STUDY GUIDE 2022

Ecosystem Restoration

FORESTS ONTARIO

ONTARIO ENVIROTHON 2022

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Acknowledgements

The following study guide was created by a team of students from the Ecosystem Management Technology Program at Fleming College. The team comprised of Sydney Shepherd, Cheryl Abernethy, Morgan Lane, and Alexandra Paetzold. The purpose of the study guide is to provide high school students with study materials that reflect the 2022 Ontario Envirothon Current Issue Topic: Ecosystem Restoration. Key topics and learning objectives and interspersed throughout this document and are accompanied by various case studies and hands-on activities.

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2022 Learning Objectives

KEY IDEAS

1. Basic principles of ecosystem restoration.
2. How ecosystems function and the services they provide.
3. The issues that aquatic and terrestrial ecosystems face and how they can be addressed in restoration efforts.
4. The importance of soils and how they can be restored to sustain healthy ecosystems.
5. How conservation and restoration efforts impact wildlife.
6. The role of various levels of government, businesses, individuals, and Indigenous groups in restoring ecosystems.

LEARNING OBJECTIVES

1. Understand the basic principles of ecosystem restoration and apply them on local, provincial, national, and international scales.
2. Define and understand key terms including ecosystem afforestation, biodiversity, species at risk, invasive species, remediation, and degradation.
3. Analyze the issues facing a variety of ecosystems and identify steps that can be taken to restore the landscape.
4. Understand the planning and process behind ecosystem restoration projects.
5. Understand the purpose and goals of a Remedial Action Plan (RAP) and how a RAP can be used for aquatic ecosystems, in particular the Great Lakes.
6. Understand the role of soils and describe practices involved in the conservation and management of healthy soils.
7. Investigate methods for restoring ecosystems critical to the survival of species at risk.
8. Understand how invasive species impact ecosystems and identify specialized techniques for invasive species management and removal.
9. Identify various levels of government, organizations, and Indigenous groups involved in ecosystem restoration and describe their respective roles.

UN Decade on Ecosystem Restoration (2021–2030)

The UN Decade on Ecosystem Restoration is a global rallying cry to heal our planet and work towards preventing, halting and reversing the degradation of ecosystems worldwide. There has never been a more urgent need to revive damaged ecosystems than now.

Ecosystems support all life on Earth. The healthier our ecosystems are, the healthier the planet and its people. The UN Decade on Ecosystem Restoration aims to prevent, halt, and reverse the degradation of ecosystems on every continent and in every ocean. It can help to end poverty, combat climate change, and prevent a mass extinction. It will only succeed if everyone plays a part.

Restoration holds huge promise, but it is also a challenge. Success requires knowledge, resources and patience. Restoration needs to happen at every scale and everyone has an important role to play: from international organizations and governments to industries and investors to communities and individuals. UN Decade on Ecosystem Restoration is underpinned by a strong and transparent partnership structure, built around clear roles and responsibilities.

Forests Ontario is taking part in the UN Decade on Ecosystem Restoration as an official Restoration Implementing Partner with long-term commitments towards forest restoration, grassland creation and rehabilitation, and community education and awareness. We are taking action by supporting and implementing on-the-ground restoration projects through our afforestation and tree planting programs. Forests Ontario is raising our voice in support of ecosystem conservation and restoration through our education programs engaging schools, landowners, municipalities, governments, forest industry, and the general public through our awareness initiatives.

The UN Decade on Ecosystem Restoration is our opportunity to bring nature back. By creating a global restoration movement, we can recreate a balanced relationship between people and the ecosystems that depend on them. Become a part of the UN Decade on Ecosystem Restoration through sharing the message of Ecosystem Restoration, engaging your friends and family to support your local ecosystem restoration initiatives, and learn more about our ecosystems and restoration to create your own actions through your participation in Ontario Envirothon.

FORESTS ONTARIO

UNITED NATIONS DECADE ON ECOSYSTEM RESTORATION 2021-2030

Tools and Resources

Ontario's Invading Species Awareness Program
http://www.invadingspecies.com/

Government of Canada - Protect Nature Challenge
https://www.canada.ca/en/environment-climate-change/services/nature-legacy/activities.html

Grow Me Instead (GMI)
https://www.ontarioinvasiveplants.ca/resources/grow-me-instead/

iNaturalist
https://www.inaturalist.ca/

Toronto and Region Remedial Action Plan
https://torontorap.ca/

Society for Ecological Restoration – Project Map
https://www.ser-rrc.org/project-database/project-map/

1.0 Introduction to Ecosystem Restoration

An ecosystem is a biological community of interacting organisms and their physical environment. Ecosystems have historically been degraded, damaged, or otherwise destroyed due to human disturbances that alter their structure or function. These damaged ecosystems that were once home to a host of plants and animals face increased stress from diminished, suboptimal habitats and have led many once-thriving species to be deemed at-risk.

Ecosystem restoration is the process of recreating, initiating, or accelerating the recovery of an ecosystem that has been disturbed, or otherwise changing the course of its recovery. This can include restoring the soils on a site, removing invasive or otherwise weedy vegetation and replacing it with more beneficial plants, and so on.

As there are a variety of ecosystems and disturbances found and occurring in Ontario, let alone Canada, there is no one-size-fits-all plan that works for all of them. Long-term studies and innovation are key steps in any restoration initiative and can be facilitated by various government and non-government organizations. Private landowners, both personal and corporate, can also be amazing and very necessary partners for restoration projects.

Ecosystem restoration occurs at the organism level but requires effort from municipal, provincial, and national governments. These efforts are at the forefront of the United Nations Decade on Ecosystem Restoration. This global effort began in 2021 and will run through to 2030 as a broad, global movement that aims to bring awareness and political momentum to ecosystem restoration, allowing restoration projects to gain the funding, partnerships, knowledge, and project resources to restore vital ecosystems.

In this study guide, students will be introduced to ecosystem restoration, the impacts made on different types of ecosystems, how different ecosystems can be restored, and who some of the key players are in restoring Ontario's ecosystems. This guide explores terrestrial, aquatic, soil, and wildlife restoration and discusses restoration efforts, action plans and case studies, as well as the organizations that have brought these restoration efforts to life.

Figure 1. Ecological Restoration Planning Framework, adapted from Parks Canada (Parks Canada, 2008).

2.0 Terrestrial Ecosystem Restoration

Terrestrial ecosystems are land-based communities made up of living organisms and the non-living environmental features that support them. There are over 30,000 plant and animal species in Ontario, over 200 of which are listed as Species at Risk. These species depend on healthy ecosystems for their survival and face increasing challenges as the quality of their habitat deteriorates.

There are many ways terrestrial ecosystems can become degraded, and there are several main drivers of ecosystem degradation facing Ontario today. In southern Ontario, the increasing human population is causing urban areas to expand onto undeveloped lands (Environmental Commissioner of Ontario, 2018). Natural lands are being cleared to make way for new cities, towns, and agricultural fields to support the growing population. In doing so, the natural areas such as forests and grasslands are severely reduced and often fragmented, leading to the loss of ecosystem function and loss of biodiversity (Noonan, Leroux, & Hermanutz, 2021). In northern Ontario, the leading causes of degradation stem from resource extraction - specifically, the fragmentation and pollution caused by the logging and mining industries (Ontario Nature, n.d.).

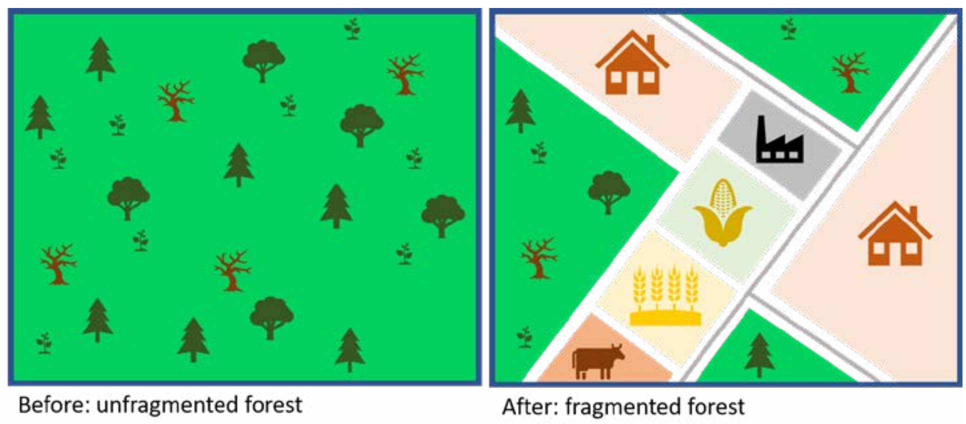
Another driver of ecosystem degradation is climate change. Changing weather patterns may increase the frequency and intensity of severe weather events, leading to a higher risk of flooding, forest fires, droughts, and temperature extremes (David Suzuki Foundation, 2021). Warming temperatures may facilitate the introduction of **invasive species** that take over an area and outcompete **native** species. Invasive species such as buckthorn and dog-strangling vine thrive in many conditions, out-competing native vegetation and decreasing biodiversity. Once established, these invasive species are exceedingly difficult to remove.

When ecosystems become degraded, they become less resilient. **Resilience** is the capacity of an ecosystem to tolerate disturbance and recover to its previous state or condition (Howell, Harrington, & Glass, 2012). For example, a healthy grassland ecosystem can withstand a major disturbance such as fire and regenerate naturally to a healthy grassland with the same ecosystem functions and services.

Another outcome of degradation is the loss of **ecosystem services** such as erosion control, carbon sequestration, provision of clean water, and crop pollination. **Fragmentation** is also a negative effect of ecosystem degradation and occurs when a formerly continuous natural area is separated into smaller, isolated fragments (Howell, Harrington, & Glass, 2012). Fragmentation is common in southern Ontario, where more and more land is being developed or converted for agricultural uses. In the northern part of the province, fragmentation occurs when roads are built and where land is cleared for resource extraction.

The main terrestrial ecosystems found in Ontario can be roughly divided into forests and grasslands, though dunes are a unique terrestrial ecosystem that has experienced degradation and is the focus of a handful of restoration projects across the province. The following subsections will provide a more in-depth look at each of these ecosystems, the value they bring, and some methods that may be used to restore them.

Figure 2. Comparison between an unfragmented forest and a fragmented forest (Cray, 2021).



2.1 Forests

Approximately 71 million hectares, or 66% of Ontario, are forested. (Government of Ontario, 2020). Healthy forest systems can provide many ecosystem services such as watershed services related to water provision and regulation, carbon sequestration and storage, soil conservation, recreation opportunities, biodiversity conservation, climate regulation and more (Government of Canada, 2020).

To learn more about Ontario's forests, refer to the Forestry Study Guide.

2.1.1 History and Pressures Facing Forests in Ontario

LOGGING

The logging industry in Ontario began at the start of the 19th century, when British timber resources were brought to a near standstill with the Napoleonic wars. Eastern White Pine (*Pinus strobus*) trees were a desired resource at the time, used for building many things including the masts of ships. Other trees in the forest were initially barriers to these grand pines, but eventually were harvested as well. By 1845, the upper Ottawa River watershed had over 12 million cubic feet of wood removed, and by the 1880s, the area was reduced to between 20 and 30% of the original forest cover (Landowner Resource Centre, 1997).

The field of forestry has grown considerably in the past century. It relies on practices and techniques developed with a better understanding of forests so that timber can be harvested while causing less damage than the past. For example, marking systems that dictate what trees to cut can reduce erosion, allowing forests to heal.

In the past 50 years, governments and not-for-profit organizations have shifted to more environmentally focused forestry practices that rely on sustainable forest management to maintain healthy forest ecosystems for future generations.

MINING

Over the past century, Ontario has been one of the leading mining provinces in Canada. There are many environmental impacts associated with mining, including mining waste disposal, soil contamination, fragmentation, and water pollution. The boreal forest region is particularly affected, as access roads and transmission lines installed to service the mines cause forest fragmentation. This fragmentation reduces forest habitat and can negatively impact wildlife (Burkhardt, Rosenbluth, & Boan, 2017).

DEVELOPMENT

Deforestation is the permanent removal of a forested area. Humans developing areas intended for recreation, urban development, industry, and travel cause tremendous pressures on forests in Ontario. Given that forest reduction reduces local and global carbon storage capacity and fragments natural ecosystems, deforestation must be monitored and regulated.

From 2009-2013, over 2400 hectares of forest were permanently removed for roads alone in Ontario (Government of Ontario, 2019). Since the Canadian definition of deforestation includes the word “permanent”, forests cleared for temporary roadways, operational sites, mines, and other industrial uses are not counted towards deforestation regulations if responsible parties indicate an intention to replant trees. This compromise between regulators and industry means at any given moment, there are fewer trees than reported by the Ministry of Northern Development, Mines, Natural Resources and Forestry (MNDMNRF) as they were not permanently removed and will be replaced in the future.

Preserving forest health is considerably more difficult on privately owned land, as the owner’s rights to build and develop are protected. As of 2018, private development deforestation was approximately 650 hectares per year and was considered acceptable (Environmental Commissioner of Ontario, 2018).

CLIMATE CHANGE

Climate change has become an increasingly prevalent concern for forests in Ontario. Impacts can range from changes in forest growth due to warming and precipitation changes, shifts in tree species range, or an increase in extreme weather events, wildfires, and other natural disturbances (Government of Ontario, 2021). Warmer temperatures can extend the range of invasive species and introduce **non-native** organisms from neighboring climates.

2.1.2 Who owns the forest and how does that affect restoration?

Almost 90% of Ontario's forests are Crown land, which is managed by the MNDMNRF. The MNDMNRF is required by law to ensure Ontario's Crown forests are managed sustainably under the Crown Forest Sustainability Act. To ensure sustainable forest management, Ontario's government bases its practices on the most up-to-date science and continuously improves its methods. (Government of Ontario, 2019). To protect and manage forests at the federal level, the government of Canada has established the following:

- A comprehensive system of legislation, regulations, policies, standards, and guides
- A forest management planning system
- A compliance program and independent forest audits to monitor progress
- A public reporting on the status of all aspects of forest management (Government of Ontario, 2019)

Privately owned forests are not bound by the same rules as Crown land, and restoration efforts can be completed by the owner. The government encourages the responsible management of privately owned forests and provides information and incentives like the Managed Forest Tax Incentive Program (MFTIP) to assist private landowners.

2.1.3 Methods of Restoration

Restoration methods will vary depending on what is being restored and the end goals of the restoration effort. The methods listed in this document are some of the more common forest restoration methods, but do not represent a comprehensive list. **Active restoration** involves implementing management techniques like the examples listed below, whereas **passive restoration** occurs naturally with no direct interventions (Noonan, Leroux, & Hermanutz, 2021).

TREE PLANTING

Tree planting is the process of planting tree seedlings to reforest an area that has been cleared or **afforest** an area that was not previously treed. The benefits of tree planting include;

- increasing carbon storage
- increasing the amount of forest cover
- regenerating future forests
- connecting existing natural spaces
- increasing wildlife habitat
- conserving biodiversity
- conserving soil and water
- moderating the climate
- boosting the local economy by providing jobs for seed collectors, nurseries, and tree planters (Government of Canada, 2020).

For more information on the economic value of tree planting in Southern Ontario, see "The Economic Value of Tree Planting in Southern Ontario" by Green Analytics and Forests Ontario (2019).

Government and not-for-profit organizations across Ontario and Canada have established tree planting initiatives such as the 50 Million Tree program and the National Greening Program to support reforestation and afforestation efforts.

NATIVE SEED COLLECTION

Seeds are often an inexpensive way to re-establish native plant species during a restoration project. The seeds can be collected from natural populations, harvested from managed populations, or cultivated from seed production system-seed farms (Pedrini, et al., 2020). Areas needing restoration often lack a seed bank in the soil or nearby areas that could re-colonize a site, and seeds must be brought in (See the section about seedbanks below).

An increase in demand for native seeds has put pressure on wild harvests and is not sustainable (Elzenga, Bekker, & Pritchard, 2019), so consideration must be made when choosing seeds to ensure they come from a sustainable source. Care should be taken to ensure that seeds used in restoration are from plants that are adapted to the climate and conditions of the target area. Seeds from too far away from the desired planting site may not survive or thrive, even if they are of the same species as what might naturally grow in the area.

Conservation authorities and field naturalist groups across the province often host workshops on native seed collection for the local public. There is also a voluntary certification program called "Ontario's Natural Selection" run by the Forest Gene Conservation Association (FGCA). This program provides high-quality, source-identified seeds from native woody species in Ontario (Forest Gene Conservation Association, 2018).

Seed Banks

Seed banks are places that store seeds from many species of plants. There are natural seed banks that exist within the soil, as well as human-constructed collections of seeds stored in specialized buildings to be later reused.

Seed banks can be especially useful in conserving species at risk. Rare or at-risk seeds can be harvested and stored at appropriate temperature and moisture levels to preserve the seeds and their genetic material. Stored seeds may be used in a variety of different ways, such as increasing crop yields, scientific inquiry, and genetic modification projects. Seeds can be preserved for thousands of years! In fact, the oldest known seed to be successfully germinated was a Judean date palm carbon-dated back 2000 years old (Science Magazine, 2008).

REMOVAL OF NON-NATIVE AND INVASIVE SPECIES

Before an area can be restored, invasive and non-native species are often removed to increase the restoration's likelihood of success. Recent research has shown that removing invasive shrubs from a deciduous forest in North America resulted in the regrowth of desired native understory plants (Pennsylvania State University, 2019). Removal methods will be dependent upon the species and whether it is a plant or animal. The Ontario Invasive Plant Council publishes Best Management Practices (BMPs) guides for many invasive plant species, with detailed instructions for removal methods.

2.2 Grasslands

Grasslands are open areas comprised primarily of grasses and flowering plants and may have a small number of trees. Historically, tallgrass prairies covered approximately 1000 km^2 of southern Ontario, but less than 1% of that remains today (Credit Valley Conservation, n.d.). The importance of grasslands is often overlooked, resulting in the conversion of natural grasslands to agricultural fields or urban development.

Figure 3. Restored grassland in Windsor, ON (Cray, 2021).

Grasslands provide many environmental benefits to both humans and wildlife. Ecosystem services provided by grasslands include carbon sequestration, water run-off control, erosion control, soil formation, pollination, biological control of pests, nutrient cycling, biodiversity, habitat, and recreational opportunities. These are also cultural landscapes, extensively used and intentionally managed by First Nations people (Anderson, 2006).

Grasslands are one of the most endangered ecosystems in the world, yet they continue to be lost, fragmented, and degraded. The expansion of urban and agricultural areas, forest expansion, and invasive species are the main threats to Ontario's grassland systems.

2.2.1 Types of Grasslands

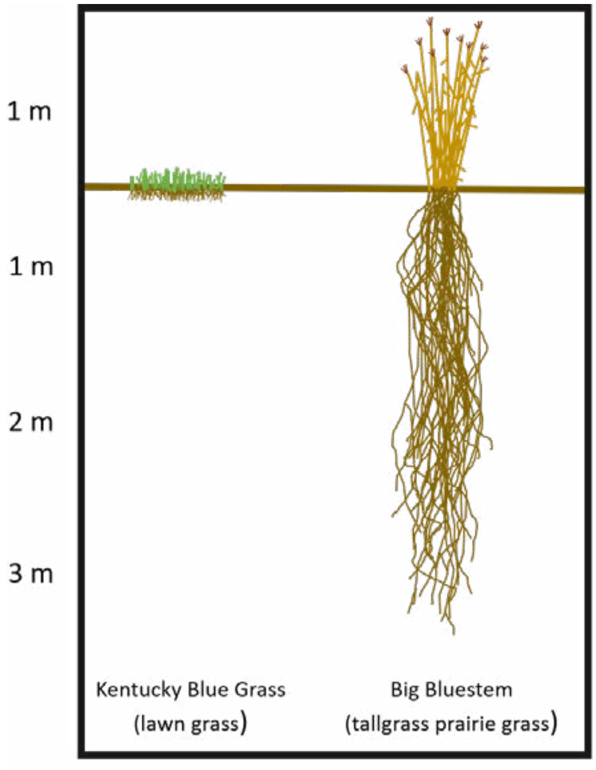
There are three main types of grasslands found in Ontario: tallgrass prairies, savannahs, and meadows. The tallgrass prairies are the most endangered grasslands in Ontario. They are made up of tall grasses that can grow to over 7 feet and wildflowers and were historically and are sometimes presently used as a source of food, fuel, and healing plants to Indigenous Peoples (Solymar, 2005). Savannahs in Ontario form most often on sandy soils and are subject to stresses such as fire, drought, and spring flooding. Plant species in a savannah ecosystem include grasses, wildflowers, and trees such as oak, hickory, or pine that are widely spaced. Meadows can be found on roadsides and abandoned farmers' fields and are dominated by grasses and herbaceous plants. They are often found in disturbed areas and represent the early stages of **succession** before an area develops into a forest.

2.2.2 Management Tactics

Grassland ecosystems require management strategies to prevent them from transitioning into shrubland or forest. In nature, this is accomplished by wildfires. Fires burn the above-ground vegetation, killing tree saplings, shrubs, invasive species, and their seeds while leaving the extensive root systems of the native grassland plants intact, allowing them to regrow successfully (Solymar, 2005). Fires also prevent succession of the area and encroachment of neighbouring forests.

As urban areas increase, people have begun to suppress wildfires. Current management methods include prescribed or controlled burns, where a fire is intentionally set in a predetermined area under certain conditions for the purpose of grassland restoration, forest management, or hazard reduction. Mowing, cutting, and grazing are also commonly used to reduce woody plant growth and reduce the vigour of non-target grasses to allow other species to grow (Solymar, 2005).

Figure 4. Comparison of root depth: tallgrass prairie and non-tallgrass prairie plants (Cray, 2021). These extensive roots are the reason why prairies are excellent at controlling erosion in otherwise sandy areas.



2.2.3 Restoration Initiatives

CARDEN ALVAR

The Carden Plain is in the City of Kawartha Lakes and southern Ramara Township, northeast of Lake Simcoe. This natural heritage area contains a globally rare **alvar** (Figure 5) that is a hot spots for species at risk and has been a focus of the Nature Conservancy of Canada's (NCC) conservation efforts since 1998. Wildfires historically controlled the encroachment of woody species, but with the suppression of natural fires the area was quickly colonized by native and invasive species.

With the help of partners and volunteers, the NCC conducts an annual removal of invasive and woody species through cutting and prescribed burns (Nature Conservancy Canada, 2020). In addition to those removal methods, the NCC has been exploring a partnership with local cattle farmers that would use grazing cattle as a method of controlling unwanted vegetation.

Figure 5. The Carden Alvar (Couchiching Conservancy, 2018).

DOWNSVIEW PARK TALLGRASS PROJECT

In partnership with Tallgrass Ontario, Downsview Park recreated a 5-acre tallgrass prairie (Figure 6) that is used to educate school children and the local public about the importance of biodiversity and habitat preservation (Tallgrass Ontario, 2020). The project began in spring 2016 with a year of site preparation on an old field. It included extensive vegetation control and the development of a test plot to determine how different species would react to the Downsview microclimate. That fall, a cover crop of oats was planted to stabilize the site, reduce erosion, and prevent non-native seeds from establishing.

In the spring of 2017, 600 tallgrass plugs were planted, followed by seeding the entire area with 26 native prairie species. The restoration project was completed in 2019; however, the Park continues to add native vegetation and remove unwanted species annually.

Figure 6. Restored section of tallgrass prairie at Downsview Park. (Downsview Park, 2021).

2.3 Dunes

Dunes are a landform made up of loose sand grains piled into mounds by wind or water. They can be found scattered throughout Ontario, often near the shorelines of the Great Lakes. Inland dune complexes are what remain of ancient lake beds where the water has long since disappeared. Dunes provide ecosystem services such as shore protection and water filtration (Lake Huron Centre for Coastal Conservation, n.d.). They also prevent sand drifting and provide nesting habitat for endangered species and feeding grounds for shorebirds.

The threats to dunes in Ontario include development, the encroachment of forests and invasive species, and recreational activities that trample or remove vegetation.

A common method of sand dune restoration involves planting marram grass *(Ammophilia breviligulata*) (Beach and Dune Stabilization with Sand Fencing and Vegetation, 2006). The grass root system holds in the sand while trapping blowing sand until the grass is eventually covered by sand. Covering stable marram grass causes the plants to grow taller and creates a cycle that allows the dunes to extend instead of losing the grains beyond their edges. Marram grass is resilient to sand disturbances but highly susceptible to human disturbance, so surrounding it with fencing protects it from humans and controls the direction of the restoration of the sand (Lake Huron Centre for Coastal Beach Conservation, 2006).

2.3.1 Restoration Initiatives

LONG POINT SAND DUNE RESTORATION

The restoration efforts in Long Point are focused on keeping the coastal beaches desirable for recreation. The local ratepayer association has ongoing efforts with the province to continuously restore sandy beaches. Maintaining strong sandy beaches, dunes, and coastlines helps control the sand spreading and reduces the municipal burden of clearing sand from roads, parking lots, and tourist attractions (Long Point Ratepayers' Association, 2018).

A significant number of sandy beaches are private property, so additional resources are spent on education. Private beach owners are encouraged to take part and even assist with restoration efforts from both the association and the province. The primary restoration method is to stabilize loose beaches with marram grass. A few years after planting marram grass, most residents will notice a significant drop in how much sand drifts across roads and driveways, and the sand remains on the beach as the residents prefer.

2.4 Case Study: Pinhey Sand Dunes

INTRODUCTION

The Pinhey Sand Dunes (PSD) are Ottawa's only inland dune complex. The dunes were formed over 10,000 years ago in what was once the Champlain Sea that covered the area after the last ice age. They have remained intact until the 1940s (Biodiversity Conservancy International, 2021). Until recently, large areas of open sandy hills were considered a barren wasteland without ecological merit. In the 1950s and 60s, a combination of Red Pine (*Pinus resinosa*) plantations, housing developments, and invasive species such as Scots Pine (*Pinus sylvestris*) and European Buckthorn (*Rhamnus cathartica*) rapidly reduced these dunes to 1% of their original 370-acre size (Figure 7) (Dang & Aitken, 2014). These dunes have been recognized to hold a diverse and unique ecosystem, prompting preservation and restoration efforts.

Figure 7. Time lapse of the disappearance of the Pinhey Sand Dunes. (Biodiversity Conservancy International, 2021).

ABOUT THE SAND DUNES

The Pinhey Sand Dunes are located on protected federal land in the National Capital Greenbelt. The sand in the area is three to five meters deep, and its surface temperatures range from 60-72°C in the summer. These dunes provide habitats for hundreds of invertebrate and plant species that have adapted to this very specific environment (Aitken, 2019).

Figure 8. Image of a restored section of the Pinhey Sand Dunes (Biodiversity Conservancy International, 2021).

The privately-owned land was donated to the National Capital Commission (NCC) in the 1950s (Dang & Aitken, 2014). At that time, the importance of the sandy habitat was not well understood, and the dunes were planted with Red Pines. As a steward of the PSD, the NCC protects the dunes and the biodiversity within them, both of which are now considered national assets. In 2011, a routine permit was requested from the NCC to study insects within the Sand Dunes. (Aitken, 2019). This ultimately led to a partnership with the Ontario Trillium Foundation, Biodiversity Conservancy International (BCI), and other donors to carry out an ambitious multi-phase restoration project which began in 2011 (Figure 8).

RESTORATION EFFORTS

The Pinhey Sand Dune restoration was a multi-phased initiative that spanned several years. Phase one of the restoration project began in 2011 and focused on the largest areas of the most salvageable dunes. The first step was to remove several of the planted trees and reclaim the open dune area, which amounted to approximately 2% of the original system. Woodchipped trails were developed to maintain weed-free trails. Next, organic matter such as weeds, dead roots, rotten and decaying wood, leaves, and organic particles measuring 1-2 millimeters were removed (Aitken, 2019). The sand was restored to its natural state using finely screened sand sifters. During the two years of phase one, the dunes were repopulated with native dune plants that had disappeared from the area. Other key goals of phase one were to educate the neighbourhood, elementary, secondary, and college-age students in the area and study the organisms in the PSD.

A dune restoration model was developed based on the work at Pinhey to establish a framework for others working on similar projects (Dang & Aitken, 2014). The NCC has since opened two more restoration sites at Pinhey.

Figure 9. A map of the Pinhey Sand Dunes showing three of the four restored dune sites in 2020 (Biodiversity Conservancy International, 2021).

Phase two was a multi-year phase designed to increase the size of the restored dune area. In the years that followed phase one, volunteers were an integral part of the restoration efforts. Over 1000 volunteer hours have been spent clearing, raking, and sifting debris from the sand, and removing unwanted vegetation (Dang & Aitken, 2014).

Work is ongoing at PSD. As of 2020, four sections have been restored (Figure 9). The NCC and BCI have been working on restoring the dunes for over a decade. They received grants from the Ontario Trillium Foundation, provincial funding, and other funders (Biodiversity Conservancy International, 2021).

DISCUSSION QUESTIONS

Q1: Why is it important to remove organic materials from the sand when restoring a dune system?

Q2: One of the key initiatives of this restoration project is to educate students of various age groups. What material would you present to elementary school students? High school students?

Q3: If you were the project manager, how would you determine if this restoration initiative was successful?

2.5 Terrestrial Ecosystem Activity

Think of a terrestrial ecosystem near where you live that has been degraded in some way. The ecosystem can be small or large. Try to determine what caused the degradation, then make a list of possible restoration methods you could use to restore it.

Factors you may want to explore:

- What are sources of contaminants or pollutants nearby?
- Are there non-native species or invasive species?
- Is there any vegetation present? If not, why?
- Is it possible to restore the entire ecosystem at once, or would you need to plan a multi-phased restoration?
- Is there any indication that restoration was attempted at this location in the past?

Review your ideas with your peers, and brainstorm what might be the best first step.

3.0 Aquatic Ecosystem Restoration

75% of the Earth's surface is covered by aquatic **biomes**. The aquatic biome can be further divided into two groups: marine systems and freshwater systems. Both groups have a strong relationship with water, but this relationship can vary depending on local characteristics. Some examples of freshwater ecosystems are wetlands, rivers, streams, lakes, and ponds. Some examples of marine ecosystems are oceans, mangroves, and estuaries (National Geographic, 2020). For more information on aquatic ecosystems, refer to the Aquatics Study Guide.

Canada is home to roughly 25% of the world's wetlands, just one type of aquatic ecosystem (NCC, n.d.). With such a high percentage of the world's fresh water supply, Canada has a responsibility in taking care of and conserving these lands.

As a result of the interconnectedness between aquatic ecosystems and terrestrial ecosystems, aquatic ecosystems are overly sensitive to degradation due to changes in the surrounding terrestrial environments (NCC, n.d.). Much of the environmental change is **anthropogenic** in nature (Table 1).

Table 1. Causes of aquatic degradation.

Eutrophication	Eutrophication causes harmful algal blooms which decrease water quality.
Invasive Species	The introduction of invasive species can negatively impact the structure of habitats and food webs.
Environmental Pollutants	Environmental pollutants negatively impact water quality and habitat by altering food webs and structure.
Microplastics	Microplastics are tiny pieces of plastic that exist within the environment. They are consumed by wildlife and can magnify their impacts up the food chain.
Climate Change	Changing climates are impacting water levels via extreme weather events such as droughts and floods.
Habitat Loss	Urbanization and development are changing land use, paving habitats, and fragmenting larger habitats into smaller, less sustainable habitats.

To conserve the function of degraded aquatic ecosystems, **remediation** and restoration processes may be necessary. Remediation involves the removal of pollutants from the environment. This process is often used in environments affected by eutrophication and heavy metal contamination. Following remediation, restoration processes can begin. Restoration involves bringing the land back to a state and function which is close to natural. (NOAA, 2016).

This section will cover eutrophication, invasive species, Great Lakes ecosystems, and restoration efforts designed to manage various aquatic ecosystems.

3.1 Eutrophication and Restoration

Eutrophication is the process that occurs in aquatic ecosystems which receive too many nutrients from the surrounding environment. The two primary nutrients responsible for eutrophication are phosphorous and nitrogen. Often, these nutrients enter water systems from agricultural and municipal run-off. Nearly half of the nitrogen applied through fertilizer ends up in run-off (Canadian Boreal Initiative, 2009).

Eutrophication results in increased algal growth. Algal blooms, which can be foul-smelling, reduce the clarity and quality of water. Algal blooms block sunlight to other species in the water, especially submerged vegetation, and fish. This lack of sunlight causes a decrease in submerged plant growth and in the ability of fish to capture prey. When the large algae and other plant masses die, oxygen is quickly depleted in the water by decomposition. This lack of oxygen leads to "dead zones" that cannot support many forms of life. As well, some algal blooms can produce harmful chemicals, reducing the water quality for human and wildlife consumption and recreation (Chislock et al., 2013).

Eutrophication is often controlled by the mitigation of nutrients entering water bodies. Mitigation has been done at the municipal level where legislation is passed to regulate nutrient use, and infrastructure is improved to reduce run-off. However, **internal loading** still exists, as there is a surplus of nutrients that remain in the sediment. One interesting method of restoring aquatic environments impacted by excess nutrient loading is **biomanipulation (**Chislock et al., 2013).

Phragmites

Common reed (*Phragmites australis*), otherwise referred to as phragmites, is an invasive plant that can be found both over land and in semi-aquatic environments. It thrives in places such as beaches, marshes, and roadside ditches. These plants grow in thick clumps that do not allow native plants to grow, choking out any potential competition.

The use of a single control measure is not always effective, as these reeds have an extensive underground rhizome system. Management options for control include mechanical excavation, flooding, herbicide application, and prescribed burning. However, in more auqatic ecosystems, herbicide is a last resort, meaning that mechanical control methods are best.

3.2 Invasive Species and Restoration

Invasive species are plants or wildlife which are introduced to an area outside of their natural range and outcompete species that are native to the area. The introduction of invasive species can change the species composition of an ecosystem. This change can be detrimental to native plants and wildlife in a variety of ways.

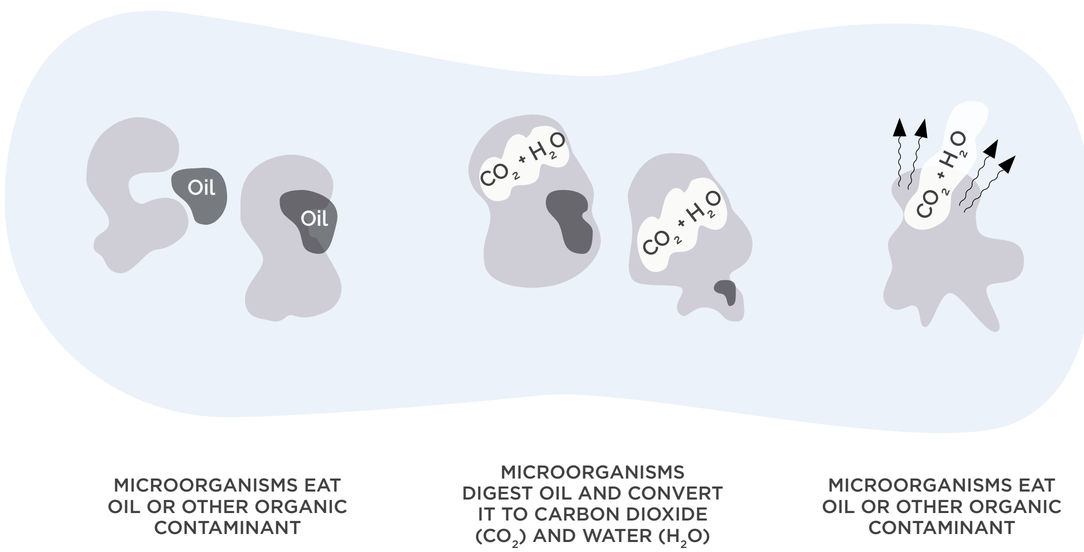
The most successful strategy is to mitigate the introduction of invasive species to an environment – once a species is established, it can be incredibly difficult to remove. Controlling invasive species can involve three methods: mechanical, biological, and chemical (Ontario Invasive Plant Council, 2016).

3.3 Environmental Pollutants and Restoration

Environmental pollutants can enter the water from many sources, though these pollutants increasingly come from urban and industrial **point sources**. Some examples of pollutants that contaminate the water are heavy metals and oils. Pollutants negatively impact the survival of wildlife species, as well as human consumption and recreation. Prior to the restoration of aquatic habitats affected by pollutants, they should be removed from the environment by remediation.

Bioremediation is the process where microorganisms digest chemicals in the environment and convert them into CO_2 and H_2O (Figure 10). This process is natural, readily available and is less impactful on the environment than other methods. This method is widely used in municipal wastewater treatment plants (Safe Drinking Water Foundation, n.d.).

Figure 10. The process of bioremediation by microorganisms (SDWF, n.d.).



Another method of remediating environmental pollutants is **phytoremediation**. Phytoremediation involves the use of plants to remove pollutants by their root system. Many plants can take up heavy metals and oils in their roots, converting these chemicals into gases released by respiration. This process takes many years and provides additional structure to the habitat in the process. However, animals may eat contaminated plants and experience negative impacts (Safe Drinking Water Foundation, n.d.).

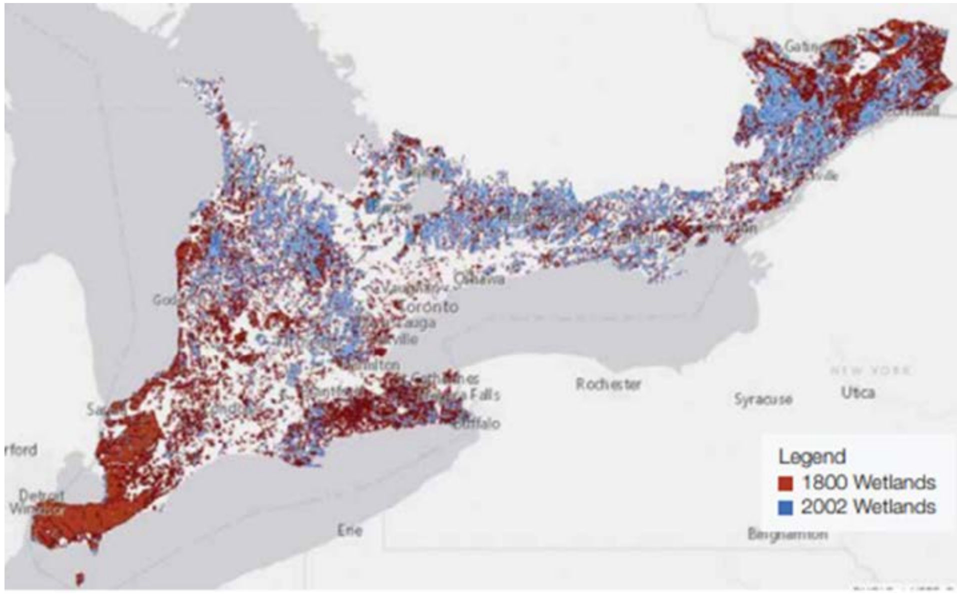


Figure 11. A map of Ontario's historic wetlands compared to the wetlands present in 2002.

3.4 Wetland Restoration

Southern Ontario has lost an estimated 72% of its wetland ecosystems. With population growth and urban expansion, that number is expected to increase even further (Figure 11). The wetlands that remain have been severely degraded due to many anthropogenic forces such as climate change, invasive species, and environmental pollutants.

Like all aquatic ecosystems, wetlands provide many ecosystem services such as nutrient filtering (aiding in slowing the eutrophication process, see section 3.1), flood control, carbon sinks and more. While many of the services that wetlands provide are difficult to quantify, it is estimated that southern Ontario's wetlands offer 14 billion dollars' worth of services to humans annually (Environmental Commissioner of Ontario, 2018). See Table 2 for estimates on the monetary value of many ecosystem services provided by wetlands (Canadian Boreal Initiative, 2009).

The field of wetland restoration is growing with the understanding of the importance of wetlands. In developing a restoration plan for wetlands, each wetland must be evaluated individually to determine which course of action is best for its restoration. No one plan will work for all wetlands, as each has its own challenges and deficiencies. There is consensus that managing wetland restoration on the ecosystem level is important to the restoration project's success (MNDMNRF, 2017).

Table 2. Average Wetland Ecosystem Service Values from Wetland Valuation Metanalysis K. Schuyt and L. Brander (Canadian Boreal Initiative, 2009).

WETLAND FUNCTION	$ CAD/HECTARE/YEAR (2002$)
Flood Control	571.02
Recreational Fishing	460.27
Amenity/Recreation	605.48
Water Filtering	354.43
Biodiversity	263.36
Habitat Nursery	247.36
Recreation Hunting	151.37
Water supply	55.38
Materials	55.38
Fuel wood	17.23
Total	**2781.28**

3.5 Great Lakes Remedial Action Plan

The Great Lakes are a unique and dominant aquatic feature that shares boundaries with both Canada and the United States of America and hold 84% of North America's surface freshwater supply (Figure 12). They are home to many species and provide many ecosystem services. Due to large size, the Great Lakes are a part of many different landscapes and are broken up by many bordering jurisdictions. This makes them a complex and difficult target for restoration efforts (MECP, 2016).

Like other aquatic systems, the Great Lakes face many environmental pressures, most of which are anthropogenic in nature (NOAA, 2019). Aside from the relatively untouched Lake Superior, health indicators suggest that the other four Lakes are in decline. The Lakes experience high nutrient loading and eutrophication, invasive species introduction and spread, water level change, and heavy metal and chemical loading. This leads to alterations in the habitat available for many species and impacts how humans interact with and use the Great Lakes (MECP, 2016).

Figure 12. Map of the Great Lakes Areas of Concern (Toronto and Region RAP, n.d.).

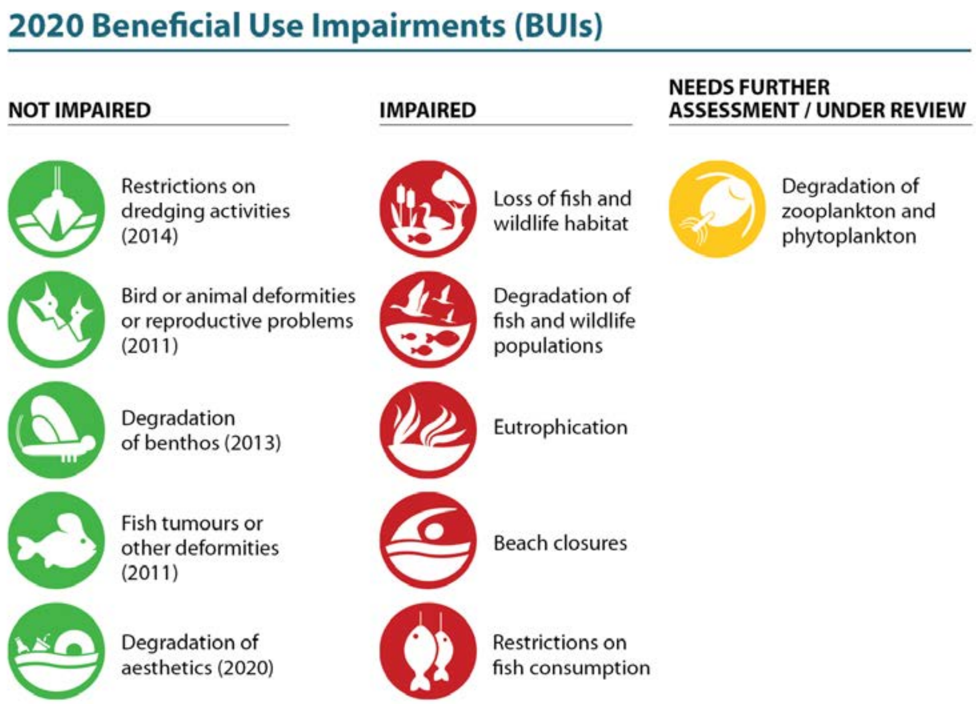
To manage and mitigate the anthropogenic effects these lake systems are facing, many organizations have created frameworks and policies, including Remedial Action Plans (RAPs). RAPs are targeted plans that aim to restore Areas of Concern, which are selected by the Canadian and United States Governments in the International Join Commission (IJC) by evaluating local environmental conditions against 14 Beneficial Use Impairment indicators (BUIs). If an area has many BUI attributions, that area may be listed as an Area of Concern, and a Remedial Action Plan may be created (International Joint Commission, n.d.).

The list of BUIs are as follows:

- Added cost to agricultural industry
- Degradation of aesthetics
- Beach closings
- Degradation of benthos
- Bird/animal deformities or reproductive problems
- Restrictions on dredging activities
- Restrictions on drinking water consumption or taste and odour problems
- Eutrophication or undesirable algae
- Fish tumours or other deformities
- Restrictions on fish and wildlife consumptions
- Loss of fish and wildlife habitat
- Degradation of phytoplankton and zooplankton populations
- Degraded fish and wildlife populations
- Tainting of fish and wildlife flavour

In 1987, Toronto and Region had 11 of 14 impairments on the BUI list and was assigned as an Area of Concern (Figure 9). Through the work of the Toronto and Region Remedial Action Plan and the creation of numerous restoration strategies, the area of concern was able to remove five impairments in 2020 (Toronto and Region RAP, n.d.). To fully delist Toronto and Region as an Area of concern, continued restoration efforts are needed.

Figure 13. Comparison of the 11 BUIs for Toronto and Region Area of Concern.



3.6 Case Study: Cootes Paradise, Hamilton

Cootes Paradise Marsh is a wetland located within the Hamilton Harbour Ecosystem, found on the western end of Lake Ontario (Figure 14). The marsh is 2.5 km^2 and surrounded by the City of Hamilton, the Town of Dundas, and the Town of Waterdown. The surrounding land is roughly 55% agricultural and 10% urban (Great Lakes Wetlands, 2014).

Figure 14. Cootes Paradise Marsh trail map: part of the Royal Botanical Gardens (Royal Botanical Gardens, n.d.).

It is the last remaining marsh habitat in western Lake Ontario and serves as a valuable habitat for many wildlife species (Great Lakes Wetlands, 2014). Cootes Paradise is located along the Atlantic Flyway path, a migration pathway of many migrating bird species (NCC, n.d.).

Prior to major urbanization, the marsh was covered with native plant species, which provided ample habitat for many wildlife species such as insects, birds, mammals, reptiles, and amphibians (Royal Botanical Gardens, n.d.). The habitat also provided a suitable place for many fish species to spawn, sheltered from larger predators found in the larger bay area (Great Lakes Wetlands, 2014). In the 1930s, Cootes Paradise marsh became a nature sanctuary as part of the Royal Botanical Gardens (Royal Botanical Gardens, n.d.).

DECLINE

With increased urbanization and agricultural demand, Cootes Paradise's habitat began to decline. Sediment was being lost from the area into the bay creating water levels that were deeper than usual. Invasive common carp *(Cyprinus carpio),* introduced to the area from foreign boats in Lake Ontario, aided in sediment loss, while sewage from the Town of Dundas was being discharged into the marsh. This resulted in a net loss of sediment and excess nutrients, namely phosphorus, entering the system, ultimately leading to eutrophication.

Harmful algae began to bloom, leading to insufficient oxygen in the water and blocked light to submerged aquatic plant species. In the 1930s, Cootes Paradise saw a 15% reduction in native marsh vegetation. This number jumped to an 85% reduction in 1985. In addition, invasive plant species were beginning to displace native plant species. This quickly created an environment that could not support the diversity of plant and wildlife species that once called the marsh home (Great Lakes Wetlands, 2014).

In 1987, the Hamilton Harbour Ecosystem was named an Area of Concern by the International Joint Commission. From here, the Hamilton Harbour Remedial Action Plan was developed, which involved the joining of many stakeholders in the creation of restoration plans for the area (Royal Botanical Gardens, n.d.). Because of its location within the Hamilton Harbour and its designation as a nature sanctuary by the Royal Botanical Gardens, Cootes Paradise was an easy place to start a restoration (Great Lakes Wetlands, 2014).

It was found that there were four main reasons for degradation to Cootes Paradise (Great Lakes Wetlands, 2014):

1. High water levels
2. Poor water clarity
3. Excess nutrients
4. Common carp disturbance

After careful consideration and ecological modelling, stakeholders in the Hamilton Harbour RAP decided that tackling the common carp invasion was the first step in the restoration process Using the common carp's annual migration to their advantage, the entry to Cootes Paradise was blocked off in the spring of 1997 to prevent the invasive fish from returning. The fishway infrastructure allowed fish of a specific size to pass freely, but fish of larger sizes (such as common carp) were caught in baskets (Figure 15). RAP members hand-sorted the fish in these baskets, allowing desirable fish to enter while returning carp into the bay. After just two years, the fishway successfully reduced common carp biomass into Cootes Paradise by 90% (Great Lakes Wetlands, 2014).

Figure 15. Picture of the Cootes Paradise Fishway.

Common carp exclusion showed some promise in restoring native plant communities. The RAP decided the next step was to plant target vegetative species in the area, such as cattails (*Typha sp.*), white water lilies (*Nymphaea sp.*), and wild rice (*Zizania sp.*).

This project resulted in native fish species being found in higher numbers than previously recorded, including rare species (Great Lakes Wetlands, 2014). Turtle nesting habitats have been re-established, Bald Eagles (*Hailaeetus leucocephalus*) have returned to the site, and many bird species both live and visit the area during their migration (Government of Canada, 2017). With the combination of planting and common carp exclusion, Cootes Paradise is on its way to returning to a functioning wetland.

DISCUSSION QUESTIONS

Q1: How did algal blooms lead to insufficient oxygen in Cootes Paradise Marsh? What caused the blooms, and how can they be prevented from returning?

Q2: What are the four main reasons for degradation in Cootes Paradise? List possible causes for each reason and explain how they were resolved.

Q3: Research deeper the life history strategies of common carp. Why did common carp have such an impact on the degradation of this area?

3.7 Aquatic Restoration Discussion Questions/Activities

Q1: Why do you think it is so hard to replicate the function of a natural wetland?

Q2: Aquatic systems are often affected by the terrestrial systems that surround them. How might this impact aquatic restoration efforts and their overall success? How can these negative impacts be mitigated, while positive impacts are enhanced?

Q3: Create a poster that demonstrates the importance of wetland restoration. You can choose any aspect of the aquatic ecosystems you wish, but it must relate to the need for restoration, or the benefits restoration provides.

4.0 Soil Restoration

Soil consists of unconsolidated material that makes up the top layer of the earth and supports the growth of plants (Canadian System of Soil Classification, 1998). Soil is made up of mineral and organic material that are both live and dead, as well as gasses and liquids, and is formed naturally through different processes with different factors that influence them.

Please refer to the Soil Study Guide for more information on soil formation and structure.

4.1 Soil Degradation

Soil is generally degraded in two ways; through natural degradation and degradation caused by human impacts. When soil is left bare, as it often is in agricultural fields or construction sites, it becomes susceptible to natural erosion (Figure 16). Bare soil can be eroded by wind, with speeds between 25 to 50 km/hour required to initiate the process and move soil particles betwee0.1 and 0.5 millimeters in (Government of Canada, 2021). The erosion process speeds up once initiated, as small soil particles and aggregates loosen, making erosion easier. These soil particles can be carried thousands of kilometers away by the wind.

Bare soil can also be eroded by water. When it rains, the water hits bare soil with enough force that it loosens it and carries the soil away. There are different types of water erosion. Sheet erosion is caused by rainfall and rill erosion when small channels form from runoff water.

Soil degradation is also heavily influenced by human-impacted degradation. Some **anthropogenic** influences on soil include resource extraction, compaction, chemical pollutants, and over-farming. These topics will be further discussed in the following sections.

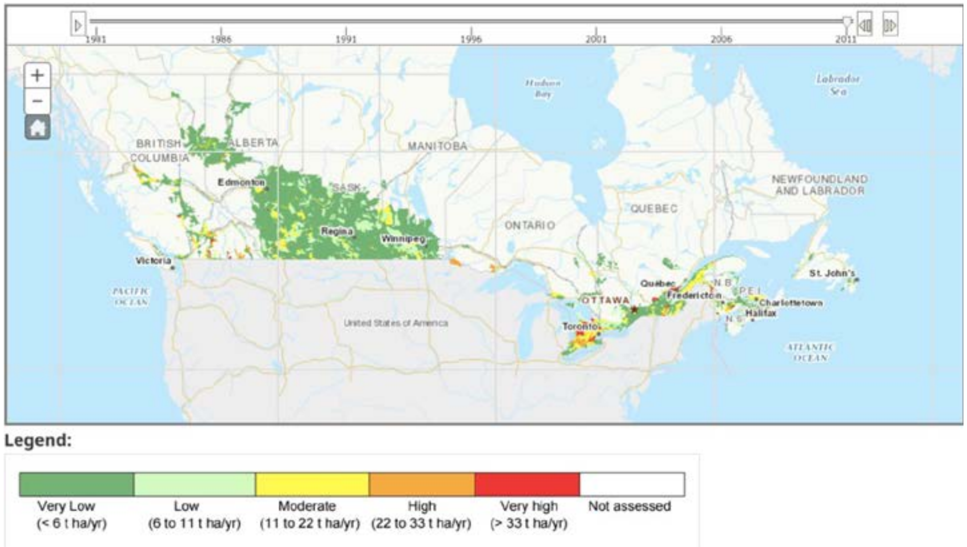


Figure 16. A map of Canada on the soil erosion indicator where areas are colour coated based on their risk to soil erosion (Government of Canada, 2021).

4.1.1 Natural Resource Extraction

Natural resource extraction uses methods such as excavation, drilling, or boring to extract aggregates, oil, and natural gas from the earth. There are multiple different ways that natural resource extraction contributes to soil degradation. Surface extraction areas such as gravel pits and surface mines leave exposed soil (Figure 17). If sites that have been used to their capacity are abandoned it can leave steep embankments, holes, gullies, or ruts in the earth. This leads to wind and water erosion of soil at these surface extraction sites. The resource processing facilities where they wash and sort the gravel/sand/rocks use a lot of energy and time and adds sediments to nearby rivers or lakes. The water runoff from the exposed soil can also lead to chemical pollution from salts, acid, and metals in the mineral material (Massachusetts Department of Environmental Protection, 2021).

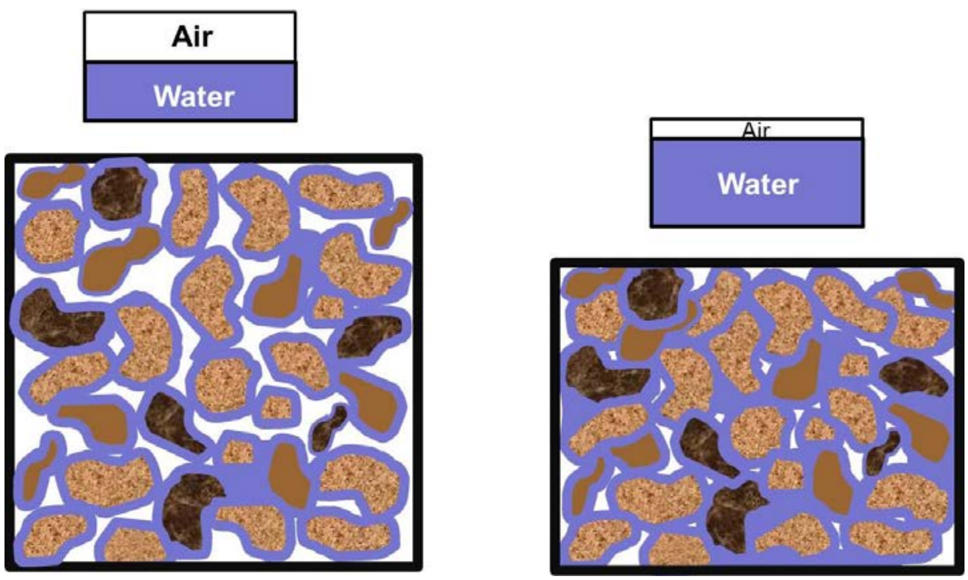
4.1.2 Compaction

Regular soil has a structure of soil particles, air, and pore spaces. When soil is compacted, it decreases the pore spaces (Figure 18) and makes it hard for water, nutrients, microbes, and plant roots to navigate through the soil. While soil compaction increases soil density, making it more resistant to wind erosion, the other consequences are too significant to ignore (Dejong-Hughes, 2018).

Soil compaction mainly affects plant growth. The roots cannot grow into the soil, which doesn't allow for proper stability, nutrient uptake, or development. When there are few to no pores in the soil, water cannot filter through the soil to the water table. This can cause flooding and immense water erosion.

Figure 17. An aggregate extraction site (Massachusetts Department of Environmental Protection, 2021).

Figure 18. A diagram showing uncompacted soil (left) and compacted soil effect on pore space (right) (DeJong-Hughes, 2018).



4.1.3 Chemical Pollutants

Chemical pollutants are a major factor contributing to soil degradation. Many human activities add chemicals to the soil. Industrial and manufacturing sites take up a large amount of space and often use transportation trucks to export and import materials. These buildings and trucks can leak chemicals into the surrounding soil. This can also happen with leaking cars on highways or in parking lots.

Landfills and waste disposal sites are subject to rainfall, which can wash all the chemical pollutants from the discarded waste down into the soil. Chemicals can mix, creating more toxic pollutants.

Farmland often builds up chemicals in its soil from the use of fertilizers, pesticides, and insecticides. The most common pollutants include lead, copper, fertilizers, pesticides, petroleum, asbestos (Rinkesh, 2021).

4.1.4 Over-Farming

There are quite a few industrial agriculture practices that contribute to soil degradation.

- Monocropping is when the the same crop is grown on the same land year after year. This depletes nutrients in the soil and prevents it from regenerating. This ultimately leads to poor crop quality and requires the use of fertilizers to increase nitrogen, phosphorous, and potassium needed for plant growth.
- Pesticides are frequently used in industrial agricultural practices to keep pests from affecting crop yield, though they can leech into the soil and cause detrimental effects to the overall health of the soil.
- Manure sources from factory farms can be spread on farmlands. This manure is loaded with antibiotics and hormones given to the farm animals.
- Mechanical tillage and industrial farming equipment cause soil compaction and erosion (Government of Canada, 2020).

4.2 Restoration Methods

There are many methods of soil restoration depending on the type of degradation and the goals of restoration. Soil restoration methods include sustainable farming practices, integrated pest management, sustainable forest management, and remediation.

4.2.1 Sustainable Farming Practices

Tillage is one of the main factors that contributes to soil degradation in an agricultural setting. Conservation tillage is a practice that reduces the amount of tillage or completely eradicates it. The heavy equipment needed to till a field compacts the soil, promotes wind erosion, and can kill the micro-organisms and macro-organisms (such as arthropods) living within the soil.

What is Green Manure?

Green manure is a crop specifically grown to be incorporated into the soil while it is still green. It can be cut and plowed into the soil or can remain on the ground for an extended period of time prior to tilling. When incorporated into the soil, these green plants will break down and introduce nutrient such as nitrogen to assist with the growth for future crops.

A conservation method is planting cover crops, which cover the bare field when it is not being used to produce a crop yield and prevents wind and water erosion. Plant roots will hold soil in place and protect it, especially in spring when snow melts (water), and winter before snow falls (wind). One example of a crop cover is green manure, which could include things like buckwheat, clovers, or ryegrass (MacKenzie, 2018).

Crop rotation is another sustainable agriculture practice that helps reduce the effect farming has on the soil. This sustainable farming method includes the planting of different crops on the same plot of land each year on a rotation. Crop rotation reduces the number of pests and the number of pesticides that must be used to control those pests. As each crop adds and/or removes a different amount of nutrients to the soil, the rotation of these crops allows for the maintenance of nutrient levels in the soil.

Did you know?

In the 1930s in Queensland, Australia, a species of cane beetle was destroying sugar cane fields. Local farmers heard that cane toads (*Rhinella marina*) would eat these cane beetles and would help save their crops. In 1935, 102 cane toads arrived in Australia from Puerto Rico and were released as a method of biological control.

However, instead of consuming solely cane beetles, the cane toads began to reproduce and invade Australia. Cane toads can grow up to 2kg in weight and produce toxins that can kill native predator species that attempt to consume them (Australian Government, 2010).

As of 2019, Australia's cane toad population sits about 200 million individuals (WWF, 2019). The cane toad case study serves as a valuable reminder of the importance of heavily regulating biological controls in restoration.

4.2.2 Integrated Pest Management

Integrated Pest Management (IPM) is an environmentally conscious method of managing pests using a combination of cultural, biological, and chemical methods, with chemical management always being the last method used. IPM assesses the behaviour and life cycle of a pest to best determine a way to control them, such as determining the best time of year to remove eggs or to release a biological control (Government of Ontario, 2021). Releasing lady beetles to control aphid populations is an example of a biological control.

4.2.3 Vegetation Barriers & Sediment Control

In areas that have bare soil, it is important to control the amount of sediment that could potentially be washing away from wind and water erosion. Silt fences can be erected to help stop the 0.1 - 0.5 millimeter-sized particles from washing or blowing away. Vegetation barriers can also help to break the force of wind and stop sediments from being carried away. A sediment pond is another method of sediment control that is a pond of water that allows the sediments to settle to the bottom and then the water evaporates (Government of Canada, 2020).

4.2.4 Sustainable Forest Management

Sustainable forest management is a way of planning for a forest's future to ensure it is protected and managed effectively. This can include maintaining biodiversity, logging methods, erosion protection, **slash** management, planting trees, and protecting areas of concern (Government of Ontario, 2021).

If active logging is going on within a forest, a sustainable forest management plan will ensure that road locations, harvesting operations, protected areas, and the timing of logging are in the best interest of the forest. Fuel handling and waste disposal are included at the planning stage to ensure there are no chemical pollutants entering the soil.

4.2.5 Soil Remediation

There are many ways to remediate soil from chemical pollutants. Testing must be done to see the level of toxicity present before a remediation plan can be made. Some remediation methods include bioremediation, chemical oxidation, addition of agents that will stabilize the soil and soil washing.

- Bioremediation can be used to help mitigate and remediate the following contaminants: hydrocarbons, nitrogen compounds, lead, mercury, and chromium (Enva Corp., 2021).
- Chemical oxidation is performed by injecting soil with reactive chemical oxidants to eradicate the contaminant. This is a useful method to treat **polychlorinated biphenyl (PCB)** pollutants.
- Soil stabilization locks the pollutant in the soil by either reducing its ability to move or converting it into a less dangerous form.
- Soil washing washes away the contaminants with a liquid wash solution, but often fine particles like clay or silt are washed away as well, so they must wash separately. This method is very time-consuming and requires a lot of energy.

4.3 Case Study: The Reclamation of Sudbury

Figure 19. A comparison showing the same part of Sudbury from 1981 to 2008.

BACKGROUND

Sudbury lies in an area where Ontario's most recent glaciers existed, meaning that it has shallow soils and plenty of exposed bedrock. Logging in the area began in 1872. The forests were clear cut, leaving the landscape bare and covered in slash. These remaining piles of woody debris caused many local fires. In 1886, the area was extensively mined for copper and nickel. The mined materials were refined by burning off the sulphur in piles of wood. These fires required more trees to be cut down for fuel, and ultimately lead to more fires in the area. The residue from burning sulphur, both in the air and the ashes for the fires, lead to the increase of toxic aluminum and acidification of soil, decreasing plant productivity.

Approximately 100 km^2 around Sudbury had been left barren due to these activities. The lack of plant life led to the erosion of topsoil, while the remaining soil lacked phosphorus, nitrogen, calcium, magnesium, and manganese. The soil was also very acidic, with a pH ranging from 2.0-4.5 (Smith, 1996).

RESTORATION

When the restoration first began in 1969, the Sudbury Environmental Enhancement Programme (SEEP) was formed. There were three main goals for the reclamation of Sudbury:

- Decrease the soil's toxicity and increase pH and nutrients to restore the chemical balance
- Establish plant cover to restore biological integrity
- Promote rare plants and restore species diversity.

Figure 20. The Sudbury landscape compared from 1980 to 2013 (CBC News, 2018).

The first step was to restore the soil in the area. Due to the extensive area that needed to be restored, imported soil was used in parks, and the remaining areas were **limed** and fertilized.

Dead trees were removed, and the infertile land was seeded, in addition to tolerant species being planted on the landscape (Smith, 1996). An aerial seeding program was created to help cover move land, distributing limed grass seed and fertilizer from airplanes.

From 1969 to 2020, over 10 million trees and nearly 50,000 shrubs were planted (Figure 20). Sudbury now has 85 flora species, 16 mammal species and numerous bird species. This restoration project has led to the Sudbury area having some of the cleanest air in Ontario, has employed 4800 people over the last 40 years, and has put the city on track to reduce its greenhouse gas emissions to 0 by 2050.

The restoration of the Sudbury land and soils is still ongoing today. There is currently a program in place that supplies groups, schools, and clubs with seedlings and equipment to plant trees and other plants within the Sudbury area (CBC News, 2018).

DISCUSSION QUESTIONS

Q1: Why was restoring soil the first step of this plan?

Q2: Do you think that importing new soil was the best plan?

Q3: How can this case study be used as an example for future restoration projects?

4.4 Discussion Questions

1. List two natural causes of soil degradation and two anthropogenic causes of soil degradation. Briefly describe each cause.
2. Name three soil restoration methods. Briefly describe each one and what impact it is used to restore.

5.0 Wildlife Restoration

Wildlife **populations**, including mammals, birds, reptiles, amphibians, and invertebrates, have specific habitat requirements which can often be altered or lost due to human impacts. Human impacts that can affect ecosystems include habitat fragmentation and habitat loss, climate change, severe weather events, and the introduction of invasive species (Morrison, 2009). These can all negatively impact native wildlife species, posing as a threat or risk to their survival. Wildlife restoration is an essential step in the recovery of these once-thriving species.

Healthy wildlife populations are essential to a functioning ecosystem, and ecosystems provide services to humanity, known as **ecosystem services** (Table 4). It is important to restore wildlife to maintain these ecosystem services and values (Government of Ontario, 2013).

Table 3. Ecosystem services (Government of Ontario, 2013).

ECOSYSTEM SERVICE	PROVIDES
Supporting Services	Soil formation, nutrient cycling
Provisioning Services	Food, fresh water, fuel, fibre, wood
Regulating Services	Climate and air quality regulation, freshwater regulation, wildlife habitat, flood regulation
Cultural Services	Aesthetics, amenities, recreation

There are a variety of different steps involved in wildlife restoration, including the initial decision of which wildlife species is being restored and in what area, collecting background data on that population, choosing appropriate restoration techniques and strategies, and monitoring the success of the restoration project after completion. Proper project design is essential in the success of any wildlife restoration project (Morrison, 2009).

This section will provide an overview on invasive species impacts on native wildlife survival, species at risk, wildlife restoration techniques and strategies, and a case study on wildlife reintroduction at Rouge National Urban Park.

For more information on Ontario's wildlife, please refer to the Wildlife Study Guide.

5.1 Invasive Species

An invasive species can be defined as an organism that has been introduced to an area that it has not previously inhabited. Introduced species can become invasive if they outcompete native species for resources, have no natural predators or natural population controls, and spread at a rapid rate. As such, they pose a significant threat to native wildlife and ecosystems through outcompeting native wildlife for resources, introducing disease to native wildlife and ecosystems, and potentially even killing native wildlife and preventing their successful reproduction.

Invasive species are most often spread through human activities. This includes on planes, boats/ships, cars, and through any other methods of travelling goods. The introduction of invasive species in these cases is frequently unintentional, though no less detrimental (NWF, n.d.). Overall, there are several ways invasive species are being spread throughout the world's ecosystems, and it is important to manage for potential consequences of these introductions.

5.1.1 Techniques for Invasive Species Management and Removal

Invasive species management and removal varies depending on the target species and goal of the removal. It is important to gain background knowledge of the invasive species' use of the new habitat and life history strategies before initiating management.

Management techniques can be split into three categories: biological control, mechanical control, and chemical control (Table 5).

Table 4. Types of invasive species management techniques (USDA, n.d.).

CONTROL TYPE	EXAMPLES
Biological	Any predators of invasive species, including mammals, insects, birds, etc.
Mechanical	Physical removal, mowing/hoeing/cutting, prescribed burning, flooding
Chemical	Herbicides, pesticides, insecticides

5.1.3 Invasive Species in Ontario

EMERALD ASH BORER

The Emerald Ash Borer (*Agrilus planipennis*) (EAB) (Figure 21) is a beetle native to Asia that was introduced to Ontario and has become invasive. EAB eggs are laid under the surface of ash bark, and the developing larvae bore into the vascular tissues of healthy ash trees (*Fraxinus sp.*). This girdles the affected trees, impacting their ability to transport water and nutrients through the cambium and ultimately leading to their demise.

EAB have caused the widespread mortality of ash trees in Ontario, biodiversity loss, loss of habitat and food resources for local wildlife, and the loss of provisioning ecosystem services. Unfortunately, there are no natural predators to these beetles in Ontario. Their management and removal are essential in maintaining ash tree populations ecosystems.

Effective invasive species management techniques for EAB include prohibiting the movement of firewood made from ash trees between regions, removing EAB infested ash trees, and reporting any sightings of EAB or infected ash trees to the Ontario Ministry of Northern Development, Mines, Natural Resources and Forestry (OFAH/OMNDMNRF Invading Species Awareness Program, 2012).

Figure 21. Image of the emerald ash borer (Agrilus planipennis) (OFAH/OMNDMNRF Invading Species Awareness Program, 2012).

ROUND GOBY

The Round Goby (*Neogobius melanostomus*) (Figure 22) is a bottom-dwelling fish species native to eastern Europe, specifically found in the Caspian and Black Seas. Since its introduction to Ontario in 1990, the round goby has become invasive, spreading to all Great Lakes and reproducing multiple times each year. The round goby feeds on small fish, zebra mussels, fish eggs, and insects.

Round Gobies outcompete local fish species for resources, and prey upon many local fish eggs, including those of species at risk. It is believed that the Round Goby is a vector species for botulism type-E, capable of killing of native fish and bird species. Effective species management techniques for Round Goby include banning the possession or use of Round Goby as bait when fishing and reporting any round goby sightings to the Invading Species Hotline (OFAH/OMNDMNRF Invading Species Awareness Program, 2012).

Figure 22. Image of the Round Goby (Neogobius melanostomus) (OFAH/OMNDMNRF Invading Species Awareness Program, 2012).

For more information on Round Gobies and Ontario's fish, please see the Envirothon Fish Guide.

5.2 Species at Risk

When the long-term survival of a wildlife population becomes threatened, they areclassified as a species at risk. There are five classifications of a species at risk in Canada and Ontario: special concern, threatened, endangered, extirpated, and extinct (Figure 23). The Species at Risk in Ontario (SARO) list works as a ranking system, with species listed as "special concern" having greater population numbers than those listed as "endangered" (Government of Canada, 2014). SARO classifications can change as wildlife populations increase and decrease in size, moving either up and off the list or lower on the list.

Figure 23. Levels of species at risk classification in Ontario and Canada (Government of Canada, 2014).

SPECIAL CONCERN	A wildlife species that may become a threatened or an endangered species because of a combination of biological characteristics and identified threats
THREATENED	A wildlife species that is likely to become endangered if nothing is done to reverse the factors leading to its extirpation or extinction
ENDANGERED	A wildlife species that is facing imminent extirpation or extinction
EXTIRPATED	A wildlife species that no longer exists in the wild in Ontario/Canada, but exists elsewhere in the wild
EXTINCT	A wildlife species that no longer exists

Most of the threats that wildlife on the SARO list is facing can be attributed to human impacts. These include climate change, habitat fragmentation and habitat loss, and invasive species introductions.

- Changes in temperatures, flooding, drought, and extreme weather events caused by climate change can alter the habitat in such a way that makes it unsuitable for native species.
- Habitat fragmentation and habitat loss can remove, or damage areas needed for breeding, nesting, foraging, etc., by different native species.

These human-caused impacts can affect the overall reproduction and survival of wildlife populations; therefore, human intervention in the form of conservation and restoration efforts is often needed (Morrison, 2009).

5.3 Wildlife Restoration Techniques and Strategies

The first step in any wildlife restoration process is choosing a vulnerable species in need of restoration efforts. To determine which restoration techniques and strategies will be the most useful, background research must be conducted on a particular population. This includes abundance and distribution, habitat requirements, ecology, food requirements, breeding and nesting requirements, and any known threats or recent disturbances of the chosen wildlife population (Morrison, 2002).

CAPTIVE BREEDING

Captive breeding is the process of capturing individuals from a wildlife population, breeding, and raising these individuals in captivity, and then releasing them back into the wild population. The goal of captive breeding is to breed captive individuals genetically like those in the wild population to ensure the release back into the wild is as successful as possible. This results in larger population numbers and breeding success for the wild population (Morrison, 2002).

TRANSLOCATION

Translocation involves relocating a population of wildlife from one area to another. The goal of translocation is to establish a new subpopulation of a wildlife species in a new geographic area. For this to be successful, the site of relocation must be suitable for that species, i.e., an abundance of resources and favourable habitat conditions. Prior research and analysis of the relocation site must be conducted. It is also important to identify any human disturbances, competitors or predators that may threaten the species' survival prior to translocation (Morrison, 2002).

REINTRODUCTION

Reintroduction is the process of returning wildlife to areas they historically inhabited. Thegoal of reintroduction is to speed up the wildlife restoration process through the reestablishment of a once-thriving species in that area. Wildlife reintroduction often involves a combination of other wildlife restoration techniques, including captive breeding and translocations (Morrison, 2002).

Wolves in Yellowstone National Park

In 1995, grey wolves were introduced to Yellowstone National Park in Idaho, USA. They had been extirpated from the area, with the last wolf killed within Yellowstone's boundaries in 1926. Their absence caused numerous changes in their native range, including a boom in elk populations that overgrazed any new growth in the valleys.

The reintroduction of wolves, the apex predator of the region, has had many positive impacts on the biodiversity of Yellowstone. With their presences came the return of beavers and a recovery in red fox populations, in addition to healthier and longer-lasting vegetation (Ripple & Beschta. 2004).

ASSISTED MIGRATION

Assisted migration is a climate change adaptation strategy that involves moving plants or animals to a different habitat that they may or may not have occupied before. Due to climate change, the boundary of the Carolinian forest is shifting northwards with changing bioclimatic conditions. Assisted migration can help plants and animals move to ecosystems that suit their needs, even across fragmented landscapes such as the majority of southern Ontario.

5.4 How can you help?

There are many ways Ontario citizens can join and participate in wildlife restoration efforts to conserve species at risk. One way to become directly involved is through volunteering or donating to the government, non-government organizations, and various stakeholders involved in wildlife restoration projects across the province. See section 6.0 Ecological Restoration Organizations to learn more about those involved in ecological restoration in Ontario.

Did you know?

To raise just one nest of Black-capped chickadee babies in spring, the parents have to find 6,000 to 9,000 caterpillars? 96% of terrestrial birds rear their babies on insects, not seeds or berries, and caterpillars are a particularly important food source. To sustain bird populations, we need to support insect populations. (Tallamy, n.d.)

NATIVE SPECIES GARDENS

An important method for restoring native wildlife is planting native species gardens. Native plant species support local wildlife populations by providing them with food, shelter, and nesting/breeding habitat (CWF, 2021). Creating more habitats for native wildlife species at risk through planting native species gardens is something Ontario citizens can do to aid wildlife restoration efforts.

Figure 24. Butterflies like this Pearl Crescent (*Phyciodes tharos*) create caterpillars that are vital for feeding baby songbirds.

Figure 25. Supporting diverse, healthy bee populations is critical to habitat restoration. Growing native wildflower gardens can promote healthy insect populations, including bees and butterflies.

COMMUNITY SCIENCE

Community science, otherwise known as citizen science, is the collaboration and participation of the public in scientific research to further overall scientific knowledge, including in wildlife restoration efforts. Ways to participate in community science include contributing to databases, collection programs, data monitoring, science engagement groups, social media, etc. (National Geographic, n.d.b).

One of the easiest ways to participate in community science is downloading a scientific monitoring application on a smartphone. An example of a community science application available for download is iNaturalist. iNaturalist was created in collaboration with the California Academy of Science and the National Geographic Society and allows the user to upload wildlife sightings with a GPS location, view other sightings around the world, and discuss scientific findings with other users (iNaturalist, 2021). It is an extremely useful tool in ecological restoration as it can provide important, freely accessible wildlife population data to those involved in wildlife restoration efforts. One of the best things about the iNaturalist app is that you don't have to be an expert to use it - every observation gets reviewed by the community, so even if you are a beginner, you can start making observations and contribute!

5.5 Case Study: Blanding's Turtles in Rouge National Urban Park

The Blanding's Turtle (*Emydoidea blandingii*) (Figure 26) is one of eight turtle species that can be found in Ontario and is currently listed as a threatened species in the province. This turtle is characterized by its bright yellow throat and dome-shaped black or brown shell. They can grow to be as large as 27cm long.

Figure 26. A Blandings Turtle (*Emydoidea blandingii*).

Blanding's Turtles typically live in wetlands and shallow lakes, but travel great distances between these water bodies during the mating and nesting season. As such, habitat fragmentation and motor vehicles pose a significant threat to their survival, along with urban predators such as raccoons and foxes that prey on turtle eggs. Due to the slow maturity and breeding of the Blanding's Turtle, the loss of adult individuals can negatively affect the survival of entire turtle populations (Government of Ontario, 2020).

Blanding's Turtles have been historically present in Rouge National Urban Park (Figure 27) and surrounding areas for thousands of years (Parks Canada, 2020). However, due to the recent expansion of the city areas, threats such as habitat loss and habitat fragmentation have made the area less suitable for Blanding's survival, resulting in fewer than seven Blanding's Turtles present in Rouge National Urban Park in 2014. In response, Parks Canada, in collaboration with the Toronto Zoo, started an on-going Blanding's turtle restoration project in 2014 with the goal of reintroducing Blanding's Turtles into Rouge Urban National Park and maintaining a stable and healthy population (Gasbarrini, personal communication, 2021; Parks Canada, 2020). First, various wetland areas within Rouge National Urban Park were restored to become suitable habitats for the reintroduction of Blanding's Turtles. Before 2014, the landscape was very fragmented, which caused the isolation of turtles within the wetland network and was not suitable to support large turtle populations. Restoring the wetland habitat to support Blanding's Turtles was essential to guarantee the success of the reintroduced individuals (Gasbarrini, personal communication, 2021).

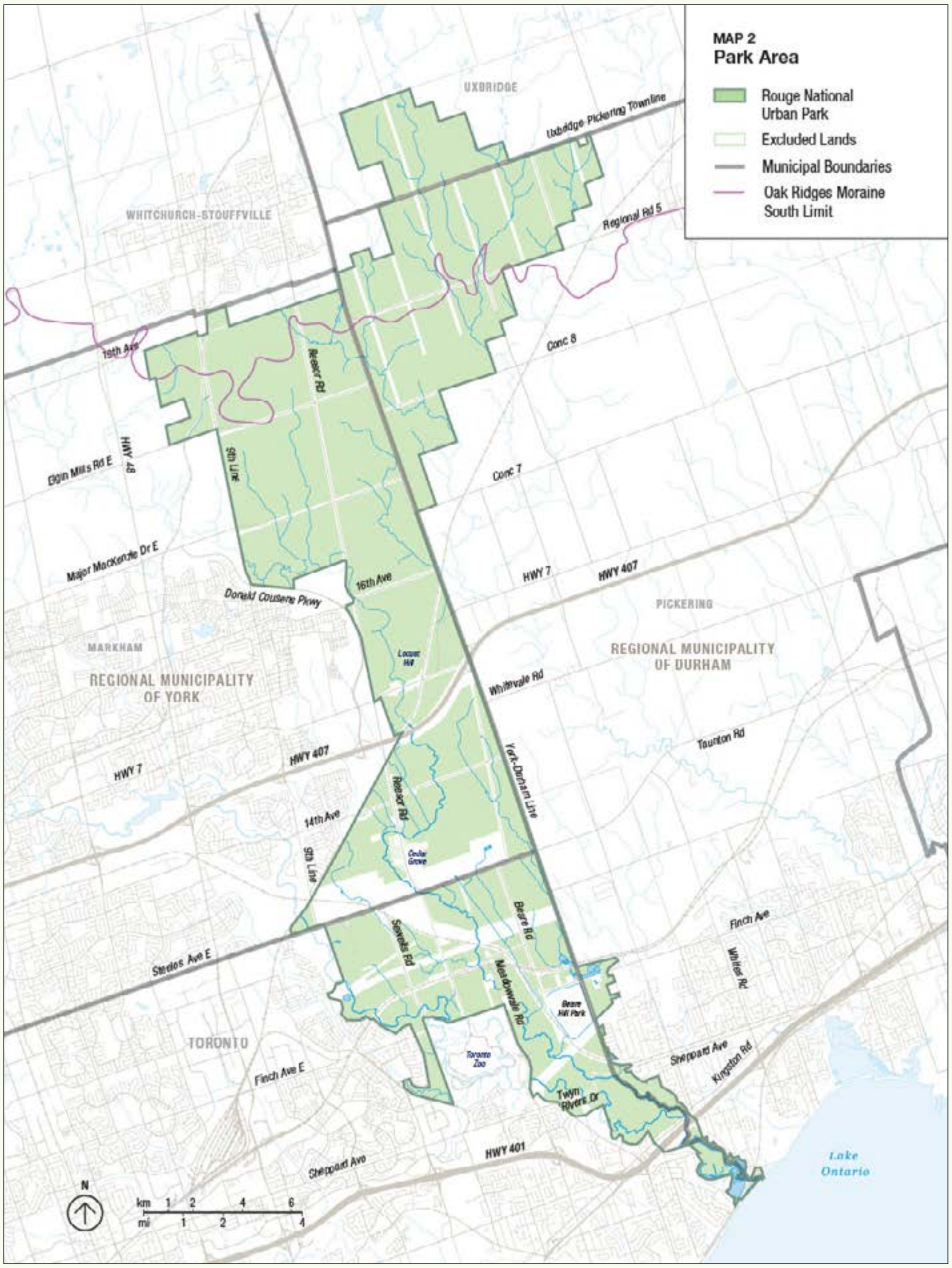


Figure 27. Rogue National Urban Park map. Specific areas of restoration cannot be disclosed to protect the Blanding's Turtles (Parks Canada, 2020).

Blanding's Turtle eggs were retrieved from sustainable and stable populations within Ontario, meaning areas in which the removal of eggs would not negatively impact the population (Gasbarrini, personal communication, 2021; Parks Canada, 2020). Egg collection is done in June, during the Blanding's turtle nesting season (Gasbarrini, personal communication, 2021). These turtles were then given a headstart at the Toronto Zoo before being released into Rouge Urban National Park (Parks Canada, 2020). Eggs are incubated at the Toronto Zoo until they hatch in August-September. Since the egg incubation temperature determines the sex of the young, turtle eggs are divided accordingly in separate incubators set to different temperatures to ensure a 60% female and 40% male sex ratio as this allows for greater reproductive success after release.

After hatching, turtles remain in captivity for up to 2 years after capture, and they do not **overwinter**. The temperature remains constant so turtles can continue to grow for the whole two years in captivity, resulting in the 2-year-old released turtles having a body size comparable to a 4 to 5-year-old wild Blanding's Turtle. A larger body size gives these turtles yet another advantage when being released (Gasbarrini, personal communication, 2021).

Approximately 60 2-year-old Blanding's Turtles are released in Rouge National Urban Park each year in June in the same network of wetlands. Before release, Blanding's turtles are fitted with radio tags for on-going tracking. Tracking allows Parks Canada and the Toronto Zoo to monitor the turtles' habitat use, foraging patterns, predator avoidance, survival, reproduction, and the restoration project's overall success.

Since this is a recent and long-term project, it is difficult to determine the impacts and success of the Blanding's turtle restoration and reintroduction in Rouge Urban National Park. However, radio tracking of the Blanding's turtle has determined that the released individuals have been successful in overwintering and reproducing during the project duration (Gasbarrini, personal communication, 2021; Parks Canada 2020).

DISCUSSION QUESTIONS:

Q1: Describe the term "head-start" and explain why it is important in turtle restoration projects.

Q2: List and explain three threats Blanding's turtles are facing in Ontario.

Q3: What is a sex ratio? What is the desired sex ratio when head-starting the Blanding's turtles? Why is this sex ratio important?

Q4: Why was it important to restore the wetland habitat in Rouge Urban National Park before Blanding's turtles are reintroduced?

5.6 Wildlife Restoration Activity

Design your own wildlife restoration project. Choose a species at risk in Ontario and explain the steps you'd take in restoring your chosen wildlife species. A list of the species at risk in Ontario can be found here.

Some questions to consider:

- Why are populations of the species you selected in decline?
- Where does your chosen wildlife species normally live?
- What are their habitat requirements? Food requirements? Nesting/breeding requirements?
- What are potential consequences of the decline of the species you selected?
- What wildlife restoration techniques would you choose and why?
- Do any invasive species threaten your selected species at risk?
- What other considerations must be made during the wildlife restoration process?

6.0 Organizations and Collaborations

Conducting ecosystem restoration projects often requires the participation and collaboration of multiple organizations for the highest level of success. There are many parties involved in ecosystem restoration efforts and projects. These include, but are not limited to, government organizations, non-government organizations (NGOs), Indigenous stakeholders, volunteers, and any experts in the field. Each stakeholder contributes valuable resources, expertise, information, and/or funding essential in the development, completion, and future monitoring of ecosystem restoration projects. The following section provides an overview on the different types of organizations and stakeholders involved in ecosystem restoration projects and how their involvement is essential in restoration efforts.

6.1 Government

The government plays an important role in ecosystem restoration efforts, often providing funding towards projects and the organizations involved. The government is also responsible for creating and passing appropriate legislation to protect ecosystems and wildlife. There are three levels of government in Canada: federal government, provincial governments, and municipal governments. This section will provide a brief overview of how various governments contribute to ecosystem restoration efforts, focusing on the Canadian federal government and the Ontario provincial government. Municipal governments are too varied across the province to accurately represent in this guide, but still play a key role in local projects.

FEDERAL

At the federal level, several acts outline environmental laws and regulations and the implementation of protected areas, all of which aim to conserve and protect native wildlife species. Examples of these acts include the Species at Risk Act (SARA), the Canadian Wildlife Act (CWA), and the Fish and Wildlife Conservation Act (FWCA).

The federal government is also responsible for the protection of certain lands throughout Canada. These are called protected areas. Types of protected areas governed federally are national parks, national wildlife areas, migratory bird sanctuaries, and areas of marine protection (Government of Canada, 2020). Ecosystem restoration projects will often occur on these federally protected lands, an example being the Case Study in sections 2.4 and 5.4.

PROVINCIAL

At the provincial level, specifically Ontario, there are multiple acts that outline environmental laws and species protection. These acts work much like the federal acts but are specifically for Ontario lands and wildlife. Examples of relevant provincial acts include the Provincial Parks and Conservation Reserves Act (PPCRA), the Wilderness Areas Act (WAA), and the Endangered Species Act (ESA).

The provincial government is also responsible for the protection of certain land throughout Ontario, also called protected areas. Types of protected areas governed provincially are provincial parks, conservation reserves, and wilderness areas (Government of Ontario, 2021). Like the federally protected areas, provincially protected areas are often locations where ecosystem restoration projects take place.

There are four main types of protected areas in Ontario; provincial parks, conservation reserves, wilderness areas, and dedicated protected areas. Ontario Parks are further subdivided into categories that determine their use and accessibility to the public.

Table 5. An outline of Ontario Parks' classification system.

CLASS	DESCRIPTION	EXAMPLES
Recreation Class Park	Parks to provide a variety of outdoor recreation opportunities. These typically have good beaches, many campgrounds, well established trails, and/or other amenities.	Bronte Creek Provincial Park Pancake Bay Provincial Park Wasaga Beach Provincial Park
Cultural Heritage Class Park	Parks to protect cultural heritage elements that are distinct in Ontario for intrinsic value, education, and research purposes	Inverhuron Provincial Park Petroglyphs Provincial Park
Natural Environment Class Park	Parks to protect provincially significant landscapes and ecosystems, as well as to provide recreational and educational experiences.	Algonquin Provincial Park Killbear Provincial Park Lake Superior Provincial Park
Nature Reserve Class Park	Parks to protect significant natural habitats, landforms, and ecosystems for intrinsic value, scientific research, and biodiversity.	Burnt Lands Provincial Park Daisy Lake Uplands Provincial Park Lake Abitibi Islands Provincial Park
Waterway Class Park	Parks to protect recreational water routes and significant terrestrial and aquatic ecosystems to provide recreational and educational experiences.	French River Waterway Provincial Park Mattawa River Provincial Park
Wilderness Class Park	Parks to protect large areas for nature and provide low-impact recreation.	Polar Bear Provincial Park Quetico Provincial Park

Both federal and provincial involvement in restoration efforts are crucial to their success. Many restoration projects depend on government funding from either or both levels. The protection of ecosystems and wildlife resulting from federal and provincial legislation provides support for species at risk and significant ecosystems, ultimately reducing further harmful impacts and disturbances from occurring.

6.2 Non-Government Organizations

There are many non-government organizations (NGOs) that are directly dedicated to ecosystem restoration or the conservation of the natural world. These organizations create and complete many restoration projects annually and provide opportunities for community members to get involved in helping their community. They include conservation authorities, the Society for Ecological Restoration, Nature Conservancy Canada, Ducks Unlimited, the Forest Gene Conservation Association, and many more.

CONSERVATION AUTHORITIES

Conservation authorities are agencies that manage the local watershed. They also have services and programs in place that help protect and mitigate various impacts on the local watershed. All conservation areas are managed by conservation authorities. Conservation authorities work closely with all levels of government as well as landowners. There are currently 36 conservation authorities located all over Ontario (Conservation Ontario, 2021). All authorities are legislated under the *Conservation Authorities Act, 1946*.

SOCIETY FOR ECOLOGICAL RESTORATION

The Society for Ecological Restoration is a global organization with over 3000 members who are experts in the field of ecological restoration (Society for Ecological Restoration, 2021). Within the organization, they help share knowledge on different restoration techniques and methods that will help complete projects all over the world. They also promote best practices and restoration policies. The Society for Ecological Restoration is working towards ensuring that ecological restoration is used more frequently as a tool in conservation and sustainability efforts.

NATURE CONSERVANCY OF CANADA

The Nature Conservancy of Canada (NCC) is an organization that works towards protecting Canada's natural spaces and restoring degraded landscapes and habitats. Some methods used by the NCC to accomplish this are removing invasive species, finding the locations of rare species, and buying land to protect. Their conservation process follows four steps: setting priorities, developing strategies, taking action and measuring success (Nature Conservancy of Canada, 2021).

The NCC is currently working towards creating a 62-acre wetland on Pelee Island, which will be their largest wetland restoration project to date. This will be a multi-year project where they will create the wetland, remove invasive phragmites, create new signage for the entire island and restore a meadow that is 20 acres in size. This wetland is expected to support migratory birds, turtles, salamanders as well as help with water filtration and flood control (Nature Conservancy of Canada, 2019).

COMMUNITY FOCUSED NON-PROFITS

All over Ontario, there are local community teams of stewards, each with their own goal of enhancing and restoring the natural environment in their neighbourhoods. One example is the Friends of Ontario Parks organizations. There are 27 Friends of Ontario Parks groups, independent of Ontario Parks, which aim to supplement and enhance the work that Ontario Parks does. Another example is the Stewards of Cootes Watershed organization which aims to protect the health and biodiversity of streams near Cootes Paradise in Hamilton, Ontario.

These community-based non-for-profit groups can get community members involved, establishing a sense of belonging and responsibility for the environment around them. This drives further change and action within these areas and is a great tool in restoration work.

6.3 Working Together

Restoring an ecosystem requires resources from a wide variety of institutions. Most programs do not include staffed labour, so the fieldwork is frequently performed by volunteers. These volunteers are usually locals interested in restoring unique ecosystems. The lands requiring these restoration efforts generally have private or municipal ownership. Controlling further damage or institutional destruction of ecosystems requires legislation and enforcement, typically a provincial or federal mandate. Nearly every restoration project is unique, which lends to organizations that specialize in niche areas of ecological expertise championing the restoration efforts. There are also larger for-profit organizations that are willing to partner in ecosystem restoration efforts for public relations or marketing appeal.

ENBRIDGE SOLAR FARM

The Enbridge Solar Farm restoration project partnered together with the County of Lambton, Enbridge, “Return the Landscape” restoration experts and several research entities to return 200 acres of an 1100-acre solar farm to a naturalized wetland (Enbridge, 2015). This wetland is a multi-year restoration project initiated in 2015 and has led to several years of valuable research (Return the Landscape, n.d.).

LAKE ONTARIO ATLANTIC SALMON RESTORATION PROGRAM

The Lake Ontario Atlantic Salmon Restoration Program is a 20 year, four-phased initiative that began in 1996. The program aims to bring back a self-sustaining population of Atlantic salmon to Lake Ontario and its tributaries. The Ontario Federation of Anglers and Hunters (OFAH) and the Ministry of Northern Development, Mines, Natural Resources and Forestry (MNDMNRF) are co-leading the restoration efforts and have over 40 partners from various sectors taking part. The OFAH directs the NGOs and private sector, and the MNDMNRF is the lead government agency (Ontario Federation of Anglers and Hunters, 2021).

Since 2006, the program has led to the stocking of over 6,000,000 young salmon, the completion of 198 habitat restorations, the development of a classroom hatchery program, and more. Without collaboration and cooperation, these organizations would not have been able to complete such an enormous task. Just four years into the project, the efforts of all involved were rewarded when a wild-born Atlantic Salmon was recorded in one of the target tributaries, the first in over 110 years.

6.4 Case Study: Loggerhead Shrike

BACKGROUND

Figure 28. An Eastern Loggerhead Shrike (*Lanius ludovicanius*) (Wildlife Preservation Canada, n.d.).

The Eastern Loggerhead Shrike (*Lanius ludovicianus*) is a small song-bird species given the nickname of "the butcher bird". These birds kill and collect their prey of small rodents and lizards by impaling it on sharp thorns or barbed wire (Wildlife Preservation Canada, n.d.). This small songbird also has a unique diet consisting of insects, as per other songbirds, but also small rodents and lizards (Environment Canada, 2015). These birds have a large-sized head and are about the size of a robin, but they feature a distinct notched beak and strong feet, like a raptor. They are listed as an endangered species in both Canada and Ontario and has a population reduced to only about 12 breeding pairs in Ontario. They breed in small, isolated pockets in the Carden and Napanee Plains, and occasionally in Smiths Falls, Manitoulin Island and along the Bruce Peninsula (Wildlife Preservation Canada, n.d.). Some individuals migrate to the Southeastern United States and return to Ontario in April to breed (Environment Canada, 2015).

While the Eastern Loggerhead Shrike population is in decline, much is still unknown about the direct threats their population face. However, it is thought that the main threat to this species is the loss and fragmentation of habitat (Wildlife Preservation Canada, n.d.).

These birds prefer short grassland habitats with scattered trees that provide both nesting and perching sites (Environment Canada, 2015). They are closely tied to alvars, a unique landscape type that consists of shallow soil overtop of a layer of limestone. This type of habitat is present at both the Napanee and Carden Plains sites. In their preferred habitat, grazing cattle often help keep the grass short, which is optimal for the birds' hunting. In recent years, native grassland is being converted to cropped agricultural land. This process also removes trees from this area which are essential pieces of habitat for this species (Wildlife Preservation Canada, n.d.).

CARDEN ALVAR PROVINCIAL PARK AND IMPORTANT BIRD AND BIODIVERSITY AREA

The Carden Alvar, located within the Carden Plains, is an extremely unique grassland habitat in Ontario that is home to many rare and uncommon species which rely on this habitat type for survival, such as the Eastern Loggerhead Shrike. This habitat has been designated as an Important Bird and Biodiversity Area (IBA) and is currently managed by the Nature Conservancy of Canada (NCC) and Ontario Parks (Ontario Parks, 2018). As of 2014 in collaboration with Couchiching Conservancy and landowners in the area, a portion of the IBA land became protected land as Carden Alvar Provincial Park (Figure 25) (Ontario Parks, 2014).

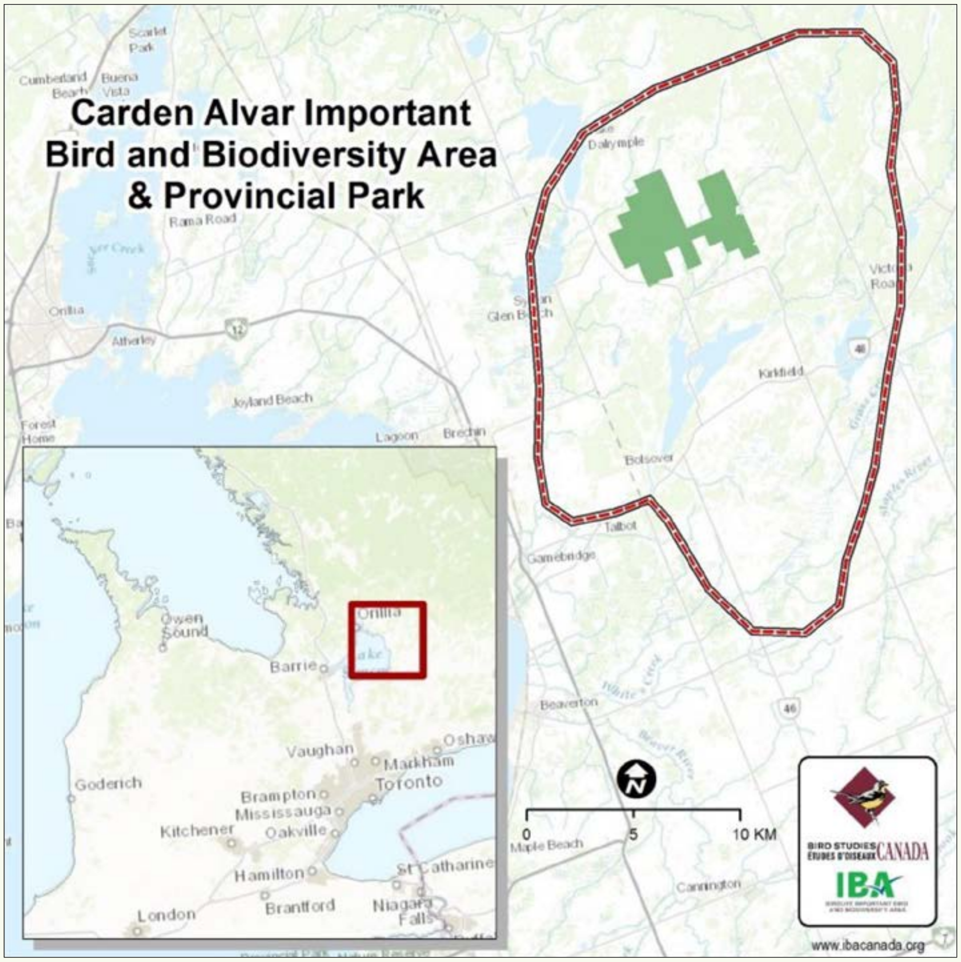


Figure 29. Map of the Carden Alvar Important Bird and Biodiversity Area & Provincial Park (Ontario Parks, 2018).

Since 2003, Wildlife Preservation Canada (WPC) is an NGO leading the IBA's Shrike Recovery Program, which involved the breeding and release of Eastern Loggerhead Shrike in the Carden Alvar IBA (Ontario Parks, 2014). Pairs of these birds are bred in captivity with partner organizations such as the Toronto Zoo, African Lion Safari and Mountsberg Raptor Centre (Ontario Nature, 2014). Before being released, the captive Eastern Loggerhead Shrike are equipped with electronic geolocators which allow the WPC to track their movements and migration, and ultimately the success of the population and restoration project.

There are many government and non-government organizations involved in the IBA Shrike Recovery Program, all of which play an important role in restoring the Eastern loggerhead shrike population within the Carden Alvar. The NCC, local landowners, Couchiching Conservancy and Ontario Parks (the Ontario provincial government) provided essential protection of the Carden Alvars where the restoration project is taking place, while WPC, the Toronto Zoo, African Lion Safari, and Mountsberg Raptor Centre were key components in the restoration project itself. Collaboration between different organizations is key when conducting and completing ecological restoration projects.

DISCUSSION QUESTIONS

Q1: What is the benefit to bringing in other organizations and stakeholders in the effort to restore the Eastern Loggerhead Shrike?

Q2: Are there any organizations or stakeholders you believe are missing from the involvement in the recovery strategy for this species?

Q3: What role might landowners play in the restoration and recovery of this species?

7.0 Conclusion

Ecosystem restoration is a growing science, more and more frequently being used as a conservation and sustainability practice to respond to the increased anthropogenic impacts putting our world's ecosystems under pressure. Habitat loss and fragmentation, climate change, invasive species introductions and urbanization are all anthropogenic forces degrading these ecosystems and threatening the survival of the wildlife within. This study guide explored various types of ecosystem restoration, including terrestrial, aquatic, soil, and wildlife restoration. Each of these restoration types is crucial in repairing and maintaining Ontario's valuable ecosystems and wildlife.

Overall, there are many working parts to ecosystem restoration efforts, from the type of restoration, background knowledge of the ecosystem and/or wildlife being restored, effective restoration methods and techniques, and participation from various stakeholders and organizations. Not one ecological restoration project is the same, however, each is equally important in conserving Ontario's ecosystems and wildlife.

8.0 Glossary

A

Active restoration: When management techniques such as planting seeds or seedlings are implemented.

Afforest (Afforestation): The establishment of a forest or stand of trees in an area where there was no previous forest cover.

Alvar: A naturally open habitat with a thin or absent layer of soil cover atop a limestone or dolostone base.

Anthropogenic: of, relating to, or resulting from the influence of human beings on nature.

B

Biodiversity: measure of the variety of living things within an ecosystem.

Biomanipulation: deliberately altering an ecosystem (often food web dynamics) by adding or removing a species.

Biome: a large area categorized by the plant and animal species which occupy it, as well as other characteristics such as climate and soil – examples are, forests, tundra, grassland, etc.

Bioremediation: using natural processes or species interactions to break down pollutants and chemicals to restore a polluted site.

D

Degradation: The simplification and loss of biodiversity caused by disturbances that are too frequent or severe to allow natural ecosystem recovery.

E

Ecosystem services: valuable services provided to society by the world's ecosystems.

F

Fragmentation: When a formerly continuous natural area is separated into smaller units of natural areas that are isolated from each other.

I

Internal load: pollutants or excess nutrients which are released from the sediment inside a water body.

Invasive species: non-native species that outcompete native species in an area.

L

Limed (Liming): treat (soil or water) with lime to reduce acidity and improve fertility or oxygen levels.

N

Native: a naturally occurring or historically present species in a certain area.

Non-native: a species which is not naturally occurring or historically present in a certain area.

O

Overwinter: the natural techniques wildlife uses to survive throughout the winter.

P

Passive restoration: When no action is taken except to cease environmental stressors.

Point sources: originating from a single place which is easily identified, for example, factory smoke stakes or drainage pipes.

Population: a group of individuals of the same species in the same area which breed with one another.

Polychlorinated biphenyl (**PCB**): an organic chlorine compound that is highly toxic and is a common pollutant found in ecosystems.

Phytoremediation: a technique where plants and plant roots are used to remove pollutants from water, air, or soil.

R

Reforestation: is the natural or intentional restocking of existing forests and woodlands that have been depleted, usually through deforestation, but also after clearcutting.

Remediation: the action of removing pollutants/contaminants from a site, often the first stage of restoration.

Resilience: the capacity of an ecosystem to tolerate disturbance and recover naturally.

S

Slash: coarse and fine woody debris generated during logging operations or through wind, snow, or other natural forest disturbances.

Succession: The orderly and predictable change in the dominant species of forest plants.

T

Tillage: the preparation of agricultural land for crops by overturning, stirring, shoveling the soil using mechanical machinery or hand tools.

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