Exploring Nature

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Course Reference Guide

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LONDON ONTARIO

Contents

Acknowledgements

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Land Acknowledgement

We acknowledge and honour the Anishanaabe, Huadenoshaunnee, and Lanape people of Southwestern Ontario as the traditional owners and custodians of the land and waterways on which Fanshawe College is located. Further, we acknowledge the cultural diversity of all Indigenous peoples, and pay respect to the Elders past, present, and future.

We celebrate the continuous living cultures of the original inhabitants of Canada, and acknowledge the important contributions Indigenous people have, and continue to make, in Canadian society. The College respects and acknowledges our Indigenous students, staff, Elders, and Indigenous visitors who come from many nations.

– *Fanshawe College Land Acknowledgement*

The more I learn about nature, the more I realize how disconnected we have become from it. I acknowledge that to truly reconnect and learn to care for our land, we must follow the lead of Indigenous peoples who have maintained a profound and respectful relationship with nature.

As someone who deeply values outdoor recreation, such as hiking, mountain biking, canoeing and camping, I am continuously reminded of the beauty and significance of this land. Engaging with nature through these activities

enhances my appreciation for its wonders and the need for its protection. I commit to treating nature with care and respect and hope to foster a relationship with the land that honours its original caretakers.

As we explore the natural world throughout this course, we do so with gratitude for the opportunity to engage with the rich biodiversity of this region.

Kari Moreland

About this Book

The content of this book will help beginners get outside and learn about nature in London, Ontario. It was designed as a course resource for students taking PHYS-1045: Exploring Nature at Fanshawe College.

Readers will learn about key topics related to biodiversity, outdoor safety, and the role of community science in conservation efforts. Readers will also learn to use iNaturalist for hands-on learning about local plants and animals and to contribute to biodiversity data for London. The resource also explains the importance of native species and the challenges posed by invasive species while drawing on examples from Environmentally Significant Areas in London.

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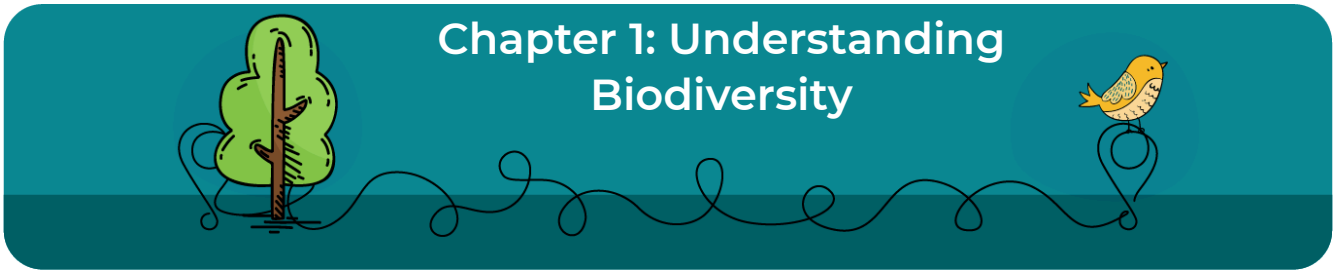
CHAPTER 1: UNDERSTANDING BIODIVERSITY



1.0 Learning Outcomes

Learning Objectives

In this chapter, you will explore concepts on the topic of biodiversity, its conservation, and the current biodiversity crisis. You will learn how the city of London is engaging in the preservation of biodiversity. By the end of this chapter, you will be able to:

Adapted: "Forest-Peterborough-Ontario", Plismo, CC BY-SA 3.0. Mods: framing

- Define biodiversity and explain its three levels: genetic diversity, species diversity, and ecosystem diversity.
- Describe the intrinsic and extrinsic values of biodiversity and why it is important for ecological stability and human welfare.
- Identify the primary human activities contributing to the current biodiversity crisis and their impacts on ecosystems.
- Explain what biodiversity conservation efforts are being taken and how to contribute to them.
- Outline the steps and strategies involved in biodiversity conservation, including habitat restoration and sustainable practices.
- Illustrate the specific challenges and opportunities for biodiversity conservation in urban environments, using London, Ontario, as a case study.

1.1 What is Biodiversity?

Biodiversity, or biological diversity, refers to the variety of life on Earth, ranging from the smallest microorganisms to the largest plants and animals (International Fund for Animal Welfare, 2024).

Understanding biodiversity is required to appreciate the complexity and interconnectedness of life on Earth.

Biodiversity is often explored through 3 main levels:

1. Genetic Diversity

Genetic diversity is the variation in the genes of organisms. An organism's genes control its traits (e.g. size, colour), so genetic diversity allows all organisms in a population to be unique. Genetic diversity is crucial to help populations adapt to changes in the environment, such as climate shifts or disease outbreaks. For example, in the event of a viral outbreak, a genetically diverse population of plants might have some individuals that are naturally resistant to the virus. These resistant plants will survive and may pass that trait onto their offspring, allowing the species as a whole to survive and adapt.

Genetic variations allow for the differences in the colours, sizes and patterns in this group of ladybugs.

"Ladybug Cluster", The Real Estreya, CC BY-NC 2.0.

A Closer Look

Genetic diversity allows for variations in traits like:

- **Coloration**: Differences in fur, feathers, or skin colour can occur within animal species.
- **Size**: Variations in body size can be seen within species.
- **Disease Resistance**: Some individuals may have genetic resistance to diseases that others are susceptible to.
- **Behaviour**: Behavioural traits can vary within a species, such as the migratory patterns in some bird populations where some individuals migrate while others remain in the same area year-round.
- **Physiological Traits**: Differences in traits like metabolism, growth rate, and reproductive timing can also be found within a species. For example, some trees might leaf out earlier in the spring than others in the same forest.

2. Species Diversity

Species diversity includes the variety of species within a habitat or a region. Ecosystems with high species diversity are often healthier. A diverse forest ecosystem with numerous plant species can support a wide range of animal species, each contributing to the ecosystem's overall health and productivity.

Species diversity also makes ecosystems more resilient. For instance, imagine a situation where a new invasive pest that kills pine trees arrives in an area. A forest that is primarily composed of pine trees is very susceptible. If most of the pine trees die, then there is little habitat left to support the animals in the area, resulting in many of the animals dying or leaving. In contrast, a diverse forest ecosystem with numerous tree species is more likely to survive the pest outbreak. The pine trees will still die, but there are enough other tree species in the forest to provide habitat to support the animal population, so the results of the pest outbreak aren't nearly as harmful.

"Diversity of Plants", Rkitko, CC BY-SA 4.0.

3. Ecosystem Diversity

Ecosystem diversity refers to the variety of ecosystems in a particular area. Ecosystems include the organisms and the abiotic (non-living) factors in a particular area. Ecosystems, such as forests, grasslands, wetlands, and oceans, each host a unique community of species and ecological processes.

As humans, we rely directly on these ecosystems to provide us with food, lumber, and even medicines. Healthy ecosystems also clean our water, filter our air and pollinate our crops (Moreland, 2024). We use ecosystems for recreation, such as hiking, swimming, or camping. We even rely on them to help boost our mental health. Getting out in nature helps to reduce cortisol, improve stress management and regulate our nervous system.

Reflection

Ecosystems are intricately connected and rely on each other to function properly and maintain the balance of the natural world. For example, forests contribute to the health of aquatic ecosystems by stabilizing soil and reducing erosion, which in turn prevents sediment from clogging waterways and harming fish habitats. Wetlands absorb pollutants and excess nutrients from agricultural runoff, which helps maintain water quality and protect aquatic life. Migratory species such as birds and fish connect distant ecosystems by transporting nutrients and energy across vast distances. This interconnectedness means that changes or disruptions in one ecosystem can have cascading effects on others. Preserving the health and integrity of all ecosystems is necessary to ensure the overall stability of the Earth.

Take a moment to think about your lifestyle. What do healthy ecosystems provide for you?

Banner Image Attribution

1.2 Biodiversity Crisis

Despite the importance of biodiversity, the Earth is currently facing a **biodiversity crisis**. The biodiversity crisis refers to the significant and rapid decline in the variety of life on Earth, driven largely by human activities.

The World Wildlife Fund's (WWF) Living Planet Report (2020) indicates that global wildlife populations have decreased by 68% since 1970. According to the International Union for Conservation of Nature IUCN (2024), over 44,000 species are currently threatened with extinction, including 41% of amphibians, 37% of sharks and rays, 36% of reef-building corals, 34% of conifers, 26% of mammals, and 12% of birds.

Jenga Analogy

As more and more species disappear, the intricate ecological networks become unstable. Imagine biodiversity as a Jenga tower. Each block represents a different species, ecosystem, or ecological process. In a well-balanced tower, every block supports the overall structure, contributing to its stability and integrity (Noseworthy, 2014).

"Biodiversity Jenga", Martin Sharman, CC BY-NC-SA 2.0.

When you play Jenga, removing one block might not immediately cause the tower to collapse. Similarly, the loss of a single species might not have an obvious or immediate impact on the ecosystem. However, as you continue to remove more blocks, the structure becomes increasingly unstable. Each block removed represents the extinction of a species or the degradation of an ecosystem, which weakens the overall system.

In the context of biodiversity, every species, no matter how small or seemingly insignificant, plays a role in maintaining the health and balance of its ecosystem. Pollinators like bees support plant reproduction, plants provide oxygen and food, predators keep prey populations in check, and decomposers recycle nutrients back into the soil. The loss of these species disrupts these critical interactions, just as removing key blocks destabilizes a Jenga tower.

As more species become endangered or extinct, the ecological "Jenga tower" grows weaker. Eventually, the loss of enough species can lead to the collapse of entire ecosystems, much like a Jenga tower toppling over. Right now, in the midst of the biodiversity crisis, our ecological Jenga tower is teetering. What's causing the fragility?

Us.

Humans.

Causes of Biodiversity Decline

Many different human activities upset the natural balance of our ecosystems, but some are more damaging than others.

The human activities that are contributing to most of the biodiversity crisis include:

Habitat Destruction and Fragmentation

Habitat destruction is the leading cause of biodiversity loss. As natural landscapes are converted for agriculture, urban development, and industrial use, species lose their homes and the resources they need to survive. Fragmentation occurs when large habitats are divided into smaller, isolated patches, making it difficult for species to move, find mates, and access food (Berg et al., 2001).

"Holzstaemme", H.J. Sydow, CC BY-SA 3.0.

The Canadian boreal forest, one of the largest intact forest ecosystems in the world, is being fragmented and destroyed by logging, mining, and oil extraction. This deforestation threatens species such as the woodland caribou, which depends on large areas of old-growth forest for their survival. Habitat fragmentation isolates caribou populations, making it difficult for them to find food and escape predators.

Climate Change

Climate change, driven by human activities like burning fossil fuels and deforestation, is altering temperature and precipitation patterns globally. These changes affect the habitats and life cycles of many species, pushing them to adapt, migrate, or face extinction.

The increasing temperatures associated with climate change are more drastic in Northern latitudes. Rising temperatures in the Canadian Arctic are causing sea ice to melt earlier in the spring and form later in the autumn. Polar bears rely on sea ice to hunt seals, their primary food source (Archer, 2024). As their hunting grounds shrink, polar bears are forced to travel longer distances and expend more energy, leading to decreased body condition, lower cub survival rates, and increased mortality.

Pollution

"Beach Plastic Waste", Fquasie, CC BY-SA 4.0.

Pollution from industrial, agricultural, and urban sources severely impacts biodiversity. Pesticides and chemicals can kill wildlife outright or create reproductive problems that threaten the species' survival. Eutrophication, caused by nutrient runoff from fertilizers, leads to dead zones in water bodies where oxygen levels are too low to support life. Plastic pollution, in particular, has become a pervasive threat. Plastic waste not only entangles marine animals, causing injury and death, but is also ingested by a wide range of species, from tiny plankton to large whales. Ingested plastics break down into microplastics. These microplastics are now found in virtually every part of the ocean, even in the most remote areas.

Mining generates more pollutants than any other industry in North America. The extraction of oil from the Alberta oil sands has significantly contributed to environmental pollution. Tailings ponds, which store the toxic by-products of this extraction process, have contaminated local water sources, which harm aquatic life. Air pollution from oil sands operations releases substances that can lead to acid rain, adversely affecting both terrestrial and aquatic ecosystems.

Overexploitation

Overexploitation involves harvesting species from the wild at rates faster than their populations can recover. This includes overfishing, hunting and logging. Overfishing has depleted many fish stocks, driving some species to the brink of extinction. The illegal wildlife trade targets animals like elephants, rhinos, and tigers for their ivory, horns, and skins, drastically reducing their populations.

The Atlantic cod fishery off the coast of Newfoundland and Labrador was once one of the world's richest fisheries—however, decades of overfishing led to the collapse of the cod population in the early 1990s. Despite a moratorium on cod fishing, the population has struggled to recover due to ongoing fishing pressures and changes in the marine ecosystem.

Invasive Species

"Zebra Mussel Cluster", NOAA Great Lakes Environmental Research Laboratory, CC BY-SA 2.0.

Invasive species are non-native organisms introduced to new environments, often through human activity. These species can outcompete, prey on, or bring diseases to native species, disrupting local ecosystems.

Zebra mussels, native to Eastern Europe, were introduced to the Great Lakes in the late 1980s via ballast water from ships (Fisheries and Oceans Canada, 2023). These invasive mussels reproduce rapidly, outcompeting native species for food and habitat. They filter out large amounts of plankton, which disrupts the aquatic food web and reduces populations of native mussel and fish species.

Going back to our Jenga analogy, the good news is that if we stop removing blocks – if we halt the destruction of habitats, mitigate climate change, reduce pollution, end overexploitation, and control invasive species then there is a good chance that the tower will remain standing. By protecting existing species and restoring damaged ecosystems, we can stabilize the Jenga Tower of biodiversity. This highlights the urgent need for proactive conservation efforts to maintain the delicate balance of our planet's ecosystems.

Reflection

It's important that we all understand our impact on biodiversity decline so that we can address these major causes of biodiversity decline.

Take a moment to think about your lifestyle. Are you part of the problem? What are some changes that you can make in your own life to help preserve biodiversity for future generations?

A Closer Look

Climate change is also disrupting crucial interactions between species.

Plants and animals have a particular phenology or timing of seasonal activities, such as flowering, breeding, migration, and hibernation. As global temperatures rise and weather patterns shift, many species are experiencing changes in the timing of life cycle events—phenological mismatch results

when shifts lead to mismatched timing between species and their environments. Phenological mismatch can make it harder for species to get the resources they need to survive.

- **Birds**: Many bird species time their migration and breeding to coincide with peak food availability. Some migratory birds may arrive at their breeding grounds earlier due to warmer temperatures. This can lead to food shortages and reduced reproductive success if the insect populations they rely on for food have not yet peaked.
- **Fish**: Many fish species, like salmon, rely on temperature cues to time their spawning migrations. Warmer water temperatures can alter the timing of these migrations, affecting the synchronization with optimal river flow conditions for spawning and the availability of suitable habitats for their young.
- **Pests**: Longer growing seasons and warmer winters can lead to higher survival rates and extended activity periods for pests, such as bark beetles. This can result in more significant damage to forests and crops, as pest populations are no longer kept in check by cold winter temperatures.
- **Pollinators**: Insects like butterflies and bees may emerge earlier in the spring in response to warmer temperatures. This can affect their availability as pollinators for plants that have not adjusted their blooming times accordingly.
- **Mammals**: Some mammals, like bears, rely on temperature and food availability cues to enter and emerge from hibernation. Warmer winters can shorten hibernation periods, leading to increased energy expenditure and the need for more food, which may not be readily available.

1.3 Why Care About Biodiversity?

A Closer Look

Video: "Why is biodiversity important – with Sir David Attenborough | The Royal Society" by The Royal Society [5:40] is licensed under the Standard YouTube License.*Transcript and closed captions available on YouTube.*

There is a misconception that people care about biodiversity simply to preserve the beauty of nature. Yes, that is one compelling reason, but there are several others!

Ecosystem Services

As we have already discussed, biodiversity underpins the ecosystem services that are crucial for human survival and well-being. Services like air filtration, water purification, climate regulation, pollination and nutrient cycling require diverse, healthy ecosystems.

Economic Value

Biodiversity has significant economic value. Agriculture, forestry, fisheries, and tourism all depend on healthy ecosystems and the variety of species they support. Biodiversity contributes to food security by supporting ecosystem functions like soil fertility, pest control, and crop pollination. Nature-based tourism, which relies on the beauty and uniqueness of biodiverse areas, generates substantial revenue for many areas.

Educational Value

Experiencing and learning about biodiversity can inspire a deeper appreciation for the natural world. By engaging directly with diverse ecosystems, we develop a stronger connection to nature, which helps us feel a sense of belonging and responsibility. This connection raises our environmental awareness, making it more likely that we'll adjust our lifestyles to live more sustainably. It also motivates us to protect and preserve natural habitats and species, possibly inspiring future scientists and conservationists.

Reflection

Nature can help make you a better student! Nature exposure, like nature walks or outdoor classes, helps learners increase concentration, feel less stressed and have more self-discipline (Kuo et al., 2019). Get out in nature and see if it helps boost your academic learning!

Cultural Services

Biodiversity enriches life through various cultural services, including recreational opportunities, aesthetic value, and spiritual significance. Diverse ecosystems offer spaces for activities like hiking and camping, inspire art and literature with their beauty, and hold spiritual meaning in many cultures. Biodiversity is integral to the cultural heritage and identity of some communities, including indigenous peoples.

Human Health

Biodiversity is essential for human health, providing a wide range of benefits, including nutritious food sources, clean air and water, natural medicines, and disease regulation. Exposure to biodiverse environments also enhances mental well-being by reducing stress and promoting physical activity.

1.4 How to Protect Biodiversity

Conservation is the practice of protecting, preserving, managing, and restoring ecosystems to ensure their sustainability for future generations (DGB, n.d.). It involves a variety of strategies and actions aimed at maintaining biodiversity.

There are many different aspects to conservation. A few are discussed below.

Research and Monitoring

Scientific research and monitoring are fundamental to understanding ecosystems and tracking species populations. Research data is used to help develop conservation strategies and then assess the effectiveness of those strategies. Community science can be used to gather data from large geographic areas (see What is Community Science for further details).

"Participatory Water Quality Monitoring", Waterlat Gobacit, CC BY-NC 2.0.

Habitat Preservation

Protecting natural habitats from destruction is crucial for the survival of many species. This includes establishing protected areas such as national and provincial parks that are protected from urban development. In London, we have protected habitats called Environmentally Significant Areas (see Biodiversity in London for further details).

Habitat Restoration

Habitat restoration is when degraded or destroyed ecosystems are returned to their natural state. This can include reforestation, wetland restoration, and reintroduction of native species. In Southwestern Ontario, many restoration projects return abandoned farmland back to natural habitat.

"Warren Brook & Cold River Habitat Restoration", US Fish and Wildlife Service, CC BY 2.0.

Government Legislation

Effective conservation often requires legal protections and policies at provincial, national, and international levels. In Ontario, the Endangered Species Act provides habitat protection for species classified as endangered or threatened. Additionally, the Invasive Species Act sets out rules to prevent the introduction and control the spread of invasive species that pose a risk to Ontario's natural environments. Nationally, the Species at Risk Act (SARA) aims to prevent wildlife species in Canada from disappearing.

A Closer Look: How to Help

Even if you aren't a scientist or conservationist, you can still help protect biodiversity. Listed below are examples of some ways that you can help.

Practice Sustainable Living

- Make small lifestyle changes to reduce the amount of resources we use.
- Take shorter showers, use public transit and buy second-hand items.
- Reduce, reuse, and recycle to minimize waste.

Support Conservation Efforts

- Support conservation organizations through donations and volunteering.
- Participate in local conservation projects like tree planting and habitat restoration.

Plant a Biodiversity-Friendly Garden

- Plant native species in your garden to support local wildlife.
- Avoid planting invasive species.
- Minimize the use of harmful chemicals.

Advocate for the Environment

- Raise awareness about biodiversity and its importance.
- Advocate for government legislation to protect our natural environments.

Protecting biodiversity requires lifestyle changes that prioritize environmental responsibility. Every small action counts. All of our actions can collectively lead to substantial positive impacts on biodiversity.

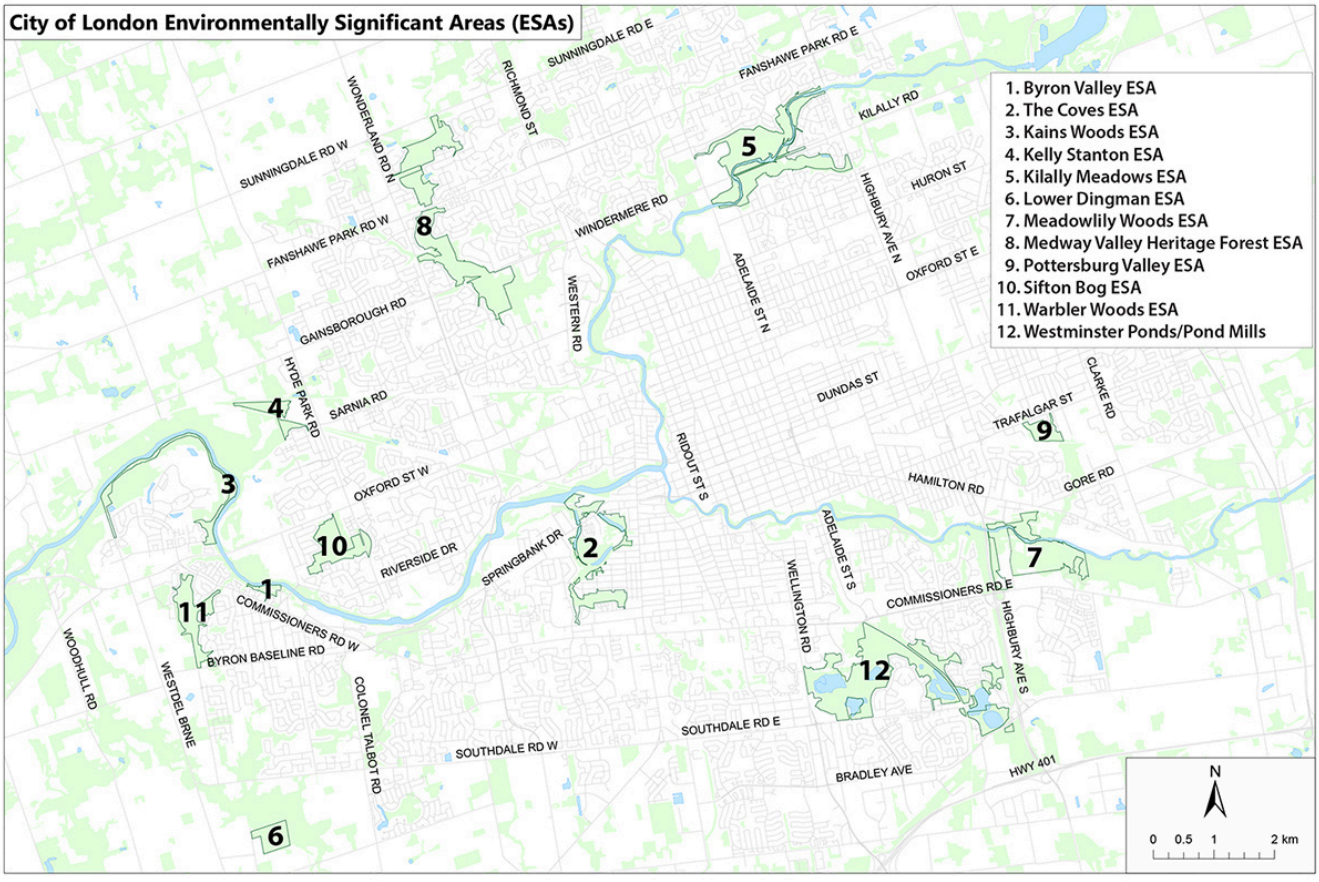
Banner Image Attribution

Untitled photo, Naturalis Biodiversity Center, CC0 1.0

1.5 Biodiversity in London

London, Ontario, is home to a rich diversity of plant and animal species. London is located in the Carolinian Zone, an ecozone characterized by deciduous forests and a temperate climate. Covering only the southern tip of Ontario, the Carolinian zone is the smallest in Canada. Although it only makes up around 1% of the country's landmass, this zone supports a variety of species that can't be found anywhere else in Canada. It has been estimated that 50% of the federally listed species at risk occur in Ontario's Carolinian Zone (Environment Canada, 2014). Despite its ecological value, urban, agricultural and industrial expansion pressures have caused extensive wildlife habitat destruction. In parts of this zone, over 90% of the original forests are gone (Environment Canada, 2014).

To help preserve the remaining Carolinian forest, London has 21 natural areas designated as "Environmentally Significant Areas" (ESAs). These areas include wetlands, forests, and meadows, which provide significant habitats for wildlife. The Upper Thames River Conservation Authority (UTRCA) manages 12 ESAs. They work to control invasive species, restore habitat, protect species at risk and monitor the general health of these ecosystems. They also maintain trail systems throughout these areas, making them accessible for the general public to get outside and engage with nature (UTRCA, n.d.).



"*ESA Location Map*", *UTRCA*, *FDEd (CAN)*.

Local organizations and community groups are actively involved in conservation projects in London, such as

tree planting, invasive species removal, and habitat restoration. These efforts are crucial for maintaining the city's biodiversity.

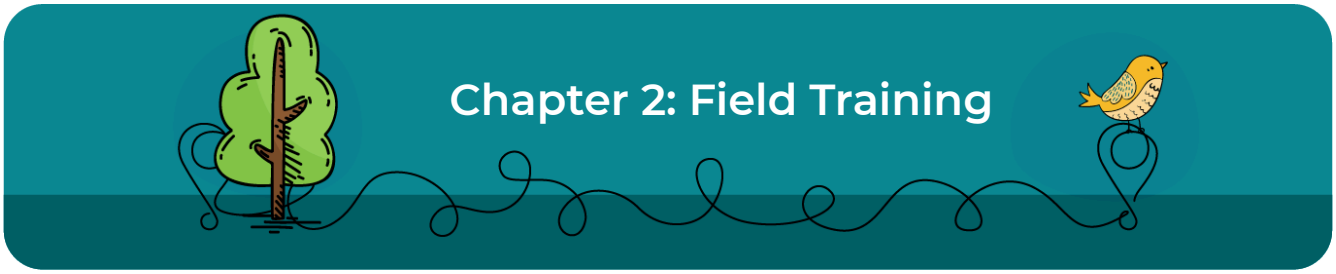
1.6 Chapter Summary

Key Takeaways

This chapter provided an overview of biodiversity and its importance. You should understand the following:

- How biodiversity contributes to ecosystem resilience, human health, and economic resources by offering services such as pollination, nutrient cycling, and climate regulation.
- The biodiversity crisis, driven by human activities like habitat destruction and climate change, threatens these vital functions and poses significant risks to both ecosystems and human well-being.
- What efforts are being made to conserve biodiversity, and the ways in which you can contribute to those efforts?
- The importance of integrating biodiversity conservation into urban planning to ensure the well-being of both nature and people.
- Efforts in London, Ontario, to preserve biodiversity, including habitat restoration and community engagement to create a sustainable urban environment.

CHAPTER 2: FIELD TRAINING



2.0 Learning Outcomes

Learning Objectives

In this chapter, you will learn about safe practices for exploring nature. Afterwards, you will be introduced to the iNaturalist app, a tool for facilitating citizen science efforts. By the end of this chapter, you will be able to:

- Describe essential safety gear and emergency supplies needed for outdoor excursions.
- Discuss the importance of understanding the environment and recognizing potential hazards such as uneven terrain or wildlife.
- Create an account and contribute to species distribution data on the iNaturalist app.
- Explain the educational benefits of using iNaturalist to enhance knowledge of local ecosystems.

Adapted: Photo, CC0 1.0. Mods: framing

2.1 Outdoor Safety

Clothing

Proper clothing is the foundation of outdoor safety. You should always check the weather forecast to help you dress for the conditions. Here are some general guidelines to help you dress appropriately.

- **Footwear:** Your footwear should be comfortable and provide support and grip. You can expect to walk on various surfaces, from gravel paths to dirt trails and grass. Hiking shoes are the best option, but sneakers/running shoes are adequate for most conditions. They will get dirty, so don't wear your favourite white shoes! In wet conditions, trails can become muddy, so hiking shoes or even rubber boots may be the best choice for keeping your feet dry. Mud, roots, and rocks can become very slippery when wet, so traction-resistant footwear will prevent unnecessary slips and falls. Sandals are not recommended under any conditions!
- **Clothing:** Your clothes should be lightweight and comfortable. Ideally, you should wear long pants (tucked into socks) and a long-sleeved shirt (Middlesex-London Health Unit, n.d.). Wear layers to adjust to changing temperatures. In colder conditions, you may need an insulating jacket and hat/mittens. In wet conditions, you should have a raincoat. In sunny conditions, wear a hat for sun protection.

Appropriate hiking clothing also helps protect you from the sun. The sun's ultraviolet (UV) radiation can cause sunburn and skin damage and increase the risk of skin cancers. Wear sunscreen on any exposed skin with a Sun Protection Factor (SPF) of at least 30 (Healthwise Staff, 2023). On hot days, you may also wish to bring a reusable water bottle to stay hydrated.

Photo, © Kari Moreland, All Rights Reserved.

Bugs

Most bugs in Southwestern Ontario will only cause minor irritation, but some can be more harmful.

For more information on outdoor health, see the Government of Ontario website's health and wellness page.

Bees

Bee stings can be painful but are not often dangerous. Most bees will only attack if annoyed, so the easiest way to prevent a sting is simply to leave the bee alone. If you are allergic to bees, then please let your instructor know and carry an insect sting allergy kit during all outdoor excursions.

Mosquitoes

Mosquito bites are a common occurrence when exploring nature. Most mosquito bites will only cause minor itching, but there is also a small risk of contracting West Nile Virus. Symptoms for someone bitten by a mosquito carrying West Nile Virus can range from nothing to high fever, tremors, or muscle weakness (Ministery of Health, 2017). You can reduce the incidence of mosquito bites by covering up and wearing light-coloured, long-sleeved shirts, pants, and socks. You can also use an insect repellent.

Ticks

Blacklegged tick (*Ixodes scapularis*)

Adult female

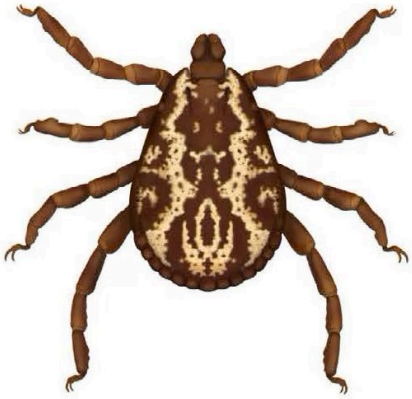
Adult male

Nymph

Larva

Lone Star Tick (*Amblyomma americanum*)

American Dog Tick (*Dermacentor variabilis*)



NOTE: Relative sizes of several ticks at different life stages.

Engorged female *Ixodes scapularis* tick. Color may vary.

Tick life stages, CDC, Public Domain.

Ticks are most common during warm months but can be active any time of year on days over 4°C (Tick Talk, n.d.). Lyme disease can be transmitted to humans through the bite of an infected black-legged tick (Middlesex-London Health Unit, n.d.). Protect yourself from tick bites by wearing long sleeves and long pants and tucking your pants into your socks. You can also use insect repellent containing DEET (Middlesex-London Health Unit, n.d.).

Ticks remain attached to you while they feed, so always do a "tick check" after hiking. Check your clothes and entire body, but pay special attention to hidden areas such as the scalp, behind the ears and underarms (Johnson, 2020).

"Tick male size comparison" by André Karwath, CC BY-SA 2.5.

Infected black-legged ticks need to be attached for at least 24 hours in order to transmit the bacteria that causes Lyme disease. If you find a tick, remove it promptly with tweezers, grasping close to the skin and pulling straight out. Do not use your fingers (Middlesex-London Health Unit, n.d.). Refer to the Middlesex London Health Unit for further information.

The most common tick in London is the American Dog Tick, which does not transmit Lyme Disease. They are often larger than black-legged ticks and can be distinguished by their body colour and pattern (Middlesex-London Health Unit, 2018).

Please note that ticks are small and can be hard to spot. An adult female black-legged tick is only the size of a sesame seed (Middlesex-London Health Unit, 2018)!

Dangerous Plants

Certain plants in Southern Ontario may be harmful if they come in contact with your skin or eyes. Here are a few dangerous plants that you may encounter around London:

Plant	Associated Risks	Appearance
Ragweed:	Common allergen that causes runny nose, sneezing, watery eyes, etc.	 "Ambrosia artemisiifolia elatior COMMON RAGWEED", Frank Mayfield, CC BY-SA 2.0
Stinging Nettle:	Contact with the plant can cause a painful stinging sensation, itching, and a rash.	 "Nettles", La.Catholique, CC BY 2.0
Poison Ivy:	Contact with the plant's oil (urushiol) can cause a red, itchy rash.	 "Toxicodendron radicans (poison ivy) 1", James St. John, CC BY 2.0

Giant Hogweed:	The sap can cause severe skin burns and blisters when exposed to sunlight.	 *Photo, Invasive Species Centre, FDEd (CAN)*

If you touch one of these dangerous plants, then please wash the affected area with soap and water as soon as possible.

You can use iNaturalist to help you identify the plants you see and determine whether they are dangerous!

Wildlife Encounters

Most animals common to natural areas in Southern Ontario are fairly low-risk; it's nevertheless wise to take some precautions:

- Observe wildlife from a distance. Do not attempt to touch animals.
- Never feed wild animals. Feeding desensitizes animals to human contact and increases the chances of negative encounters.
- If you encounter a larger animal, such as a coyote, keep your distance and stay calm. In the unlikely event that it approaches you, make yourself look bigger and yell.

Banner Image Attribution

"Hiking Trails", Petrit Bejdoni, CC BY-SA 4.0

2.2 How to use iNaturalist

Throughout this course, we will use iNaturalist to help us learn about our local biodiversity. iNaturalist is a user-friendly platform that uses image recognition software to help identify plants, animals, fungi, and other organisms in nature. The iNaturalist community, a global community of naturalists, scientists, and enthusiasts, will also help with species identification and provide additional information.

Users can post photos or sound recordings of any wild/uncultivated organism (i.e. no garden plants or pets). By sharing your observations, you'll create research-quality data scientists use to better understand and protect nature (iNaturalist, 2023).

iNaturalist is for wild organisms!

For step-by-step instructions, please see the following:

- iNaturalist on Smartphone
- iNaturalist on Web

By using iNaturalist in our course, we will:

- Gain practical experience in identifying local species
- Contribute valuable data to scientific research
- Engage with a community dedicated to understanding and preserving biodiversity

Taking Photos for iNaturalist

The ability of iNaturalist to accurately identify organisms depends on the quality of the photos that you upload. Blurry photos can make it difficult to see identifiable features. The camera on your phone is all you need to capture adequate photos of many organisms, but it can be challenging to get sharp photos when the organism is small or moving.

Bad Photo Example

“Bad photo example”, Kari Moreland, CC BY 4.0

This is a bad photo to use for iNaturalist. It is too far away, so it includes too many species.

Good Photo Example

"Tulip Tree Leaf", Kari Moreland, CC BY 4.0

"Wild Bergamot", Kari Moreland, CC BY 4.0

"Fleabane", Kari Moreland, CC BY 4.0

These photos are from the same location as the Bad Photo shown above. They are good because they are zoomed in to clearly show which organism you would like to identify. Each of these photos would be a separate observation on iNaturalist.

Photo Tips

Here are some tips to take identifiable photos for iNaturalist

1. Focus on one organism: If you have multiple species in the photo, then the image recognition software may not properly determine which organism you are trying to identify. Get up close to small organisms

and center the organism in your frame.

2. Take photos from different angles: Take multiple photos of the same organisms and submit them in the same iNaturalist observation. Photos from different angles help to capture specific features that may be important to help identify a species and distinguish it from other similar species. For example, fungi (mushrooms) are often required to have a photo from the top and a photo of the gills on the underside to provide features for identification.

"Pale Oyster Fungus 1", Kari Moreland, CC BY 4.0

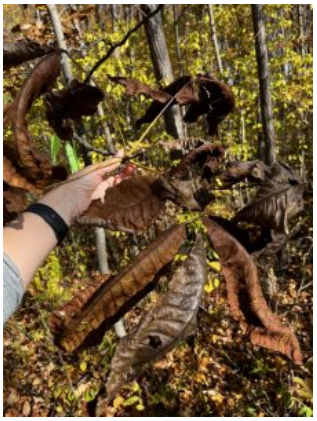
"Pale Oyster Fungus 2", Kari Moreland, CC BY 4.0

"Pale Oyster Fungus 3", Kari Moreland, CC BY 4.0

These photos of the Pale Oyster (Pleurotus pulmonarius) fungus growing on a dead American Beech tree will all be included in one observation on iNaturalist. If possible, you can also add the name of the tree that the fungus is growing on in the description. Some fungi will only grow on particular host species, so this information can help identify them.

3. Capture different features: Take multiple photos of different features of the same organism and submit them in the same iNaturalist observation. This is particularly useful for large organisms where small features may not be visible in the photo of the organism as a whole. For example, for trees, it would be

beneficial to take a photo of the entire tree but then get closer and take photos of the leaves, buds and bark as well to provide more features to help distinguish between closely related species.



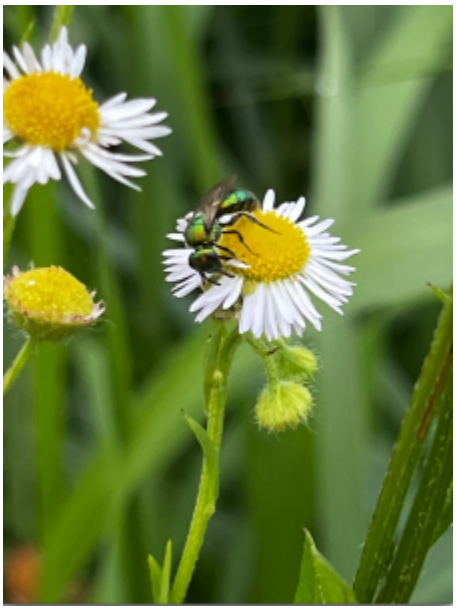
"Fall Leaf", Kari Moreland, CC BY 4.0

"Fall Stem", Kari Moreland, CC BY 4.0

"Fall Bark", Kari Moreland, CC BY 4.0

In the Fall, photos of brown leaves can still be used to help identify trees. These photos would all be included in one observation on iNaturalist

4. Get to know your phone/camera's features: Do you have a macro option? Can you zoom in? Can you make minor photo adjustments like cropping, changing exposure, or sharpening? The little changes can help make photos more clear for easier identification.



"Good Photo example", Kari Moreland, CC BY 4.0.

You may be surprised at the little organisms that your phone can capture!

5. Check out iNaturalist photo guides: Many different photo guides are designed to help you take identifiable photos of particular types of organisms.

Review the weblinks below for a few examples:

- Arachnids
- Birds
- Butterflies and Moths
- Mammals
- Plants
- Turtles

2.3 Trail Etiquette

When exploring natural areas, it is important to practice proper trail etiquette to avoid harming species or habitats.

iNaturalist in the Upper Thames River Watershed

iNaturalist is a great way to record and share biodiversity information and connect with other naturalists! When collecting data, please be sure to keep the following guidelines in mind.

Ask for Access - Don't Trespass

Only go onto private property if you have explicit permission to be there and to post observations.

If you're visiting public land, including conservation areas and other parks, find out if you need a trail pass and keep it with you at all times.

Respect Wildlife

Make sure to keep your distance from wildlife to avoid disturbing them.

Watch Where You Walk

Please be aware of your impact on habitat - if there are managed trails or pathways, please use them!

Protect Species at Risk

If you record a Species at Risk, obscure the location when uploading to iNaturalist and be sure not to give detailed location information in the comments. Click on this link to see what species are at risk in the upper Thames River watershed.

What You Find, Stays Behind

Leave plants and other natural objects behind so that others may discover and enjoy them.

Leave No Trace

Treat nature with respect and minimize your impact while out recording observations for iNaturalist projects.

Funded by Royal Bank of Canada's Tech for Nature grant which fosters new ideas, technologies and partnerships focused

UPPER THAMES RIVER
CONSERVATION AUTHORITY

"iNaturalist Guidelines" by UTRCA, FDEd (CAN).

Image Text

iNaturalist is a great way to record and share biodiversity information and connect with other naturalists! When collecting data, please be sure to keep the following guidelines in mind.

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Please be aware of your impact on habitat – if there are managed trails or pathways, please use them!

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If you record a Species at Risk, obscure the location when uploading to iNaturalist, and be sure not to provide detailed location information in the comments. The UTRCA maintains a list of species at risk in the upper Thames River watershed.

What You Find Stays Behind

Leave plants and other natural objects behind so that others may discover and enjoy them.

Leave No Trace

Treat nature with respect and minimize your impact while out recording observations for iNaturalist projects.

For further information on proper etiquette while exploring nature, consult The Seven Principles of Leave No Trace guide from *Leave No Trace Canada*.

2.4 Chapter Summary

Key Takeaways

This chapter emphasized the importance of preparation and awareness to ensure a safe and enjoyable experience in nature. You should understand the following:

- Key recommendations for dressing appropriately for the weather, staying hydrated, and protecting against sunburn and insects.
- The importance of understanding the environment, such as recognizing potential hazards like uneven terrain or wildlife and being familiar with basic first aid.
- How to install and use the iNaturalist app, which encourages citizen science by allowing users to share their findings with a global community and contribute to biodiversity research.
- The educational benefits of iNaturalist, such as improving knowledge of local ecosystems and engaging in scientific inquiry.

CHAPTER 3: COMMUNITY SCIENCE

3.0 Learning Outcomes

Learning Objectives

In this chapter, you will gain an understanding of Community Science initiatives. You will learn what role they play in conservation efforts and learn some of the community science initiatives that are taking place in London, Ontario. By the end of this chapter, you will be able to:

- Define community science and differentiate it from traditional scientific research.
- Explain how community science contributes to conservation efforts and the protection of biodiversity.
- Describe specific examples of community science initiatives in Ontario and their impacts on local conservation efforts.
- Reflect on your potential personal contributions to community science initiatives and consider ways to get involved in local projects.

"Environmental Science at Concordia University", *Frtgeer*, *CC BY-SA 4.0*

3.1 What is Community Science?

Community science is a collaborative effort where the general public participates in scientific research alongside professional scientists. This approach allows large groups of people to record observations and collect data for projects in many fields of study (see A Closer Look for more information).

In recent years, technological advances, such as smartphone apps and online platforms, have contributed to the growth in the quantity and breadth of community science initiatives. These tools often only require volunteers to submit photos or sound recordings using their own phone or camera, which makes data collection simple and accessible to the general public. The observations are then validated by experts like researchers, conservationists or knowledgeable enthusiasts. These data can be used for various purposes, such as research, conservation management or education.

Using a community science approach allows scientists access to data from long-term monitoring over vast geographic areas, which are impractical for individual scientists to collect. For example, a researcher studying bird migration timing and routes may require data spanning multiple provinces, countries or continents. If studying the effects of climate change on migration patterns, then the researchers would also need to track these species over many years. These large-scale studies are often more logistically and financially feasible using a community science approach where volunteer community scientists worldwide can contribute the data from their local geographies.

A Closer Look

Community science initiatives are common in many different disciplines. Some examples include:

Ornithology

Bird watchers from around the world can submit observations of bird species through community

science platforms like eBird. These data help track bird migration patterns, population trends, and nesting success. Scientists also use this data to reveal how birds are affected by environmental changes such as habitat loss, pollution, disease, and climate change. These insights inform conservation plans to protect birds and habitats.

Astronomy

NASA has dozens of community science projects where the general public can help NASA researchers. These projects aim to discover the universe's secrets, search for life elsewhere, and protect and improve life on Earth and in space. Over 500 community scientists have been named co-authors of scientific publications by NASA (NASA, n.d.)!

Entomology

There are many different insect-related community science initiatives to help protect endangered species, track the distribution of pests and monitor populations.

"Display – Bohart Museum of Entomology" by Daderot, CC0 1.0.

Many monarch butterflies in North America are known for migrating thousands of kilometres from Southern Canada down to their overwintering sites in Mexico. Community science initiatives help to track monarch butterfly locations, which provide insights into migration patterns, population health, and conservation needs.

Bumble bees are important pollinators, yet their populations are declining rapidly. Community scientists can upload photos of bumble bees that they spot on websites like *Bumble Bee Watch*, where scientists can then identify the bumble bee to species. These data are used to help track bumble bee distribution and identify species at risk. They are even used to inform conservation efforts, like species breeding and reintroduction into suitable habitats.

Botany

Community science data on the flowering and fruiting times of plants can be used by researchers to study how plant phenology is changing in response to climate change. Plant distribution data can be used to help monitor the locations and populations of important host plants. For example, monarch caterpillars rely on milkweed for food and shelter. Community science initiatives help to track and preserve milkweed to ensure that monarchs have access to this crucial host plant.

Hydrology

Many community science initiatives use the online Community Collaborative Rain, Hail and Snow Network platform. These projects use volunteer weather observers to measure and record daily precipitation (rain, hail, snow) in their local communities. These data can be used to study rain events, drought, snow distribution, and climate change.

Marine Biology

Community scientists can record sightings of marine mammals, sea turtles, or birds and monitor coral reefs. These data help scientists track populations, identify trends, and study ecological changes. The public can also help in beach cleanups to help prevent plastic waste from entering our oceans and harming marine wildlife.

"Blue Sea", greg89maryanto, CC0 1.0.

Banner Image Attribution

"Environmental Scienece at Whenualti Outdoors", WhenualtiOutdoors, CC BY-SA 4.0

3.2 Community Science and Conservation

Community science significantly helps conservation efforts by involving the public in collecting large-scale, long-term data crucial for monitoring ecosystems and wildlife populations. This extensive data collection enables scientists to identify species at risk, understand the impacts of environmental changes, and develop effective conservation strategies. Community science participants also develop a greater awareness and appreciation for nature, making them more likely to engage in and support conservation initiatives.

iNaturalist, a community science database, plays a significant role in conservation. iNaturalist allows users to document and share observations of local species, with photos or sound recordings to verify the species. With millions of observations and growing, this is Canada's largest community science dataset and could never have been created by researchers alone. iNaturalist provides data scientists and conservationists use to track biodiversity trends and inform conservation strategies. iNaturalist allows thousands of sightings of species, including species at risk, that would never have been documented or shared otherwise.

iNaturalist data is used in many ways:

- The Committee on the Status of Endangered Wildlife in Canada incorporates iNaturalist data into their assessments when determining whether a species is at risk of extinction
- iNaturalist observations are used to help map critical habitat for endangered and threatened species
- iNaturalist is used to locate species at risk for collecting by conservationists for breeding and reintroduction programs
- Species never before observed in Canada have been found because of iNaturalist
- Invasive species can be tracked and monitored using iNaturalist data to help identify locations where interventions may be required
- Hundreds of scientific publications include iNaturalist data

"iNaturalist Pro Using the iNaturalist App", *NPS Natural Resources*, *PDM 1.0*.

(iNaturalist, n.d.).

Additionally, the database is publicly accessible, so anyone can use it to learn what's living in their own communities. iNaturalist's image recognition software also teaches people what they are observing. Knowing what species live around you can make you more apt to want to conserve them.

Reflection

Do you know what species live in your own community? How many of these species would you be able to identify if you saw them outside your own home?

Take a few minutes and explore the iNaturalist observations in your own community. Open iNaturalist on your phone or computer, go to “Explore,” then zoom in on your neighbourhood on the map to see what observations have already been made near you.

3.3 Community Science Initiatives in Ontario

There are many community science projects across Ontario for people of all ages to contribute data in their own communities. Projects cover a broad range of topics, including air quality monitoring, mapping precipitation and tracking the spread of flu-like illnesses. However, most projects focus on engaging nature enthusiasts to help monitor wildlife and natural spaces across the province. Many of these projects aim to provide information on population status and trends to help identify species or populations requiring conservation action. Some of these projects also focus on the distribution of invasive species, such as migratory insect pests that harm plants, consequently damaging farmlands, forests, parks and other natural areas.

For a list of all of the community science initiatives in Canada, consult the Government of Canada's Citizen Science Portal.

Nature Atlases

Atlas projects collect detailed species occurrence data and can harness the collective skills and efforts of community scientists, researchers and organizations across a large spatial scale, which individual researchers or organizations cannot do alone. Occurrence data are important for research and conservation. Ontario Nature has done many atlas projects to monitor population trends and develop recovery strategies for at-risk species.

Community science was integral in creating the Ontario Reptile and Amphibian Atlas, the most comprehensive source of information on Ontario's reptiles and amphibians. Ontario has 47 species of reptiles and amphibians, including 15 snakes, eight turtles, one lizard, 11 salamanders, 10 frogs and two toads. Over half of the reptiles and amphibians documented are listed as species at risk in Canada (Ontario Nature, 2024). Understanding the distribution of reptiles and amphibians across the province is important to inform conservation management.

Review the The Ontario Reptile and Amphibian Atlas.

Invasive Species Monitoring and Control

Community science is crucial to mitigate the impact of invasive species on ecosystems. Volunteers can submit invasive species observations to iNaturalist and EDDMapS (Early Detection and Distribution Mapping System) for early detection. Mapping is the first step to prevent the establishment and spread of invasive species. Organizations like the Invasive Species Centre and the Canadian Food Inspection Agency use community science data to monitor the spread of invasive species and develop control strategies.

Volunteers can also help organizations with their efforts to control or even eradicate invasive species. In London, local organizations host removal events where volunteers help to pull invasive plants like garlic mustard and buckthorn.

"Beetle Monitoring", Forest and Kim Starr, CC BY 2.0.

Visit the Invasive Species Centre's website for more information on how invasive species are tracked.

Community Nature Project

"Turtle Crossing" by Christian Engelstoft, CC BY SA 3.0

Conservation authorities protect, manage and restore natural habitats, including rivers, lakes, forests and wetlands and develop programs to protect the wildlife. They also provide opportunities for the public to learn about nature and enjoy natural spaces.

The Upper Thames River Conservation Authority (UTRCA) is one of 36 Conservation Authorities in Ontario (UTRCA, n.d.) The UTRCA oversees the upper watershed of the Thames River, an area that covers 3,430 square kilometres in southwestern Ontario. UTRCA's Community Nature Program is a community science initiative encouraging the public to learn more about the watershed's biodiversity using iNaturalist.

The UTRCA then uses the iNaturalist data for their watershed report cards, which report on local environmental conditions to track environmental change. The data are also used to locate invasive species to help inform decisions on control measures. For example, Giant Hogweed is a public safety hazard because its clear, watery sap contains toxins that can cause severe skin inflammation. If the sap gets

on your skin and the skin is then exposed to sunlight, it can cause severe sunburns. Community science helps to locate these problematic plants for possible extermination.

On the opposite end of the spectrum, the data can also be used to locate species that require conservation. For example, turtles often lay eggs in unsafe locations (e.g. along roads, near pedestrian trails, parks). Protecting turtle nests helps to preserve these populations. The Southern Ontario At Risk Reptiles (SOARR) team rescue the eggs from hundreds of turtle nests, incubate them, and release the young back into their natural habitat. The SOARR team uses community science to locate turtles for their recovery efforts.

If you spot a turtle nest at risk in London then you can report it to the UTRCA through their turtle reporting form.

Bird Window Collisions

Window collisions kill millions of birds every year in Canada. Community science can help track bird-window collisions by enabling volunteers to report dead birds. Some buildings are more prone to bird crashes, so the community science data can help identify high-risk buildings that cause the most bird deaths.

"Fanshawe College Bird Friendly Ceramic-Frit Glass", Glass Canada, FDEd (CAN)

Western University retrofitted buildings with bird-friendly window films after community science data highlighted buildings of concern (Watson & De Guzman, 2021). The window film consists of small, dime-sized dots spread two inches apart. From a distance, these dots are barely visible, so they do not change the overall aesthetic of the building. To the bird's eye, the dots break up the reflection from the windows, creating visible obstacles to avoid.

The community science data on bird collisions also helps researchers understand the factors contributing to collisions, such as mirrored windows. This information is used to create bird-friendly building designs and window treatments to consider when planning new buildings.

At Fanshawe College, you can spot bird-friendly windows in all recent builds, including the Campus Energy Centre and Innovation Village.

Land Use Planning

Before developing or altering land, the City of London requires that environmental studies be completed to assess the impact of the proposed development on the local habitat and its ecological functions. The environmental studies consist of background information reviews and field investigations to determine the presence of significant habitat features and/or Species at Risk (City of London, 2021).

"London, Ontario" by Mcalpinestudios, CC BY SA 4.0

The City of London Environmental Management Guidelines (2021) outline the steps required for these environmental studies. For the field investigations, multi-season inventories must be completed to determine the species that live in the area. Habitats that contain rare species are more valuable than habitats that do not, so extra measures will be put in place to ensure the habitat remains unharmed. The issue is that these surveys only capture snapshots of the biodiversity and may miss rare species. Community science can help fill in these gaps. In 2021, the Environmental Management Guidelines were updated to recommend incorporating reputable community science data sources, like iNaturalist. That means that iNaturalist data can help to document important habitats for Species at Risk to protect them from future development.

The City of London has published Environmental Management Guidelines that thoroughly explore Land Use Planning in London, Ontario.

City Nature Challenge

The City Nature Challenge is an international community science competition to see which city can make the most observations of wildlife on iNaturalist over a designated 4-day period (City Nature Challenge, n.d.). This event is a fun chance to learn about nature and help track your local biodiversity.

For more information on getting involved, visit the City Nature Challenge website.

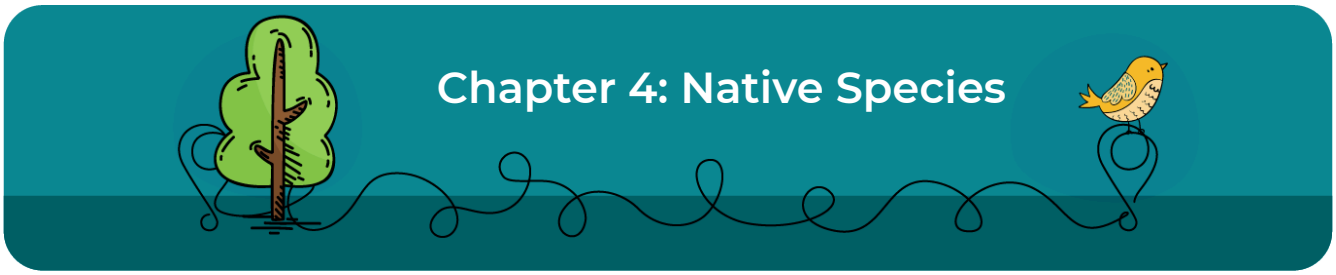
3.4 Chapter Summary

Key Takeaways

This chapter provided an overview of community science, emphasizing its definition, importance, and practical applications. You should understand the following:

- How community science involves public participation and collaboration in scientific research, enabling non-professionals to contribute to data collection, analysis, and dissemination of findings.
- How this participatory approach democratizes science, making it accessible to a broader audience while enhancing scientific literacy and fostering a deeper connection between individuals, their environment, and their communities.
- Community science's crucial role in conservation efforts in Ontario and how they help inform local conservation strategies and environmental policies.
- Several initiatives in Ontario, such as bird monitoring programs and invasive species tracking, and how to exemplify the successful integration of community efforts into scientific research.

CHAPTER 4: NATIVE SPECIES



4.0 Learning Outcomes

Learning Objectives

In this chapter, you will learn about the native species you may encounter while engaging in community science efforts. By the end of this chapter you will be able to:

- Describe what a native species is and how coevolution affects their growth and adaptations.
- Identify mutualistic relationships among native species.
- Explain the roles native species play in the regulation of their ecosystems.
- Define keystone species and explain their critical roles in maintaining the structure and balance of their ecosystems.
- Identify at-risk species and engage in conservation efforts to preserve them.

Adapted: "Crimson Bee Balm" by BlueRidgeKitties, CC BY-NC-SA 2.0. Mods: framing

4.1 Coevolution of Native Species

Non-native species, also known as exotic or introduced species, are those that have been brought to a new area from another part of the world. They are often spread by human activities, either intentionally or accidentally. Most non-native species peacefully coexist with the native plants and animals, but since they did not evolve in the region, they may not have the same level of connection to other species within the ecosystem.

Native species have co-evolved, meaning they have developed and adapted in response to each other's presence. This co-evolution results in intricate relationships that are important in maintaining balanced ecosystems.

Let's consider a couple of examples of coevolution:

Native Plants and Herbivores

Co-evolution happens frequently with plants and the organisms that eat them, called herbivores. An evolutionary change in the structure of a plant will affect the structure of an herbivore that eats the plant, which in turn affects the evolution of the plant, which affects the evolution of the herbivore... and the cycle continues.

Monarch caterpillars feed exclusively on milkweed because of their co-evolution. As a defence from getting eaten, milkweed evolved toxins called cardenolides that, when ingested, cause organisms to vomit and even lead to cardiac arrest. In turn, monarch caterpillars evolved to resist these toxins. Monarchs even incorporate the toxins into their own bodies, making them poisonous and protecting them from predation (Vernimmen, 2019).

Plants and Pollinators

Pollination Bee Dandelion by *Guérin Nicolas*, *CC BY-SA 3.0*.

Co-evolution leads to relationships between plants and pollinators where the morphology of the pollinator depends on the size and shape of the flower it pollinates, and vice versa.

For example, the common blue violet has evolved a flower shape and colour that promotes pollination by bees. Bees can see ultraviolet light, a spectrum invisible to humans. Violets have ultraviolet patterns that guide bees to the nectar and pollen. These patterns can form "nectar guides," which are like runway markings directing bees to the center of the flower where the reproductive structures are located. In turn, some bees have evolved strong, long tongues that allow them to access nectar deep within the violet's flowers. This coevolution has caused a mutualistic relationship where both species benefit. The common blue violets get fertilized, leading to higher seed production. And the bees receive a reliable source of nectar and pollen.

A Closer Look

Many pollinators are generalists, which will pollinate many different types of plants. Some pollinators have evolved to become specialists. Specialist pollinators have closer, often exclusive relationships with particular plant species.

The Violet Miner (*Andrena violae*) is a species of solitary bee that only pollinates violets. These bees have evolved long tongues that can reach the nectar hidden deep within the violet flowers. Their foraging behaviour is also closely timed with the flowering period of violets. The high degree of specialization in this relationship means that both the bees and the violets are closely dependent on each other. The bees rely on the violets for nectar, while the violets depend on the bees for effective pollination.

Banner Image Attribution

"White-Tailed Deer", Yankech Gary, CC BY-ND 2.0

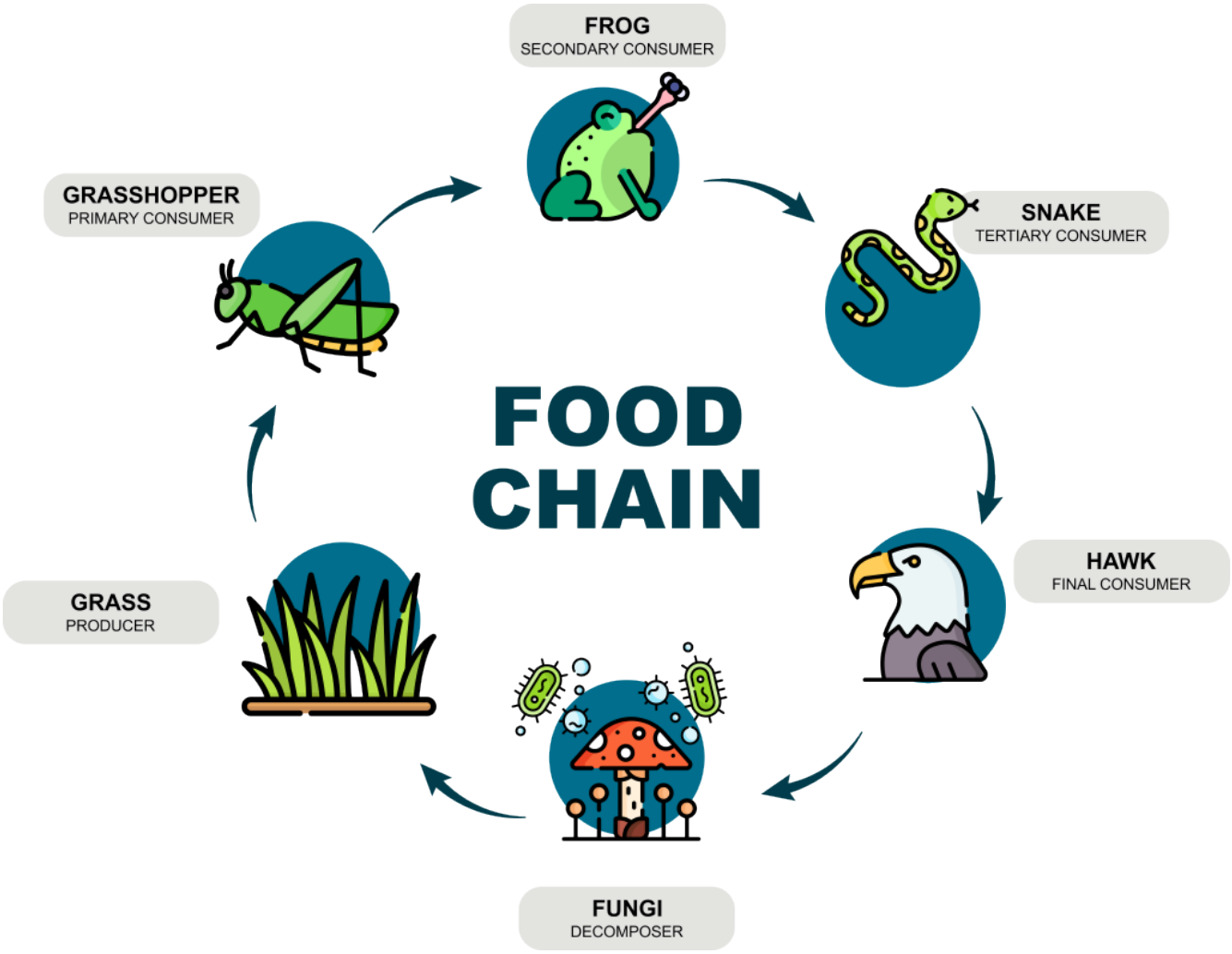
4.2 Roles of Native Species

By now, you should know that ecosystems are intricately connected and rely on each other to function properly. Native species play a crucial role in maintaining this balance. Let's explore a few of the key roles that native species play in ecosystems:

Food Chains

Native species are essential components of local food chains. Plants (primary producers) convert sunlight into energy through photosynthesis, forming the base of the food chain. Herbivores (primary consumers), such as insects, feed on these plants. These herbivores are then preyed upon by carnivores and omnivores (secondary consumers), which may then be eaten by other carnivores or omnivores (tertiary consumers). That means that the producers ultimately create all of the energy in the ecosystem, and that energy is simply transferred from one organism to another in the food chain.

Because of coevolution, native insects have adapted to feed on native plants. Many non-native plants are not suitable food sources for native insects, which results in fewer insects. Having fewer insects around might seem like a good thing, but fewer insects means that there is less food available for the upper levels of the food chain, resulting in fewer birds, mammals and other species of wildlife. In other words, a decrease in native plants leads to a decrease in overall biodiversity.



"Food Chain" by Sanaz Habibi CC BY-NC-SA

Pollination

Pollinators play a critical role in the reproductive processes of many plants by transferring pollen from one flower to another. Native insects pollinate our native plants but are also crucial pollinators for our agricultural crops to help increase the yield and quality of our produce.

Seed Dispersal

Many native animals help disperse seeds, aiding in plant reproduction and the spread of vegetation. Many bird species feed on fruits and berries of native plants and then disperse seeds through their droppings as they move from one location to another. Small mammals like squirrels and chipmunks transport seeds to new locations as they bury them for storage. Even ants help with seed dispersal. Certain native plants have

specialized seeds with lipid-rich components called elaiosomes. Ants are attracted to these elaiosomes, collect the seeds, and disperse them to their underground nests. This mutualistic relationship benefits both the plants (through seed dispersal) and the ants (through food).

Pest Control

"502nd Civil Engineer Squadron Pest Management Team", Andrew C. Patterson, Public Domain.

Native species often include predators and parasitoids that naturally regulate pest populations. These organisms have evolved alongside their prey or host species, developing specialized adaptations and behaviours that make them effective at controlling pest populations. When native predator populations are healthy and diverse, they can prevent pest outbreaks by feeding on pest species to maintain a balance within the ecosystem. This reduces the need for human intervention with chemical pesticides.

Keystone Species

Some native species act as keystone species in their ecosystems. Keystone species are those that have a disproportionately large impact on their environment relative to their abundance. They play a critical role in maintaining the structure of an ecosystem (Climate Adaptation Explorer, n.d.). The loss of a keystone species can lead to significant changes and potential collapse of the ecosystem.

Certain native plants are keystone species because they support a wide variety of insect herbivores, which in turn support higher trophic levels, including birds and mammals. For example, oak trees are keystone plants in our region. Oaks are host plants that feed the caterpillars of 436 species of butterflies and moths (Lepidoptera), more than any other plant. To compare, some non-native plants, like ginkgo trees (Ginkgo biloba), only support one species of caterpillar. Caterpillars are needed in our ecosystems because they are a crucial food source for other wildlife. 96% of birds require caterpillars to feed their young (National Wildlife Federation, n.d.). For some species, parents must catch over 6000 caterpillars to feed the babies in one clutch!

This again shows the intricate connections within our ecosystems. Without oaks, we won't have as many caterpillars, which in turn leads to fewer birds, and the effects ripple throughout the entire ecosystem. This is particularly concerning given the looming threat of oak wilt in Southwestern Ontario. Check out Oak Wilt in *Chapter 5.4 Invasive Species in London* to learn more.

A Closer Look

Globally, insect populations are declining at alarming rates.

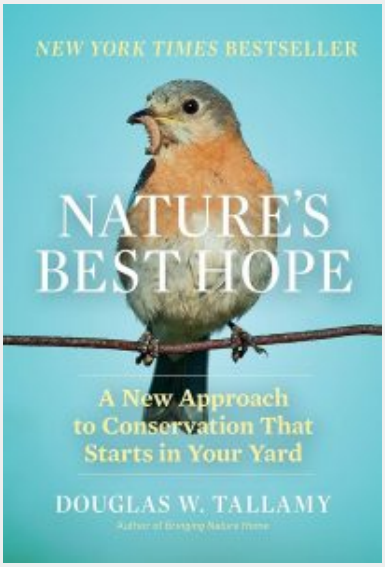
Douglas Tallamy, an entomologist and ecologist, advocates for the use of native plants in landscaping to support insects and help increase biodiversity.

You can learn more about Tallamy's work in his book:
Nature's Best Hope: A New Approach to Conservation That Starts in Your Yard

Consider enhancing biodiversity in your own yard by incorporating some native plants. Check out these resources to get started:

Keystone Native Plants

Gardening with Native Plants



Book cover, Douglas W. Tallamy & Adrianna Sutton, FDEd (CAN)

Reflection

Do you like bugs?

Insects have a bad reputation. Popular media portrays them as creepy, dangerous, or dirty. Some people fear them because of their unfamiliar features like antennae and multiple legs. Others associate insects with past negative experiences like mosquito bites or bee stings. Most people only see bugs as nuisances or threats but overlook the good that they do. They are vital in pollination, decomposition, and as a part of the food web. Understanding their ecological importance can help shift perspectives.

So I ask again, do you like bugs?

Let's work to appreciate insects and abandon our irrational fears and prejudices.

4.3 Species at Risk

The federal Species at Risk Act (SARA) was passed in 2002 with the goal of preventing species from becoming extinct and implementing the measures needed for their recovery. It gives legal protection to wildlife and the habitat they need to survive.

Species at Risk listings are based on scientific assessments conducted by government agencies, conservation organizations, and experts in various fields. These categories help prioritize conservation actions and allocate resources effectively to protect and recover species at risk in Canada.

SARA classifies species into different levels based on their risk of extinction (Government of Canada, 2013):

- **Extinct**: A species that no longer exists anywhere in the world.
- **Extirpated**: A species that no longer exists in the wild in Canada but still exists elsewhere in the world.
- **Endangered (EN)**: A species facing imminent extirpation or extinction in Canada if nothing is done to reverse the factors leading to its decline. They are legally protected under the federal Species at Risk Act.
- **Threatened (TH)**: Species are likely to become endangered if the factors causing decline continue. They are also protected under SARA.
- **Special Concern (SC)**: Species that may become threatened or endangered because of biological characteristics or identified threats.

The Committee on the Status of Endangered Wildlife in Canada (COSEWIC) evaluates the status of wildlife species and provides updated recommendations for listing. There are currently over 800 Species at Risk in Canada, including over 360 listed as endangered (Shape of Nature, n.d.).

Species at Risk in Ontario (SARO) also classifies species into different levels based on their populations within Ontario (Endangered Species Act, 2007). Many species at risk are listed under both SARA and SARO, but some species can be listed under one act but not the other. There are over 200 species at risk in Ontario (Kolarich, 2024) and over 50 located in London (Upper Thames River Conservation Authority, 2021).

Here are some examples of species at risk in London:

Monarch (Danaus plexippus)

Federal – Endangered, Provincial – Special Concern

Description

The Monarch is a showy orange and black butterfly with small white spots. These butterflies are relatively large, with a wingspan reaching 9-10 centimetres. The caterpillars have black, white and yellow stripes and can be found feeding on milkweed. The Monarch is one of a few butterflies that migrate. Monarchs spend the winter in Oyamel Fir forests found in central Mexico (Government of Canada, 2023d; Government of Ontario, 2014d).

Threats

The largest threat to Ontario Monarchs is habitat loss and fragmentation at overwintering sites in Mexico. Forests are being logged and converted into agricultural fields and pastures (Government of Canada, 2023d; Government of Ontario, 2014d).

"Monarch Butterfly", William Warby, CC BY 2.0.

Spiny Softshell (Apalone spinifera)

Federal – Endangered, Provincial – Endangered

"Eastern Spiny Softshell Turtle (Apalone spinifera spinifera)", Peter Paplanus, CC BY 2.0.

Description

The spiny softshell is a freshwater turtle with a round, rather flat, leathery shell. Unlike any other Ontario turtles, this species has a soft shell. The shell can grow up to 54cm long and is olive or tan in colour with dark blotches. The head is relatively narrow with a snorkel-like snout (Government of Canada, 2023e; Government of Ontario, 2014e).

Threats

The most significant threat to spiny softshell turtles is habitat degradation. Turtle habitat is being destroyed due to riverbank stabilization, development along shorelines, and recreation. Nest mortality can be very high due to human recreational activities at nest sites and nest predation by raccoons and foxes (Government of Canada, 2023e; Government of Ontario, 2014e).

Barn Swallow (Hirundo rustica)

Federal – Threatened, Provincial – Special Concern

"Barn Swallow", Alan Vernon, CC BY 2.0.

Description

Barn swallows are medium-sized songbirds (15-18 cm long). It has a glossy metallic blue back and upper wings and a rusty-red forehead and throat. It has long tail feathers, which form a distinctive, deep fork (Government of Canada, 2023a; Government of Ontario, 2014a).

Threats

The primary threat to barn swallows is a lack of food supply. Barn swallows feed on flying insects like flies, moths and bees. Habitat loss, pesticide use and climate change have caused significant declines in insect populations. The lack of insects for barn swallows leads to lower reproductive success and increased mortality (Government of Canada, 2023a; Government of Ontario, 2014a).

Butternut (Juglans cinerea)

Federal – Endangered, Provincial – Endangered

Description

Butternut is a medium to large, deciduous tree of the walnut family. It has compound leaves with 11 to 17 leaflets and hairy stalks. The Butternut fruit is a sticky-hairy, egg-shaped husk enclosing an edible nut that serves as a food source for small mammals like squirrels. Butternut is one of only two walnut species native to Canada, where it is at the northern limit of its native global distribution. Butternut trees can be found scattered across most mixed deciduous forests in Southern Ontario (Government of Canada, 2023b; Government of Ontario, 2014b).

"Juglans Cinerea", H. Zell, CC BY-SA 3.0

Threats

The primary threat to butternut trees is butternut canker, a non-native fungal disease that spreads quickly and can kill a tree within a few years. Butternut canker was first confirmed in Ontario in 1991 and has had a devastating impact on butternut populations. There is no known treatment for infected trees (Government of Canada, 2023b; Government of Ontario, 2014b).

Eastern Hog-nosed Snake (Heterodon platirhinos)

Federal – Threatened, Provincial – Threatened

"Eastern Hognosed Snake", John Brantmeier, CC BY-SA 4.0.

Description

The Eastern Hog-nosed Snake is a large, non-venomous, thick-bodied snake that can grow up to one metre long. It is easily identified by its distinctive upturned nose. When approached, this harmless snake coils up, flattens its head and neck to look like a cobra, hisses loudly and strikes with a closed mouth. If this frightening display doesn't scare the predator or person away, the snake rolls onto its back with its mouth open and tongue sticking out in an extravagant death-feigning defence roll (Government of Canada, 2023c; Government of Ontario, 2014c).

Threats

Major threats to the Eastern Hog-nosed Snake include habitat loss from intensive agriculture and

residential development, road mortality from an increase in road networks and harming or killing by people (Government of Canada, 2023c; Government of Ontario, 2014c).

A Closer Look

There are some species in London that are at risk of disturbance from humans, such as poaching (e.g. turtle nest sites), foraging (e.g. certain fungi or edible plants), intentional harm (e.g. snakes) and even photography (e.g. photographers overcrowding nesting sites of rare birds). In these instances, sharing location information can jeopardize the species at that site, particularly for stationary organisms, so it is best to "obscure" the location on iNaturalist. An "obscured" location only displays as a large rectangular box (around 20 km x 20 km), and the exact coordinates are not visible (iNaturalist, n.d.; shauns, 2024).

Users can specify how the location is displayed when recording an observation. The default is for observations to be "open", meaning visible to the public, but you can hide the exact coordinates by adjusting the "Geoprivacy" to "Obscured" (iNaturalist, n.d.; shauns, 2024).

It is best practice to obscure location for species at risk observations. You may also wish to obscure the location for observations in your own home and backyard to keep the location of your residence private.

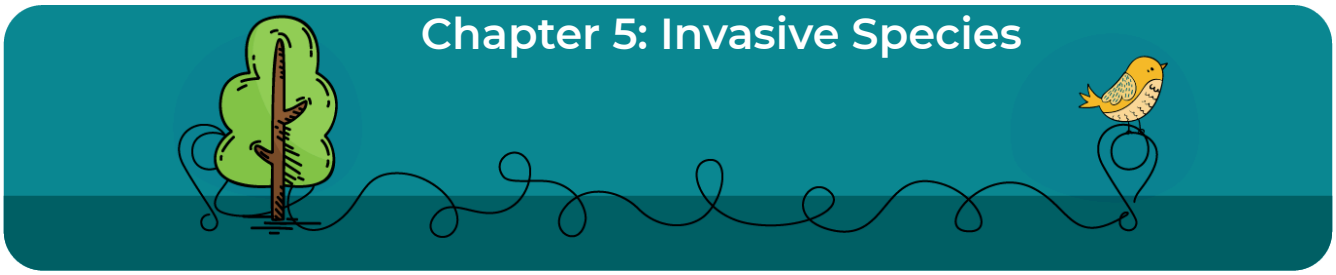
4.4 Chapter Summary

Key Takeaways

This chapter explored the intricate relationships and roles of native species within ecosystems. You should understand the following:

- The concept of coevolution and how species mutually influence each other's evolution, using examples like pollinators and flowering plants to illustrate these adaptive processes.
- The diverse roles of native species, such as keystone species and ecosystem engineers, and their crucial contributions to maintaining ecological balance and supporting biodiversity through various interactions like predation, competition, and mutualism.
- The issue of species at risk and the factors that lead to the decline of native species populations include habitat loss, pollution, and climate change.

CHAPTER 5: INVASIVE SPECIES



5.0 Learning Outcomes

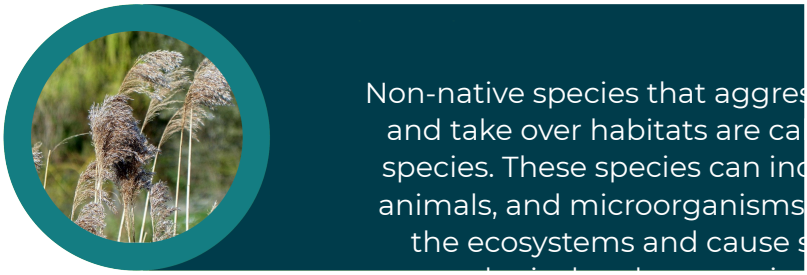
Learning Objectives

In this chapter, you will learn about invasive species and how their introduction to unfamiliar ecosystems can have many consequences for the health of those ecosystems and their populations. By the end of this chapter, you will be able to:

- Define what an invasive species is, and distinguish it from native species and non-invasive non-native species.
- Discuss how invasive species get introduced to new ecosystems.
- List some actions to prevent the spread of invasive species.
- Explain what control measures are used to prevent the spread and growth of invasive species.
- Identify some of the invasive species you might encounter while engaging in community science efforts in Ontario.

"Emerald Ash Borer", Shenandoah National Park, CC0 1.0

5.1 What are Invasive Species?



As the Upper Thames River Conservation Authority (2021) reports, not all non-native species are invasive. Ontario has more than 500 species of non-native plants, but most of them do not harm our local ecosystems. Only the non-native species that aggressively spread are considered invasive. Invasive species outcompete native species for resources such as food, water, and habitat, and they often lack natural predators in their new environment. This allows them to increase quickly in abundance and even completely overtake entire habitats.

In London, we have many invasive plants that invade natural areas and spread quickly. These plants often have particular characteristics that allow them to succeed. These plants may:

- Produce a lot of seeds or have aggressive rhizomes (horizontal underground stems that can produce new plants),
- can grow in a range of soil and moisture conditions,
- are not eaten by native predators,
- out-compete and replace native plants, and
- do not provide the food and habitat required by many native insects, birds or animals.

The UTRCA has distributed a listing of the invasive and non-native plant species you might encounter in and around Ontario.

Ontario is also now home to many non-native wildlife species that have been introduced from other continents and are now able to survive and reproduce in the wild. Some of these species become invasive and displace our native wildlife.

The UTRCA has distributed a listing of the invasive and non-native wildlife you might encounter in and around Ontario.

A Closer Look

The presence of invasive species can affect local ecosystems in many ways:

Competition for Resources

Invasive species often outcompete native species for vital resources such as food, water, and habitat. Their rapid growth and reproduction rates allow them to dominate these resources, leading to a decline in native populations.

Predation

Some invasive species are predators that directly consume native species. This predation can lead to significant declines or even extinctions of native species, particularly if the native species have no evolved defences against the invader.

Habitat Alteration

Invasive species can change the structure and composition of habitats. For instance, invasive plants may alter soil chemistry or water availability, making the environment less hospitable for native species. Aquatic invasives can change water quality and clarity, affecting the entire ecosystem.

Disease Transmission

Invasive species can introduce new diseases to native populations. These diseases can spread rapidly among native species, which may have no natural immunity, leading to widespread illness and mortality.

Genetic Impact

Invasive species can hybridize with native species, leading to genetic dilution and loss of unique native genotypes. This can reduce the genetic diversity and resilience of native populations.

Overall, the presence of invasive species reduces biodiversity and weakens ecosystems, making them less resilient to environmental changes and further invasions. They also disrupt ecological processes, which can diminish the ecosystem services they provide to humans.

Banner Image Attribution

"Common Reed (Phragmites australis)", AnenomeProjectors, CC BY-SA 2.0

5.2 How do Invasive Species Spread?

Pathways are the routes by which invasive species are introduced to an area. Invasive species can spread through natural pathways or man-made pathways. Natural pathways, including wind, water, and animal dispersal, are common in helping an invasive species spread once they are established in a new habitat. The most common ways for invasive species to get introduced to new areas are through man-made pathways, including:

Travel

Many invasive species are accidentally introduced as humans travel. They can hitchhike on vehicles, clothing, or cargo and can be easily transported around the world. The first invasive species in North America were unintentionally brought by European settlers. For example, brown rats (Rattus norvegicus) were spread here and all around the world as stowaways on the ships of settlers.

Today, people are unintentionally bringing new invasive species to Canada through travel and tourism. The Canada Border Services Agency (2023) plays an important role in helping to keep harmful foreign species from entering Canadian ecosystems: “various food, plant and animal products are restricted or prohibited entry because they can harbour invasive species, foreign animal diseases, and plant pests”.

Global Trade

Global trade has made it more common for invasive species to cross international borders, often unintentionally. Ships can transport aquatic invasive species in their ballast water. For example, zebra mussels (*Dreissena polymorpha*) first arrived in the Great Lakes in ballast water carried by ships from Asia (Upper Thames River Conservation Authority, n.d.-b). There are now Ballast Water Regulations that require ballast water to be cleaned before release to reduce the spread of aquatic invasive species.

For an example of an invasive species introduced by boat, read about the **Zebra Mussel** in *Chapter 5.4 Invasive Species in London*.

Terrestrial plants and animals are also spread by global trade. For example, the emerald ash borer (*Agrilus planipennis*) is an invasive wood-boring beetle that is native to Asia. It was likely introduced to Detroit in the 1990s, hidden inside wooden shipping crates. The Emerald Ash Borer spread to Ontario in 2002, killing up to 99% of ash trees in its path. To this day, it continues to devastate the ash tree population as it spreads in all directions across North America, where ash trees are present (National Resources Canada, 2024).

Now, there are regulations for wood packaging materials used in international trade requiring wood to be treated to kill any possible pests to prevent their spread.

> For another example of international trade introducing invasive species, read about the **Emerald Ash Borer** in *Chapter 5.4 Invasive Species in London*.

Recreation

Various recreational activities can spread invasive species. For example, after the zebra mussels were introduced into the Great Lakes through global trade, they were then spread locally by boaters and anglers. The mussels or their larvae could attach to boats and equipment and were transferred from contaminated sources to other water bodies around Ontario. Public education campaigns like Clean Drain Dry are used to help prevent the spread of aquatic invasive species via recreation.

Another common way for people to unintentionally spread invasive species recreationally is through moving firewood. Firewood can contain larvae for invasive pests, like the Emerald Ash Borer. When you transport that firewood to other locations, you are also unwittingly helping the invasive species spread to new areas. There are regulations that restrict the movement of firewood to slow the spread of the Emerald Ash Borer and other invasive pests.

Horticultural Practices

Horticultural practices are one of the most significant sources of invasive species through the intentional and unintentional movement of plants and soil. Gardeners and landscapers often introduce exotic plants for their aesthetic appeal or hardiness without realizing these species can escape cultivation and invade local ecosystems. Once they have established in a new area, natural dispersal mechanisms, such as wind, water currents, and animal movement, can further spread these invasive species.

Common ornamental garden plants like Lily of the Valley, goutweed, Japanese knotweed, and honeysuckles, among many others, have spread aggressively into natural habitats and outcompete native flora. Additionally, soil and mulch used in gardening can harbour invasive plant seeds, insects, and pathogens.

Although horticulture is the most significant pathway for the introduction of invasive plants, Canada's legislative framework is out-of-date and fragmented. Many plants that are known to be invasive and damaging to local ecosystems are still being sold for landscaping. In Ontario, it is illegal to sell certain plants (e.g. knotweeds, phragmites, dog-strangling vine), but it doesn't regulate many other known invasives (e.g. goutweed, Lily of the Valley, Japanese barberry, English ivy, honeysuckles, Norway maple, etc.). Canada is in need of a comprehensive database with invasive plant ratings and regulatory tools to prevent invasive plants from being sold to the public. The Canadian Coalition for Invasive Plant Regulation is a group of volunteers

that are working to raise awareness about the negative impacts of invasive plants and are actively advocating for improving regulations.

> For an example of Horticultural Practices introducing invasive species, read about **Japanese Knotweed** in *Chapter 5.4 Invasive Species in London*.

Pets

Many animals and plants sold for aquariums are not native to Canada. Some owners release pets into the wild when they become too large, too difficult to care for or when they simply don't want them anymore. These released pets may survive, reproduce and spread, becoming aquatic invasive species. For example, disinterested owners often release goldfish into creeks and ponds when they no longer want the fish at home. Feral goldfish were first detected in London in 2001, and the population has since boomed, causing significant damage to our local aquatic ecosystems. Under federal law, it is illegal to release goldfish and other aquatic species in the wild, but many people ignore this law. Further public education is needed to explain the impacts of releasing aquatic pets in the wild to try to prevent further release and subsequent destruction.

> For an example of pets becoming invasive species, read about wild **goldfish** in *Chapter 5.4 Invasive Species in London*.

Intentional Introduction

Humans have intentionally introduced species for various reasons, including economic benefits, aesthetic enhancement, pest control, recreational activities, and cultural or historical significance. For example, many species, including Norway Maple, Common Buckthorn, and House Sparrows, were brought to Canada to make European settlers feel more at home by recreating familiar landscapes.

The intentional introduction of species has led to unintended ecological consequences, as the introduced species become invasive and disrupt ecosystems. A prime example of this is the introduction of the European starling to North America. In 1890, approximately 100 starlings were released in Central Park, New York, by a group led by Eugene Schieffelin. This group aimed to introduce all bird species mentioned in the works of William Shakespeare to North America. The starlings quickly adapted to their new environment and spread across the continent.

For an example of intentional introduction of invasive species, read about the **European Starling** in *Chapter 5.4 Invasive Species in London*.

5.3 Control Measures

Controlling the spread of invasive species requires a combination of public awareness, preventative measures, and active management strategies.

Public education campaigns can inform people about the dangers of invasive species and the common man-made pathways that allow them to spread. There are many ways the public can adjust their own actions to prevent inadvertently spreading invasive species:

- Be aware of border regulations and declare what you are travelling with so that inadmissible goods can be disposed of properly.
- Clean and dry boats and equipment before moving them between locations.
- Always buy and burn local firewood.
- Plant native species in your own yard, and never plant invasive species. Refer to the Grow Me Instead guide for plant recommendations that help to combat climate change and biodiversity loss.
- Never release unwanted pets into the wild.
- Spread awareness about invasive species and how your individual actions can help!

Early detection and rapid response are crucial for preventing invasives from becoming established. Community Science plays an important role in being able to detect and report new invasive species sightings so that control methods can begin.

Control measures can be broken into three categories:

1. Mechanical Methods

Include manual methods such as cutting, pulling, mowing, girding, and solarization (smothering vegetation with plastic to kill it) for invasive plants. Egg mass removals are common to try to prevent the spread of some invasive insects.

Mechanical methods require significant amounts of manual labour, so it is a good way for the public to get involved to help! In London, you can attend events to help remove invasive plants like garlic mustard and common buckthorn.

2. Chemical Treatments

This involves the use of herbicides and pesticides. These chemicals must be applied in accordance with federal and provincial regulations.

"Invasive plant control with herbicide", National Park Service, CC0 1.0.

3. Biological Controls

Introducing natural predators or pathogens (e.g. insects, fungi, bacteria, viruses) to stop or slow the spread of invasive species. Careful consideration must be taken to ensure that the biological control agent does not in itself become a pest. Agents for biological control must be approved by federal and provincial authorities before release.

By combining all of these efforts, we can reduce the impact of invasive species and protect native biodiversity.

The downy woodpecker, a natural predator to the Emerald Ash Borer, was introduced in New York City to control their activity. "Downy woodpecker", Steven Bellovin, CC BY-NC-ND 4.0

5.4 Invasive Species in London

Here are some examples of invasive species that you are likely to encounter in London:

Common Buckthorn (*Rhamnus cathartica*)

Description

"Common Buckthorn", Jo Zimny Photos, CC BY-NC-ND 2.0

Common Buckthorn, also known as European Buckthorn, is a woody plant that ranges in size from a shrub to a small tree. Buckthorn leaves are opposite to sub–opposite with veins that start at the stem and curve toward the tip of the leaf. It has black buds that lie close to the twig. A small thorn extends out from the end of most twigs. The bark is smooth and shiny when young and rough and textured when mature. Buckthorn has many clumps of black berries starting in the late summer.

Introduction

Common buckthorn was brought over from Europe around the 1880s and was planted widely around the country in hedgerows and windbreaks.

Impact

Common buckthorn is the most common tree in London and is continuing to spread. Birds and animals eat buckthorn fruit and spread the seeds in their droppings. The seeds contain laxative properties that ensure they are spread widely and rapidly. Seedlings often get established on the edge of a forest and then quickly spread into the interior, forming dense stands that can tolerate shade and suppress other vegetation. Buckthorn is usually the first shrub to leaf out in the spring and the last to drop its leaves late in the fall, making it difficult for native species to compete for sunlight. It also changes the nitrogen composition of the soil, which makes it even harder for other species to survive.

Management

A variety of chemical and mechanical methods are used to control the spread of buckthorn. You can help by volunteering at removal events around London, where small plants are pulled and larger ones removed using a weed wrench tool.

Adapted from Common Buckthorn by the Invasive Species Centre, used under Fair Dealing for Educational Purposes (Canada). Modifications: restructured and summarized.

Garlic Mustard (*Alliaria petiolata*)

Description

Garlic mustard resembles several native Ontario plants. The easiest way to distinguish garlic mustard from other plant families is to crush the leaves. If they emit a strong garlic smell, then the plant is most likely garlic mustard.

First-year plants produce a rosette of dark green, kidney-shaped leaves. Second-year plants have triangular, alternate, sharply toothed leaves and produce white flowers with four small petals in May.

Introduction

Garlic mustard is an invasive plant native to Europe that was brought to North America in the early 1800s for use as an edible herb.

"Garlic Mustard", Tony Atkin, CC BY-SA 2.0

Impact

Garlic mustard is one of Ontario's most aggressive forest invaders. It can enter a new area and become the dominant plant in the forest understory within 5-7 years, even in mature forests.

Garlic mustard displaces native spring ephemeral wildflowers through direct competition and by releasing allelopathic chemicals that change the soil chemistry and prevent other species from growing nearby. These chemicals also inhibit the growth of native trees by affecting their mycorrhizal fungi network (beneficial fungi in the soil that help trees and plants absorb nutrients and water into their roots).

Management

Garlic mustard populations are managed through various mechanical and chemical control methods. You can help by pulling garlic mustard by hand. This will need to be repeated more than once and is more likely to be successful when followed by replanting with native species. Keep an eye open for garlic mustard pull events in London, where you can learn more and lend a helping hand.

Garlic mustard is edible. Try it in the early spring in your salads, or make a garlic mustard pesto!

Japanese Knotweed (*Fallopia japonic*)

Description

Japanese knotweed can grow in a wide range of habitats, including along rivers, wetlands, roadsides and ditches. It has hollow, smooth, purple to green-coloured stems up to 2.5 cm in diameter that grow in bamboo-like clumps. The plant can grow 1m in height in just three weeks and maxes out at 3m. It has a horizontal root system that can grow very quickly and spread up to 10m away from the parent plant.

Introduction

Japanese knotweed is native to eastern Asia and was introduced to Canada as a horticultural plant in the early 1900s. In Ontario, Japanese knotweed distribution is not well-documented, but most observations have been in the 2000s.

"knotweed", Liz West, CC BY 2.0.

Impact

Japanese knotweed forms dense thickets of vegetation that aggressively outcompete native plants. It also appears to have allelopathic properties, although further research is needed. This plant can also significantly damage infrastructure as it is able to grow through concrete/asphalt up to 8 cm thick and even through building foundations. In Ontario, Japanese knotweed is currently confined to southern parts because it is intolerant of persistent freezing conditions. Unfortunately, it is likely to spread further north as the climate warms.

Management

Both root and stem fragments can regenerate, making knotweeds very easy to spread and very difficult to kill. Mechanical control on its own is not an effective management tool due to the likelihood of missing fragments, which will quickly re-establish the population. Chemical control is the recommended treatment strategy for knotweeds, but they typically require treatment with herbicide for 3-5 years.

Adapted from Japanese Knotweed by the Invasive Species Centre, used under Fair Dealing for Educational Purposes (Canada). Modifications: restructured and summarized.

Common Reed (*Phragmites australis*)

Description

"Common Reed (Phragmites australis)", AnemoneProjectors, CC BY-SA 2.0

Phragmites is a robust, erect perennial grass growing to 5m in height. Although it grows mostly in wetlands, it can also be found growing in roadside ditches and on beaches. The invasive form of phragmites looks very similar to a native species (Phragmites americanus), making identification difficult. Invasive phragmites have tan or beige stems, with blue-green leaves and large, dense seedheads. In contrast, native phragmites have reddish-brown stems, yellow-green leaves, and smaller, sparser seedheads. Additionally, invasive phragmites grow in very dense stands with up to 200 stems per square metre, which crowds out other species. In comparison, native phragmites does not grow as tall or dense and allows for biodiversity within a stand.

Introduction

Invasive phragmites have been damaging ecosystems in Ontario for decades. It is not clear how it was transported to North America from its native home in Eurasia.

Impact

Invasive phragmites is an aggressive plant that decreases biodiversity. It spreads quickly and out-competes native species for water and nutrients. Biochemicals are also released from its roots into the soil to hinder the growth of surrounding plants. Invasive phragmites spread also reduces available natural habitat and food supply for many wildlife species. Stalks are dense and rigid, preventing wildlife from easily navigating through or nesting in a stand.

Management

Invasive phragmites is primarily controlled by applying herbicides to kill the plant. After treatment, standing dead stalks are often cut, rolled and/or burned to allow native plants to re-establish.

Adapted from Invasive Phragmites by the Invasive Species Centre, used under Fair Dealing for Educational Purposes (Canada). Modifications: restructured and summarized.

Red-Eared Slider (*Trachemys scripta elegans*)

"Red-eared Slider Turtle at the Tama River", *Josephus37*, *CC BY-SA 4.0*

Description

Red-eared sliders are medium-sized freshwater turtles with distinctive red patches on either side of their head. Both their carapace (shell) and skin are olive to brown in colour, with yellow or green stripes running down their neck, legs, and tail. These turtles spend most of their time basking in the sun on logs or rocks protruding from the water.

Introduction

The primary mode of introduction for red-eared sliders is through pet release. This turtle species is a popular pet around the world and has introduced populations on every continent except Antarctica.

Impact

Red-eared sliders compete with native turtles for food and habitat. Since these turtles are larger than most of our native species, they also outcompete the other turtles for basking space on logs and rocks. Turtles need this access to warm sunshine to maintain healthy digestion and metabolism. Most native turtle species in London are already facing threats from habitat loss, road mortality and pollution. Many native turtle species are listed as Special Concern under the federal Species at Risk Act, so the additional threat of non-native competitors is of vital concern.

Management

Putting a stop to pet release is the most effective way to protect native species and habitats from invasive red-eared sliders.

Adapted from Red-eared slider by the Invasive Species Centre, used under Fair Dealing for Educational Purposes (Canada). Modifications: restructured and summarized.

Zebra mussel (*Dreissena polymorpha*)

Description

The zebra mussel is a small freshwater mussel named for the striped pattern of its shell. It is typically found attached to objects, surfaces, or other mussels.

Introduction

Originally from Asia, zebra mussels arrived in the Great Lakes via ballast water from transoceanic ships in 1986 and have since spread throughout North America. They were first discovered in Fanshawe Reservoir in 2002.

Impact

Zebra mussels filter plankton out of the water, which depletes it as a food source for native species. This filtering also increases the amount of sunlight able to penetrate the water, leading to toxic algal blooms, which decreased water quality and harms other wildlife. These small mussels can also grow in dense colonies on the shells of native species, suffocating populations of already threatened populations of freshwater mussels.

"Zebra Mussel", Bj.Schoenmakers, CC0 1.0

Management

Controlling zebra mussel populations requires a multi-faceted approach combining immediate removal and long-term strategies to prevent new infestations. Current infestations can be removed manually but is very time-consuming. Chemicals can also be used to treat localized infestations but must be used cautiously to avoid harming non-target species.

Preventative measures are the most effective way to control zebra mussels. Public education on cleaning boats and equipment is crucial to prevent transferring mussels from contaminated sources to other waterways around Ontario.

Adapted from Zebra and Quagga Mussels by the Invasive Species Centre, used under Fair Dealing for Educational Purposes (Canada). Modifications: restructured and summarized.

Goldfish (*Carassius auratus*)

Description

Goldfish are common pets that are known for their bright orange colour. This orange colour is the result of selective breeding over thousands of years. Goldfish vary in size depending on their habitat. Goldfish kept in smaller indoor aquariums only tend to grow about 2.5-5 cm long but can grow much larger in wild ecosystems.

"Above & Below", SnoShuu, CC BY-NC-ND 2.0

Introduction

Goldfish are one of the most available fish species in the aquaculture industry because they are a low-maintenance pet. As a result, the primary pathway of spread is intentional release once their owners are no longer willing to care for them.

Photo, Devon Peacock/Global News, FDEd (CAN)

Impact

Goldfish are extremely damaging to local aquatic ecosystems. When released into the wild, goldfish can grow to be about the size of a football and may live up to 30-40 years old. These fish reduce the populations of native fish species by preying on them and outcompeting them for food.

Management

Reducing the spread of goldfish is as simple as not letting them loose in the wild. You also should not flush the fish down the toilet, alive or dead, because it can pass disease to other fish species. Before purchasing a goldfish, consider what you will do with it once you no longer wish to care for it.

Adapted from Goldfish by the Invasive Species Centre, used under Fair Dealing for Educational Purposes (Canada). Modifications: restructured and summarized.

House Sparrow (*Passer domesticus*)

Description

House sparrows are small, plump songbirds that grow to be 15-17cm long. Males have vibrant and distinct colouration, whereas females appear more monotone and streaky brown (Read more in the *A Closer Look box* on sexual dimorphism below).

"House Sparrow", Lip Kee, CC BY-SA 2.0

Introduction

Birds from England were intentionally released into New York City in the mid-1800s as a control method to decrease linden moth populations.

Impact

House sparrows are territorial and aggressive. They disrupt native songbird biodiversity by preventing native species from nesting/reproducing successfully. House sparrows get the ideal nesting sites over native species because they build their nests in March before many native birds return from migration. House sparrows will also compete with native birds for staple food resources, especially at bird feeders, where they will overcrowd and chase other approaching species away.

Management

There are many approaches to managing house sparrows, including preventing nesting, controlling food availability and even destroying nests. You can help control house sparrow populations by blocking the entrances to your backyard birdhouses until native species return (early to mid-April). This gives native species a chance to claim these nesting locations.

Adapted from House Sparrows by the Invasive Species Centre, used under Fair Dealing for Educational Purposes (Canada). Modifications: restructured and summarized.

European Starling (*Sturnus vulgaris*)

Description

European starlings are stocky black birds about the size of robins. They have glossy black plumage with a metallic/iridescent sheen and long, pointed bills.

"European Starling", Tyler Ingram, CC BY-NC-ND 2.0

Introduction

In 1890, approximately 100 starlings were released in Central Park, New York, by a group led by Eugene Schieffelin. This group aimed to introduce all bird species mentioned in the works of William Shakespeare to North America. The starlings quickly adapted to their new environment and spread across the continent. There are now over 200 million starlings in North America alone.

Impact

European Starlings have become one of Ontario's most numerous birds. They are aggressive birds that outcompete native bird species for nesting sites and food. The Global Invasive Species Database includes starlings in its "100 of the World's Worst Invasive Alien Species" list.

Management

Controlling starling populations is a challenging task due to their adaptability and prolific breeding. Homeowners can install bird spikes or other physical barriers on ledges, roofs, and other structures to prevent starlings from perching and roosting in particular areas, but there are no large-scale measures to control the population of starlings.

Adapted from European Starlings by the Cornell Lab of Ornithology, used under Fair Dealing for Educational Purposes (Canada). Modifications: restructured and summarized.

Emerald Ash Borer (*Agrilus planipennis*)

Description

Emerald Ash Borers (EABs) are highly destructive invasive beetles that primarily target ash trees (Fraxinus species). They are bright metallic green and are around 8-14mm long.

Introduction

Native to Asia, EABs were likely introduced to Detroit in the 1990s, hidden inside wooden shipping crates. The EAB spread to Ontario in 2002, killing up to 99% of ash trees in its path.

"Emerald Ash Borer", NatureServe, CC BY-NC 2.0

Impact

The EAB has killed millions of ash trees in Ontario, Quebec, and many U.S. states. The adult beetle lays eggs on ash trees, which then hatch into larvae. The larvae feed on the inner bark, which disrupts the tree's nutrient and water transport systems, eventually girdling the tree and leading to mortality. To this day, it continues to devastate the ash tree population as it spreads in all directions across North America, where ash trees are present.

Management

There are regulations in place to reduce human-mediated spread of the EAB. Regulations for wood packaging materials used in international trade require wood to be treated to kill any possible pests to prevent their spread. Additionally, regulations restrict the movement of firewood to slow the spread of invasive pests, including EAB. You can help prevent the spread of invasive species by always following these regulations.

Adapted from Emerald Ash Borer by the Invasive Species Centre, used under Fair Dealing for Educational Purposes (Canada). Modifications: restructured and summarized.

Beech Leaf Disease

Description

"Aceria Fagineus on Common Beech Fagus Sylvatica", Len Worthington, CC BY-SA 2.0

Beech Leaf Disease (BLD) is a serious and emerging threat to beech trees, primarily affecting American beech (*Fagus grandifolia*) trees. The disease is characterized by dark green, interveinal banding on the leaves, which can be observed from early spring. As the disease progresses, leaves become leathery and curled and have a thickened texture. Eventually, the disease causes premature leaf drop, leading to a decline in the tree's overall health.

BLD is likely caused by an invasive nematode, *Litylenchus crenatae mccannii*. Further research is being conducted to determine if the nematode itself produces a toxin that causes the disease or if there is another pathogen involved.

Introduction

Little is known on the origins of BLD but it is believed that the nematode may have been introduced to North American through the human transport of wood. BLD was first discovered in North America in 2012 in Ohio. It was first documented in Ontario in 2017.

Impact

Beech trees are already at risk from beech bark disease, so BLD could devastate our local beech trees. Beech trees are valuable nut-producing trees and provide food for many forest-dwelling animals.

Management

As of this time, the transmission of this disease in not currently known, so no effective control or eradication measures have been developed. Research is currently underway to determine the vector that beech trees are infected by this disease. Best management practices will be updated as research continues.

Adapted from Beech Leaf Disease by the Invasive Species Centre, used under Fair Dealing for Educational Purposes (Canada). Modifications: restructured and summarized.

Oak Wilt (*Bretziella fagacearum*)

"Quercus shumardii Buckley", *Diego Alex*, *CC BY-SA 4.0*

Description

Oak wilt is named after the characteristic leave wilting observed on infected trees. *Bretziella fagacearum*, a fungus, spreads through the vascular system of oaks and restricts the movement of water and nutrients up towards the leaves. The leaves of infected oaks can start to wilt and drop prematurely, eventually resulting in complete defoliation. The leaves will begin turning brown at the outer edges first and will move in towards the middle margin. Leaf discolouration and wilting typically starts at the top of the canopy and moves down over time.

Introduction

Bretziella fagacearum is believed to have been present in North America since the early 1900s. It was first detected in Ontario at a residential property in Niagara Falls in June 2023, marking the first instance of the invasive pathogen in Canada. Oak wilt has not yet been observed in London, but the public should help monitor local oak trees for signs of infection.

Impact

Oak wilt could have devastating impacts to oak populations in Canada. All species of oak trees (Quercus sp.) have been found to be susceptible to oak wilt, with species of red oak being the most seriously affected. The loss of oak trees could impact the survival of many insects and forest-dwelling animals by reducing their food supply.

Management

When a diseased red oak dies, the fungus produces sporulating mats on the dead tree. Nitidulid beetles, or bark beetles, then feed on these fungal mats and pick up spores on their bodies, which they then carry from the infected tree to wounds on healthy trees. To prevent spore mats from forming, infected or dead oaks should be removed and disposed of.

The best way for you to help is by reporting any sightings of possible infection using iNaturalist or EDDMapS. Early detection allows for early intervention.

The fungus can also be spread from humans through the transport of infected wood products. You can help reduce further spread by ensuring that you never transport firewood.

Adapted from Oak Wilt by the Invasive Species Centre, used under Fair Dealing for Educational Purposes (Canada). Modifications: restructured and summarized.

Spotted Lanternfly (*Lycorma delicatula*) – Potential

Description

Spotted lanternfly (SLF) is an eye-catching insect native to China that has become an invasive pest in the United States and has the potential to spread to London. The insect is approximately 1" long with wings that are pinkish-grey with black spots and black veins at the tips. While getting ready for flight, the forewings open, and the bright red underwings become visible.

Introduction

SLF was first detected in Pennsylvania in 2014 and has since spread throughout the Eastern United States. The SLF is an imminent threat to Ontario, including London.

Impact

The SLF is a voracious eater that feeds on over 70 species of plants and trees. It threatens to severely impact Ontario's viticulture (wine), fruit-tree, and maple industries, which have a combined estimated worth of over $530 billion/year in Canada.

Management

Southwestern Ontario is currently monitoring for SLF. Community science can help ensure early detection to allow for a rapid response if the SLF arrives.

Because of its distinctive appearance, the SLF is not easily confused with any other insect known to occur in Canada. Community scientists should learn to recognize SLF at all life stages (eggs, nymphs and adults) and report all sightings to the Canadian Food Inspection Agency.

Community scientists can also help by uploading observations of the Tree of Heaven, SLF's primary host, onto iNaturalist or EDDMapS. Mapping the locations of these trees can help identify areas most at risk so that these areas can be monitored more closely. The Tree of Heaven itself is an invasive species, so may even be destroyed to help reduce the chances of SLF invasion.

The United States Department of Agriculture is also turning to community scientists for help with mechanical control. They are requesting that the public search for spotted lanternfly egg masses on vehicles, trees, and other outdoor surfaces during early spring then smashing them or scraping them off, sealing them in a plastic bag and disposing of them in the trash (USDA, 2024).

Description	Photos (Hidden egg mass, young nymph, adult – closed wings)	Photos (Visible egg mass, mature nymph, adult – wings open)
The spotted lanternfly will lay their eggs on smooth plant and non-plant surfaces. The eggs will hatch in spring or early summer. Freshly laid eggs will be covered in a grey waxy coating.	 Photo, Pennsylvania Department of Agriculture, Bugwood.org, CC BY 3.0	 Photo, Lawrence Barringer, Pennsylvania Department of Agriculture, Bugwood.org, CC BY 3.0
The lanternfly nymph will be identifiable by the white spots on its back and legs. More mature nymphs will also have red colouration.	 Photo, Lawrence Barringer, Pennsylvania Department of Agriculture, Bugwood.org, CC BY 3.0	 Photo, Lawrence Barringer, Pennsylvania Department of Agriculture, Bugwood.org, CC BY 3.0

Description	Photos (Hidden egg mass, young nymph, adult – closed wings)	Photos (Visible egg mass, mature nymph, adult – wings open)
Adult lanternflys have uniquely coloured light brown/grey wings with spots at the front and speckled bands at the back. Their rear wings are red in colour and have black spots near the front and white and black bands at the back. Their abdomen is yellow with horizontal black stripes.	 *Photo, Lawrence Barringer, Pennsylvania Department of Agriculture, Bugwood.org, CC BY 3.0*	 *Photo, Lawrence Barringer, Pennsylvania Department of Agriculture, Bugwood.org, CC BY 3.0*

Adapted from Spotted Lanternfly by the Invasive Species Centre, used under Fair Dealing for Educational Purposes (Canada). Modifications: restructured and summarized.

A Closer Look

Sexual dimorphism refers to the differences in size, coloration, shape, or other physical characteristics between males and females of the same species. These differences often arise due to evolutionary pressures related to mating and reproduction, such as mate attraction or competition. For example, male lions have manes while females do not. Manes serve as a sign of health and strength in male lions which helps to attract females and deter rival males. Female lions, or lionesses, have a sleeker appearance, allowing them to be more efficient hunters.

Here are a few examples of sexual dimorphism in species around London:

Northern Cardinal (*Cardinalis cardinalis*)

Males are bright red with a black mask around their beaks which helps them attract females. Females are primarily brown with red tinges, which provides better camouflage while nesting.

"Cardinalis cardinalis (northern cardinals) 15", James St. John, CC BY 2.0

"White-tailed Deer", CC0 1.0

White-tailed Deer (*Odocoileus virginianus*)

Males (bucks) are typically larger than females (does) and possess antlers, which they use to compete with other males for mating opportunities. Females lack antlers and are slightly smaller.

Mallard Duck (*Anas platyrhynchos*)

"Anas platyrhynchos male female quadrat", Richard Bartz, CC BY-SA 2.5

Male mallards have a distinctive iridescent green head, a white neck ring, and a chestnut-brown chest, which they use to attract females. Female mallards are mottled brown, which allows for better camouflage while they incubate eggs and rear young.

What other examples of sexual dimorphism can you think of?

5.5 Chapter Summary

Key Takeaways

This chapter defined invasive species, their methods of spreading, control measures, and specific cases of invasive species in London. You should understand the following:

- Invasive species are non-native organisms that cause harm to the environment, economy, or human health.
- The characteristics that enable invasive species to thrive, such as rapid reproduction and a lack of natural predators.
- The mechanisms of spread, noting that invasive species can be introduced intentionally or accidentally through human activities like trade, travel, and landscaping, as well as through natural processes like wind and water currents.
- Various control measures to manage invasive species, categorized into mechanical, chemical, and biological methods.
- Specific examples of invasive species in London and their impacts on local ecosystems and efforts to control them.

Additional Resources

Chapter 1

The IUCN Red List of Threatened Species

Biodiversity Loss by Britannica

Living Planet Report 2022 by WWF (World Wild Fund)

What is Biodiversity? by WWF (World Wild Fund)

Toward a 2030 Biodiversity Strategy for Canada: Halting and Reversing Nature Loss by the Government of Canada

The Biodiversity Action Guide by The Nature Conservancy

Do Experiences with Nature Promote Learning? Converging Evidence of a Cause-and-Effect Relationship by Ming Kuo, Michael Barnes, and Catherine Jordan in Environmental Psychology volume 10.

Conserving Biodiversity by the Government of Ontario

The Need to Plant Native Species by Bipin Dhinsa for Thames Talbot Land Trust

State of Ontario's Biodiversity 2020 Summary by Ontario Biodiversity Council

Environmentally Significant Areas in the City of London by Upper Thames River Conservation Authority

Chapter 2

Noxious Weeds in Ontario by the Government of Ontario

How to Prepare for a Hike by the Government of Canada

Ticks in Middlesex-London by Middlesex-London Health Unit

Tick-Borne Diseases by the Center for Disease Control (CDC)

iNaturalist in the Upper Thames River Watershed by iNaturalist

Giant Hogweed by Upper Thames River Conservation Authority

iNaturalist.ca – Using the iNaturalist App by Upper Thames River Conservation Authority

iNaturalist.ca – Adding an Observation Online by Upper Thames River Conservation Authority

The Seven Principles of Leave No Trace by Leave No Trace Canada

Chapter 3

Citizen Science Portal by the Government of Canada

The Ontario Reptile and Amphibian Atlas 2009-2019 by Ontario Nature

Community Nature Project by Upper Thames River Conservation Authority

Western Ramps Up Effort to Prevent Deadly Bird Crashes by Brandon Watson and Mari-Len De Guzman, Western News

City of London Environmental Management Guidelines by the City of London

City Nature Challenge

Chapter 4

The Tree Atlas by the Government of Ontario

Doug Tallamy TA Baker Professor of Agriculture and Natural Resources, Department of Entomology and Wildlife Ecology, University of Delaware

Native Gardening 101 by the Nature Conservancy Canada

Garden for Wildlife – Keystone Native Plants Eastern Temperate Forests – Ecoregion 8/a> by National Wildlife Federation

Gardening with Native Plants by Upper Thames River Conservation Authority

Recommended Native Trees & Shrubs for Naturalization Projects in the Upper Thames River Watershed by Upper Thames River Conservation Authority

Recommended Native Wildflowers & Grasses for Naturalization Projects & Gardens in the Upper Thames River Watershed by Upper Thames River Conservation Authority

How Monarch Butterflies Evolved to Eat a Poisonous Plant/ by Tim Vernimmen & Knowable Magazine in

Species at Risk in Ontario by the Government of Ontario

Species at Risk in the Upper Thames River Watershed by Upper Thames River Conservation Authority

Monarch (Danaus plexippus) by the Government of Canada

Monarch by the Government of Ontario

Spiny Softshell (Apalone spinifer) by the Government of Canada

Spiny Softshell by the Government of Ontario

Barn Swallow (Hirundo rustica) by the Government of Canada

Barn Swallow by the Government of Ontario

Butternut (Juglans cinerea) by the Government of Canada

Butternut (Species at Risk) by the Government of Ontario

Butternut Canker by the Government of Ontario

Eastern Hog-nosed Snake (Heterodon platirhinos) by the Government of Canada

Eastern Hog-nosed Snake by the Government of Ontario

Chapter 5

Invasive Exotic (Non-native) Species and Diseases by UTRCA (Upper Thames River Conservation Authority)

Invasive Non-Native Plants in the Upper Thames River Watershed by UTRCA (Upper Thames River Conservation Authority)

Exotic (Non-Native) Wildlife in the Upper Thames River Watershed by UTRCA (Upper Thames River Conservation Authority)

A Quick Reference Guide to Invasive Plant Species by the Credit Valley Conservation

Forest Health: Beech Bark Disease by UTRCA (Upper Thames River Conservation Authority)

Forest Health: Oak Wilt by UTRCA (Upper Thames River Conservation Authority)

Garlic Mustard by the Government of Ontario

Invasive Species in Ontario by the Government of Ontario

USDA Asks Residents to Look for Invasive Egg Masses by the USDA (United States Department of Agriculture Animal and Plant Health Inspection Service)

European Starling by the Cornell Lab of Ornithology

Ballast Water Regulations by the Government of Canada

Phytosanitary Entry Requirements by the Government of Canada

Hazards of Moving Firewood by the Government of Canada

Managing Invasive Species in Ontario by the Government of Ontario

Aquatic Invasive Species Regulations by the Government of Canada

Acts, Regulations and Other Regulatory Information by the Canada Border Services Agency by the Government of Canada

A Guide for Southern Ontario – Beautiful Non-Invasive Plants for Your Garden by Grow Me Instead

Common Buckthorn by Invasive Species Centre

Japanese Knotweed by Invasive Species Centre

Invasive Phragmites by Invasive Species Centre

Red-eared Slider by Invasive Species Centre

Zebra and Quagga Mussels by Invasive Species Centre

Goldfish by Invasive Species Centre

House Sparrow by Invasive Species Centre

Emerald Ash Borer by Invasive Species Centre

Forest Health: Beech Bark Disease by UTRCA (Upper Thames River Conservation Authority)

Spotted Lanternfly by Invasive Species Centre

Contact CFIA Online by the Canadian Food Inspection Agency

Spotted Lanternfly by the Government of Canada

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Version History

This page provides a record of edits and changes made to this book since its initial publication. Whenever edits or updates are made in the text, we provide a record and description of those changes here. If the change is minor, the version number increases by 0.1. If the edits involve a number of changes, the version number increases to the next full number.

The files posted alongside this book always reflect the most recent version.

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