Ontario Envirothon Study Guide

Ontario Envirothon

# WILDLIFE

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

FORESTS ONTARIO

**The Ontario Envirothon Modules have been designed to assist students and teachers in preparing for the Ontario Envirothon program.**

Every year, more than 500,000 students, teachers, and families across North America take part in the unique learning experience of Envirothon. Through team-based competitions, Envirothon engages high school students in learning about four main areas of the environment—soils, aquatics, wildlife, and forests. A combination of classroom learning and interactive workshops allows students to strengthen their scientific knowledge of natural ecosystems and develop the foundational skills required to pursue studies and careers in the environmental sciences. Specifically, Envirothon supports students in developing:

- A scientific understanding of natural ecosystems (soils, wildlife, forests, aquatics).
- Practical experience in resource management practices and technologies.
- The ability to apply scientific knowledge and creativity in developing innovative and sustainable solutions to major environmental challenges.
- Stronger communication, collaboration, and problem-solving skills.

The North American Envirothon (NAE), a program of the National Conservation Foundation who partners with 56 provinces and states to coordinate events during which students receive training in essential resource management technologies and practices. This includes tasks such as invasive species monitoring, habitat restoration, water and soil analysis, and forest management. Students are then tested on their ability to apply these practices. In addition, a timely and relevant fifth subject area is chosen each year to accompany the four main areas; a resource guide is developed to prepare students for this subject.

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Reviewed and updated by Ryan Johnstone in June 2020

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# Learning Objectives

## Overall Objectives

Students must be able to:

A. Understand and use identification tools to identify common Ontario mammal, bird, fish, and herptile species
B. Understand and describe the concepts and processes of wildlife ecology, including habitat and community dynamics
C. Understand and describe the impact of humans and human development on wildlife and wildlife ecology, and vice versa
D. Understand and describe practices involved in the conservation and management of wildlife and wildlife resources

## Specific Objectives

Students must be able to:

***A. Understand and use identification tools to identify common Ontario mammal, bird, fish and herptile species***
1. Demonstrate the ability to use a field guide, dichotomous key, or index to identify a variety of wildlife, including but not limited to: insects and larvae (aquatic and terrestrial), reptiles, mammals (terrestrial and aquatic; large and small), birds, amphibians, and fish
2. Identify the presence of wildlife based on a variety of indicators, including but not limited to: scat, eggs, tracks, patterns on trees, sounds and calls, pest evidence, feathers, and nests

***B. Understand and describe the concepts and processes of wildlife ecology, including habitat and community dynamics***
1. Identify specific biotic and abiotic habitat components for common Ontario wildlife species
2. Identify the requirements for survival for common Ontario wildlife species
3. Know and explain why a certain species' habitat requirements might change and describe the changes
4. Understand and describe the concept of carrying capacity with reference to a variety of common Ontario wildlife species
5. Understand and describe succession in terrestrial (bare ground) and aquatic (pond) environments
6. Define predator, prey, herbivore, carnivore, and omnivore, and explain how each of them interact with each other
7. Understand and explain how predator-prey relationships and carrying capacity are related, and provide examples
8. Compare and contrast the difference between adaptable (generalized) and non-adaptable (specialized) wildlife

***C. Understand and describe the impact of humans and human development on wildlife and wildlife ecology, and vice versa***
1. Identify and explain reasons for wildlife habitat loss in Ontario
2. Explain how a change in weather/climate, topography, or land use might modify the process of succession

3. Examine the factors (natural and external) that affect the survival and equilibrium of populations in an ecosystem
4. Understand and describe the effects that climate change has on wildlife ecology
5. Identify Ontario's rare, threatened and endangered wildlife species, as identified by COSEWIC, and explain how selected species were reduced to those levels
6. List examples of wildlife species that are non-native to Ontario
7. Identify and explain how non-native species arrived in Ontario
8. Describe how various non-native species have naturalized to Ontario, and explain if and how they have been harmful

***D. Understand and describe practices involved in the conservation and management of wildlife and wildlife resources***

1. Identify the rights of Ontario's First Nations with regard to wildlife resources
2. Understand and describe how the impacts of climate change on wildlife populations are being mitigated
3. Explain how Ontario's rare, threatened, and endangered wildlife species, as identified by COSEWIC, are being managed to return populations to healthy levels
4. Recommend measures to remove/reduce impact of non-native species on Ontario Ecosystems
5. Interpret a variety of laws, agreements, treaties, etc. that govern Ontario's wildlife resources
6. Identify a variety of major stakeholders and agencies, including federal, provincial and municipal government bodies, that play key roles in the management of wildlife resources in Ontario

## Application/Analysis

**Students must be able to:**

1. Identify wildlife species common to Ontario using a field guide, dichotomous key, or index
2. Classify wildlife as rare, threatened, or endangered species based on COSEWIC status categories
3. Analyse and evaluate population case studies by producing population growth curves for each of the study's populations, and use the graphs to explain how different factors affect population size
4. Identify wildlife signs and describe their significance
5. Identify animals as predators, prey, herbivores, carnivores, or omnivores
6. Identify an area as suitable habitat for certain wildlife species
7. Draw and explain food chains and food webs

## Evaluation/Synthesis

**Students must be able to:**

1. Evaluate and assess a site as suitable habitat for common Ontario wildlife species
2. Describe and evaluate factors contributing to environmental resistance and the carrying capacity of ecosystems
3. Investigate sites for evidence of common Ontario wildlife species
4. Analyse how the change in one species' population can affect the entire ecosystem's food web

# 1.0 Identification Tools

The following tools are recommended resources that can help you better prepare for the Envirothon program.

## Envirothon Guides

**Copies of the Ontario Envirothon Mammal and Bird Identification Guide can be found below:**

- Mammal Identification Guide
- Ontario Bird Identification Guide

## Apps and Websites

**Audubon Guides provides information on the following:**
http://www.audubonguides.com/field-guides/mobile-apps.html

- Insects and Spiders
- Birds
- Mushrooms
- Wildflowers
- Butterflies
- Mammals
- Trees
- Fish
- Reptiles and Amphibian

## Additional Resources:

- Nature Tracking – iTrack Wildlife
- The Cornell Lab – All About Birds of North America
- iNaturalist
- eBird
- Ontario Nature
- Birds Canada
- Federal - Species at Risk
- Provincial – Species at Risk

# 2.0 Wildlife Ecology

## 2.1 Introduction

Ecology is a natural science field that explores the relationship between living organisms and their **biotic** and **abiotic** surroundings. Wildlife ecology is a branch of ecology that investigates the relationship between anthropogenic systems and wildlife, with the goal of understanding these interactions. In order to better manage **populations**, it is important that we recognize wildlife and society are interconnected. Population management focuses on the individual within the population and takes many forms including reduction (e.g., hunting) or re-introduction (e.g., captive breeding) techniques.

We define wildlife as the collection of all animals that grow and live outside of captivity in a specific ecosystem. The species that compose this grouping can change depending on the geographic scale being considered – the wildlife in north America is very different from the wildlife in our own backyards. Therefore, wildlife includes vertebrates such amphibians, reptiles, fish, mammals, birds, and invertebrates such as terrestrial or aquatic insects. Within the scientific community the term wildlife is commonly only applied to fauna (animals) and not flora (plants), however this has been challenged by some modern definitions which include both. In addition, domestic animals (i.e. cows and pigs) that have become wild, or feral, are typically not considered wildlife.

All government and non-government wildlife management agencies in Canada have an interest in wildlife populations, however, their jurisdiction typically dictates what populations they manage. For instance, herptiles (reptiles and amphibians), fish, and terrestrial mammal populations are often monitored at the provincial and municipal level, whereas migratory birds and international fisheries (i.e. The Great lakes) are managed at the federal level. Non-government agencies are involved across jurisdictions. Regardless, all entities are committed to the conservation of wildlife and use varying definitions of the term. As our societies evolve, we have begun to express a wider range of perspectives and opinions regarding the value of animals, and as a result the term wildlife has become more inclusive. The beauty of such a fluid definition allows the user to apply the term subjectively – it can include all vertebrate and invertebrate life that is wild.

Regardless of the definition of wildlife used, it is known that all wild organisms require resources for the persistence of their species. These resources are grouped together in areas known as **habitats**. Animals are **adapted** to their environment and therefore have specific habitat requirements that may be similar or different from **interspecific** species, resulting in overlap with other animal’s needs. Animals with overlapping requirements can sometimes find themselves in competition for limited resources (i.e. interspecific competition). The resources available in a habitat determine species abundance and distribution, and when in short supply they can be the **limiting factor** (ECCC, 2013a). Habitat is comprised of four components: Food, Shelter, Water and Space.

**Food** – food is a requirement to meet an animal’s energy demands for various processes, such as growth, reproduction, predatory avoidance, and survival during long winters or migrations. Certain species are more specific regarding what food items they invest time into locating and consuming (i.e. **specialist** vs. **generalist** species**)**.
**Shelter** – shelter is used by animals to protect themselves from the elements, avoid predation, or raise their young. Dense vegetation is a common form of cover, but downed woody debris, cavities, pits, mounds, and rock piles can also serve similar purposes.
**Water** – water is an essential requirement for all living organisms. Certain species obtain water from their diet/food and some are required to ingest it directly. Like humans, wildlife species are unable to survive without water as it forms the basis of their biological functions.
**Space** – animals require space to survive. Overcrowding increases competition for food, cover, and water, and can also lead to the rapid spread of disease or parasites. For example, moose (*Alces alces*) require dense forests to raise and protect newborn calves, while bald eagles (*Haliaeetus leucocephalus*) require large trees to raise their young.

Ultimately, the individual is influenced by intrinsic and extrinsic factors which cause populations to fluctuate. Populations are typically driven by the available resources (**carrying capacity**), predators, disease, and **environmental stochasticity**. It is important to note that constant population size is not typically observed in the natural world without human intervention.

## 2.2 Habitat Types

There are various habitat types in Ontario that support a diversity of wildlife. These habitats can be grouped into one of two categories: terrestrial or aquatic. Terrestrial habitats include forests and grasslands which are characterized by various species of trees, shrubs, and grasses. Aquatic habitats include lakes and wetlands that are characterized by surface waters which support unique vegetation that is adapted to living in or near these inundated environments. Below are examples of significant habitat types that are common in Ontario.

### 2.2.1 Wetland Habitat

Wetlands are considered transitional habitats, forming the connection between aquatic and terrestrial ecosystems (MNRF, n.d.). They include a variety of sub-habitats such as bogs, swamps, marshes, and fens (Figure 1). Each of these are unique in their own way and can be characterized by their distinct composition of wildlife and vegetation communities.

**Figure 1** – Wetland in Algonquin Park (Hands, n.d)

Wetlands are valuable habitats on the landscape and perform many functions that improve the quality of water. They filter suspended sediments from water columns, absorb nutrients, contain and mitigate harmful chemical compounds, and drastically reduce the chances of, and damage from flooding and erosion (Minister of Public Works and Government Services Canada, 2004). Additionally, wetlands provide essential habitat for a number of fish and wildlife species, including many species at risk that rely on wetlands during all or part of their lifecycles.

Wetlands of various sizes support different types of **hydroperiods** which are utilized by different wildlife species. Generally, larger wetlands have several different habitats within, supporting an increased diversity of wildlife species (Minister of Public Works and Government Services Canada, 2004). Large wetlands can support mass amounts of migrating waterfowl in the spring and fall, serving as **staging areas**. Small wetlands are used by spawning fish during the early spring, and vernal ponds are important breeding sites for several amphibian species and resident waterfowl. All wetlands, no matter their composition, play an important role on the landscape by providing wildlife with essential habitat throughout their annual cycle.

For more information about wetlands refer to the Ontario Envirothon Aquatics Module.

### 2.2.2 Forest Habitat

**Figure 2** - Northern Goshawk (Delaney n.d.)

Forests make up a significant portion of Canada, covering approximately 3.5 million km$^2$ (Dyk et al., 2015) and are home to many species of terrestrial plants and animals. A forest ecosystem's ability to support wildlife depends on the amount of forest cover, size of individual forest patches, forest type, and linkages to other natural landscapes. Therefore, it is important that forest ecosystems maintain a certain level of connectedness across the landscape.

In Ontario, there are four main forest regions, including the Hudson Bay Lowlands in the far north, the boreal forest which spans across northern Ontario, the Great Lakes-St. Lawrence region with includes southern and central Ontario, and the deciduous forests of southern Ontario (MNRF, 2014a). These forest regions directly influence the wildlife that inhabit them. For example, the Hudson Bay Lowlands is home to various arctic mammals including the artic fox (*Vulpes lagopus*) and polar bear (*Ursus maritimus*), whereas the boreal forest and Great lakes St. Lawrence regions are home to similar species such as black bears (*Ursus americanus*) and gray wolves (*Canis lupus*). Within these forest regions there is a large diversity of bird species, though most notably within the deciduous and boreal forest regions (MNRF, 2014a). Our understanding of the habitat requirements and distribution of forest wildlife is considerable. Although, we have comparatively more knowledge of forest birds than any other group of wildlife (Figure 2), which is why they are most often used as an indicator for assessing forest health (Minister of Public Works and Government Services Canada, 2004).

For more information about forests refer to the Ontario Envirothon Forestry Module.

### 2.2.3 Grassland Habitat


**Figure 3** - Bobolink (Wilson, 2018)

Grasslands are complex habitats that play a vital role on the landscape for maintaining wildlife populations in Ontario, and across Canada. They provide animals with a unique habitat and supply a variety of resources. Grasslands are used by a diversity of wildlife, including both vertebrates and invertebrates. They provide nesting and nursery habitat for small mammals and birds, such as the meadow vole (*Microtus pennsylvanicus*) and mallard (*Anas platyrhynchos*). Grasslands also provide food resources for a variety of consumers, including hunting grounds for red fox (Vulpes Vulpes) and grazing habitat for white-tailed deer (Odocoileus virginianus). Most notably, grasslands act as refuge for threatened species of songbirds, such as the bobolink (Figure 3; *Dolichonyx oryzivorus*) and eastern meadowlark (*Sturnella magna*; McCracken et al., 2013) Grasslands also provide ecosystem integrity by maintaining soil microbe communities that are important for vegetative growth, and reduce the effects of landscape erosion (Ducks Unlimited, 2020). Unfortunately, we have seen a drastic decline in grassland habitat following European settlement, primarily driven by intensified agricultural practices (McCracken et al., 2013).

### 2.2.4 Riparian Habitat

The riparian zone is the habitat within a stream corridor or valley, particularly the interface of trees and shrubs between the stream and land. Riparian vegetation serves a number of functions such as bank stabilization, physical and chemical pollutant filtration, and shading to help regulate in-stream water temperature. Riparian habitats appear in many forms such as wetlands, forests and vegetation buffers along streams and rivers (Figure 4). The various forms of riparian zones serve a critical role in maintaining habitat function and connectivity by providing habitat and travel corridors for terrestrial and aquatic wildlife (Minister of Public Works and Government Services Canada, 2004). In Ontario, there are a number of species of wildlife that benefit from riparian habitat including river otters (*Lontra canadensis*), muskrat (*Ondatra zibethicus*), brown trout (*Salmo trutta*), and white-tailed deer (*Odocoileus virginianus*) which utilize the water source or vegetation community. In addition, there is a wide variety of birds and invertebrates that can be found in riparian zones (Mayntz, 2018).


**Figure 4** - (left) Satellite image of riparian corridor in agricultural dominated landscape, in St. Jacobs, Ontario (Google Earth 2020); and riparian habitat at ground level in southwestern Ontario (DailyTrib, 2018).

## 2.3 Biodiversity

Biodiversity is a measure of the variety of living species within a specific ecosystem, or the earth and is measured in relation to species diversity, genetic diversity, and ecosystem diversity. Ontario is home to a variety of species, and as humans we depend on high biodiversity for clean air and water, food and fibre, tourism, and outdoor experiences. Alternatively, low biodiversity threatens our food supplies, medicines, and energy sources. It is important we recognize that as a society, we have the power to manipulate biodiversity, whether to our advantage or detriment. Ultimately, it is in our own self-interest to protect biodiversity in the areas in which we live and preserve the interconnectedness of the ecosystems that we are part of.

The preservation of biodiversity has ecological benefits. Biodiverse systems experience increased redundancy and resiliency, providing stability to the ecosystem. Redundancy occurs when more than one species performs the same vital ecosystem function, if one species is removed there is another species to fill the role. Resiliency is the ability of a species to recover from, or resist the impacts of, natural or anthropogenic disturbance. Biodiversity plays a crucial role in ecosystem resiliency and redundancy by supporting the reorganization of community structure following a disturbance. Ecosystems with naturally low biodiversity are not necessarily at a disadvantage. However, when an ecosystem with naturally high biodiversity is reduced by human disturbance the results can be disastrous. Threats to biodiversity are discussed in section 3.2 Threats to Wildlife. The relationship between biodiversity and ecosystem resilience and redundancy is vital for the persistence of balanced ecosystems.

**DID YOU KNOW?**

Ontario is home to hundreds of vertebrate species, including more than 80 mammal species, over 470 bird species, about 60 reptile and amphibian species, more than 160 fish species, and over 20,000 species of insects, spiders, and other invertebrates. There are more than 3,380 species of plants, over 1,000 species of fungus and algae, and hundreds of species of lichens and moss. (Ontario Biodiversity Strategy, 2011).

## 2.4 Food Chains and Species Interactions

Within an ecosystem there are food webs and **food chains**. Food webs are composed of many inter-connected food chains that interact at one or several levels. Thus, food webs can be simplistic or extremely complex. Regardless of their complexity, the basic operation and format of these food systems is dependent on the organisms involved and their **trophic level** (Figure 5).

Organisms that produce energy from inorganic compounds are called primary producers and they make up the base, or the first trophic level, of any food chain. Plants are good examples of primary producers, utilizing carbon dioxide and energy from the sun they produce oxygen and complex sugars using a process known as photosynthesis. Primary consumers, commonly known as **herbivores**, are animals which are anatomically designed to feed on primary producers (e.g. white-tailed deer consuming clover).

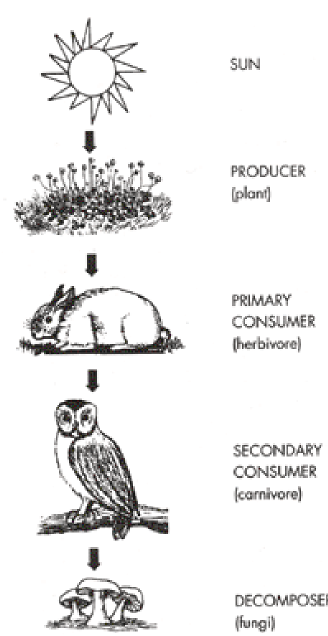


**Figure 5** - Simple Food Chain (Clipart, n.d.).

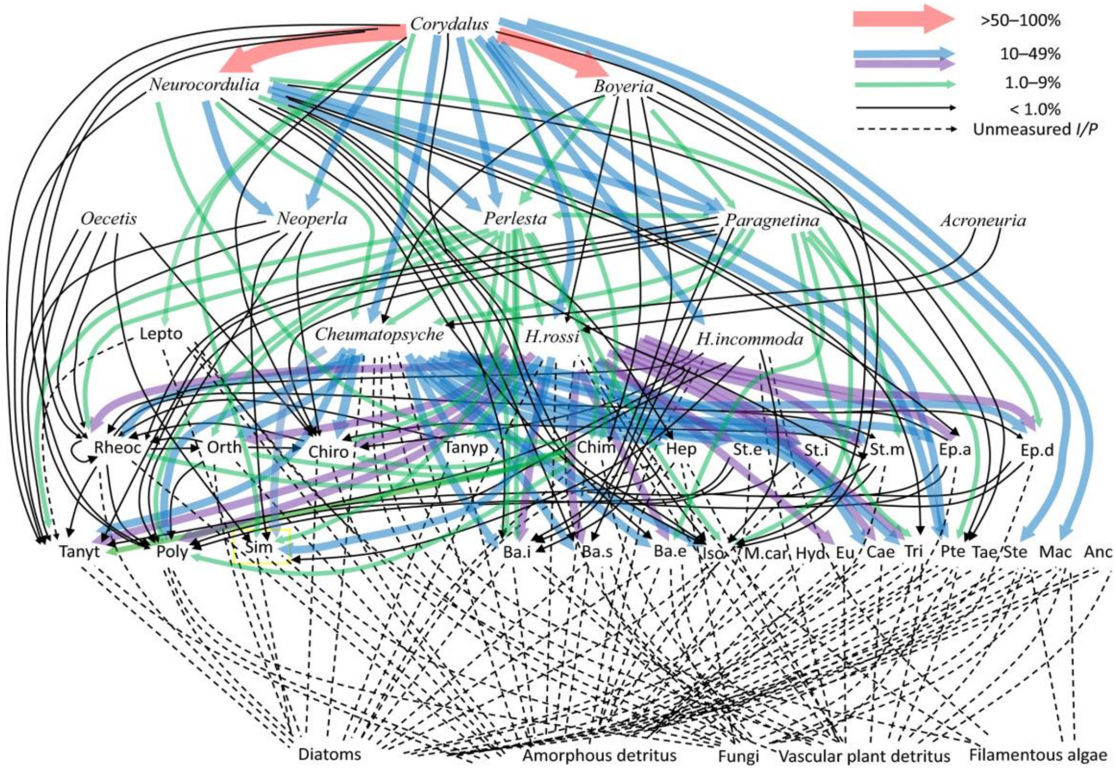


**Figure 6** - Illustration of a complex food web that highlights ingestion/production relationships of aquatic invertebrates in a riverine habitat. Thickness of arrows indicates proportion of prey ingested by predator (<1 to 100%). Dashed lines show direct connections to producers (Benke 2018)

As you progress along the food-chain there are secondary and tertiary consumers. Some of these consumers are **carnivores**, animals which are anatomically designed to feed on other animals (e.g. wolves). Within this category there are two classifications, carnivores can be predators that hunt and kill other animals; or scavengers, which feed on the carcasses and remains of already dead animals. Lastly, **omnivores** are animals which feed on both plant and animal matter (Schraer & Stoltze, 1993). Omnivores can be either secondary or tertiary consumers (e.g. bears).

An ecosystem with a high level of biodiversity will consist of complex food webs with a variety of species at all trophic levels. The many interconnected food chains are an accurate representation of the species relationships and interactions in an ecosystem (Khan Academy, n.d.). Typically, food webs will include a vast amount and variety of plant species, a moderate number of herbivore or prey species, and two or three top carnivores. Ecosystems with lower biodiversity contain less species in total, and therefore have more simplified food webs. Generally, these food webs will consist of fewer primary producers and herbivorous species, and a single top carnivore.

### 2.4.1 Species Interactions

Within ecosystems and the complex food webs that compose them, animals are constantly interacting with their habitat and each other. There are two categories of animal interactions and it is important to differentiate between them. Intraspecific interactions occur when animals of the same species are in contact with one another. An example of this may be territorial defense of habitat or breeding. Alternatively, interspecific interactions occur when two different species are in contact with one another. A common example is the predator/prey relationship.

Within interspecific interactions there is symbiosis which is the close and long-term interaction between animals. This is further broken down and classified by the outcomes of the relationships observed. Three common outcomes of symbiotic relationships are mutualism, parasitism, and commensalism (Table 1).

**Mutualism:** Mutualism occurs when each individual species involved in the interaction benefits. The animals work together, directly or indirectly, and each benefit from the relationship. An example of a mutualistic relationship is the pollination of flowers by bees. Bees fly from flower to flower gathering nectar, which they convert into food. During this process, they also act as a vector of transport for pollen, helping to pollinate the plant aiding in their reproduction.

**Parasitism**: Parasitism is a non-mutual relationship between animals in which one organism benefits at the expense of the host organism. During such interactions, a parasite attacks a host and lives on or in the organism, typically causing harm to the host. One such example is the deer tick, which feeds on the blood of deer while potentially infecting the deer with a variety of diseases.

**Commensalism**: Commensalism is when one animal benefits while the other is not affected. The benefits in a commensalism relationship for an organism may be food, shelter, transportation, or dispersal. One example of commensalism is the attachment of barnacles to whales. The barnacles benefit by being transported from one area to another and are provided with access to new resources, while the whale is unaffected by their presence.

**Table 1** - Simplistic species interactions table indicating the outcome for the individuals. (+) Indicates a positive outcome, or gain; (-) indicates a negative outcome, or loss; (0) indicates a neutral outcome, neither gain nor loss.

| Interaction | Species 1 | Species 2 |
|---|---|---|
| Mutualism | + | + |
| Parasitism | + | - |
| Commensalism | + | 0 |

## 2.5 Population Dynamics

In ecology, the term population dynamics refers to how the size and distribution of wildlife populations change over time (Figure 7). These changes are often a reflection of intrinsic or extrinsic factors acting on the many individuals that make up a population and alter their habitat. An example of an intrinsic factor that affects the population is disease. An extrinsic factor that affects the population may be increased or decreased hunting pressure, extreme variations in climatic conditions, or anthropogenic interference. Due to these pressures, populations of wildlife species fluctuate annually. It is important to understand these population dynamics so that we can identify when problematic change has occurred. For instance, a dramatic drop in population size can indicate disease outbreak within a species. Inversely, unusual spikes would suggest an increase in population size, which may spark interspecific competition. Ultimately, it is changes in population that are not consistent with long-term trends which require investigation.

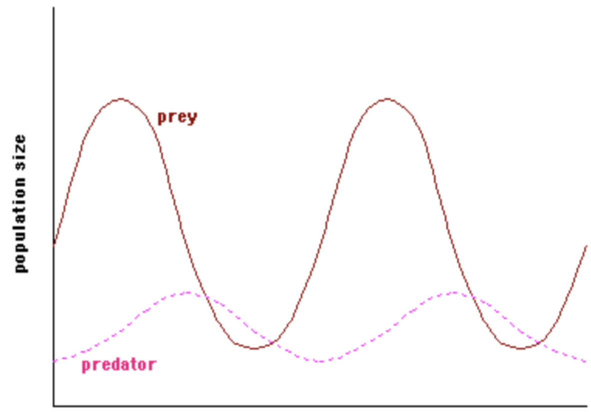

**Figure 7** – Theoretical predator-prey population dynamics over time (Beals et al. 1999).

Investigating the carrying capacity of a habitat is a practical approach for understanding population dynamics as it can tell us the maximum number of individuals that a habitat can support without collapsing. Once population reaches or extends beyond capacity, we typically observe a drastic decline or "crash". However, there are circumstances where populations do not collapse immediately but over a prolonged period of time. This is typical of a generalist population who can temporarily adapt or alter their resource requirements. Fortunately, immediate collapse of populations as a result of exploiting carrying capacity is uncommon as natural predator-prey relationships often regulate population numbers which prevents them from exceeding carrying capacity (Figure 8). Similarly, the predator population is also kept in check by the abundance of the prey population and fluctuates accordingly. It is evident that predator-prey relationships are essential in regulating populations and therefore preventing their collapse by exceeding the carrying capacity of the ecosystem (McGraw-Hill Companies, n.d.).


**Figure 8** - The alpha male of the former Chippewa Harbor wolf pack standing over a moose carcass on Isle Royale, Michigan (Mihell 2018).

# Case Study – Wolves and Moose on Isle Royale

Diversity in wildlife populations is a common indicator of ecosystem health and is important for all species. Therefore, understanding biodiversity and the dynamics of the underlying populations that compose it is crucial for maintaining healthy, resilient ecosystems. A common example of interspecific species interactions and the role it plays in population dynamics is the predator/prey relationship observed between moose (*Alces alces*) and gray wolf (*Canis lupis*) populations on Isle Royale during the early 20th century. This relationship highlights the interplay between populations of different species in confined habitats.

In 1915, Isle Royale in Lake Superior was ideal moose habitat, rich in aquatic vegetation and shrubs with approximately 200 moose inhabiting the island. Without any predators present, the moose population grew substantially, reaching numbers well over 5,000 individuals by 1928. As a result, it was reported one year later that vegetation resources had been drastically depleted. With such a large moose population, the island was incapable of providing enough food, and starvation and disease ensued (McGraw-Hill Companies, n.d.). By 1941, the moose population had collapsed and was composed of 171 individuals.

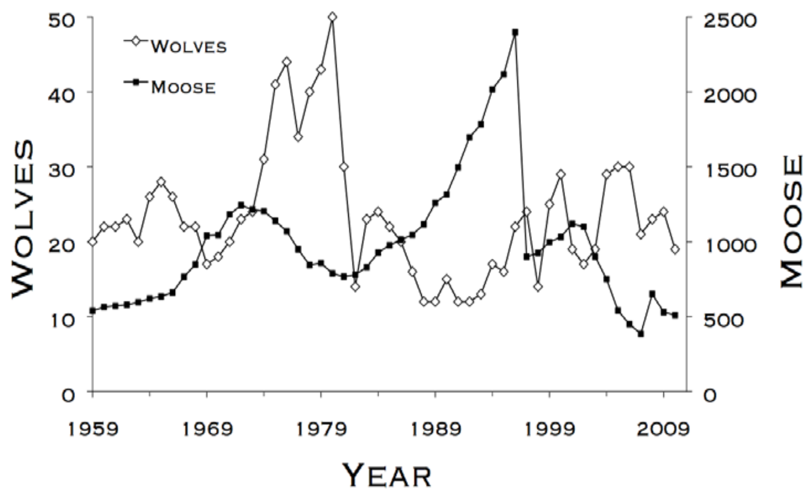


**Figure 9** - Five Decades of Fluctuating Wolf and Moose Populations (Vucetich, 2012).

Wolves are natural predators of moose and began to appear on Isle Royale in the early 1940s (Figure 9). Both wolf and moose numbers fluctuated annually based on food supply. With predators present though, the moose population did not drastically increase such like it had in previous years. The wolf and moose populations fluctuated sinuously such that as wolf population grew the moose population decreased due to predation, forcing the balance of wolf-moose population dynamics to shift. Eventually, the wolf population dropped from 50 individuals in 1982 to only 12 by 1988. The wolf population increased once more in the late 1990s.

Scientists speculated the shift in the wolf population could be the result of a variety of factors:

1. Wolf food supply was inadequate with younger, stronger moose being more difficult to catch;
2. Disease may have been introduced by canines from the main land; and/or
3. With a small initial population, inbreeding depression may have occurred leading to defective genes, suppressing reproduction viability and increasing mortality.

This study highlights the many factors that influence population dynamics including genetics, resources, disease, and the species diversity of a system. The study further highlights the tremendous influence of symbiotic relationships, and the importance of understanding biodiversity and population dynamics (McGraw-Hill Companies, n.d.).

## 2.6 Indicator Species

An indicator species is an animal whose presence and/or abundance suggests specific environmental conditions and ecosystem health. Indicator species serve as valuable assessment tools and can show a change has occurred in the biological conditions of a particular ecosystem. By studying indicator species, scientists are able to assess the health of an ecosystem (Jaffe et. al., 2012). Examples of indicator species include:

**Invertebrates:** Terrestrial and aquatic invertebrates serve as valuable indicators for ecosystem health. Their relatively short life-spans, distinctive and established life stages, and relative abundance allows us to investigate changes in habitat structure and function. Honeybees and butterflies are pollinators that indicate and strongly influence the health of plant populations. They are highly sensitivity to a plethora of factors, including temperature and weather; parasites; as well as air, water, and soil quality. Each of these factors can help us assess the overall health of an ecosystem (Elizabeth, 2019). In addition, benthic macro-invertebrates are heavily dependent on sediments in aquatic ecosystems and readily accumulate pollutants and toxins through consumption (Pastorino et al. 2020).

**Fish:** Fish serve as unique indicators of pollution and ecosystem health, not only through presence and abundance, but through biological sampling. Fish have predatory feeding habits, and an entirely aquatic life cycle which makes them vulnerable to **biomagnification** and **bioaccumulation** of toxicants and pollutants (Chovanec et al., 2003).

**Amphibians**: Amphibians are useful tools for assessing environmental contamination and pollution, ecosystem health, and habitat quality (Waddle, 2006). Their soft eggs, semi permeable skin, dependence on moist semi-aquatic environments, predatory feeding habits, and amphibious life cycles make them vulnerable to changes on both land and in water. In addition, they are often found in abundance. As a result, amphibians are often used to monitor and track changes in water quality and overall environmental health (Elizabeth, 2019).

**Mammals:** Mammals can be used as bioindicators because they inhabit a variety of terrestrial and aquatic ecosystems. They are direct connections to their environment and exhibit various behavioural strategies, providing insight into prolonged change and contamination of their habitat (Sutherland et al., 2018). The health of individuals is representative of their diets, which makes them vulnerable to environmental contaminants but allows us to assess the health status of ecosystems and populations. For example, the American mink (*Neovison vison*) has been used to monitor the effects of PCBs in both terrestrial and aquatic habitats (Sutherland et al., 2018).

**Birds:** Avian species can serve as indictors of ecosystem health in a variety of ways, including presence/absence, abundance and density, and reproduction rates (Chambers, 2008). The presence of particular species is used as an indicator of forest health and maturity (Egwumah et al., 2017). Similarly, the overall health of a system may be interpreted as a result of nesting success. In addition, birds can be used to monitor the health of systems that are inaccessible or too large. For example, plastic waste levels have been assessed in the Great Lakes by exploring consumption of plastics in aquatic foraging birds (Sigler 2014, Krantzberg, 2019).

## 2.7 Seasons and Wildlife

In North America, wildlife are exposed to annual, seasonal changes commonly referred to as the four seasons. These annual changes can have significant impacts on wildlife behaviours. Across species, we see many adaptations to account for extreme changes in local climate. Two very common behavioural adjustments that animals have adopted in response to seasonal climatic change are migration and hibernation. There are several variations within these two major behavioural responses that are observed among and between different species.

### 2.7.1 Migration

Migration has been adopted by individuals and populations with the ability to temporarily relocate. Migration is commonly defined as the annual or seasonal movement of animals from one area to another. Migration takes many forms (e.g. direct vs indirect) and does not always include every individual in a population. Typically, individuals or populations are migrating to avoid harsh environmental conditions, to find resources (food and shelter), or travelling to safer breeding grounds (Parry, 2010). A variety of species from all animal groups throughout North America exhibit migratory behaviour. We observe migration via flight, water, and land; and these patterns may be latitudinal (north to south), longitudinal (east to west), or altitudinal (up to down) to varying distances.

#### *Bird Migration*

Approximately 450 bird species in Canada are considered to be 'migratory' (ECCC, 2014a). The general trend observed among migratory birds is a latitudinal, long-distance migration. Many of these birds migrate south in the early fall towards more favourable environmental conditions and abundant food supplies. The individuals will return in the spring to breed and raise their offspring. However, not all birds conform to this habituation. Some species of birds are short distance migrants or do not migrate at all such as the Canada goose (*Branta canadensis*). This population exhibits short distance migrations, or no migration depending on the **sub-species**. Other species exhibit extremely long-distance migration, such as the arctic tern (*Sterna paradisaea)*, whose journey often spans from the North Pole to the South Pole (The Arctic Tern Migration Project, n.d.). In addition, various songbirds, waterfowl, and shorebirds will overwinter as far as South America, and as north as New York State. Examples of Ontario migratory birds include:

- Arctic tern (*Sterna paradisaea*) – Circumnavigation
- Canada warbler (*Wilsonia canadensis*) – Latitudinal, long distance
- Canada (Gray) Jay (*Perisoreus canadaensis*) – Non-migratory
- Common Eider (*Somateria mollissima*) – Longitudinal, short distance
- Black-capped Chickadee (*Poecile atricapillus*) – Latitudinal, short distance

For a complete list of Ontario's migratory birds, check out Birds Canada's Migratory Landbird report at http://www.bsc-eoc.org/download/StateofONbirds.pdf.

## North American Flyways

No two bird species travel the exact same migration route or distance, and many migration routes have varying levels of complexity. However, bird migrations are often restricted to land masses and follow landscape features such as coast lines, mountain ranges, and large river systems. In North America, we track and monitor migration using various technologies because understanding where and when birds are migrating is crucial for their conservation. The conventional approach used for managing migratory waterfowl populations are the North American Flyways (Figure 10). The flyways were defined using traditional **mark-recapture** techniques and now characterize waterfowl migration travel routes (Ducks Unlimited n.d.). There are four distinct flyways: the Atlantic, Mississippi, Central and Pacific flyway. These routes vary in landscape characteristics, habitat, and food requirements.


**Figure 10** - North American Flyway delineation map (Ducks Unlimited, n.d.).

## Ontario's Mississippi Flyway

The province of Ontario is often considered part of the Mississippi Flyway This flyway is abundant in waterbird species, as Ontario provides valuable nesting habitat and stopover sites. The general landscape composition of this flyway is flat with no significant ridges, mountains, or hills (The Nutty Birdwatcher, 2001). This flyway encompasses all of Ontario including the entirety of the Great Lakes, and the Canadian segment of the Mississippi river system (Ducks Unlimited, n.d.). Nearly half of all North American bird species spend some time on the Mississippi flyway, including the mottled duck (*Anas fulvigula*), little blue heron (*Egretta caerulea*), and brown pelican (*Pelecanus occidentalis*; Audubon, 2015). Common Ontario waterfowl species in the Mississippi Flyway are mallards (*Anas platyrhynchos*), tundra swans (*Cygnus columbianus*) and common goldeneye (*Bucephala clangula*).

### *Mammal Migration*

Migration is not only observed in birds – many mammal species migrate as well. This includes marine mammals such as seals and whales, flying mammals such as bats, and terrestrial mammals such as caribou (*Rangifer tarandus caribou*) and polar bears (*Ursus maritimus*). Many arctic mammals are forced to migrate due to the seasonal melting and forming of ice (Ontario Parks, 2014). The migration of bats in Canada is triggered by cool fall temperatures, which forces them to travel to either caves, warm tree cavities, or further south in order to pass the winter months (Hinterland, 2005). Some common examples of Ontario's migratory mammals include:

- Hudson Bay Polar Bear (*Ursus maritimus*)
- Beluga Whale (*Delphinapterus leucas*)
- Barren-ground Caribou (*Rangifer tarandus groenlandicus*)
- Little Brown Bat (*Myotis lucifugus*)

### *Invertebrate Migration*

While many invertebrate species found in Ontario have developed strategies to withstand the cold including dormancy, adaptive cellular-level 'antifreeze', or die-offs leaving dormant larval stages over the winter (McDonough, 2011) some have found avoiding the winter entirely to be the most effective strategy. Migratory invertebrates include beetles, dragonflies, butterflies, and moths. Migratory invertebrates often travel by flight from Canada to the southern United States. One well known example, the monarch butterfly (*Danaus plexippus)*, makes long distance migrations travelling as far south as Mexico (NCC, 2019).

Some common examples of Ontario's migratory invertebrates include:

- Green Darner (*Anax junius*)
- Giant Swallowtail Butterfly (*Papilio cresphontes*)
- Black Saddlebag (*Tramea lacerata*)

### *Fish Migration*

A common aspect of fish **phenology** that is often overlooked is migration. Similar to other classes of vertebrates and invertebrates, migration plays an important role in fish population dynamics. There are several different stages of fish migration that are characterized as long or short distance movements, though all of which are required for successful completion of their life cycle (Smith, 2012). **Catadromous** and **anadromous** migrations are two common types of fish migration observed during spring and fall spawning periods. Another type of migration to consider is the movement of fish from shallow to deep water, and vice versa. This can occur during the winter when the dissolved oxygen levels become depleted due to high biological oxygen demand in shallow areas, or during the summer when shallow waters become warm.

#### Salmonid Migration

In Ontario, several of our native salmonid populations migrate in the fall to spawn, including brook trout (*Salvelinus fontinalis*) and Atlantic salmon (*Salmo salar*). Non-native established populations of rainbow trout (*Oncorhynchus mykis*s) migrate upstream in the spring to spawn. This annual migration is not only vital for maintaining the fisheries population, but it also holds a social and traditional values in the hearts of many outdoors enthusiasts and Indigenous communities.

## 2.7.2 Hibernation

Animals that cannot migrate have adopted their own strategies for survival during the changing seasons. **Hibernation** is a practical alternative in which animals enter a state of highly reduced metabolic activity and lowered body temperature (Encyclopaedia Britannica, 2018). In Ontario, and the northern hemisphere, animals that have adopted hibernation as their tactic for combatting relatively extreme seasonal variations in temperature and weather can slow their metabolism and use only stored energy sources to survive the winter (Scientific American, 1997). They remain in their dormant state in a **microhabitat** known as a **hibernaculum**. We often use the term hibernation very generally and apply it to all types of winter dormancy observed in herptiles, fish, mammals and invertebrates. However, there are many different types of hibernation, and depending on the species, there are variations of these methods. Most commonly we observe true hibernation and torpor in mammals, brumation in herptiles, and diapause in insects.

### *Hibernation and Torpor*

The incorrect use of the term hibernation results in confusion and makes understanding this concept more challenging than necessary. In ecology, we less frequently use the term torpor. These two words describe similar patterns exhibited by animals, though they are distinct in and of themselves. Torpor is when an individual intentionally reduces their metabolic activity process and lowers their body temperature. Daily torpor is characterized by a reduced metabolism and low body temperatures with continued, intermittent foraging and activity. Conversely, true hibernation is a prolonged state of torpor lasting up to several weeks in which the animals do not forage and rely on energy reserves and food caches within their hibernacula (Ruff and Gesier, 2015). Based on these accepted definitions, the only Ontario mammals that are true hibernators are our bat species and the woodchuck (*Marmota monax*). Bears are not considered true hibernators because they exhibit characteristics of daily torpor. A comparable adaptation to hibernation is **estivation**, in which animals enter prolonged dormancy during extremely dry and summer months.

### *Brumation*

In general, herptile species have a similar strategy for winter survival as they too enter a period of prolonged dormancy known as brumation. However, this strategy is characteristically different because they are **ectotherms**, or cold blooded. Therefore, herptiles cannot regulate their body heat and rely entirely on the ambient temperature of their surroundings during dormancy. Unlike the occasional arousal observed in true hibernating mammals, this tactic forces herptiles to remain completely dormant, or torpid, for the entire length of the winter (Wilkinson et al., 2017).

**Figure 11** - Eastern garter snake (Crowley n.d.)

In Ontario, we have both terrestrial and aquatic reptiles and amphibians such as the common snapping turtle (*Chelydra serpentina*), spotted salamander (*Ambystoma maculatum*), and eastern garter snake (*Thamnophis sirtalis*). All of these species have very different strategies for winter survival. Snapping turtles, and many other turtles will burrow into the mud at the bottom of wetlands. Inversely, the spotted salamander will brumate in small burrows under decomposing organic material. Garter snakes (Figure 11) will congregate at hibernacula burrows where they will brumate in large groups to maintain body temperatures and avoid freezing. These different tactics provide the herptile with a warm, moist microhabitat that helps them maintain their body temperature and avoid **desiccation**.

### Wood frog

The wood frog (Figure 12; *Lithobates sylvaticus*) is an **endemic** woodland frog species in North America whose populations range from northern Alaska to the east coast of Canada and the United States.


**Figure 12** - Wood frog (DeWay, 2020).

The wood frog, and many other temperate woodland frogs though to a lesser extent, has a unique adaptation – their bodies produce antifreeze. Wood frogs freeze-tolerance is associated with their ability to produce high concentrations of **cryoprotectants**, glucose, and/or glycerol, and urea which are produced in and mobilized from glycogen in the liver (Costanzo et al., 2014). These compounds limit freezing injury by lowering the equilibrium freezing/melting point of body fluids which preserves the integrity of cell membranes, reducing ice formation and avoiding cell rupture due to expansion (Costanzo et al., 2014).

### *Diapause*

Insects and other invertebrates are often left out during discussions of hibernation; however, they too undergo periods of dormancy. Though there are various types of inactivity observed in insects, dormant behaviours known as diapause are used as a survival technique in response to seasonal variation (Hadley, 2020). Diapause, similar to hibernation and brumation, is an insect's natural response to changes in environmental factors (e.g. day length, food, temperature) in which the insect enters a prolonged period of dormancy (Hadley, 2020). Ultimately, this adaptation helps the individuals survive extended periods of unfavorable conditions.

| | Duration | Example Species |
|---|---|---|
| **Daily Torpor** | • Short, intermittent periods of dormancy with activity and foraging bouts<br>• Self-regulated body temperature | • Bears |
| **Hibernation (Prolonged Torpor)** | • Prolonged dormancy with no activity or foraging<br>• Self-regulated body temperature | • Woodchuck<br>• Bats |
| **Brumation** | • Prolonged dormancy with no foraging<br>• Ambient temperature regulation | • Turtle<br>• Snakes |
| **Diapause** | • Prolonged dormancy with no foraging<br>• Ambient temperature regulation | • Insects |

# Discussion Questions

1. How is wildlife defined in this guide? Do you agree with this definition? If not, how would you change it?
2. List and describe the four components of habitat.
3. Why might species be managed based on physiological capabilities?
4. How can population dynamics be used to monitor wildlife populations?
5. Explain the terms “redundancy’ and “resiliency” in relation to biodiversity. How do these concepts contribute to ecosystem stability?
6. Describe the characteristics of hibernation, torpor, brumation & diapause.

# 3.0 Humans and Wildlife

## 3.1 Global Change

Humankind is a significant geologic force that is driving the conversion of landscapes and manufacturing products that are not produced naturally (Crutzen, 2006). As a global society we are consuming resources at rates which exceed the earth's natural ability to replenish, and impeding ecosystem function in the process. As a result of these behaviours this recent era of industrialization has been named the "Anthropocene" (Crutzen, 2006).

If our current habits continue, five major changes are expected to occur around the globe (Table 2). These changes will not only impact Ontario's biodiversity, but biodiversity at global scales, potentially leading to a massive decline in the number of plant and animal species. However, there is hope for the future of biodiversity. Vast improvements in technology, paired with careful use and management of natural resources, and effective restoration of the natural environment are some of many ways to counter the progression of impacts that Anthropocene activities have on our natural world.

**Table 2** - Impacts of Global Change on Biodiversity (Sage 2019)

| Expected Changes | Impacts of Changes |
|---|---|
| 1. Atmospheric Carbon Dioxide Enrichment | • increased photosynthesis<br>• faster plant growth<br>• reduced transpiration<br>• increased occurrence and intensity of fire<br>• increased competition for water, food, and nutrients. Changes in forage quality<br>• ocean acidification and decrease in calcification |
| 2. Climate Change<br>*Forecasted warming of 7-8°C in Ontario in the long-term* | • drier soils<br>• warmer winters<br>• disruptions of natural cycles<br>• increased frequency & intensity of storms<br>• altered photosynthesis |

| | |
|---|---|
| 3. Land Use Change | • changes in agricultural production<br>• reduced diversity of crops<br>• increased occurrence and intensity of fire |
| 4. Terrestrial Eutrophication<br>*An expected increase in the amount of terrestrial nitrogen through use of fertilizers* | • increased growth of weeds<br>• reduced biodiversity due to the lack of ability to compete with weeds |
| 5. Invasive species | • infection and/or consumption of natives species<br>• loss of species<br>• altered hydrology of an area<br>• altered soil properties<br>• altered regional climate<br>• altered disturbance regimes |

The impacts of global change and the current state of the Anthropocene could ultimately have devastating effects on biodiversity. It is important for an ecosystem to maintain key functions and processes after being subjected to damage caused by ecological disturbances (NCC, n.d). Reduced resiliency of an area results in increased vulnerability, and with fewer species contributing to the overall function of the ecosystem, the redundancy of the system is impacted. For this reason, current concerns regarding the impacts of the Anthropocene and global change have a focus on biodiversity.

One common example, and a pressing concern is climate change. Increasing global temperatures will result in variable seasons and drastically alter the floral and faunal composition of landscapes. In turn, this will result in habitat changes for many plant and animal species. Climate change is expected to specifically impact biodiversity in the following ways:

- Insect and/or disease breakout patterns may change, becoming more prevalent and severe
- Plant distribution will change, resulting in different types of vegetation communities
- Animal distributions will continue to change which may result in extirpation or extinction
- An increase in the frequency of extreme events and variable seasons may affect plant and animal communities, resulting in changes to abundance and distribution.

Specific to Ontario's biodiversity, the Ontario Ministry of Natural Resources and Forestry (MNRF) has identified several impacts of climate change:

- Alterations to migration timing and routes
- Changes in breeding seasons and affects to wildlife reproduction
- Altered food availability
- Decreased ice cover, changes in lake freeze-up, and earlier snowmelt
- Changes in air and water temperatures
- Non-seasonal migration to more favourable habitats
- Altered relationships between predators and prey

- Potential decline in specialist species with narrow habitat requirements
- Hybridization

For more information regarding the impacts of Climate Change on Ontario's biodiversity, visit: http://www.ontario.ca/document/climate-change-and-terrestrial-biodiversity

## 3.2 Threats to Wildlife

Of the growing threats facing Ontario's plant and animal species, there are 5 which are particularly impactful:

1. Habitat loss and degradation
2. Pollutants
3. Invasive species
4. Overexploitation
5. Disease

The variability of these threats is what makes them so problematic. Habitat loss can occur at many different scales and takes many different forms, negatively affecting the individual and subsequently the population. Pollutants are a constant struggle for animals and their impacts are influenced by their toxicity and density. Invasive species and disease are a growing concern that have the ability to outcompete or negatively impact native species. Overexploitation has been a constant battle for particular species, though not all wildlife species or populations are subject to it. Overarching all of these threats is climate change, which has the potential to increase the effects of each one of these threats, and also presents its own array of problems.

For more information regarding the impacts of Climate Change refer to the Ontario Envirothon Climate Change Guide.

### 3.2.1 Habitat loss & Degradation

Habitat loss and degradation are perhaps the greatest concern for Ontario's wildlife. Certain types of habitats are disappearing at a tremendous rate. In particular wetlands are being filled-in for agricultural and industrial development; forests are being clear cut or fragmented for development and natural resource extraction; and grasslands are being ploughed, fenced or converted to pasture for high densities of livestock (Champagne, 2005). These alterations are driven by human demand and are a result of direct human land-use alterations.

One of the greatest contributors to habitat loss is population expansion and **urbanization**. Our increase in population has resulted in heightened demands for industrial facilities, housing complexes, urban centres and natural resources. As a result, urbanization has converted many wildlife habitats into neighbourhoods, factories, airports, and shopping malls (Champagne, 2005). Although urbanization has destroyed many species' habitats, it has not removed species altogether. Many generalist species, such as black bears and raccoons (*Procyon lotor*), have adapted to live amongst human obstructions, resulting in an increased volume of human-wildlife interactions.

### 3.2.2 Pollutants

In addition to the effects of urbanization on habitat loss, the by-products of our daily lives such as sewage, exhaust, trash, agricultural/lawn chemicals and industrial emissions infiltrate the natural environment through air and water (National Wildlife Federation, 2015). These products are used in different industries, around the house, and in agriculture operations. Common pollutants that affect aquatic and terrestrial wildlife, even with their limited or discontinued use, are Mercury, Polychlorinated Biphenyls (PCBs), dioxins, herbicides and insecticides. Pollutants enter natural systems and make their way through the food webs and ecosystems, eventually ending in the wildlife species living in the affected or connected habitats. Unfortunately, these products can pose serious direct and indirect health risks to exposed species (Champagne, 2005).

Many pollutants are hydrophobic (water-hating) and lipophilic (fat-loving), meaning they are not easily diluted in water and readily bond to fatty tissues of organisms. As a result, pollutants can cause serious problems when introduced to terrestrial and aquatic systems because they are persistent and cannot be - or are *very* slowly, broken down by natural processes. These persistent pollutants are transferred along food chains and among food webs faster than they are broken down or excreted (Van Der Hoop, 2013). There are two routes that pollutants can enter these systems, bioaccumulation and biomagnification (Figure 13)**,** both of which are a direct representation of the animal's habitat and diet. Bioaccumulation is the buildup of contaminants in an organism's system from pollutants they have encountered in their environment and diet. The concentration of persistent pollutants accumulates in an individual over extended periods of time (i.e. lifetime).

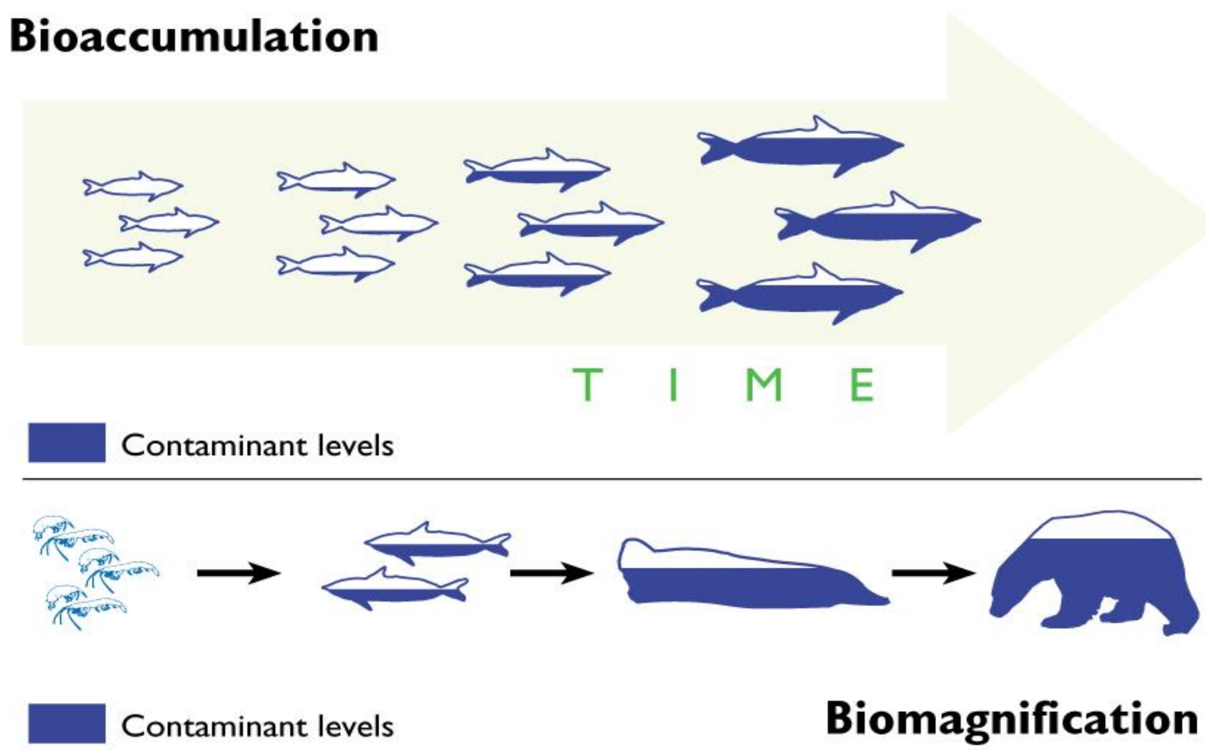


**Figure 13** - Bioaccumulation and biomagnification (Van Der Hoop, 2013).

Biomagnification refers to an increase in the concentration of substances as you progress along a food chain. The concentration of the pollutant is often greater across the top of food webs and among the individuals at higher trophic levels.

Both bioaccumulation and biomagnification refer to very similar, converse concepts regarding the build-up of pollutants within a system or individual. A top predator will bioaccumulate large amounts of pollutants in its lifetime as a result of the biomagnification of pollutants within their diet. This can have acute or chronic affects depending on the substance.

### 3.2.3 Invasive Species

Non-native species or "alien species" are a species or subspecies which are intentionally or unintentionally introduced, often by human activity, to an environment which is outside of their natural distribution. Non-native species can be non-invasive or **invasive**. Invasive non-native species are characterized by their tendency to spread and cause damage to the introduced ecosystem and can also impact the economy and human health. Invasive species pose a significant threat to biodiversity, as they are able to out-compete native species and alter ecosystems, resulting in a reduction of native flora and fauna (OFAH & OMNR, n.d.). One example of such a species is the zebra mussel (Figure 14; *Dreissena polymorpha*). This freshwater mussel was introduced into Ontario's lakes, and has disrupted ecosystem composition, clogged water intake pipes and has negatively affected public beaches (Ministry of Natural Resources, 2016). Other examples of non-native invasive species include the Asian carp *(Cyprinus carpio)*, purple loosestrife *(Lythrum salicaria)*, sea lamprey *(Petromyzon marinus)*, emerald ash borer *(Agrilus planipennis)*, didymo *(Didymosphenia geminate)*, Mute swan (*Cygnus olor*), European Starling (*Sturnus vulgarus*) and round goby (*Neogobius melanostormus*).

**Figure 14** - Zebra mussel (Fisheries and Oceans Canada, 2019).

For more information on invasive species refer to the Ontario Envirothon Invasive Species Guide.

### 3.2.4 Harvest and Overexploitation

In Ontario, and across Canada, wildlife managers regulate harvest rates through permitting and licensing for **game species**, which allows managers to effectively control populations through regulated harvest. The allowable harvest is based on current estimates of the populations – if populations are low, there is limited or no harvest – if populations are high, harvest limitations are liberal. This approach has a proven track record and is the pinnacle of North American wildlife management framework. However, this method does not work when overexploitation and unregulated harvest take place. Overexploitation is the harvest of individuals at a rate higher than can be sustained by the natural reproductive capacity of the species. All populations are subject to annual reductions, whether natural or anthropogenic. However, reductions due to unregulated or overharvest can have dramatic impacts on the persistence of a population, ranging from reduced genetic variability to complete collapse.

There are many case studies of the impacts of overharvest in Ontario. For example, wild turkey (*Meleagris gallopavo*) populations has previously collapsed due to unregulated harvest, though are now a provincial success story for reintroduction programs. Similarly, Lake Ontario's native Atlantic salmon population is deemed extirpated as a result of over-fishing. This population has since been re-introduced through hatchery stocking programs from various government and non-government agencies. In addition, many other fish species of Ontario are susceptible to the effects of unsustainable use through overfishing, examples include the shortnose Cisco (*Coregonus reighardi*), shortjaw Cisco (*Coregonus zenithicus*) and the Lake sturgeon (*Acipenser fulvescens*) (Ministry of Natural Resources, 2016).

### 3.2.5 Disease

Disease plays an essential role in controlling populations. However, despite being a normal occurrence, factors such as climate change can influence the distribution, occurrence and increase the impact of disease felt by a population. Most ecosystems include disease-causing organisms such as bacteria, fungi, viruses, and parasites.

A healthy ecosystem with greater genetic and species diversity is more resilient to the impacts of disease for several reasons. First, greater genetic diversity increases resistance to battle a particular disease, and the probability of transmission of this trait. Second, diversity and resiliency imply that an array of species exist to fulfill overlapping roles. The loss of one species to disease may be less impactful when there are numerous other species that are able to withstand that disease. Unhealthy ecosystems or those with lower biodiversity can be more vulnerable to the impacts of disease, as the loss or decline of a species can cause immediate impacts to which the ecosystem cannot quickly adapt.

### *Chronic wasting disease (Spongiform encephalopathy)*

Chronic wasting disease is a highly contagious, chronically fatal disease that infects cervids such as white-tailed deer, moose and elk. A prion, which is a modified protein, causes the disease (National Wildlife Federation, 2015) which attacks the central nervous system and affects the infected animals' behaviour and overall health. This can be problematic for Ontario wildlife managers as it directly impacts a game species which can have cascading problems for population management and regional economies.

### *Whirling disease*

Whirling disease is a parasite, *Myxobolus cerebralis*, that can infect trout, salmon, and whitefish. This disease damages nerves and cartilage of developed and developing fish, leading to mortalities in juveniles and causing adult fish to swim in a repetitive, whirling (circular) motions (Figure 15). This behaviour makes it difficult for the individual to forage and increases their vulnerability to predation (National Wildlife Federation, 2015). This is problematic as whirling disease has the potential to directly affect the population dynamics of desirable game species in the province of Ontario and beyond.

**Figure 15** - Brown Trout infected with Whirling Disease (Trout Unlimited Canada n.d.)

### *White-nose Syndrome*

White-nose Syndrome is a disease which impacts Ontario's native bat populations. Hundreds of thousands of bats have been infected since the disease was first observed. The fungus (*Pseudogymnoascus destructans)* effects bats by infecting the skin of their muzzles, ears, and wings causing irritation and arousal from hibernation (National Wildlife Federation, 2015). Infected bats can display erratic behaviour such as daytime flying and movement towards the cave entrances during winter months. This unnecessary additional activity consumes their limited fat stores, leading to starvation.

**Figure 16 -** Ontario bat showing fungus associated with White Nose Syndrome (MNRF, 2010).

## 3.3 Species at Risk

Species at risk refers to any wildlife species that is in danger of becoming extirpated or extinct (COSEWIC, n.d). The Committee on the Status of Endangered Wildlife in Canada (COSEWIC) is the organization that assesses the status of species believed to be at risk throughout Canada. COSEWIC was established in 1977 and is composed of members representing experts from the scientific community; specialists in community and Indigenous traditional knowledge; and federal, provincial, and territorial agencies responsible for managing wildlife (COSEWIC, n.d). Within Ontario the Committee on the Status of Species at Risk in Ontario (COSSARO) is responsible for determining which species should be listed as a Species at Risk (MNRF, 2014b).

COSSARO and COSEWIC use the best available scientific information, community knowledge, and traditional Indigenous knowledge to determine which species should be listed 'at risk'. Members of both organizations also assess reports on the status of wildlife species that are believed to currently be at risk. Based off the reports they then assign these species to one of the following five categories:

1. **Extinct**: a wildlife species that no longer exists.
2. **Extirpated**: a wildlife species no longer existing in the wild in Canada or in a specific geographic range but occurring elsewhere.
3. **Endangered**: a wildlife species facing imminent extirpation or extinction.
4. **Threatened**: a wildlife species likely to become endangered if threats are not addressed.
5. **Special concern**: a wildlife species that may become a threatened or an endangered species because of a combination of biological characteristics and identified threats.

Not included in the Species at Risk status, but still an important category to consider:

> **Rare Species**: an organism that exists in low numbers in a defined area or in a very restricted area, as a result of its biological characteristics or because it is at the edge of its range, but these numbers are not threatened.

For an official and up-to-date list of Species at Risk in Canada under any of the above statuses, please visit the Government of Canada's Species at Risk Registry here:
https://www.canada.ca/en/environment-climate-change/services/species-risk-public-registry.html

For an official and up-to-date list of Species at Risk in Ontario with any of the above statuses please visit: https://www.ontario.ca/page/species-risk

### 3.3.1 Why are they at Risk?

The number of native Canadian plant and animal species that are at risk of disappearing is growing. Species face a number of ongoing threats that vary in complexity, although habitat destruction and environmental contamination as a result of human impact are the most prevalent stressors (ECCC, 2014b). Other factors contributing to the decline of species populations include the spread of disease, invasive species infringement on natural habitats, and overexploitation of already exhausted species (Hogan, 2014).

The international trade of plants and animals is estimated to be worth billions of dollars annually. The global wildlife trade is diverse and is comprised of live plants and animals as well as a vast array of other animal products (e.g. bones, organs, hides, etc.). Some species have become heavily exploited, and as a result have gained higher trading values; this increased value in combination with other factors (e.g. habitat loss) is enough to severely deplete at-risk populations, bringing these species closer to extinction.

Plants and Animals at Risk in Ontario

- 6 extinct species (no longer exist in the wild anywhere).
- 16 extirpated species (no longer exist in Ontario but are found elsewhere in the wild).
- 115 endangered species (facing imminent extinction or extirpation in Ontario).
- 56 threatened species (at risk of becoming endangered if threats are not addressed).
- 50 species of special concern (species with characteristics that make them sensitive to human activities and/or natural events).

(Updated as of May 2020)

# Discussion Questions

1. Are there any Species at Risk in your area? What is the main reason for the decline of this species? How can your school or community aid in recovery efforts?
2. How have humans impacted local plant and wildlife populations in your region? List both the positive and negative impacts.
3. Can you think of any major or minor disturbances/natural disasters that have occurred in Ontario in your lifetime? What were the resulting impacts on biodiversity?
4. Compare and contrast bioaccumulation and biomagnification. Describe the process for both concepts and how they intersect.
5. Select a wildlife disease to research. Is it impacting wildlife in your area? How?

# 4.0 Conservation and Management

## 4 .1 Indigenous Rights and Wildlife

Indigenous peoples have directly relied on natural resources for centuries. Their peoples have a rich tradition of hunting, trapping, and fishing which continues today. As a result, Indigenous communities have developed an intimate knowledge and connection to their territorial lands, its wildlife and the natural forces that shape it. This respect for the land is depicted in many of their traditional songs, dances, festivals, and ceremonies. For example, among the Woodlands First Nations, a hunter would talk or sing to a bear before it died, thanking the animal for providing much-needed food (Government of Canada, 2017).

A “Treaty Right” is another classification that protects the traditional rights of Indigenous peoples. More specifically, a treaty is an agreement between an Indigenous group and the British Crown. For example, in the Robinson Treaties of 1850, Indigenous leaders of the Ojibway communities living along the northern shores of Lake Huron and Lake Superior agreed to cede 50,000 square miles of land to the British Crown in exchange for various payments and the promise that Indigenous peoples could continue hunting and fishing throughout the ceded territory (Government of Ontario, 2015).

These traditions and customs that were practiced prior to European colonization are referred to as Indigenous rights. Although these rights vary from group to group depending on their distinctive cultures, they generally designate rights to specific land for cultural purposes. Additionally, hunting for food, community, or ceremonial traditions is also a protected right, and these activities may be carried out in a modern way with contemporary equipment. However, the commercial trade of game and furs is viewed by the courts as a product of European influence rather than integral to Indigenous societies prior to contact, and thus is not a protected right (The Canadian Encyclopedia, 2019).

## 4.2 Managing Wildlife Populations

Wildlife are monitored to ensure their populations remain stable and that access to adequate habitat and resources is unobstructed. Wildlife is also monitored to understand life cycles and behaviour so we can better manage populations. Wildlife managers serve many roles including maintaining landscape and habitat, directly controlling populations (e.g. culling), conducting research and communicating their findings. In addition, wildlife managers analyze the interactions between wildlife and a variety of different factors such as habitat loss, humans, and invasive species, of which all may contribute to a decline or increase in population numbers. Understanding the drivers behind population dynamics provide valuable insight that can ultimately help mangers control population dynamics.

There are two fundamental ethics that guide wildlife management: conservation and preservation. Conservation allows for the mindful use of a resource (e.g. seasonal hunting, trapping, and fishing) under careful supervision by wildlife managers and enforcement officers who implement regulations defined in Acts to avoid the overexploitation or mistreatment of species or habitats. Alternatively, preservation removes humans from the system, prohibiting consumption of resources and minimizing human impacts within existing ecosystems or populations. This practice is often used when species and/or ecosystems are sensitive to human disturbance. There are various degrees of wildlife management, from complete population control (stocked fisheries) to indirect managed (stocked, self-sustaining populations). Deciding on the most appropriate degree of wildlife management for an ecosystem depends on the goal of the management and must account for all factors involving the environment, economy, and society. Techniques for managing wildlife populations vary by species and project, however, the overall goal and reasons for management remain largely the same – managing the resources to ensure its persistence.

## 4.3 Monitoring and Tracking Species

### *Radio Telemetry and GPS Tracking*

There are multiple techniques and tools that wildlife managers use for tracking species movement and exploring habitat use. Radio Telemetry is an active tracking technique that uses the transmission of very high frequency (VHF) radio signals to locate a transmitter that is placed on the animal of interest. For this technique the animal is captured, and the transmitters are attached using various styles of collars, backpack harness' or implants. Radio telemetry allows biologists to monitor large mammals such as wolves, elk, and bear, as well as smaller mammals such as martens and shrews (Ministry of Environment, 1998).

Another, more contemporary technique for tracking animal movement and habitat preference is the use of GPS (Global Positioning System) transmitters. GPS tracking is a passive technique that relies on communication between the transmitter and satellites through communication networks. Within the last decade this technology has become more advanced, and wildlife managers and research scientists are capable of deploying GPS transmitters on a variety of species from large mammals to small migratory birds. GPS technology is commonly attached to the captured animal using a collar or backpack harness (Figure 17). The technique provides researchers with high resolution information regarding the location and movement behaviour of the animal relative to landscape features.

**Figure 17** – Female mallard with a backpack harness GPS transmitter used to invesitgate habitat use and movement patterns (Dyson 2019)

### 4.3.1 Mammals

In Ontario, the MNRF is largely responsible for the monitoring and management of terrestrial mammal populations. Monitoring programs include radio telemetry and GPS tracking, large and small mammal trapping, **furbearer** management and harvest reports which assist decision making regarding the extent of management required for populations. Radio telemetry and GPS tracking provides mangers with valuable insight into how species are using the landscape and allows them to further hypothesize reasons why animals behave in such ways. Like many other class-specific monitoring programs (e.g. birds), trapping is an effective approach for estimating population size, abundance and density. It is important to understand, though, that each of these programs relies on a suite of additional support from external data sources and statistical modelling.

> **Harvest Reporting and Furbearer management**: In Ontario and across Canada, provincial level natural resource agencies rely on harvest reporting to track the number of individuals removed from a population through hunting and trapping. This information is vital for the conservation of species. Harvest reports include information regarding spatial, temporal and biological data such as date, time, location, species, age, and sex. Harvest reporting surveys in Ontario include moose, white-tailed deer, wild turkey, and bear. In addition to hunter harvest, there is furbearer trapping. Monitoring furbearer populations is completed through data collection from trappers. Critical information includes trend data such as the amount of time spent trapping, the number of animals harvested, and the number of pelts sold.

### 4.3.2 Amphibians

In Ontario, amphibian populations are monitored by provincial government agencies and regional conservation authorities. Due to the nature of these surveys, they are also dependent on community volunteers. Monitoring frogs and toads throughout Ontario relies on call recognition surveys during the spring breeding periods. Each species has a unique call, allowing surveyors to detect a particular species presence, location, and timing. This help researchers assess species abundance and distribution. This is a cost efficient and user-friendly method making it a valuable approach for monitoring frog populations.

There are many ways for the community to get involved in amphibian monitoring in Ontario such as backyard surveys and road call counts. In addition, the *FrogWatch* program, an affiliate of the Toronto Zoo Adopt-a-Pond program, is a way to involve volunteers in frog monitoring. It was implemented to encourage community involvement in monitoring frogs and protecting local wetlands. Additionally, volunteers can get involved with the *Great Lakes Marsh Monitoring Program*, an affiliate of Bird Studies Canada (Toronto Zoo, n.d.; Bird Studies Canada, n.d.).

> **Backyard Surveys**: Volunteers have the opportunity to conduct a backyard survey by listening for three minutes in their backyards each night between April and August. Volunteers are asked to record species observed/heard, relative humidity, air temperature, and time of night. Information provided is useful in detecting changes in population, calling dates and emergence of amphibians.

> **Amphibian Road Call Counts**: During an amphibian road call count, surveyors are to identify and estimate number of species by sight and sound. Volunteers are assigned a designated survey route where traffic, aircraft, or other man-made noises are not of concern. This allows surveyors to identify and estimate species without noise obstructions.

Data collected over the years indicates annual amphibian breeding sites and density estimates.

### 4.3.3 Birds

Birds provide many important ecological services throughout their annual cycle, serving as vectors for plant dispersal and acting in multiple roles in various food webs. Due to their important relationship with various ecosystems, changes in bird populations can be investigated to gage ecosystem health. In Ontario, bird populations are monitored by federal, provincial and municipal authorities. Federal entities include the Canadian Wildlife Service (CWS), which acts as a provincial extension of the government of Canada; NGOs like Birds Canada and Ducks Unlimited Canada are key contributors to research and funding; and the Ontario MNRF.

Birds are relatively abundant and easy to observe through sight and sound, and there are many different species of birds with diverse habitat requirements for breeding, migrating, and over-wintering. Therefore, bird surveys tend to be cost effective and user-friendly for assessing population status. Some of the many ways we can monitor bird populations include:

**Christmas Bird Count**: The Christmas Bird Count is North America's longest-running citizen science project. Information is collected by thousands of volunteers who watch and count birds in the field or at feeders for portions of the day. The results are used to assess population trends and distribution of birds. The count is done one day in the winter in various locations across North America.

**Bird Banding**: Bird banding is a capture-mark-recapture (or re-sight) method in which birds are captured using various techniques and affixed with aluminum leg bands and then released (Figure 18). This method relies on recapture, re-sighting, or harvest reporting of the aluminum leg band identification numbers. This provides researchers with a starting point and an end point, with the possibility of multiple re-sights and recaptures in between. These banding data are useful in both research and management projects, as it helps identify individuals and keep track of species or subspecies, and most importantly estimate population size. In addition, banding can assist in monitoring migration patterns, within-season movements, survival and harvest rates, reproductive success, and population growth (Government of Canada, 2020).

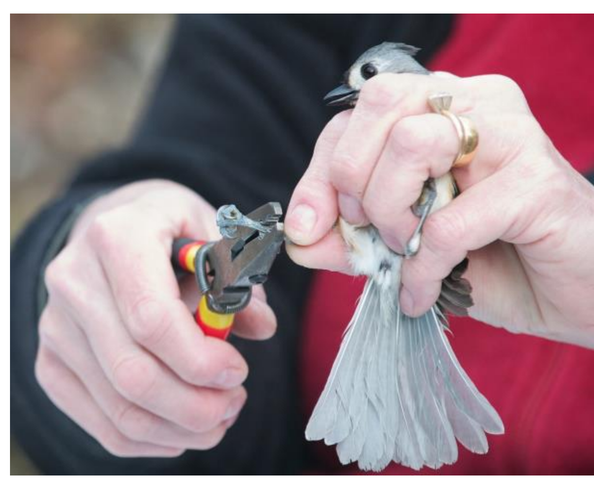

**Figure 18** - Male tufted titmouse (*Baeolophus bicolor*) receiving an aluminum leg band (Unknown, n.d.)

**Breeding Bird Survey (BBS)**: The BBS is a continent-wide volunteer based roadside survey designed to measure long-term changes in breeding bird populations (Konze and McLearen, 1997). Canadian participants survey assigned routes during the spring with the during peak breeding season. The starting point and direction of routes are selected randomly in order to sample a range of habitats. Each of the participants surveys their individual route for as many consecutive years as possible; routes consist of 50 stops spaced 0.8 km apart along a 39.4 km route. The participants record the total number of individual bird species heard or seen within 0.4 km of each stop during a three-minute observation. Data on starting and finishing times, as well as weather conditions, are also recorded (ECCC, n.d.).

### 4.3.4 Insects

The depletion of natural resources and collapse of ecosystems as a result of extensive agriculture, forestry and urbanization has immediate, negative impacts on many important terrestrial and aquatic invertebrate populations. These insects are vital components for thousands of food chains providing the foundation for terrestrial and aquatic ecosystem food webs, through direct consumption and pollination (McCarthy, 2017). In Ontario, there are a variety of researchers who monitor terrestrial insect populations including NGOs and academia; and provincial and municipal authorities who also study aquatic insects.

In recent years, there has been a large push for terrestrial insect population management as our understanding of the cascading effects of pesticides and insecticides has drastically increased. Two prime examples are bumble bees and the monarch butterfly (Figure 19). In Canada, some of our native bumble bee species have received federal designations for endangered, special concern, and threatened, including the rusty-patched bumble bee (*Bombus affinis*), yellow-banded bumble bee (*Bombus terricola*) and the western bumble bee (*Bombus occidentalis occidentalis*) respectively (Environment Canada 2014b, COSEWIC, 2015). Of the many species found in in Ontario, the yellow banded and the rusty-patched bumble bee are monitored and managed individually. Similarly, monarchs are a federally protected insect that are monitored in Ontario and across the country, using a variety of techniques (Environment Canada 2014c), including:

**Figure 19** - Tagged Monarch Butterfly (Entomologist David James, Washington State University, 2013).

- Habitat assessments
- Breeding and population monitoring
- Population censuses
- Monitoring migration
- Individual monarch assessments

These techniques are used to monitor and assess local densities of breeding monarchs throughout their range, numbers of individuals passing through migratory stop over sites, and size of area occupied in their winter range. One specific program, the Monarch Larva Monitoring Project (MLMP) assesses the timing and location of fall and spring migratory cycles. However, it is often difficult to assess population dynamics due to the large area of the Monarchs annual migratory cycle. The goal for the MLMP is to understand how and why monarch populations vary in time and space (Oberhauser et al., 2009).

### 4.3.5 Fish

Fisheries are active in 24% of Canada's 250,000 freshwater inland lakes, the Canadian portion of the four Great Lakes, and countless rivers and streams (MNRF, 2006). Monitoring fisheries populations in the province is very important not only for ecosystem structure and function, but also because fisheries provide commercial and recreational economic benefit, all of which is redirected back into the fishery. In the province, fisheries are managed at the federal, provincial and municipal level of governments and also with help from NGOs. There are several measures in place to ensure the health of freshwater ecosystems. Fisheries habitats are regularly monitored, maintained and repaired; and native species are actively protected from disease and invasive species. Additionally, fish populations are routinely monitored through techniques such as electro-fishing, tagging and marking as well as trap netting.

**Electro-fishing**: Electro-fishing employs an electrical current which momentarily stuns fish or forces them to involuntarily swim towards an electrical field for collection (EPA, 2014). Electrofishing is a common technique used by fisheries biologists and conservation authorities to sample fish populations in bodies of freshwater including lakes, rivers, streams and ponds (Figure 20). Fisheries managers use this method to learn details about fish populations such as species composition, age and sex distribution, and presence of invasive species (Smith-Root International, 2015).

**Figure 20** - Participants learning how to use Back-pack Electrofishing Equipment in a training workshop (Smith-Root International, 2015).

**Tagging and Marking**: Information gathered through tagging and mark-recapture can aid researchers in the evaluation of abundance, migration patterns, birth rates, mortality rates, and harvest levels of different aquatic populations. The mark-recapture method is the most commonly used technique; this is where a fish is captured, marked with a tag and then released. Upon re-sampling, any previously marked individuals are recorded. Tags can be applied using various methods including anchor tags, passive integrated transponders (PIT) tags, and suture tags depending on the species and the research goal.

**Netting and Trapping**: In Ontario, there are several methods for netting and trapping species. End of spring trap netting (ESTN) is a standard live release passive capture program designed to estimate the relative abundance and biological measures to assess the status of Walleye (*Sander vitreus*) populations in Ontario during the spring. In the fall, fall walleye index netting (FWIN) can also be completed. In addition, other passive netting techniques include modified fyke netting (MFN) and near shore community index netting

(NSCIN) which are not specifically focused on species capture but instead provide insight into fisheries populations that use the littoral zone. The data collected can be used to investigate fisheries population dynamics, fishing pressure, and generalized comparisons with other lakes in Ontario. These program takes place year-round, with modifications made for trapping through the ice during the winter.

## 4.4 Mitigation Measures

### 4.4.1 Solutions for Preserving Biodiversity

Habitat loss is one of the greatest threats' species are confronted with throughout Ontario and across Canada. Therefore, reducing habitat loss is one of the most effective ways of preserving biodiversity in any given ecosystem. Increased development and road construction have led to declines in, and fragmentation of, contiguous habitats. Regional planners can be proactive when developing communities, ensuring a thorough habitat assessment is completed prior to construction with the goal of maintaining the best quality habitat. In addition, planners can consider developing with animal movement behaviours and habitat use in mind. For example, reducing the amount of fragmentation by maintaining travel corridors and naturalized green spaces (i.e. forests and grasslands) provides optimal habitat for animals in developed areas. In addition, increasing public awareness of biodiversity loss is just as important for maintaining the local biodiversity in our communities.

The Canadian Biodiversity Information Facility provides some tips on how to increase biodiversity:

- Develop a community-based monitoring program
- Transform an empty lot into wildlife habitat
- Create natural spaces around buildings
- Join a conservation group
- Fish sustainably
- Assist in completing a wildlife survey or bird count
- Take part in an endangered species recovery project

**FUN FACT**

Canada was the first industrialized nation to ratify an international agreement to conserve the world's biological diversity. The treaty, known as the "Convention on Biological Diversity," took effect in December 1993 (Government of Canada, n.d.).

Governments must also do their part. Implementing legislation to protect species that are currently, or are expected to become, at risk is a powerful way to conserve biological diversity. In Ontario, legislation such as the provincial *Endangered Species Act* and the federal *Species at Risk Act* help to protect species by developing management plans that aim to increase their population size and protect necessary resources such as food, shelter, and general habitat. In addition, recovery plans identify ways to improve the status of species that are designated as threatened, endangered, or extirpated, and provide suggested methods on how best to do so.

### 4.4.2 Habitat Protection

Governments and other stakeholders (i.e. Indigenous groups, private organization, non-government organizations, the public, etc.) have a joint interest in the protection and wise use of Canada's wildlife and ecosystems. In particular, Environment and Climate Change Canada oversees a network of protected areas, National Wildlife Areas (NWA) and Migratory Bird Sanctuaries (MBS), with the intent of conserving ecosystems that support a diversity of healthy wildlife populations (ECCC, 2013b). There are laws and policies in place to prevent harm from being done to habitats that fall within these protected areas, including:

- Canada Wildlife Act
- Migratory Birds Convention Act
- Species at Risk Act
- Canadian Environmental Assessment Act
- Wildlife Policy for Canada
- Federal Policy on Wetland Conservation

The CWS oversees much of the on-the-ground protection of wildlife habitats under instruction from Environment and Climate Change Canada. CWS is responsible for protecting and managing deteriorating habitats of migratory birds, federal species at risk, and other species of national interest (ECCC, 2013b). Provincial parks and local conservation areas are managed provincially and regionally and serve similar functions to those of NWAs.

## 4.5 Wildlife Management, Protection and Recovery

### 4.5.1 Endangered Species Act (ESA)

In Ontario, the ESA is the primary provincial legislation protecting listed wildlife species. The ESA provides broad protection provisions for species at risk and their habitats, enhanced support for volunteer participation from private landowners and partners and effective enforcement provisions. This legislation demands strong protection measures for species at risk and their habitats, as well as the creation of stewardship programs to assist in the protection of species at risk. Furthermore, when a species is listed as endangered or threatened, the MNRF engages individuals and agencies with expertise on the species to write recovery strategies and management plans.

### 4.5.2 Species at Risk Act (SARA)

Under SARA, the Government of Canada must take into consideration the designations made by the Species at Risk Advisory Committee when establishing the federal list of Wildlife Species at Risk. Passed in 2002, this Act requires federal organizations to provide guidelines on appropriate recovery strategies for listed species. All governments and stakeholders must utilize and follow these strategies to protect species at risk and the natural habitats essential to their survival. The legislations within SARA encourage people to balance their needs with the needs of species at risk.

### 4.5.3 Convention on International Trade in Endangered Species (CITES) of Wild Fauna and Flora

CITES is an international agreement between governments, with the objective to ensure that the international trade of wild plant and animals does not threaten their survival. Since coming into effect in 1974, 183 parties have joined the convention, with Canada being the 10th country. Although many internationally traded wildlife species are not endangered, CITES helps to protect the future use of these resources by serving as an additional level of protection (CITES, n.d.). Participation in the Convention is voluntarily, though many countries have used the CITES framework to help implement national laws.

### 4.5.4 Wild Animal and Plant Protection and Regulation of International and Interprovincial Trade Act (WAPPRIITA)

WAPPRIITA's role is to protect both Canadian and foreign plant and animal species which are at risk of overexploitation through illegal trade. This Act also protects Canadian ecosystems from the introduction of invasive species considered to be harmful by regulating international trade of wildlife species and derived products (ECCC, 2014d).

### 4.5.5 International Union for the Conservation of Nature (IUCN) Global Species Programme

The IUCN Global Species Programme together with the IUCN Species Survival Commission (SSC) is responsible for assessing the conservation status of species on a global scale (IUCN, n.d). Their responsibility is to provide scientifically based and objective information regarding the current status of globally threatened flora and fauna. Conservation status information is essential to inform decisions regarding the conservation of biodiversity at both local and global levels (IUCN, n.d). The IUCN Red List of Threatened Species was created to globally identify individual species at risk of extinction. It is universally recognized as the most in-depth global approach for the evaluation of the conservation status of plants and animals (IUCN, n.d).

## 4.6 Citizen Science

Citizen science is a practice in which members of the general public collect and share data relating to various topics, with the overall goal of increasing the collective knowledge of the natural world. The increasing interest in this practice can be attributed to the advancement of technology which allows researchers and scientist to collaborate with public participants and provides a convenient platform for data sharing (Adler et al. 2020). Moreover, this approach is becoming more appealing to researchers as the data provided by citizen scientists is increasingly available and applicable for effective management and conservation initiatives. In addition, and one key aspect of any research project is cost – data collection is expensive. Citizen science is volunteer based; therefore, data collection is very cost efficient, which in turn may allow researchers to allocate funds to projects that are unattainable through citizen science.

Citizen science-based projects play an important role in understanding wildlife ecology, both in the province of Ontario and around the globe. Many of these projects have common scientific goals which can be met using citizen science data. Citizens have collected both regional and local data regarding species distribution and population dynamics, habitat loss, effects of climate change on species distribution, and the spread of biological invasions (e.g. invasive species and disease; Adler et al., 2020). This vast array of species- and population-specific data, which may otherwise be unattainable, provides additional insight into many of the notions of wildlife ecology.

In Ontario, there are various organizations that offer citizen science programs including Ontario Nature and Birds Canada. These organizations rely on dedicated and involved nature enthusiasts to contribute their knowledge and understanding of the natural environment. Projects aim to provide people of all age groups and abilities with opportunities to contribute and to learn from others. Examples of citizen science programs include the Ontario Breeding Bird Atlas, Bumble Bee Watch, EDD Maps Ontario (invasive species mapping) and MilkWeedWatch. Additionally, individuals can get involved through online resources such as eBird, iNaturalist, and Project Feeder Watch.

# Discussion Questions

1. What are the two fundamental ethics that guide wildlife management? Describe each.
2. Select one of the species types listed in this section of the guide and describe how their populations are monitored.
3. The Canadian Biodiversity Information Facility provides suggestions for increasing biodiversity which are listed in this section of the guide. What additional activities could you suggest which would increase or protect biodiversity in your area?
4. Within Ontario the ESA is the primary legislation protecting listed wildlife species, do you feel this legislation provides enough protection? If not how would you propose changing it?
5. How can citizen science help inform wildlife management and protection?

# Glossary

**Abiotic –** non-living chemical and physical parts of the environment that affect living organisms and the functioning of ecosystems (i.e. light, humidity, pH, temperature).

**Adapt (ed/ation) -** the process by which an organism makes adjustments to suit their environment. Adaptations be generic (inherited) or behavioural.

**Anadromous** – the movement of migratory fish from the sea to freshwater spawning sites.

**Bioaccumulation -** the storing and building up of contaminants in the tissues of organisms.

**Biomagnification** – the process by which increased levels of contaminants occur in a top predator due to eating prey who have themselves consumed contaminants at a lower level.

**Biotic** –living components that shape an ecosystem (i.e. predators, prey, diseases).

**Carnivore(s) -** a meat eater.

**Carrying Capacity** – the maximum population of a species that an ecosystem can support without experiencing environmental degradation.

**Catadromous** – the movement of migratory fish from freshwater to marine spawning sites.

**Crypto protectants** – Biologically produced substance the protects biological tissues from freezing damage (i.e. cell rupture).

**Desiccation -** drying out; the loss of water content.

**Ectotherm –** an organism which relies external sources to generate body heat; cold-blooded

**Endemic** – species which are restricted to limited, specific geographic locations (i.e. ecological region, province, country).

**Environmental Stochasticity** – See Stochastic – Unpredictable fluctuations of environmental patterns in space and time.

**Food chain** – liner representation of energy transfer from plants through a series of animals, with repeated eating and being eaten.

**Food web** – Illustrated representation of interconnected food chains for an ecological community, demonstrates energy transfer between organisms.

**Furbearer** – A mammal that has fur, or a pelt, of commercial value.

**Game species -** legal designation for animals that may be managed and hunted only under regulation.

**Generalist** – Animals that are capable of surviving in a wide range of environmental conditions and habitats with limited and variable resources.

**Habitat -** the food, water, shelter and space necessary for the survival of a species.

**Herbivore -** a plant eater.

**Hibernacula** – a place where a species seeks refuge during hibernation.

**Hibernation -** the act of passing the winter in a state of torpor, which may include sleep, lowered metabolism and lowered body temperature.

**Hydroperiod –** seasonal pattern of water levels in a wetland, incudes flooding and/or soil saturation.

**Interspecific** – occurring between different species.

**Invasive -** a species that encroaches upon and pushes out the native species.

**Limiting factor(s) -** environmental conditions that limit the growth, abundance, or distribution of an organism or a population of organisms in an ecosystem.

**Mark-recapture** – a method used to monitor animals' population size. A sample of the population is captured, marked, and released. Re-sighting and recaptures are used to generate population estimates.

**Microhabitat** – A small habitat with different characteristics than thee surrounding, larger habitat. Differences can be biotic and abiotic.

**Omnivore -** eats both plants & animals.

**Phenology** – The study and understanding of seasonal variation in plant and animal cycles and behaviours.

**Population(s) -** the number of a particular species in a defined area.

**Primary consumer** – an organism that feeds on primary producers.

**Specialist –** animals that has very specific habitat and feeding requirements.

**Staging Area** – a location for rest or foraging used by migrating animals.

**Stochastic –** random probability of occurrence; cannot be precisely predicted.

**Subspecies** – a rank of taxonomic classification below species that can be determine by genes, appearance, or geographic location.

**Trophic level** – the position an organism occupies in a food chain.

**Urbanization** – the process of making an area or landscape more urban.

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