The Importance of Trees in the GTA

A Report for The University of Toronto Mississauga and The Association for Canadian Educational Resources.

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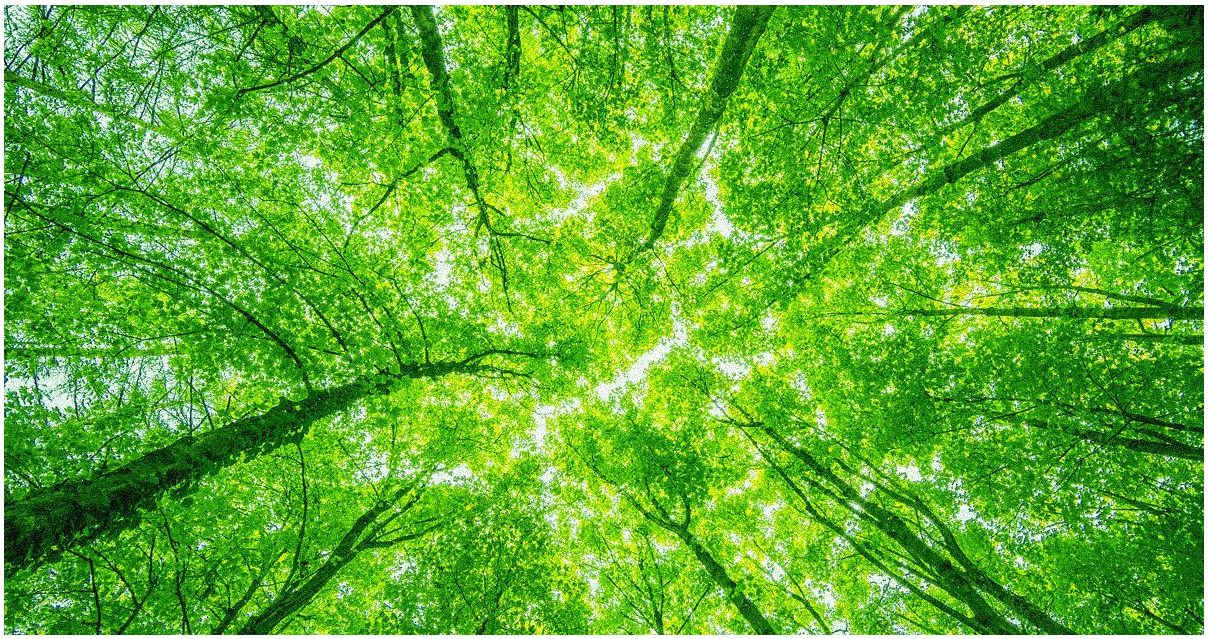
March 23, 2020



Many cities are deciding on which one tree species should be planted in urban spaces. Multiple species of trees on various school locations in Mississauga and Brampton were measured for their height, diameter at breast height (DBH), crown volume, and the amount of sequestered carbon dioxide. The measurements were compared to the last date they were measured. It is clear that not one species thrived the most. After analysing the data it is clear that all species should be planted to increase biodiversity. Increasing biodiversity; especially during the current climatic changes, by planting various tree species will provide an increase in community safety, human and environmental health benefits and ecosystem services.

INTRODUCTION

Trees are the biggest plants on earth. “Trees give us oxygen, store carbon, stabilise soils, provide tools, provide a link to the past and future, and give shelter and life to the world’s wildlife” [3]. Trees also benefit human health. They are great providers of shade (canopy cover). These covers can act as a natural filter by trapping dust, absorbing pollutants, act as a noise barrier and protect living organisms from harmful ultraviolet (UV) rays from the sun[3]. Trees are also great at reducing wind speeds and help prevent flooding by absorbing stormwater[3].

In the United Kingdom (UK), research has been conducted to see if there is a link between happiness and trees. The conclusion of the study states that, “within minutes of being surrounded by trees and green spaces, your blood pressure drops, your heart rates slows down and your stress levels come down” [3]. This shows that people are generally less stressed and can have a healthier, long life being surrounded by trees and greenery.

With that being said, trees are extremely important to humans, not only for their environmental benefits but also their health benefits. For that reason biodiversity of trees and planting the right species of trees is extremely important to ensure they truly benefit the environment and help build a sustainable community. Therefore, the question of what species should be planted arises.

Association for Canadian Educational Resources (ACER) Historical Background:

In 1987, Alice Cassleman, a retired biology teacher, founded the Association for Canadian Education Resources (ACER), also known as, “Climates Sake” [1]. Cassleman, built a twenty year career in the Toronto Region Conservation Authority (TRCA), and is a founding member and chair of the Council of Outdoor Educators of Ontario (COEO) [1].

Biodiversity allows forests and communities to become mature and resilient. ACER understood this need and decided to create biodiversity plots. As of now, there are 80 in Canada and 18 in Ontario[4]. These one-hectare plots allow ACER and their partners to monitor their forests' growth and health[4].

With this idea ACER has also created many programs that educate the communities on climate change in an engaging and interactive way. One funded

program is called Planting For Change (P4C)[5]. Planting for Change is a program that supports school children by creating a schoolyard planting site that acts as a mini-climate change outdoor lab, that is easily accessible as a teaching tool, complimenting climate change, geography, math, science and world studies[5]. With this program ACER members would provide five various species of trees; that represent different major Canadian tree species, equipment and materials used to plant the trees. The students and teachers would then monitor the growth patterns and engage in various educational topics[5]. By participating in this program children are able to try new activities in a safe, fun environment, while learning about important scientific and mathematical problems. ACER has also provided Internship placements for university and college students to help the interns gain knowledge on trees and gain experience using various field equipment.

Research Problem

To conduct this research problem and to determine which species grows better in Southern Ontario, five Mississauga schools, two Brampton schools and a campus tree inventory plot situated on the University of Toronto Mississauga Campus (UTM) were chosen to explore different tree species growth patterns in relation to their locations. This will help determine what species survive better in our environment to ensure they are being planted, while increasing biodiversity. By doing so this will allow the various Canadian communities to thrive emotionally and physically.

METHODOLOGY

During the warmer months the UTM biodiversity plot that was measured by a previous ACER intern, as seen in Figure 2, was re-measured. Figure 2, was used as a reference to locate the previously measured trees. The diameter, height, crown width, GPS location and health were recorded for each tree. In the cooler months the trees found at the Mississauga and Brampton schools were measured in the same manner, except the GPS tracker was not used. Instead maps provided by ACER were used to determine what trees were present and now absent. Once all measurements were recorded, the amount of carbon sequestered per tree and species was found using the diameter per species at 1.3m.

Figure 1: Materials used to re-measure the trees at each school and UTM plot. Moving left to right: Caliper, Clinometer by Invicta, Diameter (DBH) tape, 30m measuring tape, 1.5m measuring tape. A clipboard with mature and juvenile data sheets and tree maps were also used. (not pictured is a GPS).

Figure 2: Aerial map of the previous ACER intern's UTM tree inventory area,, 2016.

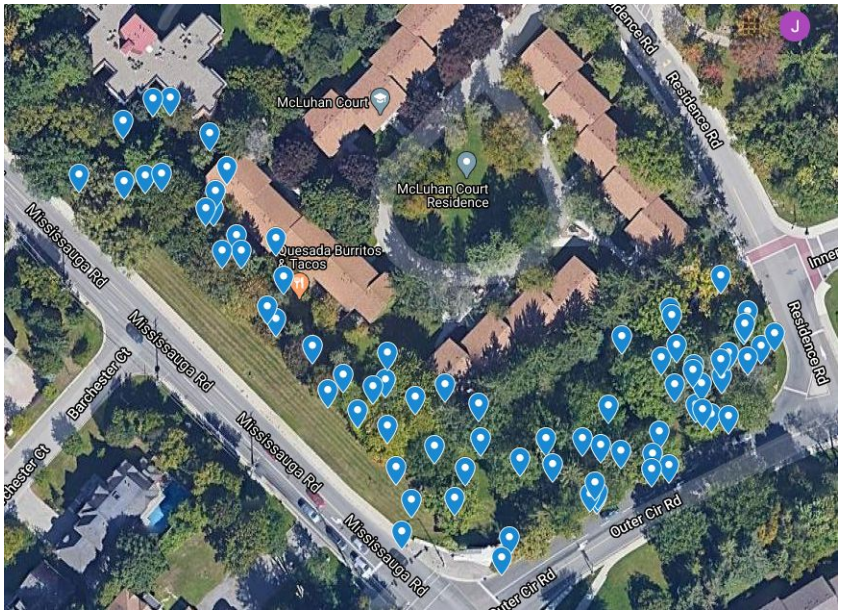


Figure 3: Aerial map of the newly measured UTM tree inventory area, 2019. Taken from Google Maps and ACER.

Tree Diameter at Breast Height DBH:

A diameter tape (DBH) was used to measure 1.3m from the base of the tree. Once the measurement was found, the DBH tape was used to wrap around the 1.3m height, ensuring the tape was leveled and not twisted. When the diameter (cm) was found the measurement was recorded in the data sheet.

Height of the tree and crown depth:

A 30m tape measure was used to measure a distance of 20m away from the tree. Once standing 20m away the clinometer was used to measure the three required angles, as seen in Figure 3. The clinometer was first used to point at the top of the tree. Once the angle depth was found and confirmed by a partner using the side window, the measurement was recorded. Then the clinometer was pointed to the base of the tree, again once the angle was confirmed by the partner, it was recorded into the data sheet used to find the total height. Finally, the clinometer was pointed at the lowest visible branch, again the partner confirmed the measurement and recorded it into the data sheet. Once all three angles were found a "Tangent Table" and the equation: **[20 x tan(Øu)] – [20 x tan(Øl)]**, (where Øu represents the upper angle and Øl represents the lower angle) was used to find the height.

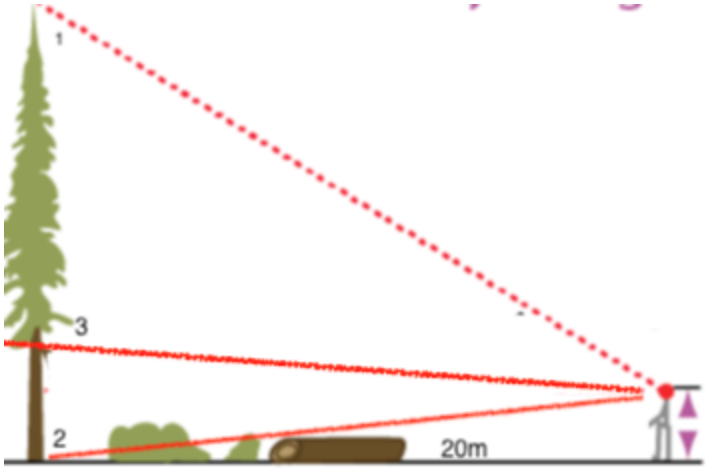


Figure 4: Three needed angles to find the height of the tree and crown depth.

https://bigtrees.forestry.ubc.ca/measuring-trees/height-measurements/

Crown Volume:

To find the two crown widths of the tree, the 30m measuring tape was used. With two people holding each end of the tape, the largest perpendicular branches were measured throughout the whole width of the tree. Once each measurement was found, the measurements were recorded. Then the two measurements were multiplied to find the crown area. Multiple the crown area with the height of the species to get the crown volume.

GPS Tracking:

Once each tree was measured, a handheld GPS Tracker was used to re-tag each tree. As seen in Figure 4, the remaining trees were recorded and compared to the previous map.

Carbon sequestered per tree:

The DBH at 1.3m from the base was used with the Carbon Calculator on the ACER-ACRE website (https://www.acer-acre.ca/QR/opencarbonresult.php) to find the amount of carbon the tree sequestered for each species. The measurements were recorded into an Excel spreadsheet and each species was compared.

RESULTS

University of Toronto Mississauga Location:

Three years after the initial measuring of the UTM plot, only 80 out of the 100 trees were found and 9 out of the 12 species were identified. Over the three years it was clear that the missing or unidentified trees were either cut down or blocked off in construction zones. The four species that were found in abundance were the Red Oak (*Quercus rubra*), Norway Spruce (*Picea abies*), Crabapple (*Malus spp.*), Sugar and Norway Maple (*Acer saccharum* and *Acer platanoides*). The others that were found included Willow (*Salix alba*), American Sycamore (*Platanus occidentalis*), Red Pine (*Pinus resinosa*), Easter White Cedar (*Thuja occidentalis*) and White Oak (*Quercus alba*).

Red Oak:

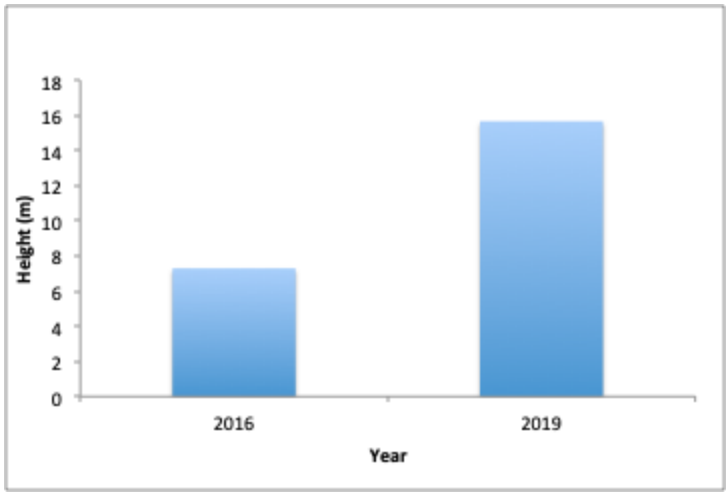


Figure 5: Average height of all Red Oak trees found at the University of Toronto Mississauga (UTM) campus tree inventory area, throughout July, 2019 in comparison to the 2016 measurements.

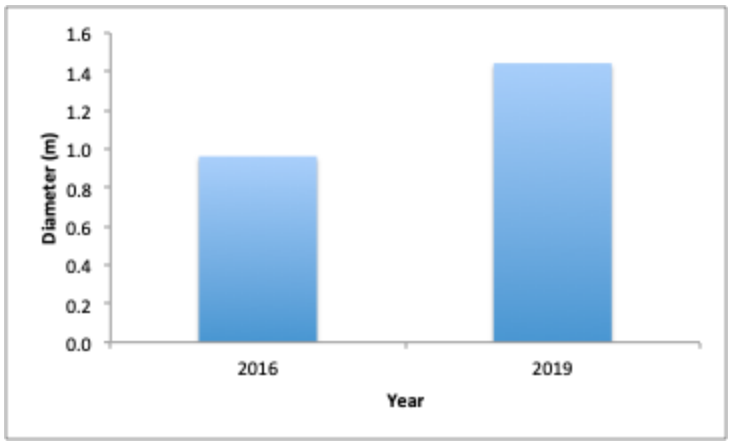


Figure 6: Average DBH at 1.3m of all Red Oak trees found at the University of Toronto Mississauga (UTM) campus tree inventory area, throughout July, 2019 in comparison to the 2016 measurements.

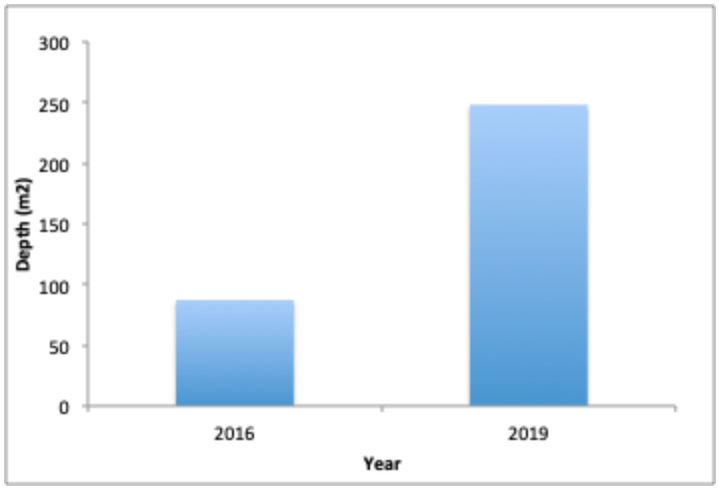


Figure 7: Average crown volume of all Red Oak trees found at the University of Toronto Mississauga (UTM) campus tree inventory area, throughout July, 2019 in comparison to the 2016 measurements.

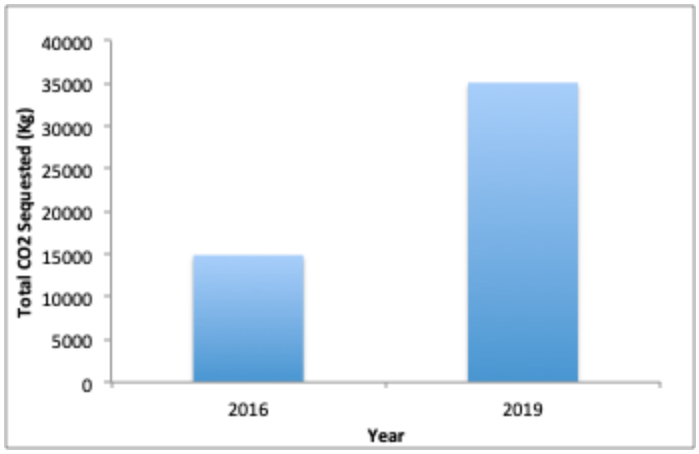


Figure 8: Average carbon dioxide sequestered by all Red Oak trees found at the University of Toronto Mississauga (UTM) campus tree inventory area, throughout July, 2019 in comparison to the 2016 measurements.

When examining the Red Oak data, it is clear that they grew significantly in the 3 years. They are located along Outer Circle drive in rows. As seen in Figure 5, the height increased on average by 8m. With this significant increase in height the crown width and the amount of sequestered carbon dioxide also increased, as seen in Figure 7 and 8. With this increase in crown volume the Red oaks are able to provide more shade and store more carbon dioxide. On the campus the Red Oak trees had phenomenal health and showed no disease. They also seemed to strive in the environment they were placed in.

Norway Spruce:

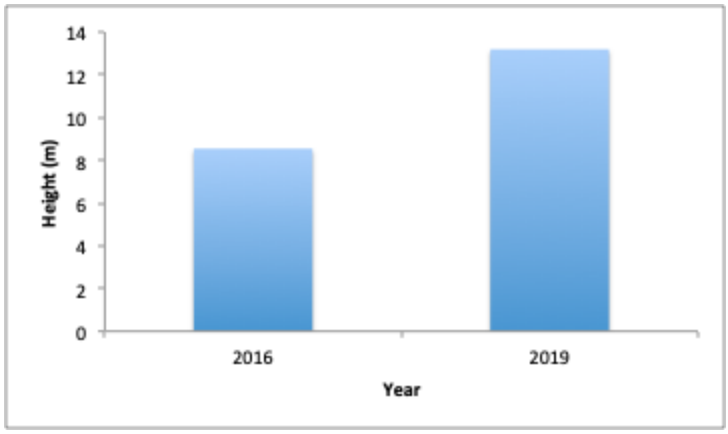


Figure 9: Average height of all Norway Spruce trees found at the University of Toronto Mississauga (UTM) campus tree inventory area, throughout July, 2019 in comparison to the 2016 measurements.

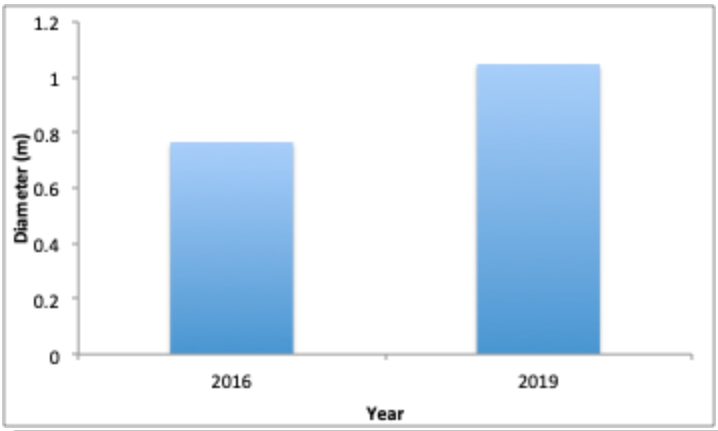


Figure 10: Average DBH at 1.3m of all Norway Spruce trees found at the University of Toronto Mississauga (UTM) campus inventory area, throughout July, 2019 in comparison to the 2016 measurements

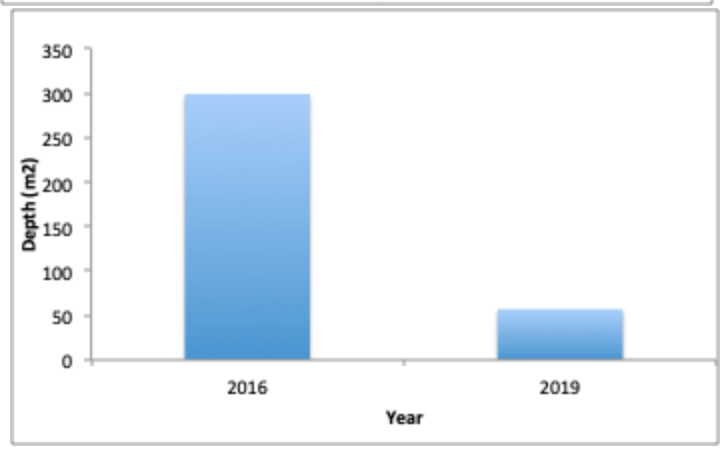


Figure 11: Average crown volume of all Norway Spruce trees found at the University of Toronto Mississauga (UTM) campus tree inventory area plot, throughout July, 2019 in comparison to the 2016 measurements. Missing and dead trees were not included.

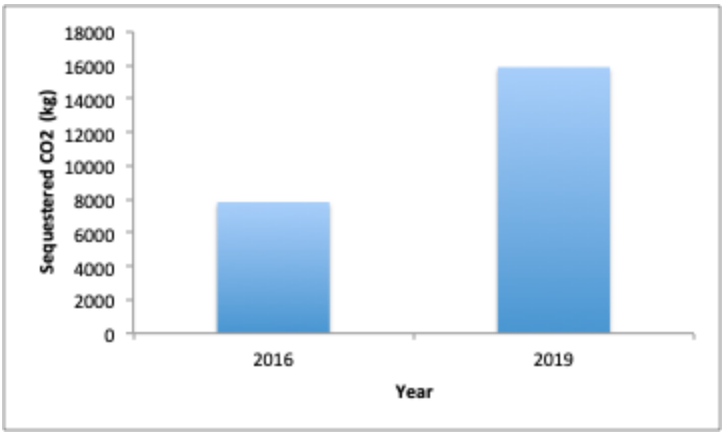


Figure 12: Average carbon dioxide sequestered by all Norway Spruce trees found at the University of Toronto Mississauga (UTM) campus tree inventory area, throughout July, 2019 in comparison to the 2016 measurements.

These Norway Spruce trees are located along Outer Circle drive and Mississauga Road. When examining the Norway Spruce data it seems that the trees average height, Average DBH and average sequestered carbon increased but the crown volume

decreased. The reason for this decrease was the lack of Norway Spruce trees that were accessible for measuring and missing lower limbs. At the time of measuring only 29 were found, whereas 44 were identified in 2016. Many of the Norway Spruce trees were blocked off in construction sites or were placed in areas behind fencing in student housing units. It was also noted that some were either misidentified or cut down. When examining the health of these Spruce trees, they were mostly healthy but approximately 6 of them had dry lower branches. The 6 trees were not measured. The significant decrease in crown volume may also have been related to human error when measuring in 2016. Another reason for the decrease may have been the environment they were planted in.

Crabapple:

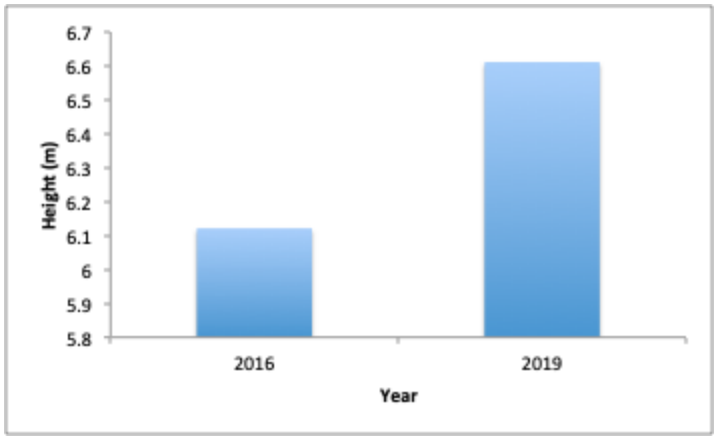


Figure 13: Average height of all Crabapple trees found at the University of Toronto Mississauga (UTM) campus tree inventory area, throughout July, 2019 in comparison to the 2016 measurements.

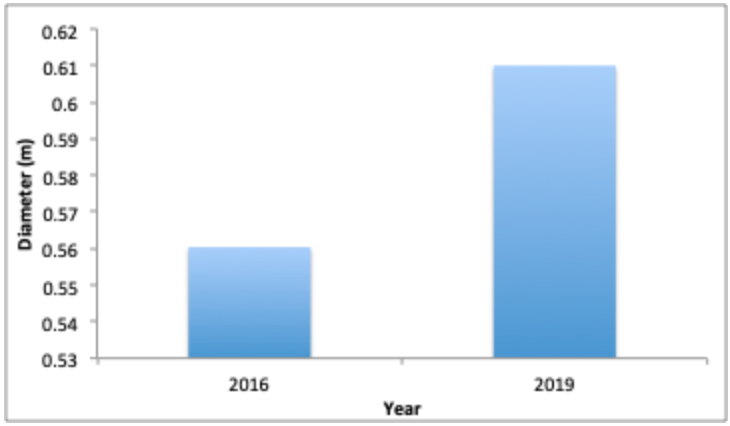


Figure 14: Average DBH of all Crabapple trees at 1.3m found at the University of Toronto Mississauga (UTM) campus tree inventory area, throughout July, 2019 in comparison to the 2016 measurements.

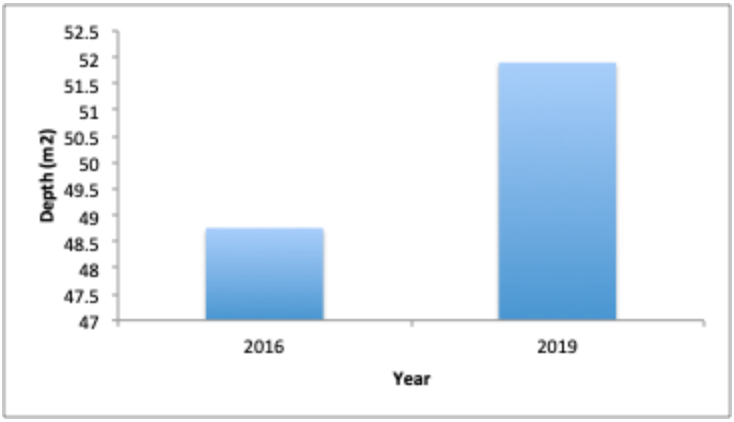


Figure 15: Average crown volume of all Crabapple trees found at the University of Toronto Mississauga (UTM) campus tree inventory area, throughout July, 2019 in comparison to the 2016 measurements.

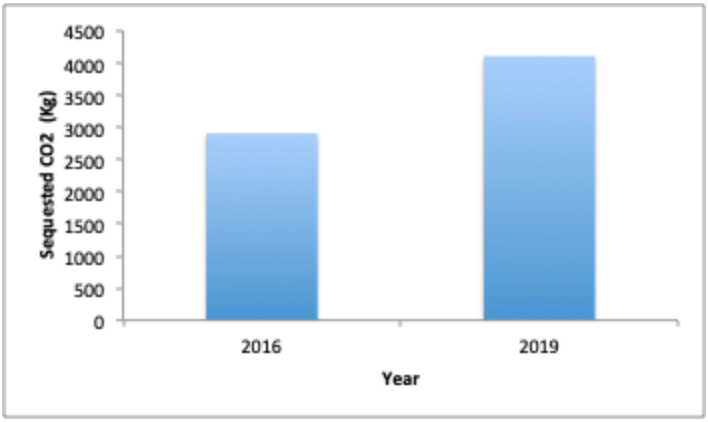


Figure 16: Average carbon dioxide sequestered by all Crabapple trees found at the University of Toronto Mississauga (UTM) campus tree inventory area, throughout July, 2019 in comparison to the 2016 measurements.

When examining the Crabapple data it is clear that this species is surviving greatly in this location and environment. All of the Crabapple trees were found and all seemed healthy. Many of them were located on the perimeter of the entryway of the campus and found on the perimeter of the student residency. As seen in Figure 13, the height increased by 6 m. For a tree that is not very tall that seems to be significant. With the increase in height the crown width also increased by an average of 0.5m. Again showing that more shade can be provided by this species. Likewise the Crabapples increased their ability to store carbon dioxide, again displaying their environmental benefit in this location and that they are striving.

Sugar Maple:

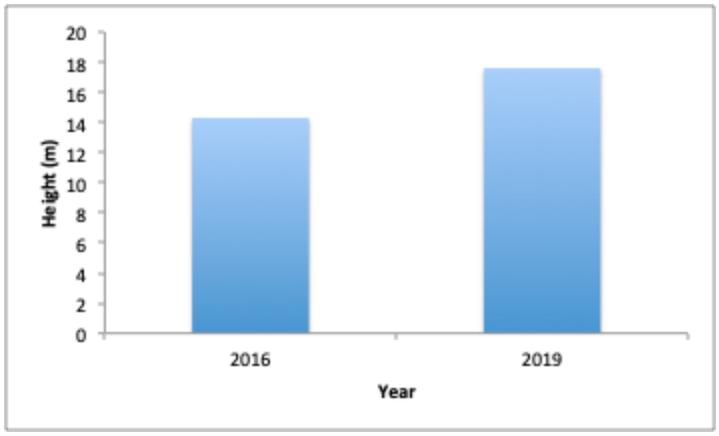


Figure 17: Average height of all Sugar Maple trees found at the University of Toronto Mississauga (UTM) campus inventory area, throughout July, 2019 in comparison to the 2016 measurements.

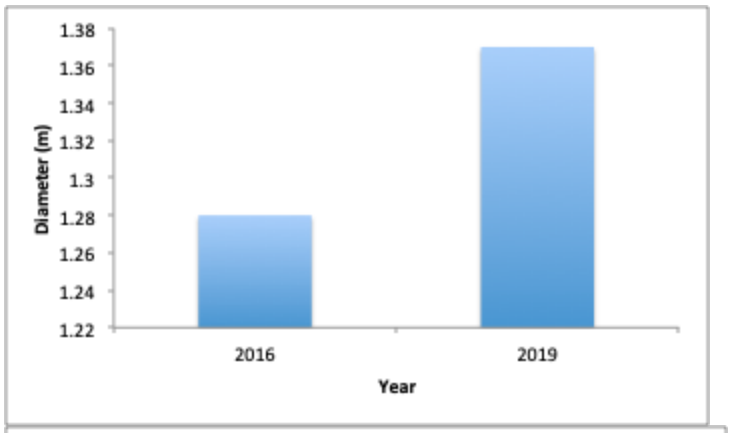


Figure 18: Average DBH at 1.3m of all Sugar Maple trees found at the University of Toronto Mississauga (UTM) campus inventory area, throughout July, 2019 in comparison to the 2016 measurements.

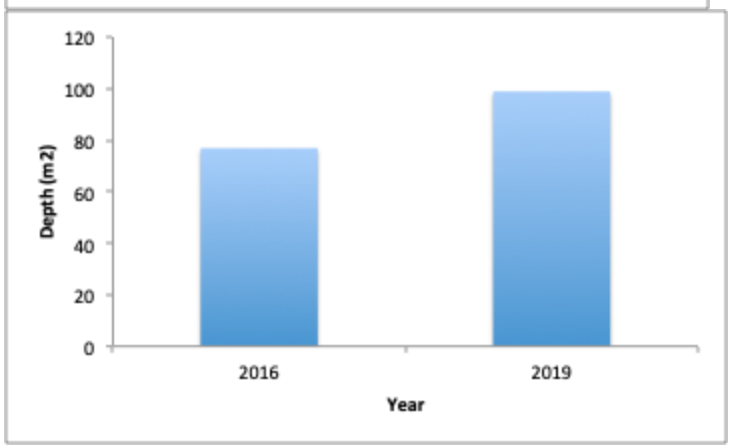


Figure 19: Average crown volume of all Sugar trees found at the University of Toronto Mississauga (UTM) campus inventory area, throughout July, 2019 in comparison to the 2016 measurements.

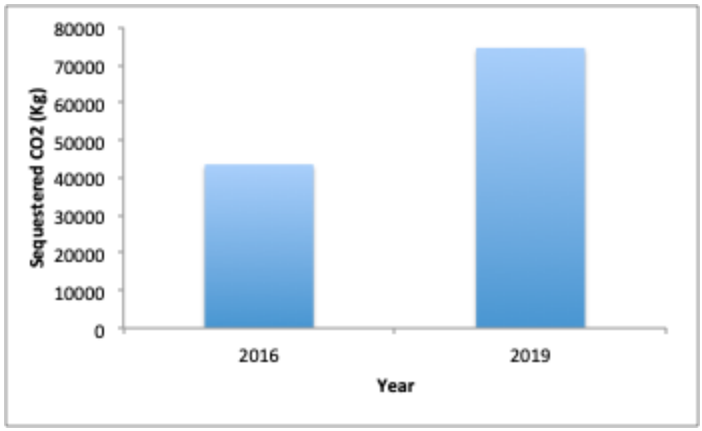


Figure 20: Average carbon dioxide sequestered of all Sugar Maple trees found at the University of Toronto Mississauga (UTM) campus inventory area, throughout July, 2019 in comparison to the 2016 measurements.

When examining the Sugar Maple trees it was clear that they were surviving well in their environment. They are located along Mississauga Road, as seen in Figure 2, depicted in purple and green. One problem that arose when measuring was the misidentification of Sugar and Norway Maple trees. The previous intern identified some as Norway Maple but they were later identified as Sugar Maple. Another problem was that about three were missing and no stump or reminance of a previous tree were not found. The missing trees were not included in the data. The ones that were present displayed good health. As seen in Figures 17-19, on average the Sugar Maple trees are increasing in all measurements. Again, showing that they are thriving in their environment.

Norway Maple:

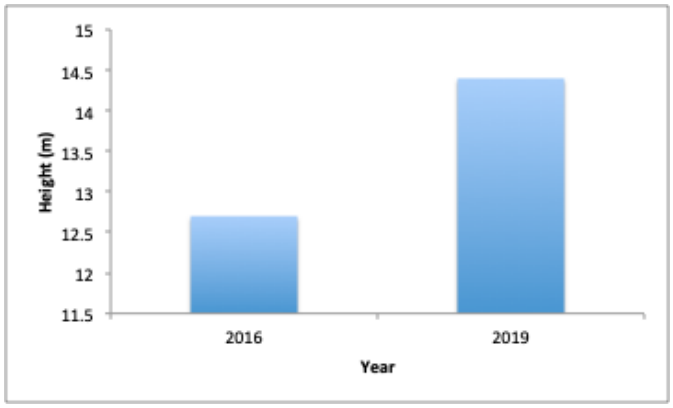


Figure 21: Average height of all Norway Maple trees found at the University of Toronto Mississauga (UTM) campus inventory area, throughout July, 2019 in comparison to the 2016 measurements.

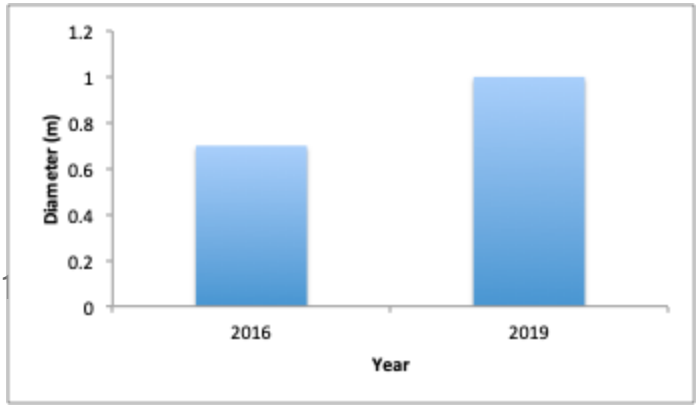


Figure 22: Average DBH at 1.3m of all Norway Maple trees found at the University of Toronto Mississauga

(UTM) campus inventory area, throughout July, 2019 in comparison to the 2016 measurements.

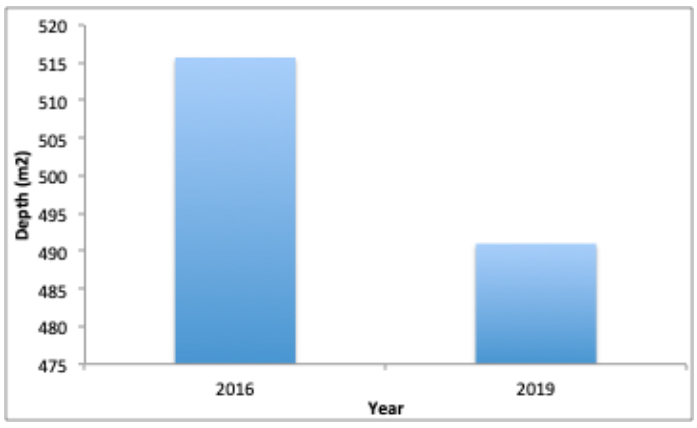


Figure 23: Average crown volume of all Norway Maple trees found at the University of Toronto Mississauga (UTM) campus inventory area, throughout July, 2019 in comparison to the 2016 measurements.

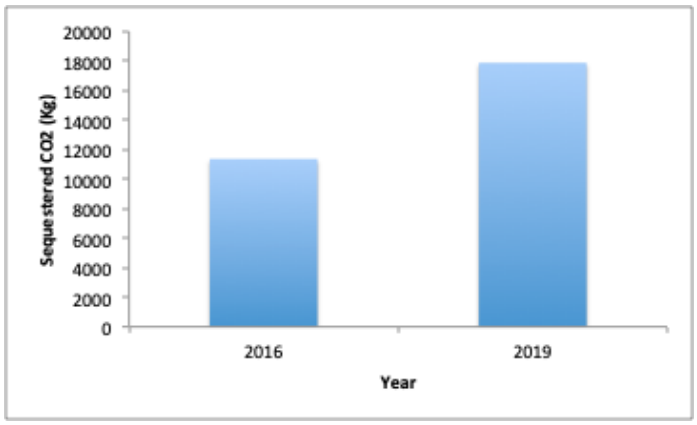


Figure 24: Average carbon dioxide sequestered of all Norway Maple trees found at the University of Toronto Mississauga (UTM) campus inventory area, throughout July, 2019 in comparison to the 2016 measurements.

The Norway Maple were found at the same locations as the Sugar Maple trees. As seen in Figures 21-23 the trends are similar to the Sugar Maple, where they are increasing in height (by an average of 2m), in DBH and in sequestered carbon. In contrast there was a decrease in crown volume by an average of $25m^2$. This decrease may have been from human error when measuring and the misidentification of species. As mentioned before, some of the maple trees were identified as Norway Maple instead of Sugar Maple and vise versa in 2016. All in all, this species thrived in a similar manner to the Sugar Maple.

Willow:

The Willow was located up a hill and the roots were under the sidewalk causing it

to rise and the tree itself to slant. Also one of the two Willows was cut down. As seen in Appendix A1, the average height of the Willow tree, the average DBH and the average amount of carbon dioxide sequestered increased. Even though the other tree was missing the increase depicted there was significant growth in all measurements. When observing the tree itself it looked healthy and had no visible health problems.

American Sycamore:

When examining the American Sycamore trees, only one was found. As seen in Figure 2, two of them were tagged. When looking for the second one it was concluded that it never existed and it must have been misidentified, since there was no stump in the area tagged and no other tree around it looked like a sycamore tree. As seen in Appendix A2, the species has increased in average height, volume, DBH and sequestered carbon dioxide. With that being said the one tree did seem physically healthy and was located on a flat surface, down a hill near the resident building.

Red Pine:

When examining the Red Pine data it is clear that they were surviving well in this location. Three years ago only one was tagged, but two Red Pines were found. The two Pines are located beside each other in a mulched area beside a resident window. As seen in Appendix A3, in all measurements they increased. A possible reason for this increase may have been the additing of the other tree and the addition of the mulch, which may have increased their soil moisture. It was also noted that they were physically healthy and their height increased greatly.

Eastern White Cedar:

Three Eastern White Cedars were identified and tagged in 2016 but only two were found during the 2019 re-measuring. It was suspected that the one tree was cut down because a stump was present at the location. As seen in Figure 2, they are located along Mississauga Road, in front of a residential building and a couple meters away from the sidewalk. As seen in Appendix A4, they were not surviving well. Their average height, average crown volume, average DBH, and average amount of sequestered carbon dioxide decreased significantly. A reason for this may have been the location. They were located behind the Willow tree, which may have blocked sunlight and caused competition. The location was also by a path the students use to move between buildings,

with that being said the students may have disterbed their habitat.

White Oak:

In 2016 two White Oak trees were found, whereas in 2019 three were spotted. This shows that it must have been misidentified previously. As seen in Appendix A5, the average height, average DBH, average crown volume and average sequestered carbon dioxide increased. This shows that this species is thriving well in this environment and is able to provide lots of needed shade.

Mississauga and Brampton Schools:

Figure 25: Location of the schools used for re-measuring in Mississauga and Brampton between June-July and October 2019. Image taken from Google Maps.

These schools are part of the previously mentioned program, Planting for Change. Five schools in Mississauga were chosen for the re-measuring and two schools in Brampton. Each school had 6 species of trees; White Spruce, Sugar Maple, Bur Oak, Basswood, and Hop Tree. A Red Maple was planted on each plot as a signature species to represent the maple on the Canadian flag (Cassleman, A., 2020). For that reason the Red Maple was not graphed. Each school also had different tree tagging methods, such as using bright tape, and locations for the trees.

St. Joan of Arc Secondary School:

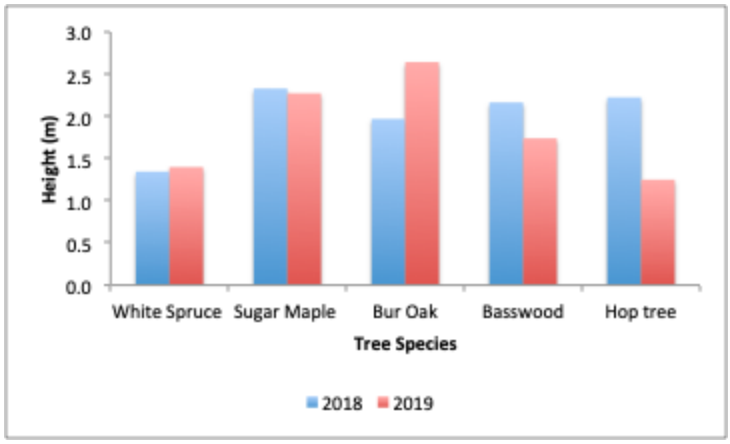


Figure 26: Average height of all trees found at St. Joan of Arc Secondary School's biodiversity plot, collected on October 23rd, 2019 in comparison to 2018 measurements.

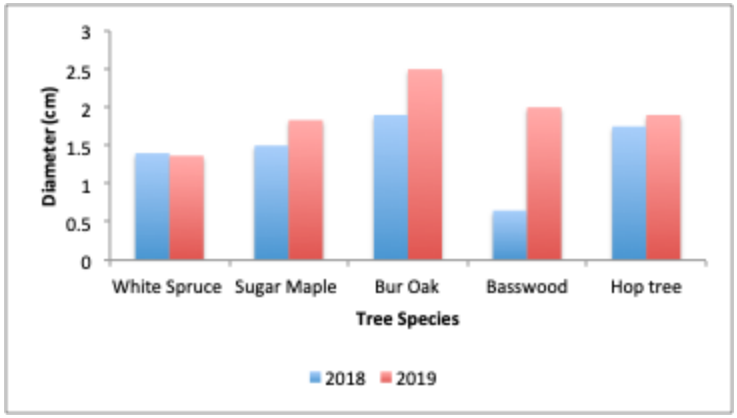


Figure 27: Average DBH of all trees found at St. Joan of Arc Secondary School's biodiversity plot, collected on October 23rd, 2019 in comparison to 2018 measurements.

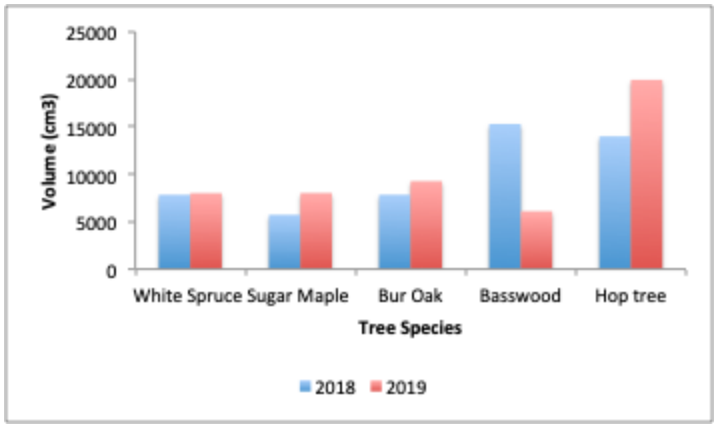


Figure 28: Average crown volume of all trees found at St. Joan of Arc Secondary School's biodiversity plot, collected on October 23rd, 2019 in comparison to 2018 measurements.

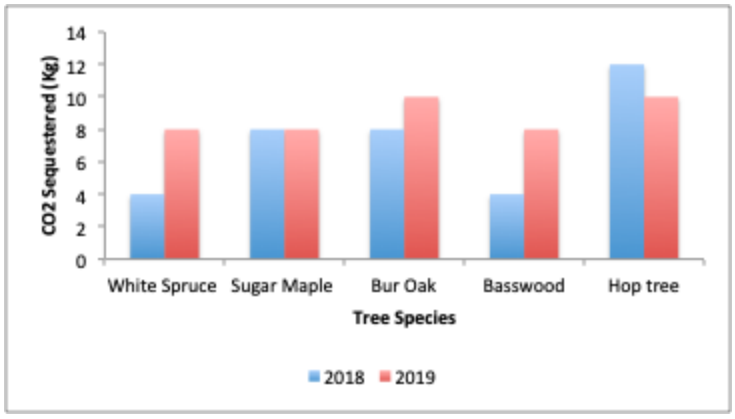


Figure 29: Average sequestered carbon dioxide of all trees found at St. Joan of Arc Secondary School's biodiversity plot, collected on October 23rd, 2019 in comparison to 2018 measurements.

St. Joan of Arc Secondary School is located on 3801 Thomas St, Mississauga, ON, as seen in Figure 21a. It is located in a suburban neighbourhood, surrounded by a park, grass and roads. The Planting for Change Trees are located between the school parking and a field. The trees are planted around sitting stones in a semicircle.

The trees themselves were taken care of by groundskeepers, teachers and students involved with the program and were tagged with metal tags supplied by ACER. Looking at the data, the Bur Oak seemed to strive the best, except in the crown volume. The Hop Tree also strived strongly in all aspects and the spruce seemed to increase slowly over the year. Whereas, the Basswood had the lowest growth rates.

West Credit Secondary School:

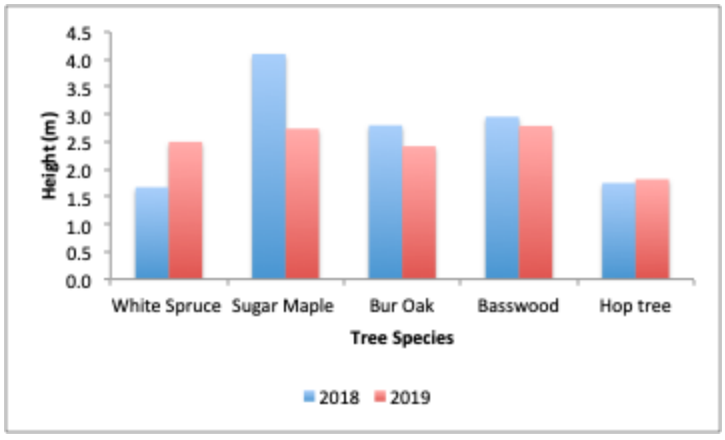


Figure 30: Average height of all trees found at West Credit Secondary School's biodiversity plot, collected on October 23rd, 2019 in comparison to 2018 measurements.

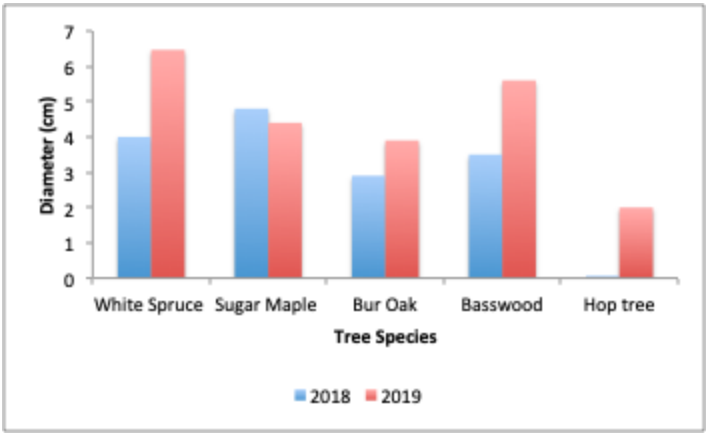


Figure 31: Average DBH of all trees found at West Credit Secondary School's biodiversity plot, collected on October 23rd, 2019 in comparison to 2018 measurements.

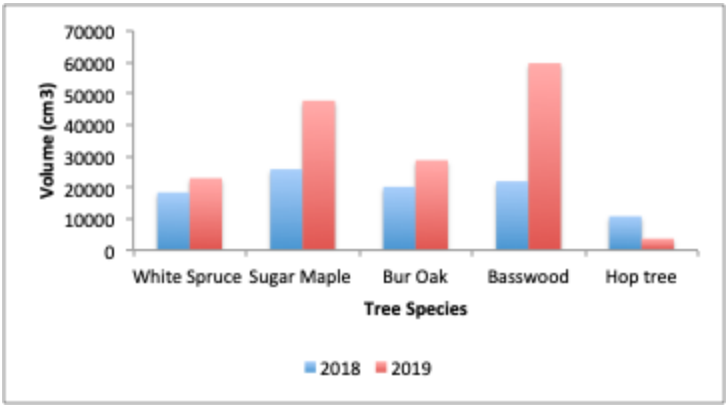


Figure 32: Average crown volume of all trees found at West Credit Secondary School's biodiversity plot, collected on October 23rd, 2019 in comparison to 2018 measurements.

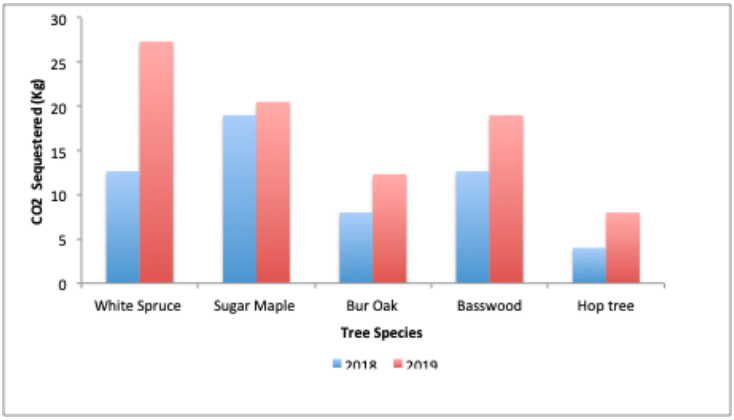


Figure 33: Average sequestered carbon dioxide of all trees found at West Credit Secondary School's biodiversity plot, collected on October 23rd, 2019 in comparison to 2018 measurements.

West Credit Secondary School is located at 6325 Montevideo Rd, Mississauga, ON, as seen in Figure 25a. The high school is again, in a suburban area surrounded by houses and roads. The Planting for Change plot was located beside a parking lot and some portable classrooms. Many of the trees were missing because of recent construction. Some of the trees were also damaged because a transplantation was made when

construction started. Some of the present trees had metal tags but many did not. Looking at the collected data it is clear that the trees did not diminish in health despite the construction. The trees were also planted in a triangular formation a few feet away from each other.

The White Spruce, Bur Oak, Basswood and Sugar Maple seemed to do the best, and the average height for the Hop Tree decreased, as seen in Figure 30. A reason for this decrease in height may have been human error when measuring out the 20m or while using the clinometer.

Fallingbrook Middle School:

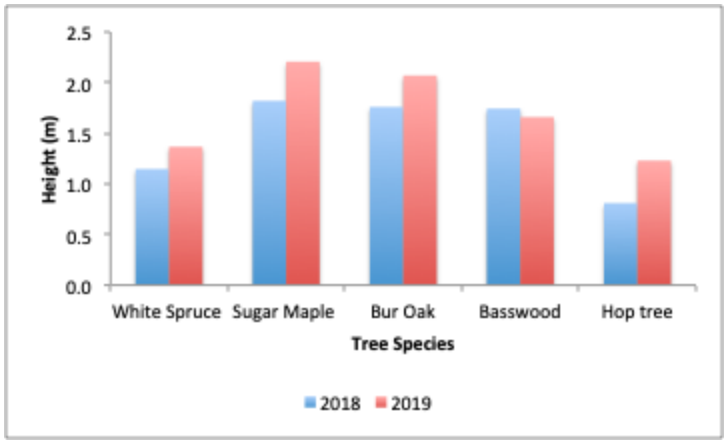


Figure 34: Average height of all trees found at Fallingbrook Middle School's biodiversity plot, collected on October 23rd, 2019 in comparison to 2018 measurements.

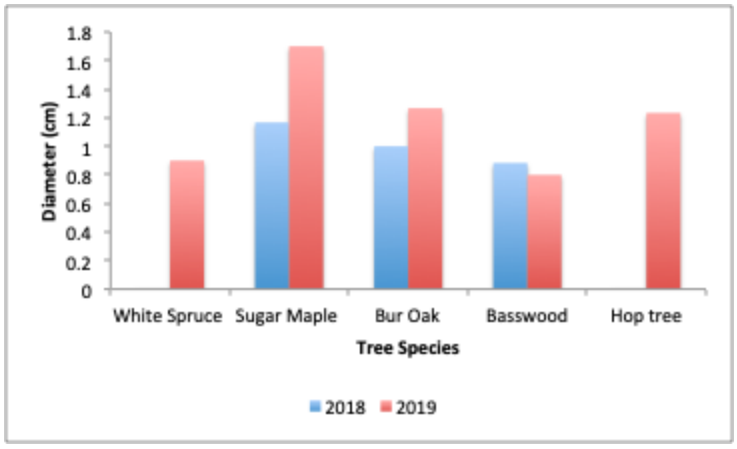


Figure 35: Average DBH of all trees found at Fallingbrook Middle School's biodiversity plot, collected on October 23rd, 2019 in comparison to 2018 measurements.

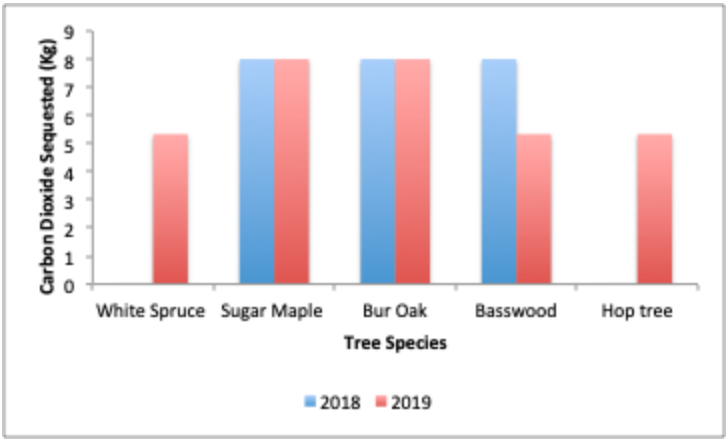


Figure 36: Average sequestered carbon dioxide of all trees found at Fallingbrook Middle School's biodiversity plot, collected on October 23rd, 2019 in comparison to 2018 measurements.

Figure 37: Average crown volume of all trees found at Fallingbrook Middle School's biodiversity plot, collected on October 23rd, 2019 in comparison to 2018 measurements.

Fallingbrook Middle School is located at 5187 Fallingbrook Dr, Mississauga, ON, as seen in Figure 25. It is in a suburban neighbourhood surrounded by a field and a park. At this location, the plots were divided into two areas; one beside the parking lot near the back of the school and the other was at the front of the school. At each plot the saplings were clearly tagged and well taken care of. Only one of the trees near the front of the school seemed to be damaged, by what seemed like a passer-by who may have caught their jacket on a branch. The trees were also planted in a circular formation.

When examining the data, in Figure 34, all species increased in average height. The Sugar Maple, and Bur Oak grew the most in height. As seen in Figures 33-37, all of the trees increased in average DBH, average volume and with their ability to sequester carbon dioxide, except for the Basswood, where it decreased it's average ability to sequester carbon dioxide. As seen in Figure 36 the White Spruce and Hop Tree have no 2018 measurements because

they were shorter than 1.3m. For that reason a DBH measurement could not be made.

St. Gerard Elementary school:

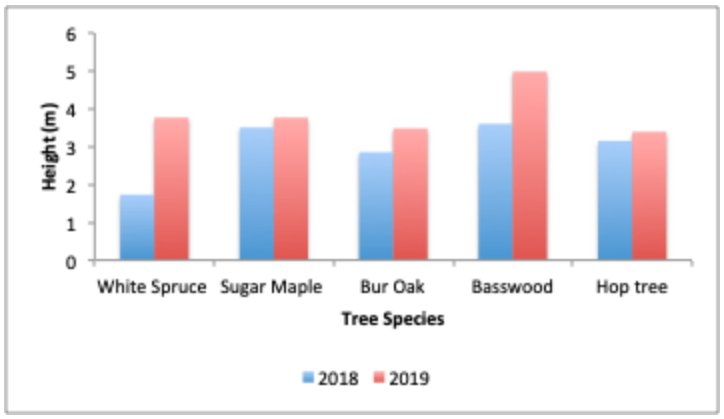


Figure 38: Average height of all trees found at St. Gerard Elementary School's biodiversity plot, collected on October 23rd, 2019 in comparison to 2018 measurements.

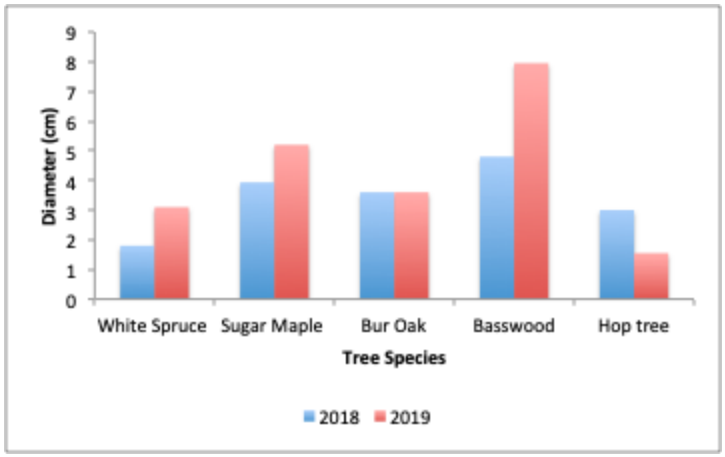


Figure 39: Average DBH of all trees found at St. Gerard Elementary School's biodiversity plot on October 23, 2019 in comparison to 2018 measurements.

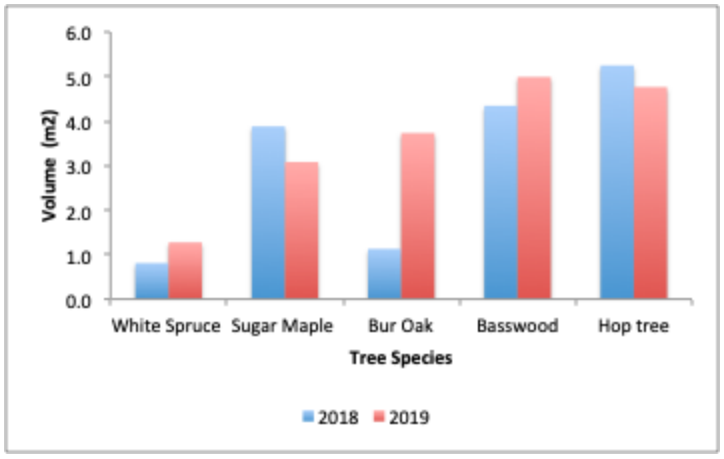


Figure 40: Average crown volume of all trees found at St. Gerard Elementary School's biodiversity plot, collected on October 23rd, 2019 in comparison to 2018 measurements.

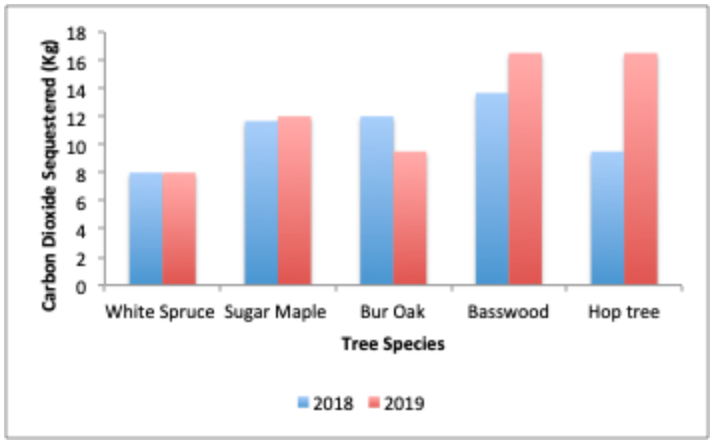


Figure 41: Average sequestered Carbon dioxide of all trees found at St. Gerard Elementary School's biodiversity plot, collected on October 23rd, 2019 in comparison to 2018 measurements.

St. Gerard Elementary School is located on 1300 McBride Ave, Mississauga, ON, as seen in Figure 25. This school was located between some busy roads, a strip mall and a church. The trees were located near a fence and lacked sunlight because of tall shrubs. The trees were missing almost all of their tags and were not taken care of by the groundskeepers, teachers and students. Many of the trees were either missing or hard to find.

The Hop tree decreased in average DBH and crown volume, whereas the rest increased. A reason for this decrease may have been human error when measuring. The Bur Oak decreased in the average amount of sequestered carbon dioxide. A reason for this decrease may have been the location of the trees and the lack of care.

Applewood Heights Secondary School:

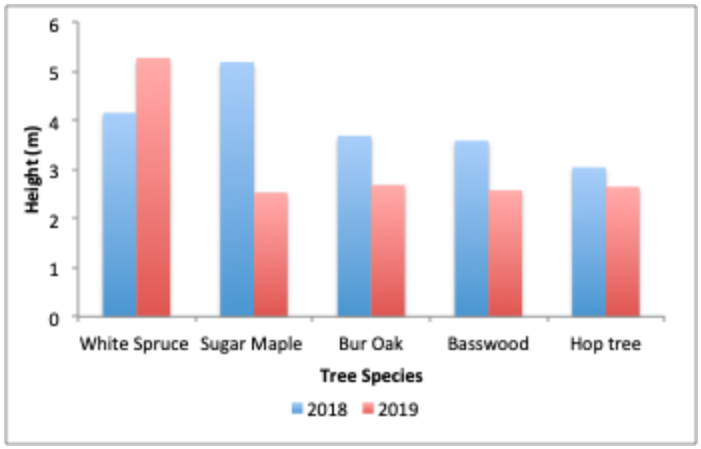


Figure 42: Average height of all trees found at Applewood Heights Secondary School's biodiversity plot, collected on October 23rd, 2019 in comparison to 2018 measurements.

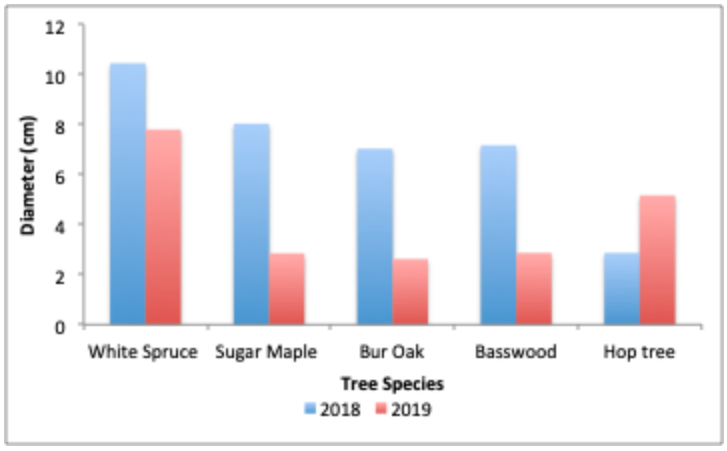


Figure 43: Average DBH of all trees found at Applewood Heights Secondary School's biodiversity plot, collected on October 23rd, 2019 in comparison to 2018 measurements.

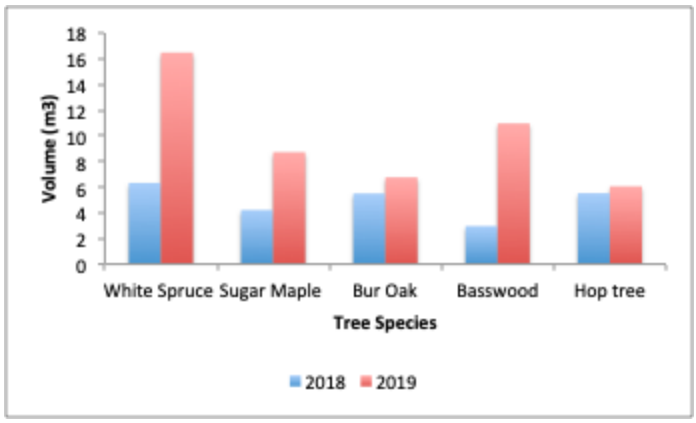


Figure 44: Average crown volume of all trees found at Applewood Heights Secondary School's biodiversity plot, collected on October 23rd, 2019 in comparison to 2018 measurements.

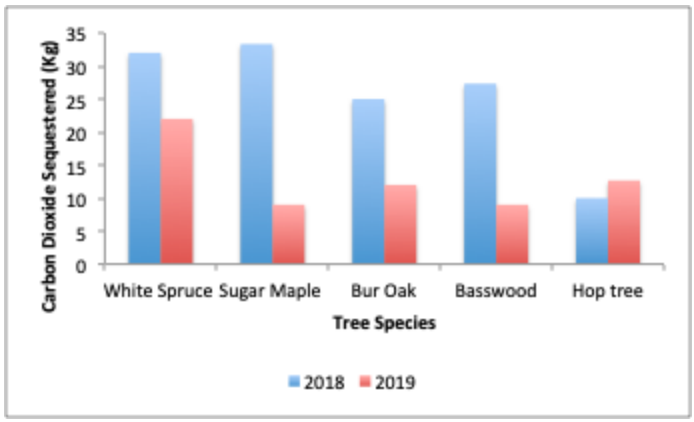


Figure 45: Average sequestered carbon dioxide of all trees found at Applewood Heights Secondary School's biodiversity plot, collected on October 23rd, 2019 in comparison to 2018 measurements.

Applewood Heights Secondary school is the last school in Mississauga. It is located on 945 Bloor St, Mississauga, ON, seen in Figure 25. Again, it is located in a suburban area

near a park, a field and residential houses. The trees were located in a rectangular plot beside a parking lot with overgrown grasses. Each tree was tagged with bright pink tape and they were easy to find. There was also one tree missing because it was cut down.

As seen in Figures 42-45, most of the trees seemed to decrease in average height except the White Spruce. When looking at the average DBH the Hop Tree was the only species that increased. When looking at the average crown volume data, all species increased during the year. All species decreased in the average amount of sequestered carbon dioxide. A reason for the decreases may have been human error when measuring the heights with the clinometer and not getting an accurate DBH because of the tall grasses and shrubs getting in the way of the trunk, thus causing the carbon sequestration measurements to decrease. Another reason may have been competition between the species since they were all located beside each other in an unweeded area.

Central Peel Elementary School:

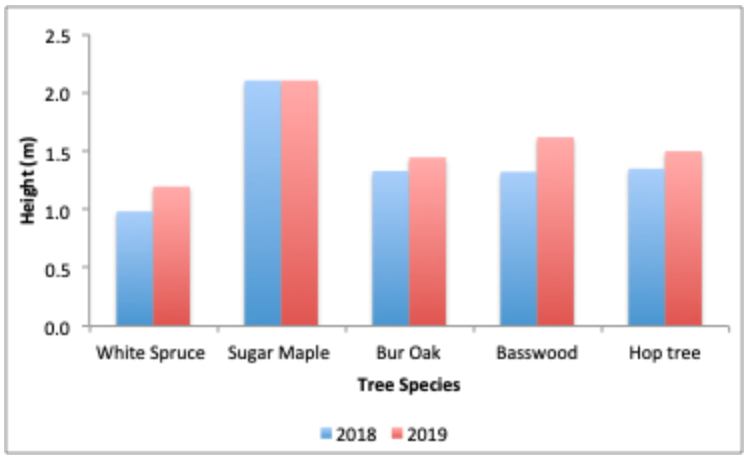


Figure 46: Average height of all trees found at Central Peel Elementary School's biodiversity plot, collected on July 26rd, 2019 in comparison to 2018 measurements.

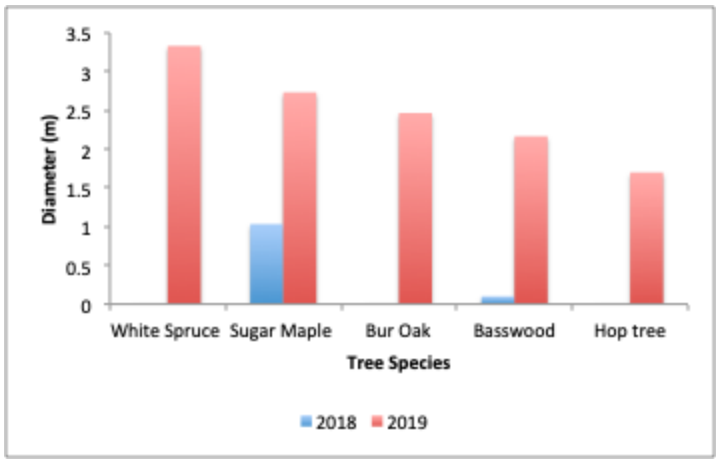


Figure 47: Average DBH of all trees found at Central Peel Elementary School's biodiversity plot, collected on July 26rd, 2019 in comparison to 2018 measurements.

Figure 48: Average crown volume of all trees found at Central Peel Elementary School's biodiversity plot, collected on July 26rd, 2019 in comparison to 2018 measurements.

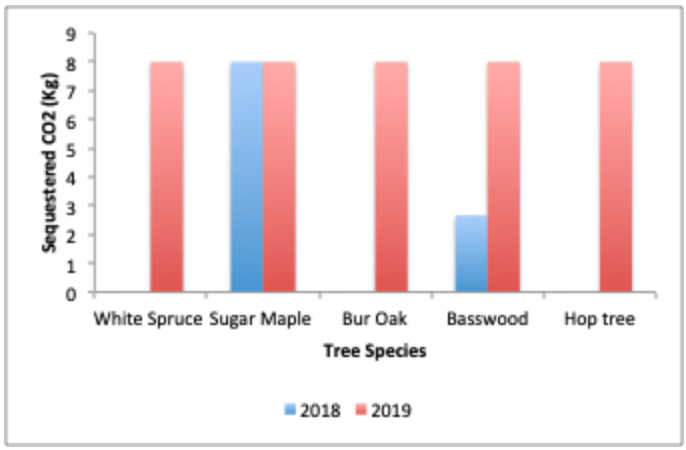


Figure 49: Average sequestered Carbon Dioxide of all trees found at Central Peel Elementary School's biodiversity plot, collected on July 26rd, 2019 in comparison to 2018 measurements.

Central Peel Secondary School is located on 32 Kennedy Rd N, Brampton, ON. It is surrounded by stores and a strip mall. The trees were located behind the school near a ravine. All of the trees were planted in a line a few feet apart, surrounded by mulch and tall grasses. All of the trees were tagged with the metal tags ACER supplied the school with.

All of the 5 species increased in average height, average DBH, average crown width and developed their ability to sequester carbon dioxide because of their increase in DBH. In Figure 47 some 2018 measurements were missing because the trees were not tall enough to measure the DBH. As seen in Figure 49 some of the 2018 measurements were not measured because the tree trunk was too thin to sequester carbon dioxide. A

reason for all of the species to increase significantly may have been the added mulch. With the mulch it allows the soil to retain water, prevents weeds to grow and helps keep the soil at a constant temperature.

Conestoga Public School:

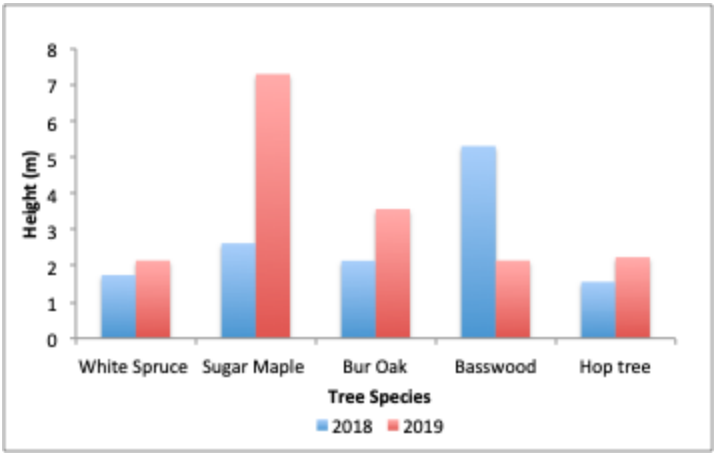


Figure 50: Average height of all trees found at Conestoga Public School's biodiversity plot, collected on July 26rd, 2019 in comparison to 2018 measurements.

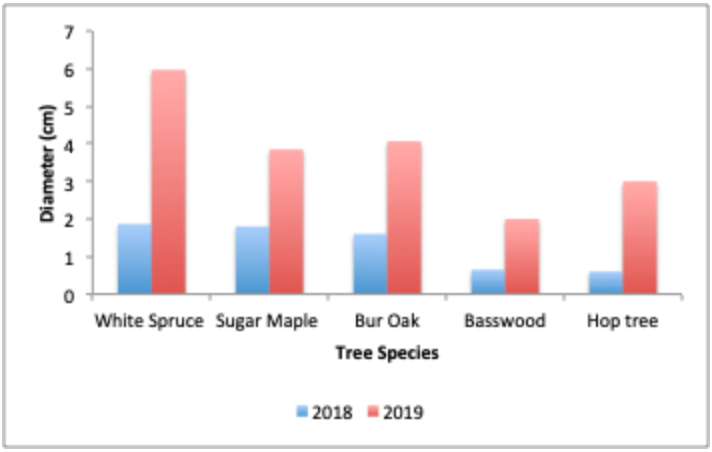


Figure 51: Average DBH of all trees found at Conestoga Public School's biodiversity plot, collected on July 26rd, 2019 in comparison to 2018 measurements.

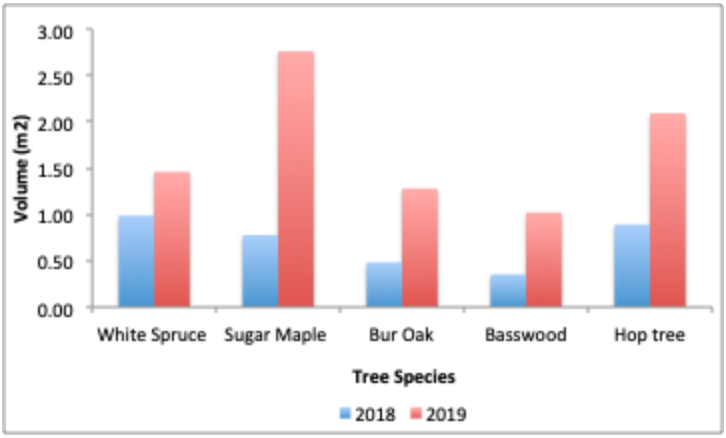


Figure 52: Average crown volume of all trees found at Conestoga Public School's biodiversity plot, collected on July 26rd, 2019 in comparison to 2018 measurements.

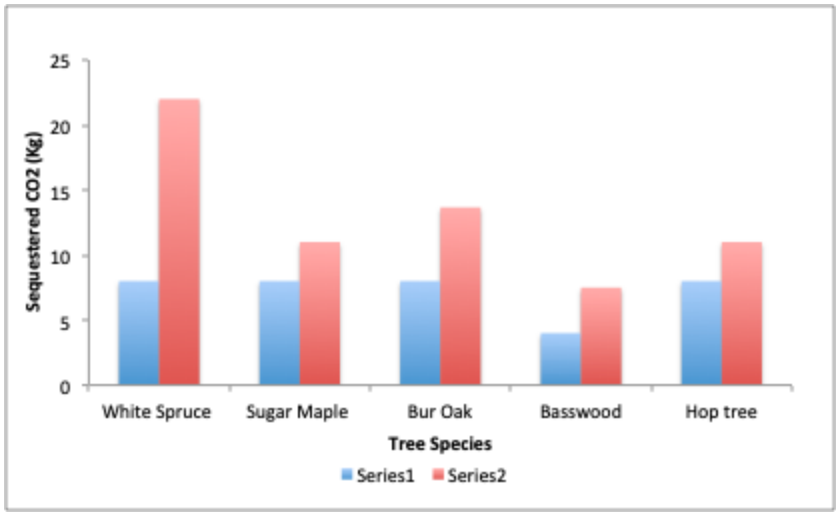


Figure 53: Average sequestered Carbon dioxide of all trees found at Conestoga Public School's biodiversity plot, collected on July 26rd, 2019 in comparison to 2018 measurements.

Conestoga Public School is located in 300 Conestoga Dr, Brampton, ON, as seen in Figure 25. The tree plot is located behind the school in between the playground and the school field. All of the trees were missing the tags. It was suspected that the groundskeeper cut the tags off since zip ties used to secure the metal tags were found cut on the ground. The trees were also well kept and surrounded by mulch.

When examining figures 50-53, it is clear that all species increased in average DBH, average crown volume and average sequestered carbon dioxide. When looking at figure 50, the Basswood decreased in average height. A reason for this decrease may have been human error. The three species that thrived the most are, White Spruce, Sugar Maple and Bur Oak. Whereas the Basswood, and Hop Tree did increase in most measurements but not as drastically.

DISCUSSION

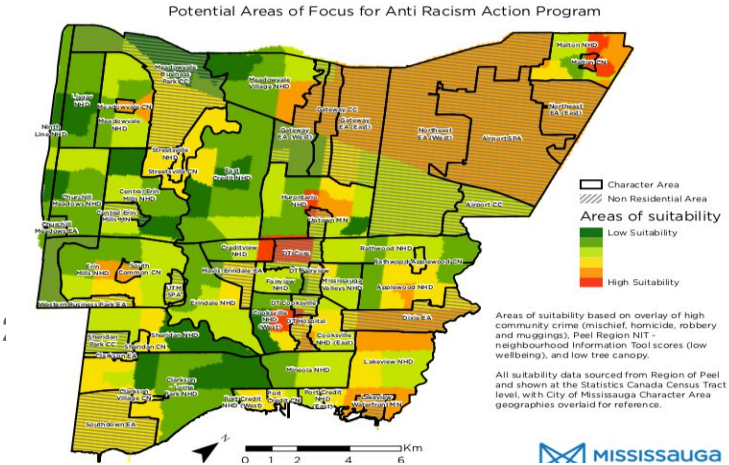


Figure 54: Displaying various levels of suitability for incorporating tree canopy in Mississauga.

Biodiversity and its importance

Biodiversity is, “the variety of life on earth at all its levels that sustain life”[7]. This means the presence of different types and species of life interacting together in the same area. Biodiversity is important because it helps all living organisms learn from other species and create a rich and better functioning society and environment. With the presence of other species, we can learn how to adapt and become resilient to changes, whether environmental or anthropogenic. Also, with the presence of other species it can help mitigate changes and environmental problems such as an invasion of an invasive species that only affects Maple trees. If a whole forest has maple trees, that whole forest would be destroyed, but if there were many species in that area, the forest would still be able to provide the needed services and managing the issue would be easier.

A research study conducted in Germany looked at forests in 6 European countries. They compared forest plots with single species to plots with multiple species[6]. They concluded that the multispecies forest plots thrived better. They saw that the trees in the multispecies plots grew faster, collected more carbon dioxide and were more resilient to forest regeneration[6]. Whereas the single species plot did have growth but it was not as drastic and the plots did not provide the same environmental benefits as the multispecies plot.

The study also noted that as the climate is currently changing and the summers are getting hotter and drier, it would be easier to manage multi species forests since each species would react differently. With that, each tree would be helping the others and provide the wildlife and humans specific environmental need[6]. With that being said with the current climate change issues the trees that fit the environment that they are in are surviving. Since trees cannot physically move from unfavourable locations, only specific species can survive and interact with each other. By having multiple species in each environment it will allow the ecosystem to not diminish with the various changes.

Importance of trees

Trees serve an important role not only for the environment but for society. They provide many services for the environment, improve human health and safety and affect socioeconomic factors.

Environment

Trees act as a natural air filter, they remove dust, smoke and fumes[8]. They also help reduce the Greenhouse effect by removing carbon dioxide and releasing oxygen[8]. Trees also act as a great sound barrier and are a better alternative to fences[8]. Trees provide shade, and habitat for wildlife. They are also great at reducing flash flood by reducing the flow of water. They are also great at stabilizing soil by reducing erosion with their roots.

Health, safety and economy

Trees also provide many health and safety benefits. A study was done in Toronto, Ontario looking at a correlation between human health and trees[9]. The study consisted of using high resolution satellite imaging, and tree data with a questionnaire of self reporting health questions targeted towards certain people in various Toronto neighbourhoods[9]. The study concluded that, “people who live in neighbourhoods with a high density of trees on their streets reported having significantly higher health perception and less cardio-metabolic conditions” (Kardan et al., 2015, 1). Trees can also reduce blood pressure, stress, and improve memory[9]. The researchers also stated that adding just 10 more trees in a city block would improve health perceptions in ways comparable to an increase of someone’s income by $10,000[9]. Another study done in the United States, reports an increase in well-being after people had a brisk walk in a forested, green space[12].

Having access to a view of trees also reduces crime rates, aggression and helps people recover faster after illnesses or surgery [9]. Being exposed to trees also helps

improve an individual's mental health[9]. A study done in Baltimore examined the relationship between canopy cover and crime rates. They found that a 10% increase in canopy cover would result in a 12% decrease in crime rates [10]. The researchers also found that by planting trees in public areas crime rates would reduce greatly because public trees affect people 40% times more than trees on private land[10]. Likewise this study found that areas with trees that are unkempt had a slightly higher amount of crime because it would encourage people to hide in the lower branches and be on private property without being seen[10]. Therefore, in order to use trees to decrease crime rates, proper pruning of the lower hanging branches needs to be instilled.

Trees also affect the socio-economic sector of our society. Trees provide shade, as seen previously the crown width of the trees were mostly increasing, thus increasing shade. A study done in South Africa researchers compared three low-income neighbourhoods and their tree landscapes. They found that the more trees present in the towns the better the community thrived[11]. The communities with more trees had more shade, which allowed their homes to stay cool during the day, and use the trees wood for energy and heat[11]. They also compared how in higher-economic neighbourhoods trees were used for aesthetic purposes and for their fruit[11]. For this reason urban planning in low-economic areas is extremely important.

As seen in Figure 54, Mississauga has some hotspots of suitability for incorporating a higher amount of tree canopy. The map displays an overlay of high community crime, neighbourhood information (such as wellbeing) and low tree canopy. By understanding this map and planting trees in the suitable areas it will help decrease many neighbourhood issues to help create a healthier community.

Based on the data, which trees should be planted?

As mentioned before, the results displayed that all the species were surviving but they were growing at different speeds depending on the location and the care they received. Since all of the locations had different trends it is important to understand which species decreased over time at each school.

At the UTM tree inventory plot the Red Oak, Norway Spruce, Crabapple, Sugar Maple, Norway Maple, Willow, American Sycamore, Red Pine and White Oak all survived well over the three years. The only species that did not survive well is the Eastern White

Cedar. This species decreased in all measurements.

At the Joan of Arc Secondary School biodiversity plot the only species that did not increase in average height was the Hop Tree. The Basswood and Hop Tree were also the only species that decreased in average crown volume. At the West Credit Secondary School biodiversity plot the Sugar Maple, Bur Oak and Basswood decreased in average height and the Hop tree decreased in average crown volume. In Falling Brook Middle School only the Basswood species decreased in average DBH and average sequestered carbon dioxide. At St. Gerard Elementary School the Red Maple decreased in average height, the Sugar Maple and Hop tree decreased in average crown volume and finally the Bur Oak decreased in average sequestered carbon dioxide. In the Applewoods Height Secondary School all of the trees average growth rates in each category decreased, except the White Spruce increased in average height. In the Central Peel Public School all of the species seem to be doing well. Finally in Conestaga Public School all species were increasing in all categories except the Basswood decreased in average height.

As seen at UTM, all of the trees were increasing in height and in most species crown width and carbon sequestration increased. As mentioned before a reason for the differences in crown width and carbon sequestration may have been human error, therefore it can be safe to assume that each species increased in their environmental services. With the school locations it was clear that some species were thriving more than others because of the different locations, and care the groundskeepers were providing.

With that being said, not one species is really doing better than the others. They are each growing and surviving in the various environments and there were no major significant changes but any changes may have been human error. As mentioned before natural competition is very common in ecosystems, where trees are fighting for sunlight and water. This could have been another reason for decreases in some categories. Therefore, when deciding which tree species to plant in new locations or forests, it is clear that all of the species should be planted.All species are surviving but some are surviving better than others . By planting multiple species it will increase biodiversity and help the trees interact with each other to ensure the plots are providing the necessary societal environmental services.

CONCLUSION

Biodiversity with trees is extremely beneficial to our community and environment. Through the re-measuring of the trees at the UTM tree inventory area and the 7 schools located Mississauga and Brampton, it was clear that each tree species grew differently in each location. All species survived but some grew better than others in the locations. For that reason each multiple species should be planted in new green areas. By doing so it will benefit the community and environment more than just planting one species. Since all species react differently in various environmental and climatic changes, having multiple species will allow the green areas to flourish and become mature. Likewise, human and environmental health and the economy will positively benefit through the understanding of the importance of biodiversity in Canadian green spaces.

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Appendix A: Smaller Sample Size:

A1. Willow:

	Average Height (m)	**Average DBH at (1.3m)**	**Average Carbon Dioxide Sequestered (Kg)**	**Average Crown volume (m3)**
2016	**16.37**	**2.35**	**52210.5**	**131.29**
2019	**26.54**	**4.43**	**169442**	**276.08**
Change	**10.17**	**2.08**	**117231.5**	**144.79**

A2. American Sycamore

	Average Height (m)	**Average DBH at (1.3m)**	**Average Carbon Dioxide Sequestered (Kg)**	**Average Crown Volume (m3)**
2016	**10.11**	**0.64**	**3601**	**95.77**
2019	**13.26**	**1.10**	**16059**	**115.03**
Change	**3.15**	**0.46**	**12458**	**19.255**

A3. Red Pine:

	Average Height (m)	**Average DBH at (1.3m)**	**Average Carbon Dioxide Sequestered (Kg)**	**Average Crown volume(m3)**
2016	**10.84**	**0.61**	**3330**	**36.56**
2019	**22.05**	**1.56**	**44282**	**131.98**
Change	**11.21**	**0.95**	**40952**	**95.42**

A4. Eastern White Cedar

	Average Height (m)	Average DBH at (1.3m)	Average Carbon Dioxide Sequestered (Kg)	Average Crown Volume (m3)
2016	**15.79**	**1**	**4818**	**97.41**
2019	**7.17**	**0.49**	**2064.5**	**9.57**
Change	**-8.62**	**-0.51**	**-2753.5**	**-87.84**

A5. White Oak

	Average Height (m)	Average DBH at (1.3m)	Average Carbon Dioxide Sequestered (Kg)	AverageCrown Volume (m3)
2016	**11.53**	**0.55**	**2240.50**	**24.69**
2019	**15.33**	**0.79**	**6444.67**	**32.89**
Change	**3.80**	**0.24**	**4204.17**	**8.20**