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# Causes and Effects of Invasive Species on the Economy of Canada

Invasive species can be described as any living organism, that overtakes a foreign area. They are not native to the ecosystem and can potentially cause harm. Some examples include plants, fungi, insects, or amphibians. In relation to the Humber River field trip, the issue of invasive species is a notable one. This report will examine the ways in which different types of invasive species around Ontario and globally, affect the physical, biological, social, and political aspects of the planet. These species "cost the global economy over \$1.4 trillion US dollars per year and are one of the top five drivers of environmental degradation and species extinction" (Pimentel et al. 2001; Wilson, 2002). Additionally, the National Wildlife Federation says 42 percent of endangered and threatened species are threatened by various invasive species, as well, human health and economies are at risk. These species cause different land and water issues and are often a result of industrialization and globalization.

When considering the city of Toronto, and how it has expanded over the last couple of centuries, after officially becoming a city in 1793, it is clear that urbanization and economic growth has played a pivotal role in its expansion. Today, the GLSL region, which is comprised of the Great Lakes and the St. Lawrence, "is an economically integrated, binational region that was, until recently, the world's most significant concentration of industrial production" (Anderson, Maoh, and Gingerich. 2019). The estimated GDP of this area is equal to one-third of the United States' GDP and double the GDP of Canada. With thousands of cargo, freight trains and transportation trucks importing goods and services into the country, and city every day, it is understandable that foreign species travel into our borders this way.

Ecosystems consist of various abiotic and biotic elements, they "are not random collections - everything is intrinsically connected and mutually dependent" (Atkinson, 2019). When a new factor or organism is introduced into the ecosystem it can disrupt its natural cycles and wreak havoc on the preexisting elements. In a recent study, which was conducted by Linders et al. (2019) they consider the direct and indirect effects of invasive species, and how biodiversity loss affects the ecosystem, along with how this loss is a key component in global change. Their study confirms the evidence that biodiversity plays an essential role in offsetting global effects on ecosystems and highlights the need to reverse the degradation of the environment, specifically biodiversity loss. It also discusses the significance of collateral impacts. In order to see the parallels between biodiversity and invasive species; it is important to understand that invasive species actually contribute to the growth of biodiversity (this being the diversity of different organisms, ex: genetic, species, ecosystem levels), along with its decline.

An invasive species that was particularly relevant to the field trip, is the Zebra Mussel. This freshwater species has made its way from the depths of Ukraine and Russia to North America. According to Ontario's invading species awareness program, Zebra mussels are present in all the Great Lakes, the Mississippi River watershed and Lake St. Clair. Contrary to Zebra Mussels, Quagga Mussels are limited to the southern Lakes; Michigan, Lake Ontario, Erie, and Huron. The impacts of these Mussels include filtering water so much that food webs change, increasing toxic algae, and harming fish eggs. Along with this, they can affect recreational activities.

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When considering the location, according to the Humber River website, the river accumulates from roughly 750 creeks and tributaries. The footprint constructed by the system as it flows southwards to Lake Ontario is the Humber River watershed. The principal source of the Humber shares a limited geographical region, known as the 'headwaters' with three other drainage systems in southern Ontario. Moving downstream from the mouth of the Humber River, all the way to Lake Ontario, these bodies of water contain unexpected exotic species, one of which includes Zebra and Quagga Mussels in Lake Ontario. Along with this organism, the Rudd is a type of minnow that has populated the waters and become invasive. Canadian Yachting (2019) explains, Rudd originates from Europe and is now present in North America. They were first found in the St Lawrence River in the 1990s and have spread west to Lake Ontario, up the Humber River. Rudds are invasive because females can lay up to 200,000 eggs annually and these eggs hatch within two weeks. Rudd then compete with domestic fish, degenerating their natural spawning environment. Invasive species that are present in the lakes and rivers, often have no trouble surviving and reproducing; regardless of the new, unfamiliar conditions.

Lake Ontario which is notorious for being an "unclean" body of water, is this way because according to Kurt?Karakus et al. (2019) it receives contaminants from upstream areas in Canada and the United States. Primarily from the major Canadian city centers that are west of Lake Ontario, Hamilton, and Toronto. As previously stated, it is also home to many invasive species, such as the Zebra Mussel, Quagga Mussel, and Rudd. The concept of hydrology, which looks at water and its circulation in fluvial systems (rivers), is an important component in understanding watersheds and drainage basins. Refer to figures 3 and 4, which demonstrate the water cycle of Lake Ontario and its hydrology, specifically the key river headwaters which are located North of the Municipality of Peel, in the area of Caledon.

Another infamous example of an invasive species is the Cattail. These plants grow at a rapid rate and force out other species. Lishawa et al. (2019) call attention to the fact that invasive plant species not only change ecological functions but cause loss of biodiversity. Cattails, along with other invasive plants, "evict" the surrounding species in a range of different ecosystems. This plant also referred to as Typha, is found primarily in wetlands. A wetland is a type of ecosystem that is covered by water and has strong viability for aquatic plant vegetation. for instance, areas around Albion Hills. Bansal et al. (2019) examined how "hybridization and anthropogenic disturbances have resulted in large increases in Typha abundance in wetland ecosystems throughout North America at a cost to native floral and faunal biodiversity" They conducted various studies, which look at how Typha has the ability to "colonize habitats" and become the primary form of vegetation, because of their size and rapid growth. Cattails are now associated with numerous ecological impacts in conjunction with agricultural and wetland systems. This plant is extremely common around North America today and must be dealt with accordingly. As demonstrated in figure 5, which is a catchment area of the Humber, Cattails are visible along the edge of the water.

It is important to note the various techniques and methods that are being implemented and developed in order to combat foreign species from populating. For example, a recent study was done to detect and survey the growth of the Asian Longhorned Beetle in the city of Toronto. This species, which originates from China and Korea, is a type of beetle that attacks and kills different types of trees, by feeding off them. According to Ontario's invading species awareness program, the ALHB (Asian Longhorned Beetle) was first spotted in a Toronto industrial park in 2003. Provincial invasive species management dealt with the issue by eliminating host trees, to eradicate their habitat and prevent the increase. It was then eliminated between 2007 and 2012,

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demonstrating that early detection and quick response was successful. However, in 2013, the Asian Longhorned Beetle was detected again near Pearson International Airport.

As mentioned, the biggest contributor to the cause of invasive species is the transportation of goods and services (planes, ships, transport trucks), therefore the fact that the ALHB was detected near one of the biggest airports in North America, is to be expected. In a 2019 research study, scientists Yemshanov et al. (2019) developed a model that administered survey sites to reduce expected mitigation costs and the expected time until the first detection of invasive species. They then applied the system to the issue of locating the Asian longhorned beetle in the GTA. Researchers described the Beetle as perhaps the most harmful alien insect on the continent. This species is just one of the estimated 1442 invasive species in Canada.

Though similar in appearance, they present a myriad of different effects and consequences. The results from the study, "suggest that preferences for minimizing mitigation costs or time to detection are more consequential for ambiguity-averse managers than they are for risk-neutral decision-makers" (Yemshanov et al., 2019). The Asian Longhorned beetle making its way to Toronto, Canada, is one of the many instances where exotic organisms can travel overseas and populate in foreign nations, by different means. In association with the Exotic Longhorned beetle, there are many social, physical, biological, and political impacts to consider. Natural Resources Canada, states that potential consequences include the following:

- The loss of maple trees could affect Canada's multi-million dollar maple syrup industry.
- Economic (loss of jobs, money).
- Political & Social: the loss of hardwoods could affect the cultural, spiritual, and/or economic values of Indigenous people.
- Physical/Environmental.
- The loss of hardwoods could affect Canada's forest industry through the loss of billions of dollars in wood products.
- The loss of hardwoods could impact the tourism and recreation industries by affecting tree canopy tourism for "fall-color tours".
- The Asian longhorned beetle could have a significant, negative ecological impact if eradication measures are not effective.

It becomes evident that when a species invades a certain area or even a country, it produces ripple effects that extend beyond simply just the presence of the organism. Binimelis, Born, Monterroso, and Rodr?iguez-Labajos. (2008) explain that when looking at the chain reaction of effects that invasive species cause; they have the capabilities to affect the goods and services that ecosystems produce, for example, freshwater, food, recreation, etc. This, in turn, affects the system and ultimately the human species. Similar to the concept of watershed management and stormwater management, invasive species must be managed. When considering the long term effects of invasive species, "identifying the impacts of invasive species is required in order to evaluate the consequences of invasion processes and to implement management measures" (Binimelis et al. 2008). It can be gathered that there are different types of impacts. Firstly, direct consequences on the function of the ecosystem, and human activity. Secondly, would be indirect effects, which could be referred to as "externalities" or "side effects". This type of effect tends to arise from "the implementation of response actions, such as control costs or side effects of the introduction of biological control agents" (Binimelis et al. 2008). Even when constructing a project such as "Reimagining Bolton Camp", issues that invasive species prompt must be taken into consideration when planning various aspects of the park.

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Humberwood park was an important aspect of the field trip because it demonstrated the different catchment areas that the Humber river has. As invasive species move downstream, this area of the GTA exemplifies the ways that species can harm each other. For example, the ducks in the water ingesting possibly dangerous exotic organisms/bacteria will then carry it up the food chain. As well, plants, as stated the Cattail, could disrupt the different species around this stream. Within the GTA, many research studies have been conducted in order to understand invasive species and the extent of their consequences. A study done by Foster and Sandberg (2004) contends that there is tension between communities and invasive species management within the GTA. When accounting for Toronto public green space, specifically the Leslie Street Spit, Don Valley Brick Works and High Park, they learn that to residents, "invasives are often compatible with recreational interests, whereas naturalization efforts are ecologically sensitive and costly" (Foster and Sandberg. 2004). This case study suggests the different social impacts that invasive species cause, for instance, how naturalization often benefits rich neighborhoods as opposed to poor, along with the many strains that it can have on a community and local conservation authorities. The data that is presented disputes that although invasive species can sometimes benefit certain aspects of an ecosystem, management efforts can cause externalities.

The significant issue of invasive species has been long discussed, and consistently disrupted the biodiversity of many ecosystems. The cause primarily being the rise of globalization and the exporting and importing between countries, along with traveling and human activities. Invasive species, whether they be Zebra Mussels, Quagga Mussels, Rudd, the Exotic Longhorned Beetle, or Cattails, present many issues, these being social, physical, biological, economical and environmental. It is important to consider invasive species management as a useful tool in offsetting the long term effects of invasive species.