Envirothon Study Guide

Urban and Community Forestry

2015

This Study Guide is to be used to help Envirothon teams prepare for the 2015 Envirothon Program.

FORESTS ONTARIO

2015 Envirothon Study Guide

This study guide has been prepared in partnership with Forests Ontario and the Credit For Product team at Fleming College, Lindsay, ON.

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1.0 Urban and Community Forestry

Students will:

- Understand what urban forestry is and what an urban forest looks like
- Learn different aspects directly related to urban forestry
- Learn the history of Urban Forestry in Canada
- See how urban forestry is applied across Canada

1.1 Introduction

Urban and Community Forestry can be defined as the planting and care of amenity or landscape trees, collectively, in human settlements. Urban and community forests broadly include urban parks, street trees, landscaped boulevards, public gardens, river and coastal promenades, greenways, river corridors, wetlands, nature preserves, natural areas, shelter belts of trees and working trees at industrial brownfield sites. Using the terms urban forestry or community forestry are determined by the size of the community. Community forestry may be a term used in small, rural-oriented municipalities. In large towns and cities, urban forestry is a more appropriate term. For the purposes of this study guide, they will be used interchangeably.

Urban forestry is an integrated, city wide approach to the planting, care and management of trees in the city to secure multiple environmental and social benefits for people who live in urban areas. Urban forests are the green spaces occurring in big cities, small towns, and in the spaces between. Planning decisions, human action and movements, and the alteration of landscape features within urban forests influence these trees.

Urban woodlands are a critically important part of the urban forest landscape. These are the greenbelts and more naturalized areas that represent the remnant forests and relics from pre-urbanization. Often they are represented in our cities and towns by areas such as natural river valleys and ravine systems that have not been developed, largely because of inaccessibility, the instability of the slopes and the potential for flooding. These urban woodlands can be excellent representatives of the original forest ecosystems that once existed there. Despite heavy urban stresses upon them, they can contain a diversity of native tree and understory species, including wildflowers. They can serve as stopover and migratory paths for birds and as natural corridors for fish and mammals.

Urban woodlands serve a wide variety of functions. They provide stable cover and erosion protection in sensitive areas, habitat and migratory paths for wildlife species, and connected and accessible systems of natural areas for human recreation. They protect water quality and quantity. They are places of diversity. These “anchors of the urban forest” are thus highly valued landscapes in urban settings, and this value rests heavily on maintaining them as an intact, connected system.

1.2 The Benefits of Urban Forests

Urban forests provide many benefits to our urban environment. These benefits include: **Improving Air Quality, Energy Conservation, Improving Water Quality, Reduce Noise Pollution, Improve Wildlife Habitat, Increase Property Value, Improve Appearance, and Enhance Psychological Well-Being.** They also contribute to total economic value and human well-being. They provide social and cultural goods and services that contribute to human well-being because of urban forests. These include health, aesthetics, spirituality, inspiration, social/psychological values, cultural heritage, education, and recreation. Ecosystem functions that provide human benefits with no negative effect are: gas regulation, climate regulation, disturbance prevention, water regulation, soil retention, nutrient cycling, waste treatment and habitat.

Urban Forests are dynamic ecosystems that provide needed services to the environment. The value of trees in the community is something that is often overlooked however they make human habitats more livable.

1.3 History of Urban Forestry in Canada

Canada contains 10% of the world's forests which until recently, was the basis of the Canadian economy. This explains why "industrial forestry" has continued to dominate the programs that define "forestry" within Canada. It is amidst this history that the development of Canada's cities took place. From a population of 5 million in 1901 in which 80% of the population lived on farms and in rural areas, Canada has now attained a population of over 30 million of which 78% live in cities, towns and populated areas. This change has been accompanied by urban infrastructure changes - including more streets, sewers, underground services (gas, electricity and water) and buildings.

At the turn of the 20th Century, many municipalities began to see the need to protect and replant trees, and this began municipal tree planting along roadsides. The creation of municipal parks departments and agencies to manage vast tracts of public, urban land was a response to these phenomena. Monoculture type plantings were common. Highway and road construction rarely considered the integration of trees in site designs. Forests were seen as an impediment to growth and quickly eliminated to accommodate suburban expansion.

1.4 Threats to Urban Ecosystems

Urban trees exist is harsh environmental conditions and have several factors preventing them from reaching their full genetic potential. Urbanization and natural threats are both contributors to the decline of urban trees.

Urbanization has put many limits on trees and forests including lack of growing spaces above and below the ground, contaminated and compacted soils, road salt effects, and has cause physical damage by trenching, mowers, snow removal activities and cars.

Urban areas are a source of many invasive plants and pests due to the import and export of goods and services out of these large areas. Along with this transportation is the potential for more invasives to be brought into Canadian cities. Invasive plants and pests are of high concern in and around the urban settings and can greatly affect the overall health of urban trees. Urban forests are also entry points for these invasive species into some of our more natural and larger forest tracts surrounding the urban areas. This adds to the need for control and management of invasive species as to help protect urban and larger natural forest ecosystems. There are many examples of invasive species impacting the health of urban forests including Dutch elm disease. In the 1940's Dutch elm disease killed 80% of the Elms in Toronto and 90% in Montreal and it is said that the loss of elms in many North American cities was the crisis that first raised public awareness of the urban forest.

1.5 Public Awareness

The Canadian Urban Forest Network (CUFN) is a Canadian action group that speaks up for Canada's urban trees. The network seeks to build value for both people who practice urban forestry and for those who are interested in urban forestry. CUFN facilitates the exchange of information about urban forestry in Canada and aims to increase awareness about the urgent issues facing Canada's urban forests.

2.0 Forests

In this section, students will:

- Understand the numerous benefits of urban/community forests to society, often referred to as ecosystem services
- Understand the economic, social, and environmental benefits of urban/community trees to local communities
- Understanding of threats to urban/community forests such as invasive species, insect and diseases, climate change, fire, air pollution, lack of management capability and development pressures
- Understand what a tree inventory is and what it is used for

2.1 Forests in Canada

Approximately 50% of Canada's landmass is covered by forests, which account for 10% of the world's forest cover. There are eight identified forest regions in Canada.

Acadian

- Located in the Maritimes, dominated by coniferous species
- Predominant Species: red spruce, balsam fir and yellow birch

Figure 1: Natural Forest Regions throughout Canada (Canadian Geographic, 2014)

Boreal Forest

- The largest forested area in Canada, dominated by coniferous tree species, with a mix of deciduous species.
- Predominant tree species: white spruce, black spruce, balsam fir, jack pine, white birch, trembling aspen, tamarack, willow

Carolinian (Deciduous)

- Forest located in southwestern Ontario between Lakes Huron, Erie and Ontario. Dominated by deciduous tree species, with a few conifer species such as eastern red cedar and eastern white pine
- Predominant tree species beech, maple, black walnut, hickory and oak

Coast

- Located in British Columbia, dominated by coniferous species
- Predominant Species: western red cedar, western hemlock, Douglas- fir

Columbia

- Located around British Columbia, dominated by coniferous species
- Predominant Species: red pine, eastern white pine, eastern hemlock, yellow birch, maple

Great Lakes/ St. Lawrence Forest

- Forest extends inland from much of the Great lakes and St. Lawrence River to southeastern Manitoba. This forest region is composed of a mix of coniferous and deciduous tree species
- Predominant tree species: red pine, eastern white pine, eastern hemlock, yellow birch, maple, oak

Montane

- Located in British Columbia and Alberta, dominated by coniferous species
- Predominant Species: Douglas-fir, lodgepole pine, ponderosa pine and trembling aspen

Subalpine

- Located in British Columbia and Alberta, dominated by coniferous species
- Predominant Species: Engelmann spruce, subalpine fir, lodgepole pine

2.2 Urban Forest Ecosystems

"The urban forest ecosystem is a collection of living organic matter (plants, animals, people, insects, microbes, etc.) and dead organic matter (lawn clippings, leaf-fall, branches) on a soil (with all its urban characteristics) through which there is cycling of chemicals and water and flow of energy" (Duryea et al 2000). Issues can arise in urban and community forests when they are managed as individual trees instead of whole forest ecosystems. Cities across Canada inventory and manage these tree species to meet many important needs including

energy conservation, **aesthetic value**, and recreational activities in the city. However, opportunities for urban forests to provide additional ecological benefits such as storm-water management, wildlife management, and biodiversity need to be considered.

An urban forest is owned and operated by a variety of different groups in vast political regions across Canada. This includes, Conservation Authorities and other non-profit organizations, municipalities and homeowners. Conservation Authorities are non-profit organizations with members who are appointed by local municipalities. They develop programs that protect land resources and promote watershed stewardship practices that lead to healthy, sustainable communities and industries. City owned trees are maintained by Urban Forestry Services. This is especially evident in Canada's largest city, Toronto, where 40% of urban trees are situated on public property, including an estimated 3.5 million trees within the parkland system and approximately 600,000 trees on the streets. Municipal by-laws are actively implemented and enforced by Urban Forestry Services to protect city owned trees. Therefore, the maintenance of virtually all urban forests are handled either by the local municipality, Conservation Authorities, or thousands of individual landowners.

2.3 Important Urban Forest Functions

Urban forests play an important role and provide numerous **ecosystem goods and services**. Forests are known to moderate climate and store carbon. They also create habitat and nurture environments rich in **biological diversity**. Forests can provide landscapes and resources essential to a host of recreational, cultural, traditional and spiritual pursuits that Canadians hold high in value. With ongoing urbanization urban forests must be managed sustainably to ensure that continuous ecosystem services are not lost.

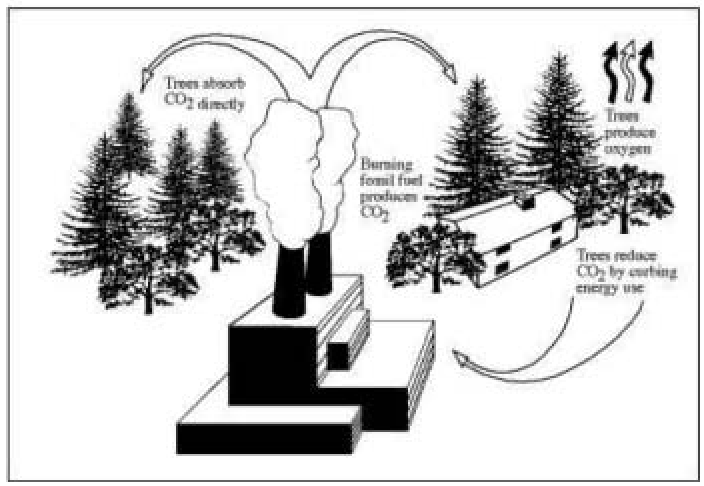


Figure 3: Forest Functions within an Urban Area (USDA Forestry Services, 2011)

2.3.1 Urban Heat Island Reduction

Forest cover in urban and developed areas is vital for urban temperature regulation. In the summer time urban trees provide natural cooling – helping to lower urban **heat island** effects.

Transpiration from trees and canopies not only affect air temperature directly but also contribute to heat storage, wind speed, relative humidity, surface roughness and more. These factors help reduce mid-day air temperatures under trees in a lawn type setting by almost 2^{o}C cooler than the same lawn with no trees. Emissions of many pollutants and/or **ozone**-forming chemicals increase with temperature - therefore trees improve air quality in urban settings.

2.3.2 Air Pollution Filtration

Urban trees buffer climate change and improve local air quality. Trees do this by drawing pollutants and carbon dioxide, a common greenhouse gas, from the atmosphere. With the **pollution-abatement** attribute of trees the urban forest has been linked to "green infrastructure". Green infrastructure provides important ways to build with nature and contribute to making a healthier overall environment. Green infrastructure provides benefits such as stormwater management, improved air quality, clean water, healthy soils and increased aesthetics.

Airborne particles in urban cities can cause serious health problems or temporary irritation in our lungs. However, urban street trees can remove particulate matter (at least temporarily) primarily on leaf surfaces. Trees are capable of removing both gaseous pollutants (ozone, sulfur dioxide, nitrogen dioxide and carbon monoxide) and airborne particles. The "stomata" on green leaves regulate these pollutants by letting them in and oxygen out.

2.3.3 Socioeconomic Benefits

There are many **socioeconomic** benefits provided by our urban forests. These benefits include desirable environments for people to live, increased real estate value, medical and psychological benefits and benefits to local economic development. The presence of trees and forests in the urban environment can create a more pleasant place to live, work and spend leisure time. These benefits can provide incentives for homeowners to invest in trees as they produce direct economic gains to local communities through property taxes. Urban residents can have reduced stress and improved physical health with the presence of urban trees and forests. These trees provide aesthetic surroundings, increased enjoyment of everyday life, and a greater sense of meaningful connections between people and the natural environment.

Energy Effects on Buildings

Trees create shade, however most people don't know that trees can significantly increase/decrease temperatures on buildings because of the shade they provide. The location of the planted tree is of utmost importance as poorly placed trees can increase energy needs by shading in the winter or blocking summer breezes. Benefits for lower energy bills go to homeowners while everyone benefits from the reduced energy demand.

2.4 Impacts of Urbanization

Urban forests are under constant stress associated with human development and activity. Restrictive soil volume and crown space, soil compaction, soil and air pollution, high salinity and vandalism limit which species can successfully grow in urban environments.

2.4.1 Biodiversity Loss

The loss of biodiversity within urban forests and street trees is of critical concern as diversity plays an important role in long-term **ecosystem function**. Many factors contribute to biodiversity loss including:

- habitat destruction
- competition from invasive species
- human demand for certain species and products
- environmental changes associated with climate change

Preserving large areas of natural habitat preserves biodiversity. However, this is not always practical in an urban area where there is little natural habitat remaining. Instead, urban forest managers are encouraged to promote biodiversity in the urban ecosystem. This can be done by planting an assortment of tree and understory species. Non-native invasive species can be found in urban areas either because of their introduction or because they were originally selected as good urban plant species. Urban forestry managers are encouraged to plant species that are native to the area and manage species that are **invasive.**

2.4.2 Management Techniques

There are many management techniques urban foresters can follow to ensure the health of urban forests. Gaining a better understanding of the diversity of species in all parts of the urban forest (street trees, parks, woodlots, abandoned sites and residential areas) is critical. Managers can begin successful management by conducting tree inventories. This will help to determine what you have and where you have it. Useful information is collected in tree inventories, including tree species, location and overall health. These inventories can also be used as an educational tool for the public and advocate for increased funding and urban forest program support.

The USDA Forest Services has developed state-of-the-art software that provides urban forestry analysis and benefits assessment tools. The i-Tree Tools assists communities of all sizes to strengthen their urban forest management and efforts by quantifying the structure of community trees and the

environmental services that trees provide. For more information on this software visit www.itreetools.org

Planting

When planting trees in an urban setting**, native species** should always be preferred. However, “cultivars” and non-native species that are not invasive should also be given some consideration. For example, many **tree cultivars** such as the London Plane Tree ‘Bloodgood’ have been hybridized and bred to perform well under unfavourable urban conditions. Given the amount of stress urban trees are under, it is always important to plant the right tree in the right place.

Figure 4: (DBH) tape, measures diameter at breast height. Used when conducting Forest Inventories to classify trees.

(meonuk.com, 2014)

Invasive Pests

The frequency of invasive pest introduction is increasing, often with devastating results. For example the Emerald Ash Borer is an exotic pest from Asia which attacks many North American ash species (Figures 5 and 6). Ash trees are planted extensively on urban streets as they provide adequate shade and perform well under urban stresses. It is estimated that up to 15 million ash trees in urban and forested areas have been killed by the Emerald Ash Borer in North America. While we may not be able to predict the future stresses that will be placed on our urban forest, we can learn from the past and aim to plant a variety of native tree species, so that urban forests are less susceptible to outbreaks like this.

Figure 5: Impact of Emerald Ash Borer on canopy of urban tree. (Forests Ontario)

Figure 6: Emerald Ash Borer

(http://arthropodecology.com/, 2012)

Case Study: Insects and Disease

Threatening Urban Forests in the Maritimes

Stresses on Urban Trees

Unlike natural forest ecosystems, urban forests face many stresses associated with heavy human development and activity. Stresses acting upon a tree in an urban forest can vary. Trees roots in larger forest ecosystems do not get paved over; the grass is not treated with herbicides; their environment does not interact with road salt; there is no reflected heat from nearby buildings; there are no snowplows or lawnmowers; nor are there utility companies cutting off branches to make room for overhead wires.

Aside from many of the physical stresses associated with development and activity in urban forests, there are also a number of insects and diseases that can bring stress to urban and natural forests. Even though these pests may be the same in both setting, they may have very different effects. There have been 3500 species of insects and over 400 species of fungi recorded in the forests of the Maritimes. Many of these species are also present in urban forests, and many trees within the urban forest are affected.
Not all species are equally vulnerable to one specific pest but they all have their own enemies and probably unknown ones yet to be discovered.

Pests on the Various Parts of the Tree

Pests can have variable effects on different parts of the tree. Below is a summary of the various parts of the tree that are affected and examples of different pest species found in the Maritimes.

Foliage

Insects affecting foliage remove or destroy chlorophyll, discolouring the leaves and making them look unsightly. Besides affecting aesthetic value, chlorophyll removal also stresses the tree through partial starvation. This makes the tree more vulnerable to attack by other insects or diseases. Some foliage damaging insects are defoliators, leaf miners, leaf rollers, leaf skeletonizers and sucking insects.

Examples: forests tent caterpillar, gypsy moth (Figure 7), birch leafminer, elm leafminer, maple leaf roller and elm leaf beetle.

Adapted from: Insects and Diseases of the Urban Forest in the Maritimes, Laszlo R. Magasi, 1995

Trunks

Diseases affecting tree trunks are of major concern for arborists and urban foresters. Insects affecting tree trunks mine the inner bark and sapwood, interfering with water conduction throughout the tree. By altering they way in which water and nutrients are carried throughout the trunk of the tree, these insects can cause mortality in many urban trees. Many fungi get into trees through open wounds and cause decay. They destroy the wood and weaken its physical strength, which can lead to breakage.
Examples- Bronze birch borer, apple tree borer and bark beetles.

Shoots

Insects that affect the shoot often show the same symptoms as foliage destroying pests. Adult pests lay their eggs under the bark, the larvae tunnel and feed inside the shoot and eventually kill it.
Examples: European pine shoot moth, white pine weevil and balsam twig aphid.

Branches

If a tree is in good health, insects affecting branches are rarely important. Most fungi that cause twig and small branch mortality are weakly parasitic and successfully attack only trees under stress. However, black knot on cherry, a disease that attacks cherry and plum species causes a canker-like growth that can kill the tree.
Example: Cytospora canker

Roots

Diseases affecting the roots of urban trees are often undetectable during casual observation. The roots are extremely important for both water and nutrient uptake and for anchoring the tree to the ground.
Example: Shoe-string root rot

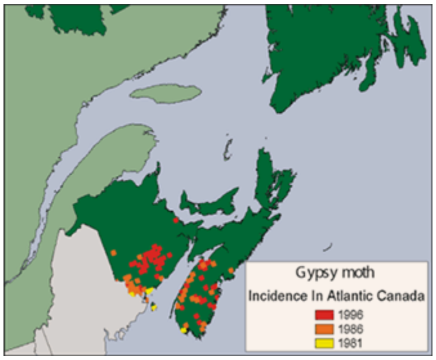


Figure 7: An example of a foliage destroying pest- gypsy moth and its incidence in Atlantic Canada.

2.6 Activity: Hazardous Tree Risk Assessment

Students will:

- Understand how to conduct a Hazardous Tree Risk Assessment and its importance to Urban Forestry
- Understand how to use management techniques and identify urban street trees

Urban trees are constantly faces stress that can create situations in which the trees become a risk to the community, structures or utilities. The risk can be minimal and typically outweighs environmental, social and economic benefits offered by such trees. However tree owners and managers must assess the level of risk as trees age or become weakened by pests, disease, and other stresses. Tree owners ultimately decide what risk level he or she is willing to accept and what modifications must be made. An experienced arborist can aid in this decision by conducting professional risk assessments that specifies the likelihood of whole or partial tree failure, the consequences of such failure and the potential targets affected. Refer to Appendix A for an activity that will challenge students to gain a better understanding of Hazardous Risk Assessment.

2.7 Questions for Discussion

1. Why is it important to conduct a Hazardous Tree Risk Assessment on urban street trees?

2. Why is it important to identify urban street trees, the DBH (cm) and height when conducting a Hazardous Tree Risk Assessment?

3. What kinds of ecosystem functions do urban trees provide?

4. Who owns the urban forest?

5. Name three good management practices for Urban Forestry managers

6. Why should we be concerned about invasive pests? Name one invasive pest and what tree it specifically attacks?

3.0 Aquatics

In this section, students will:

- gain an understanding of what an aquatic ecosystem is as well as the different types of aquatic ecosystems
- gain an understanding of the hydrological cycle in a forest ecosystem
- gain background information on benthic invertebrates and how to test them
- learn about wetlands, wetland loss and how to manage a wetland in order to avoid disturbance
- learn management techniques for urban forests and aquatic ecosystems specific to certain geographic areas

3.1 Introduction to Aquatics

Water is an essential part of our lives and is the basis for all life on our planet and it is important to understand the interaction between our urban forests and aquatic ecosystems. Water covers roughly 75% of our earth's surface and 96% of this is found in oceans. The remaining 4% is found in polar ice caps, groundwater, freshwater lakes and rivers and atmospheric vapour. Forests and watersheds have a direct relationship as forest management has an impact on watersheds and vice versa, and understanding this relationship is important in making management decisions. As human disturbance greatly influences functions of the environment, it is important to address the impact of such disturbances on aquatic ecosystems. The relationship between urban and community forestry and watersheds is extremely significant and draws specific attention to the importance of protecting our water resources.

3.2 Types of Aquatic Ecosystems

Aquatic ecosystems include lakes, rivers, streams, coastal estuaries and oceans. All of these ecosystems work together and are vital to the health of the environment, the health of humans, and the economy. There are two main types of aquatic ecosystems. One of the most significant forms of aquatic ecosystem in the urban forest ecosystem, classified as a **freshwater ecosystem**, are wetlands.

3.2.1 Wetlands

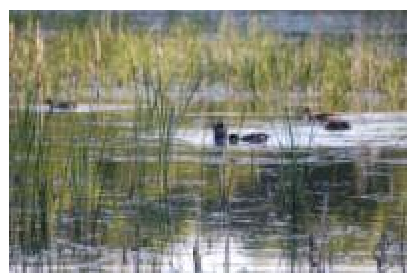
A wetland is any area that holds water either temporarily or permanently. They are **submerged** or **permeated** by water. These aquatic ecosystems are characterized by plants and are divided into five sub-categories of wetland. These categories are: **marshes, swamps, bogs, fens**, and shallow/ open water (Figure 8). Wetlands are particularly useful areas as they absorb the impact of environmental events such as large waves or floods, filter **sediments** and toxic substances, supply food and habitat to different species, provide products for food, energy, and building material, and are valuable recreational areas for activities such as bird watching.

Figure 8: Examples of wetlands.

Left and Down: Bog and Fen

Right and Down: Marsh and Swamp

(Ducks Unlimited, 2014)



3.2.2 Wetland Loss

Wetland ecosystems are very ecologically significant however, due to urban development, extensive losses have occurred in the form of the draining and flooding of the wetland. These have occurred in part because of development. They are also being affected by pollutants. The primary pollutants are nutrients, pesticide, and heavy metals. Although wetlands can improve watershed water quality, the capacity in which they are able to process pollutants can be reached and exceeded. Wetlands are currently threatened by air pollution, water pollution, and alterations of the **hydrological cycle** within a wetland. Presently, some urban plans have dedicated themselves to enhancing natural areas, such as wetlands. This is an example of **watershed management**.

3.2.3 Watershed Management

A watershed is the area of land where all of the water is under it or drains off of it goes into the same place. The watershed must be managed to protect and preserve the natural features that are important to our society and to ensure that the continued use of wetlands is sustainable. This type of management preserves a healthy ecosystem and a dependable supply of contaminant free water. Watershed management also recognizes the fact that watersheds have a stress limit before the damage becomes irreversible or they are destroyed. This type of management requires the combined effort by governments, environmental organizations, and citizens.

3.2.4 Holland Marsh

Holland Marsh is a wetland located within the valley of the Holland River in the York Region of Ontario (Figure 9). It is made up of 21,000 acres which have been divided into two distinct areas: the agricultural area and the marsh. For the agricultural area, the marsh has been drained and flooded in order to create farmland. Other areas remain wetland, both recreational and undisturbed. The agricultural area has been named 'the crown jewel of **horticulture**' and is the source of a significant percentage of produce in the province of Ontario. It provides a multi-million dollar contribution to Ontario's economy.

Figure 9: Holland Marsh

The wetland area is currently being protected by the Ministry of Natural Resources and Forestry and is known as the Holland Marsh Provincial Wildlife Management Area. Five hundred and seventy three hectares of wetland are being provincially managed. This wetland area provides facilities for wetland conservation, habitat improvement, etc. This wetland is accessible for bird watching and waterfowl hunting however hunting is monitored and managed very carefully. This effort by the Ministry of Natural Resources and Forestry is an example of **watershed management**.

3.3 The Hydrological Cycle

3.3.1 Overview of the Hydrological Cycle in a Forest Ecosystem

Trees have been defined as solar powered chemical machines that mine the soil for minerals. In addition to drawing in required nutrients, trees also suck up water. This is the main reason why forests are a key link between the atmosphere and the land in the water cycle. The forest **canopy** intercepts the rain and its **kinetic energy**. The kinetic energy can be **absorbed** by the forest canopy and forest **litter.** Without this protection, erosion from rainfall will occur.
Some of this rainfall is transferred back into the atmosphere through the process of **evaporation**, while the rest gets absorbed into the soil (Figure 10). Some of the water will be evaporated from the vegetation and this process is referred to as **interception loss**.
The sun's energy evaporates water from inside the leaves of the tree canopy and this process is called **transpiration**. Most of the water in the soil is sucked up by plant roots to replace water that is transpired from the **foliage.** Depending on the soils and the geology of the landscape along with other factors, some of the remaining water will **infiltrate** the soil and some of it will move slowly into nearby water bodies. When the water gets absorbed deep into the soil, it is called **percolation**.

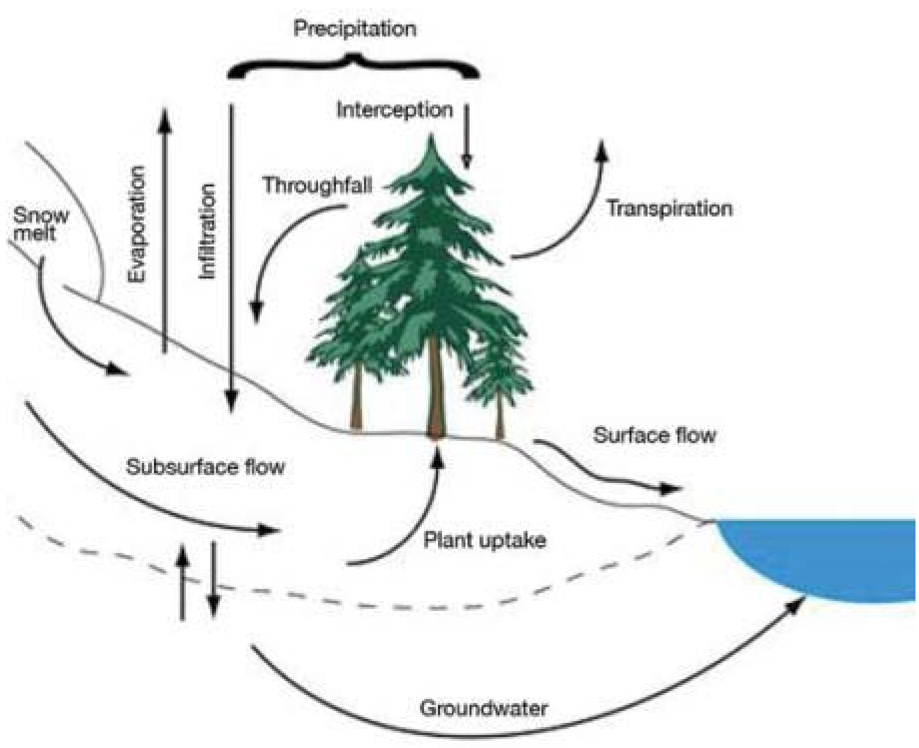


Figure 10: Year Round Depiction of Hydrological Cycle (Government of Canada, 2013)

Combining the loss of water through evaporation into one measurement is called **evapotranspiration** (Figure 11). This process includes transpiration, interception evaporation, soil evaporation, and water body surface evaporation.

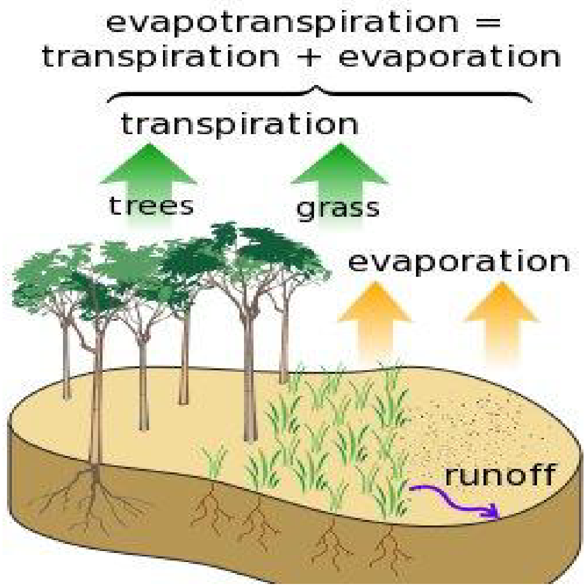


Figure 11: Evapotranspiration in forests (MwToews, 2007)

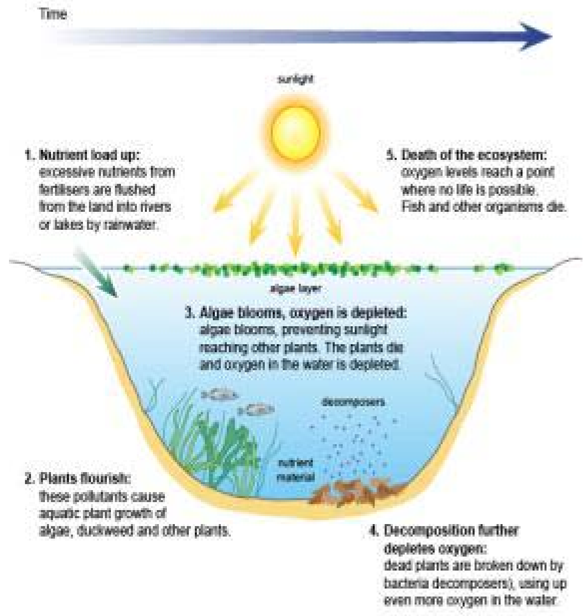
3.3.2 Flooding and Run-Off

When native forests are removed and replaced by **impervious surfaces** or other vegetation, the water that would have been returned to the atmosphere washes off the landscape. Flooding and erosion resulting from the altered landscapes can create serious concerns for aquatic organisms and their habitats. As impervious surfaces don't absorb water, the water washes off and can cause erosion, deterioration of habitat and flooding. Impervious surfaces can also cause the rapid transport of runoff into nearby urban water bodies such as streams. This has the ability to scour stream bottoms, and erode stream banks. Vegetation on the side of streams and aquatic habitat are washed away and conditions for destructive landslides are created. **Non-point source pollution** occurs when chemicals concentrated on the landscape are washed away and cause pollution that affects water quality. A lot of progress has been made to reducing and cleaning this type of pollution, however treating these problems are difficult and costly. Re-establishing the urban forest can help by reducing run off and rehabilitating aquatic habitat and ecosystems.

3.3.3 Eutrophication and Water Quality

Figure 12: Eutrophication

(BBC, 2014)



Nutrients are essential for the growth of terrestrial and aquatic ecosystems, but the level of nutrients plays an important role in the health of the ecosystem. Nutrients, pesticides, herbicides, and energy producing chemicals can become concentrated in urban environments because of their excessive use. These nutrients find their way into aquatic ecosystems The input of excess nutrients into an aquatic ecosystem is called **nutrient loading** and this can cause **eutrophication** (Figure 12**)**. Symptoms of eutrophication include: decrease in water quality, algal blooms, nuisance species, unpleasant taste of water, lack of oxygen, death of fish, and altered species diversity and richness. The nutrients in storm water runoff are a leading source of disturbance in aquatic ecosystems because they disrupt ecological relationships. The most common nutrients that affect these ecosystems are nitrogen and phosphorous. Nitrogen used in fertilizers cause the dense growth of algae which will out-compete aquatic plants such as sea grass which is critical spawning habitat for some species of fish. Also, aquatic plant communities often provide the primary source of organic carbon energy which forms the foundation of the ecosystem. These changes to the ecosystem that take place due to eutrophication and a decrease in water quality can have impacts on connecting ecosystems.

3.4 Benthic Organisms in Aquatic Ecosystems

3.4.1. Background of Benthic Organisms

The benthic community is made up of a variety of organisms that live in and on the bottom of water bodies. These are known as benthos, and can include worms, clams, crabs, lobsters, sponges, and other tiny organisms that live in water body sediments. Benthos are divided into two different groups, the **filter feeders** and the **deposit feeders**. Filter feeders are organisms such as clams that filter their food through sucking up particles out of the water. The filter feeders pump water through their bodies. As they are filtering this water for their food, they remove sediments and organic matter which cleans the water. Organic matter not used in the water column is deposited on the bottom of the water body. It is then turned into nutrients by the benthic organisms which are given back into the water column. This is an important source of nutrients to water bodies which is critical to their health. Deposit feeders are organisms such as snails that ingest or sift through sediment and consume the organic material. These organisms live off of the energy and food produced by the bodies of organisms that have died in the upper layers of the water body. This provides a down flow of food and energy from the upper layers to the benthic community. Benthic organisms are more **abundant** in shallow waters because dead food material is more abundant, and food arrives from sediments from other water bodies (i.e. river sediments flowing into lakes). Benthic organisms also feed by coming out at night and rising to feed off of upper level organisms.

Benthos can be divided further into two other categories based on size. Larger benthic organisms which are visible without a microscope are called **macro-invertebrates**. These include clams, snails, worms, crayfish and larvae. Smaller organisms which require a microscope to be visible are referred to as **micro-invertebrates**.

Benthic invertebrates are very important to aquatic ecosystems because they are a major link in the food chain.

3.4.2 Testing the Benthic Community

There are many ways to sample organisms from the benthic community (Figure 13). Sediment samples can be taken from the bottom of water bodies and tested in laboratories. Traps can be set up in order to catch larger organisms such as lobsters and oysters. **Dredging** is the most successful form of sampling benthos. Collecting sediment along with water allows for the sample to be filtered so that all organisms can be observed and accounted for. Testing the benthic community allows for the assessment of the health of the water body in which the organisms live.

Figure 13: Testing the aquatic community (Forests Ontario)

Case Study: City of Victoria Urban Forestry Master Plan

The City of Victoria Master Plan is one of several plans that adhere to the goals and policies within the City's official community plan. One of these goals is for "Victoria's urban environment, including urban forests, and public and private green spaces to support healthy and diverse ecosystems." The goal of the Urban Forest Master Plan is to protect, enhance, and expand Victoria's urban forest goals.

The City of Victoria has been blessed with a forest that consists of attractive treed landscapes. The flowering cherry trees along downtown streets to ancient, graceful oaks and evergreens that grow in parks, institutional settings and backyards, are just a few of the beautiful characteristics of the city.

Victoria's urban forest is part of a larger regional forest, along with its two major creeks (Bowker and Cecilia), the Gorge waterway and their respective watersheds. Like other cities, Vitoria has its share of challenges with its urban forests. One challenge that is important is the effect that the changing climate can have on the aquatic environments within the urban forests. The changing climate will bring with it more extreme rain storms and the urban forests must be adapted to these changes. Another challenge is that urban development has degraded the quality of the city's watersheds and biodiversity over time. This means that renewal of the urban forest is required in order to provide an opportunity to restore watershed health and biodiversity.

These challenges, among others, created the vision for the Urban Forestry Master Plan. One of the goals of the plan is to design and manage the urban forest to maximize watershed health, biodiversity and the conservation of sensitive ecosystems.

In order to address some of the challenges, the City has worked to implement certain initiatives. For example, to address the issue of climate change, an accelerated street tree replacement program that is focused on drought resistant stock has been implemented to ensure trees will be adapted to the rapidly changing climate.

The City is also developing a storm water plan that will encourage more pervious surfaces and the use of onsite rainwater best practices, including tree conservation and tree planting. As well, the City will be reducing pesticide use and using integrated pest management techniques that avoid the use of pesticides and herbicides. This is supported by a pesticide by-law that limits the use of pesticides on private property for cosmetic uses. This has been implemented in order to conserve the quality of watershed health, biodiversity, and the conservation of sensitive ecosystems.

With the importance of watershed function outlined within the Urban Forestry Master Plan, streams and wetland that have been filled in are being restored to their natural function. Rain gardens are being designed to manage most rain events, while diverting heavy rainfall to the pipe system. The City of Victoria will be working towards strategies that increase pervious cover and in association with greater urban forest cover, this strategy will enhance watershed health, conserve moisture and improve the quality of rain water as it moves through the urban ecosystem.

Case Study: Nova Scotia Wetland Conservation Policy

Historically, there was a great amount of wetland loss following European settlement in the province of Nova Scotia. This is true for two main types of wetlands in the province - salt marshes and freshwater wetlands. While salt marshes have been lost due to agricultural purposes, freshwater wetlands have been lost in fertile regions such as the Annapolis Valley, and significant loss near urban centers. The loss or degradation of wetlands results in loss or decrease in the ability to provide ecosystem services effectively, or support the ecological functions they normally perform such as controlling flooding and reducing contaminants. Nova Scotia's wetlands contribute an estimated $7.9 billion worth of benefits in ecosystem services, and the economic consequences of wetland loss are substantial.

Municipalities are becoming more aware that conserving, constructing or restoring wetlands is more significant than constructing expensive management systems (such as water treatment plants) that attempt to carry out the natural functions of a wetland. On October 14th, 2011, the province of Nova Scotia released the Nova Scotia Wetland Conservation policy. This is a new policy that provides direction and a framework for the conservation and management of wetlands in Nova Scotia.

This policy highlights the important roles that wetlands play and their value to society. It represents a commitment to managing Nova Scotia's wetlands in a consistent manner and to maintaining a high level of wetland integrity for future generations while still allowing sustainable economic growth within the communities.

One of the many objectives within this policy is to encourage the use of buffers to better ensure the integrity of wetland adjacent to development (i.e. residential, commercial, industry) and other operations. This will include educating private landowners, land developers, municipal land-use planners and farmers about beneficial management practices as well as incorporating the use of buffers and Wetland Protection Plans in Environmental Assessment approvals for projects with a high potential to have a negative impact on wetlands. The government realizes that effective wetland conservation and preventing the net loss of wetlands is unlikely to be achieved simply through policy alone and acknowledges the critical role of stewardship by Nova Scotians in the success of any wetland conservation efforts. In the future, the government plans to continually evaluate wetland conservation tools and practices from other provincial, federal, and U.S. state jurisdictions and to adopt or adapt to those most sufficient and effective to the province of Nova Scotia.

Province of Nova Scotia, 2011

Province of Nova Scotia, 2011

3.7 Aquatic Activity: Constructing Your Own Wetland

Students will:

- create their own wetland
- develop an understanding of the hydrological cycle
- develop knowledge of how a wetland ecosystem works
- develop an understanding of how stressors such as development can affect the fragile ecosystem

The purpose of this experiment is to engage students and provide them with the knowledge of how the hydrological cycle in a wetland works. Refer to Appendix B for an activity that will challenge students to construct their own wetland.

3.8 Questions for Discussion

1. Describe the hydrological cycle in a forest ecosystem. What are the main processes and how do they work?

2. What is a wetland? Why are they significant? How are wetland ecosystems in danger?

3. What is non-point source pollution? How is this related to Urban Forestry? How does non-point source pollution affect aquatic ecosystems?

4. What is eutrophication and how does it affect the health of an aquatic ecosystem?

4.0 Soils

In this section, students will:

- Develop knowledge of soil properties such as soil color and texture
- Learn the various Canadian natural forest soil classification to better understand urban forestry strategies for specific areas
- Be able to describe the differences between urban soils and natural soils
- Learn various types of soil management strategies in relation to urban forestry

4.1 Introduction to Soils

Soils are formed by the physical and chemical weathering of **bedrock** and glacial **parent material**. Soils are constantly being modified and shifted due to water, wind, and gravity effects. Glacial action has **eroded** overlying deposits, leaving exposed bedrock in many areas across Canada. As a result, the soil composition closely reflects this underlying bedrock, **tills**, and other **morainic** and **lacustrine** materials deposits. The development of soil composition in Canada depends on five combinations over time including climate, parent material, terrain, vegetation, and other organisms.

The physical, chemical, and biological processes that occur in urban soils supply vegetation with the resources they need to survive and thrive in these ecosystems. Microorganisms in the soil break down plant litter, releasing nitrogen, phosphorus, and other nutrients essential to plant growth. The composition of soil determines how much nutrients and moisture are available for plant life to survive. Soils store water and nutrients for plants to draw from when they need them. The soil is a living system that is linked to nutrient cycles, energy flows, and other ecological processes of urban forest ecosystems. Urbanization has a great effect on altering soil properties, and we must use correct conservation and management strategies to protect these soil resources.

4.1.1 Soil Colour

Soil colour provides useful information about soils such as indicating changes that have occurred since the soil formation. A red/brown colour indicates that the soil minerals have been exposed to iron. When the soil is exposed to water and air, the soil undergoes **oxidization**, giving the soil a reddish colour, just as an object would do if not protected from rain. If the soil is consistently exposed to water, but not enough air, the dominant colour would be a grey/blue. This generally happens to soils that are positioned within close proximity to the water table, and are considered to be **waterlogged**. If the soil is a dark brown/black colour, organic matter is usually present. As well as indicating change, the soil colour also gives some information on the parent material. For example, shallow soils are developed on chalky limestone material are often greyish white in colour below the surface.

4.1.2 Soil Texture

Soils consist of four components: minerals, air, water, and organic matter. Soil texture refers to the mineral makeup of the soil. The mineral portion is made up of three distinct particle sizes: sand, silt, and clay. Sand is the largest particle size that can occur in a soil. It is largely mineralized quartz, although other minerals can be present, and has a very grainy feel to it. Quartz contains no plant nutrients, and due to the large grain size, nutrients and water **leach** out making sand a poor soil fertilizer. This is why sandy soils are less productive than loam soils. Silt is also largely made up of quartz and has the same problem with productivity, although the soil grains are much smaller. The smallest of soil particles is clay. Clay soils contain plant nutrients and because they are the smallest particle, it has the largest surface area. Because of this they have the ability to retain moisture and nutrients for plant development.

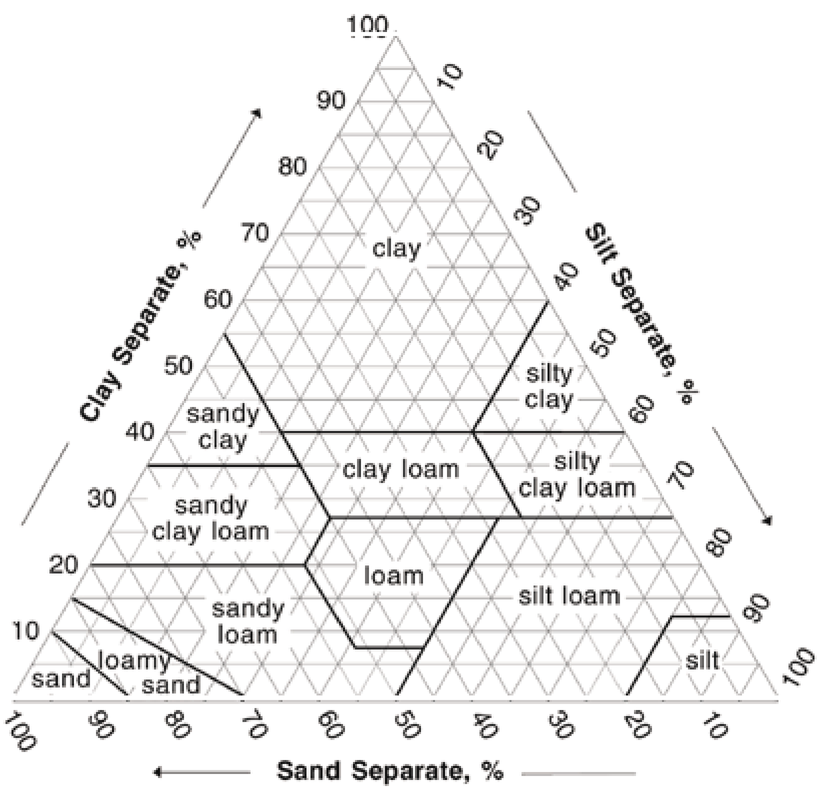


Figure 14: Soil textual triangle (Pedosphere, 2012)

Soil texture is determined based on the relative portions of sand, silt, and clay (Figure 14). Using the textural triangle is a good way to determine the texture of a soil. A loam soil is the best soil for plant productivity, and most soils are classified as a type of loam. Loam soil is a mixture between sand, silt, and clay. The type of loam soil is highly dependent on the dominant mineral present.

4.2 Canadian Forest Soil Classification

In forest ecosystems, soil classification helps scientists in assessing land productivity, suitability of a site for a particular tree species, and the potential impact of management practices on soil's physical and chemical properties. Soil classification information facilitates improved land management decisions that maintain soil productivity and therefore preserve long term ecosystem health. Figure 15 shows a map of **soil order** present in Canada.

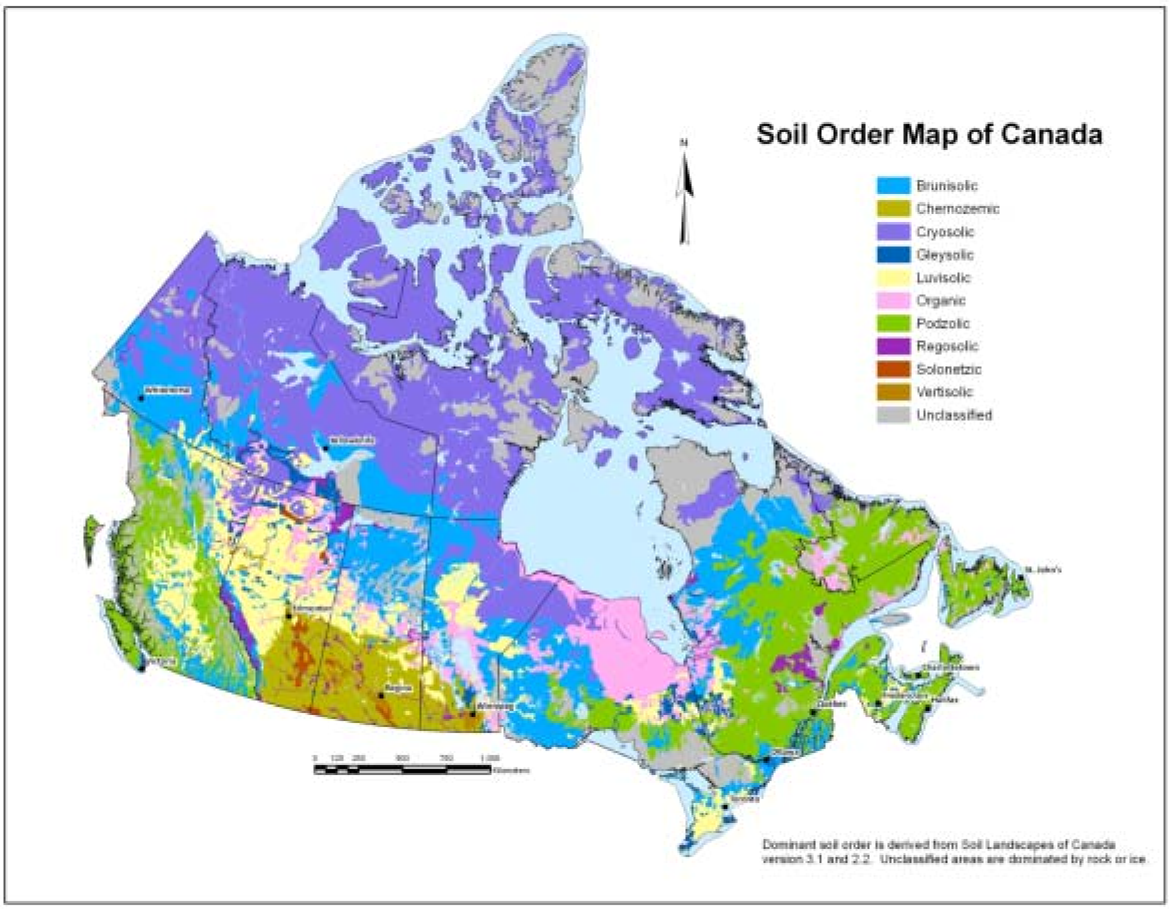


Figure 15: Map of soil orders throughout Canada (Soils of Canada, 2012)

There are four main soil orders associated with forested landscapes throughout Canada: Organic, Luvisolic, Brunisolic, and Podzolic.

Organic soils (Figure 16) occur where water accumulates to a degree that decomposition of organic matter by microorganisms is decreased or eliminated, allowing layers of organic matter (commonly called **peat**) to build up over time. Therefore, organic soils are generally found in poorly drained landscapes across Canada.

The remaining three orders found in better drained forests and their distribution is dependent upon the parent material and by climate. Luvisolic soils (Figure 17) are dominant in forested landscapes underlain by tills, and are derived from underlying sedimentary rocks or on clayey lacustrine deposits. The glacial materials have a **sedimentary rock** origin, making Luvisolic soils relatively high in clay and in **base cations** such as calcium and magnesium. The main feature of Luvisolic soils is the textural difference between the A and B horizon – the A horizon has less clay than the B horizon. The high base cation content of these soils give a neutral or **alkaline** pH value although some acidic Luvisols are found, especially in eastern Canada.

Figure 16: Organic soil profile (Hewitt, 2013)

Figure 17: Luvisolic soil profile

Brunisolic and Podzolic soil orders (Figure 18) are found in the same parent material type and differ primarily in terms of soil moisture available for soil forming processes. They are both forested soils found on sandy parent materials. These areas are primarily underlain by **igneous rock**, most prominently on the Canadian Shield, but are also found in other regions on sandy deposits. Podzolic soils are dominant on sandy deposits in areas where the mean annual precipitation is above about 700 mm. At mean annual precipitation levels below this, Brunisolic soils are found on the same types of sandy deposits, generally across Northwestern Ontario and the Canadian Shield in the prairie provinces. **Coniferous** dominated plant communities are the major vegetation type found on both types of soils.

Parent materials derived from igneous rocks typically have an acidic pH because of the mineralogical composition of the sediments. The acidity of the upper soil is further increased by the decomposition of organic products from the coniferous leaf litter. This creates a chemical **weathering zone** in the upper part of the soil. Aluminum, iron, and other metal ions are weathered and released into the soil. In Podzolic soils these metal ion forms combine with the organic decomposition products, creating **chelate** complexes, and move with draining water into the B horizon where they are deposited. In Brunisolic soils the weathering may occur but formation of the complexes is limited, and the distinctive B horizons that exist in Podzolic soils do not form.

Figure 18: Difference between Brunisolic (left) and Podzolic (right) soil profiles (University of Calgary, 2012).

Recognizing the various soil orders associated with forests would help better understand which soils are present in urban areas across Canada. This would aid in the correct implementation of urban forest practices, along with the corresponding urban soil management.

4.3 Urban Soils

Soils found in an urban environment have various different properties than soils found in a natural forest. In an urban setting, human activity is the main process for soil modification, whereas in a natural forest, the soils are subject to modification through processes such as wind, water, and organism activity.

4.3.1 Vertical Variation

When urbanization occurs in an area, one major change to soil is the difference in **horizons** (Figure 19). Urban soils are either disturbed or the entire soil profile is **fill**. The fill in the horizon is the dumping and spreading of material from a variety of sources that is spread over an existing area, usually in the case of construction. A portion of the soil horizon may be disturbed by mixing of the soil materials, which is usually done when soil is scraped away, piled, then put back in that location or transported to another location to be used as **topsoil**. This process, called **lithologic discontinuity**, creates an abrupt change from horizon to horizon which is unique to urban soils. Each of the horizons may also differ in texture, structure, organic matter content, **pH**, and **bulk density**.

Figure 19: Typical urban soil where fill has been added to a site to raise the elevation of the area (USDA).

4.3.2 Soil Erosion and Compaction

Soil erosion and compaction is another major change that urban soils undergo due to human activity. When the vegetation is stripped from the land for different land use, the soil becomes more susceptible to erosion and compaction. Soil erosion will take place in areas where frequent runoff occurs from storm events. The impermeable surfaces in the urban environments redirect storm and waste water, which erodes the natural slopes in the landscape, particularly river banks. Soil compaction also occurs in urban areas due to foot and wheel traffic, leading to the loss of topsoil.

These urban conditions tend to destroy the structure of the surface soils and prevent further formation. When forces are exerted on the surface, the soil is compressed and the soil **aggregates** are broken down into smaller pieces, leading to a decrease in **pore space**. As pore space decreases, the bulk density of the soil increases. These properties influence other soil properties such as water infiltration and permeability, water holding capacity, soil aeration, and the ability for vegetation roots to penetrate the upper layers. Measuring bulk density is a good indication of the extent of compaction in an area. Bulk densities found in natural soils are generally 1.00 - 1.34 Mg/m^3. However in urban areas, the bulk density was found to range between 1.74 - 2.18 Mg/m^3, with root penetrability limited at values exceeding 1.70 Mg/m^3. These values in urban soils are exceeding the natural bulk density values, and restrict root penetration of various plant species.

Table 1: General relationship of bulk density to root growth based on soil texture. (USDA)

Soil Texture	Ideal bulk densities for plant growth ($grams/cm^3$)	Bulk densities that affect root growth ($grams/cm^3$)	Bulk densities that restrict root growth ($grams/cm^3$)
Sands, loamy sands	< 1.60	1.69	> 1.80
Sandy loams, loams	< 1.40	1.63	> 1.80
Sandy clay loams, clay loams	< 1.40	1.60	> 1.75
Silts, silt loams	< 1.40	1.60	> 1.75
Silt loams, silty clay loams	< 1.40	1.55	> 1.65
Sandy clays, silty clays, clay loams	< 1.10	1.49	> 1.58
Clays (> 45% clay)	< 1.10	1.39	> 1.47

4.3.3 Chemical Variation

Soils that are present in urban areas are found to have different chemical properties than natural soils. Urban soils tend to have a higher pH level, which alters the way the soils react with different nutrients needed for plant growth. Calcium and sodium chloride (salt **compound**) are the main drivers in raising the pH levels of urban soil. Calcium and sodium chloride are used as de-icing agents, therefore as spring melt occurs, these agents will likely leach into surrounding soils. Other reasons for calcium released into the soil is through irrigation of vegetation with calcium enriched water, weathering building rubble containing cement and plaster, and surface weathering of buildings and sidewalks under the acidic atmosphere of an urban environment.

As urbanization progresses, landscapes are reshaped, filled, or cut so large cities can be built or expanded. These landscapes generally contain a high percentage of **anthropogenic** materials such as wood, paper, glass, plastic, metal, asphalt, and organic garbage mixed within the soil. The decomposition process of anthropogenic materials creates **by-products** which can be toxic to some plants and animals.

Herbicides and pesticide residues are also present in urban soils. They occur as either remaining from previous agricultural operations, or are residues from direct application to urban vegetation.

4.3.4 Temperature Regimes

Urban areas create heat islands, which results in the loading of heat into the soil. Therefore, temperature regimes in urban soils are found to be higher than in surrounding forest soils. The lack of canopy coverage and absorption of heat through buildings and street surfaces increases the day and night air temperatures. These factors, along with a lack of organic layer on the soil surface for insulation, leads to increased soil temperatures. The high temperatures increases the amount of water evaporated, which dries the soil and makes it susceptible to further warming. Soil temperatures control the growth of roots and soil organisms, as well as chemical processes. Warmer temperatures will increase the rate of chemical and biological processes, which could lead to plant death.

To prevent the warming of urban soils, **mulching** or other surface soil protection could help decrease the day time maximum temperatures. This will help prevent the soils from drying out, which will promote root growth and development.

4.4 Urban Soil Management

When an urban forestry practice is implemented in an area, the soil must be managed in order for these practices to be successful. Tree roots are underground, and therefore often not thought of. However, a trees living system occurs just as much underground as it does above ground. Neglecting to nourish the soil surrounding tree roots can lead to tree mortality. Approximately 90% of a tree's roots are found in the top 30 cm of soil. With the roots being so close to the surface, soil compaction is a leading problem for urban trees.

Soil compaction is a major issue in urban areas containing clay and silt soils, along with frequent traffic. Compacting the soil removes the air from the soil and destroys the soil structure, making it difficult for roots to penetrate the soil. Compaction can also occur when the trees are being planted, and too much soil is placed around the tree. During construction and implementation of urban forestry practices, if practices to preserve or restore healthy functioning soils in landscapes are not applied, changes to soil structure, biology, and organic matter content and the effects of compaction can cause the soil to function more like impervious surfaces.

4.4.1 Management Strategies

Several soil management strategies can help to increase the health of our urban forests. For example, to help keep the soil from becoming compacted from human traffic, sod should be removed and replaced with mulch. This will cut down on foot and wheel traffic (such as lawn mowers), and it will keep grasses and other plants from using the water and nutrients that are essential to the tree. Using mulch also conserves water, eliminates weeds, and mimics the soil conditions of a natural forest. Using natural or organic mulches such as chipped bark, compost, or wood chips that have been composted for at least one year is recommended. This is because fresh mulch consumes nitrogen as it decomposes, and will lead to a lack of nitrogen uptake by the tree itself.

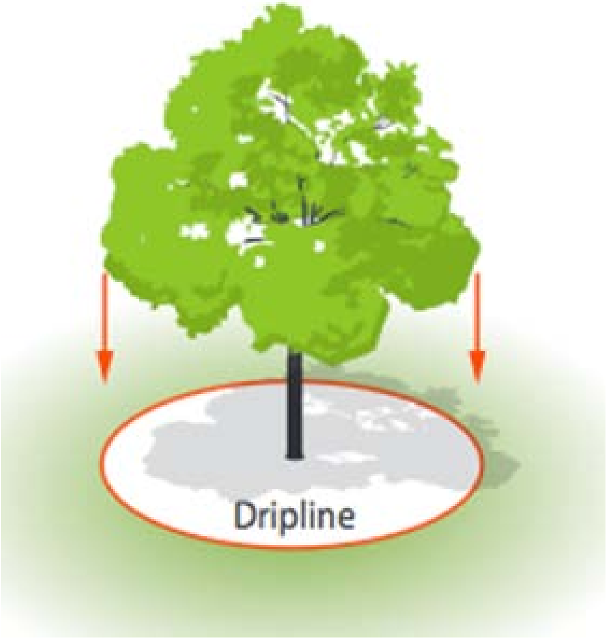
Topsoil placed around the tree, and under the mulch, should contain at least 5-10% organic matter. The organic matter in the topsoil helps with water holding capacity and the biological health of the soil. The total uncompacted topsoil depth should reach at least 30 cm in areas where shrubs and trees will be planted because they need rich, deep soil to thrive.

Restoring healthy soils can be done through reverse compaction methods. This is accomplished through the use of subsoiling or tilling, and the incorporation of compost or mulch, to help increase organic matter content. Compost also has soil binding properties, acting like glue to help hold soil particles together, making it more resistant to erosion. When subsoiling and tilling is combined with compost, studies have shown that the volume of runoff produced by a landscaped area constructed on compacted soil can be reduced by 70-90%.

The best soil management practices leave as much existing trees, vegetation, and soil undisturbed as possible. As well, existing topsoil that is stripped and stockpiled should be preserved on site for the reapplication in areas to be landscaped. Finally, restoring post-construction soils in areas to be landscaped should be done to help meet the minimum soil quality and depth standards. By improving conventional construction practices and municipal standards to ensure all landscaped areas contain healthy functioning soils, the impacts of urbanization on the local water cycle and the health of our urban rivers, lakes and wetlands can be reduced.

Case Study: City of Saskatoon, Saskatchewan

The Urban Forestry department of the City of Saskatoon implemented a policy when working around city trees based on protecting tree roots. The purpose of the guidelines helps builders reduce the number of trees which are un-necessarily damaged or removed as a result of any construction activities. Severing tree roots, compacting soil, or changing the grade in the critical root zone of a tree can impact both the health and stability of a tree. To prevent soil damage to city trees, workers are only permitted to excavate on one side of the tree. All exposed roots must be pruned with a sharp pruning tool to provide a clean severance of the root. Exposed roots must be protected from drying during construction and backfilled as soon as possible. To prevent compaction, 1.5 cm of wood chip mulch must be placed on any area under the dripline of a protected tree if it is not fenced off.



Using a physical barrier, such as protective fencing is the best way to prevent tree damage. In Saskatoon, protective fencing must be constructed of either solid wood or a snow fence fastened to metal stakes approx 1 m apart. The fencing must be 1.2 m high from the ground, and not interfere with access to fire hydrants or obscure intersections and traffic signs. The fencing must be sturdy with the posts firmly in the ground to keep it in place, and to continue to stay in good condition throughout the construction process.

Table 2: Tree Protection Zone Radium Requirements

Trunk Diameter @ 1.2m	Good Protection	Better Protection
1 – 20 cm	2.0 m	3.0 m
21 – 50 cm	2.5 m	4.5 m
50+ cm	3.5 m	6.5 m

By implementing these guidelines to protect their urban trees, the City of Saskatoon is demonstrating good urban soil management practices. These practices should be taken into consideration in cities across Canada, as it could reduce the impacts of urbanization on urban forests.

4.5 Soil Activity: Measuring Bulk Density

Students will:

- Calculate soil bulk density
- Demonstrate an understanding soil compaction in urban areas
- Develop knowledge about natural soil properties versus urban soil properties

Bulk density is an indicator of soil compaction and soil health. It affects infiltration, rooting depth/restrictions, available water capacity, soil porosity, plant nutrient availability, and soil microorganism activity, which influence key soil processes and productivity. It is the weight of dry soil per unit of volume typically expressed in g/cm^3 (See Appendix C for activity sheet).

4.6 Questions for Discussion

1. How does the bulk density from your urban environment differ from the bulk density values of a natural environment?

2. What do these values of the urban soil indicate?

3. What are some practices that can improve the bulk density of your urban soil sample?

5.0 Wildlife

In this section, students will:

- understand the importance of wildlife in the urban environment
- understand the importance of wildlife conservation
- understand the types of urban wildlife
- understand the trophic levels and role of species
- understand the adaptation of animal wildlife to urban environments
- understand wildlife management methods in urban forestry
- understand the importance of wildlife centres

5.1 Introduction

A healthy urban forest supports a variety of wildlife species. It is only natural that wherever trees are planted, wildlife is sure to follow. There are some species you may see every day and many more that are present but active only at night. Urban wildlife can be present in such high numbers that they become part of our everyday life. Millions of people living in cities come into contact with wildlife and maintain a sense of interconnection with the natural environment by visiting their local park, green space, and even the trees in their front yard.

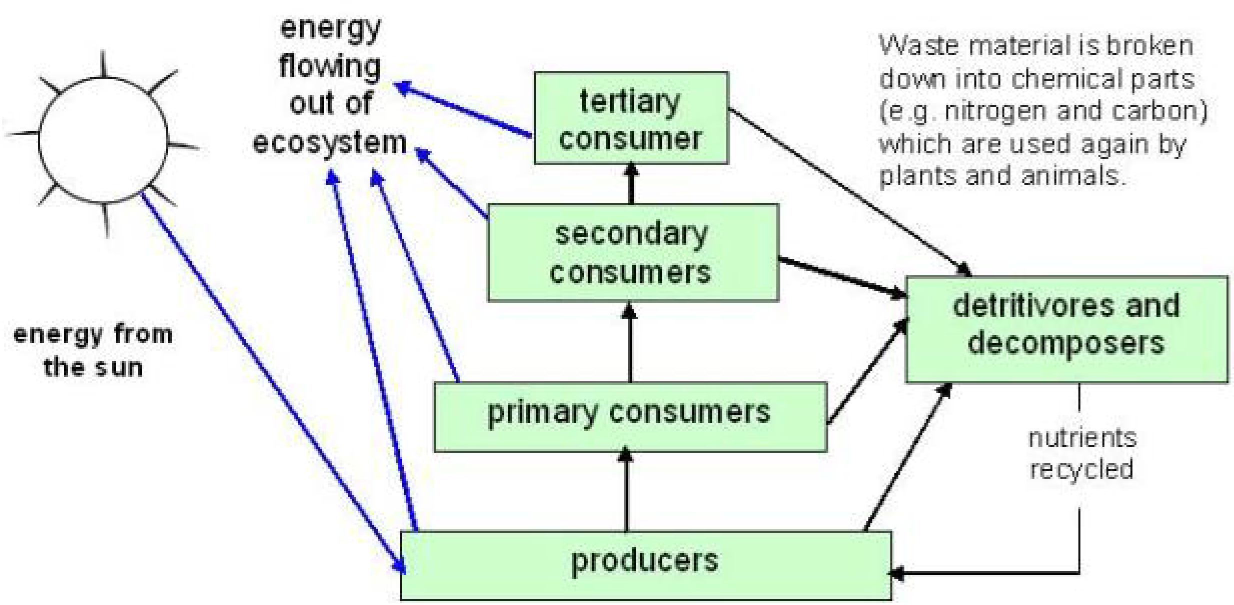
To ensure the productivity of urban forests for wildlife in particular, it is necessary to understand the structure needed to sustain them. The creation of parks, open spaces, corridors, and buffers allow direct access to wildlife. A forest ecosystem with a variety of tree species, age characteristics, and ground covers supports a greater amount of wildlife than a single tree planted on the sidewalk. Trees in particular provide shelter and food for a variety of wildlife species from microorganisms to birds, and small to large mammals, such as fox and deer. They serve as stopover areas and migratory paths for birds and as natural corridors and links to different forested areas. Bacteria and fungi contained in trees cause decay and provide habitat for birds, insects, and other small mammals. Urban forests also contribute to the overall health of aquatic ecosystems, such as a stream or river by providing habitat, shelter, and food for aquatic organisms like beavers, fish, and turtles.

With the constant development of cities and the increasing human population, the importance of our urban forests for wildlife is undeniable. The expansion of cities and dominance of humans is threatening natural habitats for wildlife, so in order to maintain populations, larger green spaces, parks, and open spaces need to be planted or protected. Growing our urban forests has never been more crucial.

5.2 Role of Species & Trophic Levels

In each **ecosystem** there are many **trophic levels** and each species falls under one of these categories. The categories are: primary producer (plant), primary consumer (herbivore), secondary consumer (omnivore), tertiary consumer (carnivore) and decomposers (**fungi**, bacteria) (Figure 20). Within trophic levels species hold various roles that contribute to ecosystem function such as decomposers, scavengers, prey, and predators (see Table 3).

Figure 20: Trophic Levels



(Field Studies Council, 2009)

Rules about energy moving up through trophic levels:

1. Only a fraction of the energy available at one trophic level is transferred to the next trophic level. Usually around 10%.
2. There is almost always some foundation species that directly harvests energy from the sun, for example, grass.
3. The amount of energy available to one trophic level is limited by the amount stored by the level below because energy is lost in the transfer from one level to the next.

Table 3. Each species has a role and function to play in the ecosystem.

Species Role	Examples	Role in Ecosystem Function
Decomposers	• Insects • Worms • beetles	• breaks down **organic matter** to return to nutrients to the soil • acts as indicators of **biodiversity** and ecosystem health
Scavengers	• birds • rodents • reptiles • mammals	• feed on dead and decaying matter in the ecosystem • speed up decomposition
Prey	• songbirds • rodents • reptiles • amphibians • butterflies	• primary consumers, provide food for predators • maintains the habitat by removing excess plant material and insects
Predators	• mammals • birds of prey • reptiles • amphibians	• secondary consumers • keep prey populations in balance • occupy the top level in the food chain

5.3 What is Urban Wildlife?

Urban wildlife consists of species that utilize human dominated ecosystems. Although urban species vary in how they use and exploit developed areas, they all come into contact with humans either in cities or in urban-rural areas. Examples of common urban wildlife species in Canada include squirrels, pigeons, raccoons, coyotes, sparrows, and house mice.

Characteristics of urban wildlife:

- May utilize human food sources, such as birdfeeders, garbage, or pet food
- Are typically omnivorous and generalists with regard to food and habitat
- Are often strong competitors and can exclude native species
- May have a higher tolerance of human disturbance
- Can change their behavior and adapt to major environmental disturbances

5.4 Generalists vs. Specialists

A generalist species is able to survive in a wide variety of environments and can make use of many different resources. They often have high rates of reproduction and short life spans, which leads to high populations and the ability to tolerate disturbance and changing environments. A specialist species, on the other hand, can only survive in certain environments or has a limited diet. They generally have smaller distributions and lower populations. Many urban species are generalists that can take advantage of urban resources and are also relatively successful. Urban environments support species with flexibility in their resource use and competitive advantages based on resources that are abundant.

5.5 Types of Urban Wildlife

Urban wildlife species can be considered human obligates, associates, exploiters, adapters, or avoiders and is outlined below. These classifications relate to the degree to which urban wildlife benefits from or is harmed by human caused habitat change. Whereas some species are able to take advantage of human food subsidies or refuge from predators, others persist in human dominated landscapes by avoiding contact with people as much as possible.

Human obligates might not be considered wildlife by some because they are often domestic animals, but they play a major role in urban wildlife community composition. Obligates compete with, disturb, and most importantly, predate on native wildlife species. The interactions between obligates and natives can influence the community function and diversity. Domestic cats, for example, are known for their impressive predatory skills and their impacts on native and migratory bird species.


(Kennedy, 2012)

Who are they? Domestic cat, domestic dog, livestock (cow, goat, sheep)

Human associates and exploiters are often generalist or omnivorous species that can take advantage of food supplied by humans. Human food sources can be gardens, garbage, domestic animals, pet food, or other human exploiters. Exploiter populations are able to achieve much higher numbers in urban areas than in wild due to the endless amount of available food. The relationship between exploiters and local residents can vary; songbirds that use backyard feeders are often viewed positively, whereas predators that kill pets are usually regarded negatively. Property damage and disease transmission can also contribute to negative attitudes towards exploiters, such as raccoons.

(Cooper, 2013)

Who are they? Raccoon, Virginia Opossum, European Starling, House Finch, Rock Dove, house mouse, California Gull, American Crow, House Sparrow, Eastern Grey squirrel, Coyote

Human adapters are species that may take advantage of human resources and survive in human dominated areas, but do not always receive an added benefit from living with humans. These species are often located on the edge of development and may be common in areas dominated by rural development. Adapters generally do not cause many problems with humans and are often generalists that can use a wide variety of habitats. Deer are sometimes referred to as human adapters, as they can reach high population sizes from wild areas to suburban habitats.

(McKay, 2012)

Who are they? Bobcat, Coyote, White-tailed Deer, Black Bear, American Robin, Red Fox, Striped Skunk, Northern Cardinal, American Goldfinch, Red Tailed Hawk

Human avoiders are not expected to use urban areas, but may occasionally wander into these areas or use it as a stopover area on a migratory path. Avoiders often have either a history of negative encounters with humans or very specific habitat requirements for reproduction or foraging that cannot be attained in human settlements. These species can experience high mortality rates or decreased reproductive rates in human dominated habitats, as they are sensitive to human disturbance. Mountain lions, for example, occasionally come into conflict with human communities by eating livestock or pets because it is an easy meal.

(Griffith Park Connectivity Study, 2012)

Who are they? Mountain Lion, Grey Wolf, Grey Fox, Pileated Woodpecker (This category is mainly local native species with particular habitat requirements. Native wildlife is highly distinct and diverse across Canada, unlike urban wildlife. When thinking about human avoiders, consider which species you see in conservation areas or national parks that could not live in urban environments).

For more information check out your city's website and navigate to its wildlife page to learn more about the wildlife around you!

5.6 Toronto Wildlife Centre

Toronto Wildlife Centre (TWC) is a leader in wildlife rescue, veterinary care, rehabilitation, and education. It is Canada's busiest wildlife centre with over 74,000 wild animals admitted for care since 1993. They work with many other agencies and organizations such as Ministry of Natural Resources and Forestry, the Toronto Zoo, the Owl Foundation, and Animal Alliance of Canada.

Q: What are the most common reasons for wild animals being admitted to TWC?

A: Almost every animal brought in to TWC has become sick, injured or orphaned due to some sort of human related activity. The most common reasons include: attacks by cats, hit by cars, collisions with windows, destruction of habitat, attacks by dogs, and becoming orphaned.

Q: What are the most common species admitted to TWC?

A: TWC regularly admits the species that are common to Southern Ontario, including Rock Pigeons, Eastern Grey and Red Squirrels, numerous species of migratory songbirds (e.g. warblers), Raccoons and Striped Skunks. Each year, close to 200 different species are admitted.

Q: What's the rarest, most unusual, dangerous or strange animal TWC has ever admitted?

A: TWC has admitted a wide variety of species over the years, some found in very unusual circumstances, including a Striped Skunk that had hitchhiked on a truck all the way from California, Grey Wolves suffering from mange, a Brown Pelican and two Purple Gallinules that had blown far off course from their native Florida, a scorpion that had traveled in a suitcase from Costa Rica, and many more accidental travelers.

5.6.1 TWC Case Study: Understanding How to Deal with Urban Wildlife

In February of 2013, a coyote was shot to death by a police officer because it was seen in a residential neighbourhood in Toronto. Unfortunately people have unrealistic fears about coyotes, but attacks on people are essentially unheard of. Hundreds live peacefully in Toronto and in other surrounding municipalities in the pockets of green spaces and natural areas.

At Toronto Wildlife Centre, the staff has worked with many coyotes and notice that they are very nervous and afraid of people. They receive many calls on the wildlife hotline about coyotes each year, usually in the winter when food is scarce and coyotes travel outside their natural habitat in search of something to eat. Every situation can be resolved with education or simple information to limit attractants. The most common message for coyotes and other wildlife is to not feed them. Feeding wild animals rewards them for travelling into neighbourhoods and familiarizes them with people.

5.7 Adaptation of Animal Wildlife to Urban Environments

In recent decades, we have seen an increase in birds and mammals colonizing into cities. Urbanization has only occurred in the last 100-200 years, so cities are an explosion of new environments to wildlife. Urban development destroys natural habitats, but also creates new ones. The construction of parks, housing, roads, and waterways can even encourage species to colonize by creating corridors and networks to desirable habitats. We would assume that these animals are moving to the city because they are being displaced by **climate change** and habitat destruction, but that is only part of the reason. Cities are becoming greener and more attractive to animals. They have been slowly adapting to the close proximity to humans, stresses, predators, and threats in urban and suburban environments. However cities also offer new food sources, insulation, and shelter from adverse weather conditions. The rich resources of food in particular attract many bird and mammal species. For species such as the house sparrow, mallard, and gull, this may be the only component of their diet (especially in the winter).

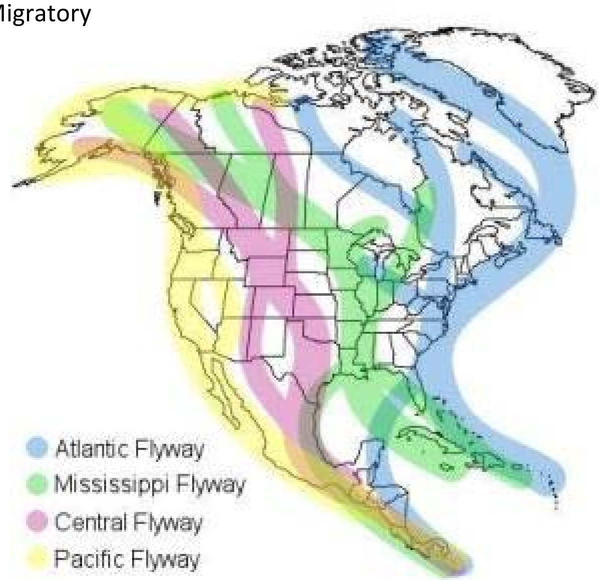
(Loucks, 2012)

Did you know? Peregrine falcons have adapted to living in many cities and make use of tall buildings that provide suitable ledges for nesting and depend on the large populations of pigeons and starlings in cities for food. They dive and catch their prey in mid-air.

5.8 Fatal Light Awareness Program

An estimated 1 to 10 birds die per building each year. The City of Toronto has over 950,000 buildings that could potentially kill over 9 million birds each year. The estimated number of migratory birds killed annually by colliding with buildings across North America ranges from 100 million to 1 billion. Many bird experts now claim that human-built structures are the leading cause of **mortality** for migratory birds in North America. The busiest migratory bird corridors: the Pacific, Central, Mississippi and Atlantic Flyways are natural passages and provide major stopover areas where birds rest and feed. Unfortunately coastlines are now built up with lighted office towers and reflective buildings from our urban areas, which are a deadly obstacle.

Figure 21: Flyaway Paths of Migratory Birds in Canada



(Ashley, 2012)

Why do birds collide with buildings?

- They are attracted to the bright lights left on overnight, causing them to collide with buildings
- During the day they cannot see the pane of glass and they instead focus on the reflection or see through the glass to a plant inside the building

How does Fatal Light Awareness Program (FLAP) help?

- FLAP is an organization governed by a Board of Directors and 100 volunteers
- They pick up injured or dead birds (about 164 species) in the Toronto region
- About 60% of the birds are found dead
- Over 80% of the injured birds rescued by volunteers are **rehabilitated** and released
- Published collision prevention guidelines for corporate and residential structures

How can you help?

- Relocate your bird feeder and birdbaths half a meter or less from your windows (the short distance doesn't allow birds to build up enough momentum to injure themselves)
- Move houseplants away from windows, as they perceive houseplants as a possible perch or refuge
- Close curtains and blinds to reduce the dangerous illusion of passage through a window
- Report a bird collision by emailing FLAP and share your eye-witness story

5.9 Wildlife Management

An increasing amount of Canada's land is being covered by pavement, buildings, and constructed green spaces and this **urbanization** of humans into former wildlife habitats will continue in the future. This shift from rural to urban has changed the landscape and the agenda regarding wildlife management. In fact, it is believed that the main focus of wildlife professionals will soon be the management of urban wildlife.

Wildlife management involves manipulation of animal populations and habitats to preserve species and to provide wildlife resources for human needs. To some degree, we have impacted wildlife habitats and management is needed for most habitats, such as restoring populations of endangered species. First a management strategy is defined, which must focus on the requirements of desired species or communities. Is the aim to increase, decrease, or maintain populations? Too many white-tailed deer in an urban park, for example, will over **browse** the area, wiping out their own food source and the habitat of many other species. The population density that is pleasing to people is also an important factor. Second, an effective management strategy must consider the biology and **ecology** of species, such as food, cover, water, and space requirements. This makes management difficult because biologists understand the full requirements of very few species. Third, management must consider and evaluate different approaches to wildlife management. These categories may include: control of predators, restocking/transplanting, feeding, creation/management of habitat, or establishment of protective regulations.

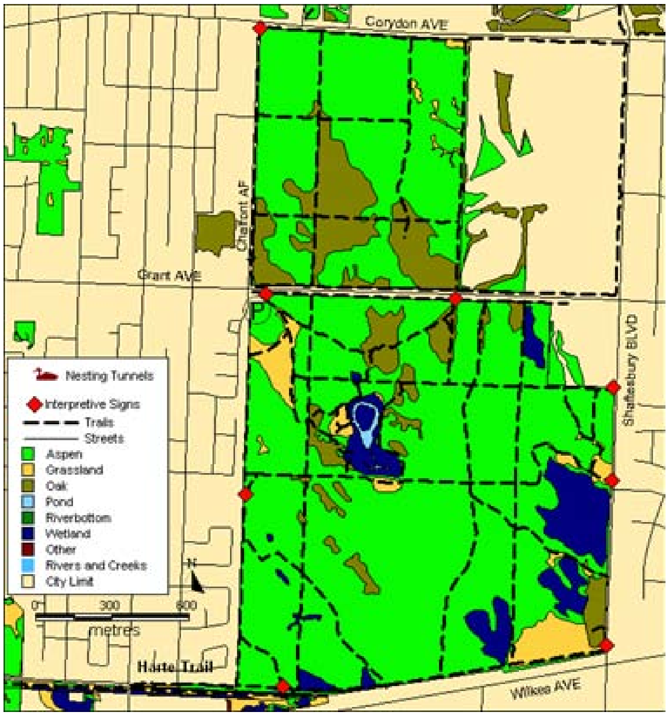
(Examiner, 2010)

Case Study: Assiniboine Forest Winnipeg, Manitoba

Assiniboine Forest is 280 hectares of aspen-oak forest located within the city of Winnipeg, Manitoba. It is one of the largest urban nature parks of its kind in Canada composed of forest, prairie, pond and marsh. It provides residents a chance to escape the city, view wildlife and experience nature.

This area was slotted for development in 1920, but when the great depression hit, plans came to a pause. Over the next couple of decades, local residents used the forest for recreation. A city councillor became interested in protecting the forest and the wildlife in it and in 1973 it was preserved as a municipal nature park.

"Assiniboine Forest offers a wilderness within a city."



Benefits from this urban forest include:

- improved air quality
- decreased soil erosion
- improved water quality
- creation of wildlife habitat
- allows people to view wildlife in their natural habitat
- builds the gap between urban and natural settings

Wildlife Species Present

This urban forest is home to more than 39 species of mammals (eg. deer and fox) and more than 80 species of birds. The forested area as well as the pond constructed by Ducks Unlimited provides excellent habitat for waterfowl.

Edges

Edges define the transition from one habitat to another. The length, width and straightness of an edge will have an effect on the ecosystem. In this forest there are a lot of long straight edges because of the roads surrounding the forest patch. This also affects the safety of the wildlife that tries to travel outside of the area.

Patches

The major landscape change impacting the wildlife in the forest is habitat fragmentation. Fragmentation reduces the capacity of the landscape to support healthy wildlife populations. The patch is small and there is no connectivity to other patches, therefore, species number and diversity is low compared to a larger connected forest.

A Threat to the Forest

Invasive species are prevalent in Assiniboine Forest, such as European Buckthorn. This plant is replacing the native maples, ashes, dogwoods, cranberries and many others. This also has a negative effect on the wildlife that needs the native vegetation to feed on.

Corridors

Links between patches are crucial to ensure species movement and diversity. In many cases across Canada, patches have been isolated by human uses such as roads and railways. Care must be taken in city planning to ensure links are provided between natural areas rather than having discontinuous patches like Assiniboine Forest.

5.11 Wildlife Activity: Wildlife Observation

Students will:

- Gain experience making proper recordings of wildlife
- Gain experience describing wildlife habitat, signs, behaviour, and identification features

The purpose of this activity is to engage students with the wildlife located in their area. For more information about the activity please refer to Appendix D.

5.12 Questions for Discussion

1. What are the 4 species categories/roles and what is an example for each?

2. What is the difference between a generalist and specialist species?

3. What are the 4 types of urban wildlife?

4. Why do animals migrate into cities? How do they adapt?

5. Why are windows dangerous for birds?

6. What does wildlife management involve?

7. Name 3 species commonly admitted to wildlife centres.

6.0 Additional Resources

National Websites

Canadian Forests

The Canadian Forests website is specifically about forests and forestry in Canada. It provides quick access to all the Internet sites of the federal and provincial governments, the forest industries, service and supply companies, associations and NGOs, consultants, education and research, forestry news, employment opportunities, and much more

http://www.canadian-forests.com/urban_forestry_civic.html
http://www.canadian-forests.com/urban_information.html

Canadian Urban Forest Network

This is an advocacy group for Canadian Urban Forestry whose mission is to increase awareness of the urgent issues facing Canada's urban forests and to stimulate action to address those issues. Their vision for Canadian towns and cities is a canopy of trees, sheltering and protecting our communities; part of a green infrastructure that promotes habitat, healthy air, clean water, quality of life and economic prosperity.

http://tcf-fca.ca/programs/urbanforestry/cufn/pages.php?lang=en&page=aboutus

Tree Canada

For over twenty years, Tree Canada has engaged communities, governments, corporations, and individuals in the pursuit of a greener and healthier living environment for Canadians. They provide Canadians with education, technical expertise, and resources to plant and care for urban and rural trees. Tree Canada has planted nearly 80 million trees and greened more than 550 schoolyards across the country.

http://treecanada.ca/en/programs/urban-forests/

Canadian Urban Forest Research Group

This represents a small community of urban-forest researchers and professionals that aims to advance urban-forest research and relay new knowledge to urban forest professionals and interested citizens in support of developing sustainable urban forests across Canada.

http://www.canadianurbanforest.ca/

Ontario Websites

Forests Ontario

Forests Ontario is the voice of Ontario's forests through the support and promotion of forest restoration, stewardship, education and awareness. They are dedicated to the renewal and stewardship of Ontario's forests. They are a provincial resource and trusted authority for those seeking to invest in the future of our forests - through donations, sponsorship, volunteerism, tree planting, community awareness events and forest management.

http://www.forestsontario.ca/
http://www.forestsontario.ca/files/healthy_dose/TO_HP_4WEB_FA.pdf

Ontario Urban Forestry Council
This council is a not-for-profit volunteer organization dedicated to the health of the urban forests in the province. They provide information, advice, provide public speakers for events, workshops and advocate conservation.

http://www.oufc.org/

The Urban Forest Stewardship Network

This website and network is an online resource for organizations, community groups and individuals working on urban forest initiatives across Ontario. It is a platform for sharing experiences and resources, and for capacity building. The UFSN is where we all come together and work to enhance our living green infrastructure.

http://ufsn.ca/

Ontario Nature: Urban Forests

This document outlines why urban forests are important and talk about the vision for urban forests in Ontario.

http://www.ontarionature.org/discover/resources/PDFs/factsheets/urban_forest.pdf

Quebec

Quebec's Urban Forestry

Urban forestry is a reality in the province of Quebec. Several major events have encouraged greater recognition of urban forestry in Quebec. For more information please go to:

http://joa.isa-arbor.com/request.asp?JournalID=1&ArticleID=2193&Type=2

Nova Scotia

Halifax Urban Forest Master Plan

The Halifax Regional Municipality designed an urban forest master plan (UFMP). The overall goal of the UFMP is to ensure a sustainable future for our urban forest. The multi-year community engagement process and research initiatives that led to the development of the Plan has resulted in an integrated social, ecological, and economic strategy that strives to incorporate the values of Halifax citizens.

http://www.halifax.ca/RealPropertyPlanning/UFMP/documents/SecondEditionHRMUFMP.pdf

Prince Edward Island

Charlottetown Urban Beautification and Forestry

The City of Charlottetown recognized the importance of a healthy environment for the betterment of residents and merchants of Charlottetown, and has set one of their goals to better focus on Urban Beautification and Forestry initiatives.

http://www.city.charlottetown.pe.ca/urbanbeautificationandforestry2.php

Summerside Forest Management Plan

Summerside has a five year plan that began in 2003 for the removal, replacement, and maintenance of urban trees in the area. This document shows an outline of the plan, along with progress made to their urban areas.

http://lin.ca/sites/default/files/attachments/SummersidePEI2003ForestManagement.pdf

New Brunswick

Fredericton, New Brunswick

Our Valuable Trees: Fredericton regards the importance of its urban forest as second to none and an extremely valuable resource. The many trees and green spaces contribute to the health and the wellbeing for all who live, work and play in the Capital City.

http://www.fredericton.ca/en/environment/trees.asp

Saskatchewan

City of Regina, Saskatchewan

The City of Regina's Urban Forestry Management Strategy provides a comprehensive strategy for managing Regina's urban forests in an arboriculturally sound and cost-effective manner. It builds on existing programs, standards and specifications used to manage the urban forest and proposes new programs, policies and procedures as well as some modifications to current practices.

http://www.regina.ca/opencms/export/sites/regina.ca/residents/parks/.media/pdf/regina_urban_forest_management_strat_report.pdf

Saskatoon, Saskatchewan

The City of Saskatoon's Urban Forestry Department works towards ensuring that their urban forest does not diminish and will be enjoyed by future generations as Saskatoon is often described as an oasis on the prairies and the city of trees.

http://www.saskatoon.ca/DEPARTMENTS/Infrastructure%20Services/Parks/Urban%20Forestry/Pages/default.aspx

Alberta

Edmonton, Alberta

Edmonton, Alberta's Urban Forestry Management Plan is a 10 year strategy for sustainably managing and enhancing their diverse urban forest so that it will continue to serve the community for generations to come.

http://www.edmonton.ca/environmental/documents/Urban_Forest_Management_Plan.pdf

Manitoba

Manitoba's Urban Forest

Manitoba's urban forests recognize a legacy of forefathers who planted countless trees along streets and public spaces. This provides Manitoba beautification, shade and shelter as largely deciduous green spaces provide wildlife habitat and shelter year-round. For more information please go to

http://www.gov.mb.ca/conservation/forestry/ded-urban/index.html?print

British Columbia

District of Saanich, British Columbia

The District of Saanich, British Columbia Urban Forest Strategy provides a long term plan for achieving a sustainable forest.

http://www.saanich.ca/parkrec/parks/trees/urban.html
http://www.saanich.ca/parkrec/parks/trees/pdf/UrbanForestStrategyOctober14thDraft.pdf

City of Victoria, British Columbia

The City of Victoria, British Columbia's Urban Forest Master Plan sets out a vision, goals and strategies for the management of Victoria's urban forests for the next 50 years.

http://www.victoria.ca/EN/main/departments/parks-rec-culture/parks/urban-forest.html
http://www.victoria.ca/assets/Departments/Parks~Rec~Culture/Parks/Documents/urban-forest-master-plan.pdf

7.0 Glossary of Terms

Abundant: present in great quantity

Adsorbed: to gather (a gas, liquid, or dissolved substance) on a surface in a condensed layer

Aesthetic Values: Aesthetics is a branch of philosophy dealing with the nature of art, beauty, and taste, with the creation and appreciation of beauty.

Ash Volatiles: Chemicals emitted by the ash tree's bark and leaves

Biological Diversity: the degree of variation among and within plant and animal species in an environment

Biomass: biological material derived from living, or recently living organisms

Bogs: wet, spongy ground with soil composed mainly of decayed vegetable matter

Browse: feed on leaves, twigs, or other high-growing vegetation

Canopy: a covering, usually of fabric, supported on poles or suspended above a bed, throne, exalted personage, or sacred object

Climate Regulation: carbon regulation, cloud formation

Cultivar: is a plant or grouping of plants selected for desirable characteristics

Deposit feeders: an aquatic animal that feeds on small specks of organic matter that have drifted down through the water and settled on the bottom

Disturbance Prevention: storm protection, drought recovery, flood control

Dredging: any of various powerful machines for dredging up or removing earth, as from the bottom of a river, by means of a scoop, a series of buckets, a suction pipe, or the like

Ecology: the scientific study of interactions among organisms and their environment, such as the interactions organisms have with each other and with their abiotic environment

Ecosystem Function: the physical, chemical, and biological processes or attributes that contribute to the self-maintenance of the ecosystem; in other words, what the ecosystem does. Some examples of ecosystem functions are wildlife habitat, carbon cycling, or trapping nutrient

Ecosystem Goods and Services: The quantifiable goods and services that an ecosystem provides to humans, including consumables and non-consumable

Eutrophication: characterized by an abundant accumulation of nutrients that support a dense growth of algae and other organisms, the decay of which depletes the shallow waters of oxygen in summer

Evaporation: the process of changing from a liquid or solid state into vapor; pass off in vapor

Evapotranspiration: the process of transferring moisture from the earth to the atmosphere by evaporation of water and transpiration from plants

Fen: low land covered wholly or partially with water; boggy land; a marsh

Filter Feeders: an aquatic animal that feeds on particles or small organisms strained out of water by circulating them through its system: includes most of the stationary feeders, as clams, oysters, barnacles, corals, sea squirts, and sponges

Foliage: the leaves of a plant, collectively

Freshwater Ecosystems: an ecosystem composed of water that is fresh and absent of salt

Gas Regulation: maintenance of air quality

Habitat: suitable living and reproductive space for resident and migrating species

Horticulture: the cultivation of a garden, orchard, or nursery; the cultivation of flowers, fruits, vegetables, or ornamental plants

Hydrological Cycle: describes the continuous movement of water on, above and below the surface of the Earth

Invasive Species: organism (plant, animal, fungus, or bacterium) that is not native to an area and has negative effects on native species

Impervious Surfaces: not permitting penetration or passage; impenetrable

Infiltrate: to filter into or through; permeate

Interception Loss: due of evaporation, interception of liquid water generally leads to loss of that precipitation for the drainage basin

Kinetic Energy: the energy of a body or a system with respect to the motion of the body or of the particles in the system

Litter: dead plant material, such as leaves, bark, needles, and twigs, that has fallen to the ground

Macro-invertebrates: animals that have no backbone and can be seen with the naked eye

Marine Ecosystems: an ecosystem of or pertaining to the sea; existing in or produced by the sea

Marsh: a tract of low wet land, often treeless and periodically inundated, generally characterized by a growth of grasses, sedges, cattails, and rushes

Micro-invertebrates: an invertebrate of microscopic size

Mortality: the state of being mortal, or susceptible to death; the opposite of immortality

Native Species: a species is defined as native to a given region or ecosystem if its presence in that region is the result of only natural processes, with no human intervention. Every natural organism has its own natural range of distribution in which it is regarded as native.

Non-point Source Pollution: generally results from land runoff, precipitation, atmospheric deposition, drainage, seepage or hydrologic modification; comes from many diffused sources

Nutrient Cycling: processing of nutrients

Nutrient Loading: when nitrogen and phosphorus from fertilizer gets into the soil and water and affect various ecosystems

Ozone: a colorless unstable toxic gas with a pungent odor and powerful oxidizing properties, formed from oxygen by electrical discharges or ultraviolet light. It differs from normal oxygen (O2) in having three atoms in its molecule (O3).

Percolation: the process of (a liquid) passing through a porous body; filter

Permeated: to pass into or through every part of

Pheromones: a chemical substance produced and released into the environment by an animal, esp. a mammal or an insect, affecting the behavior or physiology of others of its species

Pollution- abatement: refers to technology applied or measure taken to reduce pollution and/or its impacts on the environment. The most commonly used technologies are scrubbers, noise mufflers, filters, incinerators, waste—water treatment facilities and composting of wastes.

Rehabilitate: to bring (someone or something) back to a good condition

Sediments: the matter that settles to the bottom of a liquid; lees; dregs

Socioeconomic: relating to or concerned with the interaction of social and economic factors

Soil Retention: weathering of rock and decomposition of organic matter

Submerged: under the surface of water or any other enveloping medium

Swamps: a tract of wet, spongy land, often having a growth of certain types of trees and other vegetation, but unfit for cultivation

Transpiration: to emit or give off waste matter, watery vapor, etc., through the surface, as of the body or of leaves

Urbanization: the increasing number of people that live in urban areas

Waste Treatment: role of vegetation in removal or breakdown of excess nutrients

Watershed Management: the study of the relevant characteristics of a watershed aimed at the sustainable distribution of its resources and the process of creating and implementing plans, programs, and projects to sustain and enhance watershed functions that affect the plant, animal, and human communities within a watershed boundary

Water Regulation: run-off control, filtering, water storage

LIST OF APPENDICES

Appendix A: Forest Activity

Appendix B: Aquatics Activity

Appendix C: Soils Activity

Appendix D: Wildlife Activity

Appendix E: References

APPENDIX A

Forest Activity: Hazard Tree Risk Assessment

FOREST ACTIVITY
HAZARD TREE RISK ASSESSMENT

STUDENTS WILL:

- Understand how to conduct a Hazardous Tree Risk Assessment and its importance to Urban Forestry
- Understand how to use management techniques and identify urban street trees

MATERIALS

DBH tape
Local Tree Identification Guide
Clinometer (optional)
Pencil
Basic Tree Risk Assessment Form

BACKGROUND

Urban trees are constantly faces stress that can create situations in which the trees become a risk to the community, structures or utilities. The risk can be minimal and typically outweighs environmental, social and economic benefits offered by such trees. However tree owners and managers must assess the level of risk as trees age or become weakened by pests, disease, and other stresses. Tree owners ultimately decide what risk level he or she is willing to accept and what modifications must be made. An experienced arborist can aid in this decision by conducting professional risk assessments that specifies the likelihood of whole or partial tree failure, the consequences of such failure and the potential targets affected.

In North America, three risk assessment methods have gained the greatest acceptance among tree care professionals, municipal urban forestry programs, and government agencies. These methods are:

- International Society of Arboriculture (ISA) Tree Hazard Evaluation Method (Matheny and Clark 1994)
- United States Department of Agriculture (USDA) Forest Service Community Tree Risk Evaluation Method (Pokorny 2003)
- ISA Tree Risk Assessment Best Management Practice (BMP) Method (Dunster et al. 2013; Smiley et al. 2011)

There are three different levels of Risk Assessment as defined by the ANSI A300 Standards for Tree Care Operations

- Level 1- Limited Visual: A limited visual risk assessment is sometimes referred to as a walk by or a drive by assessment. It is most common in urban forest scenarios where trees are abundant and resources for inspection are relatively scarce. A limited visual is not necessarily a complete 360-degree inspection and may be employed in situations where access is limited. Professionals conducting a limited visual assessment identify high-risk trees that are mitigation priorities.

- Level 2 – Basic Visual: A basic visual assessment is a 360-degree inspection from the ground that is more thorough and typically includes height and diameter measurements. An assessor may use binoculars for crown inspections, a mallet for sounding hollows, a probe for inspecting cavities, and other common tools to conduct the inspection.
- Level 3 – Advanced Assessment: An advanced assessment can be an aerial assessment or an assessment that includes quantitative decay detection, health evaluation, wind load assessment, and static load assessment. Given the more advanced tools and methodologies employed, this service is often offered at a premium to the customer and typically reserved for heritage or high-value trees.

INSTRUCTIONS

For this activity students will be completing a modified version of the ISA Tree Risk Assessment Best Management Practice Method. This form (Page 67-69) allows user to identify multiple defects and provides a flexible yet standardized means of coping with multi-faceted assessment scenarios. The time required to complete this assessment professionally is approximately 20-25 minutes for a basic, 360-degree visual assessment. Time required decreases as user gain greater familiarity with the process and form. The ISA Tree Hazard Evaluation Form is best suited for a commercial arborist or urban forester working with individual trees or smaller tree populations. This method is intended for trees receiving a basic risk assessment (level 2). Four main categories will be evaluated they include:

1. **Basic Information** – defines and classifies tree and assessment. Species can be determined by using a local tree identification guide. DBH tape and will also be used for measurements. If your team does not have a clinometer to measure the height of the tree, please check out this YouTube video for equipment free ways to measure height https://www.youtube.com/watch?v=F6fltSqImFM

2. **Target Assessment –** used to identify target(s)- people, property, or activities that could be injured, damaged or disrupted by a tree failure, within striking distance of the tree part concerned**.**

- **Description of target—**brief description such as “people near tree” “house,” “play area,” or “high-traffic street.” Location of the target can be noted by checking one of the distance boxes to the right of the description.
- **Target zone—**identify where the targets are in relation to the tree or tree part:
  - **Within drip line—**target is underneath the canopy of the tree.
  - **Within 1 × Ht**—target is within striking distance if the trunk or root system of the tree fails (1 times the height of the tree).
- **Frequency—**an estimated amount of time the target is within the target zone. Use corresponding numbered codes (1–4):
  - **1. Rare—**targets are very uncommon in the target zone**.**

- **2. Occasional—**the target is present infrequently or irregularly.
- **3. Frequent—**the target is present for a large portion of the day or week.
- **4. Constant—**the target is present at all times or nearly all times.

3. Site Conditions

- **History of failures**—note and describe evidence of previous whole-tree failures on the site, and estimate the time frame for how recently they occurred. Previous branch failures should be noted in the Crown and Branches box (located in the Tree Defects and Conditions Affecting the Likelihood of Failure section of the form)
- **Site changes**—factors affecting the root system of the tree or the change in exposure of the tree to wind; check all that apply:
  - **None**—no evidence of recent site changes.
  - **Grade change**—soil was added or removed from the site
- **Soil Conditions**- Factors that can affect the ability of the root system to mechanically support the tree, as well as the general health and vitality of the tree; check all that apply:
  - **Limited volume**—soil volume limited by rocks, water table, building foundations, size of a container, or other factors
  - **Saturated**—soil saturated due to poor drainage, high water table, excess irrigation, or location in a low area. May be saturated now or have a history of inundation.
  - **Shallow**—rooting depth limited by one or more factors including high water table, rock ledges, compacted layers, or underground structures such as parking decks.
  - **Compacted**—soil is severely compacted, limiting the depth, spread, and distribution of the root system.
  - **Pavement over roots**—concrete, asphalt, pavers, or other materials restricting root growth or water movement into the root zone. If present, enter the percentage of the area within the drip line that is paved

4. Load Factors

- **Wind exposure-** factors that affect wind load on the tree: check all that apply
  - **Protected-** trees, or buildings near the tree, moderately reduce the impact of wind on the tree
  - **Full-** tree is fully exposed to wind
  - **Wind Funneling-** wind may be "funneled" or "tunneled" (By building, canyons, large stands of trees) toward the tree so that wind velocity experienced by the tree is increased
- **Crown size –** mass of foliage and branches growing outward from trunk of tree
- **Crown Density**- the relative wind transparency of the crown:
  - **Sparse**- crown allows a large degree of wind and light penetration; varies with species
  - **Average**- indicates moderate wind and light penetration

        - **Dense**- crown does not allow much light or wind penetration
- **Interior Branches** – increase wind resistance but dampen branch/tree movement
    - **Sparse**- little wind resistance and damping
    - **Average**- moderate wind resistance and damping
    - **Dense-** significant wind resistance and damping

5. **Tree Defects and Condition (Crown, branches, trunk, and roots and collar)**

<u>Crown</u>

- **Dead twigs/branches-** small diameter, dead branches; check box if present and indicate percentage and maximum size(s) in diameter
- **Hangers/Broken-** broken or cut branches remaining in the crown; record the number and maximum size in diameter
- **Architecture-** indicate if the crown is balanced, unbalanced or leaning
- **LCR-** Live crown ratio: the ratio of crown length to total tree length
- **Pruning History**- check appropriate boxes if pruning is known and relevant:
    - **Crown cleaned**- pruning of dead, dying, diseased, and broken branches from the tree crown
    - **Thinned**- selective removal of live branches to reduce crown density. Other pruning types include, but are not limited to, structural, pollarding espalier, and vista, and may be included in your notes
    - **Lion Tailed**- inappropriate pruning practice removing an excessive number of inner and/or lower lateral branches
    - **Topped –** inappropriate pruning techniques used to reduce tree size; characterized by intermodal cut
- **Likelihood of failure-** is the crown likely to fail

<u>Branches and Trunk</u>

- **Dead/Missing bark**—check box if a stem or co-dominant stem is dead or if areas of dead cambium are present where new wood will not be produced.
- **Cracks—**separation in the wood in either a longitudinal (radial, in the plane of ray cells) or transverse (across the stem) direction; check box if present and describe
- **Co-dominant stems**—stems of nearly equal diameter arising from a common junction and lacking a normal branch union. Note the size, location, and number, if relevant, under Main concern(s) in the Trunk box
- **Decay indicators -** Abnormal bark texture/color—may indicate a fungal or structural problem with the trunk; check box, if present, and add notes if it is a concern.
- **Cankers/Galls/Burls**—check box if relevant and circle which one(s); may or may not affect the structural strength of the tree:
    - **Canker**—localized diseased areas on the branch; often sunken or discolored.
    - **Gall**—abnormal swellings of tissue caused by pests; may or may not be a defect.
    - **Burl**—outgrowth on the trunk, branch, or roots; not usually considered a defect.

- **Cavity/Nest hole-** mark yes or no; if yes, indicate the size of the hole as a percentage of the trunk circumference missing
- **Sap ooze**—oozing of liquid that may result from infections or infestations under the bark. May or may not affect structure or stability; check box if present.
- **Weak attachments-** branches that are co-dominant; check box if present and describe
- **Overextended branches-** check box if braches extend beyond tree canopy
- **Evidence of response growth-** reaction wood or additional wood grown to increase structural strength of trunk
- **Likelihood of failure-** the rating for the crown and branches of greatest concern

Roots and Collar

- **Collar buried/Not visible**—check box if the root collar is not visible and, if possible, determine and note the depth below ground.
- **Root plate lifting**—soil cracking or lifting indicates the tree has been rocking, usually in high winds; check box if present, and note under Main concern(s).
- **Stem girdling**—restriction or destruction of the trunk or buttress roots; check box if it is a failure concern
- **Soil weakness**—check box if there is a soil condition affecting the anchorage of the tree's root system; note under Main concern(s) if significant.
- **Decay**—check box if present and identify/describe under Main concerns.
- **Response growth**—reaction wood or additional wood grown to increase the structural strength of the roots or root collar; note location and extent
- **Main concern(s**)—conditions in the roots and root collar that may affect likelihood of failure. Note the main concern(s); if there are no concerns, write "none".
- **Cavity**—definite indicators of heartwood decay; measure the size of the opening and record the percentage of the tree's circumference affected.
- **Cut/Damaged roots**—check box if present; measure and record the distance from the trunk to the cut

To view more detailed, step-by-step instructions for this form, see the ISA *Tree Risk Assessment Manual* or visit:

http://1www2.champaign.isaarbor.com/education/resources/ISABasicTreeRiskAssessmentForm_Instructions.pdf

Basic Tree Risk Assessment Form

Using Excerpts from J.Dunster; *Tree Risk Assessment Manual*

(intended use: training purposes for Fleming College Tree Sciences and Practices course)

Basic Information:

Address: ___________________________ Date of Assessment: _________________

Species: ______________Scientific Name:____________________Assessor Name(s): ____________

Tree #: ________ DBH: ______(cm) Height: ________(m) Crown Spread: __________(m)

Target Assessment:

Target #	Description of Target	Target Zone: drip line	Target Zone: 1X height	Frequency
1				
2				
3				
4				
5				

Frequency rating: 1. rare, 2. occasional, 3. frequent, 4. constant

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Site Conditions:

Past Failures: **yes / no**

Site changes: **none** **grade change** { **i:** cut depth: __________ **ii:** fill depth: __________ } **roots cut/damaged**

Soil conditions: **limited volume** **saturated** **shallow** **compacted** **pavement covering**

Load Factors:

Wind Exposure: **protected** **partial protection** **fully exposed**

Crown Size (i.e. S,M,L,XL): ____________ Mass above serious defect (ie. S, M, L, XL):_____

Crown Density: **Sparse** **Average** **Dense** Interior Branches: **Sparse** **Average** **Dense**

Tree Defects and Condition:

Crown			
Dead tips/branches: Y or N		_______% of crown dead	Max. diameter:
Hangers/Broken limbs: Y or N		________:Quantity	Max. diameter:
Architecture:	Balanced [ ]	Unbalanced [ ]	Leaning [ ]
LCR:______%	**Pruning History**:	Crown cleaned [ ] Lion tailed [ ] Topped [ ]	Thinned [ ] Elevated [ ] None [ ]
Major concern/notes: ____.			
Likelihood of failure:	Imminent [ ] Possible [ ]	Probable [ ] Improbable [ ]	

Branches		
Dead/Missing Bark [ ] Previous failure [ ] Decay present [ ]		Cracks [ ]: Other similar branch structure? Y or N Cankers/Galls/Burls [ ]
Cavity/Nest hole [ ] size:	Weak attachments [ ] Qty:	Overextended branches [ ]
Evidence of response growth: **none minor average significant**		
Major concern/notes: ____.		
Likelihood of failure:	Imminent [ ] Possible [ ]	Probable [ ] Improbable [ ]

Trunk		
Dead/Missing Bark [ ]	Abnormal bark texture/colour [ ]	Cracks [ ]
Co-dominant stems [ ]		Included bark [ ]
Decay indicators [ ]	Cankers/Galls/Burls [ ]	Sap ooze [ ]
Lightning damage [ ]	Heartwood decay [ ]	Conks/Mushrooms [ ]
Cavity/Nest hole [ ]	size: __________.	Poor taper [ ]
Lean: ________ degrees		Corrected? Y or N
Evidence of response growth: **none minor average significant**		
Major concern/notes: ____.		
Likelihood of failure:	Imminent [ ] Possible [ ]	Probable [ ] Improbable [ ]

Roots and Collar		
Collar not visible [ ]		Girdling root [ ]
Lifted root plate [ ]	Soil weakness [ ]	
Decay indicators [ ]		Cankers/Galls/Burls [ ]
Cavity/Nest hole [ ] size: __________.		Sap ooze [ ]
Cut/damaged roots [ ] Distance from trunk: _________.		
Evidence of response growth: **none** **minor** **average** **significant**		
Major concern/notes: ____.		
Likelihood of failure:	Imminent [ ]	Probable [ ]
	Possible [ ]	Improbable [ ]

Most serious defect(s): ____

____

____

Overall likelihood of failure: Imminent [ ] Probable [ ] Possible [ ] Improbable [ ]

Risk mitigation (check all that apply): Emergency [ ] Remove tree [ ] Move target [ ]

Prune defective part [ ] Reduce defective part [ ]

Cable/Brace [ ] Monitor [ ] Advanced assessment follow up [ ]

Comments: ____

____

APPENDIX B

Aquatics Activity: Constructing Your Own Wetland

AQUATICS ACTIVITY
CONSTRUCTING YOUR OWN WETLAND

The purpose of this experiment is to engage students and provide them with the knowledge of how the hydrological cycle in a wetland works.

Students will:

- Create their own wetland
- Develop an understanding of the hydrological cycle
- Develop knowledge of how a wetland ecosystem works
- Develop an understanding of how stressors such as development can affect the fragile ecosystem

Materials

- 2- Liter Soda Bottle
- Scissors
- Pebbles
- Soil
- Water
- Aquarium Charcoal
- Plants (moss, ferns)
- Plastic Wrap
- Cheesecloth
- Heavy-duty Rubber Band
- Plastic Box (Shoebox size)
- Clay
- Bulb Syringe
- Piece of Carpet
- Dirt
- Rocks
- Small Piece of Wood

Procedures

1. Cut the top off of a 2-liter soda bottle right where the lid starts curving. This will be the structure for your wetlands ecosystem.
2. Mix pebbles and aquarium charcoal. Add them to the bottom of the bottle to create drainage for your wetlands ecosystem. The layer should be about 1-inch high.
3. Add a layer of soil that is 2 inches high on top of the pebbles. Water the soil until it reaches its saturation point.
4. Add plants that do well in moist soil. Moss, ferns, lichens and other plants can be purchased from a garden shop or fish supply store. Cover about two-thirds of the soil with plants.

5. Add larger rocks and similar-sized pieces of wood inside the bottle. Set them in the empty spaces where you did not place plants.
6. Cover the ecosystem with plastic wrap. Leave it in place until humidity builds up. Then remove the plastic wrap and cover the container with three or four layers of cheesecloth. Use a heavy-duty rubber band to hold the cheesecloth in place.

Wetlands Classroom Demonstration

7. Soften clay by squeezing it in your hands. Cover half of the bottom of the shoe box, filling the short side, with clay. Build it into a triangular wedge. The top end of the wedge should be about 1 1/2 to 2 inches tall. It should taper down until the clay is flat. Push the clay firmly against one end of the shoe box.
8. Use a bulb syringe full of water to "rain" on your clay. Make observations about what happens to the water. Remove the water with the bulb syringe.
9. Place a 2-inch wide piece of carpet across the inside of the shoe box. It should touch the flattened edge of the clay. The carpet represents the wetlands. Squeeze the same amount of "rain" out of the syringe onto the clay. Notice the difference in the amount of water that comes out on the empty side of the shoebox.
10. Mix dirt with water. Squeeze a bulb-full of the dirty water on to the clay. Watch what happens as the water filters through the carpet and on to the empty side of the box. Explain how the carpet in the shoe box acts like the wetlands in nature.

APPENDIX C

Soil Activity: Measuring Bulk Density

SOIL ACTIVITY
MEASURING BULK DENSITY

Students will:

- Calculate soil bulk density
- Demonstrate an understanding soil compaction in urban areas
- Develop knowledge about natural soil properties versus urban soil properties

Materials:

- 3 inch diameter aluminum
- wood block
- rubber mallet or weights
- folding trowel
- butter knife
- sealable bags and parker pen
- scale (1 g precision)
- 1/8 cup measuring scoop
- paper plate
- 18-inch metal rod (to check for compaction zone)
- access to a microwave

Procedure:

1. Clear all residues then drive the aluminum ring into a depth of 3 inches using a small mallet or weight and a block of wood.

2. Remove the ring by cutting around the outside edge with a small 4 inch butter knife. To prevent loss of soil, hold the small folding trowel under the ring.

3. Remove excess soil from the bottom of the cylinder using the butter knife.

4. Place the soil sample in a plastic sealable bag and label it.

5. Weight the sample and record the total soil weight in Table 2.

USDA

6. Weight an identical clean, empty plastic bag and record the weight in Table 2.

7. Weigh the paper plate to be used and record the weight in Table 2.

8. To extract a subsample, mix the sample thoroughly in the bag. Then take a 1/8 cup and scoop the loose soil from the plastic bag, placing it on the paper plate.

9. Weight the moist subsample and record it in Table 2.

10. Place the paper plate with the subsample in the microwave and dry for two or more 4 minute cycles.

11. To determine if the soil is dry, weight the subsample after each cycle. When the weight of the soil no longer changes, it is dry. Record this weight in Table 2.

12. Calculate the bulk density by using the equation given at the beginning of the activity using the values recorded.

Table 2: Bulk Density measurement

Sample Site				
a. Entire sample weight (sample bag) (g)				
b. Weight of sample bag (g)				
c. Weight of paper plate (g)				
d. Weight of plate and moist subsample (g)				
e. Weight of moist subsample soil (g) **(d-c)**				
f. Weight of dry soil and plate (g)				
g. Weight of dry soil (g) **(f-c)**				
h. Soil bulk density (g/cm^3)				

Calculations:

Volume of soil core (cm^3) = πr^3 x height

Bulk Density (g/cm^3) = dry weight of subsample/ volume of soil core

APPENDIX D

Wildlife Activity: Wildlife Observation

WILDLIFE ACTIVITY
WILDLIFE OBSERVATION

The purpose of this activity is to engage students with the wildlife located in their area.

Students will:
- Gain experience making proper recordings of wildlife
- Gain experience describing wildlife habitat, signs, behaviour, and identification features

Materials:
- Handout "Wildlife Observation Field Notes" See Appendix D
- Pencil, binoculars, camera, measuring tape and GPS

Procedures:
1. Students will record the exact date, time, temperature, and weather events observed upon starting the activity
2. Students will record 5 wildlife species or signs observed, as well as their habitat, behaviour, status, and any other comments
3. Students will use the knowledge gained from the study guide, as well as additional resources such as identification books and the internet to determine species identification
4. Students will draw a map of their observations from starting point to end point with each observation numbered in its location

What counts as a wildlife observation?
- A sighting
- A track on the ground
- A vocalization such as a bird song, coyote howl, or a raccoon hiss
- A sign such as a woodpecker hole, deer antler rub, scat, bird nest, or fox den

Name:	Date:	Time:
Temperature:	**% Cloud Cover:**	**Precipitation:**

OBSERVATION 1   **GPS Coordinates**

OBSERVATION 2   **GPS Coordinates**

OBSERVATION 3   **GPS Coordinates**

OBSERVATION 4   **GPS Coordinates**

OBSERVATION 5   **GPS Coordinates**

APPENDIX E

References

REFERENCES

Adams, C., Lindsey, K. 2006. Urban Wildlife Management. CRC Press. Boca Raton, Florida. Retrieved from:
http://books.google.ca/books?id=KMsXrj_fi4gC&pg=PA2&lpg=PA2&dq=urban+wildlife+management&source=bl&ots=TXWh020v_c&sig=qSmXS5eQ208X2bVV93cJNpBmmI&hl=en&sa=X&ei=KV4eU7m1LoWnqQGqq4CwBg&ved=0CHoQ6AEwCA#v=onepage&q=urban%20wildlife%20management&f=false

Adams, L. 1994. Aspects of Wildlife Management. Urban Wildlife Habitats: A Landscape Perspective. University of Minnesota Press. Chapter 7. Retrieved from:
http://books.google.ca/books?id=cfCEI6tQtlcC&pg=PA81&lpg=PA81&dq=urban+wildlife+management&source=bl&ots=GtCBZ1igz&sig=MFf1YyLOPw72EcFCLz0vUouKlL8&hl=en&sa=X&ei=mV4eU66TBsqprQG2rYDgDg&ved=0CCkQ6AEwADgK#v=onepage&q=urban%20wildlife%20management&f=false

Alvey, A. (2006) Promoting and preserving biodiversity in the urban forest. Urban Forestry and Urban Greening. 5: 195-201

BBC. (2014). Problems and solutions in the environment: pollution and eutrophication. Retrieved from: http://www.bbc.co.uk/schools/gcsebitesize/science/edexcel/problems_in_environent/pollutionrev4.shtml

Canadian Food Inspection Agency. (2013). August 2013 Report: Emerald Ash Borer Confirmed Finds in Ontario and Quebec. Retrieved from: http://www.marketwired.com/press-release/august-2013-report-emerald-ash-borer-confirmed-finds-in-ontario-and-quebec-1822294.htm

Canadian Forest Service. (2012). Emerald Ash Borer. Great Lakes Forestry Center, Sault Ste. Marie, Ontario. Retrieved from: http://cfs.nrcan.gc.ca/pubwarehouse/pdfs/31501.pdf

Center for Watershed Protection and US Forest Service. (2008). Watershed forestry resource guide. Urban Watershed Forestry, Retrieved from: http://www.forestsforwatersheds.org/urbanwatershed-forestry/

Chadwick, M., Francis, R. 2013. Urban Ecosystems: Understanding the Human Environment. Routledge. New York, NY. Retrieved from:
http://books.google.ca/books?id=JVWJWKzTrJkC&printsec=frontcover&source=gbs_ge_summary_r&cad=0#v=onepage&q&f=false

City of Edmonton. (2014). Natural areas and urban biodiversity. Retrieved from: http://www.edmonton.ca/environmental/natural-areas.aspx

City of Toronto. (2014). City Owned Trees. Retrieved from:
http://www1.toronto.ca/wps/portal/contentonly?vgnextoid=976fdada600f0410VgnVCM10000071d60f89RCRD&vgnextfmt=default , on March 5th, 2014

Defenders of Wildlife. 2013. Fact Sheet: Peregrine Falcon. Defenders of Wildlife. Retrieved from: http://www.defenders.org/peregrine-falcon/basic-facts

Downing, A. (2011) Air what’s a tree got to do with it? Retrieved from: www/ecology.com/2011/09/02/air-and-trees/ on March 5th, 2014

Ducks Unlimited Canada. (2014). What is a wetland. Retrieved from:
http://www.ducks.ca/learn-about-wetlands/what-wetland/

Dwyer, J., McPherson, G., Schroeder, H. and Rowntree, R. (1992) Assessing the benefits and costs of the urban forest. Journal of Arboriculture 18(5): 227-234

Environmental Commissioner of Ontario (2005). Sustaining the urban forest. Planning a landscape, ECO Annual report, 201-205.

Environmental Defense. (2012). The scoop on Lake Simcoe. Retrieved from:
http://environmentaldefence.ca/scoop-lake-simcoe-sept-2012

Flap Canada. 2014. Why Birds Collide With Buildings. Flap Canada. Retrieved from:
http://www.flap.org/who-we-are.php

Government of Canada (2013). Natural resources Canada: Forest classification. Retrieved from: www.nrcan.gc.ca/forests/canada/classification/13179 on March 1st, 2014

Government of Manitoba. 2014. Winnipeg – Urban Wildlife Adventures. Watchable Wildlife Manitoba. Retrieved from: http://www.gov.mb.ca/watchablewildlife/winnipeg.html

GYE& Associates Ltd. (2013). City of Victoria Urban Forestry Master Plan. Retrieved from:
http://www.victoria.ca/assets/Departments/Parks~Rec~Culture/Parks/Documents/rban%0Forest%20Master%20Plan%202013%20Final%20Approved.pdf

Korhnak, L. (2000). Restoring the hydrological cycle in the urban forest ecosystem. University of Florida. Institution of Food and Agricultural Science. Retrieved from:
http://edis.ifas.ufl.edu/pdffiles/FR/FR07000.pdf

Long , A., & Ramachandran Nair, P. K. (1999). Trees outside forests: Agro-, community, and urban forestry. New Forests, Retrieved from: http://link.springer.com/article/10.1023/A:1006523425548

Luniack, M. 2004. Synurbization – adaptation of animal wildlife to urban development. Proceedings 4th International Urban Wildlife Symposium. Retrieved from:
http://cals.arizona.edu/pubs/adjunct/snr0704/snr07041f.pdf

Ministry of Natural Resources. 2013. Living with Wildlife. Wildlife Management. Retrieved from:
http://www.mnr.gov.on.ca/en/Business/FW/2ColumnSubPage/STEL02_168419.html

Ministry of Natural Resources. (2014). Watershed management and planning. Government of Ontario. Retrieved from: http://www.mnr.gov.on.ca/en/Business/Water/2ColumnSubPage/STEL02_163404.ht

Nature Blog Network. (2012). Labrish Jamaica: musings on earth and life. Retrieved from:
http://labrishjamaica.blogspot.ca/2012_09_01_archive.html

Pike, R. (2013). Hydrology: Forest hydrological cycle basics . Streamline Watershed Management, 7(1), Retrieved from: http://www.forrex.org/sites/default/files/publications/articles/streamline_vol7noat1_0.pdf

Roberts, J. M. (2013). The role of forests in the hydrological cycle. Forests and Forest Plants,3, Retrieved from: http://www.eolss.net/sample-chapters/c10/e5-03-04- 02.pdf

Society for Freshwater Science. (2013). What is the benthos. Retrieved from: https://www.freshwater-science.org/about-sfs/what-is-the-benthos-.aspx

South Simcoe Community Information Center. (2014). Holland marsh provincial wildlife management area. Retrieved from: http://southsimcoecic.cioc.ca/record/ALL0952

Tidal Marsh Monitoring. (2010). Tidal marsh monitoring: invertebrate monitoring methods. Retrieved from: http://www.tidalmarshmonitoring.org/monitoring-methods invertebrates.php

United States Geological Survey. (2013). The hydrologic cycle and interactions of ground water and surface water. NATURAL PROCESSES OF GROUND-WATER AND SURFACEWATER INTERACTION. Retrieved from http://pubs.usgs.gov/circ/circ1139/pdf/part1a.pdf

University of Manitoba. 2013. Urban Wildlife. Assiniboine Park. Retrieved from: http://www.arch.umanitoba.ca/greenmap/pages/GM_KS_AssinPark/pages/3.html

Winnipeg. 2013. Assiniboine Forest. Public Works. Retrieved from: http://www.winnipeg.ca/publicworks/naturalist/ns/AF/index.asp