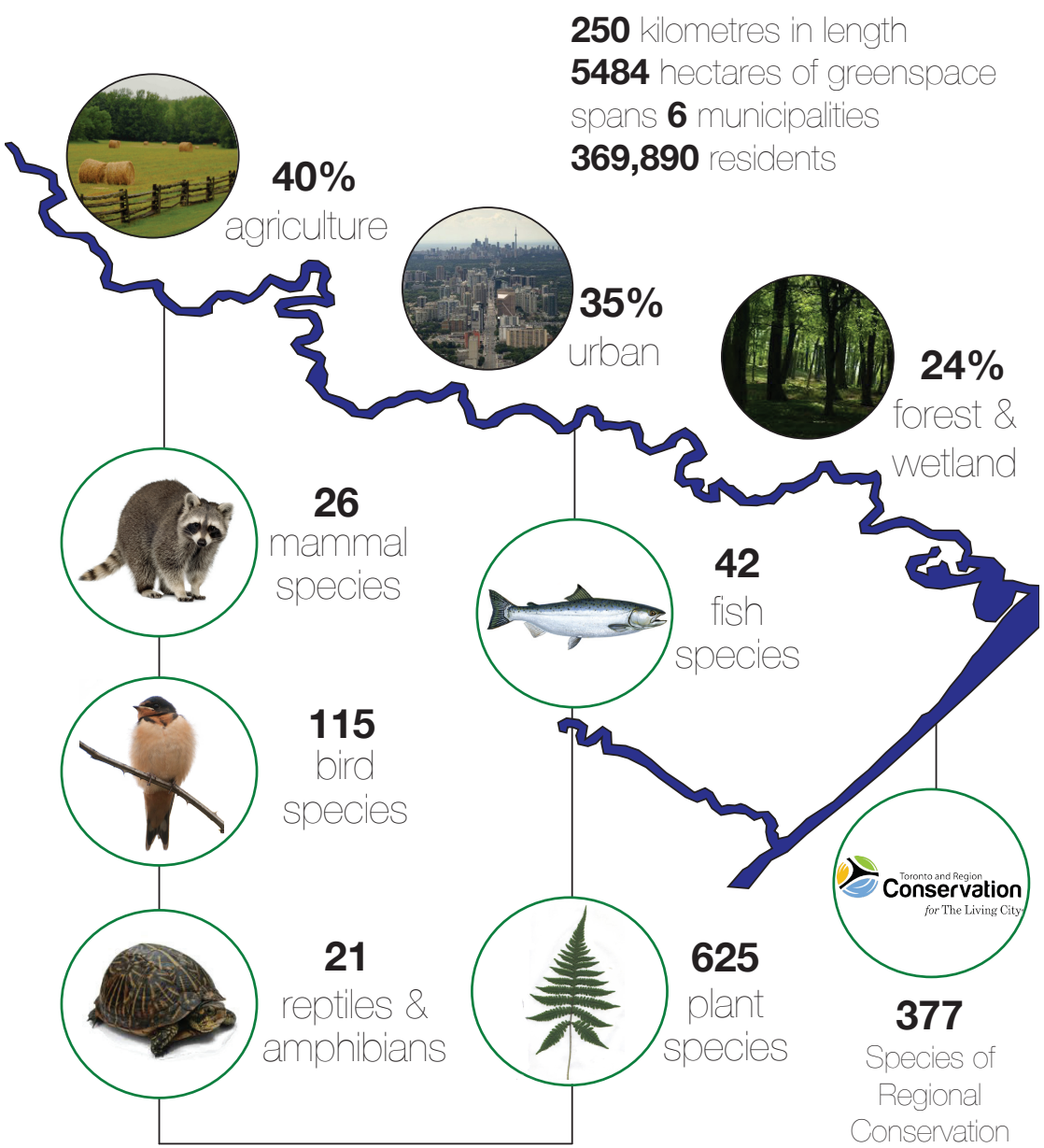
The Humber watershed has undergone many changes throughout its history, particularly in the past 100 years. Environmental concerns in the 1940s stemming from extensive deforestation of the Humber watershed led to the formation of the Humber Valley Conservation Authority. As well, after Hurricane Hazel struck the region in 1954 causing the worst documented flooding the region had experienced, the country's first flood warning system was established and flood plain regulation and management was initiated to ensure the region was protected from future flooding. The Toronto and Region Conservation Authority was also formed in 1957 in the wake of Hurricane Hazel. Because of its recreational values and its cultural heritage, which has contributed to much of the country's development, the Humber River was designated as a Canadian Heritage River in 1999. It is the only waterway in the Greater Toronto Area to receive this designation (TRCA, 2013; CHRS, 2011).

ROUGE RIVER WATERSHED

The Rouge River Watershed encompasses 336 square kilometers of land and water in the Regions of York and Durham, Cities of Toronto and Pickering, and in the Towns of Markham, Richmond Hill and Whitchurch Stoufville. The watershed is comprised of all of the lands that drain to the Rouge River and its tributaries, starting in the Oak Ridges Moraine, flowing down to Lake Ontario (TRCA, 2013).

The Rouge watershed is the healthiest in the city's ravine system, but because of past land use practices, the ravine is showing signs of stress. Restoration efforts are becoming increasingly important to counteract ongoing population growth and subsequent development. There are many parks and conservation areas located within the Rouge watershed; however, Rouge Park is the largest in the area. It is the largest natural park in North America, covering an area of over 47 km2 (11,500 acres). It is situated within the outskirts of the City of Toronto (Rouge Park and Toronto and Region Conservation Authority, 2007) and has been designated by the Federal Government as Canada's first National urban park. As such, the park and its lands are protected. Rouge Park encompasses the lower portion of the Rouge River watershed and is flanked on both the east and west sides by areas of urban development, however urban encroachment remains far less compared to the Don River ravine system. The headwaters of the Rouge River are found in the Oak Ridges Moraine, which is located north of Toronto. The river and its tributaries flow south into Lake Ontario, through marshlands located at Rouge Beach. The park also provides refuge for several rare and vulnerable flora and fauna species such as the rare Carolinian forest, covering less than 1% of the country's land mass (Rouge Park, 2010).

Like the Don and the Humber, the Rouge watershed has an important place in Toronto's history. The Rouge was a route to the north and Lake Huron, and served as a gateway to the fur trade. Iroquois tribes settled along the ravine, establishing a village called Ganetsekwyagon just east of the mouth of the Rouge. In the late 1600s, two priests from Quebec travelled to the area to convert the locals, and after being well received, they established a permanent mission along the river. As settlement within the ravine progressed, lumber and grain was exported, and docks were built to allow for the establishment of boatyards at both the Rouge and Highland Creeks, which allowed for a number of ships to be built (Seymour, 2000; TRCA, 2013).



Photos:
Wikipedia, 2013; UMassAmherst, 2009; Bumblebee.org, 2013; Connecticut Botanical Society, 2005; NW Bird Blog, 2010; Ontario EcoCentres, 2013; Wookmark, 2013; Ontario Fish Species, 2013; Seasons in the Valley, 2013; Toronto Star, 2012
(TRCA, 2013)

REGULATORY FRAMEWORK – PROTECTING TORONTO'S RAVINES

Toronto's ravines play an important role in the city's history, and in distinguishing the city's geographical landscape. In an attempt to preserve and protect the historic and geographic value of the ravines in the city, the Toronto Official Plan has designated the Rouge, the Don, and the Humber as forming part of the city's natural heritage system. Toronto's natural heritage system is an enhancing mosaic that integrates the following features and functions:
Significant landforms and physical features, including hydrological features and functions

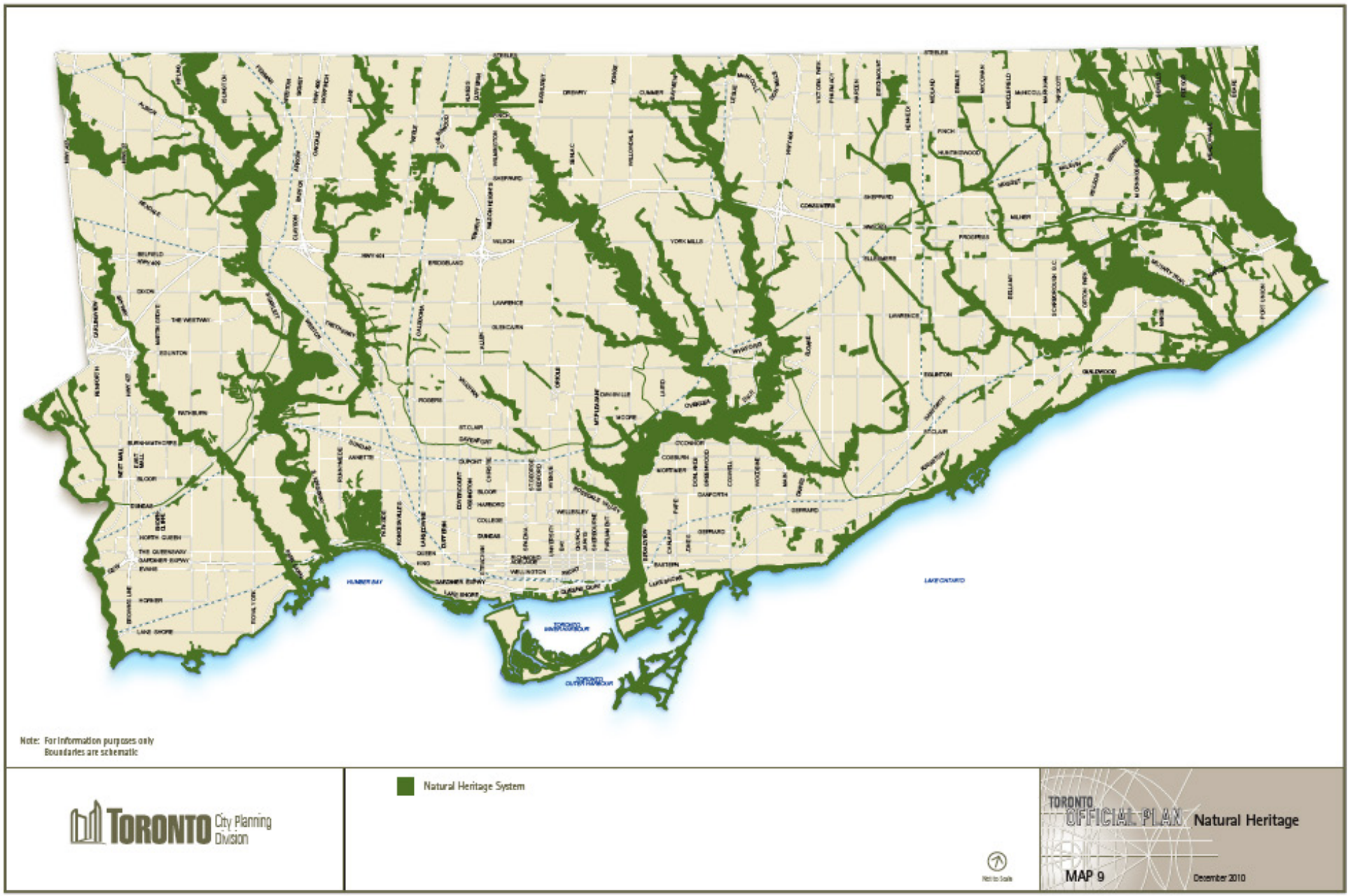
- The riparian zone, which encompasses aquatic habitat adjacent to the watercourse that is essential to a healthy system
- Valley slopes and flood plains
- Terrestrial natural habitat types, including species of concern
- Significant biological features.

As such, the natural heritage system is made up of areas where protecting, restoring and enhancing ecological functions should have high priority in our city building decisions.

The Provincial Policy Statement (PPS) dictates that natural heritage features and areas shall be protected for the long term, and that the diversity and connectivity of natural features and the long-term ecological function and biodiversity of natural heritage systems should be maintained, restored, or where possible, improved. Policy indicates that "development and site alteration shall not be permitted on adjacent lands to the natural heritage features and within significant wetlands in the entirety of Southern Ontario unless the ecological function of the adjacent lands has been evaluated and it has been demonstrated that there will be no negative impacts on the natural features or on their ecological features" (PPS 2005).

Ravine protection is also an important feature of the Toronto Municipal Act. The new Ravine Protection By-law, passed by City Council on October 3, 2002, is a tool to protect features (trees and landform) and functions (ecology and hydrology) of the ravine system by encouraging environmentally responsible management. The new By-law replaces previous ravine by-laws and expands the area of protection to the entire city.

Planning and enhancing the natural environment and biodiversity is a high priority for the City of Toronto. The Official Plan protects important natural areas and functions, and requires that the natural environment be taken into account as part of



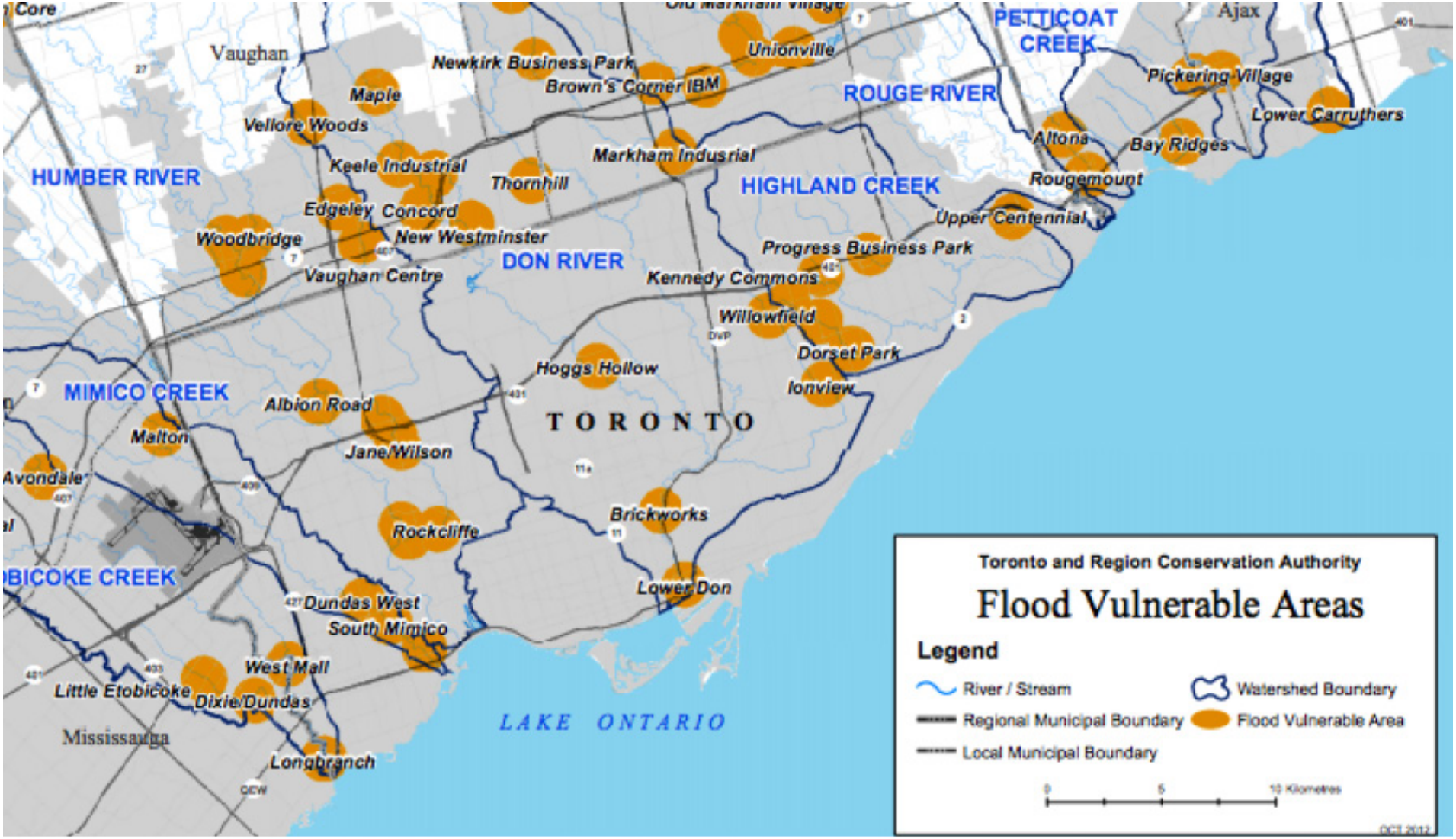
(Source: City of Toronto, 2011)

our city building activities.

Toronto's natural heritage features and functions have been mapped and are identified as a Natural Heritage System in the Official Plan. Most of these areas are located within the extensive network of valleys and ravines that cross the city, and are protected by zoning and land use designations. These areas provide habitat for a wide variety of native plants and wildlife, and help sustain local biodiversity. When a new development is proposed in or near the natural heritage system, the proposed development's impacts must be evaluated, and measures taken to protect and improve the system to mitigate negative impacts. Furthermore, policies aim to protect the ravine system by stating that any changes to the built environment must reduce the risk to life, health, safety, property, and ecosystem health.

In terms of land use, the Humber, Lower Don, and Rouge watersheds vary. In each watershed, land use designations are largely "natural areas", but also consist of land designated as parks and open spaces. Development is generally prohibited within parks and open space areas except for recreational and cultural facilities, conservation projects, cemetery facilities, public transit and essential public works and utilities. An important feature of the parks and open space designation is that, where possible, linkages between parks and open spaces are to be created in order to provide continuous recreational corridors (Toronto OP).

Finally, though not identified in the Official Plan, the Ministry of Natural Resources (MNR) has identified Hazard Lands within all three watersheds. In conjunction with Official Plan policies pertaining to the floodplain, hazard lands are areas that are hazardous to life and property because of erosion and flooding.

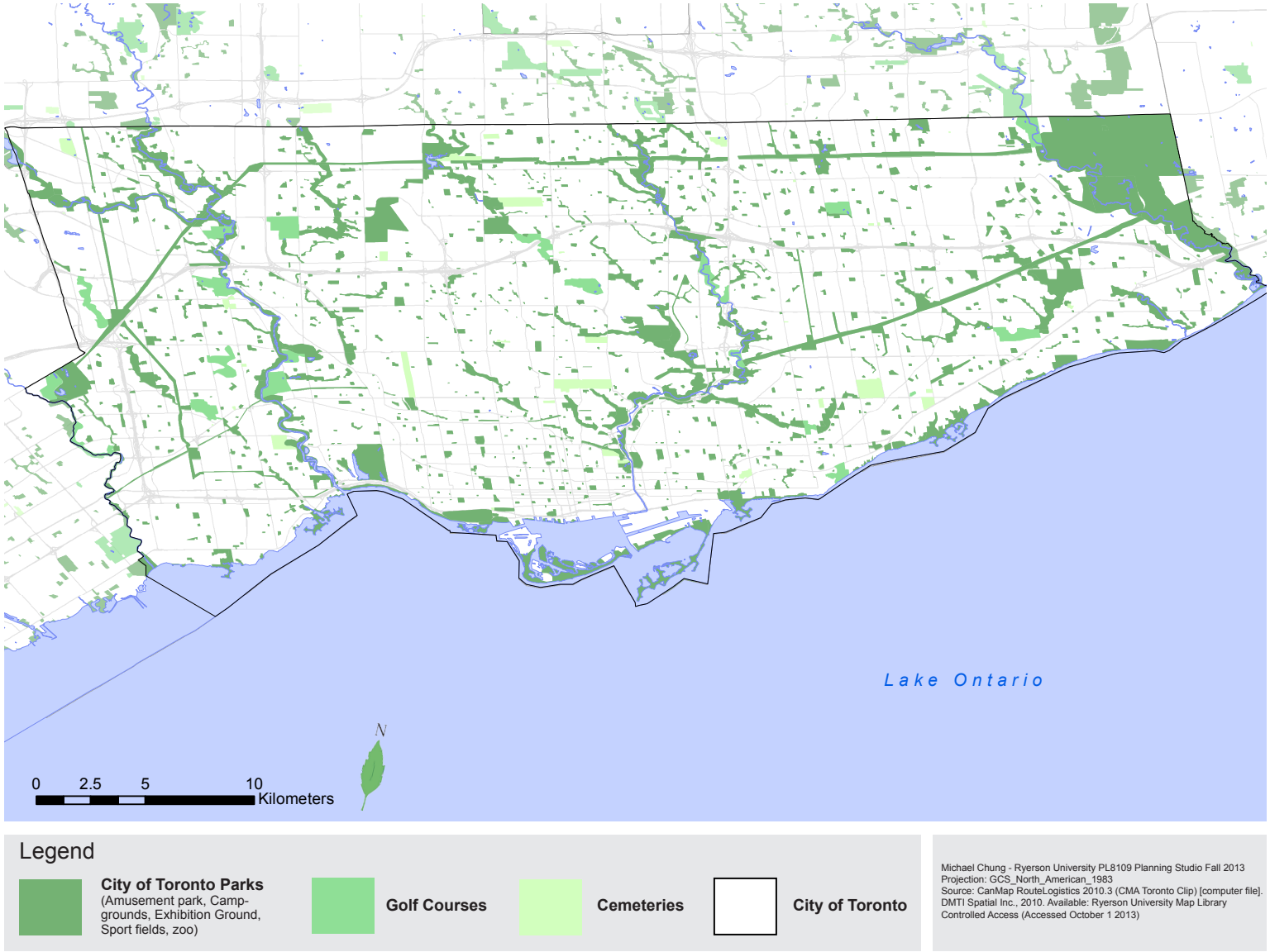


(Source: Toronto and Region Conservation Authority)

COARSE GRAIN CONNECTIONS

'Coarse grain' refers to large-scale, city-wide connections

This map shows all of the possible landscape connections in the City of Toronto. It includes conventional greenspaces like parks and natural heritage areas, as well as contributing greenspaces like hydro corridors, golf courses, and cemeteries. It is important to consider these contributing greenspaces as part of the city's overall greenspace network because they provide an opportunity to improve the connections between and within Toronto's ravine system.

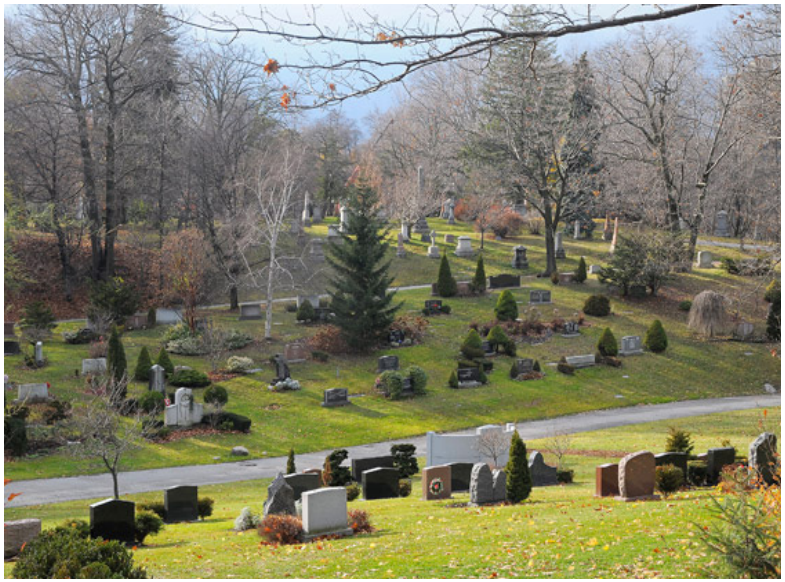


Private Greenspaces - Golf Courses and Cemeteries

Privately owned golf courses and cemeteries play a contributing role in the city's greenspace network. There are currently two golf courses that border the Humber River and one that borders the Don River. They allow the movement of wildlife along the water's edge with minimal safety concerns. As well, nocturnal species can benefit from these spaces, as they tend to be used only during the daylight hours.

Mount Pleasant Cemetery is a large greenspace that is largely undisturbed by the surrounding roadways. As well, this cemetery provides linkages to the Lower Don Trail along the Beltline Trail through Moore Park Ravine and David Balfour Park.

Including these types of greenspaces in our thinking about landscape connectivity can generate better ideas about how landscape connectivity can be improved within the city.



Mount Pleasant Cemetery
(Photo Source: Flack, 2009)

Don Valley Golf Course
(Photo Source: City of Toronto, 2013)

Park Space and Trail Connections

Parks provide valuable greenspace within Toronto, especially in dense areas. Parks contribute to the city's network of greenspace, and provide important connections throughout the city. The addition of new park space can improve linkages within the city's landscape. The expansion of the Waterfront Trail along Lake Ontario, which will better connect the three watersheds, is a good example of how new or redeveloped park space can provide better connections and access to other natural areas within the city.

Toronto's Official Plan contains a designation for Parks and Open Spaces and stipulates that linkages between parks and open spaces should be obtained where possible. Creating continuous corridors for users between parks and open spaces has the potential to improve the recreational user experience and provide residents with greater accessibility to greenspace. Additionally, improved connections between parks and open spaces can provide better linkages for wildlife, and can contribute to the amount of suitable habitat they can access. Overall, park space provides important connections for both humans and wildlife, and improves the health of the city as a whole.

Trinity Bellwoods Park, Toronto
(Photo Source: Kluke, 2013)

Trail in Crothers' Woods
(Photo Source: Flack 2011)

Transit Corridors as Greenways

Transit corridors can be 'greened' to improve streetscapes and increase the permeability of streets. A reduction in the amount of surface water runoff that is directed to the city's storm-water management system can mitigate the effects of heavy rainfall. Increasing the amount of greenspace along city streets can also create symbolic or visual connections to surrounding greenspaces. A number of cities in Europe and North America utilize green trackways.

As part of Metrolinx's Big Move project, they have developed plans for the implementation of a series of new transit corridors. The Eglinton Light Rail Transit (LRT) line from Mount Dennis to the Golden Mile in Scarborough is on such project. When completed, it will provide an important connection between the Humber and Don ravines. Within the plan, significant emphasis is placed on greening sections of the LRT corridor. There are a number of options for greening, including the inclusion of a mature tree canopy, the provision of direct linkages to the ravines from bordering stations, providing better connections to adjacent parks and open space, and installing low maintenance grass on the above ground portion of the LRT tracks. Greening this transit corridor is important because it will contribute to a better-connected network of green space within the city, particularly because the LRT route passes over existing green space, including the Gatineau Hydro Corridor. While greening the LRT tracks will contribute to the city's network of green space, it will not enhance the mobility needs of wildlife. As such, measures should be taken to ensure the safety of wildlife along the LRT route.

Le Tramway, Paris - Before greening
(Photo Source: City of Toronto, 2013)

Le Tramway, Paris - After greening
(Photo Source: City of Toronto, 2013)

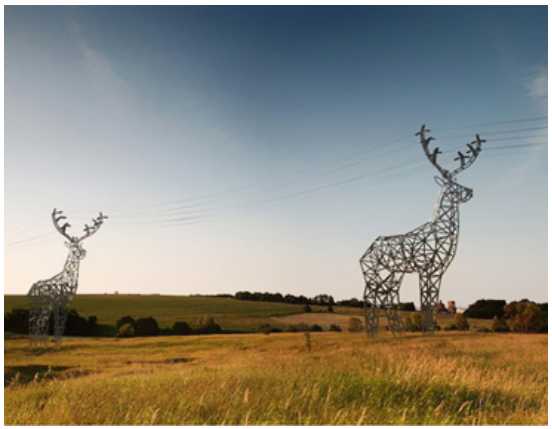
Light rail on grass tracks, Freiburg
(Photo Source: Silver Spring Trails, 2012)

Lawn trackage flanked by privet hedges, Basle, Switzerland
(Photo Source: Smiler, 2013)

Hydro Corridors

Hydro Corridor Path
(Photo Source: Biking in a Big City, 2011)

"Corridors and connections are often in the spaces between preserves, the mixed use spaces occupied by human communities. Bridging barriers for wildlife means bridging the needs of the people living in that landscape" (Lester, 2012).



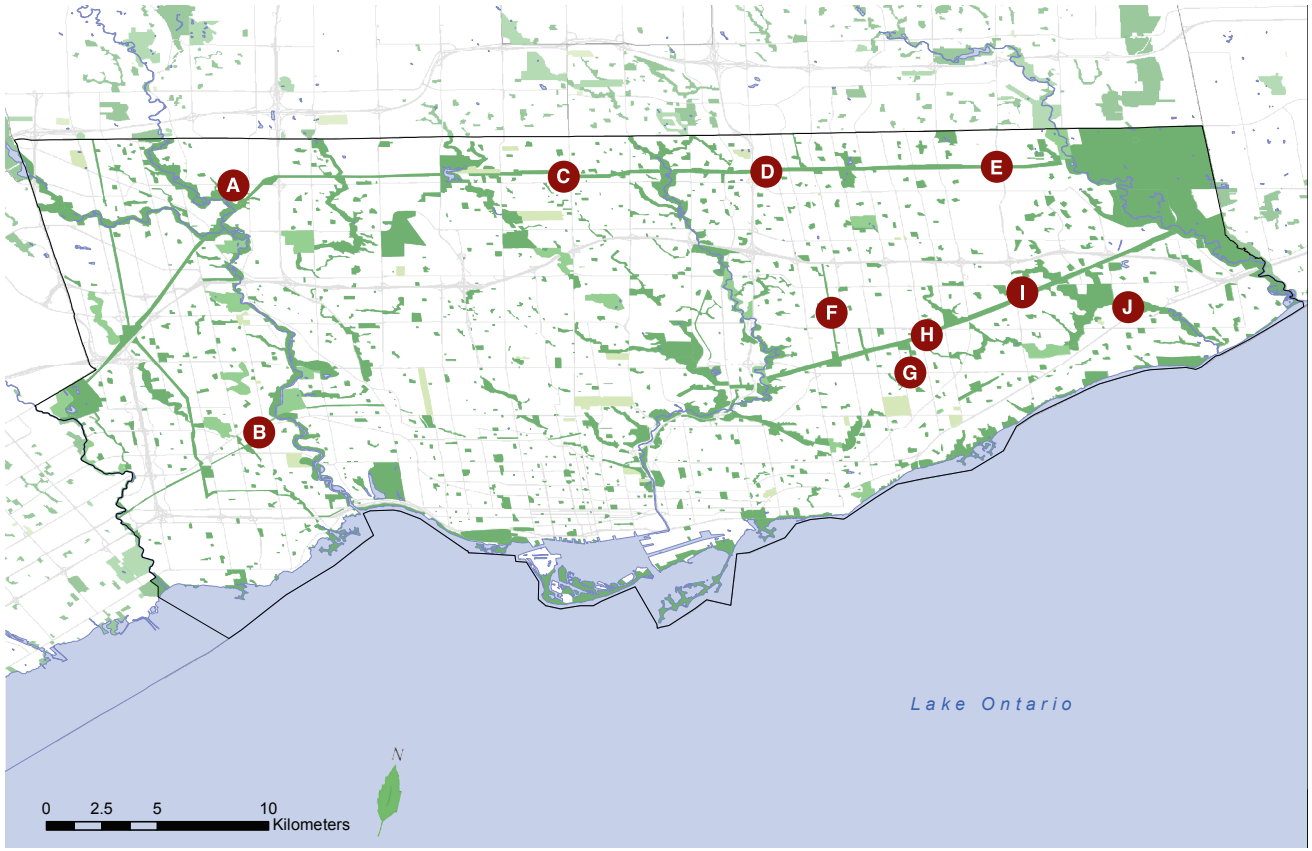
A symbolic wildlife connection - Deer-shaped hydro pylons, Moscow
(Photo Source: The Electric Blog, 2013)

Within natural environments, hydro corridors are viewed as 'disturbance corridors', as they are disturbed lands that differ from their surrounding environment. However, in an urban setting, hydro corridors can provide important linkages to other green spaces or natural systems within the city (Bennett, 2003).

The City of Toronto is currently working to create multi use paths within the city's various hydro corridors. These trails are part of a larger network of trail projects the city is currently working on to help provide residents and visitors with greater access to green space. As well, these paths will be part of Toronto's Bikeway Network, which will help provide linkages for cyclists across the city. The projects are being funded through the Recreation Infrastructure Canada (RInC) program, and will be managed as a joint initiative between Transportation Services and Parks, Forestry & Recreation. New amenities, such as benches, bike parking, waste bins, landscaping, light fixtures, and crossing signals will be placed along the trail, particularly at major intersections. As well, safe crossing infrastructure will be implemented at major road crossings (City of Toronto, 2013).

Opportunities for wildlife connectivity

While these projects will improve connections for human users, such as cyclists, runners and pedestrians, the projects lack a vision for creating better connections for wildlife in the city. In places where safer road crossing infrastructure is being implemented, there are opportunities to determine areas where wildlife crossing infrastructure can also be implemented to reconnect fragmented habitats, and to foster greater ecological connectivity within the city. As each area map shows, there are a number of roadways that intersect each corridor, and as such, there are a number of opportunities for further study into how wildlife crossing structures can be integrated into the trail system.

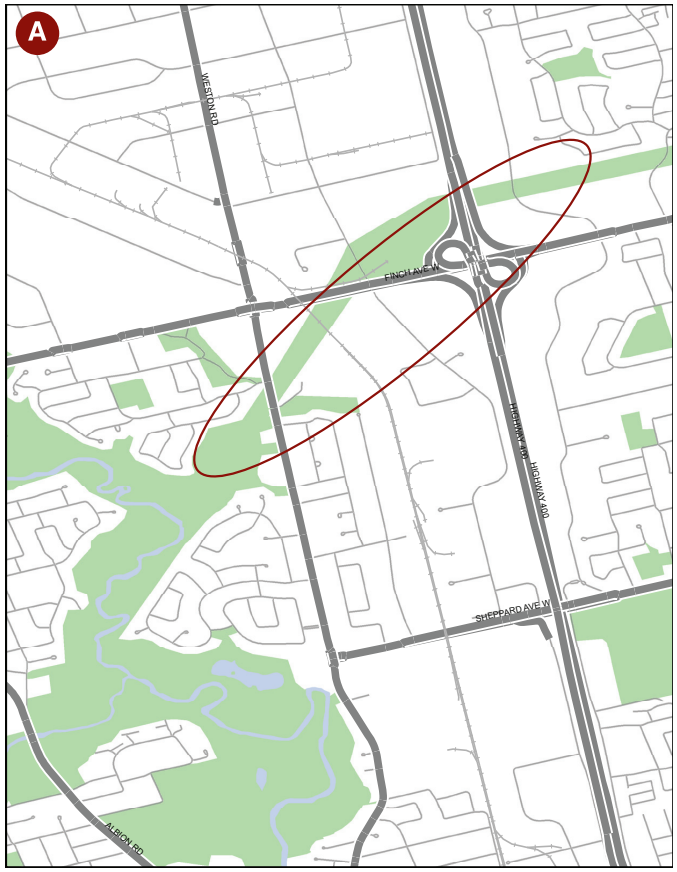


Sites within the city's hydro corridors identified by the City of Toronto for trail redevelopment projects.

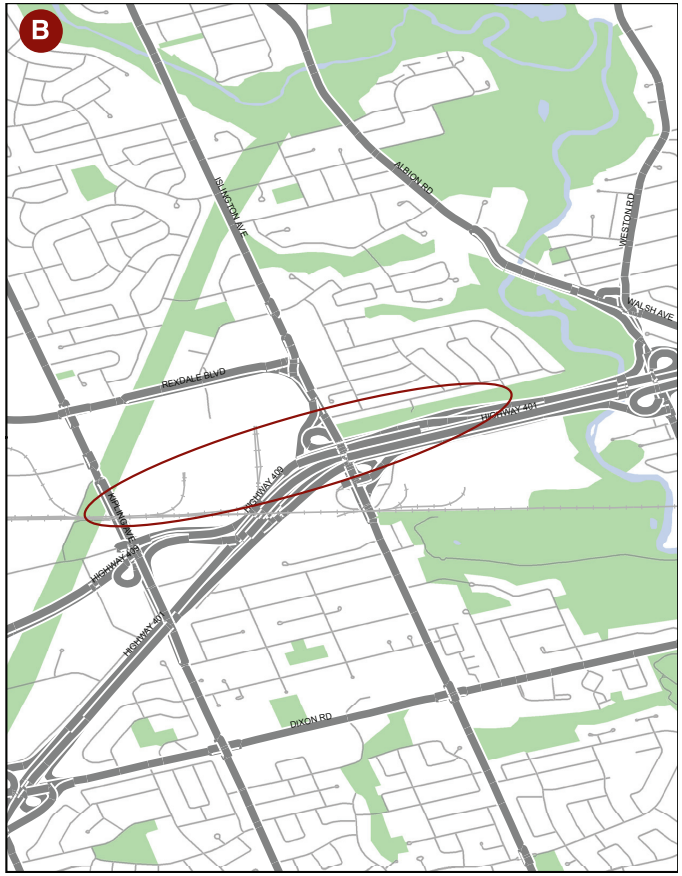
Finch Hydro Corridor, Toronto
(Photo Source: Micallef, 2008)

Gatineau Hydro Corridor, Toronto
(Photo Source: Dodge, 2011)

Sites A & B



Humber Valley
(3.4 km from east arm to Finch Hydro Corridor Trail)
This project will provide an important link between the Humber Trail and the Finch Hydro Corridor across the HWY400 corridor. A feasibility study is required to determine alignment options, approvals and costs.
(City of Toronto, 2013)

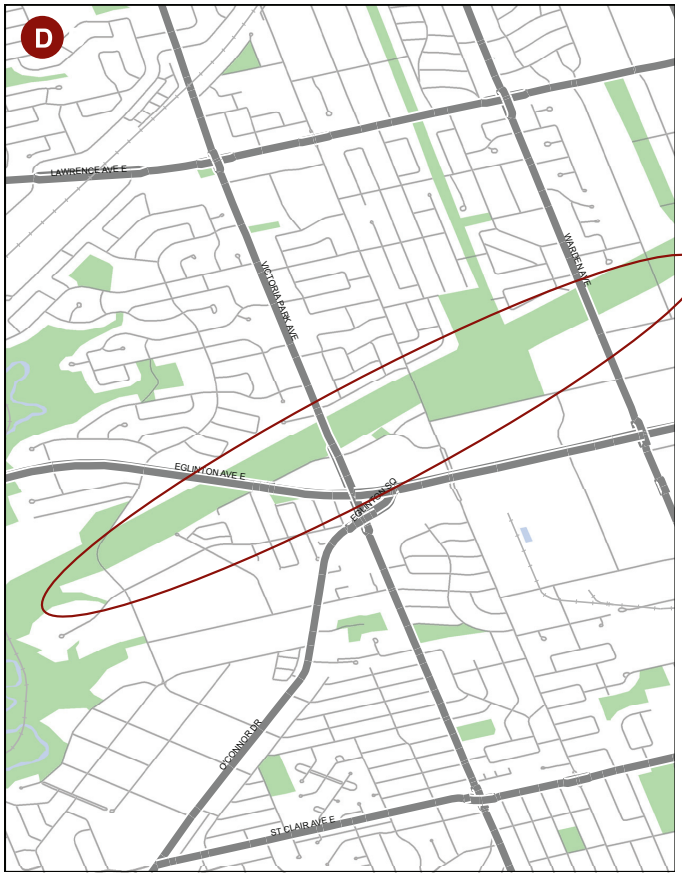


Etobicoke Creek Hydro Corridor
(2.7 km from Namco Road to Humber Trail)
This project will provide trail alignment mainly within the hydro corridor connecting the Humber Trail (Irwin) to Etobicoke North GO Station (Kipling Avenue).
(City of Toronto, 2013)

Recommendation
Construct an overpass crossing structure over HWY400.

Sites C & D

Yonge Street to Don Trail (5.2 km)
This project will extend the Finch Hydro Corridor Trail east from Hendon Park (just west of Yonge Street) to the Don Trail system. A connection through TTC/GO parking lots needs to be resolved to complete the trail. The city is proposing a temporary on-street route along Cummer/Drewry. The missed connection that currently exists provides an opportunity for the city to determine how better connections can be made for wildlife in addition to the enhanced connections being created for human users of the trail.
(City of Toronto, 2013)

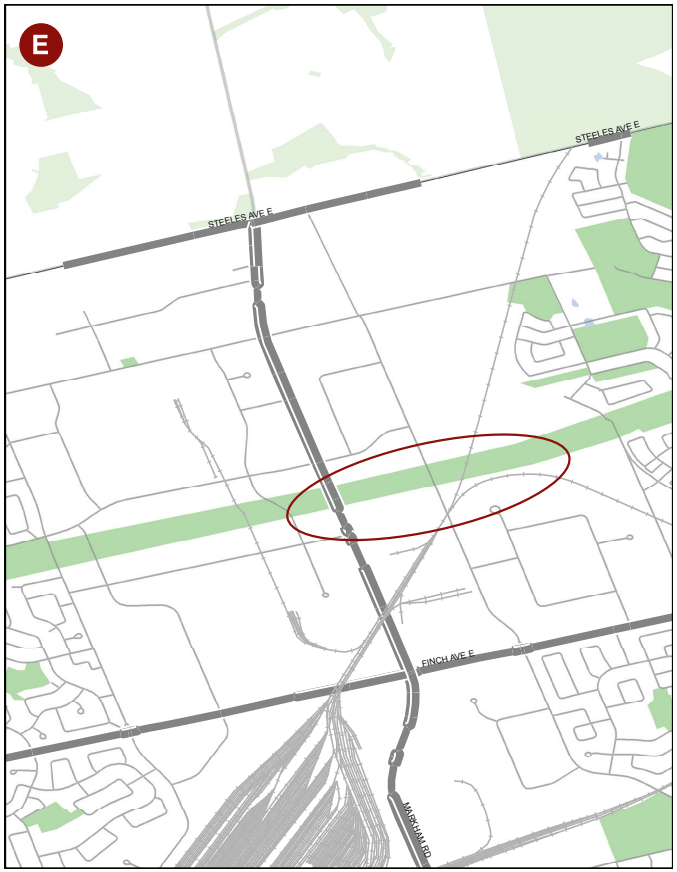


Don Trail to Birchmount Road (5.7 km)
This project extends the Finch Hydro Corridor Trail east from the Don Trail to Birchmount to connect with the existing Scarborough Finch Hydro Corridor Trail.
(City of Toronto, 2013)

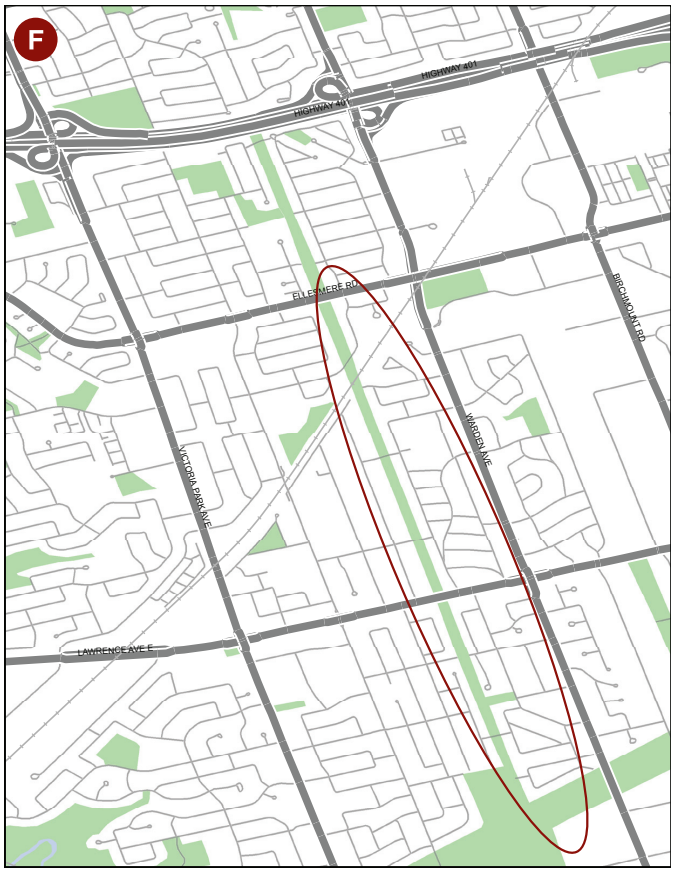
Recommendation

Construct an overpass crossing above the TTC/GO parking lots to provide a safer route for humans and wildlife.

Sites E&F



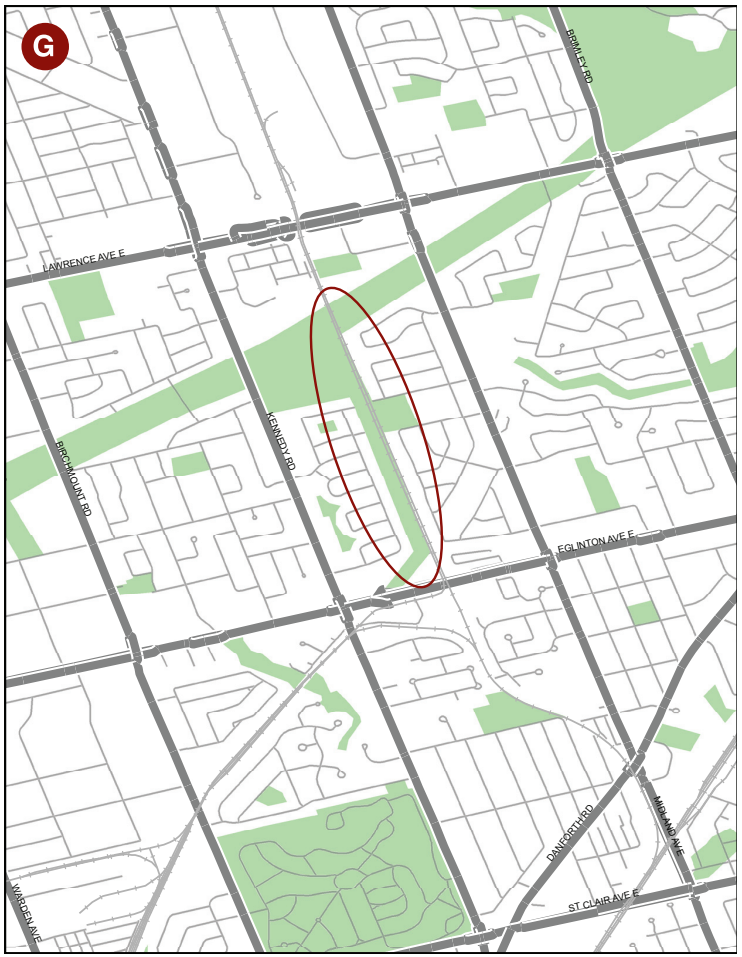
Finch Hydro Corridor East Connection + Scarborough Rail Trail Connection (4.7 km)
This project will extend the Finch Hydro Corridor Trail east from Middlefield Road to Morningside Avenue to connect the existing Scarborough Rail Trail. Before work on this trail can begin, a feasibility study is required to evaluate alignment options, including potential on-street connections. This feasibility study provides an opportunity to evaluate where and/or how wildlife crossing structures or connectivity measures can be implemented in this area.
(City of Toronto, 2013)



Warden Hydro Corridor (4.1 km)
This project will develop a trail within the Warden Hydro Corridor (east of Warden) connecting the existing Gatineau Hydro Corridor Trail north to Ellesmere Road.
(City of Toronto, 2013)

Recommendation
Construct an underpass or overpass crossing where major roads intersect with each hydro corridor.

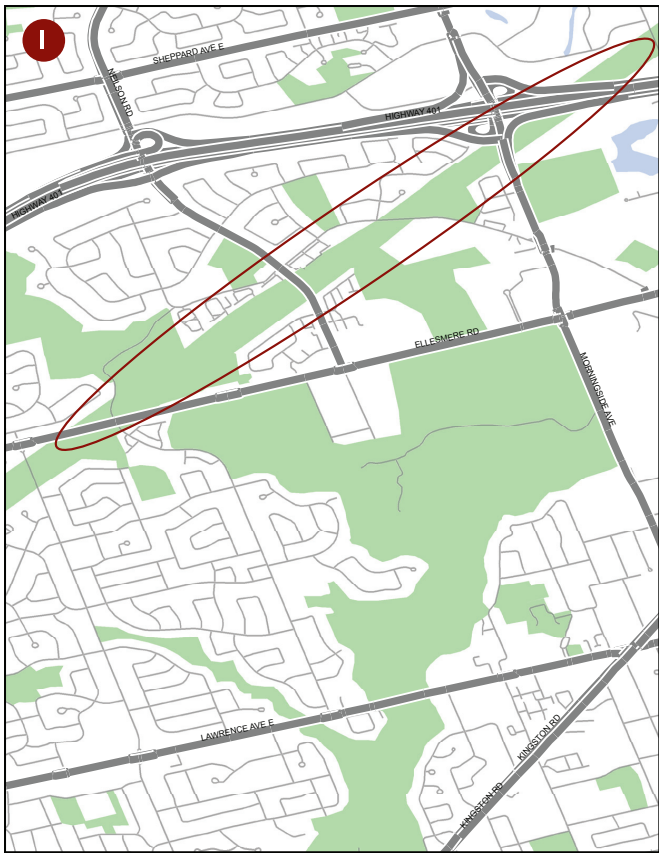
Sites G & H



Mooregate Avenue to Kennedy TTC Station
This project will create a trail along the Taylor Creek Hydro Corridor from Mooregate Avenue to the Kennedy TTC Station. This trail will connect with the existing Gatineau Hydro Corridor Trail (City of Toronto, 2013).

Victoria Park to Mooregate Avenue
This project will provide upgrades to the existing Gatineau Hydro Corridor Trail from Victoria Park to Mooregate Avenue. (City of Toronto, 2013)

Sites I & J



Gatineau Hydro Corridor Connection
(3.4 km from Ellesmere Road/Military Trail to Conlins Road)
This project will close the gap in the Gatineau Hydro Corridor between Scarborough Golf Club Road and Conlins Road. A feasibility study is required to evaluate route alignment options, including within the Ellesmere Road right-of-way.
(City of Toronto, 2013)

Lower Highland Creek
(2.9 km from Gatineau Hydro Corridor Trail to Highland Creek Trail)
This project will provide an important connection between the Gatineau Hydro Corridor Trail, Highland Creek Trail and the Waterfront Trail. A trail along Highland Creek is not viable because of flooding and erosion concerns. A feasibility study is required to evaluate route alignment options, including on-street and private property access. TRCA approval is also required. An assessment of wildlife connectivity within the area should coincide with the feasibility study (City of Toronto, 2013).

Recommendation
Assess the possibility of constructing wildlife crossing structures when the feasibility studies for these projects is undertaken. If there is an on-road portion of trail, an overhead crossing structure should be constructed.

Expanding Parks and Open Space

As Toronto continues to grow and become more densely populated, there will be an increased need to expand the amount of greenspace available for public enjoyment, and to maintain wildlife habitats. The current strains being put on wildlife habitats within the city is a consequence of rapid urban growth, but through greenspace preservation and expansion practices, these effects can be mitigated. Chicago's Go to 2040 Plan highlights the need to increase the amount of preserved greenspace as the population grows. The efforts in Chicago focus on land preservation along waterway corridors, enhancing forest conservation and developing a collaborative approach between private and public organizations. In the City of Ottawa, a Greenspace Master Plan provides tools to develop and preserve greenspace networks. These tools include "covenants, easements, agreements with landowners and progressive land management techniques" such as restrictive legislation (Greenspace Master Plan, 2006, page 22). Purchasing new land, or acquiring land through exchanges and donations are other ways the city can obtain new greenspace to adequately meet the needs of residents and wildlife. The City of Toronto can look to Chicago and Ottawa for ideas about how to expand its network of greenspace.

South side pedestrian promenade along the Queen's Quay portion of the Waterfront Trail.
(Photo Source: Bricoleurbanism, 2007)

Ecological Rehabilitation

Ecological rehabilitation also provides a means by which the city can expand its greenspaces.

Since the Industrial Revolution, humans have tended to view nature as being external to the city. Urbanization has led to a collision of humanity and nature, with landscapes continuously being conquered. When nature is considered, it is viewed merely as an amenity to be preserved in pockets, or replicated in small 'green spaces'. Urban expansion has led to significant resource depletion and fragmentation of natural areas. When fragmented, natural areas become isolated pockets surrounded by hard urban edges. Ecological restoration is one way by which the relationship between urban space and natural landscapes can be better supported.

Ecological restoration attempts to re-establish the key ecological structures and functions of natural systems to allow them to return to a self-organizing and self-sustaining system (Bunting & Filion, 2010). Due to the extent of human interference, this process is extremely difficult. Ecological rehabilitation is a more practical solution, and so is preferred over restoration measures. Rehabilitation seeks to mitigate the worst impacts of pollution and human interference on natural systems to restore some of their original ecological function (Sartori and Assinni, 2001).

Ecological rehabilitation is a means by which better connections can be made within Toronto's ravine system. Currently, hard infrastructure, such as paved roads and highways, carves its way through large portions of the city's natural systems, which has resulted in significant habitat fragmentation. All that remains are isolated patches of suitable habitat, but these patches are being put at further risk because of human interference (Murphy and Martin, 2001). Small habitats support fewer species and smaller populations, leading to genetic isolation and local extinction. To improve connectivity in fragmented landscapes, corridors and stepping stones are often used. Corridors are relatively narrow, linear strips of green space or vegetation between isolated habitat areas, while stepping stones are small unconnected patches of habitat that are close enough together to allow movement across the landscape (Vaughan et al., 2010).

In our area of study there are already efforts underway to naturalize the mouth of the Don River. The Toronto and Region Conservation Authority (TRCA) in cooperation with the Toronto Waterfront Revitalization Corporation (TWRC) is proceeding with the Don Mouth Naturalization and Port Lands Flood Protection Project (DMNP). The implementation strategy for this project is unknown at this time; however, its mandate is underpinned by several reports including the 1991 Bringing Back the Don and in 1994 the Forty Steps to a New Don. The work done by the

TRCA in this area highlights the appetite for, and inertia behind, efforts to re-naturalize or rehabilitate natural areas in and around Toronto's three major ravine systems.

There are numerous other examples of naturalization projects within the three watersheds:

- Work on the re-naturalization of Upper Mimico Creek began in 2006 and is still underway (TRCA, 2009). As part of their efforts to re-naturalize the creek, TRCA and its partners constructed three wetlands, planted 900 metres of aquatic and riparian vegetation, installed wildlife habitat structures, removed hard engineered structures and planted almost 2000 new trees and shrubs (Ibid.).

Rendering of a renaturalized Lower Don Trail (Photo Source: Bricoleurbanism, 2007)–

- Similar work was done for the East Don Parklands Wetland Enhancement Project, where new wetlands and riparian and for est habitats were created (TRCA, 2013).
- The TRCA and its partners have also done considerable work along areas of the Rouge River. Marshland north of the Toronto Zoo had been damaged as a result of an old drainage ditch, but has since been revitalized, and is now home to many species that were previously forced to vacate the site (TRCA, 2013).
- The Port Union Waterfront Park was created in Scarborough and features a series of six headlands and cobble beaches along Lake Ontario, as well as an elevated boardwalk and an important pedestrian bridge spanning the mouth of the Rouge River (Ibid.).
- On their webpage, TRCA lists 14 different environmental restoration projects in the Humber watershed, spanning 5 different municipalities (TRCA, 2013).

The work done by the TRCA in these areas highlights the momentum for efforts to re-naturalize/rehabilitate natural areas in and around Toronto's three major ravine systems.

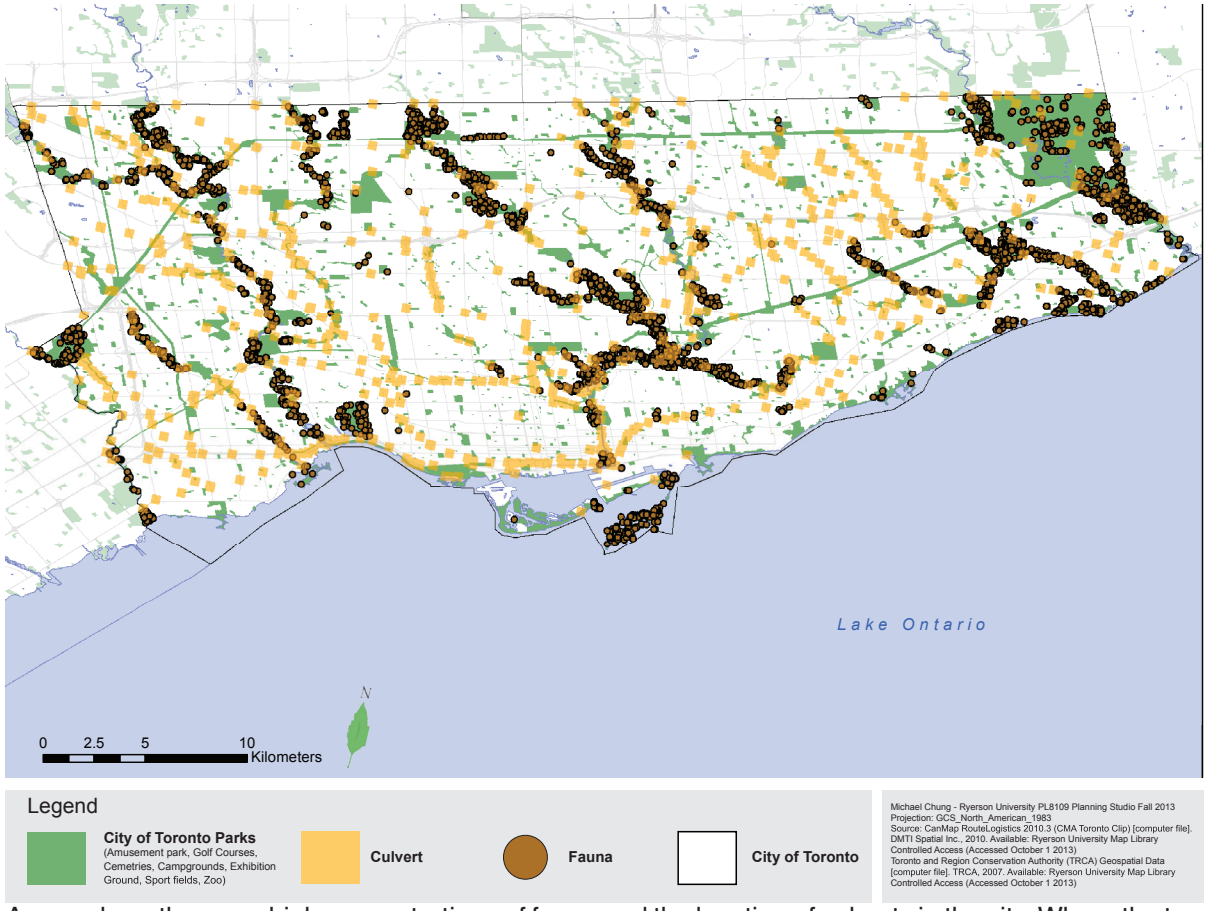
Finally, and most importantly, in order to achieve measurable and long-lasting success, social perceptions need to be addressed. The viability of rehabilitation efforts, especially those in and around urban areas, hinges on how socially successful they are in gaining public acceptance for restoration activities and practices, and building broad-based support to assist with implementation and maintenance.

Rendering of a renaturalized Don River

(Photo Source: Bricoleurbanism, 2007)

FINE GRAIN CONNECTIONS

'Fine grain' refers to site-specific connections, such as those in the Humber, Don and Rouge watersheds.



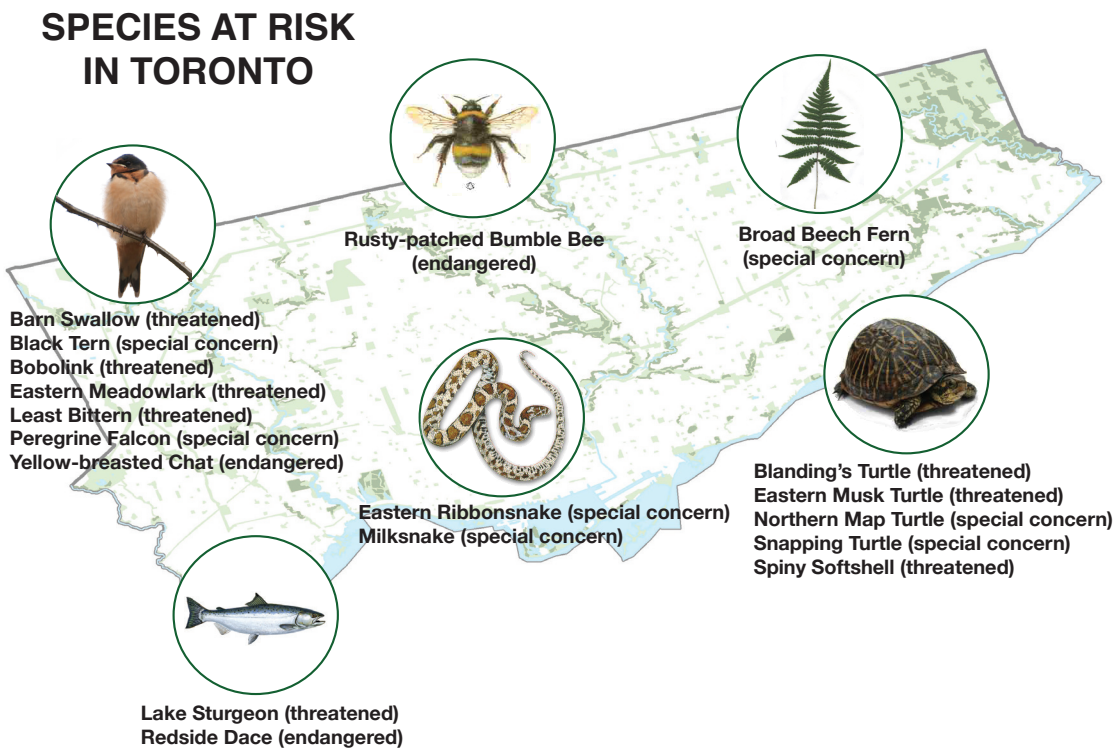
Areas where there are high concentrations of fauna and the location of culverts in the city. Where the two intersect, opportunities exist to adapt the culverts to be used as crossing structures.

The influence of human activity within Toronto has grown steadily more harmful to natural systems over the last 300 years, and has resulted in varying degrees of habitat fragmentation in the ravine system (Toronto, 2013).

As animal habitats become fragmented due to human transportation corridors and urban expansion, methods are required to ensure that connectivity between the fragments is maintained and will ensure animals remain safe when moving among the fragments. Different animals are affected more severely by the fragmentation of their habitats as they search for resources and reproduce (Majka, 2013; OREG, 2013). The resilience of different species is reliant upon the connectivity of their ecosystems and by ensuring that there are safe linkages between fragmented habitats to reduce the number of human-animal interactions. Many of these interactions occur on roadways and transit corridors, resulting in costly animal fatalities (OREG, 2013).

All three of Toronto's ravines exhibit some form of habitat fragmentation. Generally, the concentration of clusters for amphibians, reptiles, and small mammals are greater in the areas of the ravine system that have managed to maintain significant amounts of tree cover and natural feature, whereas areas with larger concentrations of infrastructure possess fewer wildlife clusters. In the Don watershed, the vast amounts of highway, road, and rail infrastructure have significantly fragmented the natural landscape. In combination with the channelization of the Lower Don, these infrastructure barriers have resulted in significant changes to the distribution of species (Toronto, 2013). Because of the industrialization of the waterfront, as well as its location adjacent to the City's downtown, the Lower Don (that is to say the area south of the Evergreen Brickworks) has very little tree cover, and as a result, limited clusters of animal populations. This example highlights the importance of habitat suitability in attracting diverse and resilient populations of wildlife.

Addressing habitat fragmentation at all scales will also aid in the protection of endangered species. Among many other species of special concern, the Ministry of Natural Resources has currently identified nearly twenty threatened or endangered species in the Toronto Region, including the Yellow-breasted Chat, the Redside Dace, the Rusty Patch Bumblebee, the Blanding Turtle, the Eastern Musk Turtle, the Spiny Soft Shell Turtle, the Barn Swallow, and the Eastern Meadowlark (Ministry of Natural Resources, 2013). These species should be awarded special attention whenever human infrastructure is threatening to bisect natural landscapes. Moreover, the use of mitigation me asures and/or crossing structures that minimize the impacts to these species when capital road projects or road reconstruction projects are proposed in proximity of their habitats should be made a priority.



Ministry of Natural Resources, 2013
Photos: Wikipedia, 2013; UMassAmherst, 2009; Bumblebee.org, 2013; Connecticut Botanical Society, 2005; NW Bird Blog, 2010; Ontario Fish Species, 2013

Assessments completed to date suggest that nonfunctioning crossing structures are prevalent (Podloucky, 1989; Meinig, 1989). The failures of such structures appear to stem from inadequate considerations of placement, architectural design, and behavior of targeted organisms (Podloucky, 1989; Puky, 2003). Having completed a survey of literature on safe animal crossings, some best practices will be illustrated, with a focus on examples from Ontario. In summary, crossing structures can take several forms. Some are built specifically for the movement of wildlife, whereas others are originally designed for other purposes but also have the potential to facilitate wildlife dispersal across roads (MTO, 2006). Many technical solutions have been developed, mainly as a result of engineering inventions. There is no standard solution, and the actual plans are influenced by several factors, such as the spatial patterns of migration, species composition, and local topography (Woltza et al, 2008). That being said, there are two main classifications of crossing structures that dominate the literature. Overhead crossings are structures that span overtop of roadways in order to allow wildlife to maintain migration and breeding patterns in a fragmented ecosystem (OREG; Ontario, 2010). The advantage of these structures is that they are not confining and provide exposure to ambient conditions, such as rainfall, temperature, and light (MTO, 2006). The disadvantage to these structures is that they are very expensive to build. Because of the cost, these structures should be reserved for areas where very high numbers of animals (such as deer and elk) are known to disperse and in areas of deep forestation (Jackson & Griffin, 1998). These types of structures are therefore not likely to be required in a major urban center like the City of Toronto, unless combined with a solution for a pedestrian or bikeway overpass. Underpasses are the other main class of crossing structures. Rather than going overtop of the road, underpass crossings allow for increased linkages in the landscape by going underneath roadways. There are many different sizes of underpass crossings, from open span bridges to box culverts. Underpass crossings are generally not confining, but they do require the road above to be elevated (MTO, 2006). The advantages of this type of crossing structure in relation to their overpass counterparts is that they are generally less costly, particularly if they are implemented as part of a capital road project or a road reconstruction project (TAC, 2008). Furthermore, higher underpass crossing structures will increase openness, and therefore produce more natural conditions. The disadvantage of these structures is that they can sometimes be noisy if appropriate substrates are not used. The following best practices will focus on various types of underpass crossings that are recommended for improved wildlife connectivity in Toronto.

Large-scale underpass crossings

Large-scale underpass crossings in the form of open span bridges provide improved ecosystem connectivity by spanning natural drainage areas (OREG, 2013). Re-adapting existing bridge infrastructure by lengthening it beyond drainage areas can improve connectivity and allow wildlife to pass underneath the bridge along the banks of creeks and rivers (OREG, 2013). Underpass crossings of this size affect a variety of sizes of animals and minimize trans-

portation infrastructure affects on drainage. During the construction of the Bayview Extension in Toronto, an open span bridge was used to help mitigate landscape fragmentation and improve connectivity. Multiplate arches can also be used to allow the safe passage of animals below. These types of connections work best in areas with variations in elevation (OREG, 2013).

Underpass crossing in Banff, Alberta (Photo Source: White, n.d.)

Culverts

Culverts are classified as an underpass crossing and are an excellent example of existing infrastructure that can be retrofitted to improve connectivity for animals. These types of projects are well suited to be completed at the same time as road resurfacing or road widening projects. Despite the variability in findings, properly designed tunnels continue to be promising as conduits for a wide range of wildlife species. When designing culverts for wildlife crossing, the materials used in the culvert must reflect the surrounding ecosystem to encourage wildlife use. An understand-

ing of the target species' crossing locations, "wildlife infrastructure" requirements that must be met, and road infrastructure requirements and issues, is crucial for increasing the likelihood of successful use of tunnels/culverts by the target species (MTO, 2006). A tunnel system's effectiveness often depends on many variables, including, size, placement, light, temperature, moisture, substrate, vegetative cover and noise levels (Jackson and Griffin, 1998).

Studies conclude that for the high number of different species living in this area, larger tunnel diameters and openness ratios (determined by dividing width by height by length) exceeding 0.4 appear to best facilitate road crossing (Woltza et al, 2008). Similarly, larger structures should be used on wider roadways. Where possible, the slope of a culvert should be gradual enough to allow animals to see through the culvert to the opposite side of the roadway. This is especially important for species that are hesitant to enter darkened tunnels. Furthermore, culvert temperature, moisture, light, and substrate should be consistent with ambient conditions to increase culvert use, particularly for ectotherms. Vegetation cover also increases the use of a crossing structure because it maintains connectivity with surrounding habitat (Garrah, 2012). Some cover in the form of logs, rocks, brush and other natural debris should be included for smaller species. Natural lighting, especially within underpass structures beneath wide roadways, may enhance use by some species.

Exclusionary and well-adjusted fencing should be applied on either side of the roadway and tied into underpass structures to maximize use by wildlife and minimize access to the roadway. The most effective barrier design for preventing access to the road surface and funneling small mammals to underpass structures is a guard rail barrier that is buried a minimum of 6 inches below the ground (12 inches would be optimal) and extends 42 inches above ground (MTO, 2006).

An excellent example of the use of culverts can be found along Highway 10, north of the Village of Caledon, for a turtle crossing. They were installed as part of the road widening of Highway 10, and they are a good example of the adaptive reuse of existing infrastructure (Ontario, 2010). The ends of the culvert were cut back to increase the amount of light entering it to make it more attractive for wildlife. Since studies have shown that turtles can climb fences, a fine wire mesh was used to direct turtles to the culvert opening and prevent them from climbing onto the road.

Another example of the mesh fencing includes a 90-degree bend at the top of a 1 meter high fence along the Credit River as an extra deterrent to the turtles (Ontario, 2010). Monitoring of the culvert sites commenced in 2011 to measure the level of use by smaller wildlife. When designing culverts for wildlife crossing, the materials used in the

culvert must reflect the surrounding ecosystem to encourage wildlife use. Different substrate material must be used depending on the species being targeted with the crossing structure. A second example of culvert use is along Laird Road at Highway 6 near Guelph. It provides safe crossing for amphibians, as this site has been identified as a hot spot of high fatalities due to habitat fragmentation.

Box culvert for turtles, Ottawa, Ontario (Photo Source: Kluke, 2013)

Tunnel Systems for Amphibians

Particularly vulnerable to fragmented habitats are amphibians and reptiles. Unlike mammals that scurry when frightened, amphibians and reptiles are vulnerable to the effects of roads because they are slow-moving organisms that typically access multiple habitats seasonally to complete their life cycles. In particular, most amphibians have a biphasic life history that requires travel between aquatic breeding sites and terrestrial foraging sites (British Columbia Ministry of the Environment, 2011). In addition to direct mortality, the shoulder of roads are attractive nesting areas because of suitable exposure, soil characteristics and the lack of vegetation due to regular brushing activities as part of road maintenance.

Directive fencing
(Photo Source: Lake Jackson Ecopassage, n.d.)

In areas where there is a juxtaposition of clusters of amphibian populations and large infrastructure barriers, amphibian tunnels should be considered. For optimal use, box culverts with a large diameter (1 to 1.5m) that provide a moist microclimate and continuity with native soils adjacent to the structure should be implemented (Woltza et al, 2008). As a general rule, longer tunnels should have larger openings; however, maximizing the openness ratio has been identified as far more important in promoting amphibian use. Generally, amphibian migration takes place on humid and wet nights. These specially designed tunnels have slots that allow air, moisture and light inside, creating a suitable environment for them to enter (Parks Canada, 2008). Where possible, tunnel structures should be provided with grates along the top to allow for both light and moisture to enter (MTO, 2006).

These tunnels are to be used with exclusionary fencing in order to provide migratory amphibians safe road crossings. Fences for smaller animals like amphibians must be designed so as to not allow these creatures to slip or dig underneath the bottom of the fence (Jackson and Griffin, 1998). Using a short retaining wall is often effective to prevent this from happening. Alternatively, material barriers should be buried a minimum of 6 inches in the soil (Woltza et al, 2008). If material fencing is used, a zigzag pattern, allowing for an angle of 60 degrees, should be used to help funnel wildlife toward the crossing structure (MTO, 2006). Fencing should extend for a length of 30-50m from the road crossing structure and should reach heights of 36 inches tall. That being said, care must be taken to ensure that the barrier is not too high to climb for larger mammals that cannot fit through the tunnel.

MTO (2006) provides an excellent list of studies concerning tunnel dimensions/materials.

Amphibian tunnel

(Photo Source: Legacy Habitat Management Limited, n.d.)

Gravity Pipes for Fish Crossing

In 2007, the Ministry of Transportation presented improved Gravity Pipe Design guidelines that require designers to consider fish habitat when installing culverts along highways that cross creeks and rivers. Designs must use natural fish habitat substrate for safe fish travel during fluxes in water velocity and water levels. Monitoring for obstructions must also take place.

Exclusion Fencing

Fencing reduces the interactions between wildlife and humans along transportation corridors, while directing animals to the safety of specially designed crossings (OREG, 2013). The use of barrier fencing to funnel wildlife toward crossing structures significantly increases their use, particularly for animals that typically avoid crossing structures (Garrah, 2012). It should be noted, however, that fencing should only be used in areas where wildlife road mortality

is severe, as fencing can also be detrimental if it fragments a habitat more than the road itself (Grandmaison, 2011). The selection and installation of exclusionary fencing can present some challenges, particularly if multiple species are being excluded (Ministry of Natural Resources, 2013). For example, some reptiles and amphibians are able to dig under fencing while others can climb over. Some may also take advantage of burrows dug by other animals.

When installing fencing in conjunction with underpass crossings, the direct connection of fencing and culvert headwalls is preferred. Bolts fastened to concrete headwalls provide a stable anchor point for fencing connections. Where a direct connection to culvert headwalls is inhibited by hydrology or topography, we suggest that the fencing be placed above the culvert to maintain continuity (MTO, 2006). Ideally, exclusionary walls or fencing should have a zigzag configuration and if made from concrete, L-shape elements with an overhanging lip. Unlike fences, the barrier wall top should be level with the road surface to provide escape routes (Grandmaison, 2011).

To maintain effectiveness, the bottom of the fence wall should be buried or secured firmly to the ground and minimum height recommendations should be considered. Fences 0.6 m in height are effective barriers to most amphibians and reptiles (Woltza et al, 2008). For long term fencing projects, materials such as heavy-duty geotextile, woven wire, wood, concrete, sheet metal, vinyl panels or galvanized mesh should be used (Ministry of Natural Resources, 2013). Unlike fencing, concrete barrier wall tops should be level with the road surface to provide escape routes (British Columbia Ministry of the

Animal Warning Sign System

Signage systems are generally implemented in tandem with crossing structures (Lister, 2012). They are specifically targeted to drivers to warn of wildlife that is known to cross the road in a certain area. Increased driver awareness may reduce the number of collisions between animals and humans as a result of these signs. In turn, this can reduce the number of fatalities of either animals or humans (Ontario, 2010). This is a more inexpensive measure to assist in combating negative human-wildlife interactions.

Turtle crossing sign, Ottawa, Ontario
(Photo Source: Kluke, 2013)

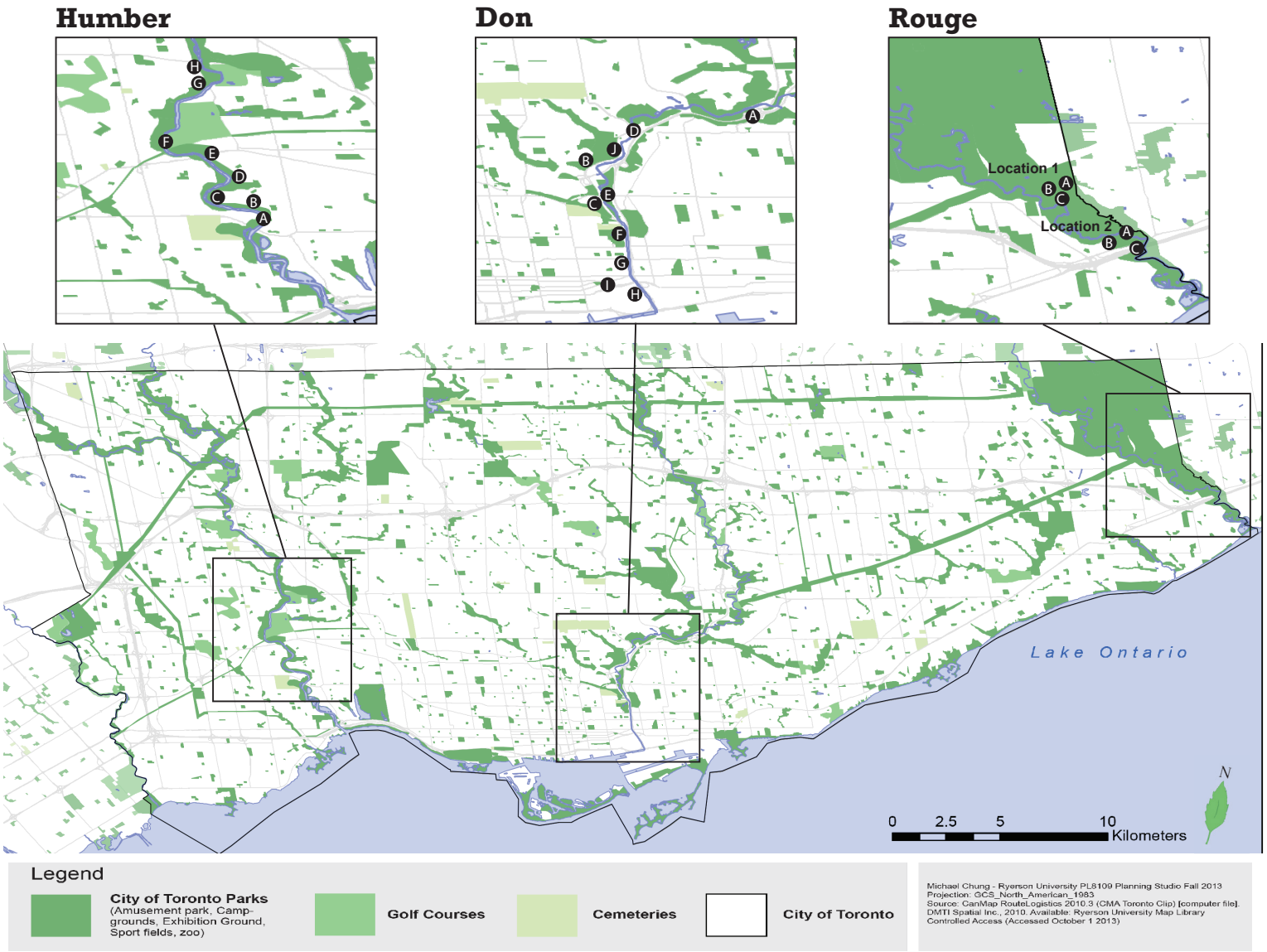
Overhead Crossing

There are a growing number of examples that use bridges constructed overhead of transportation infrastructure to allow safe passage of animals (Ontario, 2010; Arc-Solutions, 2013). The use of fencing to direct animals to safe crossings is necessary to ensure that animals cross transportation corridors using this infrastructure. This type of crossing structures allows wildlife to maintain their migration and breeding patterns within fragmented landscapes. Without fencing, the bridges would go unused and wildlife fatalities would not be reduced (OREG, 2013; Ontario, 2010). The aim of overhead crossings/ bridges is to allow animal movement to continue while not impacting traffic. They also ensure animal safety and resiliency. Wildlife overhead crossings have been used in Europe extensively, but the uptake of this type of crossing solution has not been as extensive in North America (Arc-Solutions, 2013). In Ontario, a wildlife bridge exists in the Burwash area, 1 km north of Highway 637. Its construction was part of the Highway 69 expansion project (On-tario, 2010). The designs for the 30 meter wide bridge crossing over the four lanes of Highway 69 includes landscaping that aims to be seamless with the natural environment surrounding it. As such, the designs include boulders, shrubs, trees, etc. As this was the first animal bridge crossing in Ontario, a monitoring system was set up upon completion in 2010, to provide animal track counts and video imagery to assess the level of use (Ontario, 2010). Arc-Solutions (2013) promote ongoing monitoring of animal bridges, as the data collected informs future designs and implementation. Monitoring is also important to ensure there are no obstructions impeding animals from using the crossing structure (Majka, 2013).

Monitoring of these wildlife crossings should occur to ensure that they are being used and are actually reducing fatalities resulting from transportation infrastructure. Future solutions should build on existing best practices, while focusing on creating transferable conceptual designs. Increasing transferability can rely simply on the use of common construction techniques, which reduces costs and increases accessibility (Arc-Solutions, 2013). In built up environments, existing infrastructure can be retrofitted to improve connectivity and encourage sustainable practices. Wildlife crossings have the opportunity to go beyond their functional aspect of safety and resiliency for both humans and animals – they can become engaging pieces of design work.

Wildlife Overpass Crossing Structure
(Photo Source: Jackson, n.d.)

Connectivity in the Humber, Don and Rouge

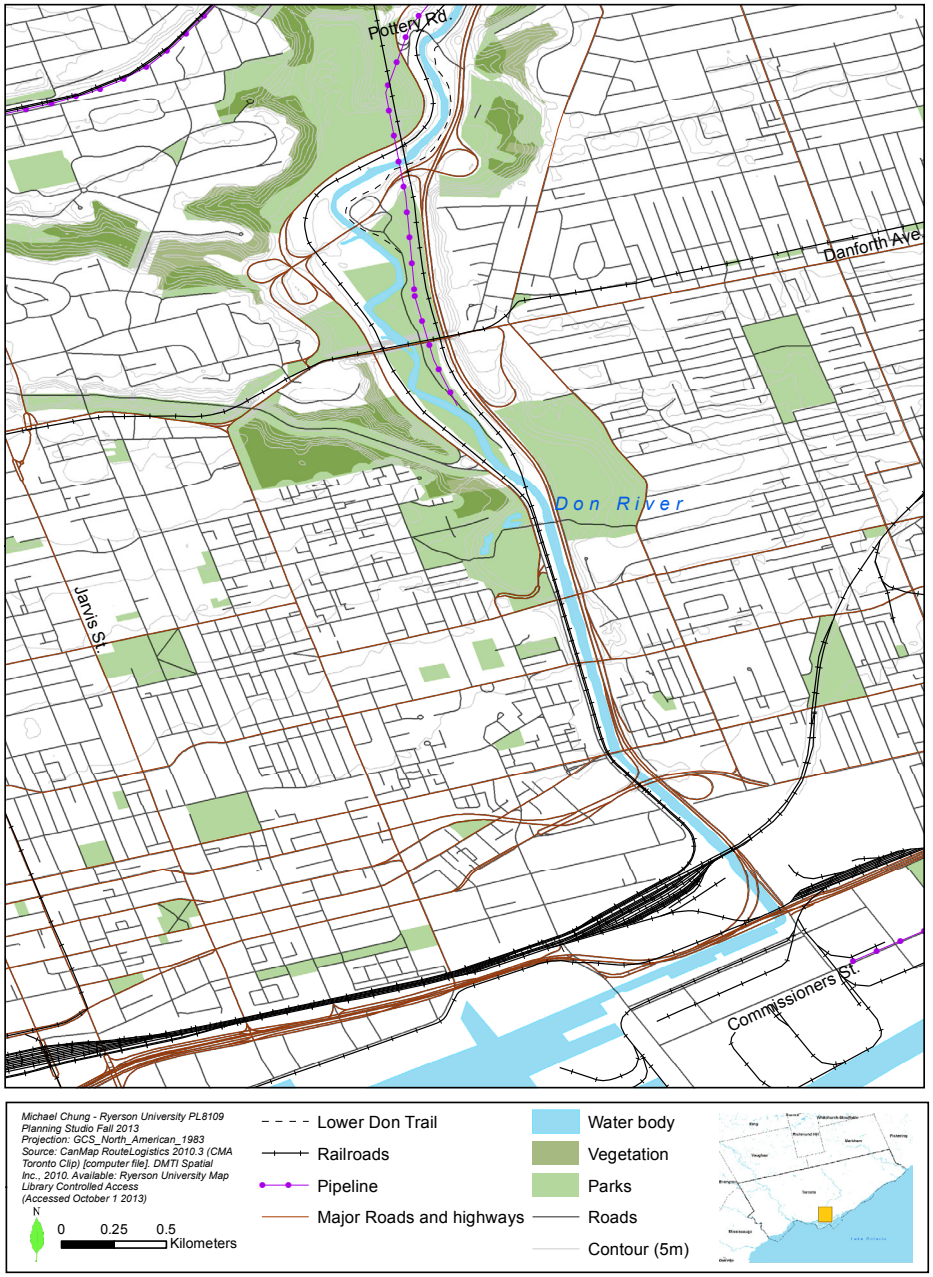


Sites within the Humber, Don and Rouge where site analysis was undertaken. Each site provides an example of a missed connection, and a recommended solution for creating a more connected landscape.

Lower Don

Study Area Description
This study area focuses on the 6 kilometers south from the entrance to the Evergreen Brick Works at Bayview Avenue to the mouth of the Don River, as well as the Don Mills Interchange. This study area was chosen because the natural area has been heavily impacted by man-made infrastructure, including a large number of transit corridors that fragment any remaining green space and vegetation.

A number of sites have been chosen in the Don because they demonstrate missed opportunities for providing effective connectivity measures for both humans and wildlife. Recommendations for improving connectivity within each site are provided with each example.

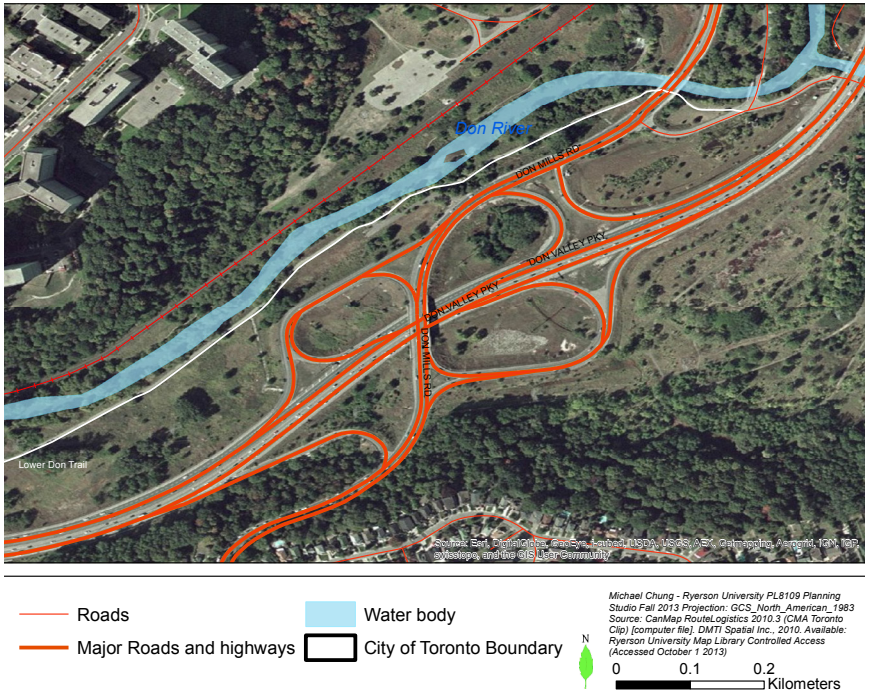


Lower Don Study Area

Site A - Don Mills Interchange

The highest concentrations of reptile and amphibians in the Lower Don Watershed live in the area surrounding the Don Mills Interchange (City of Toronto, 2013). The habitat suitability of this area is likely the reason for such high concentrations of these species. However, the GO rail corridor and the Don Valley Parkway completely bisect this area and pose a number of threats to existing wildlife habitats. While humans have the ability to cross these infrastructural barriers using Don Mills Road, animals are for the most part, forced to remain on one side or the other.

When the Don Mills Interchange was constructed, an opportunity to provide a network of culvert crossings for wildlife in this area was missed. If these culverts had been designed in such a way that would facilitate the safe movement of amphibians, reptiles, and small mammals from one side of the road to another, they could have provided an excellent wildlife crossing underneath a very dangerous piece of infrastructure, while performing their intended function of channelizing drainage from the east side of the interchange to the river on the west side (see Appendix A for more information about culverts).



Satellite image showing the Don Mills Interchange

Recommendation

Implement a network of culvert crossings at a strategic location in close proximity to the Don Mills Interchange.

Site B - Unused Trestle Bridge

The unused trestle bridge east of the Brick Works, and the abandoned rail corridor that runs parallel to the Don trail both provide opportunities for improving human connectivity within the Don watershed. Adaptive reuse of these corridors can provide safer access to the Brick Works for trail users, who currently have to travel along Bayview Avenue, which is an unsafe route for pedestrians and cyclists. The utilization of this existing infrastructure has the potential to provide better physical and ecological connections within this area.

Recommendation

Re-adapt unused trestle bridge and rail corridor adjacent to the Don Trail to improve access to the Brick Works.

Unused trestle bridge passing over Bayview Avenue
(Photo Source: Roth, 2013)

Case Study

The Highline in New York City is an excellent example of the adaptive re-use of railroad infrastructure. The Highline is an urban park built on a historic elevated freight line running along Manhattan's west side (Highline, 2013). Sitting thirty feet above the ground, the Highline is currently one mile in length, but there are expansion plans in the works. The Highline was constructed after a Trail Use Agreement allowed public access to the abandoned freight line. Extensive community interest has ensured its success (Highline, 2013).

Site C - Stairs at the Base of Rosedale Heights

The stairs at the base of Rosedale Heights can be improved to provide a connection from Castle Frank Subway Station to the Brick Works. Signage and a public right-of-way are needed from Castle Frank Station to the top of the stairs, and a safe linkage to the multi-use trail that has been proposed along Bayview Avenue is needed at the base of the stairs. Currently, the trail runs along the east side of Bayview, but the staircase is located on the west side of the road. Improved crossing signals for pedestrians and cyclists should be put in place. This type of connective infrastructure would create a more effective connection for human users of the space, but additional measures are needed to allow for the safe passage of wildlife across Bayview Avenue. This can be achieved by adapting culverts in this area to direct wildlife under the road.

Recommendation

Implement crossing signals and a public right-of-way for pedestrians and cyclists from Castle Frank Station to the top of the stairs.

Case Study:
Safe Road Crossing for Cyclists and Pedestrians

Guidelines established by the United States Department of Transportation (2002) for safe pedestrian crossing can be used to improve connections at this site. Installing crosswalks, lighting, traffic and pedestrian signals and reducing speed limits are well-established methods that increase pedestrian safety along roadways. Other methods that are not as common include raised medians, narrowed streets, traffic calming measures and signage that warns drivers of an upcoming crosswalk (Administration, 2002). These methods can also be adapted to provide safe crossings for cyclists.

Pottery Road Crossing Structure
(Photo Source: Plant Architect, n.d.)

Pottery Road Bridge
(Photo Source: Roth, 2013)

Site D - Pottery Road Crossing

Both the Pottery Road Bridge and crossing structure are examples of infrastructural improvements that provide better connections for humans, but act as barriers to wildlife.

An opportunity to construct an underpass crossing for wildlife was missed when the Pottery Road Bridge was built in 2011 (Yuan, 2013). This bridge presented itself as an excellent opportunity for improved wildlife connectivity by expanding the bridge beyond the banks of the river but it was constructed without this connectivity measure taken into consideration. As well, the unique crossing structure that was installed on Pottery Road can only be navigated by human users of the space. It is proposed that an underpass crossing be installed to allow for wildlife to safely cross Pottery Road. Additionally, it is proposed that the bridge be extended beyond the banks of the river to allow for the safe passage of wildlife along the river's edge.

Recommendations

1. Install an undepass crossing under Pottery Road.
2. If the bridge is designated for reconstruction, it should be constructed to extend past the banks of the bridge.

Site E - Bloor Street Viaduct

Because of abrupt elevation changes from the Prince Edward Viaduct to the Lower Don Trail, accessibility is an issue. Installation of elevators can improve connectivity to the Lower Don Trail from the Prince Edward Viaduct by providing a fully accessible entry point to the trail. Elevators generally take up less space than both stairs and ramps, and as such, the installation of this type of connective infrastructure would not significantly impact the spatial needs of wildlife in the area. Elevators are innovative and long-term solutions for improving accessibility, and can be installed in any area where a bridge is used. However, the design of the elevator must take into account the needs of wildlife in the area to mitigate any negative impacts to their habitats.

Furthermore, there is a high concentration of amphibians in this area, and when the single-purpose drainage culverts were installed, an opportunity to provide effective crossing structures was missed. Because of the suitability of habitat on either side, this type of wildlife crossing is needed to support the physical and structural preferences of amphibian species. The most logical animal crossing in this location is a series of amphibian tunnels installed in conjunction with barrier fencing. Given that the rail and road infrastructure in this area is at a higher grade than the trail and river, these tunnels would better support the mobility needs of the amphibians wishing to traverse these barriers. Furthermore, because the proposed location of these tunnels is in a low lying area, achieving appropriate microclimates in these tunnels would not be challenging. In fact, it is likely that these crossings could also aid with drainage. Barrier walls or fences would need to be erected in an area like this to mitigate amphibian road mortality, and to direct these species into the tunnels (Vancouver Island University, 2011).

Recommendations

1. Install an elevator from the Bloor Street Viaduct to the trail system below.
2. Construct an amphibian tunnel in the vicinity.

Bloor Street Viaduct seen from Lower Don Trail (Photo Source: Roth, 2013)

Case Study: Highline Elevator

Elevators to the Highline provide access to the park for all users of the space. Close to half of the park's entry points have elevators, and the entire length of the Highline has been made fully accessible (Highline, 2013).

Single Purpose Drainage Culvert (Photo Source: Sauve, 2013)

Site F - Riverdale Pedestrian Bridge

An excellent connection for users of the Lower Don Trail is the Riverdale Pedestrian and Cyclist Bridge that crosses the Don Valley Parkway, the Don River, Go tracks and Bayview Avenue. It provides a necessary link between Riverdale Park East and West and to the Lower Don Trail. The bridge itself is fully accessible for trail users, but the stairs connected to the Lower Don trail are not accessible. This bridge demonstrates how infrastructure intended to create better connections for humans can sometimes act as a barrier to wildlife in the area. The bridge itself does not hinder wildlife that may be following the Don's riverbanks, as the bridge extends beyond the banks of the river. However, the bridge limits the east to west movement of wildlife navigating the Lower Don Trail.

Stairs Leading to Riverdale Bridge
(Photo Source: Roth, 2013)

An opportunity to install an underpass crossing structure to improve east to west mobility was missed at the time of construction. The proximity of Bayview Avenue to the GO rail tracks provides a unique opportunity to create a wildlife crossing that better connects Riverdale Park East to the Don River. Based on City of Toronto fauna data, crossings in this area would serve a high number of reptiles, amphibians, and small mammals (City of Toronto, 2013). Proposed for this area is a culvert structure that is capable of meeting the needs of multiple species. Furthermore, concrete barrier fencing is needed to create a more effective piece of connective infrastructure. Given that there is no significant elevation change at this site, the crossing infrastructure should be provided below grade.

GO Tracks running under Riverdale Bridge - potential site for an underpass crossing
(Photo Source: Roth, 2013)

Recommendation

Install an underpass crossing structure at this site to improve east to west connections for wildlife.

Site G - Queen Street Bridge Stairs

This staircase provides access for pedestrians and cyclists from the Queen Street Bridge to the Don Trail, but it does not provide a fully accessible access point. The staircase is located next to a highly channelized portion of the Don River where there is very little suitable wildlife habitat. As such, this connective infrastructure does not negatively impact wildlife in the area.

Infrastructure that provides greater accessibility (i.e. ramps or elevators) should be installed on the Queen Street Bridge, as well as on the Gerrard Street and Dundas Street bridges. The installation of these measures can provide better connections to the Lower Don Trail from surrounding neighbourhoods, like East Chinatown and Regent Park. However, as with any other piece of connective infrastructure, the needs of wildlife must be taken into consideration to ensure they do not hinder the movement of wildlife in these areas.

Recommendation

Install an elevator or ramp at all bridge sites to increase access to the trail system.

Gerrard Street Bridge
(Photo Source: Roth, 2013)

Underpass tunnel leading to Corktown Common
(Photo Source: Roth, 2013)

Site H - Corktown Common Tunnel

This tunnel, which runs beneath an active railway, provides a safe connection between the Lower Don Trail and Corktown Common. While this tunnel was constructed to provide greater connectivity for humans, it may also serve the mobility needs of wildlife in the area. As well, a portion of the park has been renaturalized, making the area more hospitable for wildlife.

Ramp from Eastern Avenue Bridge to Underpass Park
(Photo Source: Roth, 2013)

Site I - Ramp to Underpass Park

The ramp that extends from the Eastern Avenue Bridge to Underpass Park provides an indirect link to both Corktown Common and the Lower Don Trail. It is fully accessible for all users and connects pedestrians and cyclists with the urban grid system. Prior to the construction of this ramp, the area was lacking in greenspace and suitable wildlife habitats, and as such, this ramp does not create additional challenges for wildlife.

Site J - Bayview Avenue Site

Bayview Avenue transects the Don Valley, creating barriers for pedestrians, cyclists and wildlife. Pedestrians and cyclists using the Lower Don Trail have difficulty in accessing the Brick Works, as Bayview Avenue is a fast-moving multi-lane road. As well, wildlife is forced to cross the road at grade to access greenspaces located on either side of the road, which can easily result in wildlife injury or mortality.

To provide better connections for pedestrians and cyclists, the Lower Don Trail Master Plan (2013) proposes the installation of a multi-use trail that connects the Beltline Trail with the Lower Don Trail along Bayview Avenue. The trail will use the existing shoulder on Bayview Avenue, along with a barrier, to provide a safer connection. In addition to the plans outlined in the Master Plan, it is recommended that a wildlife crossing structure be put in place to allow wildlife to move across Bayview Avenue safely. Adapting culverts, or constructing amphibian tunnels at specific locations can improve landscape connectivity and enhance the mobility needs of wildlife in this area.

Recommendations

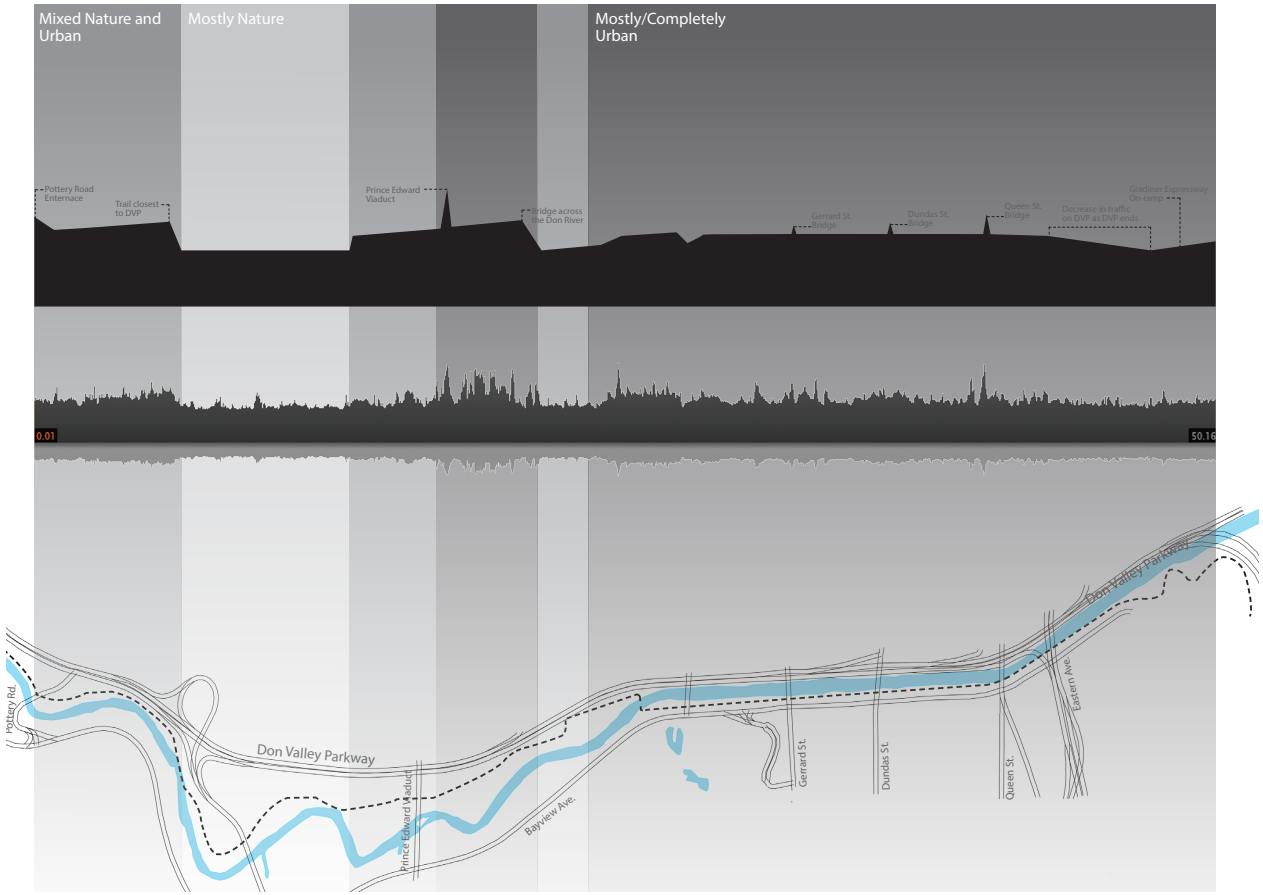
1. Construct a multi-use trail that connects the Beltline Trail to the Lower Don Trail.
2. Install a culvert underneath Bayview Avenue.

Rendering of a culvert running under Bayview Avenue

(Photo Sources: Lower Don Master Plan, 2013; Cameron, 2013)

Lower Don: Sound Map

Despite the existing connections along the trail, the quality of user experience may be poor due to the noise from adjacent transit corridors. This graphic depicts the type and level of noises that can be heard while walking along the Lower Don Valley Trail from Pottery Road to Lake Shore Blvd. The dominant noise type experienced on the trail is mostly urban, with much of the noise being generated from the Don Valley Parkway and the subways and streetcars that pass over the trail. This analysis demonstrates the impacts of urbanization on our natural systems. The noises generated near the trail are detracting from the user experience, and are reducing the attractiveness of the area for both humans and wildlife.

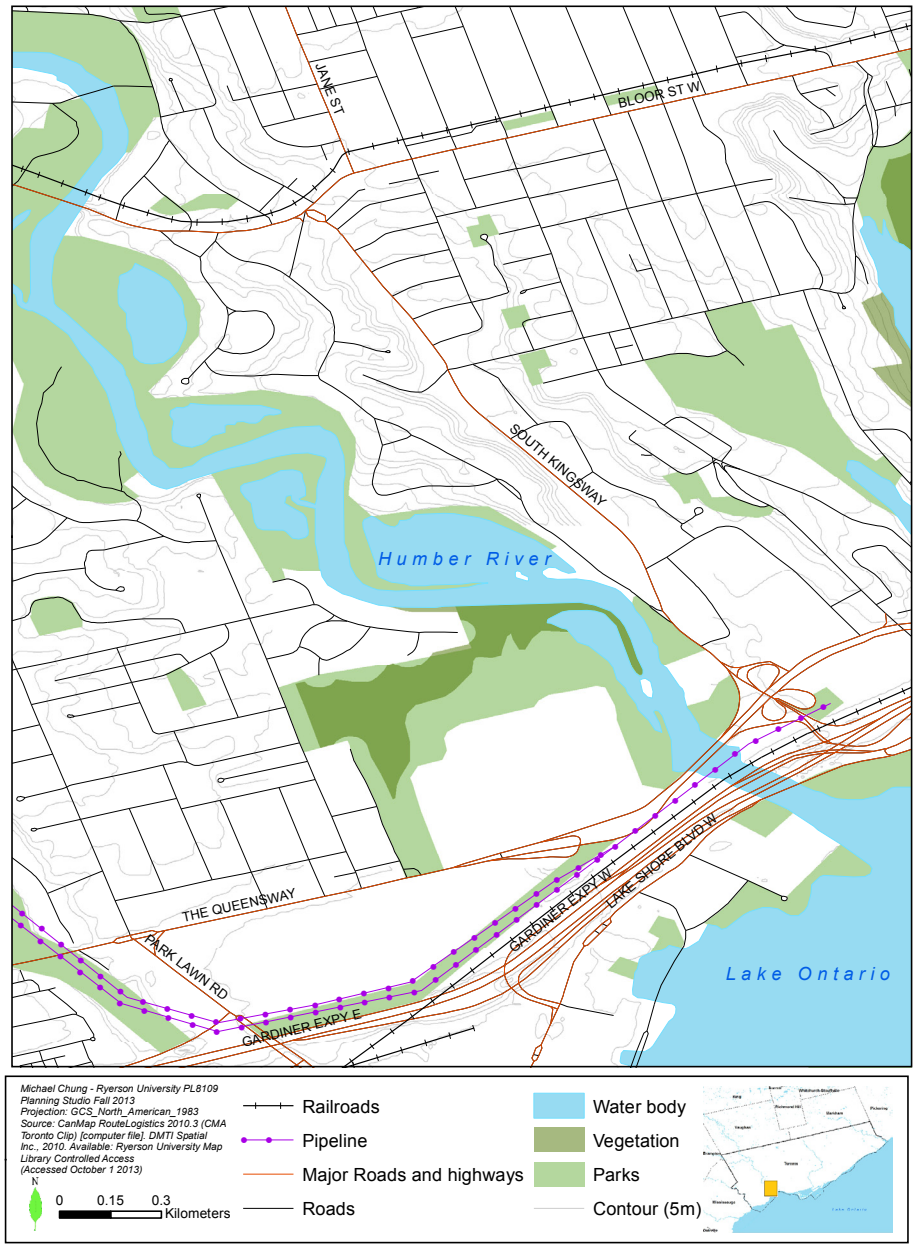


(Chung, 2013)

Humber River

Study Area Description

The area of study along the Humber River is bounded by Bloor Street at the south and Eglinton Avenue at the North, and the natural areas between the bordering neighbourhoods provide the east and west boundaries. This area was chosen because of the mix of highly urbanized areas and preserved green spaces.



Humber River Study Area

Site A - Old Mill Heritage Bridge

The Old Mill Bridge is the first access point to the Humber River in the study area. It is a heritage bridge, built from stone in 1916 (Hulley, 2013). This bridge provides an access point to the multi-use trail on the east side of the river from Old Mill subway station. The bridge is quite narrow, and there are no sidewalks, only a painted line on the road, presumably indicating space for bike or pedestrian usage. This is an unsafe crossing for both humans and animals, as there is no separation from vehicular traffic. The design of this bridge is safeguarded by heritage protection regulations, and as such, it would be difficult to seek any reconstruction because of its protected status.

Old Mill Bridge
(Photo Source: Roth, 2013)

Unsafe pedestrian crossing near Old Mill Bridge
(Photo Source: Roth, 2013)

Recommendation

Installation of signage to indicate this bridge is shared between many types of users.

Site B - Parallel Trails

The section of the Humber River between Old Mill Road and Eglinton Avenue has two parallel trails - at times only one metre apart - for pedestrian and cyclist use. The trails are found on the east side of the river from Bloor Street to just north of Dundas Street West, where the trails meet and cross over the river and run along the west side up to Eglinton Avenue. The path running closest to the river is designated for pedestrian use only, and is marked out with crushed gravel, making it inaccessible for those using mobility aids. The other is an asphalt path designated as a multi-use trail for all users. This path is considered to be highly accessible and is connected to each of the trail access points. Having two trails directly adjacent to each other does not seem logical. A single multi-use path would improve the ease by which wildlife and humans are able to navigate along the river's edge.

Recommendations

1. Because it is closest to the river, remove the gravel pedestrian path and allow it to renaturalize.
2. Retrofit the asphalt path into a divided cyclist/pedestrian trail with clear markings to mitigate conflict between users of the trail.

Parallel Paths
(Photo Source: Roth, 2013)

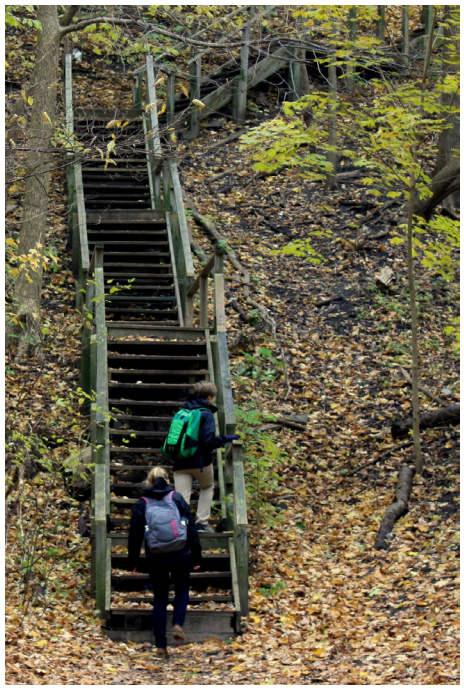
Multi-use and pedestrian paths between Old Mill Road and Eglinton Avenue
(Photo Source: Roth, 2013)

Case Studies: Divided Multi-use Trails

In theory, cyclists yield to pedestrians. In practice, this is not always the case, and more often than not cyclists expect pedestrians to get out of their way. Having a line drawn on a pathway designating cyclists to one side and pedestrians on the other can reduce the chances of user conflict. Examples of this can be seen throughout a trail system in Bonassola, Italy, and on San Francisco's Golden Gate Bridge.

Bonassola Cycle Trail, Italy
(Photo Source: Cranbrook Guardian, 2011)

Designated lanes on Golden Gate Bridge, San Francisco
(Photo Source: Reisman, 2011)



Stairs to Baby Point Road
(Photo Source: Roth, 2013)

Baby Point Gateway
(Photo Source: Google, 2013)

Site C - Staircase to Baby Point Road

This steep and wooden staircase is the first pedestrian access point after the entrance at Old Mill Road. It is situated just south of Magwood Park and connects the Humber trail to Baby Point Road, a residential neighbourhood overlooking the ravine. There are two key issues associated with this access point: safety and signage. The safety of the staircase is questionable. It is old and weathered, it has been constructed with noticeably uneven stair spacing, and there is a wide gap beneath the handrail. On wet days, the wooden surface can become quite slippery.

In terms of visibility and signage, this access point is not very apparent from either the Humber trail or from the street. Within the ravine, the staircase is hidden in heavy tree cover. Pedestrians have to wander from the paved path to notice the presence of a natural trail that leads to the staircase, and there is no signage indicating that the stairs lead to Baby Point Road. For pedestrians entering the ravines from the neighbourhood, there is a small path that leads to the top of the stairs. However, this path is indistinct and located between two houses. There is no sign indicating that this is a public access point to the Humber River.

The staircase likely does not infringe upon the movement of wildlife within the ravine. It is constructed upon the steep edge of the ravine, out of the way of the heavily used path, and hidden from human activity at the nearby park. This staircase is not suitable for safe human or animal use. It is recommended that the stairs be reconstructed with higher safety standards and newer materials. As well, this access point needs to be made more visible with gateway signage.

Recommendation

Reconstruct the staircase with higher safety standards and newer materials.

Site D - Entrance to Trail via Magwood Park

This is a safe and accessible entrance for trail users through the park. Located adjacent to the neighbourhoods of Warren Park and Baby Point, it provides an excellent connection to the trail. Pedestrian and cyclists enter at grade, as all grade changes occur gradually within the neighbourhood. There is no additional construction required beyond the paved pathway and its ongoing maintenance. This entrance has allowed for the ease of movement of humans of various levels of accessibility and has not hindered animal movement as the at-grade trail can be easily traversed. A lack of signage stating the connection to the Humber Trail may reduce the use of this access point for users who are unfamiliar with the area.

Recommendation

Increase signage with the addition of a wayfinding map to orient visitors.

Site E - Entrances near Dundas Street West

There are two entrances located immediately south of where Dundas Street West crosses over the Humber River. The first one connects the trail to Lundy Avenue. This entrance is accessible for both pedestrians and cyclists, and there is visible signage indicating it as a gateway to the Humber trail. This is the superior of the two entrances in terms of visibility and safety. The second entrance, a set of cement stairs, is located at the end of Old Dundas Street, about 100 metres away. This entrance is less visible, and is at the end of a dead-end street with no signage posted. At this point on the trail, a sign informs cyclists to dismount their bikes and walk, as the trail is not paved for a small stretch.

Recommendation

Increase signage at entry points to denote access points to the Humber River.

Accessible entry point to Magwood Park

(Photo Source: Roth, 2013)

Entry point to trail from Old Dundas Street

(Photo Source: Roth, 2013)

Site F - Pedestrian Bridge

The pedestrian bridge passing over the Humber River located north of Dundas Street and South of a CP Rail Bridge provides an excellent connection across the Humber River. The bridge is wide and is fitted with materials that make it fairly accessible for those using mobility devices, and provides ease of movement for pedestrians. Its surface is currently fitted with wide wooden boards that might make it difficult for some users to navigate. A future improvement project might see the bridge fitted with a material that has a flat and porous surface. Signs are posted to advise cyclists to dismount before accessing the bridge to lessen conflict between users. The construction of the bridge does not impede the movement of wildlife along the river's edge. The bridge's structural posts are set far enough back from the river's edge that it allows for the movement of wildlife underneath the bridge and parallel to the river. Benches are provided in recessed sections of the bridge for pedestrian use, and are not in the way of active users. Given that the area is well populated by people during the day, it is unlikely that wildlife would use the bridge as a means of crossing the river during daylight hours.

Sign outlining rules for users of the bridge
(Photo Source: Roth, 2013)

Pedestrian bridge extends beyond the banks of the river allowing wildlife to pass through
(Photo Source: Roth, 2013)

Pedestrian bridge seating
(Photo Source: Roth, 2013)

Site G - Underpass at Scarlett Road

This is a newly constructed pedestrian underpass that allows for the safe passage of trail users beneath the Scarlett Road Bridge. Before this underpass was constructed, trail users had to cross the road with no sign of any safety precautions being taken. Now, the underpass requires that cyclists dismount to prevent any interference with pedestrian use of the trail. However, the underpass was constructed without considering the need for wildlife accessibility along the river's banks on both sides of the Humber. Since the underpass was constructed on the west side of the Humber River, the east bank is the only remaining accessible wildlife connection beneath the Scarlett Road Bridge. This is an example of a connection that has focused predominantly on human needs and has impeded wildlife movement along the riverbank on the western side of the Humber. Ideally, the underpass crossing for humans would have been constructed to ensure that the western riverbank stayed intact, and that both human and wildlife connectivity was taken into consideration.

Recommendation

Increase the width of the western riverbank to allow wildlife to use it as a means of passing under the bridge.

New underpass at Scarlett Road
(Photo Source: Roth, 2013)

Underpass crossing at Scarlett Road
(Photo Source: Roth, 2013)

Site H - Eglinton Gateway

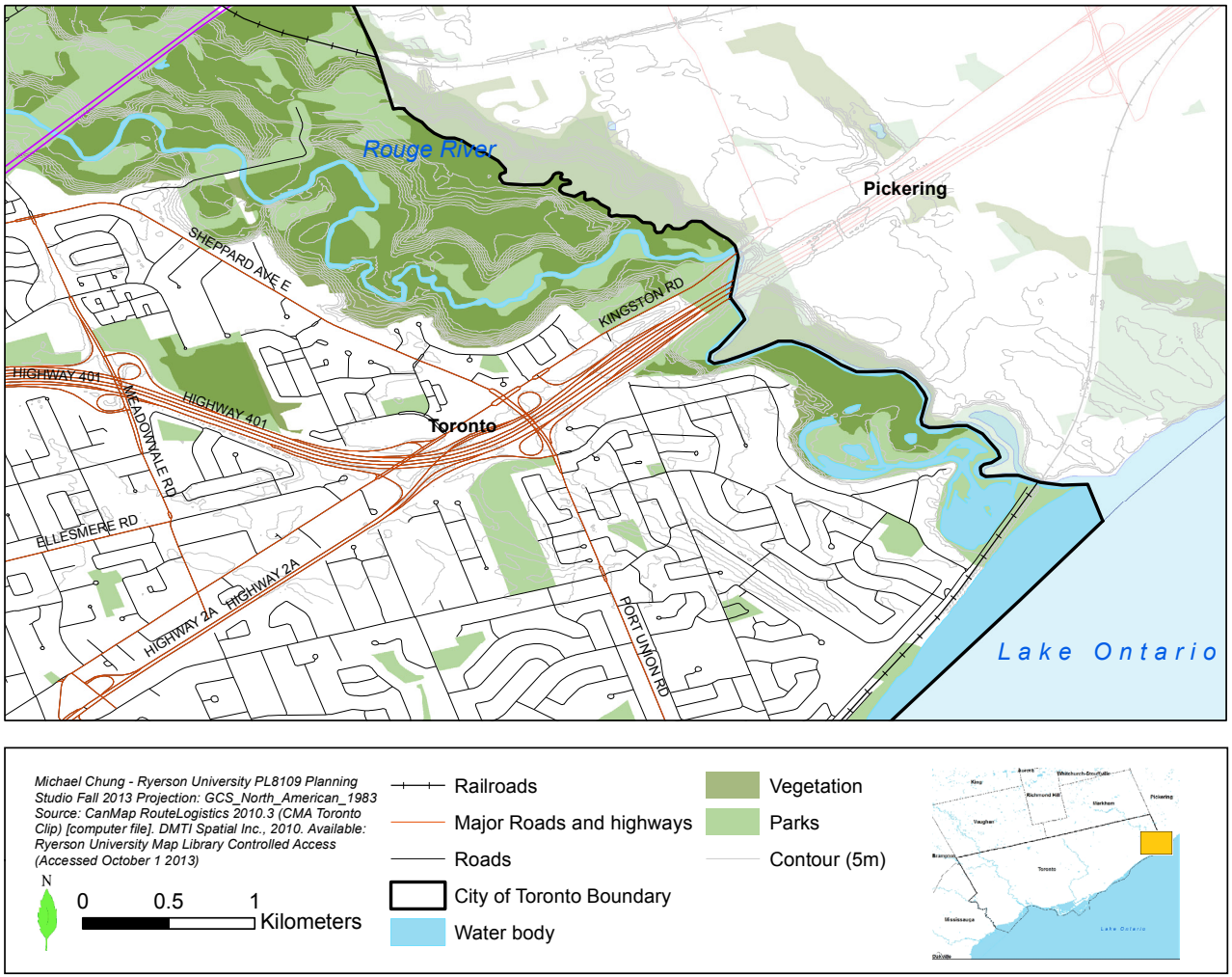
There is not a drastic elevation change at this entrance to the trail along the Humber River, which allows the trail to be integrated easily into the rest of the urban fabric. It is a fully accessible entry point to the trail for users of all capabilities. However, despite there being excellent signage along the trail, there is poor signage at this entrance denoting that the pathway is part of a larger trail that follows the Humber River.

This site has been identified by the City of Toronto's Eglinton Connects team as a connection point between the new Light Rail Transit (LRT) line and the Humber ravine. The Eglinton LRT is being designed as a green corridor connecting the Don Valley and the Humber Ravine and will improve pedestrian connections to the ravine system. The connection from the LRT station at Mount Dennis is seen as a design opportunity to create more meaningful connections to the Humber Ravine. The current Greening Eglinton plan states that there is a need to create safe pathways for pedestrians and expand the awareness of the ravine as a natural asset (Greening Eglinton, 2013). The plan does not consider the provision of safe crossings for wildlife, and does not provide solutions for the prevention of pedestrian infrastructure becoming barriers to wildlife. The plan should be updated to provide for both human and wildlife connectivity measures that do not hinder flow of any users of the pathway. Any infrastructure that will be implemented to improve the connection for pedestrians from Mount Dennis station must not be designed without considering wildlife patterns and movements.

Recommendation

Wayfinding signage must be placed at this site to indicate that this entry point leads to the Humber Trail.

Study Area Description
Two locations within the Rouge Park were chosen to examine the current state of human and animal connectivity. Location one is found in the Tywn River Area of the Rouge Park, and location 2 is area immediately surrounding the Glen Rouge Campground. Stock was taken of existing infrastructure, as well as areas of possible improvement. Overall, the trail systems within the park are relatively well maintained and signed; however, human and wildlife connectivity is a serious concern in some locations. The Rouge River runs in the middle of the forested areas and therefore acts as a natural boundary.



Rouge River Study Area

Remains of demolished concrete bridge
(Photo Source: Ketchabaw, 2013)

Rendering of a new bridge crossing the Rouge River
(Photo Source: Ketchabaw, 2013; Edit: Cameron, 2013)

Location 1: Site A - Old Concrete Pedestrian Bridge

When travelling along Twyn Rivers Drive between Sheppard Avenue East and Altona Road there is a large gravel parking lot located on the south side. The river is a few meters south of this parking lot, yet there is no designated place to cross to the other side of the river and the trail system on the south side. In the past there was a concrete pedestrian bridge over this section of the river that made for easy crossing. The bridge, which was not in a state of disrepair, was demolished decades ago and large slabs of concrete still lay in the water today. The most apparent opportunity for better connectivity at this site is the reconstruction of this demolished bridge, as it is located in an opportune location to attract and facilitate human crossings between the banks of the river. This will allow people to gain access to both the north and south sides of the Rouge River at this location. The gravel parking area is clearly in place to attract visitors to a pre-determined location, so it only makes sense to provide the necessary infrastructure to prevent them walking along the roadway and across the narrow bridge further west. For instance, a smaller wooden bridge could be used to replace the large concrete bridge that was demolished. This would also provide an opportunity for the bridge to be constructed in a manner that does not impede the movement of wildlife living in the area, and could serve as a wildlife crossing structure if fitted with appropriate materials. Wood from the Rouge valley could be used and upon completion an informational panel could be installed. The panel could discuss the importance of the natural heritage features within the Rouge, relay important information about animal habitats and species-at-risk, and encourage better stewardship by educating and creating awareness.

Recommendation

Reconstruct the pedestrian bridge to allow access to both the north and south sides of the Rouge River.

Location 1: Site B – Twyn Rivers Drive and Bridge

Twyn Rivers Drive bisects this area of the Rouge Park and poses a real danger for humans and wildlife looking to move north or south across the landscape. To access the Twyn Rivers Drive Bridge from the parking lot a person can either walk along the trail that follows the Rouge River or along the unpaved shoulders of the road. Currently there is no signage provided in the parking lot area to guide users of the trail system to this crossing structure. A map showing the location of the nearest bridge should be provided near the parking lot area. As well, bicycle use is prohibited in the Rouge Park and as such, cyclists are confined to the shoulders of Twyn Rivers drive at this location. This is extremely dangerous, as the road does not have a paved shoulder on either side and has sharp bends, which reduces visibility around corners, and leads to conflicts between the various types of users needing to gain access to this bridge. The bridge spans the river and was designed exclusively to accommodate motor vehicles. Because the road and bridge do not have paved shoulders or sidewalks, pedestrians and cyclists are forced to share the roadway with motorists. Twyn Rivers Drive and the narrow bridge also act as a barrier to wildlife looking to follow the river's edge as the banks disappear either forcing animals to enter the water or cross the road. As well, this site does not have any fencing to direct wildlife away from the roadway or to deter them from crossing.

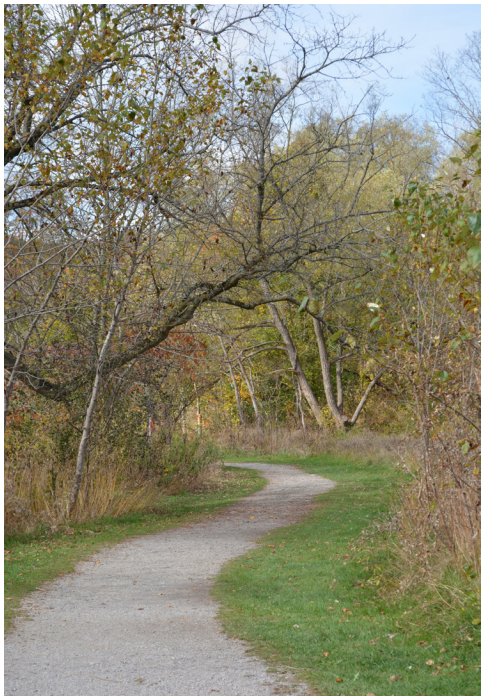
The bridge currently does not support multi-modal transportation and creates a very dangerous environment for pedestrians, cyclists, and wildlife. The roadway surrounding the existing narrow bridge, and the bridge itself, needs to be designated for review when re-surfacing or road widening occurs. The installation of a paved shoulder should be the first priority. Strategic placement of culverts and tunnels should be used in areas where wildlife is being struck by vehicles, to allow for safe crossing. Directive fencing or barriers would also need to be installed to guide wildlife to these crossing structures. Improving the width of the

Existing conditions near Twyn Rivers Drive Bridge
(Photo Source: Ketchabaw, 2013)

Rendering showing how this connection point can be improved.
(Photo Source: Ketchabaw, 2013; Edit: Cameron, 2013)

riverbanks under the Twyn Rivers Bridge would create a continuous path along the water's edge for wildlife to use as a means of passing under the roadway. In addition, just north and south of the existing bridge, the trails continue on either side of the road, however, crossing is made difficult because of sharp bends in the road and the high speeds of travelling vehicles on these roads. Unfortunately, Twyn Rivers as it exists now is too narrow to accommodate a solution similar to what was installed on Pottery Road to connect sections of the Don Trail.

Recommendation
A multi-use trail along Twyn Rivers Drive and Bridge should be installed to better accomodate all users.



Rouge Park trail system
(Photo Source: Ketchabaw, 2013)

Location 1: Site C – Trail System and Signage
The trail system at this site is well established and extensive, although it is all unpaved and therefore not accessible to everyone. The existing trail system at this site has natural ground cover and therefore does not restrict the movement of wildlife across designated hiking trails. As mentioned, informational signage at the parking lot is non-existent. As the parking lot is where people who use this site begin their journey, extensive signage and informational boards would be very useful. At present, this site does not have any signage related to the wildlife found within the area. The incorporation of wildlife crossing signage to inform pedestrians, cyclists and motorists that wildlife are present and will likely cross their paths when they are moving through the area is also needed.

Recommendation
Informational panels and a wayfinding system should be implemented at this access point.

Location 2: Site A – Pedestrian Bridge

At this location there is a pedestrian bridge that is found just north of the 401 overpass, and is large enough to facilitate the movement of pedestrians across the river. The rationale for having a pedestrian bridge at this location and not at Location 1 is unknown. The pedestrian bridge at this location could serve as a crossing for certain species looking to gain access to both sides of the river, and would likely be more attractive if it was retrofitted or naturalized to better suit their crossing needs. At this site, the Rouge River provides a natural connection for a number of species, including fish, amphibians, reptiles, and birds. However, the rivers banks in some locations are relatively steep because of erosion and do not provide an accessible route for wildlife along the water's edge.

Recommendation

Retrofit this bridge with new materials that can accomodate the movement of a variety of species.

Pedestrian bridge across the Rouge River

(Photo Source: Ketchabaw, 2013)

Porous paving stones found under the 401 overpass
(Photo Source: Ketchabaw, 2013)

Trail system at Location 2
(Photo Source: Ketchabaw, 2013)

Location 2: Site B – Trails and Signage

The trail that leads from the parking lot located just north of Kingston Road to the pedestrian bridge is paved and therefore accessible. South of the parking lot, Kingston Road and the 401 both pass over the Rouge River with large bridge segments. Underneath these bridge segments is a wide and flat path that is a mixture of gravel, dirt and porous paving stones. The portion of the trail at this location found beneath, and south of the 401 overpass, uses porous paving stones to delineate the trail. Porous paving stones can prohibit the movement of certain species, particularly small reptiles, and therefore contributes to habitat fragmentation. However, the collection of overpasses at this site allow for wildlife to move under the road infrastructure and parallel to the river primarily on its west side.

East to west and north to south connections are well maintained and easy to traverse, though the north to south connection is not accessible for all users, especially those with mobility devices. A critical point of consideration in the discussion of human connectivity at this site is accessibility. It is especially easy to overlook in a natural setting where one automatically assumes that able-bodied individuals will use the space. However, there is a balance to be struck between keeping a location in a natural state and creating accessible locations. What is an appropriate level of accessibility is beyond the scope of this analysis, but as it stands, people with disabilities would not be able to navigate the trails and roadways at both locations 1 and 2.

Recommendation

Replace porus paving stones with those made of a natural material to allow for the movement of species of all sizes.

Location 2: Site C - 401 Underpassage

The collection of overpasses at this site allow for humans and wildlife to move under the road infrastructure and parallel to the river primarily on its west side. While the armature of the 401 does allow for safe wildlife crossing underneath it, noise pollution and lack of sunlight penetration likely deter many species from using this corridor for passage.

Directive fencing is needed along the edge of Kingston Road to guide wildlife away from, and to discourage them from crossing the road. Fencing is used under the 401 overpass to prevent both people and wildlife from gaining access to the highway. The current fencing has not been maintained and would require a finer grain of mesh to prevent small mammals, amphibians, and reptiles from passing through. While the highway overpasses can serve as a sheltered area and a means for wildlife to cross the landscape and avoid the highway, it has virtually no plant life or natural ground cover, as sunlight is blocked from reaching the ground. Again, this likely deters some species from using this corridor to access the north or south sides of the 401 and Kingston Road. The removal of the porous paving stones to provide natural ground cover would allow for the movement of all species no matter their shape or size. Renaturalization of the area under the expressway with plants that are tolerant of shade could serve to attract wildlife to this area. The introduction of plant species could also serve to muffle the noise from the traffic overhead that might discourage wildlife from using the space.

Recommendation

Install barrier fencing around 401 overpasses to ensure humans and animals cannot gain access to the roadway.

Trail passing under the 401

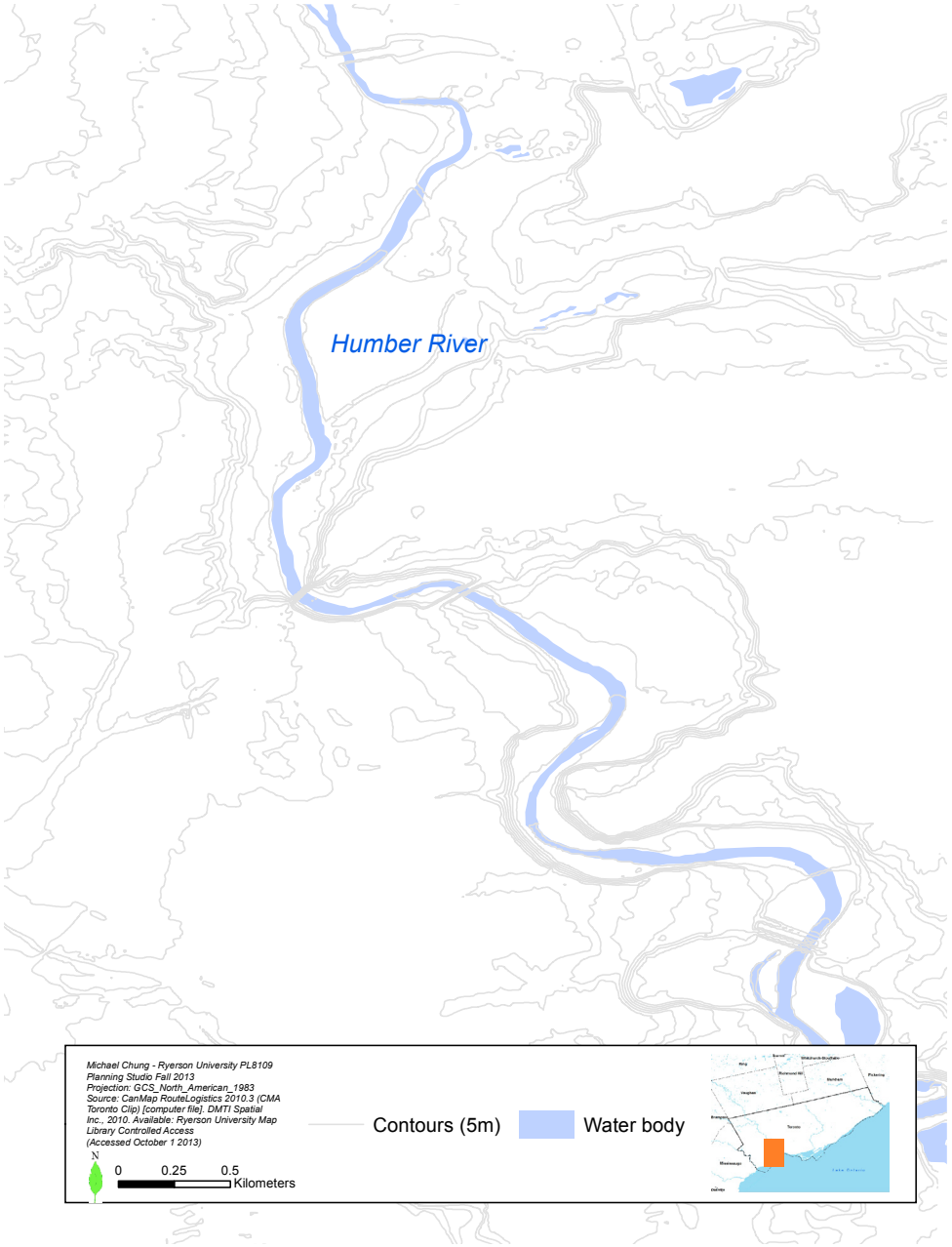
(Photo Source: Ketchabaw, 2013)

Pedestrian bridge across the Rouge River

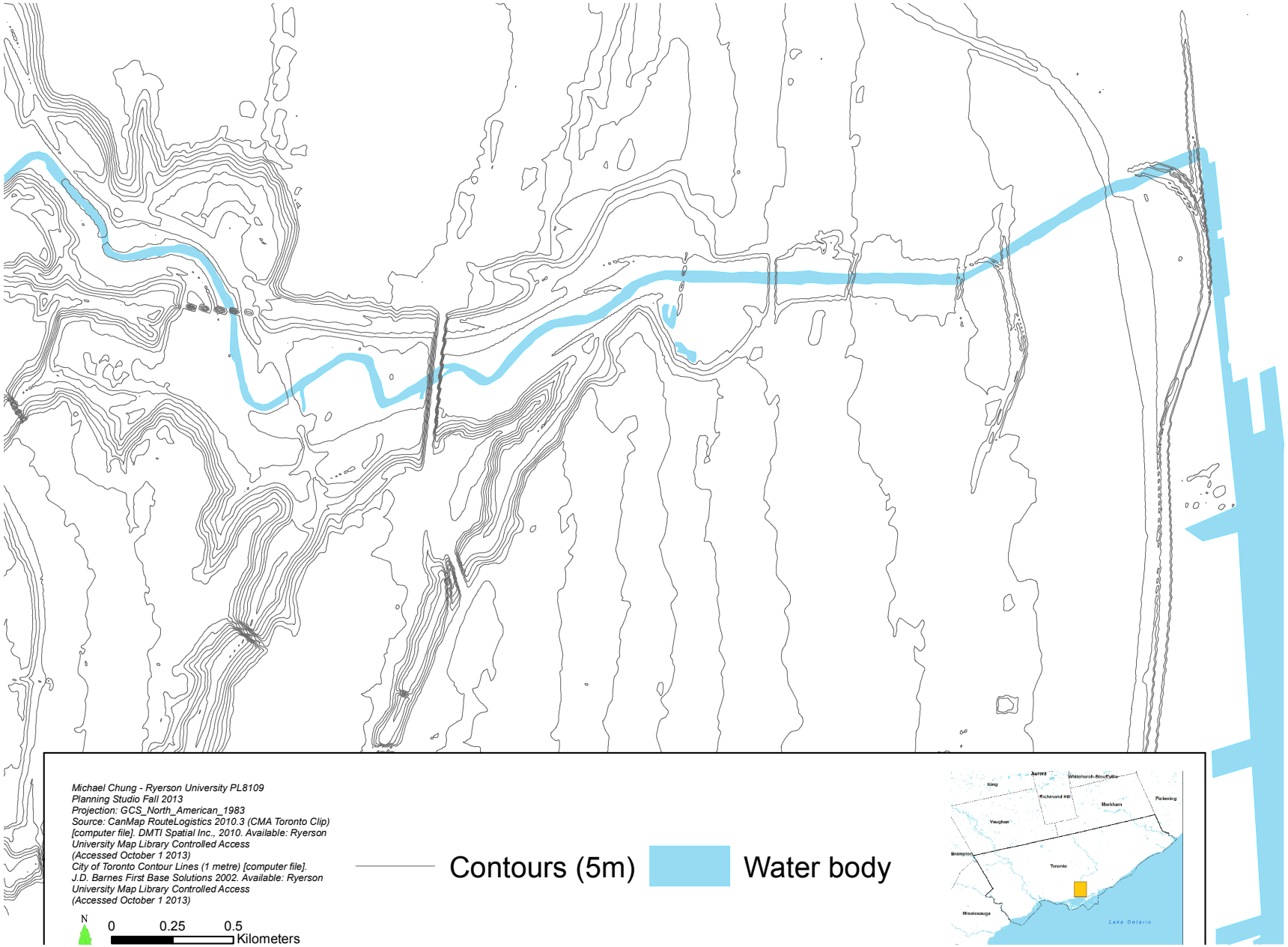
(Photo Source: Ketchabaw, 2013)

Elevation Changes

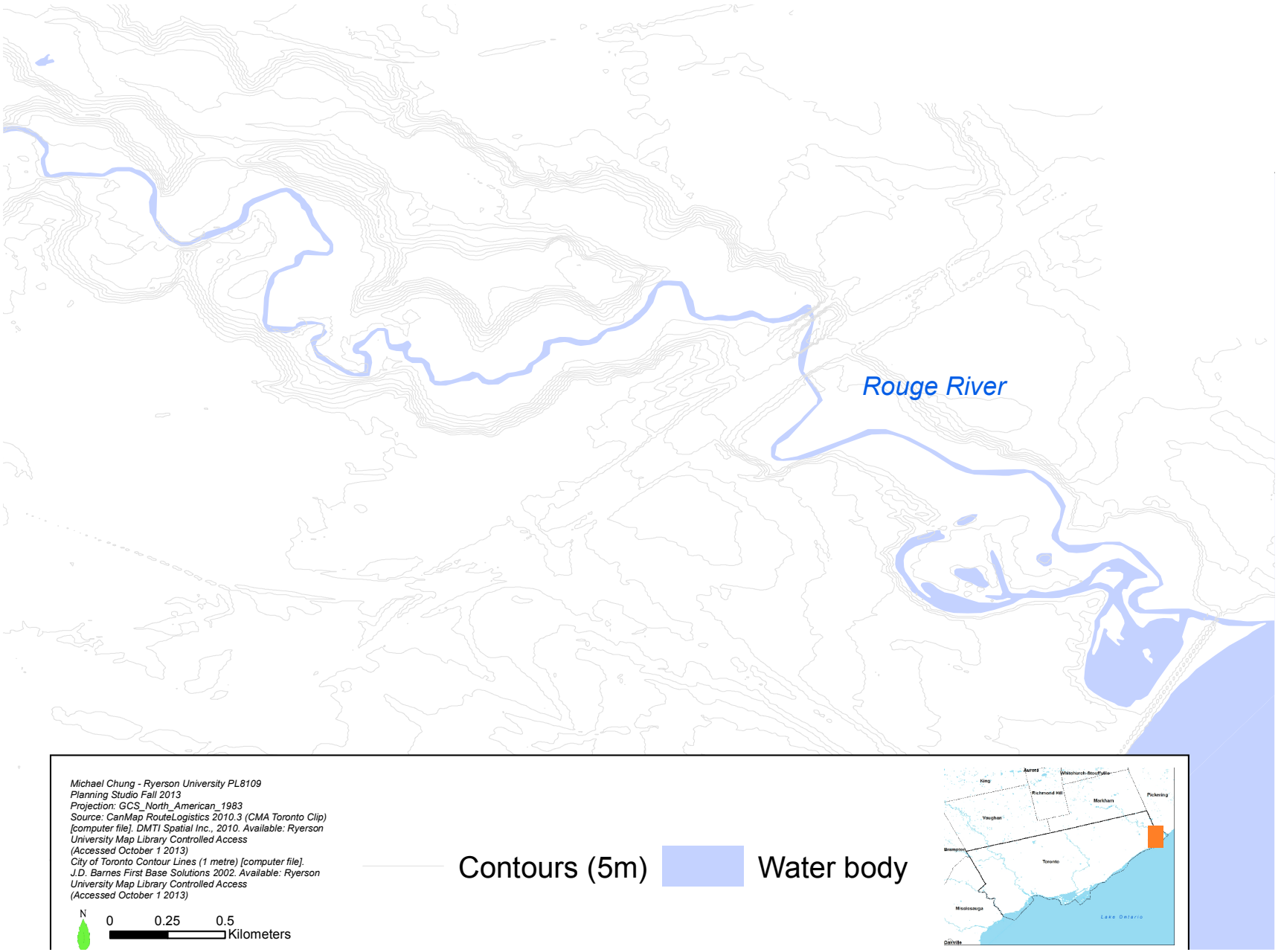
Each of the study areas in the Humber, Don and Rouge watersheds have very different changes in elevation. The Rouge study areas do not have any major changes in elevation, but sections along the Humber and Don Rivers are extremely steep, as demonstrated by the narrow contour lines on the elevation maps. These drastic elevation changes pose connectivity challenges for people as they limit accessibility to the entrances of the trails. Stairs are commonly used to overcome the changes in elevation, but they are not accessible for all users. The installation of a ramps or elevator would ensure that all individuals can easily access the trails. However, any infrastructure that is constructed to provide better access for humans must not hinder the mobility needs of wildlife. For example, staircases must be built to allow wildlife to pass beneath without any barriers.



Humber Ravine Elevation Map



Lower Don Elevation Map



Rouge Ravine Elevation Map

Overcoming Elevation Changes: The Highline, Stairs and Ramps

(Photo Source: The Highline, 2013)

The Highline, New York City
The Highline is a fully accessible linear park and trail system located in New York City. It is a former freight line that is elevated 30 feet above street level (The Highline, 2013). Staircases provide access to the trail, but to ensure that it is fully accessible for all users, a number of entrances to the trail provide access to elevators.

(Photo Source: Roth, 2013)

Stairs
Staircases are a traditional and common application to accommodate changes in elevation. A series of staircases are used within the Toronto ravine system. Riverdale Park has an excellent staircase connected to the pedestrian and cyclist bridge. It provides a link between Riverdale Park East and Riverdale Park West, and also provides an entry point to the Lower Don Trail.

(Photo Source: Roth, 2013)

Ramps
Ramps provide excellent elevation change connections for pedestrians and cyclists. Newly constructed Underpass Park has been connected to the Adelaide Street East Bridge with a ramp. Despite requiring a larger footprint than elevators, ramps provide accessible connections.

Recommendations

In today's climate of decreasing public investment in civic infrastructure, we are faced with an increasing need to repair existing and often crumbling transportation infrastructure. There are a number of opportunities to adaptively reuse or retrofit some structures for wildlife crossing purposes, whereas new structures may test alternative and emerging sustainable materials at lower lifecycle costs (Lister, 2012). Addressing wildlife road mortality in the road planning stage by constructing roads in locations that minimize habitat fragmentation or with integrated mitigation measures will have the greatest chance of success at minimizing impacts of road mortality on wildlife populations (Garbutt, 2009; Glista et al., 2009). Integrating mitigation measures into road construction plans may also prove economical in the long-term compared with the need to retrofit roads with crossing structures (Garrah, 2012).

Moving forward, the most effective way to increase wildlife connectivity in the City of Toronto is by establishing a better connection between capital infrastructure projects and animal road crossing structures. It is likely that any new capital infrastructure projects planned within Toronto's ravine system will lead to further wildlife habitat fragmentation. The inclusion of adequate crossing structures can help reduce the consequences of habitat fragmentation by enhancing the ability of wildlife to travel through bisected landscapes (Vancouver Island University, 2011). To this end, the following provides a set of criteria that should be examined whenever a capital road project or a road revitalization project is undertaken within Toronto's ravine system. These criteria were chosen based on the analysis of missed connections from each watershed, as well as a body of research about site-specific wildlife crossings:

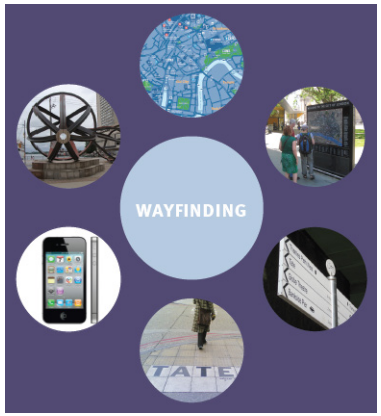
- Hot spot for wildlife death
- Hot spot for population clusters (amphibians, reptiles, mammals)
- Clusters of endangered species
- Clusters of vulnerable species (i.e. reptiles and amphibians because of their slow moving nature)
- Suitable ecosystems on both sides of the crossing
- Existing infrastructure that can be retrofitted
- Where there is an opportunity for directive fencing to be installed in conjunction with crossing structures

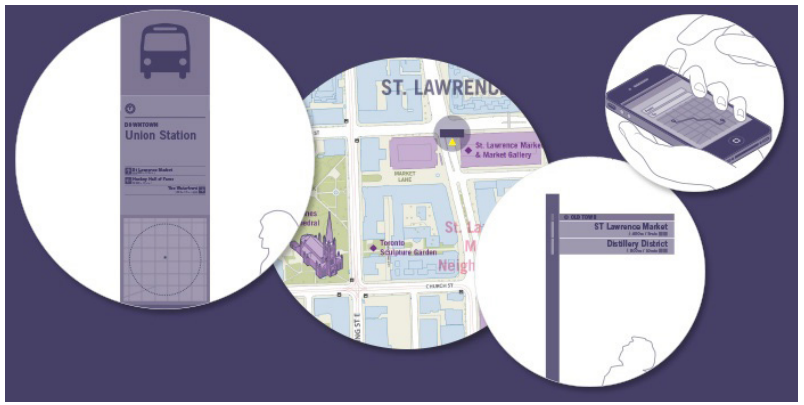
CULTURAL CONNECTIONS

Even though there are existing and proposed physical connections in the ravine system, humans must be motivated to navigate them. The creation of cultural connections can be achieved through the use of signage and public art. Each individual visitor to the ravines will develop a personal relationship with the landscape based on their awareness of the site's history, their own past relationship with the landscape and their experience interacting with the landscape.

Wayfinding is both functional and symbolic. Signage can provide tangible benefits to the ravine system by clarifying the relationship between the trail and the surrounding city streets and by educating users about native plants and animals. On the other hand, using public art for purposes such as daylighting provides the wayfinding strategy with a symbolic component.

Functional





Symbolic

Davie Street Village, Vancouver

Cabbagetown, Toronto

(Photo Sources: Curzon, 2008; Crew Magazine, 2013; City of Toronto 360 Wayfinding Strategy, 2013)

Public Art

The Lower Don Trail, the Humber Ravine, and the Rouge River Ravine would all benefit from public art, although only the Lower Don Trail has a public art initiative in the works. The Lower Don Trail Master Plan will provide a guide for integrating art into the natural setting of the ravine, so for the purpose of this manual, the focus is on types of public art that relate to the overarching goal of creating connections – in this case, cultural connections.

Public art should be placed at locations that would benefit from being highlighted, like the entrances and exits and strategic intervals along the trails. Art pieces should be durable and reflect the natural environment. Art can also be used to highlight the history of a trail and the cultural connections that have been created with the environment over time. The use of natural, durable materials and culturally specific imagery and themes will help visitors to the trails create lasting and meaningful cultural connections with the landscape. These recommendations can be used to guide the public art initiative in the Lower Don Trail and inform other public art initiatives that may be introduced in nature trails anywhere.

The Watershed Wall at Evergreen Brick Works is a public art piece that highlights the rivers , creeks and ravines that run through the city.
(Photo source: Martel-Bryden, 2013)

Watershed Wall, Evergreen Brick Works

"Instead of the repetitive criss crossing of city streets, the piece depicts ghostly homages to the lost rivers of Toronto etched into the rusted steel. To consider this work as a map is to confront Toronto's ecological essence. "Where is your watershed address?" is the question the installation asks the occupants of the region."

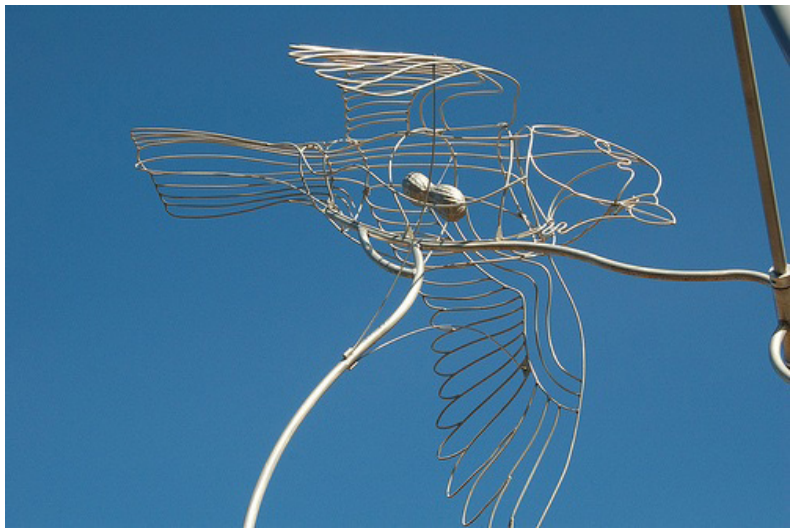
"The whole purpose of the artwork is to reconnect us to the watersheds that sustain us - to look at a map of Toronto from a different perspective and raise our water consciousness."

- Sardella, 2010

Public Art Case Study

The Valley Trail Public Art Project Competition in Whistler, British Columbia has produced thoughtful and appropriate public art projects in a natural setting. The art pieces that are most applicable to the Toronto context can be placed in two broad categories: landmark art pieces and animal awareness art pieces. The landmark art pieces are permanent installations, they are made of resilient materials, and they are memorable and culturally significant. This type of art reassures newcomers to the trail that they are on a designated path and helps them create a mental map of the trail over time. Public art pieces along the trail also depict animals in situations that mimic their natural behaviour. These art works remind visitors that they share the trail with wildlife. The Valley Trail Public Art Project Competition has produced high quality art works that are sensitive to Whistler, B.C.'s cultural and historical context. While Toronto has a different cultural and historical context, inspiration can be taken from these creative and meaningful works.

Totem Pole along the Whistler Valley Art Trail
(Photo Source: The Whistler Valley Art Trail Competition, 2013)



Bird Statue along the Whistler Valley Public Art Trail
(Photo Source: The Whistler Valley Art Trail Competition, 2013)

Daylighting

The Don River is more than what meets the eye. Portions of the river have been submerged beneath the built environment. Public art can be used to increase awareness about the invisible presence that the river has beneath the city's streets. Suitable artistic forms are bronze cast in sidewalks or, a less permanent option, is paint on the surface of sidewalks. Other innovative public art approaches to daylighting can be suggested by artists are who are commissioned by the city either through a competition, open call or selection process.

A painted river on Gould Street on Ryerson University's campus brings to light Moss Park Creek, a river that runs under the campus, and increases awareness of the city's extensive river network, much of which is buried under the city.
(Photo Source: Cameron, 2013)

Signage

Signage in the three ravine systems differs in quality. The signs in the Humber Ravine system are well maintained and they look clean and new. Their state is due in part to their high placement, out of reach of potential vandals. The signs in the Rouge River Ravine System will be updated as part of the rebranding of the ravine as a national urban park. The Lower Don Trail signage is currently aging, inconsistent and poorly maintained. The signage in the Lower Don Trail will also be updated soon in accordance with the strategy outlined by the Lower Don Trail Master Plan.

All three ravine systems should have signage at the entrances and exits to the trail as well as at nodes that are evenly spaced throughout the trails for wayfinding. Wayfinding signage should clarify the relationship between the trail and the surrounding city streets. It should also indicate the distances between exits and the location and length of identified walking and biking routes. It is also important for signage to educate visitors to nature trails. Information about the native animal species is important, especially when certain species, like coyotes, require caution. Information about plant species and the history of an area make visiting a trail an educational experience and it helps visitors to appreciate a trail and feel more of a connection to their environment.

Toronto 360° Wayfinding Strategy

The City of Toronto currently has a wayfinding strategy that aims to increase signage in the downtown core to help tourists and locals alike navigate the city on foot. It is recommended that this strategy be expanded into the ravine system to better integrate our natural systems with the urban fabric that surrounds them.

Vandalized sign along the Lower Don Trail
(Photo Source: Roth, 2013)

Educational panels along the Humber Ravine Trail
(Photo Source: Roth, 2013)

Gateways - Highlighting Entrances

Dramatic gateway transformations help to identify and celebrate the entrances to trails. The Humber, Don and Rouge Trails lack effective gateway signage. The use of public art can improve access points within each trail and improve wayfinding throughout each trail system.

Access along Scarlett Road, Humber Trail
(Photo Source: Roth, 2013)

Existing Gateways

Baby Point Gateway, Humber Trail
(Photo Source: Roth, 2013)

Oxhey Woods Gateway, Northwood, United Kingdom
(Photo Source: Cordell, 2012)

Potential Gateways

Trillium Trail Gateway, Kitchener, Ontario
(Photo Source: City of Kitchener, 2013)

Trail Maps - Highlighting Entrances

Entrances

Precincts and Nodes

Existing and proposed entrances, recincts and nodes along the Lower Don Trail. These areas have been identified as ideal locations for the placement of pubic art and signage. Maps similar to these should be produced for the Humber and Rouge Watersheds
(Photo Source: The Lower Don Trail Master Plan Presentation, 2013)

Create a wildlife friendly garden

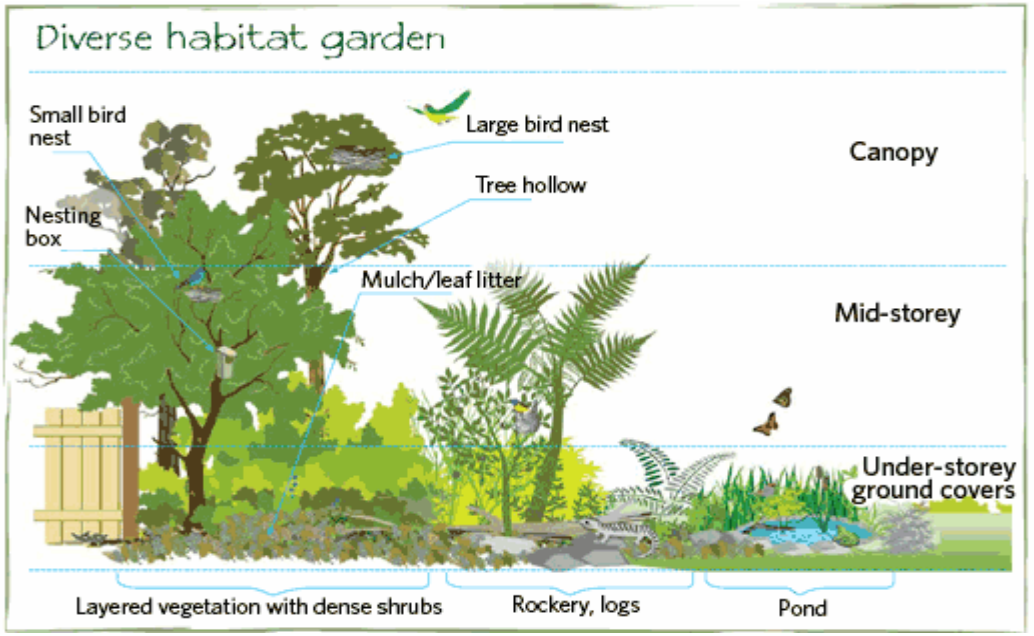
Gardens provide vital habitats for wildlife, and contribute to a larger network of greenspace, allowing for species to move freely across the city. They help to reconnect fragmented habitats within the city. Gardens also absorb carbon, provide floodwater management, and help cool the city. There are a number of ways to make your garden wildlife friendly:

- Include layers of vegetation that mimic natural landscapes, including drought resistant plants, broad leaved trees, wildflowers, trees and shrubs of various heights, and groundcover.
- Allow flowers to go to seed. Seed-eating birds eat seed heads of plants through the late summer and fall.
- Plant trees and shrubs that hold their seeds and berries during the winter months. Finding food sources during the winter is a challenge for birds in the city
- Add plantings to windowsills or balconies. They create shelter areas and stopping points for insects and birds as they travel through the city.
- Use mulch. It enriches the soil, encourages growth and helps to prevent water loss in your garden.
- Add a green roof to any sheds in your yard.
- Avoid using chemicals.
- Install a bird feeder in early fall and keep it clean and stocked until the spring. This helps to supply food for birds during the colder months.
- Place a birdbath or fountain in a sheltered area.
- Install nesting boxes for birds.
- Install a pond.
- Avoid using exclusionary fencing on your property.

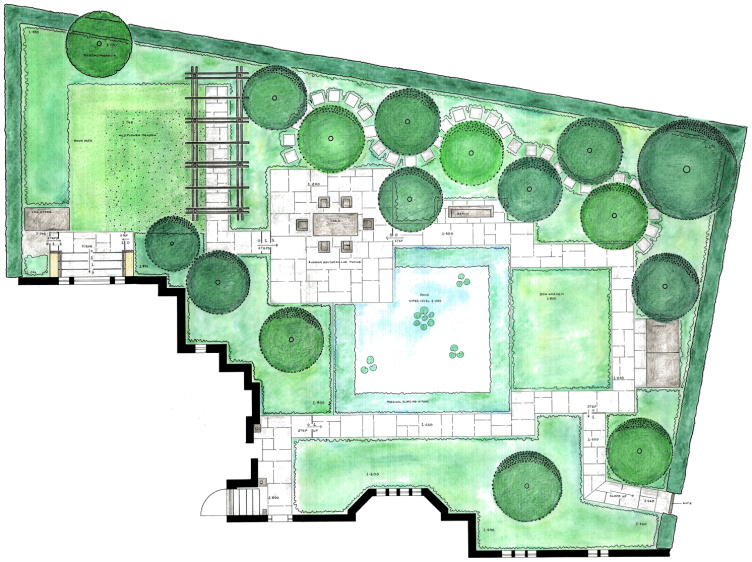
For more information about how you can make your garden wildlife friendly, visit the following sites:

- Canadian Wildlife Federation – Wild about Gardening (www.wildaboutgardening.org)
- Evergreen Native Plant Database (www.evergreen.ca)
- Ontario Nature (www.ontarionature.org)
- Toronto and Region Conservation Authority – Bird Gardens (www.trca.on.ca)
- The Ecologist – Green Living (www.theecologist.org/green_green_living/gardening

A wildlife friendly garden
(Photo Source: Hawes, 2009)



(Photo Source: City of Ryde, 2012)



Design of a wildlife friendly garden
(Photo Source: Jane Hamel Garden Design, 2012)

Deer in a backyard
(Photo Source: Zhang, 2008)

Get involved in local conservation efforts

- There are a number of organizations within Toronto working to create a more sustainable and resilient future for the city.
- **Toronto Environmental Alliance (TEA)** is a not-for-profit organization that works to find solutions to the city's environmental problems and to promote a greener Toronto. For more information about getting involved with TEA, visit www.torontoenvironment.org.
- The **Toronto Zoo** is involved in a number of conservation initiatives and depends on the public as an important resource for these conservation efforts. To find out how you can get involved with the Toronto Zoo, visit www.torontozoo.com/conservation.
- The **Toronto and Region Conservation Authority (TRCA)** provides a number of ways for the public to become involved with their conservation efforts. The TRCA offers ways for families, individuals, and communities to get involved. Visit http://trca.on.ca/get-involved/index.dot for more information.
- **Evergreen** is a national charity that works to create more livable cities. **Evergreen Brick Works** is a community environmental centre located within the Don Valley, and is an important outlet for supporting Evergreen's projects. There are a number of ways in which you can get involved with Evergreen Brick Works to help support the development of a more sustainable and livable city. Visit http://ebw.evergreen.ca/.
- Support the **#LOVETHERAVINES** campaign. Visit www.lovetheravines.com to find out more about this campaign and to provide support in their mission to protect Toronto's ravines.
- **Park People** is a Toronto alliance for improving the city's parks. If you would like to get involved in your local park, visit www.parkpeople.ca.
- The **Centre for City Ecology** provides community members with opportunities to participate in discussions about Toronto's planning and development. For more information, visit http://cityecology.net/

MOVING FORWARD

The work that has been done in this project leaves room to grow and be built upon. Described in this section are a number of possible ways to move the research of landscape connectivity within urban environments forward. One suggestion for a future project is to study the benefits of, and the process involved in developing a Greenspace Master Plan for the City of Toronto. This type of plan was created for the City of Ottawa in 2006. It serves as an inventory of all the greenspaces in the city, including natural lands, open space and leisure lands, as well as greenspaces surrounding city infrastructure, institutions and business parks. The plan includes an objective of increasing greenspace connectivity and it also sets strategic directions for managing and extending Ottawa's greenspace network (City of Ottawa, 2006). A greenspace master plan would aid Toronto in developing city-wide goals for increasing landscape connectivity and to help identify where infrastructure and development projects intersect with key greenspaces and sensitive natural areas. Future development pressure on the city's greenspaces can be assessed and preventative actions can then be taken to protect these areas. This would ensure that the construction of access points are sensitive to both human and wildlife needs and can be planned before development begins. A potential future study can examine these benefits, among others, and determine how this type of plan can be established and who should be involved.

A limitation that was identified while carrying out this project is the lack of coordination between organizations within Toronto who are advocates for the ravines and the city's greenspace network. Moving forward, greater collaboration between stakeholders and better coordination of their efforts needs to be achieved. Specifically, the clarification of roles and responsibilities in greenspace management is an important next step. The potential role for a Greenspace Master Plan to serve this purpose should be further explored. A Master Plan would be useful for identifying the key organizations involved in managing Toronto's greenspaces. It could also be used to clarify each organization's role, responsibility, and jurisdictional authority over specific inventoried lands. Some organizations have already been identified throughout this work, and there other organizations whose mandates and initiatives can be identified and integrated with other work being done in the city. Examples include: City of Toronto Departments of Environmental Planning, Transportation Planning, Parks, and Engineering; private organizations such as the Toronto Region Conservation Authority (TRCA), Ontario's Ministry of Transportation, and Waterfront Toronto; non-governmental organizations, such as Evergeen and the Ontario Road Ecology Group (OREG), that have been involved in protecting, maintaining or expanding Toronto's green space network.

Finally, to carry this work forward, it is important to better understand the patterns of animal movement across the city to help inform the alignment of animal crossing structures with capital infrastructure projects. It is challenging to recommend

the implementation of these structures without the knowledge of specific species habitats, hibernation and breeding areas, and their movement between them. A more complete database of wildlife movement and migration patterns would greatly benefit the city's ability to implement wildlife crossing structures where they are most needed. For example, the Ministry of Natural Resources has an excellent database of endangered, threatened and at-risk species, and the measures to be taken for their protection. As such, a multi-disciplinary approach would be optimal for gathering data on wildlife migration in the city. Encouraging more sharing of data layers between departments and across agencies of varying disciplines is a recommended next step. This will also facilitate more communication between invested stakeholders, and will help to encourage new ones to be more involved. Organizations like Parks Canada, the Ministry of Natural Resources, OREG, and the TRCA should be involved in this type of project.

Awareness of the benefits of having greenspace, and more importantly a connected greenspace plan, must be conveyed to all disciplines involved in Toronto's city planning and building. Ongoing education programs for engineers and other city departments must be developed as part of larger education campaigns within the city to support the health and preservation of greenspace. This type of education will require collaboration between groups and transparency of data and information. Work that focuses on data sharing across departments and between organizations will inform education campaigns for professionals and the public. Despite only a few potential future projects being listed, there is significant potential for several other projects to stem from this work.

RESOURCES

ARC Solutions: Road Ecology, Landscape Ecology, Infrastructural Design
www.arc-solutions.org

City of Toronto: Parks, Forestry and Recreation
http://www.toronto.ca/parks

Ecological Society of America. Ecological Society of America. Retrieved from http://www.esa.org/esa/

Evergreen Brick Works
www.ebw.evergreen.ca

Forman, R.T.T. (1995). Land Mosaics: The Ecology of Landscapes and Regions. Cambridge University Press. 632p.

Forman, R.T.T. (2008). Urban Regions: Ecology and Planning Beyond the City. Cambridge University Press. 408p.

Forman, R.T.T., and Alexander, L.E. (1998). Roads and their major ecological effects. Annual Review of Ecology, Evolution, and Systematics, 29, 207-31.

Forman, R.T.T., Sperling, D., Bissonette, J.A., Clevenger, A.P., Cutshall, C.D., Dale, V.H., Fahrig, L., France, R., Goldman, C.R., Heanue, K., Jones, J.A., Swanson, F.J., Turrentine, T., & Winter, T.C. (2003). Road Ecology: Science and Solutions. Washington DC: Island Press. 481pp.

Homepage / Waterfront Toronto. Homepage / Waterfront Toronto. Retrieved from http://www.waterfrontoronto.ca/

Ontario's Greenbelt | Possibility grows here. Ontario's Greenbelt | Possibility Grows Here. Retrieved from http://greenbelt.ca/

Perlman, D.L. and J.C. Milder (2004). Practical Ecology for Planners, Developers, and Citizens. Washington DC: Island Press.

Reeves, W. and C. Palassio, eds. (2008). HTO: Toronto's Water from Lake Iroquois to Lost Rivers to Low Flush Toilets. Toronto: Coach House Books.

Roots, B.I., D.A. Chant & C.E. Heidenreich (1999). Special Places: The Changing Ecosystems of the Toronto Region. Vancouver: UBC Press. 342 pp.

Steiner, F.R. (2008). The Living Landscape: An Ecological Approach to Landscape Planning. Second Edition. Washington DC: Island Press. 356 pp.

Task Force to Bring Back the Don (1991). Bringing Back the Don. City of Toronto.

APPENDIX - CITY OF TORONTO TRAIL MAP

WALKING AND HIKING...

a great way to explore the city and its parks, trails, waterfront and natural areas.

Tips for Exploring Toronto on Foot

- Walk with others
- Wear a broad-brimmed hat, comfortable footwear and clothing
- Carry a light fanny pack/backpack with identification and a drink
- Be aware of your surroundings
- Cross streets safely at traffic lights and crosswalks
- Use caution on all routes, as recreational trails may be slippery or obstructed
- Be courteous to others. Keep to the right.
- Respect our environment and keep Toronto beautiful
- Follow sun safety recommendations

Walking and Hiking is Good for Your Health!

You are never too young or too old to go for a walk. Walking is good for you as it:

- Refreshes the mind and increases energy
- Is a natural movement
- Is a terrific stress and tension reliever
- Provides time for sharing and socializing
- Lowers blood fats, blood pressure and improves digestion
- Strengthens bones, helping to prevent or control osteoporosis
- Helps you to reach and maintain a healthy weight
- Trains your heart, lungs and muscles to work better
- Is available just outside your door

WALKING RESOURCES

Many community associations and walking groups produce detailed walking maps as well as offer guided walks. We encourage you to seek out these additional resources to continue exploring Toronto's parks, trails, waterfront and natural areas.

Toronto Discovery Walks are a series of 11 self-guided tours of areas of interest throughout the city (see map legend). Discovery Walks brochures are available at civic centres, can be downloaded at www.toronto.ca/parks or by calling Parks, General Inquiry Line at 416-392-1111.

The Intohealth Partnership has created a series of free walking guides, called "LET'S WALK". Visit www.intohealth.ca to view these guides or receive other information on being physically active in the city.

The ***Walk into Health Pedometer Lending Program*** is available at select Toronto Public Library branches. A pedometer is a small tool that counts your steps and can encourage you to walk and explore more. Visit www.toronto.ca/health/walkintohealth

Hike Ontario provides access to all hiking trail clubs in Ontario as well as local walking information. Visit www.hikeontario.com

High Park Community Advisory Council offers monthly Sunday walking tours of the park. Visit www.highpark.org or call 416-392-1748.

Walk the Don is a series of self-guided interpretive walks within the Don River watershed. View trail guides and maps at www.trca.on.ca/walkthedon

Toronto Bruce Trail Club operates an extensive hiking program offering over 300 hikes annually. Visit www.torontobrucetrailclub.org or call 416-763-9061.

Toronto Field Naturalists conducts organized walks year round. Visit www.torontofieldnaturalists.org or call 416-593-2656.

The Safari Walking Group, for people who are blind or low vision, walk weekly during spring, summer and early fall.

Contact safariwalk@sympatico.ca

Heritage Toronto conducts free guided neighbourhood walking tours. Visit www.heritagetoronto.org or call 416-338-3886.

Lake Ontario Waterfront Trail stretches across the city's waterfront. For a listing of events and to obtain maps, visit www.waterfrontrail.org or call 416-943-8080.

LEAF is an organization that offers guided Toronto Tree Tours through neighbourhoods. Visit www.leaftoronto.org or call 416-413-9244.

The Rouge Valley Naturalists conducts guided nature walks and theme hikes year-round. Visit www.rougevalleynaturalists.com or call 416-282-8265.

The Outing Club of East York offers year-round walking and hiking both inside and outside Toronto. Visit www.outingclubofeastyork.org or contact info@ocey.org

BEYOND WALKING

Learn a skill, swing a racquet, kick a ball, ride a bike, take a swim, go camping or tee off. These are just a few of many activities available to you right here in Toronto!

Power of Movement, by providing program and activity listings across the city, supports and encourages all residents to increase their physical activity and to make healthy choices.

power of movement
Parks, Forestry & Recreation
Move your way, everyday!
416 338-MOVE (6683)

To find out more about our recreation programs, pick up a Toronto FUN Guide at your local community centre, call Access Toronto at 416-338-0338 or visit www.toronto.ca/parks

EXPLORE THE OUTDOORS THE HEALTHY WAY

Sun Safety Recommendations

While outdoors, be sun safe!
Visit www.toronto.ca/health/sun

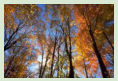
- Limit time in the sun between 11:00 a.m. and 4:00 p.m.
- Look for shaded areas to do outdoor activities.
- Wear a hat with a wide brim or with a flap to cover the back of the neck.
- Wear clothing to protect as much skin as possible.
- Put on UV protective sunglasses.
- Use a sunscreen with SPF 15 or higher and UVA & UVB protection.

Air Quality Health Index

The Air Quality Health Index (AQHI) measures air quality on a scale from 1 to 10 and tells you when it's best to be active outdoors. The higher the reading, the greater the health risk and the need to take precautions when active outdoors. For more information, visit www.airhealth.ca

HELP DOUBLE TORONTO'S TREE CANOPY AND GROW THE URBAN FOREST

More than three million trees live in our parks, ravines and along our streets. Trees provide a natural habitat for birds and wildlife, protect soils from erosion, provide shade, generate oxygen, and absorb harmful pollutants.

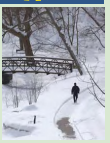


Toronto Urban Forestry works to protect and grow our urban forest as a natural legacy for future generations. For information about programs and services, visit www.toronto.ca/trees or call 416-338-TREE (8733).

You can help grow Toronto's urban forest. Join us at the annual city-wide Trees Across Toronto (TAT) events. Information on this event and other volunteering, sponsorship and donation opportunities is available at www.toronto.ca/parks/tat

Also, visit www.toronto.ca/greentoronto or call 416-392-LEAF (5323). Tax-deductable donations can be made through the Toronto Parks & Trees Foundation at www.torontoparksandtreesfoundation.org

WELCOME



This map, prepared by Toronto Parks, Forestry and Recreation, helps hikers and leisure walkers to navigate through the many parks and recreational trails that help make Toronto "A City within a Park".
It is available ***free of charge*** at local Civic Centres.

The map of the city has been divided into east and west, with Yonge Street as the dividing line. There is sufficient overlap on both sides of the map should your route cross the centre of the city.

While every effort has been made to ensure the accuracy of information, users of this map bear full responsibility for their own safety and well-being, as well as for the results of their own negligence. For some ideas about safety, see the "Tips for Exploring Toronto on Foot" section of this map.

Most recreational trails indicated on this map have hard surfaces, signage and are maintained seasonally. Hard surfaces include asphalt, concrete, compacted gravel and wood boardwalks. Most paths are multi-use and are shared by pedestrians, cyclists, in-line skaters and others. Many other existing recreational trails, not noted on the map, have soft surfaces that include wood chip, loose gravel, limestone and dirt.

Some park washrooms operate only in warm seasons while others operate year round. Winter as well as physically accessible washrooms are indicated with special icons in the map legend.

Winter walking requires extra planning and safety precautions as most trails are not cleared of snow or ice; ***use at your own risk***.

We hope you find this map to be a useful and helpful resource as you explore Toronto on foot—there's a lot of ground to cover!

WHERE TO PUT YOUR BEST FOOT FORWARD

Toronto has one of the most diverse trail systems in the world. With more than 200 kilometres of off-road recreational trails, 90 of which are paved and an additional 8200 kilometres of sidewalks, there is much to explore and no better way to do it than on foot.

Toronto has six major watersheds, plus the Lake Ontario waterfront, each featuring recreational trails that may travel through woodland, meadow and wetland habitat. You can see extraordinary wildlife, magnificent trees, gorgeous wildflowers and spectacular views of the natural and urban landscape.

Toronto boasts close to 1,500 named parks and more than 7,300 hectares of greenspace under the stewardship of Parks, Forestry and Recreation. Larger parks such as Centennial Park, High Park and Toronto Islands Park have an extensive network of recreational trails. Other parks including the Toronto Music Garden and L'Amoreaux Park have shorter paths for less demanding walks or strolls.

In the winter, you can walk through the Allan Gardens or Centennial Park Conservatories and experience nature from the inside. Take the time to smell the flowers at the annual fall, winter and spring flower shows.

Please direct any comments or questions about this map to parks@toronto.ca

This map has been produced by Toronto Parks, Forestry and Recreation, in partnership with Toronto Public Health - Designed by City of Toronto, City Planning, Urban Design, Graphics and Visualization. ' 2008/2009

WORKS CITED

Administration, F. H. (2002). Safety Effects of Marked vs. Unmarked Crosswalks at Uncontrolled Locations. McLean: Turner-Fairbank Highway Research Center.

Arc-Solutions. (2013). Arc. Retrieved September 10, 2013, from Arc-Solutions: http://arc-solutions.org/

Aroom, K. R. (2011). Riverpark: Adaptive Reuse of South Capitol Street Bridge. Washington D.C.: Department of Plant Sciences and Landscape Architecture.

Ausenco (n.d.). Hamilton GO Centre Pedestrian Tunnel Extension. Retrieved from http://www.ausenco.com/case-studies/pedestrian-tunnel-extension.

Bennett, A.F. (2003). Linkages in the Landscape: The Role of Corridors and Connectivity in Wildlife Conservation. The IUCN Forest Conservation Programme. Deakin University: Melbourne.

British Columbia Ministry of the Environment (2011). Herpetofauna and Roads Workshop - Vancouver Island University. Nanaimo, BC. Retrieved from http://www.env.gov.bc.ca/wld/frogwatch/docs/2011/Herpetofauna_and_RoadsWorkshopProgram_Feb222011.pdf

Bunting, T. & Filion, P. (2010). Canadian cities in transition: New directions in the twenty-first century (4th ed.). Oxford University Press.

CHRS (2011). Humber River – Fact Sheet. The Canadian Heritage Rivers System. Retrieved from http://www.chrs.ca/Rivers/Humber/Humber-F_e.php.

City of Chicago (2013). Parks and Open Space. CMAP GO TO 2040. Retrieved from http://www.cmap.illinois.gov/2040/open-space.

City of Ottawa (2006). Greenspace Master Plan: Strategies for Ottawa's Urban Greenspaces. Retreived from http://ottawa.ca/sites/ottawa.ca/files/migrated/files/con022221.pdf

City of Toronto (2013). Don Valley Golf Course. Parks, Forestry and Recreation. Retrieved from http://www.toronto.ca/not-available.htm?vgnextoid=ba49dada600f0410VgnVCM10000071d60f89RCRD

City of Toronto (2013). Lower Don Trail Master Plan. Parks, Forestry and Recreation.

City of Toronto (2013). New and upgraded Multi-Use Trails. Retrieved from www.toronto.ca/cycling/rinc_projects/.

City of Toronto (2013). Wayfinding. Transportation. Retrieved from http://www.toronto.ca/transportation/walking/wayfinding.htm

Garrah, E (2012). Wildlife Road Mortality of the 1000 Islands Parkway in South Eastern Ontario - Peak times, hot spots, and mitigation using drainage culverts. Queen's University Thesis – Environmental Studies. Kingston, ON. http://qspace.library.queensu.ca/jspui/bitstream/1974/7232/1/Garrah_Evelyn_finalsubmission201205_MES.pdf

Grandmaison, D (2011). Wildlife Linkage Research in Pima County - Crossing Structures and Fencing to Reduce Wildlife Mortality. Arizona Game and Fish Department. Retrieved from http://rtamobility.com/documents/RTACulvertFencingStudyFR112111.pdf

Guardian, T.C. (2011). The Case for Bicycle Lanes – Conclusion. Citizens for a Livable Cranbrook Society. Retrieved from http://livablecranbrook.blogspot.ca/2011/07/case-for-bicycle-lanes-conclusion.html.

Green Links Atlas. Retrieved November 7, 2013, from http://shim.bc.ca/atlases/greenlinks/aboutatlas.htm

City of Ottawa (2006). Greenspace Master Plan - Strategies for Ottawa's Urban Greenspaces (Rep.). City of Ottawa Planning and Development.

Holling, C. S. (1973). Resilience and stability of ecological systems. Annual Review of Ecology and Systematics, 4(1), 1-23.

Hulley, R. (2013). The Old Mill Bridge. Toronto and Region Conservation Authority. Retrieved from http://www.trca.

on.ca/the-living-city/watersheds/humber-river/newsletter/archive/?id=140941.

Jackson, S.D. & Griffin, C.R. (1998). Toward a practical strategy for mitigating highway impacts on wildlife. Proceedings of the International Conference on Wildlife Ecology and Transportation. Center for Transportation and the Environment. Fort Myers, FL, USA - pages 17-22.

Kindlmann, P. & Burel, F. (2008). Connectivity measures: a review. Landscape Ecology 23: 879-890. Retrieved from http://www.twp.org/sites/default/files/terminology%20CLLC.pdf

Kofinas, G., & Chapin III, F. (2009). Sustaining Livelihoods and Human Well-being during Social-Ecological Change. In Folke, C., Kofinas, G., & Chapin, F. (Eds.), Principles of Ecosystem Management: Resilience-Based Natural Resource Management in a Changing World. (pp. 55-75).

Lester, L. (2012). Landscape connectivity: corridors and more, in Issues in Ecology #16. Ecological Society of America, EcoTone. Retrieved from http://www.esa.org/esablog/research/landscape-connectivity-corridors-and-more-in-issues-in-ecology-16/.

Lister, N-M. (2012). Reconciling Mobility: Redesigning the Road, Reweaving Landscape. Minding Nature, 5(1): 19-29.

Majka, D. (2013). Corridor Design. Retrieved from http://corridordesign.org/designing_corridors/linkage_designs/mitigating_barriers

Meiklejohn, K., Ament, R., & Tabor, G. (n.d.) Habitat Corridors & Landscape Connectivity: Clarifying the Terminology. Center for Large Wildlife Conservation: A Project of the Wild Foundation.

Ministry of Natural Resources (2013). Reptile and Amphibian Exclusion Fencing. Retrieved from http://www.mnr.gov.on.ca/stdprodconsume/groups/lr/@mnr/@species/documents/document/mnr_sar_tx_rptl_amp_fnc_en.pdf

Ministry of Natural Resources (2013) Species at Risk in Toronto. Retrieved from

http://www.mnr.gov.on.ca/en/Business/Species/2ColumnSubPage/MNR_SAR_WHTS_RSK_TRNT_EN.html

Ministry of Transportation (2006). Environmental Guide for Wildlife in the Oak Ridges Moraine. http://www.raqsa.mto.gov.on.ca/techpubs/eps.nsf/8cec129ccb70929b852572950068f16b/342fd860378b95e1852572f00060ca78/$FILE/MTO%20Env%20Guide%20Wildlife%20ORM%20Appdx%20B.pdf

Ministry of Transportation (2007). MTO Gravity Pipe Design Guidelines. St. Catherines: Ontario Government.

Ministry of Transportation (2010). Road Talk. Province of Ontario. Retrieved from http://www.mto.gov.on.ca/english/transtek/roadtalk/rt16-4/

OREG (2013). Ontario Road Ecology Group. Toronto Zoo. Retrieved from http://www.torontozoo.com/conservation/RoadEcologyGroup.asp?

Parks Canada (2008). Waterton Lakes National Park – Salamander Crossing. Retrieved from http://www.pc.gc.ca/pn-np/ab/waterton/natcul/natcul1/w/1.aspx

Peck, S. (1998). Planning for Biodiversity: Issues and Examples. Washington DC: Island Press.

Podloucky, R. (1989). Protection of amphibians on roads: examples and experiences from Lower Saxony. pp. 15-28 In T.E.S. Langton (ed.) Amphibians and Roads, proceedings of the toad tunnel conference. ACO Polymer Products, Shefford, England.

Public Art Program. Welcome to Whistler. Retrieved from http://www.whistler.ca/public-art.

ResilientCity.org (2013). Retrieved from http://www.resilientcity.org/index.cfm?pagepath=Resilience&id=11449

Schollen (2008). Glen Stewart Ravine Design Guidelines. Toronto: City of Toronto.

Science for Environmental Policy (2012). The Multifunctionality of Green Infrastructure. Retrieved from http://ec.europa.eu/environment/integration/research/newsalert/pdf/IR3.pdf

Seymour, M. (2000). Toronto's Ravines: Walking the Hidden Country. Ontario: Boston Mills Press.

Strickland, W. (2013). Beltline Trail Study. City of Toronto. Retrieved from http://www1.toronto.ca/wps/portal/contentonly?vgnextoid=88488d0195ce1410VgnVCM10000071d60f89RCRD

Taylor, P. Lanscape Connectivity: A Return to the Basics. Retrieved from http://landscape.acadiau.ca/Phil_Taylor/PDF/TaylorFahrigWith.pdf

Tepper, L. (2011). Road Ecology: Wildlife crossings and highway design. The Design Observer: Group/Places.

Toronto (2013). Reptiles and Amphibians. Biodiversity Series.

Toronto and Region Conservation Authority. (2006). Terms of reference – Don Mouth naturalization and Port Lands flood protection project. Retrieved from http://www.waterfrontoronto.ca/explore_projects2/lower_don_lands/don_mouth_naturalization_and_flood_protection

Toronto and Region Conservation Authority. (2009). 2009 annual report. Retrieved from http://trca.on.ca/about/annual-reports

Toronto and Region Conservation Authority. (2013). Humber river watershed projects & plans. Retrieved from http://trca.on.ca/the-living-city/watersheds/humber-river/projects--plans.dot

Toronto and Region Conservation Authority. (2013). Rouge watershed projects & plans. Retrieved from http://trca.on.ca/the-living-city/watersheds/rouge-river/projects--plans.dot

Toronto and Region Conservation Authority. (2013). Don watershed projects and plans. Retrieved from http://trca.on.ca/the-living-city/watersheds/don-river/projects--plans.dot

Toronto Official Plan (2010). Map 9 - Natural Heritage.

Toronto Standard (2011). How the Don River Tells the Story of the City. Retrieved from http://www.torontostandard.com/the-sprawl/how-the-don-river-tells-the-story-of-the-city.

Transportation Authority of Canada (2008). Environmental Standards and Practices - Envisioning a Greener Future. Retrieved from: http://www.tac-atc.ca/english/resourcecentre/readingroom/conference/conf2008/docs/aw3/ontario-greener.pdf

TRCA. (2008). Humber River Watershed Plan - Pathways to a Healthy Humber. Toronto: TRCA.

TRCA (2013). Don River Watershed. Toronto and Region Conservation Authority. Retrieved from http://trca.on.ca/the-living-city/watersheds/don-river/.

TRCA (2013). The Humber River Watershed. Toronto and Region Conservation Authority. Retrieved from http://trca.on.ca/the-living-city/watersheds/humber-river/.

TRCA (2013). Don River Watershed Report Card. Toronto and Region Conservation Authority. Retrieved from http://trca.on.ca/dotAsset/157161.pdf.

TRCA (2013). Humber River Watershed Report Card. Toronto and Region Conservation Authority. Retrieved from http://trca.on.ca/dotAsset/157169.pdf.

TRCA (2013). Rouge River Watershed Report Card. Toronto and Region Conservation Authority. Retrieved from http://trca.on.ca/dotAsset/157176.pdf.

TRCA (2013). Rouge River Watershed. Toronto and Region Conservation Authority. Retrieved from http://trca.on.ca/the-living-city/watersheds/rouge-river/.

Vancouver (2013). Cycling Road Signs and Markings. Streets and Transportation. Retrieved from http://vancouver.ca/streets-transportation/cycling-road-signs-and-markings.aspx.

Vaughan (2013). Trails and Open Space Initiatives. City of Vaughan.

Vaughn, K. J., Porensky, L. M., Wilkerson, M. L., Balachowski, J., Peffer, E., Riginos, C. & Young, T. P. (2010) Restoration Ecology. Nature Education Knowledge 3(10):66

Walker, et al. (2002). Resilience Management in Social-ecological Systems: a Working Hypothesis for a Participatory Approach. Ecology and Society, 6(1), 14. Retrieved from http://www.ecologyandsociety.org/vol6/iss1/art14/.

Woolley, F. (2013). Can an element of danger make life safer? Worthwhile Canadian Initiative: A mainly economics blog. Retrieved from http://worthwhile.typepad.com/worthwhile_canadian_initi/2013/04/can-an-element-of-danger-make-life-safer.html.

Wu, J., & Wu, T. (2013). Ecological Resilience as a Foundation for Urban Design and Sustainability. In Pickett, S., Cadenasso, M. & McGrath, B. (Eds.), Resilience in Ecology and Urban Design: Linking Theory and Practice for Sustainable Cities.(pp. 211-229).

PHOTO SOURCES

Bricoleurbanism (2007). MVVA wins Lower Don Lands competition. Retrieved from http://www.bricoleurbanism.org/category/development-in-toronto/.

Bumblebee.org (2013). North American bumblebees. Retrieved from http://www.bumblebee.org/NorthAmerica.htm.

Cameron, Aaron (2013). Ryerson University.

City of Ryde (2012). Attracting Wildlife. Retrieved from http://www.ryde.nsw.gov.au/Living+in+Ryde/Around+Your+Home/Attracting+Wildlife

City of Toronto (2013). Eglinton Connects > Greening Eglinton Report.

Chung, Michael (2013). Ryerson University.

Connecticut Botanical Society (2005). Long Beech Fern. Retrieved from http://www.ct-botanical-society.org/ferns/phegopterisconn.html.

Curzon, S. (2008). Cabbagetown Flag. Flickr. Retrieved from www.flickr.com/photos/suebie68/3389160230/

Cranbrook Guardian (2011). The Case for Bicycle Lanes – Conclusion. Retrieved from http://livablecranbrook.blogspot.ca/2011/07/case-for-bicycle-lanes-conclusion.html.

Crew Magazine (2013). Vancouver Reveals Canada's First Rainbow Crosswalk. Retrieved from www.crewmagazine.com/article/vancouver-reveals-canadas-first-rainbow-crosswalk/

Dodge, V. (2011). Gatineau Hydro Corridor. Dodgeville. Retrieved from http://valdodge.com/2011/11/09/gatineau-hydro-corridor/

Evergreen Brick Works (2013). Fertile Ground For Rediscovery. Retrieved from http://ebw.evergreen.ca/about/transformation/look/fertile-ground.

Flack, D. (2009). Harolding in Mount Pleasant Cemetery. Blog TO. Retrieved from http://www.blogto.com/city/2009/12/harolding_in_mount_pleasant_cemetery/.

Flack, D. (2011). Crothers' Woods is a hidden gem in the heart of the city. BlogTO. Retrieved from www.blogto.com/city/2011/11/crothers_woods_is_a_hidden_gem_in_the_heart_of_the_city/

Harbourfront Centre (2013). Queens Quay Revitalization. Retrieved from http://www.harbourfrontcentre.com/construction/.

Hawes, M. (2009). Green Living – Gardening – A wildlife-friendly garden is a lazy gardener's dream. The Ecologist. Retrieved from http://www.theecologist.org/green_green_living/gardening/313009/how_best_to_create_a_wildlife-friendly_garden_first_relax.html.

International Food Policy Research Institute (n.d.). Understanding Resilience. Retrieved from www.ifpri.org/ghi/2013/understanding-resilience?print

Jackson, S. (n.d.). Wildlife and Highways: An Overview. Retrieved from http://www.fhwa.dot.gov/environment/critter_crossings/photo06.cfm

Jane Hamel Garden Design (2012). The Wildlife Friendly Garden. Retrieved from http://www.janehamelgardendesign.co.uk/the-wildlife-friendly-garden/

Ketchabaw, Megan (2013). Ryerson University.

Kluke, Jenny (2013). Ryerson University.

Lake Jackson Ecopassage (n.d). Providing a Safe Path for Wildlife. Retrieved from http://www.lakejacksonturtles.org.

Leal, B. (2013). The City Invites You To Rethink Eglinton. Urban Toronto. Retrieved from http://urbantoronto.ca/news/2013/10/city-invites-you-rethink-eglinton.

Legacy Habitat Management Limited (n.d). Amphibian Climate Tunnel. Retrieved from http://www.legacy-habitat.co.uk/amphibian-climate-tunnel.html

Martel-Bryden (2013). Ferrucio Sardella's Living Water Map. Art & Science Journal. Retrieved from http://www.artandscience-journal.com/post/51889087039/ferruccio-sardellas-living-water-map-in-2010

NOW Magazine (2013). 10 things you didn't know about Toronto's river valleys. Retrieved from http://www.nowtoronto.com/news/story.cfm?content=194571.

NW Bird Blog (2010). Barn Swallow – Juvenile. Retrieved from http://nwbirdblog.blogspot.ca/2010/08/barn-swallow-juvenile_18.html.

Ontario EcoCentres (2013). Program Partners. Retrieved from http://www.ontarioecocentres.org/.

Ontario Fish Species (2013). Coho Salmon. Retrieved from http://www.ontariofishspecies.com/coho-salmon.html.

Plant Architect (n.d). Pottery Road Pedestrian and Bicycle Crossing. Retrieved: November 18, 2013. http://worldlandscapearchitect.com/pottery-road-bicycle-and-pedestrian-crossing-toronto-canada-plant-architect/#.Uo98v5Gmcds

Reisman, W. (2011). Golden Gate Bridge work will force bikes, feet to share path. SF Examiner. Retrieved from http://www.sfexaminer.com/sanfrancisco/golden-gate-bridge-work-will-force-bikes-feet-to-share-path/Content?oid=2188851.

Roth, Jennifer (2013). Ryerson University.

Ryaboi, T. (2013). 15 harrowing moments from the Toronto rain storm. blogTO. Retrieved from http://www.blogto.com/city/2013/07/15_harrowing_moments_from_the_toronto_rain_storm

Seasons in the Valley (2013). Rural Fences. Retrieved from http://seasonsinthevalley.blogspot.ca/2013/07/rural-fences.html.

The Electric Blog (2013). The Electric Green Line Toronto is Holding an Ideas Competition. Retrieved from http://signature-electric.ca/blog/2013/01/17/the-electric-green-line-toronto-is-holding-an-ideas-competition/

The Highline (2013). The Highline. Retrieved September 26, 2013, from The Highline: http://www.thehighline.org/

Toronto Star (2012). Density Toronto: As GTA population rises, so do expectations for denser living. Retrieved from http://www.thestar.com/news/gta/2012/10/19/density_toronto_as_gta_population_rises_so_do_expectations_for_denser_living.html.

UMassAmherst (2009). Snakes of Massachusetts. University of Massachusetts Amherst, College of Natural Sciences. Retrieved from http://www.masnakes.org/snakes/milk/.

Urban Toronto (2012). Queen's Quay Revitalization Promises New Waterfront Attraction. Retrieved from http://urbantoronto.ca/news/2012/06/queens-quay-revitalization-promises-new-waterfront-attraction.
van Bruggen (n.d.) Ravine City. NOW Magazine. Retrieved from http://www.nowtoronto.com/news/story.cfm?content=194566.

White, P. (n.d.) Wildlife Crossings. TransWild Alliance. Retrieved from http://www.transwildalliance.org/photoGallery/

Wikipedia (2013). Turtle. Retrieved from http://en.wikipedia.org/wiki/Turtle.

Wookmark (2013). Raccoon. Retrieved from http://www.wookmark.com/image/17322/raccoon-jpg-jpeg-image-2090x1672-pixels.