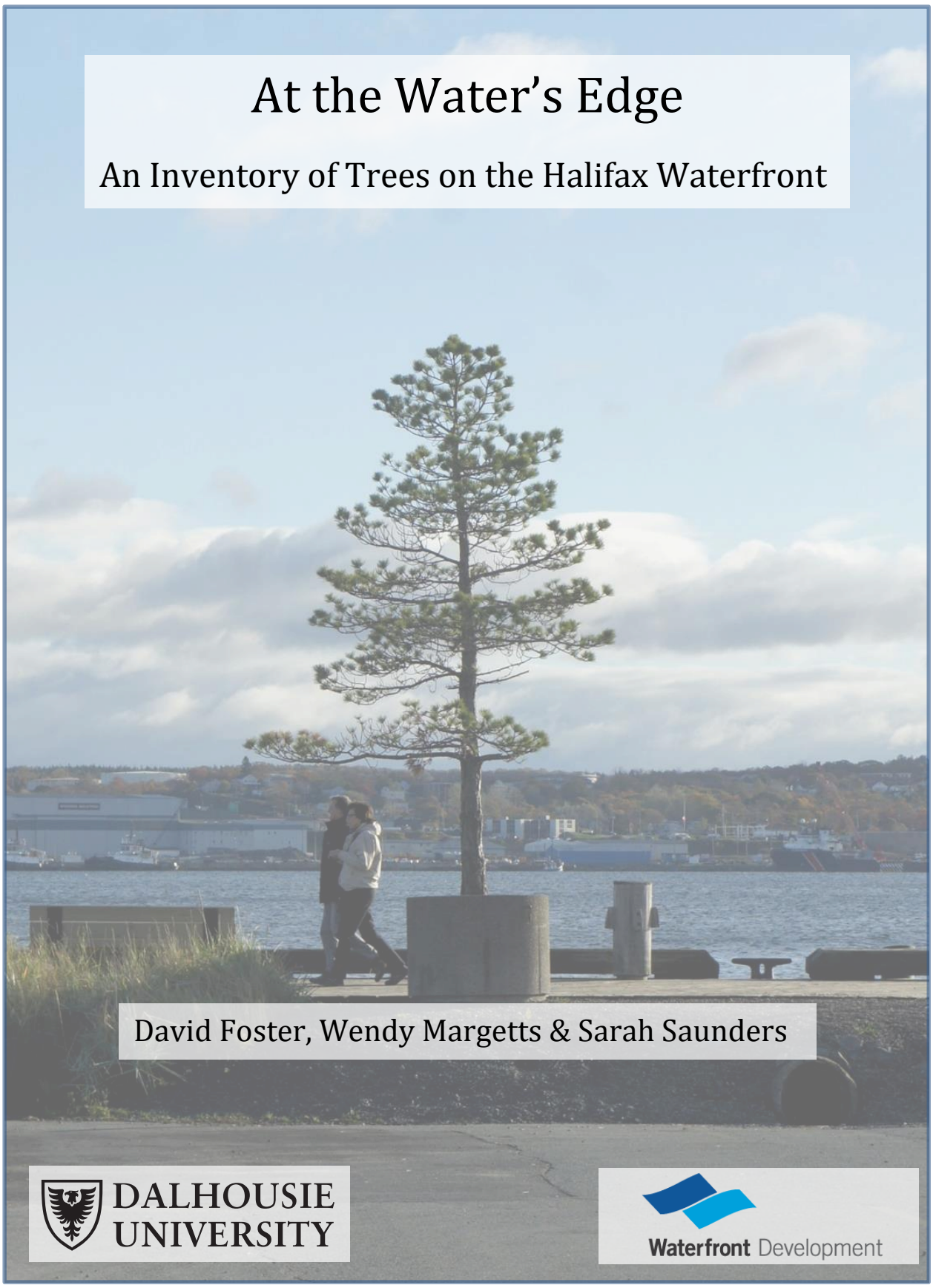
At the Water's Edge

An Inventory of Trees on the Halifax Waterfront



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1 Introduction

Urban forests, or all of the trees within a city, are important for a variety of reasons. Ecologically, they enhance biodiversity, provide habitat, and offer ecosystem services such as stormwater control, improved air quality and noise reduction (HRM Urban Forest Planning Team, 2013). Trees also provide shade, which helps improve the energy efficiency of buildings and protects infrastructure such as roads (HRM Urban Forest Planning Team, 2013). People also benefit from urban trees as their beautifying effects can enhance aesthetic appeal in a community and improve quality of life. Urban forests face many challenges such as harsh growing conditions and nutrient-poor, compacted soils (Steenberg, Duinker & Charles, 2013). Urban forest master plans, such as the one created for the city of Halifax, can help maximize the potential of city trees by providing guidelines and strategies from which to sustainably manage the urban forest (HRM Urban Forest Planning Team, 2013). Such plans can also provide direction for the expansion of the urban forest to gain the maximum benefits from new plantings.

Similarly to trees planted in parks and on streets, trees planted along waterfronts are also of great importance. That being said, the shoreline is a harsh environment in which to grow trees, and therefore special care needs to be taken with species selection and planting location. Trees along waterfronts can be subjected to salt spray, which can suppress tree growth, and also to high winds (Dale et al., 2001; Griffiths & Orians, 2004). In addition, climate change will likely increase the frequency and severity of storms, with implications for waterfronts. Trees with shallow roots or that are planted far from other trees are generally more vulnerable to high wind events that can damage or destroy the tree, cause damage to property, and potentially be health hazards (Dale et al., 2001). Trees species planted close to shores should be salt-tolerant and less susceptible to disturbance in order to withstand the challenges of growing next to the sea.

The Halifax Waterfront has undergone many changes over time. Before the influx of European settlers, the waterfront was dominated by Acadian forest (HRM Urban Forest Planning Team, 2013). Over time, vegetation was mostly cleared from the Halifax peninsula, and the waterfront became a busy shipping port. The composition of trees also changed from native species to trees imported from Europe such as Norway maple and Austrian pine (HRM Urban Forest Planning Team, 2013). In more recent years, there has been a revitalization of the waterfront as it has changed from industrial activity towards more commercial and tourism

opportunities. Waterfront Development, a provincial crown corporation, manages a variety of waterfronts including Halifax, Dartmouth, Bedford and Lunenburg (Waterfront Development, 2014a). It is responsible for the boardwalk that stretches along the Halifax waterfront, along with other spaces in the area, and is currently working on a Waterfront Master Plan to help guide future development.

According to the Halifax Regional Municipality (HRM) Urban Forest Master Plan (UFMP), the Harbour/Windsor neighborhood, which includes the Halifax waterfront, has only 4% canopy cover (HRM Urban Forest Planning Team, 2013). This is the lowest canopy cover of any neighborhood on the Halifax Peninsula. The UFMP has set a target of 20% canopy cover for the waterfront, highlighting the need for more trees in this part of the city. There are many challenges for trees along the Halifax waterfront. In addition to problems associated with salt spray and wind, there is a high proportion of impervious surfaces that limit potential tree planting sites, and a lack of species diversity in the area (HRM Urban Forest Planning Team, 2013). Waterfront Development is interested in how to maximize the public's enjoyment of the waterfront, and is currently redeveloping underutilized properties while using principles of sustainable development (Waterfront Development, 2014b).

In order to aid Waterfront Development, an inventory of trees managed by the corporation along the Halifax waterfront was taken. This was performed to provide Waterfront Development with a better understanding of the current status of its waterfront canopy. Knowing the current situation should inform better management and planning in the future. This report summarizes the type and condition of trees along the waterfront, in order to see how the waterfront fares with regard to achieving provisions in the Urban Forest Master Plan. In order to help inform the Waterfront Master Plan, recommendations for vegetation management, tree location and species selection will be given, using a case study from the City of Toronto in addition to other sources. Many opportunities exist for Waterfront Development to improve the urban forest on the land it manages, and this report aims to maximize the benefits that can be achieved through the continuing redevelopment of the waterfront.

2 Methods

A tree inventory and a jurisdictional review were carried out. Each of these was necessary to understand the status of trees on the Halifax waterfront, and to make recommendations on how to further the development of trees along the waterfront, with best practices pulled from other areas. The methods for each are discussed separately.

2.1 Tree Inventory

An inventory of trees owned or managed by Waterfront Development, a provincial Crown corporation, was carried out on the Halifax waterfront. The determination of what areas needed to be measured was determined with the assistance of Waterfront Development planning staff. Trees were measured from the northern extent of Waterfront Development property at Nathan Green Square to the southern extent where the federally administered port begins (by the Nova Scotia Power building). Lower Water Street formed the western boundary of the measurement areas, and street trees on the eastern (water) side of the street were included in the inventory.

Tree locations were recorded using the handheld Topcon GRS-1 GPS positioning system, in conjunction with the BR-1 positional correction beacon. The GRS-1, a professional grade GPS receiver, is an ideal tool for recording tree locations, a task which requires great precision. The BR-1 offers positional correction through the use of non-GPS based satellite signals and connects to the GRS-1 through Bluetooth. In addition to tagging tree location, the following information was recorded: species, height, diameter at breast height (DBH), crown condition, trunk condition, and general habitat information.

Tree identification was carried out to the species level where possible. This was aided by the use of Farrar's (1995) *Trees in Canada*. In instances where species level identification was not possible, trees were identified to the genus level. Tree height was recorded in metres and measured using a Suunto PM-5/360 PC clinometer and taken from 20 m for highest possible accuracy. Given the space constraints of the waterfront area, it was at times not possible to take a measurement from this distance. In this circumstance, tree height was approximated occularly by us. Tree diameter was measured at 1.3 m above the ground, the standard for DBH in Canada (Avery & Burkhart, 2002). For trees over 10 cm in diameter, measurements were made using a DBH tape. For tree stems under 10 cm in diameter, measurements were made using a caliper. In

instances where there were multiple stems on a single tree, all stems were measured and an average was taken as the diameter at breast height.

Crown condition was rated on a 1-4 scale based on the visual appearance of the tree crown. Criteria in the visual assessment included premature leaf loss, condition of leaves, presence of buds (in the absence of leaves), if branches were alive or dead, and condition of bark on limbs. Trees with healthy looking crowns were given a score of 1, meaning good condition. Trees with some evidence of less than optimal health were assigned a score of 2. Trees showing significant health issues were assigned a score of 3. Tree crowns showing no leaves, no buds to indicate leaf growth in the next year, and other indicators or poor health, were assigned a score of 4, indicating that the current crown is likely dead. This 1-4 system can be interpreted as good, fair, poor, and extremely poor/dead.

Trunk condition was determined through an assessment of the physical appearance of the trunk. Trees were assigned a rating of either good, damaged, or extensively damaged based on this assessment. Damage was not determined to be natural or anthropogenic. Trunks assessed as being "damaged" exhibited physical damage or bark loss to parts of the trunk. In our opinion, this damage did not, at the time of observation, pose a risk to the long-term health of the tree. Trunks assessed as being "extensively damaged" exhibited significant physical damage, including breaks in the trunk and significant bark loss. In our opinion, this damage poses an immediate risk to the health of the tree and indicates major anthropogenic or natural stressors.

General habitat conditions were recorded including if the tree is in a planter or raised bed, and the proximity of the tree to the curb or buildings. For proximities, only the closest curb, building, or wall was recorded. These data are important to determine whether environmental conditions are contributing to health issues in a single tree, and if there are any trends among trees in similar habitat conditions.

Geographic data were imported into ESRI ArcMaps 10.2.2. All other data were compiled in Microsoft Excel for interpretation, and imported into ArcMaps as linked attribute tables. Tree locations were adjusted manually in ArcMaps using site photographs and satellite imagery to ensure that tree locations are correct relative to the environment and each other.

2.2 Jurisdictional Review

The management of other waterfronts was studied in order to gain an understanding of the practices used in other cities across Canada. Search criteria were established to find a suitable comparison for the Halifax waterfront.

For the review, Canadian cities with waterfronts were identified, whether the body of water be ocean or lake. Candidate cities needed to have sufficient information about vegetation management on their waterfronts available in order to gain an understanding of current composition of the urban forest canopy and to identify future plans for management. Without this information, there would not be enough data to provide a useful comparison to the tree canopy on the Halifax waterfront.

The search was conducted using the keywords ‘plants’, ‘vegetation’, and ‘trees’ in conjunction with ‘waterfront’. Results found using this method were analyzed for depth of information about vegetation presently on the waterfront, and availability of plans for future development.

3 Results

3.1 Tree Inventory

In total, 463 trees of 29 types were identified to the most specific level possible on the Halifax waterfront. In most cases it was possible to identify trees to the species level, but due to the use of unique cultivars on the waterfront this was not always possible. Of the 463 counted and identified trees, 288 (66.2%) were either Austrian pine (*Pinus nigra*), Linden (*Tilia* spp.), or Norway maple (*Acer platanoides*) (Figure 3.1).

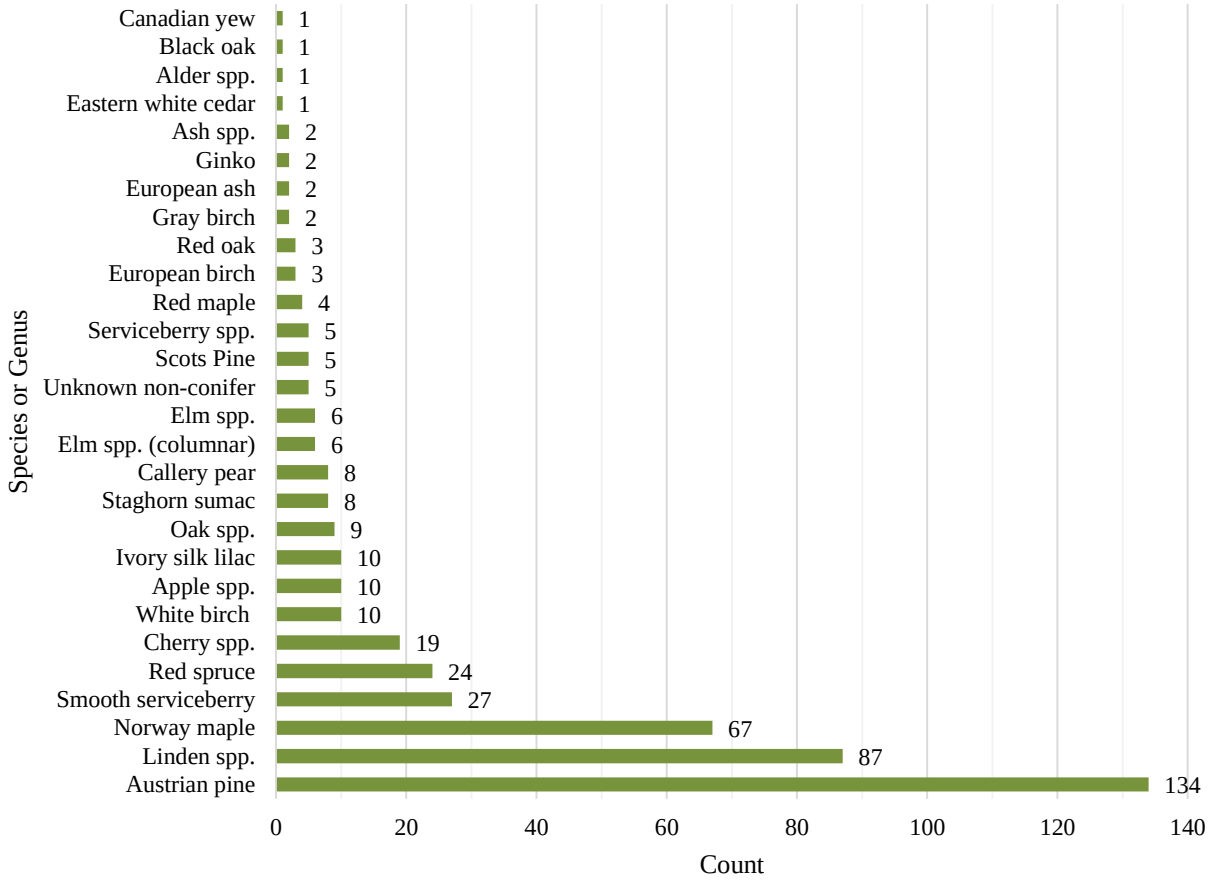

Figure 3.1 Distribution of tree species or genus (identified to the most specific level possible) for 463 trees on the Halifax waterfront.

The location of each tree inventoried on the Halifax waterfront is indicated in Figure 3.2, including an indication of whether the tree is a conifer or non-conifer.

Figure 3.2 Map of trees on the Halifax waterfront owned or managed by Waterfront Development.

Height and diameter at breast height (DBH) data both display roughly normal distributions, with 318 (68.7%) of the measured trees falling into height classes 6, 8, and 10 (Figure 3.3), and 280 (60.5%) trees falling into DBH classes 15, 20, and 25 (Figure 3.4).

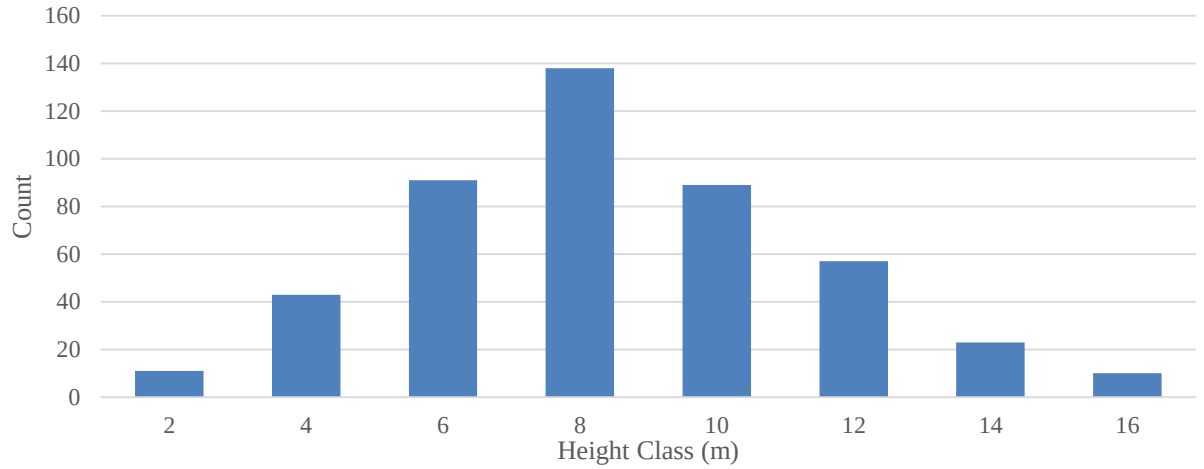

Figure 3.3 Distribution of height classes for 463 trees on the Halifax waterfront.

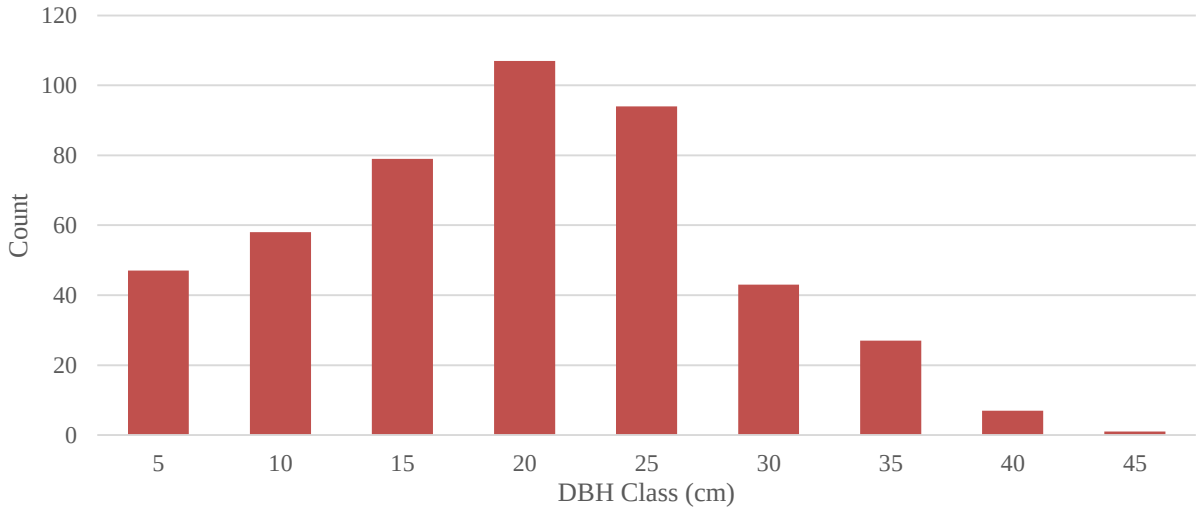

Figure 3.4 Distribution of DBH classes for 463 trees on the Halifax waterfront.

The crown condition for 401 of the inventoried trees was rated 1, indicating that the crown is in visibly good condition. Of the remainder, 57 trees were rated a 2 (fair crown condition) (Table 3.1). The majority of those given a rating of 2 were Austrian pine (26) and Norway maple (11), both non-native species. Four inventoried trees were assigned a rating of 3, indicating very poor crown condition, and one tree was assigned a rating of 4, indicating that the crown had died.

Table 3.1 Tree crown health among 463 trees on the Halifax waterfront. Class 1 indicates good crown condition, 2 indicates fair crown condition, 3 indicates poor crown condition, and 4 indicates very poor.

Species	1	2	3	4	% ≥ 2
Austrian pine	108	26			**19.4%**
Canadian yew		1			**100.0%**
Cherry spp.	18	1			**5.3%**
Elm spp. (columnar)	2	2	1	1	**66.7%**
Linden spp.	79	6	2		**9.2%**
Norway Maple	56	11			**16.4%**
Red Spruce	18	5	1		**25.0%**
Scots pine	4	1			**20.0%**
Staghorn sumac	6	2			**25.0%**
White birch	8	2			**20.0%**
Other	102				**0.0%**
Total	401	57	4	1	**13.4%**
Of ALL Trees	**86.6%**	**12.3%**	**0.9%**	**0.2%**	

Of the 463 inventoried trees, 20 exhibited trunk damage including bark loss and physical damage (Table 3.2). Three trees exhibited extensive trunk damage including bark loss which wraps around the tree, or physical damage which will inhibit further growth.

Table 3.2 Tree trunk condition among 463 trees on the Halifax waterfront. Trunks indicated as 'damaged' displayed physical distress such as bark loss. Trunks indicated as 'extensively damaged' exhibited damage which will likely lead to or is indicative of impending tree death.

Species	Undamaged	Damaged	Extensive Damage	% Damaged
Callery Pear	7	1		12.5%
European Birch	1	2		66.7%
Gray birch			2	100.0%
Ivory silk lilac	7	2	1	30.0%
Linden spp.	85	2		2.3%
Norway maple	63	4		6.0%
Red oak	2	1		33.3%
Smooth serviceberry	24	3		11.1%
White Birch	6	4		40.0%
Willow spp.	0	1		100.0%
Other	245			0.0%
Total	440	20	3	5.0%
Of ALL Trees	**95.0%**	**4.3%**	**0.6%**	

Of the 463 inventoried trees, 80 are of native species, 320 are of non-native species, and 63 are unknown (Figure 3.5). Trees which are unknown are indicated as such because they could not be identified to the species level.

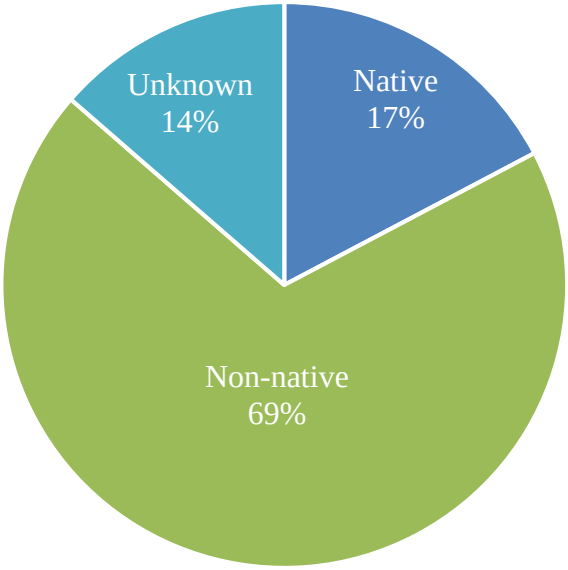

Figure 3.5 Summary of tree nativeness for 463 trees on the Halifax waterfront.

3.2 Case Study

Many cities with waterfronts matched initial jurisdictional review search criteria. After deeper analysis, searching for information available about vegetation management on their waterfront, only Toronto, Canada, matched the criteria, and is the subject of this case study.

The City of Toronto, with approximately 28% canopy cover of trees, has been called "a city within a park" (City of Toronto, 2012b, p. 4). As outlined in the Strategic Forest Management Plan, the City of Toronto has a target to increase its canopy cover to 40% while maximizing species diversity and supporting and sustaining native species (City of Toronto, 2012b).

Toronto has emphasized the importance of native tree species in urban planning documents, and currently 64% of the trees planted in Toronto are native to the area (City of Toronto, 2012a; 2012b). For all new developments, at least 50% of new plantings must be native drought-tolerant species, such as those from the Carolinian Forest, as they will require less watering, maintenance and replacement over the long term, and help to support local biodiversity (City of Toronto, 2012a). Plans also highlight the need to maximize species diversity by

avoiding a monoculture, or the planting of a single or just a few species (City of Toronto, 2012b; Waterfront Toronto, 2014). This can also help improve resiliency of the urban forest, in case a tree species is threatened by a pest or disease.

Waterfront Toronto, formerly the Toronto Waterfront Revitalisation Corporation, has been working to develop derelict formerly industrial lands near the shores of Lake Ontario in order to turn these areas into sustainable urban communities (TWRC, 2005; Prime & Palamarchuk, 2009). The goal of Waterfront Toronto is to make the waterfront a model for national and global sustainability, with the construction of green buildings and infrastructure, and the addition of new parks and public spaces, including a 1.5 km long promenade along the shore of Lake Ontario (TWRC, 2005; Prime & Palamarchuk, 2009). Also included in the plans for revitalizing the waterfront is the planting of 34,000 new trees, with a target of increasing the canopy cover to 30-35% within the development area (Waterfront Toronto, 2014). This new tree canopy will improve natural beauty, provide shade and wind protection, improve stormwater management and air quality, and reduce the heat-island effect (Waterfront Toronto, 2014).

During Waterfront Toronto's revitalization project, every effort will be made to save trees already in the area. New construction projects must have Tree Protection Plans as part of their Environmental Management Plans in order to minimize impacts on existing vegetation (Waterfront Toronto, 2013). In addition, in accordance with the Toronto Private Tree Protection Bylaw, trees with a DBH of 30 cm or more must be retained, unless authorized by permit (Waterfront Toronto, 2013). Waterfront Toronto (2014) will also make every effort to ensure that newly planted trees have the maximum chance for survival by carefully positioning new trees, using appropriate soil, and using new technologies such as silva sells to enable root growth and avoid soil compaction, which can impact the health of trees. Tree maintenance protocols will also be established to ensure that trees continue to grow and thrive (TWRC, 2005).

The City of Toronto and Waterfront Toronto have both made commitments to increasing the canopy cover of trees within the city, using native tree species and making every effort to ensure that trees that are planted have the highest chance of survival. This can be used as a model for waterfront development elsewhere, encouraging the planting of more trees to help improve biodiversity and the sustainability of the area.

4 Discussion

In total, the Halifax waterfront contains 463 trees and, according to the UFMP, has a 4% canopy cover (HRM Urban Forest Planning Team, 2013). As mentioned previously, this is the lowest canopy cover area on the Halifax peninsula. To increase canopy cover and maximize on urban forest values, Waterfront Development needs to increase the number of trees planted on its properties. The UFMP has set a goal of 20% canopy cover for the waterfront neighbourhood (HRM Urban Forest Planning Team, 2013). Toronto is currently planning on planting 34,000 new trees near its waterfront, with a goal of 30-35% canopy cover for the area. This goal shows that other jurisdictions are being even more ambitious than Halifax with regards to tree planting (Waterfront Toronto, 2013). Waterfront Development should emphasize the role and presence of green space on the waterfront and mandate that new developments along the boardwalk help increase the canopy cover.

As Waterfront Development moves forward with its revitalization of the Halifax waterfront, it could capitalize on efforts to improve canopy cover as an educational opportunity for the public by increasing its public profile. The creation of interpretive signage on the boardwalk would raise public awareness of the undertaken efforts with regard to trees, and about the importance of trees and green space. This will have an effect on the perception of management activities on the waterfront, and potentially raise public awareness of issues pertaining to the urban tree canopy.

Currently, even though 28 kinds of trees are planted along the waterfront, a low evenness of species was observed. Approximately 62% of the current trees are three species: 29% are Austrian pines, 19% are Norway maples, and 14% are a mixture of linden trees. Uniformity and levels of low evenness within an urban forest is not recommended as it creates an ecosystem with low resilience in the face of blights and diseases and, is ill-adapted to climate change (Santamour 2002; Kendal et al., 2014). The Halifax Urban Forest Master Plan and Waterfront Toronto plans both highlight the need to diversify the urban ecosystem (HRM Urban Forest Planning Team, 2013; Waterfront Toronto, 2013). The UFMP has a specific target of no more than 10% of a genus contributing to street tree populations (HRM Urban Forest Planning Team, 2013). A more diverse and even waterfront should increase resilience to future disturbances and help mitigate potential impacts of climate change (Kendal et al., 2014).

The diversification of an urban forest includes introducing trees at the species, genus, and family level. Santamour (2002) developed a "rule of thumb" stating that within the urban forest, no more than 10% of plantings should be of the same tree species, 20% of the same genus, and 30% of the same family. The 10, 20, 30 concept highlights that genetic diversity within a species does not ensure survival, and that genetically similar trees are prone to similar stresses (Kendal, Dobbs & Lohr, 2014). An urban forester must consider diversity within the genus and family of trees in order to safeguard the forest's resilience (Santamour, 2002). This theory provides a good outline for tree diversification; however, further consideration should be placed on which species are planted based on the tree's fitness to survive in the area and if the species is geographically native.

A biodiverse urban forest can provide beneficial ecosystem services if species are introduced properly. An urban ecosystem with more tree diversity will have a greater defence against disease (Santamour, 2002), and pests (Kendal, et al., 2014). The Halifax waterfront is currently dominated largely by three tree types: Austrian pine, linden spp., and Norway maple. If an infection of disease or pests spread through the current waterfront and affected one of those three types, the number of healthy trees on the waterfront would decrease greatly. A diverse forest also has a greater defence against climate change by providing some capacity of the current tree selection to have the ability to adapt to an altered climate (Kendal, et al, 2014). Urban biodiversity also allows for more complex ecosystem functioning, a greater number of niche opportunities (Jim & Liu, 2001), and an increased potential for survival during climatic disturbances (Jim & Chen, 2009).

Currently, there is a poor representation of native trees on the Halifax waterfront. Native species represent only 17.3% of the waterfront trees, while species which are non-native or of unknown origin represent 69.1% and 13.6% respectively. The UFMP has set targets for species representation, including 50% of all street trees being native, and at least 1% of all street trees representing the six Acadian old-growth species (Red spruce (*Picea rubens*), Eastern hemlock (*Tsuga canadensis*), White pine (*Pinus strobus*), Sugar maple (*Acer saccharum*), Yellow birch (*Betula alleghaniensis*), and American beech (*Fagus grandifolia*) (HRM Urban Forest Planning Team, 2013). Toronto has set similar targets of 50% native species for all new developments (Waterfront Toronto, 2013).

Preserving and planting native species on the waterfront will add to the overall sustainability of the Halifax urban forest (Clark, Matheny, Cross and Wake, 1997). Native tree species create niches for native wildlife and demonstrating their durability to the local climate (Clark, et al., 1997). Introducing non-native species creates competition with the native species. Non-native species also alter the native habitat, and have potential negative effects on the genetic biodiversity in the local area, by decreasing the gene pool of the native species (Manchester & Bullock, 2001). Planting non-native species may also increase local species diversity on the waterfront.

At present, both species diversity and the percent of native trees on the waterfront are lower than target numbers in the UFMP (HRM Urban Forest Planning Team, 2013). Because the majority of trees on the waterfront are non-native species, planting native species on the waterfront will add to the local diversity. Emphasizing the six Acadian native species on the waterfront will also address targets in the UFMP (HRM Urban Forest Planning Team, 2013).

Tree spacing is important to consider for urban forests, and can dictate the health of the trees. Urban planners should space trees based on the individual species canopy growth rates, distance to buildings or paved surfaces and the trees root structure (Semenzato, Cattaneo & Dainese, 2011). Some studies have generalized tree spacing, indicating that trees should be planted at least 1 m from the pavement, and mature trees taller than 15 m should be setback 2.5 m (Kadir & Othman, 2012). Tree spacing depends on the forester's objectives for the area. Trees should be planted closer together if an early full canopy is the goal of the project, and farther apart for the growth of larger trees in the future (pers. comm. P. Duinker, Oct 2014). When trees are properly spaced, there should be a full canopy cover within a reasonable time span, to maximize the delivery of urban-forest ecosystem services over time.

Trees planted on the Halifax waterfront are planted at varying distances both to pavement and between trees. If Waterfront Development views large trees as valuable, and a priority over early canopy closure, then spacing trees farther apart would be suggested. If Waterfront Development values a full canopy cover early in the trees' lives, then planting the trees closer together would attain the goal sooner. Earlier canopy cover is recommended because of the numerous benefits associated with canopy closure, such as providing shade, decreasing urban runoff, and filtering pollutants (Dwyer, McPherson, Schroeder & Rowntree, 1992).

A portion of the trees located on the waterfront are in sub-optimal health. Of the 463 trees identified, 62 of them, or 13.4%, had crown conditions less than optimal (Class 1) (Table 3.1). Among the most populous trees on the waterfront, 19.4% of Austrian pine, 16.4% of Norway maple, and 9.2% of linden (spp.) received crown scores of less than 1.

The cause of the poor health of many waterfront trees is currently unknown. An extensive study would be required in order to identify specific causes of crown damage. Conditions on the waterfront indicate potential environmental stressors causing sub-optimal growth and health. The Halifax waterfront has a large amount of impermeable surfaces which, in some circumstances, can lead to soil compaction (Day & Bassuk, 1994; Jim, 1993). The degree of soil compaction and porosity affects the water retention capabilities of the soil. It also restrains tree growth, by compressing the root systems and limiting the amount of water availability (Day & Bassuk, 1994; Jim, 1993). Other climatic factors, such as salt spray and high winds, can also have negative effects on tree species (Griffiths & Orians, 2004). There are management practices and technologies that Waterfront Development can implement to help restore tree health, and to ensure good health for future tree growth. Some of these include installing Silva Cells, using permeable pavements, and planting climatically appropriate tree species.

In order to improve conditions for tree growth, Waterfront Development could employ methods to mitigate soil compaction. One way to do this is to install Silva Cells, which are a segmented suspended pavement system used in sidewalks and other impermeable surfaces to support tree growth and reduce rainwater runoff (DeepRoot, 2014). The system uses framed structures that are built under the sidewalks to enable the soil to remain uncompacted. This reduces stress on trees by allowing them to extend their roots further underground. These areas also allow storm water to penetrate the surface and percolate through the soil, decreasing the effects of urban runoff by slowing the flow of water (DeepRoot, 2014).

Municipal developers have successfully implemented Silva Cells in many cities across Canada. The Athlete's Village in Vancouver was the first to install this technology in Canada. The purpose of the system was to increase tree nourishment, which would maximize the tree's ecosystem services. In Toronto, a section of the Queensway has been fitted with cells, with goals to enhance bio-retention and treatment of stormwater. The Toronto waterfront is also

currently installing Silva Cells, in order to give newly planted trees the maximum chance of survival (Waterfront Toronto, 2014). Calgary has also used Silva Cells along 2nd Ave NW to enhance tree development and reduce stormwater run-off (DeepRoot, 2014).

Additional barriers to optimal tree growth include the high percentage of impermeable surfaces on the waterfront. In order to improve growing conditions, Waterfront Development could also consider installing permeable surfaces along the waterfront. This can be done by removing and replacing current pavement, or implementing permeable surfaces during any new construction. Permeable surfaces allow water to percolate through the soil, which reduces urban runoff. The ground water created from the permeable surface would add to current underlying aquifers and provide vegetation with the hydration needed for growth. Permeable surfaces can be installed using either interlocking concrete pavement (Interlocking Concrete Pavement Institute, 2014) or permeable pavers (PaverSearch, Inc., 2014). Either solution would enhance the condition of current trees and the overall canopy by supplying more water to the trees.

Diameter at breast height (DBH) is an important metric for understanding tree health, especially when used to compare similar trees in different environments or when taken as part of a longitudinal study. There are better methods for calculating DBH than was used in this repor, which provide a more accurate depiction of the relationship between tree maturity and mass. Avery & Burkart (2002) describe these methods which require that measurements be taken at 1.3 m above the ground or higher if there are trunk abnormalities at this height, on the uphill side of the tree. If a single tree exhibits multiple stems above breast height, diameter should be measured below the swell of the stem. Trees that stem below breast height represent a challenge for measurement as traditionally these would be measured as two trees (Avery & Burkart, 2002), requiring separate inventory entries. This could result in an overestimation of the quantity of trees used in landscaping. In order to provide an accurate depiction of the biomass of a tree, future studies should examine other methods of DBH calculation such as diameter below the stem split, adding the diameters of all stems at breast height, or the use of a uniform measure of all trees such as basal area. Any of these methods would better depict the relationship between tree maturity and mass than the metric used herein.

As mentioned previously, uniformity within an urban forest can increase the susceptibility of the canopy suffering from impacts of blights and diseases. Austrian pine (*Pinus*

nigra) is susceptible to a fungal disease known as Diplodia tip blight (*Sphaeropsis sapinea*) (Cornell University, 2014). This disease is able to infect all species of pines; however, the Austrian pine is the most severely impacted by the infection (Cornell University, 2014). Infected trees exhibit browning of the needles and produce black fruiting bodies located at the base of the infected needles (Cornell University, 2014). In extreme cases, especially in high population densities, the infestation results in tree death.

Diplodia tip blight has been documented on the east coast of Canada since the early 1960s (Ginns, 1986). More recently, the Nova Scotia Department of Natural Resources indicated that the blight has become a serious issue within the province, and that the severity of the fungus elevates each year (NS Department of Natural Resources, 2013). It has been noted that the fungal disease is present in Halifax, and is likely to spread to the waterfront within the next few years (pers. comm. John Simmons, Oct 5th, 2014). Approximately 30% of the waterfront trees are Austrian pines. If there is an outbreak of this fungal disease on the Halifax waterfront, more than 100 trees could be infected, and if the outbreak is severe and results in loss of trees, a significant proportion of the canopy would be impacted. A plan for managing such an infestation is necessary, including the possibility for eventual replacement of a large portion of waterfront trees. This highlights the need for a wider diversity of species to be planted to mitigate against loss of a large proportion of the canopy cover should one of the most numerous tree species be impacted.

Below is a brief list of suggested tree species to plant on the Halifax waterfront. The list was developed through observation of Halifax and waterfront trees, and with reference to tree salt spray tolerance (Virginia State University, 2001) and the UFMP (HRM Urban Forest Planning Team, 2013). Further study of climatic influences such as salt spray, high winds, and soil compaction on the individual species needs to be completed to ensure planted tree species are suitable for the Halifax waterfront environment. The list includes, but is not limited to:

- Red maple (*Acer rubrum*)
- White spruce (*Picea glauca*)
- White pine (*Pinus strobus*)
- Red oak (*Quercus rubra*)
- Eastern cedar (*Juniperus virginiana*)
- Native ash spp. (*Fraxinus* spp.)

The Halifax waterfront has the potential to become a prized urban forest. Waterfronts face many challenges, such salt spray, intense winds, and an abundance of non-permeable surfaces. All of these challenges may be overcome with the use of environmental technologies and proper tree selection. Adding more trees to the waterfront will increase the visual appeal and environmental benefit of the waterfront canopy, and create a welcoming space for visitors, residents, and businesses. By integrating the recommendations of this report into strategic planning, Waterfront Development will be able to expand its urban forest and increase the ecological, economic and social values that trees provide.

4.1 Recommendations

The following is a summary of recommendations for the management of trees on the Halifax waterfront lands managed by Waterfront Development.

Strategic planning is needed

- A plan for the future of waterfront green spaces is needed to ensure that goals and timelines for future canopy development are set.

Increase the waterfront canopy

- In line with the provisions of the HRM Urban Forest Master Plan of eventual 20% waterfront canopy cover
- More ambitious goals such as those adopted by Toronto (30-35%) are encouraged

Plant native trees

- In line with the provisions of the HRM Urban Forest Master Plan
- Native species will provide habitats for native wildlife, and increase global biodiversity

Increase diversity (specifically evenness) of trees on the waterfront

- This will provide more visual interest and provide increased disease and climate change tolerance

Use practices and technologies that provide better tree habitat

- Silva Cells have been proven elsewhere and provide better soil and water conditions for healthy tree growth
- Permeable surfaces provide more water for trees and aid in water run-off management
- Species which are tolerant to waterfront conditions (high winds and salt spray) should be planted preferentially

Public education of initiatives

- Interpretive signage increases awareness of management initiatives and challenges facing urban green spaces and their planners

Partnership with municipality and academic institutions

- Key partners offer outside insight and resources which may not be available in-house

5 Conclusion

The Halifax waterfront has changed significantly over the last decades as it has undergone a transition from industrial waterfront to Atlantic Canada's most visited tourism destination (pers. comm. Terry Drisdelle, Sept. 30th, 2014). The work of Waterfront Development has been essential in this progress, and the organization will continue to provide leadership and expertise towards increasing the waterfront's appeal. The Halifax waterfront currently has some aesthetically appealing green spaces, but the overall tree canopy is lacking in diversity and percent coverage.

In accordance with the provisions of the HRM Urban Forest Master Plan, significant steps are necessary toward increasing canopy cover. There are also unique management challenges in maintaining tree canopy on waterfronts. Waterfront Development is moving in the right direction by seeking partnerships to better understand the canopy on its managed lands, and should continue to work towards a strategic vision for a fuller waterfront tree canopy.

The recommendations in this report are a starting point for Waterfront Development, and more research is necessary to better understand how to effectively implement these suggestions. Partnerships with the municipality and academic institutions offer another perspective on the issue, as they may be able to provide expertise which may not be available within Waterfront Development. By studying and implementing best practices and new technologies and working with community partners, Waterfront Development is well equipped to continue making progress on the Halifax waterfront's green spaces.

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7 Appendix

Table 7.1 All data collected for 463 trees on the Halifax waterfront. Trees are identified by common name for ease of use. Heights listed in italics indicate approximate measurement at the data collectors' best estimate. Crown condition is measured on a 1-4 scale where 1 is good and 4 is very poor or dead. Trunk condition is measured as good, damaged, or extensively damaged based on the threat posed to the tree's health. Habitat includes general observations about the tree's habitat including proximity to roads, paths, and buildings, and the type of ground in which the tree is planted (raised bed, pot, etc.)

ID	*Species*	*Height (m)*	*DBH (cm)*	*Crown Condition*	*Trunk Condition*	*Habitat*
1	Austrian pine	9.5	23.0	1	Good	1 m to boardwalk
2	Austrian pine	10.5	24.5	1	Good	1 m to boardwalk
3	Austrian pine	9.5	19.3	1	Good	1 m to boardwalk
4	Austrian pine	11.0	23.7	1	Good	1 m to boardwalk
5	Linden spp.	15.5	40.8	1	Good	
6	Linden spp.	14.5	32.2	1	Good	
7	Linden spp.	15.5	32.6	1	Good	
8	Linden spp.	15.5	30.6	1	Good	
9	Linden spp.	16.5	37.7	1	Good	
10	Unknown non-conifer	4.5	2.8	1	Good	1.5 m to boardwalk
11	Unknown non-conifer	4.0	8.0	1	Good	In a pot. Lights wrapped around it.
12	White birch	6.0	15.1	2	Good	In a large planter.
13	Austrian pine	4.5	14.2	1	Good	In a large planter.
14	Austrian pine	5.5	23.9	1	Good	In a large planter.
15	Austrian pine	5.0	28.0	1	Good	In a large planter.
16	White birch	8.0	15.8	2	Damaged	In a large planter.
17	Linden spp.	8.5	29.6	1	Good	1 m to curb
18	Austrian pine	11.5	34.4	2	Good	1 m to curb
19	Austrian pine	12.5	40.0	1	Good	1 m to curb
20	Austrian pine	7.5	23.8	1	Good	2 m to curb
21	Norway maple	7.5	16.1	1	Good	In a raised bed
22	Norway maple	7.0	16.1	1	Good	In a raised bed
23	Austrian pine	6.5	15.1	1	Good	1 m to curb
24	Austrian pine	9.0	23.0	1	Good	1 m to curb
25	Norway maple	8.5	34.1	1	Good	In a raised bed (2m wide)
26	Norway maple	8.5	28.0	1	Good	In a raised bed (2m wide)
27	Norway maple	10.5	35.3	1	Good	In a raised bed (2m wide)
28	Norway maple	8.5	30.3	1	Good	In a raised bed (2m wide)
29	Norway maple	8.0	23.5	2	Damaged	In a raised bed (2m wide)
30	Oak spp.	4.0	6.9	1	Good	In a planter
31	Oak spp.	4.5	7.1	1	Good	In a planter
32	Oak spp.	4.5	6.7	1	Good	In a planter
33	Oak spp.	4.5	7.5	1	Good	In a planter
34	Oak spp.	5.0	7.0	1	Good	In a planter

ID	Species	Height (m)	DBH (cm)	Crown Condition	Trunk Condition	Habitat
35	Oak spp.	5.0	6.9	1	Good	In a planter
36	Oak spp.	5.0	6.1	1	Good	In a planter
37	Oak spp.	5.0	7.0	1	Good	In a planter
38	Austrian pine	7.0	23.1	1	Good	1 m to curb
39	Austrian pine	14.5	39.7	1	Good	0.5 m to curb, large pebbles covering substrate
40	Austrian pine	11.5	27.0	1	Good	0.5 m to curb, large pebbles covering substrate
41	Austrian pine	14.5	27.8	1	Good	0.5 m to curb, large pebbles covering substrate
42	Austrian pine	15.5	32.9	1	Good	0.5 m to curb, large pebbles covering substrate
43	Austrian pine	13.5	35.0	1	Good	0.5 m to curb, large pebbles covering substrate
44	Austrian pine	12.5	26.5	1	Good	0.5 m to curb, large pebbles covering substrate
45	Austrian pine	12.5	31.7	1	Good	0.5 m to curb, large pebbles covering substrate
46	Austrian pine	12.5	26.6	1	Good	0.5 m to curb, large pebbles covering substrate
47	Austrian pine	13.5	28.5	1	Good	0.5 m to curb, large pebbles covering substrate
48	Cherry spp.	6.5	23.4	1	Good	In a raised bed
49	Cherry spp.	5.5	17.0	1	Good	In a raised bed
50	Cherry spp.	5.5	20.4	1	Good	In a raised bed
51	Linden spp.	8.5	21.0	1	Good	30 cm to curb
52	Linden spp.	5.0	7.4	1	Good	1 m to curb
53	Linden spp.	9.5	24.6	1	Good	1 m to curb
54	Linden spp.	11.5	32.5	1	Good	1 m to curb
55	Eastern white cedar	2.0	4.7	1	Good	In a raised planter
56	Linden spp.	5.5	7.3	1	Good	1 m to curb
57	Linden spp.	11.5	25.4	1	Good	1 m to curb
58	Linden spp.	11.5	25.6	1	Good	1 m to curb
59	Linden spp.	9.5	25.0	1	Good	1 m to curb
60	Linden spp.	5.5	7.9	1	Good	1 m to curb
61	Linden spp.	7.0	26.0	1	Good	1 m to curb
62	Linden spp.	4.5	7.2	1	Good	1 m to curb
63	Linden spp.	5.0	8.0	1	Good	1 m to curb
64	Linden spp.	5.5	9.2	1	Good	1 m to curb
65	Linden spp.	12.5	29.3	1	Good	1 m to curb
66	Linden spp.	11.5	33.0	1	Good	1 m to curb
67	Linden spp.	5.5	8.5	1	Good	1 m to curb
68	Linden spp.	13.5	31.5	1	Good	1 m to curb
69	Linden spp.	4.5	7.8	1	Good	1 m to curb
70	Elm spp. (columnar)	3.0	4.9	1	Good	In a raised bed, 1 m to edge
71	Elm spp. (columnar)	3.0	4.0	2	Good	In a raised bed, 1 m to edge
72	Elm spp. (columnar)	3.0	4.2	1	Good	In a raised bed, 1 m to edge
73	Elm spp. (columnar)	3.0	4.7	2	Good	In a raised bed, 1 m to edge
74	Elm spp. (columnar)	3.0	4.5	3	Good	In a raised bed, 1 m to edge
75	Elm spp. (columnar)	3.0	4.0	4	Good	In a raised bed, 1 m to edge

ID	Species	Height (m)	DBH (cm)	Crown Condition	Trunk Condition	Habitat
76	Linden spp.	11.5	27.4	1	Good	1 m to curb
77	Linden spp.	9.5	23.8	1	Damaged	1 m to curb
78	Linden spp.	12.5	31.5	1	Good	1 m to curb
79	Linden spp.	6.5	9.1	1	Good	1 m to curb
80	Smooth serviceberry	3.5	2.5	1	Good	In a raised bed, 20 cm to edge
81	Smooth serviceberry	3.5	3.1	1	Damaged	In a raised bed, 50 cm to edge
82	Smooth serviceberry	4.0	3.1	1	Good	In a raised bed, 50 cm to edge
83	Linden spp.	6.5	7.8	1	Good	1 m to curb
84	Smooth serviceberry	4.5	4.9	1	Good	In a raised bed, 50 cm to edge
85	Smooth serviceberry	4.0	2.1	1	Good	In a raised bed, 20 cm to edge
86	Linden spp.	15.5	30.3	1	Good	1 m to curb
87	Smooth serviceberry	4.5	3.5	1	Good	In a raised bed, 30 cm to edge
88	Smooth serviceberry	5.5	5.9	1	Good	In a raised bed, 30 cm to edge
89	Linden spp.	12.5	24.7	1	Good	1 m to curb
90	Smooth serviceberry	3.5	1.6	1	Good	In a raised bed, 10 cm to edge
91	Smooth serviceberry	5.5	5.3	1	Good	In a raised bed, 50 cm to edge
92	Smooth serviceberry	3.5	2.7	1	Good	In a raised bed, 40 cm to edge
93	Linden spp.	6.5	9.0	1	Good	1 m to curb
94	Smooth serviceberry	5.0	5.3	1	Good	In a raised bed, 30 cm to edge
95	Smooth serviceberry	3.5	3.5	1	Good	In a raised bed, 50 cm to edge
96	Smooth serviceberry	3.0	1.3	1	Good	In a raised bed, 30 cm to edge
97	Smooth serviceberry	3.5	3.5	1	Good	In a raised bed, 40 cm to edge
98	Smooth serviceberry	3.5	1.7	1	Damaged	In a raised bed, 40 cm to edge
99	Smooth serviceberry	4.5	5.0	1	Good	In a raised bed, 40 cm to edge
100	Alder spp.	3.5	3.5	1	Good	In a raised bed, 40 cm to edge
101	Smooth serviceberry	4.0	4.8	1	Damaged	In a raised bed, 1 m to edge
102	Smooth serviceberry	5.0	5.6	1	Good	In a raised bed, 1 m to edge
103	Smooth serviceberry	4.5	4.4	1	Good	In a raised bed, 1 m to edge
104	Smooth serviceberry	5.0	4.2	1	Good	In a raised bed, 1 m to edge
105	Smooth serviceberry	5.0	6.5	1	Good	In a raised bed, 30 cm to edge
106	White birch	5.5	8.2	1	Good	In a raised bed, 1 m to edge
107	Elm spp.	5.5	3.6	1	Good	Rocky shore next to water
108	Gray birch	5.5	7.2	1	Ext. Damage	In a raised bed, 1 m to edge
109	Gray birch	7.5	24.2	1	Ext. Damage	In a raised bed, 1 m to edge
110	Austrian pine	7.0	17.3	1	Good	In a planter
111	Staghorn sumac	2.0	2.5	1	Good	20 cm to curb
112	Norway maple	9.5	19.7	1	Good	In a raised bed, 1 m to edge
113	Austrian pine	12.0	31.3	1	Good	In a raised bed, 1 m to edge
114	Austrian pine	11.0	30.1	1	Good	In a raised bed, 3 m to edge
115	Austrian pine	12.0	32.8	1	Good	In a raised bed, 1 m to edge
116	Norway maple	8.0	16.2	1	Good	In a raised bed, 3 m to edge

ID	Species	Height (m)	DBH (cm)	Crown Condition	Trunk Condition	Habitat
117	Norway maple	7.0	18.2	1	Good	In a raised bed, 1 m to edge
118	Austrian pine	6.0	22.4	1	Good	In a raised bed, 1 m to edge
119	Austrian pine	7.0	25.6	1	Good	In a raised bed, 1 m to edge
120	Austrian pine	5.5	27.5	1	Good	In a raised bed, 2 m to edge
121	Norway maple	4.0	13.5	2	Good	In a raised bed, 1 m to edge
122	Norway maple	7.0	21.0	2	Good	In a raised bed, 1 m to edge
123	Norway maple	6.0	17.2	2	Good	In a raised bed, 1 m to edge
124	Austrian pine	7.0	22.8	1	Good	In a raised bed, 1 m to edge
125	Austrian pine	7.0	29.2	1	Good	In a raised bed, 2 m to edge
126	Austrian pine	7.0	28.8	1	Good	In a raised bed, 2 m to edge
127	Austrian pine	7.0	24.3	1	Good	1 m to curb
128	Austrian pine	9.5	30.2	1	Good	1 m to curb
129	Austrian pine	8.0	26.3	1	Good	1 m to curb
130	Austrian pine	7.5	16.3	1	Good	1 m to curb
131	Norway maple	3.5	9.5	1	Good	1 m to curb
132	Norway maple	7.0	18.7	1	Good	1 m to curb
133	Norway maple	4.5	11.7	1	Good	1 m to curb
134	Apple spp.	6.5	10.8	1	Good	1 m to curb
135	Apple spp.	6.5	9.3	1	Good	1 m to curb
136	Austrian pine	8.0	17.1	1	Good	1 m to curb
137	Austrian pine	8.0	21.7	1	Good	1 m to curb
138	Austrian pine	8.5	23.0	1	Good	1 m to curb
139	Austrian pine	9.0	16.6	1	Good	1 m to curb
140	Austrian pine	9.5	21.1	1	Good	1 m to curb
141	Austrian pine	9.0	26.0	1	Good	1 m to curb
142	Austrian pine	7.0	20.3	1	Good	1 m to curb
143	Linden spp.	9.5	20.8	1	Good	1 m to curb
144	Black oak	9.5	13.3	1	Good	1 m to curb
145	Cherry spp.	4.5	6.5	2	Good	1 m to curb
146	Cherry spp.	5.5	12.7	1	Good	1 m to curb
147	White birch	8.0	10.1	1	Damaged	1 m to curb
148	Red spruce	8.0	15.1	1	Good	1 m to curb
149	Red spruce	8.0	10.0	1	Good	1 m to curb
150	Red spruce	7.5	12.7	1	Good	1 m to curb
151	Apple spp.	7.5	15.5	1	Good	1 m to curb
152	Apple spp.	7.0	14.5	1	Good	1 m to curb
153	Austrian pine	6.5	24.5	1	Good	1 m to curb
154	Linden spp.	7.5	20.5	1	Good	1 m to curb
155	Red spruce	8.5	14.0	1	Good	1 m to curb
156	Linden spp.	8.5	20.8	1	Good	1 m to curb
157	Austrian pine	7.0	15.2	1	Good	1 m to curb

ID	Species	Height (m)	DBH (cm)	Crown Condition	Trunk Condition	Habitat
158	Austrian pine	7.5	22.0	1	Good	1 m to curb
159	Austrian pine	7.0	19.5	1	Good	1 m to curb
160	Red Spruce	7.5	14.5	1	Good	1 m to curb
161	Red Spruce	8.5	16.6	1	Good	1 m to curb
162	Red Spruce	10.5	20.0	1	Good	1 m to curb
163	Red Spruce	7.5	15.2	1	Good	1 m to curb
164	White birch	10.0	12.3	1	Good	1 m to curb
165	White birch	10.0	10.7	1	Good	1 m to curb
166	Oak spp.	8.0	10.5	1	Good	1 m to curb
167	Cherry spp.	6.0	11.0	1	Good	1 m to curb
168	Cherry spp.	6.0	5.3	1	Good	1 m to curb
169	Austrian pine	8.5	17.7	1	Good	1 m to curb
170	Austrian pine	10.5	26.0	1	Good	1 m to curb
171	Austrian pine	9.0	20.0	1	Good	1 m to curb
172	Red maple	11.5	15.6	1	Good	1 m to curb
173	Red maple	10.5	15.3	1	Good	1 m to curb
174	Austrian pine	7.5	19.0	1	Good	1 m to curb
175	Austrian pine	8.5	20.5	1	Good	1 m to curb
176	Austrian pine	8.5	24.5	1	Good	1 m to curb
177	Austrian pine	8.0	27.0	1	Good	1 m to curb
178	Austrian pine	7.5	24.0	1	Good	1 m to curb
179	Austrian pine	7.0	18.5	1	Good	1 m to curb
180	Austrian pine	8.0	16.0	1	Good	1 m to curb
181	Austrian pine	10.0	26.1	1	Good	1 m to curb
182	Austrian pine	8.5	14.2	2	Good	1 m to curb
183	Scots Pine	12.5	23.1	2	Good	1 m to curb
184	Austrian pine	9.0	24.8	2	Good	1 m to curb
185	Scots Pine	9.5	15.5	1	Good	1 m to curb
186	Austrian pine	8.5	17.8	2	Good	1 m to curb
187	Scots Pine	9.5	18.2	1	Good	1 m to curb
188	Austrian pine	9.0	18.5	1	Good	1 m to curb
189	Scots Pine	12.5	24.1	1	Good	1 m to curb
190	Austrian pine	7.5	18.5	2	Good	1 m to curb
191	Scots Pine	11.5	16.6	1	Good	1 m to curb
192	Austrian pine	9.5	21.4	1	Good	1 m to curb
193	White birch	7.0	7.3	1	Good	50 cm to curb
194	Linden spp.	9.5	27.5	1	Good	1 m to curb
195	Linden spp.	9.5	24.5	1	Good	1 m to curb
196	Cherry spp.	5.5	8.5	1	Good	2 m to curb
197	European ash	5.5	3.0	1	Good	1 m to curb
198	European ash	5.5	4.0	1	Good	2 m to curb

ID	Species	Height (m)	DBH (cm)	Crown Condition	Trunk Condition	Habitat
199	European birch	6.5	11.6	1	Damaged	1 m to curb, rock covered substrate
200	European birch	10.5	12.7	1	Damaged	1 m to curb, rock covered substrate
201	European birch	11.0	19.0	1	Good	1 m to curb, rock covered substrate
202	Red Spruce	5.5	11.6	1	Good	1 m to curb
203	Red Spruce	5.5	8.4	1	Good	1 m to curb
204	Red Spruce	7.0	11.9	3	Good	1 m to curb
205	Red Spruce	8.5	13.7	1	Good	1 m to curb
206	Red Spruce	8.5	12.2	2	Good	1 m to curb
207	Red Spruce	7.5	12.5	2	Good	1 m to curb
208	Red Spruce	5.5	10.6	2	Good	1 m to curb
209	Norway maple	7.5	30.4	1	Good	In raised bed, 30 cm to edge
210	Norway maple	6.5	19.2	1	Good	In raised bed, 1 m to edge
211	Norway maple	7.5	16.2	1	Good	In raised bed, 3 m to edge
212	Austrian pine	8.5	10.9	1	Good	In raised bed, 1 m to edge
213	Austrian pine	10.5	35.4	1	Good	In raised bed, 3 m to edge
214	Austrian pine	10.5	32.0	1	Good	In raised bed, 1 m to edge
215	Norway maple	6.5	13.2	1	Good	In raised bed, 1 m to edge
216	Norway maple	6.5	22.1	1	Good	In raised bed, 1 m to edge
217	Norway maple	7.5	22.5	2	Good	In raised bed, 3 m to edge
218	Austrian pine	9.5	25.0	2	Good	In raised bed, 2 m to edge
219	Austrian pine	10.5	28.5	1	Good	In raised bed, 3 m to edge
220	Austrian pine	10.5	25.5	1	Good	In raised bed, 1 m to edge
221	Norway maple	7.5	20.0	2	Good	In raised bed, 1 m to edge
222	Norway maple	5.5	22.1	1	Good	In raised bed, 30 cm to edge
223	Norway maple	6.5	20.9	2	Good	In raised bed, 3 m to edge
224	Austrian pine	9.0	29.1	1	Good	In raised bed, 2 m to edge
225	Austrian pine	8.5	19.0	1	Good	In raised bed, 1 m to edge
226	Norway maple	7.5	20.6	1	Good	In raised bed, 2 m to edge
227	Norway maple	6.5	22.9	1	Good	In raised bed, 1 m to edge
228	Austrian pine	6.5	22.8	1	Good	2 m to curb
229	Cherry spp.	5.5	11.4	1	Good	4 m to curb
230	Norway maple	8.0	28.6	1	Good	In raised bed, 2 m to edge
231	Austrian pine	12.0	32.1	1	Good	In raised bed, 1 m to edge
232	Austrian pine	11.5	28.4	2	Good	In raised bed, 2 m to edge
233	Austrian pine	12.0	39.4	1	Good	In raised bed, 1 m to edge
234	Norway maple	11.0	31.0	1	Good	In raised bed, 2 m to edge
235	Smooth serviceberry	2.0	3.0	1	Good	In raised bed, 1 m to edge
236	Smooth serviceberry	3.0	2.0	1	Good	In raised bed, 50 cm to edge
237	Smooth serviceberry	2.0	1.0	1	Good	In raised bed, 20 cm to edge
238	Norway maple	7.5	25.0	1	Good	In raised bed, 1 m to edge
239	Canadian yew	1.5	1.0	2	Good	In raised bed, 1 m to edge

ID	Species	Height (m)	DBH (cm)	Crown Condition	Trunk Condition	Habitat
240	Austrian pine	12.5	34.3	1	Good	In raised bed, 1 m to edge
241	Austrian pine	12.5	28.5	1	Good	In raised bed, 1 m to edge
242	Austrian pine	12.5	27.3	1	Good	In raised bed, 1 m to edge
243	Austrian pine	11.5	34.5	2	Good	In raised bed, 2 m to edge
244	Austrian pine	10.5	26.8	1	Good	In raised bed, 2 m to edge
245	Austrian pine	10.5	24.8	2	Good	In raised bed, 2 m to edge
246	Austrian pine	12.5	36.1	1	Good	In raised bed, 1 m to edge
247	Smooth serviceberry	1.5	2.0	1	Good	In raised bed, 20 cm to edge
248	Smooth serviceberry	2.0	2.5	1	Good	In raised bed, 1 m to edge
249	Smooth serviceberry	1.0	0.5	1	Good	In raised bed, 20 cm to edge
250	Norway maple	9.5	21.5	1	Good	1 m to curb
251	Norway maple	8.5	19.6	1	Good	1 m to curb
252	Norway maple	8.0	16.5	1	Good	1 m to curb
253	Norway maple	8.5	16.0	2	Good	1 m to curb
254	Norway maple	8.5	15.0	1	Good	1 m to curb
255	Norway maple	8.5	16.8	1	Good	1 m to curb
256	Linden spp.	9.5	20.8	1	Good	1 m to curb
257	Linden spp.	8.0	20.3	1	Good	1 m to curb
258	Linden spp.	8.0	19.1	2	Good	1 m to curb
259	Linden spp.	10.5	26.5	2	Good	1 m to curb
260	Norway maple	7.5	16.2	1	Good	1 m to curb
261	Austrian pine	10.5	21.3	1	Good	1 m to curb
262	Norway maple	7.0	13.6	1	Good	1 m to curb
263	Austrian pine	8.5	20.0	1	Good	1 m to curb
264	Norway maple	6.5	13.2	1	Good	1 m to curb
265	Austrian pine	9.0	24.1	1	Good	1 m to curb
266	Norway maple	7.5	13.3	1	Good	1 m to curb
267	Norway maple	8.0	16.7	1	Damaged	1 m to curb
268	Red Spruce	3.0	6.2	1	Good	2 m to curb
269	Red Spruce	7.0	11.3	2	Good	1 m to curb
270	Norway maple	9.5	24.8	1	Good	1 m to curb
271	Red Spruce	5.5	9.4	2	Good	2 m to curb
272	Linden spp.	8.0	21.0	1	Good	1 m to curb
273	Apple spp.	6.5	14.0	1	Good	2 m to curb
274	Apple spp.	8.0	21.1	1	Good	1 m to curb
275	Apple spp.	7.5	7.3	1	Good	2 m to curb
276	Linden spp.	8.0	26.1	1	Good	1 m to curb
277	Linden spp.	8.5	23.1	1	Good	1 m to curb
278	Norway maple	8.5	20.7	1	Good	1 m to curb
279	Norway maple	8.5	22.0	1	Good	1 m to curb
280	Austrian pine	8.5	17.3	2	Good	1 m to curb

ID	Species	Height (m)	DBH (cm)	Crown Condition	Trunk Condition	Habitat
281	Austrian pine	3.0	8.6	2	Good	2 m to curb
282	Norway maple	9.5	21.5	1	Good	1 m to curb
283	Austrian pine	6.5	13.0	2	Good	1 m to curb
284	Austrian pine	7.5	13.2	1	Good	2 m to curb
285	Austrian pine	7.5	20.6	2	Good	1 m to curb
286	Norway maple	7.5	20.1	1	Good	1 m to curb
287	Austrian pine	7.0	14.7	2	Good	1 m to curb
288	Norway maple	9.5	23.9	1	Good	1 m to curb
289	Norway maple	9.0	24.8	1	Good	1 m to curb
290	Unknown non-conifer	6.5	7.7	1	Good	1 m to curb
291	Linden spp.	10.5	24.3	3	Good	1 m to curb
292	Linden spp.	9.5	25.3	2	Good	1 m to curb
293	Linden spp.	8.5	19.5	1	Good	1 m to curb
294	Linden spp.	8.5	20.6	1	Good	1 m to curb
295	Austrian pine	8.0	16.8	2	Good	1 m to curb
296	Austrian pine	8.5	17.6	2	Good	1 m to curb
297	Austrian pine	8.5	18.2	2	Good	1 m to curb
298	Austrian pine	11.0	25.7	2	Good	1 m to curb
299	Austrian pine	11.0	32.6	2	Good	1 m to curb
300	Cherry spp.	6.5	17.0	1	Good	1 m to curb
301	Cherry spp.	5.0	5.0	1	Good	1 m to curb
302	Elm spp.	11.0	12.0	1	Good	10 cm to building
303	Norway maple	5.5	13.4	2	Good	1 m to curb
304	Norway maple	7.0	20.4	1	Good	1 m to curb
305	Norway maple	6.5	17.4	2	Good	1 m to curb
306	Norway maple	6.5	14.5	1	Good	1 m to curb
307	Norway maple	6.0	13.4	1	Good	1 m to curb
308	Linden spp.	7.5	27.8	1	Good	1 m to curb
309	Linden spp.	7.0	19.4	1	Good	1 m to curb
310	Linden spp.	8.5	31.0	1	Good	1 m to curb
311	Linden spp.	7.0	20.2	1	Good	1 m to curb
312	Linden spp.	6.5	19.1	2	Good	1 m to curb
313	Norway maple	6.0	13.3	1	Good	1 m to curb
314	Norway maple	5.5	9.4	1	Good	1 m to curb
315	Norway maple	6.0	12.9	1	Good	1 m to curb
316	Norway maple	5.0	13.4	1	Damaged	1 m to curb
317	Norway maple	6.0	12.0	2	Good	1 m to curb
318	Norway maple	6.5	12.3	1	Good	1 m to curb
319	Norway maple	6.5	15.6	1	Good	1 m to curb
320	Linden spp.	6.0	19.1	1	Good	1 m to curb
321	Linden spp.	8.0	18.1	1	Good	1 m to curb

ID	Species	Height (m)	DBH (cm)	Crown Condition	Trunk Condition	Habitat
322	Linden spp.	8.0	19.0	1	Good	1 m to curb
323	Linden spp.	7.0	17.5	1	Good	1 m to curb
324	Norway maple	6.5	14.7	1	Good	1 m to curb
325	Norway maple	6.5	15.8	1	Good	1 m to curb
326	Norway maple	6.0	13.4	1	Good	1 m to curb
327	Norway maple	6.0	14.6	1	Good	1 m to curb
328	Norway maple	5.0	12.7	1	Good	1 m to curb
329	Norway maple	6.0	16.0	1	Damaged	1 m to curb
330	Norway maple	5.0	15.5	1	Good	1 m to curb
331	Austrian pine	4.0	17.4	1	Good	In a planter, 1 m diameter
332	Cherry spp.	4.5	10.5	1	Good	1 m to curb
333	Cherry spp.	5.0	7.5	1	Good	1 m to curb
334	Austrian pine	5.5	19.2	1	Good	1 m to curb
335	Austrian pine	6.0	21.7	1	Good	1 m to curb
336	Austrian pine	6.0	26.2	1	Good	1 m to curb
337	Austrian pine	6.5	20.5	1	Good	1 m to curb
338	Apple spp.	6.5	17.0	1	Good	1 m to curb
339	Apple spp.	6.5	13.9	1	Good	1 m to curb
340	White birch	10.5	12.8	1	Good	1 m to curb
341	White birch	7.0	9.5	1	Damaged	1 m to curb
342	Apple spp.	8.5	28.6	1	Good	1 m to curb
343	White birch	5.5	6.5	1	Damaged	1 m to curb
344	Red oak	11.5	19.5	1	Good	1 m to curb
345	Red oak	11.5	13.6	1	Good	50 cm to curb
346	Red oak	11.5	10.6	1	Damaged	30 cm to curb
347	Austrian pine	13.5	26.5	1	Good	1 m to curb
348	Austrian pine	8.0	11.5	2	Good	2 m to curb
349	Austrian pine	13.5	25.5	1	Good	1 m to curb
350	Red Spruce	8.5	10.0	1	Good	1 m to curb
351	Red Spruce	6.5	10.9	1	Good	3 m to curb
352	Red Spruce	8.5	15.2	1	Good	1 m
353	Red maple	15.5	17.5	1	Good	3 m to curb
354	Red Spruce	6.5	10.6	1	Good	1 m to curb
355	Red maple	11.0	12.5	1	Good	1 m to curb
356	Red Spruce	11.0	14.5	1	Good	1 m to curb
357	Linden spp.	11.5	14.6	1	Good	1 m to curb
358	Linden spp.	12.5	18.1	1	Good	1 m to curb
359	Red Spruce	6.5	10.4	1	Good	1 m to curb
360	Linden spp.	12.5	15.1	1	Good	1 m to curb
361	Linden spp.	12.5	15.2	1	Good	1 m to curb
362	Linden spp.	12.5	16.1	1	Good	1 m to curb

ID	*Species*	*Height (m)*	*DBH (cm)*	*Crown Condition*	*Trunk Condition*	*Habitat*
363	Elm spp.	15.5	33.0	1	Good	2 m to curb
364	Austrian pine	12.0	13.5	2	Good	1 m to curb
365	Austrian pine	13.5	23.0	1	Good	1 m to curb
366	Austrian pine	10.5	22.0	1	Good	1 m to curb
367	Austrian pine	10.5	24.0	1	Good	1 m to curb
368	Austrian pine	12.0	24.5	1	Good	1 m to curb
369	Austrian pine	8.5	15.6	1	Good	1 m to curb
370	Austrian pine	12.0	23.4	2	Good	1 m to curb
371	Austrian pine	11.0	21.4	2	Good	1 m to curb
372	Austrian pine	8.5	19.6	1	Good	1 m to curb
373	Austrian pine	11.5	23.3	1	Good	1 m to curb
374	Austrian pine	11.5	27.5	1	Good	1 m to curb
375	Austrian pine	12.0	20.0	2	Good	1 m to curb
376	Austrian pine	11.0	14.5	2	Good	1 m to curb
377	Austrian pine	11.0	22.4	1	Good	1 m to curb
378	Austrian pine	10.5	18.5	1	Good	1 m to curb
379	Austrian pine	7.5	24.5	1	Good	1 m to curb
380	Willow spp.	8.0	16.5	1	Damaged	2 m to curb
381	Linden spp.	9.0	16.0	1	Good	1 m to curb
382	Linden spp.	8.5	19.0	1	Good	1 m to curb
383	Linden spp.	9.0	17.8	1	Good	2 m to curb
384	Linden spp.	8.0	16.5	1	Good	2 m to curb
385	Linden spp.	8.5	16.4	1	Good	2 m to curb
386	Linden spp.	8.5	18.5	1	Good	2 m to curb
387	Staghorn sumac	3.5	7.2	1	Good	50 cm to curb
388	Staghorn sumac	2.5	4.0	2	Good	50 cm to curb
389	Ivory silk lilac	*5.5*	10.8	1	Good	3 m to building
390	Austrian pine	*10.0*	23.4	1	Good	Raised planter 2 m to edge
391	Linden spp.	*9.0*	21.0	2	Good	3 m to building
392	Austrian pine	*7.0*	20.0	1	Good	2 m to edge
393	Ivory silk lilac	*5.5*	15.0	1	Good	2 m to edge
394	Ivory silk lilac	*7.0*	20.5	1	Damaged	2 m to edge
395	Cherry spp.	*6.0*	7.9	1	Good	2 m to edge
396	Austrian pine	*7.0*	20.3	1	Good	1 m to edge
397	Austrian pine	*7.5*	19.4	1	Good	2 m to edge
398	Austrian pine	*7.5*	21.0	2	Good	1 m to edge
399	Ivory silk lilac	*4.0*	7.4	1	Good	1 m to curb
400	Ivory silk lilac	*4.0*	9.8	1	Good	1 m to curb
401	Staghorn sumac	*2.5*	4.0	1	Good	1 m to wall
402	Staghorn sumac	*3.0*	4.0	1	Good	50 cm to wall
403	Ivory silk lilac	*3.0*	3.0	1	Good	30 cm to wall

ID	Species	Height (m)	DBH (cm)	Crown Condition	Trunk Condition	Habitat
404	unknown non-conifer	3.0	2.6	1	Good	30 cm to wall
405	Linden spp.	7.0	17.5	1	Good	2 m to curb
406	Linden spp.	8.0	23.8	1	Good	1 m to curb
407	Linden spp.	7.0	25.4	1	Good	2 m to curb
408	Ginko	6.5	15.7	1	Good	50 cm to curb
409	Ivory silk lilac	4.0	14.0	1	Good	1 m to curb
410	Callery pear	4.5	8.2	1	Good	1 m to curb
411	Callery pear	7.5	18.9	1	Good	1 m to curb
412	Callery pear	7.0	16.0	1	Good	1 m to curb
413	Ivory silk lilac	5.0	14.5	1	Good	1 m to curb
414	Serviceberry spp.	6.0	10.6	1	Good	1 m to curb
415	Ivory silk lilac	5.0	10.3	1	Ext. Damage	1 m to curb
416	Callery pear	5.0	8.0	1	Good	2 m to curb
417	Callery pear	7.0	18.9	1	Good	2 m to curb
418	Ivory silk lilac	6.0	13.4	1	Damaged	1 m to curb
419	Linden spp.	6.0	11.0	1	Good	1 m to curb
420	Ginko	4.5	15.4	1	Good	1 m to curb
421	Linden spp.	9.0	25.2	1	Good	1 m to curb
422	Linden spp.	9.0	22.0	1	Good	1 m to curb
423	Linden spp.	9.0	22.8	1	Good	3 m to curb
424	Cherry spp.	3.5	11.4	1	Good	1 m to curb
425	Cherry spp.	4.0	10.0	1	Good	1 m to curb
426	Cherry spp.	4.0	14.3	1	Good	1 m to curb
427	Linden spp.	6.5	21.5	2	Good	1 m to curb
428	Cherry spp.	5.5	8.8	1	Good	2 m to curb
429	Linden spp.	7.0	18.0	3	Good	1 m to curb
430	Cherry spp.	4.0	3.0	1	Good	1 m to curb
431	Staghorn sumac	1.5	1.5	1	Good	20 cm to building
432	Staghorn sumac	2.5	4.0	2	Good	5 cm to building
433	Staghorn sumac	2.0	3.0	1	Good	5 cm to building
434	Linden spp.	6.0	18.2	1	Good	1 m to curb
435	Ash spp.	11.0	22.8	1	Good	1 m to curb
436	Ash spp.	10.0	18.5	1	Good	1 m to curb
437	Linden spp.	8.0	18.5	1	Good	1 m to curb
438	unknown non-conifer	6.0	10.0	1	Good	1 m to curb
439	Linden spp.	10.0	21.2	1	Good	1 m to curb
440	Linden spp.	10.0	21.5	1	Good	1 m to curb
441	Linden spp.	9.0	21.4	1	Good	1 m to curb
442	Linden spp.	7.0	18.5	1	Damaged	1 m to curb
443	Serviceberry spp.	6.0	9.0	1	Good	1 m to curb
444	Serviceberry spp.	6.0	7.8	1	Good	1 m to curb

ID	Species	Height (m)	DBH (cm)	Crown Condition	Trunk Condition	Habitat
445	Linden spp.	9.0	21.0	1	Good	1 m to curb
446	Linden spp.	9.0	18.6	1	Good	1 m to curb
447	Linden spp.	8.0	21.2	1	Good	1 m to curb
448	Callery pear	7.0	11.5	1	Damaged	50 cm to curb inside in-ground planter
449	Callery pear	7.0	14.4	1	Good	50 cm to curb inside in-ground planter
450	Callery pear	7.0	16.5	1	Good	50 cm to curb inside in-ground planter
451	Serviceberry spp.	2.0	1.5	1	Good	1 m to curb
452	Serviceberry spp.	6.0	11.0	1	Good	1 m to curb
453	Elm spp.	10.0	16.3	1	Good	Touching wall
454	Elm spp.	7.0	12.5	1	Good	Touching wall
455	Elm spp.	8.0	12.0	1	Good	Growing out of wall
456	Austrian pine	8.0	19.8	1	Good	In a planter, 1 m diameter
457	Austrian pine	3.0	9.8	1	Good	In a planter, 1 m diameter
458	Austrian pine	9.0	20.3	1	Good	In a planter, 1 m diameter
459	Austrian pine	6.0	16.6	1	Good	In a planter, 1 m diameter
460	Austrian pine	5.0	17.0	1	Good	In a planter, 1 m diameter
461	Austrian pine	3.0	8.2	1	Good	In a planter, 1 m diameter
462	Austrian pine	8.0	16.2	1	Good	In a planter, 1 m diameter
463	Austrian pine	4.0	10.3	1	Good	In a planter, 1 m diameter