HEALTH AND MANAGEMENT OF TREES PLANTED IN TREE PITS IN THUNDER BAY'S DOWNTOWN NORTH CORE

by

Shawn Fortin

An undergraduate Thesis Submitted in Partial Fulfillment of the Requirements for the Degree of Honors Bachelor of Science in Forestry

FACULTY OF NATURAL RESOURCES MANAGEMENT

LAKEHEAD UNIVERSITY

THUNDER BAY, ONTARIO

April 2024

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ABSTRACT

Fortin, S. 2024 Health and Management of Trees Planted in Tree Pits in Thunder Bay's Downtown North Core. HBScF. Faculty of Natural Resources Management. Lakehead University.

Key Words: Aggregate, Diversity, Dominant Tree Species, Forestry, Google Maps, Median, Planting Pit, Recreational Areas, Silva Cells, Thunder Bay, Tree Trenches, Urbanization, Urban Strata Cell, Water Infiltration.

A survey of Thunder Bay's downtown north core (formerly known as Port Arthur) examined 276 trees in an attempt to correlate the size and health condition of the trees with the size of the planting site. The largest and most healthy of trees (e.g. silver maple. green ash) were planted in medians located between sidewalks and streets. The smallest trees and often the ones in the poorest health were planted in small planting pits located in sidewalks. The conclusion from this study points to the importance of soil volume for rooting as well as the poor physical properties of soil found in planting pits versus medians.

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ACKNOWLEDGEMENT

I would like to acknowledge and thank the following individuals for helping me during the writing process and making this thesis paper possible. My thesis advisor Dr. Hutchison who suggested the topic to me and aided me during the entire writing process. Furthermore, I would like to thank Dr. J. Wang for volunteering to be my second reader. Finally, I would like to thank all the friends and family who have supported me during the writing process.

INTRODUCTION

For centuries humans have used urban trees for their own benefit. Early Greek civilizations used urban trees to help keep its citizen's fed (Carrol, 2003), while the ancient cultures of the Mediterranean used tree gardens as a sign of wealth and prestige (Oosthoek, 1998). Trees could also be used during times of war to hide strategic resources and offer cover (Oosthoek, 1998). As the centuries went by the uses and importance of trees has changed dramatically. Trees are no longer being used as a large food source for the needy or signify wealth and prestige rather, urban trees are now used to help beautify city streets or to be used to provide a number of environmental and engineering benefits. Trees have proven to be an invaluable asset for cities as they provide shade cover and are proven to reduce stress and improve the quality of life (Wolf, 2020). Furthermore, trees will improve the air quality in a city creating a healthier environment for its citizens (Nowak etal. 2018). Urban trees create a stronger community. They are proven to promote social interaction, a sense of community, and stronger ties to neighbours (Kuo, 2003.) and (Westphal, 2003).

While an urban environment can be home to many trees and can be of great benefit, it's imperative that proper planting practices are in place to ensure beauty and longevity for the trees. Without proper care, urban trees become short-lived and become a large expense for the city. Proper tree care increases the survivability of urban trees which reduces how often they need to be replaced, saving costs. Currently, most urban trees in downtown areas are planted in small planting pits. This creates an undesirable environment for the trees, the small area provided by the planting pits does not allow sufficient area for roots to grow. This causes the roots to grow around the collar of the tree and can cause "root collaring" which can kill trees and severely reduce their life expectancy (Pankau, 2021). Furthermore, soil compaction proves to be another issue with urban tree growth. Soil compaction reduces the sizes of pore space available for water and air, further reducing growth and overall tree health (Purcell, 2019).

In this Thesis I will be examining the planting spaces provided for trees in Thunder Bay's downtown north core. Each street tree will be evaluated, and each planting space will be measured. Observations will be made on how different types of planting space may affect the growth of urban trees. This data will be used to better understand how urban trees in Thunder Bay are being affected by the different types of growing conditions. Hopefully, this data can be used to help better understand the street trees of Thunder Bay and help find a better way of growing urban trees. Trees will be assessed from 1-3, 1 being a very small tree and 3 being a mature healthy tree.

My hypothesis will be that most of the urban trees in the downtown area are in poor health and will need to be replaced in 10 years. These claims are due to the observations I have done on the health of the urban trees in the downtown areas and the obvious slow death that these urban trees are facing, especially those growing in planting pits.

DOWNTOWN CORES

Downtown cores prove to be a very difficult environment for urban trees. The tight spacing of tall buildings shade trees which are planted on curbs or tree belts. Heavy soil compaction from citizens walking or vehicles parking on the soil in which the tree resides makes it difficult for water to reach the roots. Soil compaction also promotes poor capillary movement further reducing water retention and nutrient retention capability of the tree roots (Czaja, *et al*. 2020). Furthermore, the reduction in soil porosity results in poor water and air permeability much lower colonization of microorganisms, and reduction in carbon absorption capacity (Czaja, *et al.* 2020). One of the major contributors of soil compaction in urban environments is construction. Heavy machinery used to build roads often cause serious soil compaction. Human traffic will only affect the first 7 to 15 cm of the soil layer while heavy machinery can cause soil compaction up to 50 cm (Morris, 2021). Vandalism also poses a threat to downtown trees. While collecting data for this thesis I was able to observe countless examples of vandalism on downtown streets. From small branches being ripped off to electrical outlets being attached to a tree's trunk. A study in South Africa showed that almost half (43%) of newly planted street trees were totally snapped (Richardson & Shackleton, 2014). Abiotic factors like soil chemistry may also play a huge role in tree health.

PARKS AND RECREATIONAL AREAS

Parks and recreational areas are a more hospitable environment than downtown cores. Parks, while they may be in urban environments, do allow ample room for trees to grow and spread their roots. Soil compaction is often less severe than in downtown environments since heavy machinery is rarely used in parks. Park soils are less susceptible to pH changes from road salt. Since most urban parks and recreational areas are large open spaces, this allows the urban forester to plant tree species that would not be suitable for a downtown environment. Trees like white pine which grow very tall and have a very wide crown will have ample room to grow in a park. While white pine is also intolerant to salt, park soil is much less saline than downtown cores.

Most urban cities experience Urban Heat Island (UHI) effects which is the result of an increase in temperature in urban environments due to the heat radiating from the asphalt and nearby buildings (Oke, *et al.* 2017). In general, urban environments run 1-3 degrees Celsius hotter than the surrounding area (Oke, *et al.* 2017). This microenvironment can cause stress on urban trees due to water loss through increased evapotranspiration. The urban island tree effect does not occur in parks to as great extent since parks aren't near any built-up urban environments.

PLANTING PITS

Tree planting pits prove to be the make it or break it point for urban trees. A properly designed planting pit will allow proper root growth and allow a tree to have a long-life span within a city's downtown core. A poorly designed planting pit will cause the tree to die at a young age. There are many different types of planting pits in downtown cores, with some better than others. There have also been innovations in the past couple of decades which improve on the old planting pit design which most cities are plagued with including Thunder Bay. Old planting pit designs do not account for soil compaction or root spread, they often only allow approximately $0.5m^3$ of growing space in downtown areas. Listed below are some alternatives which urban planners can use to increase soil availability and reduce soil compaction.

Silva Cells:

A Silva Cell is a modular suspended pavement system (Deeproot, 2021). Pillar-like structures are installed beneath the pavement which allows for sufficient support (Deeproot, 2021). Since the pillars are supporting the pavement, this removes pressure upon the soil beneath, greatly reducing soil compaction. Catch basins are installed at one end of the Silva Cell which is then attached to a distribution pipe that allows water infiltration within the system (Deeproot, 2021). An underdrain is also placed beneath the system to allow access water to leave in flooding events. Since the pillars from the Silva Cells hold the weight of the pavement, large granular rocks are not necessary in the soil (Coffman, 2002). The absence of granular rock allows more cubic meters of soil available for the tree. A study was made comparing structural granular rock versus the Silva Cell (Coffman, 2002). Structural granular rock was only able to hold 20 cubic meters of soil in a total volume of 100 cubic meters, compared to the Silva Cell system which was able to hold 92 cubic meters of soil out of the total 100 cubic meters (Coffman, 2002).

CU-Structural Soil Mixture

CU-Structural Soil Mixture or CU-Soil was first published in a paper in 1995 by Nina Bassuck, and Jason Grabosky at Cornell University (Bassuk, N. 2008). The goal was to create a soil mixture which would increase the amount of soil volume in urban planting areas, while simultaneously being able to support the load of sidewalks and streets. This would allow more soil to be placed beneath streets and walkways, increasing soil volume in urban centers. Soils below pavements need to be very compact and dense to be able to hold the load demands and reduce cracking or failure (Bassuk, N. 2008). The mixture can achieve reduced soil compaction with its high stone content, allowing root systems to grow freely, while still being able to support the pavement above.

The mixture is comprised of a minimum of 20% clay, which aids in water and nutrient retention (Bassuk, N. 2015), and must have 80% stone, 20% dry soil by weight, and mixed with hydrogel to ensure all the materials stick together (Bassuk, N. 2015). For the soil mixture to provide sufficient support and allow enough room for a root system to grow, the depth of soil must be at least 61 cm, while 91cm is recommended (Bassuk, N. 2008). The CU-soil is also quite inexpensive at USD 35-$42 per ton (Bassuk, N. 2015), which is a small price to pay for its effectiveness. For example, a case study in McCarren Park, Brooklyn New York (Bassuk, N. 2015). Proved that with an average sidewalk width and a 61 cm soil base of the CU-Soil mixture, after a 17-year observation period, the trees have grown as tall as trees which have been planted in lawns (Bassuk, N. 2015).

Tree Trenches:

Tree trenches are often large stretches of soil which are not wide but rather run horizontally along roadways. They are mostly used for stormwater management; therefore, they are designed to have high amounts of runoff flow into them (Grohmann & Menconi 2016). This can cause flooding of the trenches. To prevent this, pipes are placed beneath the trenches which bring the access water into the city's storm drainage system. Tree trenches are great because the extra soil volume from the pits running along roadways allow more room for the roots to grow. Allowing the tree to grow larger, while also being able to filter large amounts of water (Grohmann & Menconi 2016).

Figure 1: Green Line Tree Trench (Lefevre, 2016)

Strata Cells:

Strata Cells are a European product which function very similar to Silva Cells since they also reduce soil compaction and allow the growth of roots beneath sidewalks and walkways. Rather than being tall pillar like structure which hold the pavement, Strata Cells are short honeycomb like boxes that are made of 100% recycled High-Density Polyethylene (HDPE), (GreenBlue Urban, 2021). Since they are short, if a deeper soil depth is required, they can stack on one another (GreenBlue Urban, 2021). They are strong enough to hold pavements designed for pedestrians and are extremely easy to install (GreenBlue Urban, 2021). Strata Cells have a click-together assembly which is then held by the soil making installation quick and cheap (GreenBlue Urban, 2021). The downside of Strata Cells is that they are not able to hold as much weight as Silva Cells.

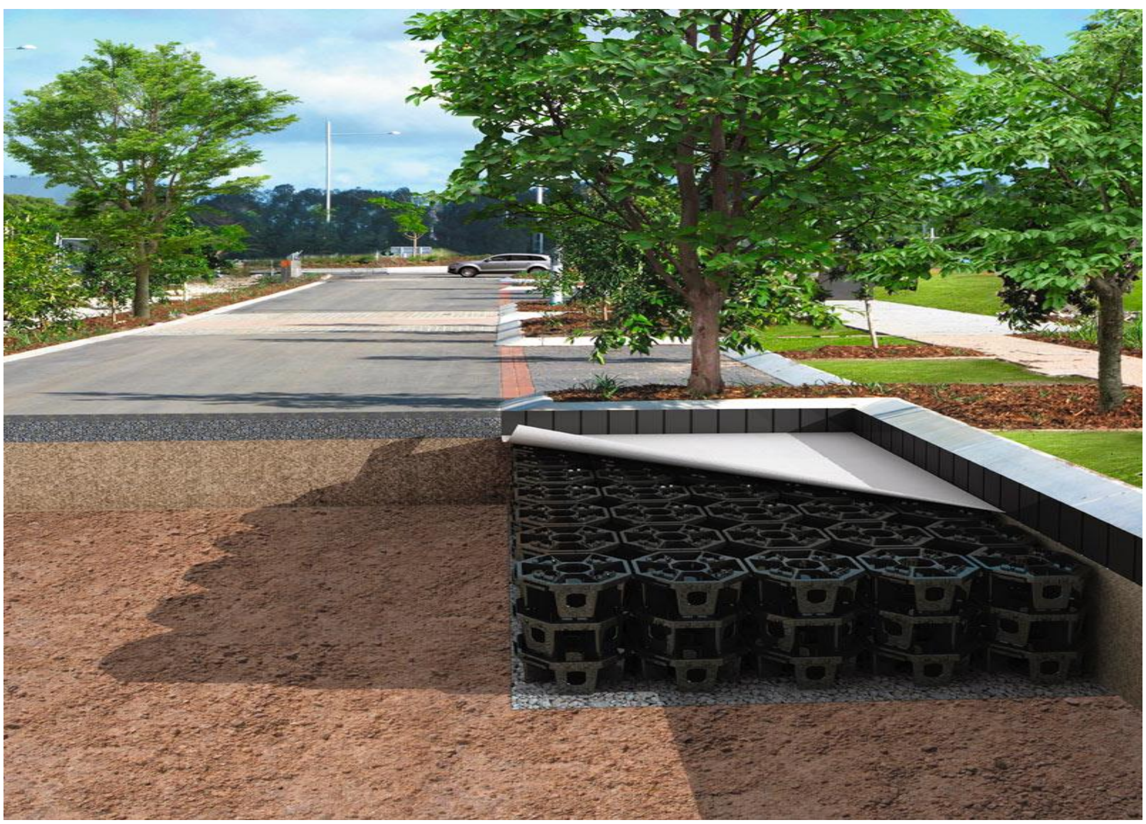

Figure 2: Milford's Silva Cell (Milford, 2014)

METHODS

All the data collected was from the downtown Port Arthur area in Thunder Bay. Each street tree had its planting pit measured and its height evaluated, tree species identification was also recorded. Trees located in parks and recreational areas were ignored since they are not relevant to the potted tree study. The only exception to this wer'e parks which had potted trees present, e.g, Wilson Street Park. Trees which were on private property were also ignored. Street trees which were planted in medians were labeled as "median".The data was formulated in a street tree inventory form. Data was collected using MyMaps on Google Earth (Figure 3). Each tree will be visible through a link. Each selected tree will have its own data set connected to it. The data collected for the street tree

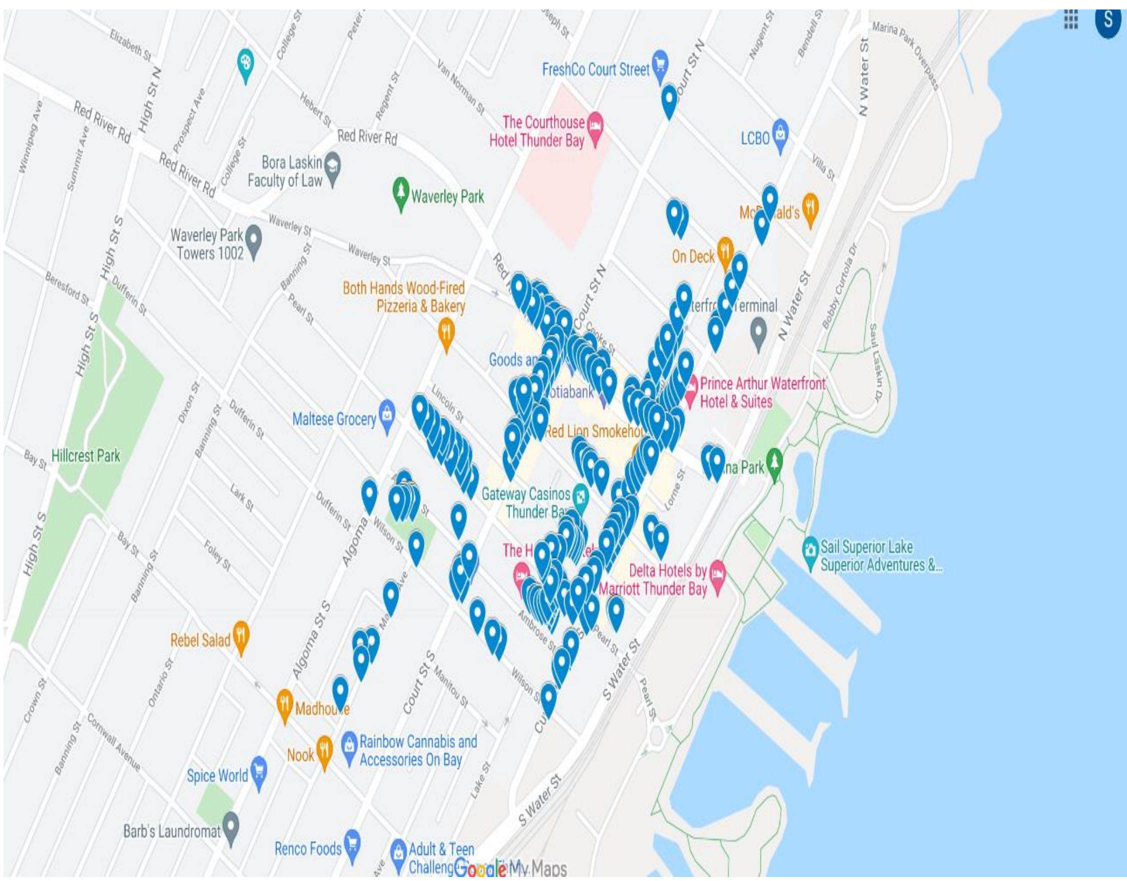

Figure 3: MyMaps Street Tree Inventory

inventory will include tree height, planting pit size and tree species identification and will be available on google earth.

Tree height was labeled in three different categories between 1-3: 1.) a tree with a height that does not exceed 2.4 m, 2.) a tree which has a height between 2.4m and 4.8m, 3.) a tree which exceeds the height of 4.8 m. Tree planting pits were classified by the following: average = a tree which is in the city's average sized planting pit (1 m x 1m), median = a street tree that is planted between a sidewalk and street. Planting pits which did not fit within the above standard were separated into two other numeric classes (1 and 2). 1. Any pit which falls between (1-3m x 1-3m), and 2. Pits which are (> 3m x 3m).

RESULTS

There was a total of 276 trees sampled in the sample area. All trees which have been sampled and recorded can be seen in the attached interactive map.

https://www.google.com/map/a/7/p/edit!mi=1aqoiZRH_QEpWsSN5yhR1ChBhtnffF&ll=48.43409030241375%2C-89.22712410101875&z=17

As seen in Figure 4 the dominant tree species were linden, maple, and ash, with 127 linden, 25 Ash, and 40 Maple, while there was a total of 46 trees that were unidentifiable. Most of the Linden trees were found in the deep downtown areas near the casino and between sidewalks. While the high number of Maple trees were found mostly in medians and on Machar Avenue.

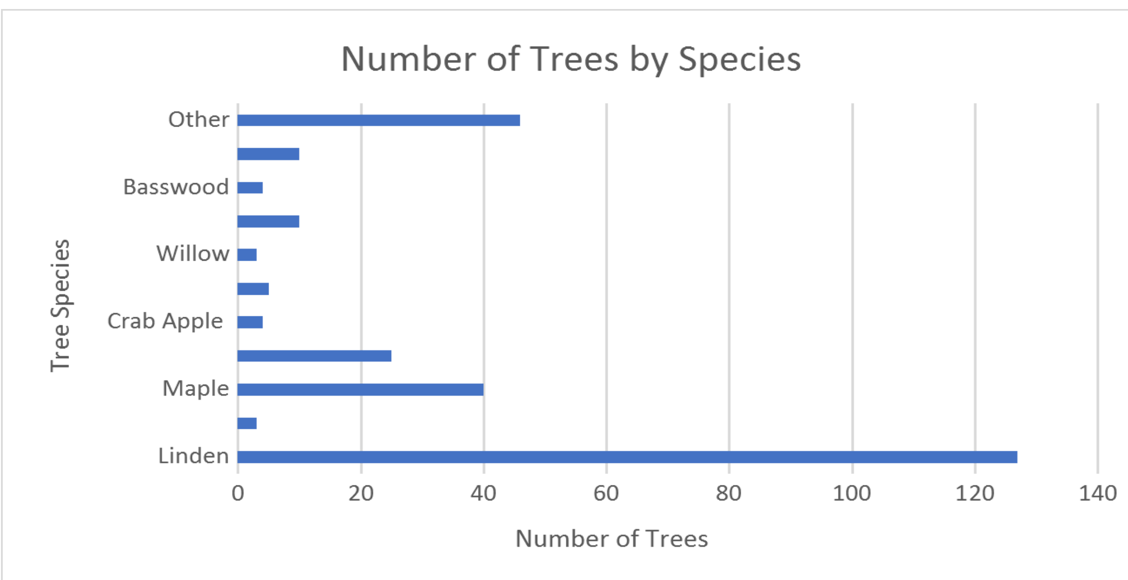

Figure 4: Number of Trees by Species

There were three different classes of tree heights 1,2, and 3. Trees found in the height class of 1 were the most dominant tree size in the sampled area, with a total of 108. While there were only 97 trees found in tree class 2 and 68 trees in the tallest tree class 3 (Figure 5)

Most of the trees found in class 1 were found in smaller planting pits and were sparsely distributed in other areas like large planting pits and medians. Trees classified in class 2 were more distributed within all planting pits, while trees found in class 3 were found in large planting pit areas.

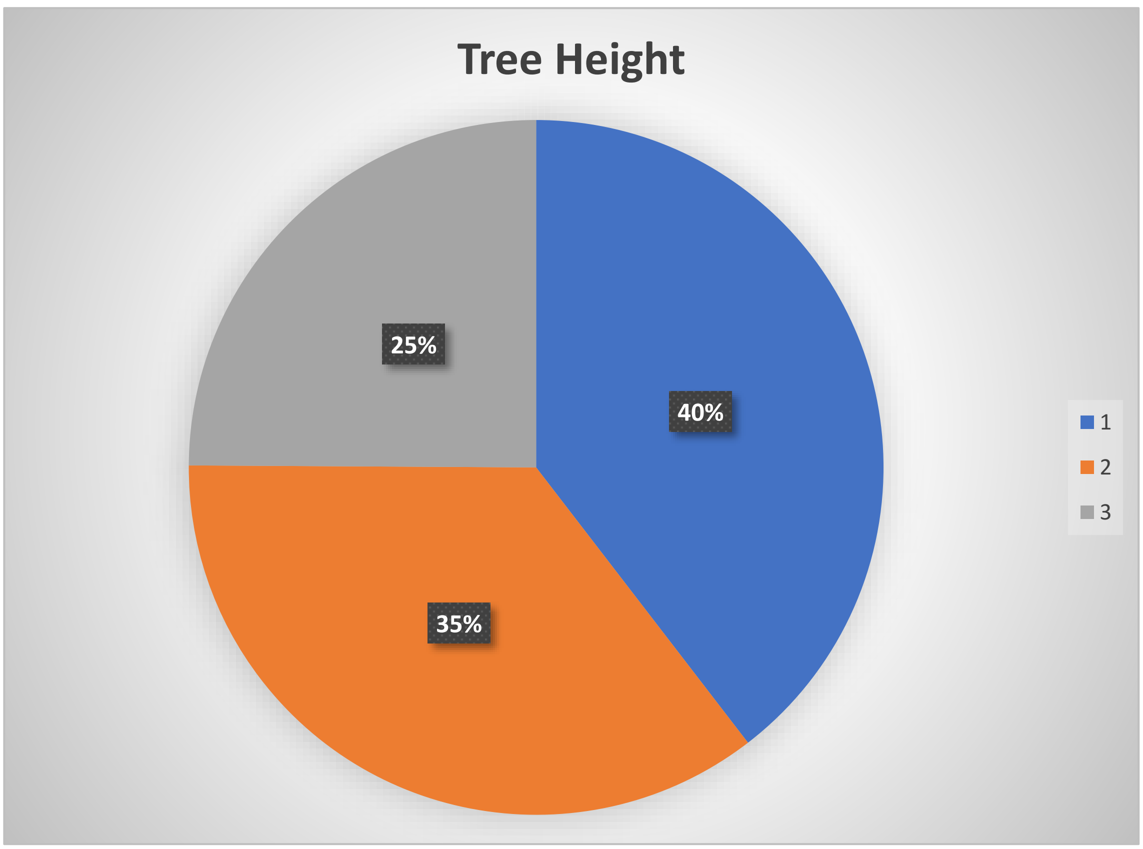

Figure 5: Tree Height

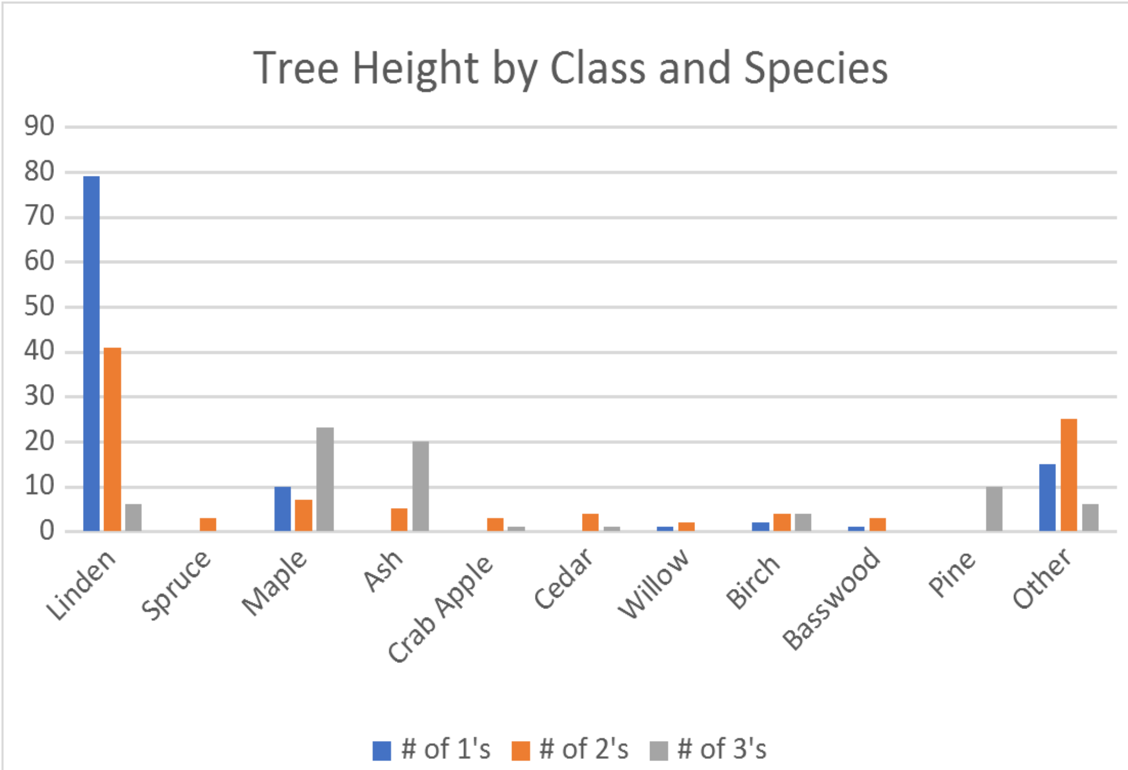

Figure 6: Tree Height by Class and Species

There were also some correlations with tree species in relation to their planting pit size (Figure 6). Linden was almost strictly found in average sized planting pits while other species like Maple were almost strictly found in medians. Medians also produce the greatest variations in tree species throughout all recorded species. Small and large planting pits proved to be the most insignificant and were sparsely found. Cedars were the most common tree species found in small planting pits while ash was commonly found in large planting pits, but both cedar and crab apple trees were almost strictly planted in small or large planting pits.

Both the average planting pits and the median sites had the highest amount of planted tree species within the sample area. With average planting pits having 117 total trees and median sites having a total of 113 trees. There were much fewer small and large planting pit areas within the sampled area, with only 20 small planting pits and 28 large planting pits (Figure 5).

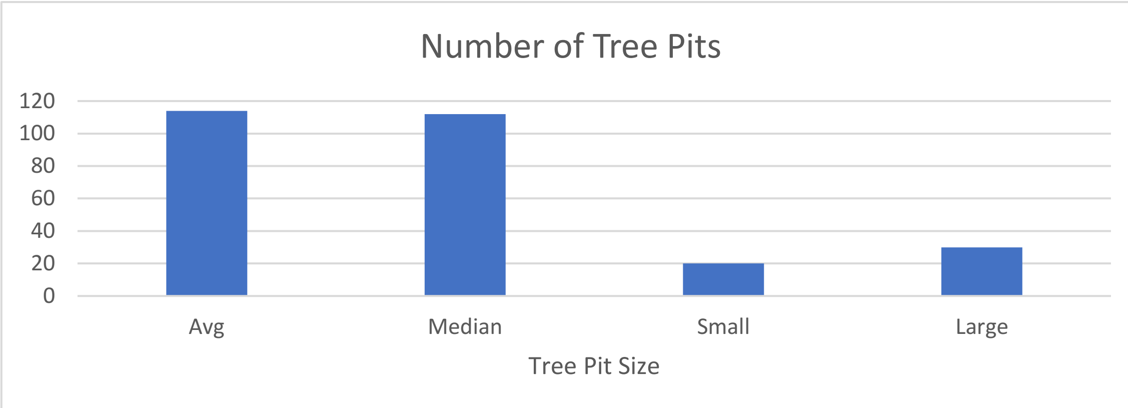

Figure 7: Number of Tree Pits

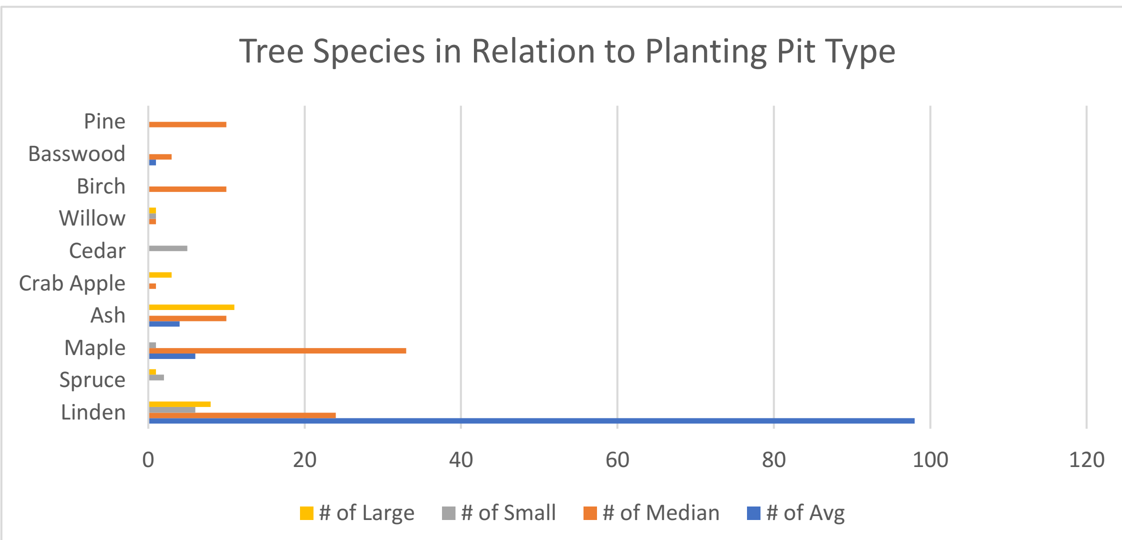

Figure 8: Tree Species in Relation to Planting Pit Type

There was also a correlation between the size of the tree planting pit and the size of the tree. The average planting pit size would produce a much smaller statured tree while the larger planting sites like medians would produce a much larger statured tree as seen in figure (9). While tree-sizes in class 2 can be found evenly distributed throughout all planting pit sizes.

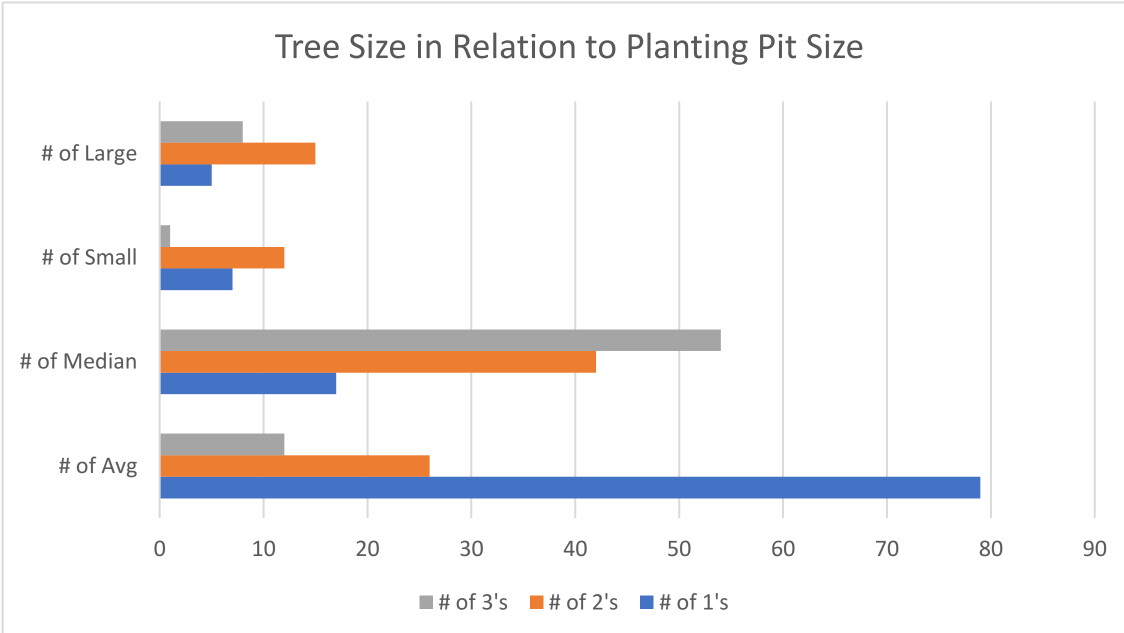

Figure 9: Tree Size in Relation to Planting Pit Size

DISCUSSION

My hypothesis was correct and there seems to be a correlation between the size of the planting pit and the size of the tree which is produced. As seen in figure 6 the average-sized plating pits produced a significant amount more trees in the height class 1. While in the median planting pit, trees in the height class of 3 were significantly more dominant. Trees in height class 1 were the less common height class in every other planting pit size other than the average-sized pits. Trees classified as a height of 3 were sparse in average-sized pits. Trees that were classified as having a tree height of 2 were for the most part well distributed throughout all planting pit sizes but, were most common in the median-sized planting sites. It is also worth noting that during the survey trees in height class 1 and 2 were not healthy when found in smaller planting pits in the downtown area. While trees found in height class 1 were much healthier in the average-sized planting pit and were also healthy in larger planting pits.

Smaller planting pits in the downtown area do not have enough soil. The lack of soil in the small planting pit area produces significantly smaller trees. With such little room for the roots of trees to grow, it causes many of the urban trees to grow much slower and die much sooner than they would if they were planted in larger planting pits. Furthermore, the lack of available nutrients and water further reinforces poor growing conditions for urban trees. The tree which was planted in the average planting pit sizes also had large piles of snow in the wintertime which was less present in the large planting pits. This would have a significant impact on the soil chemistry of the planting pits. The increase in snow from the roads may have increased the amount of salt introduced to the planting pits affecting the pH of the soil and damaging the trees. Soil compaction in the soil could also contribute to the smaller trees found in the average pit sizes. Too much soil compaction can contribute to not enough water reaching the root system of the tree, slowing its growth.

It is also worth noting that the reason for the shorter-statured trees in the average pit size may also be due to the type of tree. The data collected shows that in the sampled area trees which were in medians were trees that grew to greater heights, trees like Maple and Ash. The species of trees that were found in the smaller planting pits consisted of mostly lindens and crabapple trees which will not grow as tall as the species found in larger planting pits. That may be why there is a much higher number of short lindens and crabapple trees in the sampled area.

Since data was collected during the fall, identification proved to be difficult for some of the trees located in the sampled area. While other methods could've been used for the data collection i.e., tree records from the city. The amount of non-identifiable trees was slight and was not enough to severely affect the entire data set as a sufficient amount of trees were properly identified and recorded.

CONCLUSION

The City of Thunder Bay should consider installing more systems like silva cells and strata cells. The added volume of soil increased beneath the sidewalks and roads of the downtown core will have a significant impact on the growth of Thunder Bay's urban trees. The installation of strata cells and silva cells should be installed when road or sidewalk maintenance is underway. This would save building costs and would be a more efficient way of installing the systems. Installation of tree trenches should be used more readily throughout the inner city. Tree trenches will increase tree growth while cleaning and reducing the total amount of water runoff flowing through the city.

By allowing for an increase in the size of the urban trees Thunder Bay will make the city a more desirable and beautiful place to live. The larger crowns of the trees will also contribute to lower temperatures within the city's core. There is major economic gain from healthier trees. With a healthier population of urban trees, the City of Thunder Bay will not need to replace its urban trees as often, which will have long-term savings.

By reducing the amount of soil compaction and increasing the size of the planting areas there is potential for large, beautiful trees in Thunder Bay's downtown core.

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APPENDIX I

Table illustrating the number of trees in reference to tree size. The table is based on 13 different tree species and classified in three different height classes.

Table 1

Tree Species	# of Trees	# of 1's	# of 2's	# of 3's
Linden	127	79	41	6
Spruce	3	0	3	0
Maple	40	10	7	23
Ash	25	0	5	20
Crab apple	4	0	3	1
Cedar	5	0	4	1
Willow	3	1	2	0
Birch	10	2	4	4
Basswood	4	1	3	0
Pine	10	0	0	10
Other	46	15	25	6

APPENDIX II

Appendix includes three tables: Tree planting Pit Size, Tree Heigh, and Tree species in relation to planting pit size.

Table 2 *consists of four different variations of planting pit sizes.*

Tree Planting Pit Size	# of Tree Pits
Avg	114
Median	112
Small	20
Large	30

Table 3 *consists of three different variations in tree height*

Tree Height	# of Each Size
1	108
2	97
3	68

Table 4 *consists of three different variations in tree height in comparison to planting pits size.*

Tree height	# of Avg	# of Median	# of Small	# of Large
# of 1’s	79	17	7	5
# of 2’s	26	42	12	15
# of 3’s	12	54	1	8

APPENDIX III

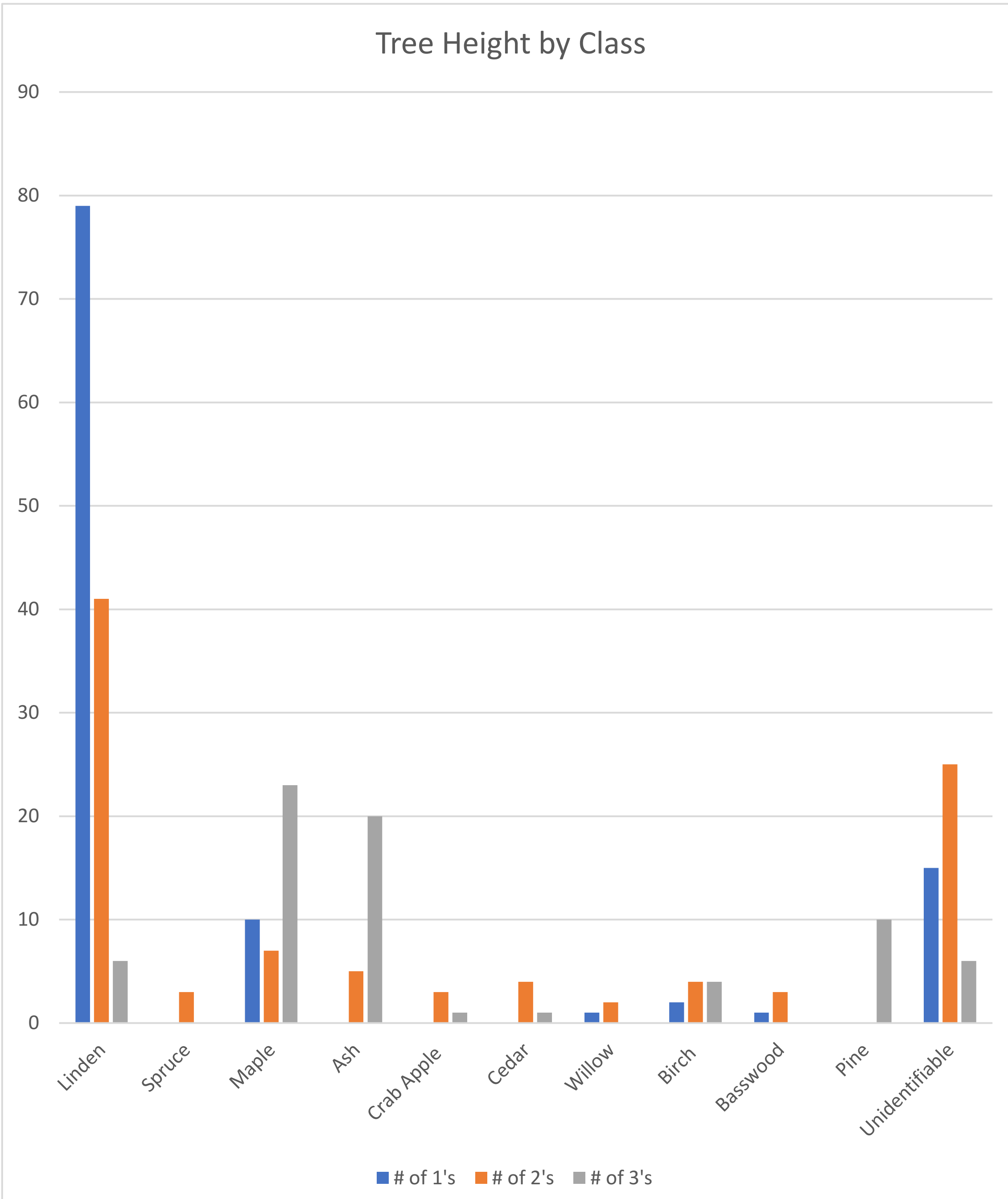
Table illustrating tree species in relation to tree planting pit size. Twelve different species, with four different planting pit size ranging from Average to Large.

Table 5

Tree Species	# of Avg	# of Median	# of Small	# of Large
Linden	98	24	6	8
Spruce	0	0	2	1
Maple	6	33	1	0
Ash	4	10	0	11
Crab Apple	0	1	0	3
Cedar	0	0	5	0
Willow	0	1	1	1
Birch	0	10	0	0
Basswood	1	3	0	0
Pine	0	10	0	0

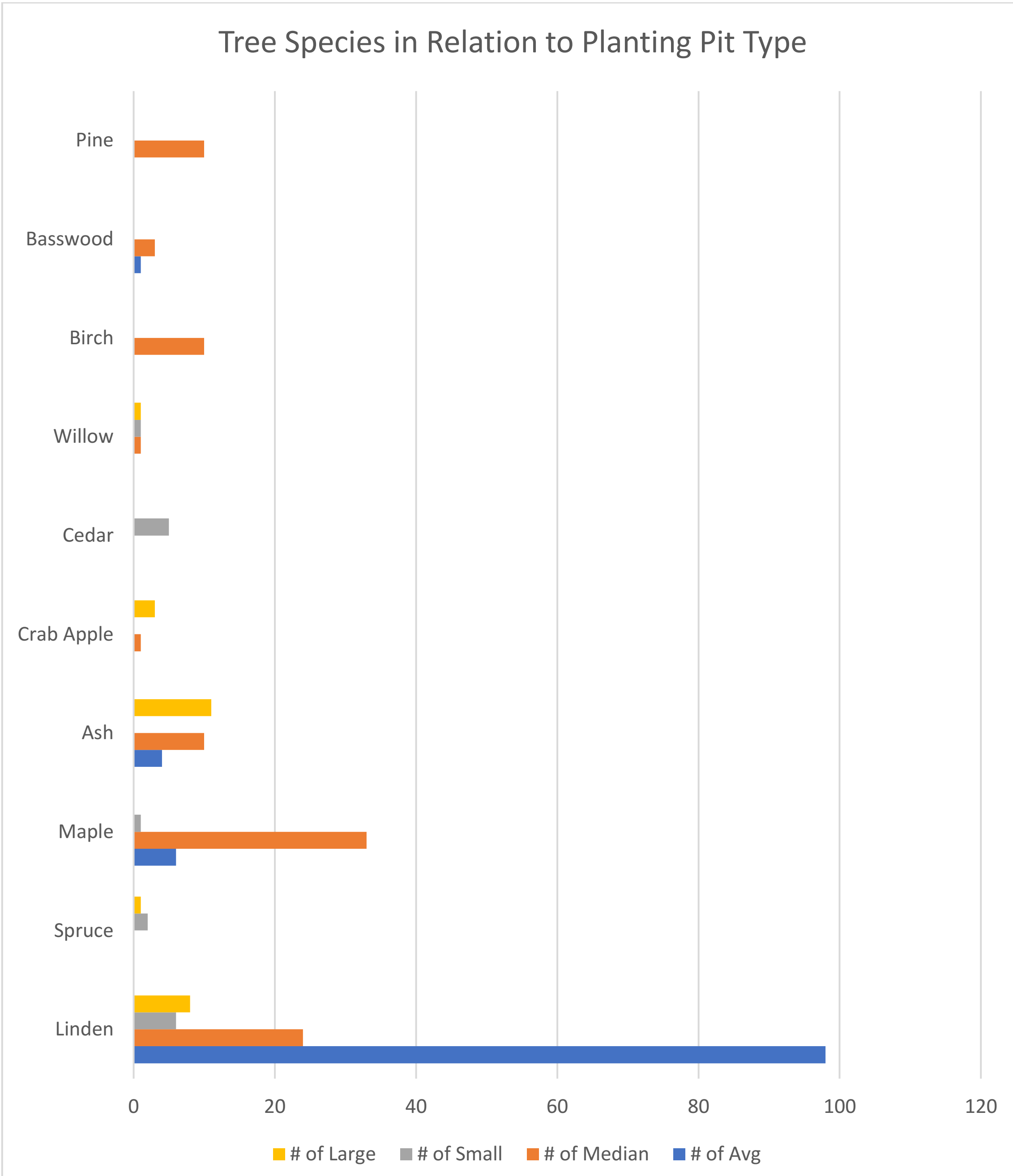
APPENDIX IV

Graphical illustration of tree height class. Thirteen different class of species are illustrated.



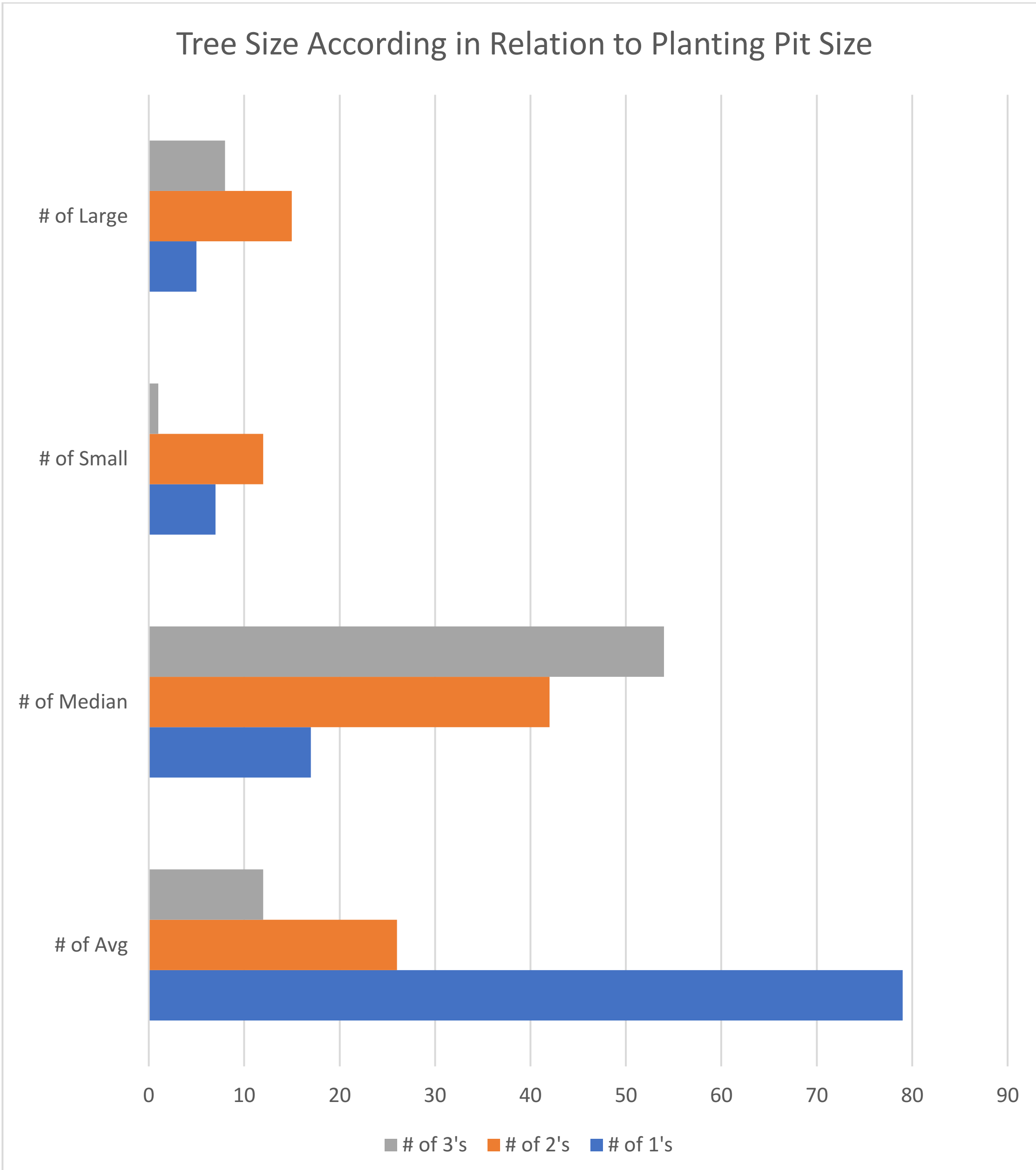
APPENDIX V

Graphical representation of twelve different types of tree species in relation to planting pit type.



APPENDIX VI

Graphical representation of tree size in relation to tree planting pit size. There are four variations in planting pit size ranging from Average to Large.



APPENDIX VII

Graphical representation of number of tree pits sampled in the sample area.