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Economic risk analysis of the emerald ash borer on the Thunder Bay campus of Lakehead University

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ECONOMIC RISK ANALYSIS OF THE EMERALD ASH BORER ON THE THUNDER BAY CAMPUS OF LAKEHEAD UNIVERSITY

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By

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An undergraduate thesis submitted in partial fulfillment of the requirements for the

Degree of Honours Bachelor of Science in Forestry

Faculty of Natural Resources Management

Lakehead University

May 2018

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Advisor Second Reader

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The reader should be aware that the opinions and conclusions expressed in this document are those of the student and do not reflect opinions of the supervising faculty members or the Faculty of Natural Resources Management.

ABSTRACT

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In addition to their beauty, these trees contribute valuable ecosystem services. As of June 2016 the emerald ash borer, an invasive beetle from Asia, has been found in Thunder Bay and has the potential to kill every ash tree in the city. In order to determine the economic risk the University is facing, an analysis was completed to determine the value and annual contributions of the ornamental ash on Thunder Bay campus. Three methods: the LEAF benefits calculator, the National Tree Benefits Calculator (NTBC), and the i-Tree My Tree benefits calculator were used to estimate the annual contributions from the trees. Values of the trees were also calculated using the basic method. The cost of removal, replacement, and treatment with TreeAzin was determined with the help of a local arborist. Once all factors were calculated, an economic risk analysis was completed to determine the best plan of action for management of ash trees and the emerald ash borer. The only scenario which yielded positive benefits was the 100% treatment according to the NTBC. Therefore, it makes economic sense to save the ash trees on campus.

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INTRODUCTION AND OBJECTIVES

Emerald Ash Borer (*Agrilus planipennis* Fairmaire) has recently arrived in Thunder Bay Ontario (City of Thunder Bay 2016). Its impact hasn't been felt by residents yet but there have been glimpses of the eventual devastation which could happen such as at ground zero on Fourth Avenue where all the ash have been removed and replaced. Thunder Bay's urban street trees consist of 25% green ash (*Fraxinus pensilvanica* Marshall) (Davey Resource Group 2011) which are all destined to die unless measures are taken to treat the trees. Urban trees provide many benefits. These benefits are translated into dollar amounts using some simple measurements and the use of models. Many models exist and all are different from one another. Ecosystem services from urban street trees include storm water management, air purification, increased property value, decreased soil erosion, household energy savings and carbon sequestration (Alexander & DePratto 2014). Some ash trees in Thunder Bay are above 50cm DBH and with increased size there is an increased amount of annual benefits generated (Alexander & DePratto 2014). The cost of losing these large street trees is sometimes more than the amount it would take to protect them from EAB using various techniques such as injections with TreeAzin as calculated by Kotska (2016).

Lakehead University campus has many ash trees but the annual economic benefit is not yet known. This study will show the value of these trees and how much the ash on Lakehead University campus generate each year for the school in terms of ecosystem services. The school can then look at how much is spent on managing these trees each year and this will help the school decide whether the trees are worth protecting and what level of protection is the most economically feasible. The research will take place on the university campus and adjacent residences. Diameter at breast height (DBH) as well as a quick evaluation will be conducted to determine the health of the tree. Focus will be on the services generated by the trees and the cost of losing their annual benefits. Cost of replacement trees will also be taken into consideration.

LITERATURE REVIEW

URBAN FORESTRY

Urban forestry is the management of trees for their contribution to the physiological, sociological and economic well-being of urban society (Carter 1993). Today a large majority of Canada's population is living in urban centres (Nesbitt *et al.* 2015). The densities in the urban centres are expected to rise in the future, which will put greater stress on our urban forests. Today, trees in city tree lawns, parks, and public land are taken care of by urban foresters or municipal staff (Miller *et al.* 2015). Urban forests provide many ecosystem services to municipalities, which makes managing them economically and environmentally important. These ecosystem services include storm water mitigation, pollution control, carbon sequestration, wildlife habitat, energy savings, and providing an esthetic city environment (Alexander & DePratto 2014).

BENEFITS OF URBAN TREES

A) ENERGY SAVINGS

As mentioned earlier, trees provide many services to everyone living in cities from individual house owners all the way to the larger municipal level. Cities tend to have higher temperatures in comparison to rural areas (Heidt & Neef 2008) which is caused by heat absorption of dark surfaces such as roads and roofs as well as lack of shading from trees to these surfaces. Heidt & Neef (2008) have stated that almost every city in the world is 1 to 4 degrees Celsius warmer than rural areas. Another factor contributing to heating of urban centres is the lack of evapotranspiration, which cools the surrounding environment (Heidt & Neef 2008). Trees reduce the cost of heating and cooling in urban centres (Dwyer *et al.* 1992). For perspective, if there were three trees for every other household in US cities, a savings of 2 billion dollars could be realized (Dwyer *et al.* 1992). That translates to 30 billion kWh (Dwyer *et al.* 1992). An increase in canopy cover from 10% to 25% in the city of Phoenix would reduce the temperature by 2 degrees Celsius (Middel *et al*. 2015).

B) STORM WATER MANAGEMENT

Trees provide storm water management in several ways. Urban street trees intercept rainfall, absorb and transpire rainfall, reduce pollutants from entering the water treatment system, and reduce erosion from surface flow in urban environments (Alexander & DePratto 2014). Urban environments have a high amount of impermeable surfaces such as asphalt and concrete which rain can not infiltrate (Nesbitt *et al.* 2015).

Urban trees can be planted under permeable surfaces to increase infiltration and storm water reduction (Nesbitt *et al.* 2015). It has been shown that storm water management is one of the most valuable ecosystem services trees can provide (Nesbitt *et al.* 2015). In some cases benefits of up to $28 per tree were recorded (Nesbitt *et al.* 2015). This is accomplished through the trees uptake of water for use in photosynthesis. During this uptake of water any pollutants within the water may be absorbed as well which is another way in which trees reduce pollution (Seitz & Escobedo 2011). Trees are capable of absorbing thousands of litres of water per year which translate into significant savings of storm water treatment for municipalities.

C) AIR POLLUTION

Trees can affect air quality in a variety of ways. Trees in urban environments can remove pollutants from the air through dry deposition on leaf surfaces, and absorption through foliage. (USDA 2005).

Air pollution consists of many chemicals such as nitric oxides (NO_x), and sulphur oxide (SO_x), particulate matter (PM) and volatile organic compounds (VOC), carbon monoxide (CO), and ozone (O_3) (Nowak *et al.* 2018). These chemicals are created through various processes including exhausts from vehicles and other fossil fuel burning processes (USDA 2005). These particulates form tiny microscopic solids or liquids, which may accumulate on the surface of foliage and bark of trees (USDA 2005). Absorption of VOC's through stomata openings is the main way in which trees help remove pollutants from the air (Nowak *et al.* 2018). Once the trees absorb the chemicals, they become incorporated into the intercellular space of the tree where they are stored (Nowak *et al.* 2006).

Reducing the amount of ozone is another way in which trees can help reduce air pollution (CUFR 2006). Ozone is a major atmospheric pollutant which contributes to climate change. Ozone is created through chemical reactions with oxides such as NO_x and other VOC's (CUFR 2006). Ozone is created at higher rates when temperatures are higher (CUFR 2006). Therefore, plants present in urban areas help reduce ozone by absorbing the VOC's and oxides through stomata while also reducing temperature which in turn slows the conversion of oxides and VOC's to ozone.

D) PROPERTY VALUE

The presence of trees in urban areas can greatly increase the value of properties up to 10% (Morales 1980). Trees provide ecosystem services which increase the value of properties (Nowak *et al.* 2007). The increase in property value is not just based on the benefits trees provide but also the leisure opportunities trees create for landowners and general beautification (Nowak *et al.* 2007). Trees have the ability to create a more energy efficient home and other desirable features like shaded patios and wind breaks (Nowak *et al.* 2007). Nowak *et al.* (2007) states that the increases in property values are partially offset by the cost of managing trees but still economically beneficial to landowners.

E) CARBON SEQUESTRATION

Carbon dioxide (CO_2) is a major contributing emission to global climate change (Nowak & Crane 2002). Carbon dioxide is considered a greenhouse gas. Increased levels of greenhouse gases are emitted in urban areas due to fossil fuel combustion from the concentration of people. This coupled with the increased temperature from artificial surfaces can exacerbate the affects of climate change in these areas (Nowak & Crane 2002).

The process of photosynthesis takes in CO_2 and water and releases oxygen. This process increases air quality through the storage of CO_2 in the form of carbon in plant tissues and through the release of oxygen into the atmosphere (Nowak *et al.* 2007). This removal and storage of carbon is termed carbon sequestration. Carbon sequestration is a valuable ecosystem service generated by urban trees which will help reduce the effects of climate change. The absorbed CO_2 is fixed by trees and stored within its tissue and therefore trees act as carbon sinks (Nowak & Crane 2002). Many people overlook the contribution that urban trees make to the storage of CO_2 and mitigation of climate change. A study by Nowak & Crane (2002) found that urban trees in Jersey City stored 19,300 t of carbon. For perspective, Jersey City has a population of 264,000 people, which is just over twice the population of Thunder Bay.

Municipalities with higher percent tree cover will have higher carbon sequestration value. Additionally, cities that have large diameter trees in good health will store more carbon. Nowak & Crane (2002) explain, that a tree with a diameter of 77cm stores 90 times more carbon than an 8cm tree. Therefore if effort is put into maintenance and care of trees then greater benefits may be realized.

ASH TREES – *FRAXINUS*

Ash (*Fraxinus*) is part of the olive family (Oleaceae) (Farrar 1995). Sixteen species of ash are native to North America with four of those being native to Canada.

Ash trees are a deciduous tree with pinnately compound leaves in opposite pairs. The seeds of the ash trees are winged and are one seeded which form in clusters that droop from the tree (Farrar 1995). Ash possess the ability to reproduce vegetatively from stump sprouts. Bark is finely furrowed with ridges. The wood is hard, strong, straight grained and prized for furniture making, basket weaving, and other hand turned objects (Farrar 1995). The different species of ash vary in size ranging from small to large. The species on campus at LU are the Green Ash (*Fraxinus pensylvanica* Marshall) and the White Ash (*Fraxinus americana* L.). Both species are medium to large size trees (Farrar 1995).

EMERALD ASH BORER

The Emerald Ash Borer (EAB) is an invasive beetle that is native to Asia. It is a small metallic green beetle which feeds on the phloem of living ash trees. It was discovered in southeastern Michigan and Windsor Ontario in 2002 (Tluczek *et al.*2011). The emerald ash borer is responsible for the death of tens of millions of ash trees in Canada and the United States. In Ontario, the beetle has been detected as far west as Thunder Bay as of 2016. The beetle has also been found in the province of Quebec. It attacks all species of ash with no specific preference (Tluczek *et al.* 2011). The pest is believed to have arrived through wood packaging materials from overseas (Poland & McCullough 2006). Emerald ash borer kills 99.9% of all infected hosts. It kills trees through the creation of serpentine galleries under the bark which girdle the tree cutting off water and nutrient flow.

The life cycle of EAB is variable. It was thought to reproduce on a 1 year cycle but in colder climates it is thought the beetle reproduces on a 2 year cycle (Cappaert *et al.* 2005). Adults emerge from trees in D-shaped exit holes in early May through to June. Beetles are thought to be able to disperse as far as 10km/year. The adults feed for 5 – 7 days on ash foliage before beginning to mate (Cappaert *et al.* 2005). Once the adults have mated the females continue to feed for another 5 – 7 days before oviposition (Cappaert *et al.* 2005). The females lay eggs in bark crevices of ash trees. The eggs are approximately 1mm in length and anywhere from 50 – 200 eggs can be laid by one female (Cappaert *et al.* 2005). Once the eggs hatch the larvae burrow into the tree and begin feeding on the phloem until around October. During that time period the larvae will go through 4 instar stages before creating a pre-pupal chamber in which the beetle will overwinter (Cappaert *et al.* 2005). Around April the larvae will complete their pupations and resume the cycle again. As mentioned earlier, in colder climates the beetles may complete their life cycle in a 2 year increment. In this case the larvae will only go through 2 instars in a given year (Cappaert *et al.* 2005). The following year it will complete its life cycle and exit to continue the cycle.

The emerald ash borer has been detected in the city of Thunder Bay as of the summer of 2016, when it was detected on the corner of Fourth Ave. and Memorial Ave. (City of Thunder Bay 2016). It was thought to have been here for several years prior to the find. Since its discovery in Thunder Bay, eight more sites have been found containing EAB. The beetle's main mode of transportation is through movement of ash wood facilitated by humans and therefore a quarantine area has been set up around Thunder Bay to contain the spread (City of Thunder Bay 2016). Although it is not known for certain, as the beetle just arrived, but it is believed that in Thunder Bay the beetle is undergoing a 2 year life cycle due to the shortened seasons and colder weather. This may be an advantage when trying to manage the insect.

The beetle is very small and hard to detect but there are some visual signs associated with the insect that help to determine infestation. The emerald ash borer begins feeding from the top of the tree then down which makes detection difficult (Cappaert *et al.* 2005). The leaves may seem sparse or yellow which may resemble a disease called ash anthracnose so this symptom may not be all that effective. Epicormic sprouts are a good indicator that the tree is stressed and may signal an EAB infestation (Cappaert *et al.* 2005). Other indicators are D – shaped exit holes and cracking bark. If an exit hole is detected the bark may be peeled off in order to reveal the serpentine galleries for confirmation of EAB.

Prism traps have been set up across the city in order to determine presence of the insect. Prism traps contain pheromones to attract adult beetles (City of Thunder Bay 2016). Branch sampling is also being conducted. Both these methods are effective early detection methods which will help in controlling the spread of EAB (City of Thunder Bay 2016).

TREEAZIN

TreeAzin is a systemic insecticide which is used to treat ash trees. It is developed from an extract of the Neem tree seed (Bioforest 2018). The insecticide is injected under the bark into the cambium of the tree, which then disperses the chemical throughout the entire tree (Bioforest 2018). TreeAzin kills EAB larvae that feed on the cambium of treated trees. The insecticide can also affect adult beetles when they feed on the foliage. Adults who eat the foliage have a reduced number of viable eggs (Bioforest 2018).

Larvae which do hatch from eggs do not complete a full life cycle and die. Treated trees have been shown to have larval death rates of 95% and frequency and length of galleries are smaller (Bioforest 2018).

MATERIALS AND METHODS

In order to determine the economic contribution ornamental ash trees have on the Lakehead University (LU) campus, the total number of trees needed to be determined. This was completed by walking around campus and identifying ash trees. Once the trees were identified some basic information was taken from each tree. Information was needed in order to use the tree benefit calculators. Information collected from each tree included species, diameter at breast height (DBH), condition, distance to buildings, GPS coordinates, aspect, and any observation deemed important. The DBH was measured using a diameter tape 1.3m above the ground and recorded. Condition was based on a 1 to 5 scale. With 1 being poor and 5 being excellent. The condition was determined by examining the overall health of the tree including roots, stems, scaffold branches, twigs, and foliage. The aspect and distance to buildings was determined through the use of Google Earth. GPS waypoints were imported into Google maps in the form of a KML file. Once the waypoints were adjusted to account for error with the GPS unit, distances and aspect relative to buildings were recorded.

As mentioned previously, in order to determine economic contributions of the trees the use of benefits calculators were used. Three different methods were used and each produced different outputs. The first method used was the Residential Tree Benefits

Estimator provided by LEAF (Local Enhancement and Appreciation of Forests, Toronto). This calculator was useful in producing amount of carbon sequestered, energy saved, air pollution, and storm water mitigated but did not create a dollar value other than the energy savings. Due to this fact, additional steps were taken to assign a value to the storm water mitigated and carbon sequestered. The second method was the i-Tree Mytree application created by the USDA (United States Department of Agriculture) Forest Service. This application was useful because all the trees could be calculated together or individually. This application did produce significantly lower values than other methods and therefore individual tree benefits were very low. Benefits for this method were provided as the actual amount as well as the dollar amount associated with it. Dollar amounts were in American dollars and therefore a conversion was necessary. Lastly the National Tree Benefits Calculator (NTBC) by Davey Tree Expert Co. and Casey Trees was used. This method also provided real amounts and dollar amounts of all ecosystem services provided by the trees. It created significantly higher values than the i-Tree method. Each tree needed to be completed individually and all units were imperial which were both drawbacks.

LEAF TREE BENEFITS ESTIMATOR

The Ontario Residential Tree Benefits Estimator is a program developed in Ontario by LEAF and Ryerson University's Dr. Andrew Millward (LEAF 2017). The program was modelled after the Sacramento Municipal Utility District (SMUD) Tree Benefits Estimator using Ontario input (LEAF 2017). This calculator is a useful tool that can be used to determine the ecosystem services generated by an individual tree. It requires the input such as the DBH, species, distance to buildings, city, aspect, and age of buildings. It then generates approximate figures of the amount of carbon stored, stormwater mitigated, air pollution absorbed, and electricity saved.

The LEAF calculator was a 4 step program. First, it asks if the tree is new or existing. All trees were pre-existing in this report. In step 2, an issue encountered was with this tool. It was missing white and green ash from the species list. There was a generic selection called broadleaf deciduous (large) which was the species selection used for all trees in this report. Once the species was selected the DBH needed to be entered. Step 3 was a question about presence of electrical heating which did not apply to this thesis and therefore no was answered for all trees in this report. Step 4 required the input of the nearest city, aspect of the tree relative to buildings, and distance to the buildings. The nearest city is Thunder Bay for all trees. The distance to buildings gave three options. The options were 0 – 6m, 6 – 10m and 10 – 15m. Most trees on the Lakehead campus were not close to buildings and for these trees no inputs were entered for the aspect and distance to buildings. Since there was only 79 ash trees on campus the calculations were completed for each tree unless the DBH, aspect, and distance to buildings were the same.

Once all information was put into the program the benefits were calculated. The outputs estimated the kWh’s saved, the value of electrical savings in a dollar amount, sequestered CO2 (kg), avoided CO2 in (kg), stormwater mitigation (L), and air pollution removed (kg). Outputs were provided for this year and over the life of the tree. For the purposes of this project the current years outputs were used. These outputs can then be used to determine the amount of lost benefits to LU Thunder Bay campus if EAB kills all the ash trees.

I-TREE MYTREE BENEFITS CALCULATOR

i-Tree is a suite of software which was developed by the USDA Forest Service in cooperation with Davey Tree Expert Company, National Arbor Day Foundation, Society of Municipal Arborists, International Society of Arboriculture, and Casey Tree (i-Tree n.d.). The suite contains numerous programs which are suited to different purposes. For this project, the i-Tree MyTree application was used. This program requires input of the species, condition of the tree, amount of sun exposure, distance to buildings, age of the building and the aspect. The output produces amounts of carbon stored, stormwater mitigated, air pollution removed, energy usage avoided, and avoided emissions as well as a corresponding dollar value.

The i-Tree Mytree benefits calculator is a 2 step process. In step 1 six inputs were needed. The address which was 955 Oliver Rd, Thunder Bay, ON. The name was the number the tree was assigned during surveys. The species of tree needed to be selected. For this project there were two species of ash which were both contained in the list. Next the condition of the tree was required. Conditions were dead, critical, poor, fair, good, and excellent. For the purposes of this project condition ratings were given using a 1 – 5 scale. Therefore, below in Table 1 is the condition numbers and their corresponding conditions used within the i-Tree calculator.

Table 1. Condition rating and associated number rating

Condition	Rating
Excellent	4 - 5
Good	3 - 4
Fair	2 - 3
Poor	1 - 2
Critical	0 - 1

Next the DBH and sun exposure were inputed. Sun exposure had three selections which were full sun, partial sun, and full shade. For the purposes of this project all sun exposures were set to full sun because no trees were competing with others for sun, and buildings were not significantly shading any trees. Step 2 of the process required a yes or no to whether a building was nearby. If the answer was yes, then the age of that building must be selected. Three options were available for age of the buildings which were before 1950, between 1950 and 1980, and after 1980. For the purposes of this project if there were buildings nearby all building ages were set between 1950 and 1980. This is due to most buildings originating from this time period. No trees were located close enough to the ATAC building to require a change. Next the distance to a building was chosen using 4 different options. The options were 0 – 6m, 6 – 12m, 12 – 18m, >18m. If a tree was greater than 18m from a building the option if a building was nearby was not selected which cancelled the need for step 2. Lastly, the aspect was chosen. The trees could all be input into the system before calculation. The trees could be calculated individually or together.

Calculating the benefits cumulatively was useful for this method due to the low estimation of benefits. Benefits were provided in quantitative amounts and the respective dollar amounts.

NATIONAL TREE BENEFITS CALCULATOR BY DAVEY TREE

The NTBC is a tool used to estimate a trees economic and environmental contributions on an annual basis to users (NTBC n.d.) This program is modelled after the i-Tree program called STREETS. The program requires the location, species, DBH, and land use type. The outputs consist of carbon sequestered, property value, air pollution removed, stormwater mitigated, natural gas savings, and electricity savings with their corresponding dollars amounts. The program also produces several graphs and illustrations explaining the numbers.

The NTBC was the most simple program of the three used. First the location needed to be selected. It requires a zip code but when a postal code was used Thunder Bay appeared and was the option chosen. It lists the climate zone in Thunder Bay as north. Next it requires the species selection in which both white and green ash were available. The tree diameter was required but they must be entered in inches. Therefore, the conversion of cm to inches was completed by dividing the DBH by 2.54. The DBH was entered once it was converted. Lastly, the calculator requires the land use type. There are 5 options which include single family residential, multi family residential, small commercial business, industrial or large commercial business, and park or other vacant land. For the purpose of this project the industrial or large commercial business option was chosen because it most resembles the universities land use type. The park or other vacant land was another option which resembled the land use at LU. The park or other vacant land was selected and compared to see if results differed but both selections resulted in the same output. Outputs were then calculated.

The outputs from this program included graphs and other illustrations. They also included both quatitative amounts and dollar amounts associated with each ecosystem service provided by the trees.

TREATMENT LEVELS

For all benefits estimators calculations were completed. Three scenarios were compared in the calculations. The “no action” scenario which involved no treatment of trees and the removal and replacement of all 79 ash trees. The 100% treatment scenario, which involves all trees being treated with TreeAzin. Lastly, the partial scenario, which involves only the treatment of trees that are over 20cm DBH with a condition rating of three or higher with non-treated trees being removed.

VALUE OF ASH USING THE BASIC METHOD

Value of the ash trees needed to be calculated in order to get a full understanding of the economic risk. Trees have a value other than what they contribute annually and therefore this must be calculated. Value of trees was calculated using the basic method. The basic method involves the DBH, condition value, species value, and location value of trees (International Society of Arboriculture 1998). The DBH and condition value were already determined. Condition values used in the basic method are in a percentage and this required a conversion of the condition rating to a percentage out of one hundred. The species value is described in the Ontario supplement to Guide for Plant Appraisal 8th edition (International Society of Arboriculture 1998). Lastly, the location value used for all trees was 75% based on professional judgment. They received this rating because all trees were in good planting spots. Instead of calculating the value of all the trees individually, the trees were separated into DBH classes. For all seventy-nine trees, the diameter classes were in 10cm increments (0-10, 10.1-20 etc.). For the Partial treatment the trees were separated into 5cm diameter class to get a more accurate value (20-25, 25.1-30 etc). Once in their classes, the average DBH and condition value was calculated and then used to determine the value of the average tree within that class. That value was then multiplied by the number of trees in that class to get a value for all ash trees. Calculations can be seen in the appendix.

CALCULATIONS

Economic losses were then calculated for each benefits calculator with the three different treatment levels. The economic losses were forecasted six years into the future. This was completed by multiplying annual contributions or losses by five and the treatment by three since TreeAzin would be injected biannually. The tree value, removal cost, and replacement cost remain the same, as they are one-time expenditures.

RESULTS

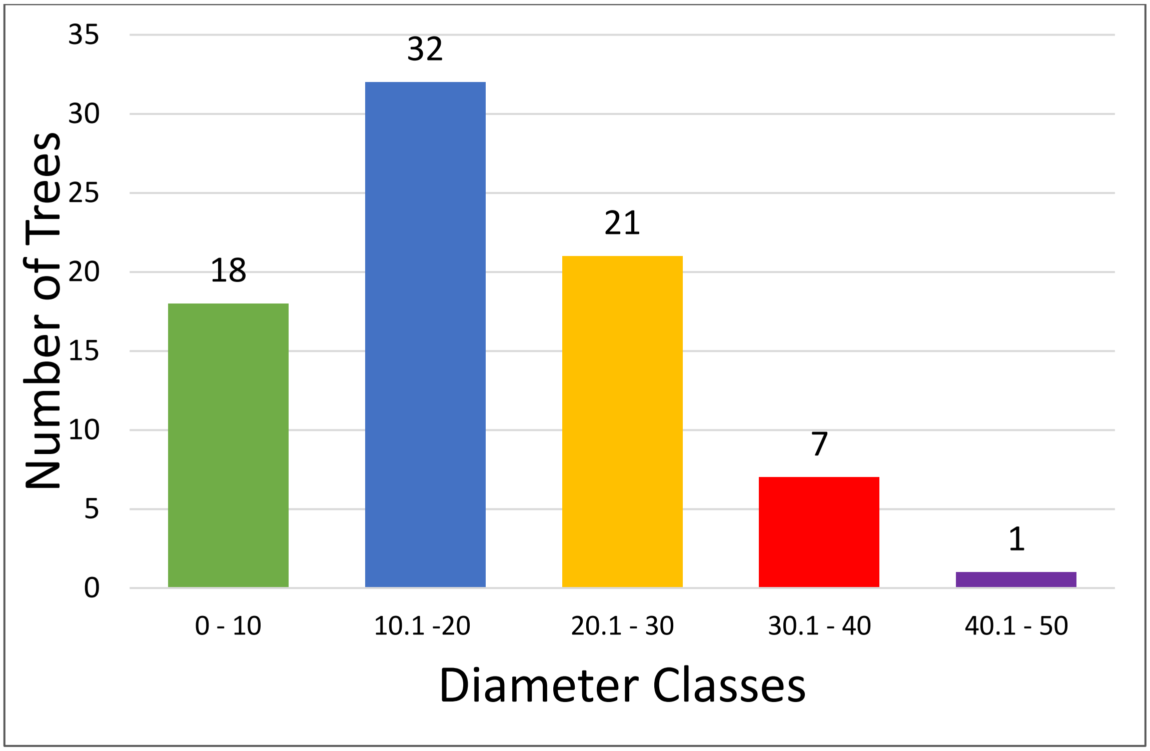

Figure 1. Diameter class distribution of all 79 ash trees

The majority of trees surveyed fell within the 10.1 – 20 cm diameter class with very few trees above 30 cm DBH (7) and only one above 40 cm DBH. Average DBH was 18.4 cm DBH.

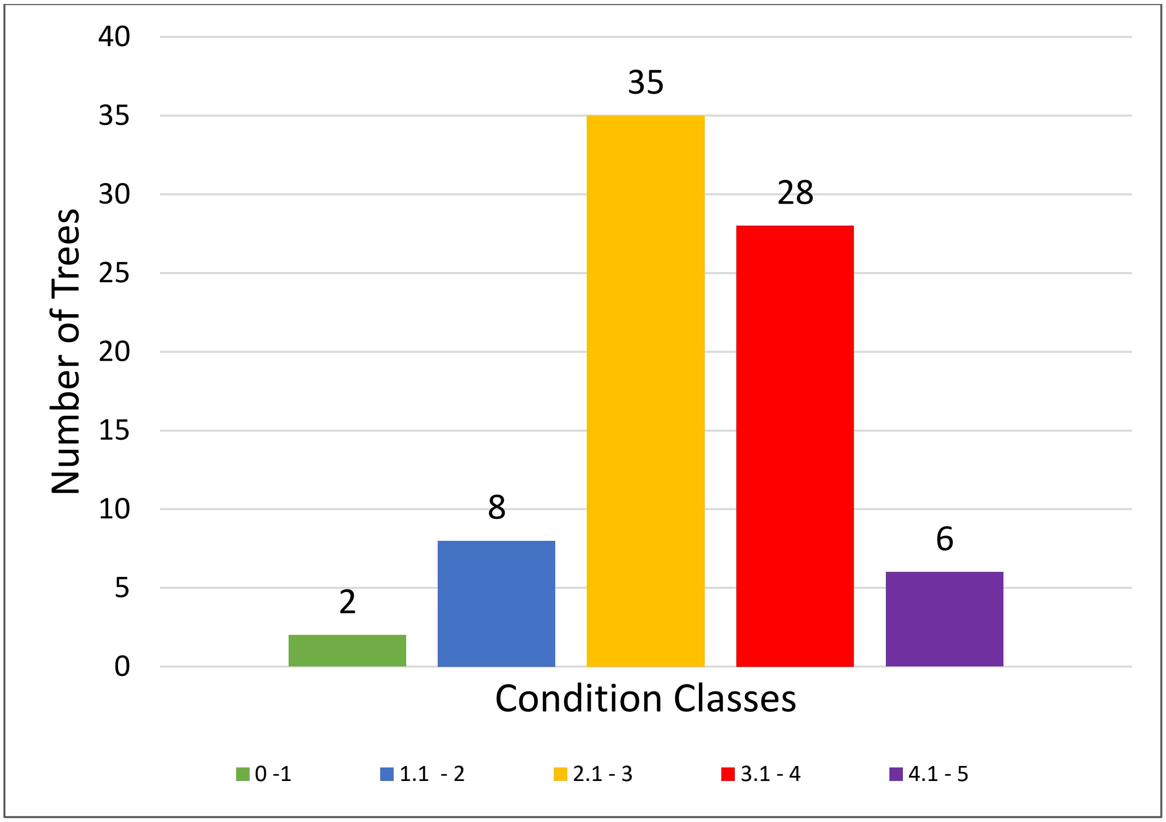

Figure 2. Condition classes for all 79 ash trees

The most common condition class of the trees surveyed were in the 2.1 – 3 range. The average condition of all trees was 3.1.

Table 2. iTree Mytree annual benefit for all trees

	CO2 Sequestered ($)	Storm Water ($)	Air pollution ($)	Energy Usage ($)	Sum
Total	104.48	621.34	20.58	128.08	874.48
Conversion to Canadian $	134.78	801.53	26.55	165.22	1128.08

Table 2 on the previous page displays the conversion of iTree MyTree annual benefits from US dollars to Canadian dollars for all 79 trees as being $1128.08 per year.

Table 3. iTree Mytree annual benefit for trees above 20cm DBH with a condition rating of 3 or higher

	CO2 Sequestered ($)	Storm Water ($)	Air pollution ($)	Energy Usage ($)	Sum	Benefits amount per tree ($/tree)
Total	62.02	377.69	16.15	80.75	536.61	6.79
Conversion to Canadian $	80.01	487.22	20.83	104.17	692.23	8.76

Table 3 above displays the conversion of the iTree MyTree annual benefits from US dollars to Canadian dollars for the trees above 20cm DBH with a condition rating of 3 or higher as being in $692.23 in total per year.

Table 4. National tree benefits calculator annual benefit for all trees

	Property Value ($)	CO2 ($)	Stormwater ($)	Air quality ($)	Electricity ($)	Natural Gas ($)	Total ($)
Total	4408.99	149.04	669.28	77.37	329.86	558.75	6193.29
Conversion to Canadian $	5687.60	192.26	863.37	99.81	425.52	720.79	7989.34

Table 4 above displays the conversion of US to Canadian dollars for the NTBC annual benefits for all 79 trees as being $7989.34 per year.

Table 5. National tree benefits calculator annual benefit for trees above 20cm DBH with a condition rating of 3 or higher

	Property Value ($)	CO2 ($)	Stormwater ($)	Air quality ($)	Electricity ($)	Natural Gas ($)	Total ($)
Total	1737.29	84.02	390.77	46.23	185.16	297.75	2741.22
Conversion to Canadian $	2241.10	108.39	504.09	59.64	238.86	384.10	3536.17

Table 5 above displays the conversion of the NTBC annual benefits from US dollars to Canadian dollars for the 29 trees above 20cm DBH with a condition rating of 3 or higher as being $3536.17 per year.

Table 6. LEAF stormwater mitigation amount converted to a dollar amount

Stormwater mitigation (L)	Stormwater in cubic metres	Storm water cu. Metres X 1.604 = $ value
237220	237.2	380.50

The stormwater mitigation value was calculated in Table 6 using the price of $1.604 which is the amount the city of Thunder Bay charges to treat household stormwater. The total value in savings was $380.50 per year.

Table 7. LEAF carbon sequestration amount converted to dollar value

Sequestered Carbon (kg)	Price per kg of Sequestered Carbon	Value of Sequestered Carbon ($)
3104	0.04	121.07

The price of carbon sequestration was calculated (Table 7) by determining the value per kg from the iTree Mytree results. The dollar amount of carbon sequestered from the iTree MyTree calculator was divided by amount sequestered in order to get a dollar amount. This value was then used to determine the value of carbon sequestered in the LEAF benefits estimator which was $121.07 per year for all 79 trees.

Table 8. LEAF benefits estimator annual contributions converted to dollar amounts for all 79 trees

	Value of electrical savings ($)	Sequestered CO2 (kg)	Avoided CO2 (kg)	Stormwater mitigation (L)	Air Pollution removed (kg)	Total ($)
Total	13	3104	21	237220	38	
Total value in $	13.00	121.1	0.0	380.5	0.0	514.57

Table 8 above displays the amount of annual benefits generated for all 79 trees by the LEAF benefits calculator and their corresponding dollar value at $514.57 per year.

Table 9. LEAF benefits estimator annual contributions converted to dollar amounts for all trees above 20cm DBH with a condition rating of three or higher

	Value of electrical savings ($)	Sequestered CO2 (kg)	Avoided CO2 (kg)	Stormwater mitigation (L)	Air Pollution removed (kg)	Total
Total	6	1726	9	124420	29	
Total value in $	6.00	67.3	0	199.6	0.0	272.89

Table 9 above displays the amount of annual benefits generated for trees over 20cm DBH with a condition rating of 3 or higher by the LEAF benefits calculator and their corresponding dollar value at $278.89 per year.

Table 10. Price of removal used in calculations

DBH	Price of removal
0 - 20	200
20 - 40	700
40+	1600

Table 10 shows the price of removal as provided by Vince Rutter of Rutter Urban Forestry.

Table 11. iTree Mytree calculations after conversion to Canadian dollars

	Count	Price of removal (-)	Price of Replacement (-)	Price of removal + replacement (-)	Price of removal and replacement of trees not treated (50) (-)	Price of Treatment per year (-)	Total Value of Trees (+)	Value of trees lost (50) (-)	i-Tree Annual Contribution From Trees (+)	Annual benefits lost (50) (-)	Total Cost ($)	Six Year Forecast
For all trees	79	34700	43450	78150		3640.25	74927.16		1128.08		-5735.01	-8503.19
For trees above 20cm with rating of 3+	29	21200	15950	37150	41000	1868.25	56537.56	18389.60	692.23	435.85	-4463.92	-7174.93

Table 12. National tree benefits calculator calculations converted to Canadian dollars

	Count	Price of removal (-)	Price of Replacement (-)	Price of removal + replacement (-)	Price of removal and replacement of trees not treated (50) (-)	Price of Treatment per year (-)	Total Value of Trees (+)	Value of trees lost (50) (-)	NTBC Annual Contribution From Trees (+)	Annual benefits lost (-)	Total Cost ($)	Six Year Forecast
For all trees	79	34700.00	43450.00	78150.00		3640.25	74927.16		7989.34		1126.25	25803.13
For trees above 20cm with rating of 3+	29	21200.00	15950.00	37150.00	41000.00	1868.25	56537.56	18389.60	3536.17	4453.17	-5637.29	-13041.78

Table 13. LEAF tree benefits estimator calculations with stormwater mitigation and carbon sequestration values calculated

	Count	Price of removal (-)	Price of Replacement (-)	Price of removal + replacement (-)	Price of removal and replacement of trees not treated (50) (-)	Price of Treatment per year (-)	Total Value of Trees (+)	Value of trees lost (-)	LEAF Annual Contribution From Trees (+)	Annual benefits lost (-)	Total Cost ($)	Six Year Forecast
For all trees	79	34700.00	43450.00	78150.00		3640.25	74927.16		514.57		-6348.52	-11570.74
For trees above 20cm with rating of 3+	29	21200.00	15950.00	37150.00	41000.00	1868.25	56537.56	18389.60	272.89	241.68	-4689.09	-8300.76

Tables 11 - 13 summarize the total cost Lakehead University would incur with all factors considered for the 100% treatment and partial treatment options according to the iTree MyTree, NTBC, and the LEAF benefits calculator respectively. They also display the total cost for a six-year forecast for both treatment options. Positive and negative signs indicate whether the value is a cost or a benefit. The number of trees removed using the partial treatment is displayed in parenthesis for the removal and replacement of trees not treated.

Table 14. No action treatment option according to all three benefits calculators.

Benefits Calculator	Price of removal (-)	Price of Replacement (-)	Total Value of Trees (-)	Annual Contribution From Trees (-)	Total Cost
i-Tree Annual Contribution From Trees	34700	43450	74927	1128	-154205
NTBC Annual Contribution From Trees	34700	43450	74927	7989	-161067
LEAF Annual Contribution From Trees	34700	43450	74927	515	-153592

Table 14 above summarizes the cost to Lakehead University using the no action treatment option. The cost to the University is displayed for all three benefits calculators. A negative sign in parenthesis indicates that the value is lost.

Table 15. Summary of costs for all benefits calculators and treatment options with six-year forecast.

				Six year Forecast	
Benefits Calculator	100% Treatment Option	Partial Treatment Option	No action Treatment Option	100% Treatment Option	Partial Treatment Option
i-Tree	-5735.01	-4463.92	-154205.24	-8503.19	-7174.93
NTBC	1126.25	-5637.29	-161066.50	25803.13	-13041.78
LEAF	-6348.52	-4689.09	-153591.73	-11570.74	-8300.76

Table 15 above displays a cost summary of all treatment options according to all three benefits calculators. There is no six-year forecast for the no action plan due to the assumption that all trees have been killed. Negative values indicate a loss. The NTBC is the only calculator with positive results. The partial treatment option is the most economically friendly option according to the iTree and LEAF benefits calculator for the current year as well as the six-year forecast. The 100% treatment option is the most economically friendly option according to the NTBC for the current year as well as the six-year forecast. The NTBC results in the highest economic losses for the no action plan.

DISCUSSION

The Thunder Bay campus of Lakehead University is likely to lose money no matter which scenario is used. The only scenario which yielded positive benefits was the 100% treatment according to the NTBC. In every other scenario, using all other benefits calculators, the net result is a negative value. With that in mind the value which is lost is marginal when compared to the no action plan. The no action plan resulted in the loss of the full value of all 79 trees and their corresponding annual benefits, along with costs to remove and replace all 79 trees, which ranged from $153,592 (LEAF) to $161,067 (NTBC). When this number is compared to the six year forecast you can see that the economic losses are much lower. The losses ranged from $7,175 to $13,042. Although it looks like it is inevitable the University will lose money there are several factors which represent flaws in the study.

COST OF REMOVALS

The cost of removal used can be seen in Table 10 in the results. Upon examination you can see that this is a flaw in the study because the prices are set for a diameter class of trees. As soon as a tree is above 20cm it becomes five hundred dollars more expensive to remove. In reality, this would not be the case. Every tree would be evaluated and priced before removal and the gap between a 19cm DBH tree and a 20cm DBH tree would be very small if not the same. Of course, removal costs are also based on the location of the trees. Most of the trees in the study are in the open and not close to any buildings. This would be an easy removal for a company and therefore they are less likely to charge as much. Another factor to consider is that many of the trees are very small. Removal would be simple and less expensive. All these factors relating to the removal of trees would result in a lower price of removal and therefore less economic loss.

BENEFITS CALCULATORS FLAWS

The three benefits calculators used in the study are different in their own ways. They all produce different outputs with varying levels of annual contributions. The NTBC estimated the annual contribution at the highest value. This is because property value was included in the annual contribution. Property value was not a factor in the other two calculators and may be the reason for their lower estimations. The seventy-nine ash trees on campus likely do not play a large role in the property value of the university due to its large size. The NTBC also required the least amount of information to estimate the annual benefits. It only required the species, DBH, and type of property where the tree was located. This is a flaw because many trees in the study are not located close to buildings and would therefore not influence energy savings. Energy savings were still calculated for every tree which represents an overestimation by this benefits calculator.

The LEAF benefits estimator is designed for the estimation of a single tree. This calculator as well as the NTBC are designed for homeowners who are interested in the value of trees on their property. They are not meant for large-scale studies that include seventy-nine trees. The LEAF estimator also did not include dollar values for the majority of its outputs. It only provided a dollar value for electrical savings, hence the need for additional calculations to attempt higher accuracy. Even after stormwater and carbon sequestration were assigned a value the air pollution could not be converted to a dollar value. This resulted in the lowest annual benefits of all three calculators.

iTree MyTree is likely the best tool which was used in this study. This program was designed to estimate the contribution of several trees. Although this program is not the same program which urban forestry professionals use on the municipal scale, it is part of the same suite of software. iTree MyTree is part of a suite of programs designed by the USDA Forest Service in cooperation with many other reputable companies. The iTree programs are used by professionals across North America to determine the value and annual contribution of trees. The iTree MyTree estimator also involved the most amount of information input before determining a value. For these reasons, I believe the iTree MyTree annual benefits were the most accurate estimations used.

FUTURE CONTRIBUTIONS

As trees age they contribute higher amounts of annual benefits (City of Thunder Bay 2016). Tree size increases and therefore their value increases as does any services they provide over time. In the calculations, this factor is not taken into account. The annual benefits that were calculated represent benefits during that current year for that individual tree. The six-year forecast did not take into account that during that time the trees will have grown and therefore be contributing higher amounts of benefits. Therefore, the six-year forecast is not accurate and less economic losses would be realized over that time.

Another factor, which is not considered, is the contributions from newly planted trees. In the first year, these trees will not be high in value or produce many annual benefits. As the trees grow however, they start gaining value and producing more benefits. After six years, the benefits may be high enough to factor into the study. This will specifically effect the partial treatment because the annual benefits lost will begin to be replaced by the new plantings. This will reduce the economic loss by the University.

CONCLUSION

The University can not afford the no action plan. It makes economic sense to attempt to save the ash trees on campus. The treatment of all trees seems to be the most economical treatment option available however, this option assumes that all trees treated will survive. There is risk in treating all the trees on campus. Many of the trees are in poor health and are very small. These trees could die from many sources other than EAB and therefore any investment in them could be lost. For this reason, the partial treatment plan makes the most sense for the University. The investment in treatment of the trees would be safe because the trees chosen are in good health. In addition, the trees chosen would be over 20cm DBH and therefore produce higher annual benefits, which maximizes the economic gains while minimizing the losses.

The ash trees on campus can serve a higher purpose other than just contributing benefits to the University. The ash tree will be a rare sight across Ontario and potentially even the country in the near future. They are beautiful trees and help beautify the University. By saving these trees, the University will be creating an opportunity for students to see these rare trees and study them. If a tree was infested by the EAB it can be used as a learning experience for students on campus. Forestry students in particular would appreciate this opportunity to be able to see and study the ash trees.

LITERATURE CITED

Alexander, C. B., DePratto, B. 2014. The value of urban forests in cities across Canada. TD economics. https://www.td.com/document/PDF/economics/special/UrbanForestsInCanadianCities.pdf. Viewed April 18th 2018.

Bioforest. 2018. TreeAzin systemic insecticide. http://www.bioforest.ca/index.cfm?fuseaction=content&menuid=12&pageid=1012 Viewed April 15th 2018.

Cappaert, D., McCullough, D.G., Poland, T.M., & Siegart, N.W. 2005. Emerald Ash Borer in North America: a research and regulatory challenge. American Entomologist. 51(3): 152 – 165.

Carter, E. J. 1993. The potential of urban forestry in developing countries: a concept paper. Food and Agricultural Organization of the United Nation. http://www.fao.org/docrep/005/t1680e/t1680e00.htm. Viewed April 18th 2018.

Centre for Urban Forest Research [CUFR]. 2006. Trees – the air pollution solution. United States Department of Agriculture.

City of Thunder Bay. 2016. City of Thunder Bay: Emerald Ash Borer strategic management plan. http://www.thunderbay.ca/Assets/Living/Urban+Forest/docs/Emerald+Ash+Borer+Strategic+Management+Plan.pdf. Viewed April 15th 2018.

Davey Resource Group. 2011. Urban forest management plan: City of Thunder Bay, Ontario. The Davey Tree Expert Company of Canada Ltd. Ancaster, Ontario. 222pp.

Dwyer, J. F., E. G. McPherson., H. W. Schroeder., R. A. Rowntree., 1992. Assessing the benefits and costs of the urban forest. Journal of Arboriculture, 18(5): 227-234.

Farrar, J.L. 1995. Trees in Canada. Fitzhenry & Whiteside LTD. Markham, Ontario. 502pp.

Heidt, V., & Neef, M. 2008. Benefits of urban green space for improving urban climate pp. 84-96. In (eds. Carreiro, M.H., Song, Y.C., Wu, J.) Ecology, Planning, and Management of Urban Forests. Springer New York. 467pp.

i-Tree. No date. About i-Tree. United States Department of Agriculture. https://www.itreetools.org/about.php. March 25, 2018.

International Society of Arboriculture. 1998. Guide for plant appraisal. International Society of Arboriculture. Champaign IL. 8, 161pp

Kotska, K. 2016. The economic benefits of ash as urban street trees in Thunder Bay. H.B.Sc.F. thesis, Faculty of Natural Resources Management, Lakehead University, Thunder Bay, Ontario, 115pp

Local Enhancement & Appreciation of Forests [LEAF]. 2017. About the estimator. https://www.yourleaf.org/estimator. March 25, 2018.

Middel, A., Chhetri, N., Quay, R. 2015. Urban forestry and cool roofs: Assessment of heat mitigation strategies in Phoenix residential neighborhoods. Urban Forestry & Urban Greening, 14(1): 178-186.

Miller, R. W., R. J. Hauer., L. P. Werner, 2015. Urban Forestry: Planning and Managing Urban Greenspaces. Waveland press, Inc. Long Grove, Illinois. 560pp.

Morales, D. J. 1980. The contribution of trees to residential property value. Journal of Arboriculture, 6(11), 305-308.

Nesbitt, N. H. L., S. B. J. Cowan., Z. C. Cheng., S. S. PI., J. Neuvonen. 2015. The Social and Economic Values of Canada's Urban Forests: A National Synthesis. Canadian Forest Service. http://urbanforestry.sites.olt.ubc.ca/files/2016/09/The-Social-and-Economic-Values-of-Canada%E2%80%99s-Urban-Forests-A-National-Synthesis-2015.pdf. Viewed April 18th 2018.

Nowak, D.J., Crane, D.E. 2002. Carbon storage and sequestration by urban trees in the USA. Environmental Pollution. 166(3): 381-389

Nowak, D. J., Crane, D. E., Stevens, J. C. 2006. Air pollution removal by urban trees and shrubs in the United States. Urban Forestry & Urban Greening, 4(3): 115-123.

Nowak, D.J., Hoehn, R., & Crane, D.E. 2007. Oxygen production by urban trees in the United States. Arboriculture and Urban Forestry. 33(3): 220-226

Nowak, D.J., Hirabayashi, S., Doyle, M., McGovern, M., & Pasher, J. 2018. Air pollution removal by urban forests in Canada and its effect on air quality and human health. Urban Forestry and Urban Greening. 29: 40-48.

Poland, T. M., & McCullough, D. G. 2006. Emerald ash borer: invasion of the urban forest and the threat to North America's ash resource. Journal of Forestry, 104(3): 118-124pp.

Seitz, J., Escobedo, F. 2011. Urban forests in Florida: trees control stormwater runoff and improve water quality. University of Florida. https://www.researchgate.net/publication/242286658_Urban_Forests_in_Florida_Trees_Control_Stormwater_Runoff_and_Improve_Water_Quality. Viewed April 18th 2018.

Tluczek, A. R., McCullough, D. G., & Poland, T. M. 2011. Influence of host stress on emerald ash borer (Coleoptera: Buprestidae) adult density, development, and distribution in *Fraxinus pennsylvanica* trees. Environmental Entomology, 40(2), 357-366pp.

United States Department of Agriculture [USDA]. 2005. Air pollution control - the tree factor. Centre for Urban Forest Research. USDA. 1-8. https://www.fs.fed.us/psw/topics/urban_forestry/products/cufr562_Newsletter_Jan05_Special_Edition.pdf . Viewed April 18th 2018.

APPENDIX I

Waypoint #	Tree #	Species	DBH	Condition Rating	Price of removal	Price of treatment $/year	Price of replacement
131	1	White Ash	10.8	4.5	200.00	54	550
132	2	White Ash	9.9	4	200.00	49.5	550
133	3	White Ash	8.1	4	200.00	40.5	550
134	4	White Ash	10.3	3.2	200.00	51.5	550
135	5	White Ash	9.0	3	200.00	45	550
136	6	White Ash	32.0	3	700.00	160	550
137	7	White Ash	9.1	2	200.00	45.5	550
138	8	White Ash	8.7	2	200.00	43.5	550
139	9	White Ash	8.6	2	200.00	43	550
140	10	White Ash	8.7	2	200.00	43.5	550
144	11	White Ash	8.6	1.2	200.00	43	550
145	12	White Ash	7.2	1	200.00	36	550
146	13	White Ash	10.3	2.5	200.00	51.5	550
147	14	White Ash	10.0	2.5	200.00	50	550
148	15	White Ash	10.3	1.6	200.00	51.5	550
149	16	White Ash	10.0	2.5	200.00	50	550
150	17	White Ash	9.5	2.8	200.00	47.5	550
151	18	White Ash	9.6	2.8	200.00	48	550
152	19	Green Ash	20.1	3.8	700.00	100.5	550
153	20	Green Ash	21.5	2.8	700.00	107.5	550
154	21	Green Ash	14.0	2.9	200.00	70	550
155	22	Green Ash	19.5	2.9	700.00	97.5	550
156	23	Green Ash	17.0	2.8	200.00	85	550
157	24	Green Ash	19.8	2.7	700.00	99	550
158	25	Green Ash	14.9	2.7	200.00	74.5	550
159	26	Green Ash	13.4	2.9	200.00	67	550
160	27	Green Ash	15.8	2.7	200.00	79	550
161	28	Green Ash	14.5	2.9	200.00	72.5	550
162	29	Green Ash	11.2	2.5	200.00	56	550
163	30	Green Ash	16.2	2.7	200.00	81	550
164	31	Green Ash	13.6	3.4	200.00	68	550
165	32	White Ash	15.0	3.5	200.00	75	550
166	33	White Ash	20.1	3.7	700.00	100.5	550
167	34	White Ash	18.0	2.5	200.00	90	550

Waypoint #	Tree #	Species	DBH	Condition Rating	Price of removal	Price of treatment $/year	Price of replacement
168	35	Green Ash	15.0	2.6	200.00	75	550
169	36	White Ash	15.2	2	200.00	76	550
170	37	White Ash	22.1	3	700.00	110.5	550
171	38	White Ash	20.4	2.7	700.00	102	550
172	39	White Ash	17.6	3.2	200.00	88	550
173	40	White Ash	18.6	2.9	200.00	93	550
174	41	White Ash	19.0	3.8	200.00	95	550
175	42	Green Ash	21.5	3	700.00	107.5	550
176	43	White Ash	23.5	4.5	700.00	117.5	550
177	44	White Ash	23.9	3	700.00	119.5	550
178	45	Green Ash	32.0	2.1	700.00	160	550
179	46	Green Ash	32.8	1.5	700.00	164	550
180	47	Green Ash	31.9	4	700.00	159.5	550
181	48	White Ash	31.6	4	700.00	158	550
182	49	White Ash	24.4	3.5	700.00	122	550
183	50	White Ash	13.8	3.8	200.00	69	550
184	51	Green Ash	10.0	1	200.00	50	550
185	52	White Ash	22.6	3	700.00	113	550
186	53	White Ash	12.8	2.8	200.00	64	550
187	54	Green Ash	16.4	3.5	200.00	82	550
188	55	White Ash	12.7	3.5	200.00	63.5	550
189	56	Green Ash	13.1	3.5	200.00	65.5	550
190	57	White Ash	10.3	4.5	200.00	51.5	550
191	58	White Ash	43.5	3.5	1600.00	217.5	550
192	59	White Ash	28.6	4	700.00	143	550
193	60	White Ash	28.0	3	700.00	140	550
194	61	White Ash	31.5	3.4	700.00	157.5	550
195	62	White Ash	25.0	4	700.00	125	550
19	63	White Ash	14.0	4.5	200.00	70	550
197	64	White Ash	19.5	3.8	700.00	97.5	550
198	65	White Ash	28.3	3.5	700.00	141.5	550
199	66	White Ash	21.7	3	700.00	108.5	550
200	67	White Ash	19.7	3	700.00	98.5	550
201	68	White Ash	23.2	3.2	700.00	116	550
202	69	White Ash	24.5	2.5	700.00	122.5	550
203	70	White Ash	33.4	3.8	700.00	167	550
204	71	White Ash	29.4	3.2	700.00	147	550
205	72	White Ash	24.5	3.8	700.00	122.5	550

Waypoint #	Tree #	Species	DBH	Condition Rating	Price of removal	Price of treatment $/year	Price of replacement
206	73	White Ash	26.5	4.3	700.00	132.5	550
207	74	White Ash	23.0	4	700.00	115	550
208	75	White Ash	23.5	4.5	700.00	117.5	550
209	76	White Ash	12.0	2.5	200.00	60	550
210	77	White Ash	15.5	3.8	200.00	77.5	550
211	78	White Ash	22.3	4.5	700.00	111.5	550
212	79	White Ash	22.0	3	700.00	110	550

APPENDIX II

National Tree Benefits Calculator Values												
	Tree Number	Species	DBH	Condition Rating	Dia. in Inches	Property Value ($)	CO2 ($)	Stormwater ($)	Air quality ($)	Electricity ($)	Natural Gas ($)	Total ($)
131	1	Ash	10.8	4.5	4.3	57.78	1.07	3.89	0.51	2.58	5.27	71.1
132	2	White Ash	9.9	4	3.9	57.38	0.93	3.41	0.44	2.24	4.55	68.95
133	3	White Ash	8.1	4	3.2	56.67	0.69	2.56	0.31	1.63	3.29	65.15
134	4	White Ash	10.3	3.2	4.1	57.58	1	3.65	0.47	2.41	4.91	70.02
135	5	White Ash	9	3	3.5	56.98	0.79	2.92	0.37	1.89	3.83	66.78
136	6	White Ash	32	3	12.6	60.03	3.79	18.03	2.28	8.19	12.07	104.39
137	7	White Ash	9.1	2	3.6	57.08	0.83	3.04	0.38	1.97	4.01	67.31
138	8	White Ash	8.7	2	3.4	56.87	0.76	2.8	0.35	1.8	3.65	66.23
139	9	White Ash	8.6	2	3.4	56.87	0.76	2.8	0.35	1.8	3.65	66.23
140	10	White Ash	8.7	2	3.4	56.87	0.76	2.8	0.35	1.8	3.65	66.23
144	11	White Ash	8.6	1.2	3.4	56.87	0.76	2.8	0.35	1.8	3.65	66.23
145	12	White Ash	7.2	1	2.8	56.27	0.55	2.07	0.24	1.25	2.57	62.95
146	13	White Ash	10.3	2.5	4.1	57.58	1	3.65	0.47	2.41	4.91	70.02
147	14	White Ash	10	2.5	3.9	57.38	0.93	3.41	0.44	2.24	4.55	68.95
148	15	White Ash	10.3	1.6	4.1	57.58	1	3.65	0.47	2.41	4.91	70.02
149	16	White Ash	10	2.5	3.9	57.38	0.93	3.41	0.44	2.24	4.55	68.95
150	17	White Ash	9.5	2.8	3.7	57.18	0.86	3.16	0.4	2.06	4.19	67.85
151	18	White Ash	9.6	2.8	3.8	57.28	0.9	3.28	0.42	2.15	4.37	68.4
152	19	Green Ash	20.1	3.8	7.9	53.12	1.64	8.05	0.74	3.29	5.36	72.2
153	20	Green Ash	21.5	2.8	8.5	56.5	1.81	8.92	0.83	3.66	5.96	77.68

National Tree Benefits Calculator Values												
	Tree Number	Species	DBH	Condition Rating	Dia. in Inches	Property Value ($)	CO2 ($)	Stormwater ($)	Air quality ($)	Electricity ($)	Natural Gas ($)	Total ($)
154	21	Green Ash	14	2.9	5.5	39.61	0.94	4.56	0.39	1.82	2.98	50.3
155	22	Green Ash	19.5	2.9	7.7	52	1.58	7.76	0.71	3.17	5.17	70.39
156	23	Green Ash	17	2.8	6.7	46.36	1.29	6.3	0.56	2.56	4.17	61.24
157	24	Green Ash	19.8	2.7	7.8	52.56	1.61	7.9	0.72	3.23	5.26	71.28
158	25	Green Ash	14.9	2.7	5.9	41.86	1.06	5.14	0.44	2.07	3.38	53.95
159	26	Green Ash	13.4	2.9	5.3	38.48	0.89	4.27	0.36	1.7	2.78	48.48
160	27	Green Ash	15.8	2.7	6.2	43.55	1.15	5.58	0.49	2.25	3.67	56.69
161	28	Green Ash	14.5	2.9	5.7	10.73	1	4.85	0.42	1.94	3.18	22.12
162	29	Green Ash	11.2	2.5	4.4	33.27	0.6	3.02	0.23	1.19	1.94	40.25
163	30	Green Ash	16.2	2.7	6.4	44.67	1.2	5.87	0.52	2.37	3.87	58.5
164	31	Green Ash	13.6	3.4	5.4	39.04	0.92	4.42	0.37	1.76	2.88	49.39
165	32	White Ash	15	3.5	5.9	58.67	1.58	6.46	0.77	3.71	7.01	78.2
166	33	White Ash	20.1	3.7	7.9	59.66	2.21	9.79	1.09	5.06	8.99	86.8
167	34	White Ash	18	2.5	7.1	59.26	1.96	8.46	0.96	4.52	8.2	83.36
168	35	Green Ash	15	2.6	5.9	41.86	1.06	5.14	0.44	2.07	3.38	53.95
169	36	White Ash	15.2	2	6.0	58.72	1.61	6.63	0.78	3.77	7.11	78.62
170	37	White Ash	22.1	3	8.7	60.05	2.46	11.13	1.33	5.6	9.78	90.35
171	38	White Ash	20.4	2.7	8.0	59.71	2.24	9.96	1.1	5.13	9.08	87.22
172	39	White Ash	17.6	3.2	6.9	59.17	1.9	8.13	0.93	4.38	8	82.51
173	40	White Ash	18.6	2.9	7.3	59.36	2.02	8.79	0.99	4.66	8.39	84.21
174	41	White Ash	19	3.8	7.5	59.46	2.09	9.13	1.02	4.79	8.59	85.08

National Tree Benefits Calculator Values												
	Tree Number	Species	DBH	Condition Rating	Dia. in Inches	Property Value ($)	CO2 ($)	Stormwater ($)	Air quality ($)	Electricity ($)	Natural Gas ($)	Total ($)
175	42	Green Ash	21.5	3	8.5	56.5	1.81	8.92	0.83	3.66	5.96	77.68
176	43	White Ash	23.5	4.5	9.3	60.18	2.66	12.16	1.35	6.01	10.24	92.6
177	44	White Ash	23.9	3	9.4	60.18	2.7	12.34	1.38	6.07	10.29	92.96
178	45	Green Ash	32	2.1	12.6	68.01	3.39	15.47	2.02	7.17	10.13	106.19
179	46	Green Ash	32.8	1.5	12.9	68.74	3.5	15.96	2.12	7.44	10.43	108.19
180	47	Green Ash	31.9	4	12.6	68.01	3.39	15.47	2.02	7.17	10.13	106.19
181	48	White Ash	31.6	4	12.4	60.04	3.72	17.68	2.22	8.06	11.96	103.68
182	49	White Ash	24.4	3.5	9.6	60.17	2.77	12.69	1.43	6.2	10.4	93.66
183	50	White Ash	13.8	3.8	5.4	58.43	1.42	5.63	0.69	3.37	6.52	76.06
184	51	Green Ash	10	1	3.9	57.38	0.93	3.41	0.44	2.24	4.55	68.95
185	52	White Ash	22.6	3	8.9	60.15	2.53	11.46	1.25	5.74	9.97	91.1
186	53	White Ash	12.8	2.8	5.0	58.23	1.3	4.96	0.62	3.1	6.12	74.33
187	54	Green Ash	16.4	3.5	6.5	45.24	1.23	6.01	0.53	2.43	3.97	59.41
188	55	White Ash	12.7	3.5	5.0	58.23	1.3	4.96	0.62	3.1	6.12	74.33
189	56	Green Ash	13.1	3.5	5.2	37.92	0.86	4.12	0.34	1.64	2.68	47.56
190	57	White Ash	10.3	4.5	4.1	57.58	1	3.65	0.47	2.41	4.91	70.02
191	58	White Ash	43.5	3.5	17.1	58.51	5.16	26.01	3.69	10.66	13.85	117.88
192	59	White Ash	28.6	4	11.3	60.09	3.35	15.72	1.91	7.33	11.35	99.75
193	60	White Ash	28	3	11.0	60.1	3.25	15.19	1.83	7.13	11.18	98.68
194	61	White Ash	31.5	3.4	12.4	60.04	3.72	17.68	2.22	8.06	11.96	103.68
195	62	White Ash	25	4	9.8	60.16	2.83	13.05	1.49	6.34	10.51	94.38

National Tree Benefits Calculator Values												
	Tree Number	Species	DBH	Condition Rating	Dia. in Inches	Property Value ($)	CO2 ($)	Stormwater ($)	Air quality ($)	Electricity ($)	Natural Gas ($)	Total ($)
196	63	White Ash	14	4.5	5.5	58.48	1.45	5.8	0.7	3.44	6.62	76.49
197	64	White Ash	19.5	3.8	7.7	59.56	2.15	9.46	1.06	4.93	8.79	85.95
198	65	White Ash	28.3	3.5	11.1	60.1	3.28	15.36	1.86	7.2	11.24	99.04
199	66	White Ash	21.7	3	8.5	59.95	2.4	10.79	1.18	5.47	9.58	89.37
200	67	White Ash	19.7	3	7.8	59.61	2.18	9.63	1.07	4.99	8.89	86.37
201	68	White Ash	23.2	3.2	9.1	60.19	2.59	11.8	1.29	5.87	10.13	91.87
202	69	White Ash	24.5	2.5	9.6	60.17	2.77	12.69	1.43	6.2	10.4	93.66
203	70	White Ash	33.4	3.8	13.1	60	3.96	18.92	2.42	8.52	12.34	106.16
204	71	White Ash	29.4	3.2	11.6	60.07	3.45	16.25	2	7.53	11.51	100.81
205	72	White Ash	24.5	3.8	9.6	60.17	2.77	12.69	1.43	6.2	10.4	93.66
206	73	White Ash	26.5	4.3	10.4	60.13	3.04	14.12	1.66	6.73	10.85	96.53
207	74	White Ash	23	4	9.1	60.19	2.59	11.8	1.29	5.87	10.13	91.87
208	75	White Ash	23.5	4.5	9.3	60.18	2.66	12.16	1.35	6.01	10.24	92.6
209	76	White Ash	12	2.5	4.7	58.08	1.2	4.46	0.57	2.89	5.83	73.03
210	77	White Ash	15.5	3.8	6.1	58.77	1.64	6.8	0.8	3.84	7.21	79.06
211	78	White Ash	22.3	4.5	8.8	60.1	2.5	11.29	1.23	5.67	9.87	90.66
212	79	White Ash	22	3	8.7	60.05	2.46	11.13	1.33	5.6	9.78	90.35
		AVERAGE	18.43	3.09	7.26	55.81	1.89	8.47	0.98	4.18	7.07	78.40
					SUM	4408.99	149.04	669.28	77.37	329.86	558.75	6193.29

APPENDIX III

Leaf Tree Benefits Estimator (This Year) for Broadleaf deciduous (Large)												
	Tree Number	Species	DBH	Condition Rating	Aspect	Distance (m)	kWh saved	Value of electrical savings ($)	Sequestered CO2 (kg)	Avoided CO2 (kg)	Stormwater mitigation (L)	Air Pollution removed (kg)
131	1	White Ash	10.8	4.5	N/A	N/A	0	0	19	0	1,754	0
132	2	White Ash	9.9	4	N/A	N/A	0	0	15	0	1,557	0
133	3	White Ash	8.1	4	N/A	N/A	0	0	8	0	1,163	0
134	4	White Ash	10.3	3.2	N/A	N/A	0	0	15	0	1,557	0
135	5	White Ash	9	3	N/A	N/A	0	0	12	0	1,360	0
136	6	White Ash	32	3	N/A	N/A	0	0	74	0	5,382	1
137	7	White Ash	9.1	2	N/A	N/A	0	0	12	0	1,360	0
138	8	White Ash	8.7	2	N/A	N/A	0	0	12	0	1,360	0
139	9	White Ash	8.6	2	N/A	N/A	0	0	12	0	1,360	0
140	10	White Ash	8.7	2	N/A	N/A	0	0	12	0	1,360	0
144	11	White Ash	8.6	1.2	N/A	N/A	0	0	12	0	1,360	0
145	12	White Ash	7.2	1	N/A	N/A	0	0	8	0	1,163	0
146	13	White Ash	10.3	2.5	N/A	N/A	0	0	15	0	1,557	0
147	14	White Ash	10	2.5	N/A	N/A	0	0	15	0	1,557	0
148	15	White Ash	10.3	1.6	N/A	N/A	0	0	15	0	1,557	0
149	16	White Ash	10	2.5	N/A	N/A	0	0	15	0	1,557	0
150	17	White Ash	9.5	2.8	N/A	N/A	0	0	15	0	1,557	0
151	18	White Ash	9.6	2.8	N/A	N/A	0	0	15	0	1,557	0
152	19	Green Ash	20.1	3.8	North	0 - 6	1	0	44	0	3,153	1
153	20	Green Ash	21.5	2.8	North	0 - 6	1	0	47	0	3,354	1
154	21	Green Ash	14	2.9	N/A	N/A	0	0	27	0	2,152	0

Leaf Tree Benefits Estimator (This Year) for Broadleaf deciduous (Large)												
	Tree Number	Species	DBH	Condition Rating	Aspect	Distance (m)	kWh saved	Value of electrical savings ($)	Sequestered CO2 (kg)	Avoided CO2 (kg)	Stormwater mitigation (L)	Air Pollution removed (kg)
155	22	Green Ash	19.5	2.9	N/A	N/A	0	0	44	0	3,153	1
156	23	Green Ash	17	2.8	N/A	N/A	0	0	37	0	2,751	0
157	24	Green Ash	19.8	2.7	N/A	N/A	0	0	44	0	3,153	1
158	25	Green Ash	14.9	2.7	N/A	N/A	0	0	30	0	2,351	0
159	26	Green Ash	13.4	2.9	N/A	N/A	0	0	23	0	1,953	0
160	27	Green Ash	15.8	2.7	North	10 - 15	0	0	34	0	2,551	0
161	28	Green Ash	14.5	2.9	North	10 - 15	0	0	30	0	2,351	0
162	29	Green Ash	11.2	2.5	North	10 -15	0	0	19	0	1,754	0
163	30	Green Ash	16.2	2.7	North	10 - 15	0	0	34	0	2,551	0
164	31	Green Ash	13.6	3.4	North	10 - 15	0	0	27	0	2,152	0
165	32	White Ash	15	3.5	N/A	N/A	0	0	30	0	2,351	0
166	33	White Ash	20.1	3.7	N/A	N/A	0	0	44	0	3,153	1
167	34	White Ash	18	2.5	West	10 - 15	11	1	40	2	2,952	0
168	35	Green Ash	15	2.6	West	10 - 15	9	1	30	1	2,351	0
169	36	White Ash	15.2	2	West	10 - 15	9	1	30	1	2,351	0
170	37	White Ash	22.1	3	West	10 - 15	13	1	50	2	3,556	1
171	38	White Ash	20.4	2.7	West	10 - 15	12	1	44	2	3,153	1
172	39	White Ash	17.6	3.2	Southwest	10 - 15	1	0	40	0	2,952	0
173	40	White Ash	18.6	2.9	West	10 - 15	12	1	44	2	3,153	1
174	41	White Ash	19	3.8	West	10 - 15	12	1	44	2	3,153	1
175	42	Green Ash	21.5	3	West	10 - 15	13	1	50	2	3,556	1
176	43	White Ash	23.5	4.5	East	6 - 10	10	1	56	1	3,960	1

Leaf Tree Benefits Estimator (This Year) for Broadleaf deciduous (Large)												
	Tree Number	Species	DBH	Condition Rating	Aspect	Distance (m)	kWh saved	Value of electrical savings ($)	Sequestered CO2 (kg)	Avoided CO2 (kg)	Stormwater mitigation (L)	Air Pollution removed (kg)
177	44	White Ash	23.9	3	Northwest	N/A	0	0	56	0	3,960	1
178	45	Green Ash	32	2.1	Northwest	N/A	0	0	74	0	5,382	1
179	46	Green Ash	32.8	1.5	Northwest	N/A	0	0	76	0	5,585	1
180	47	Green Ash	31.9	4	Northwest	N/A	0	0	74	0	5,382	1
181	48	White Ash	31.6	4	Northwest	N/A	0	0	74	0	5,382	1
182	49	White Ash	24.4	3.5	North	0 - 6	1	0	56	0	3,960	1
183	50	White Ash	13.8	3.8	Northwest	0 - 6	3	0	27	0	2,152	0
184	51	Green Ash	10	1	Northwest	10 - 15	0	0	15	0	1,557	0
185	52	White Ash	22.6	3	Southwest	6 - 10	4	0	53	1	3,758	1
186	53	White Ash	12.8	2.8	South	6 - 10	3	0	23	0	1,953	0
187	54	Green Ash	16.4	3.5	Southwest	6 - 10	3	0	34	0	2,551	0
188	55	White Ash	12.7	3.5	South	6 - 10	3	0	23	0	1,953	0
189	56	Green Ash	13.1	3.5	N/A	N/A	0	0	23	0	1,953	0
190	57	White Ash	10.3	4.5	Southeast	0 - 6	4	0	15	1	1,557	0
191	58	White Ash	43.5	3.5	Southeast	0 - 6	17	2	95	2	7,818	1
192	59	White Ash	28.6	4	Southeast	10 - 15	0	0	67	0	4,772	1
193	60	White Ash	28	3	South	10 - 15	0	0	67	0	4,772	1
194	61	White Ash	31.5	3.4	South	10 - 15	0	0	74	0	5,382	1
195	62	White Ash	25	4	South	10 - 15	0	0	59	0	4,163	1
196	63	White Ash	14	4.5	Souhtwest	0 - 6	5	1	27	1	2,152	0
197	64	White Ash	19.5	3.8	South	0 - 6	9	1	44	1	3,153	1

Leaf Tree Benefits Estimator (This Year) for Broadleaf deciduous (Large)												
	Tree Number	Species	DBH	Condition Rating	Aspect	Distance (m)	kWh saved	Value of electrical savings ($)	Sequestered CO2 (kg)	Avoided CO2 (kg)	Stormwater mitigation (L)	Air Pollution removed (kg)
198	65	White Ash	28.3	3.5	N/A	N/A	0	0	67	0	4,772	1
199	66	White Ash	21.7	3	N/A	N/A	0	0	50	0	3,556	1
200	67	White Ash	19.7	3	N/A	N/A	0	0	44	0	3,153	1
201	68	White Ash	23.2	3.2	N/A	N/A	0	0	53	0	3,758	1
202	69	White Ash	24.5	2.5	N/A	N/A	0	0	59	0	4,163	1
203	70	White Ash	33.4	3.8	N/A	N/A	0	0	76	0	5,585	1
204	71	White Ash	29.4	3.2	N/A	N/A	0	0	67	0	4,772	1
205	72	White Ash	24.5	3.8	N/A	N/A	0	0	59	0	4,163	1
206	73	White Ash	26.5	4.3	N/A	N/A	0	0	64	0	4,569	1
207	74	White Ash	23	4	N/A	N/A	0	0	53	0	3,758	1
208	75	White Ash	23.5	4.5	N/A	N/A	0	0	56	0	3,960	1
209	76	White Ash	12	2.5	N/A	N/A	0	0	23	0	1,953	0
210	77	White Ash	15.5	3.8	N/A	N/A	0	0	34	0	2,551	0
211	78	White Ash	22.3	4.5	N/A	N/A	0	0	50	0	3,556	1
212	79	White Ash	22	3	N/A	N/A	0	0	50	0	3,556	1
						Sum	156	13	3104	21	237220	38
						Average	1.97	0.16	39.29	0.27	3002.78	0.48

APPENDIX IV. Tree value for diameter class 0 – 10cm

Green Ash: *Fraxinus pennsylvanica*			
Tree Area Constant	dbh (cm)	Species Value %	SV
0.7854	9	68	0.68
Condition Value (CV)	Location Value (LV)	dbh (cm) Largest Transplantable Tree (LTT)*	Cost of LTT ($)
0.4	0.75	7	379
Basic Method			
Cross-sectional Area of actual tree:			
(Tree area constant) X $(dbh)^2$ =			
(0.7854) X $(9)^2$ =		63.62	cm^2
Cross-sectional area of LTT:			
(Tree area constant) X $(dbh)^2$ =			
(0.7854) X $(7)^2$ =		38.48	cm^2
$Cost/cm^2$:			
(Cost of LTT)/(CrossXArea of LTT) =			
(379)/(38.48) =		9.85	$\$/cm^2$
Value of tree:			
(CrossXArea of actual ree) X (Cost) =			
(63.62) X (9.85)=		626.51	$
Species Value:			
(Value of tree) X (SV) =			
(626.51) X (0.68) =		426.03	$
Condition Value :			
(Value of tree) X (CV) =			
(426.03) X (0.6) =		170.41	$
Location Value:			
(Value of tree) X (LV)=			
(170.41) X (0.75) =		127.81	$
Final Appraised Value of Green Ash (rounded to the nearest hundred) (CAN)		100	$

APPENDIX V. Tree value for diameter class 10.1 - 20cm

Green Ash: *Fraxinus pennsylvanica*			
Tree Area Constant	dbh (cm)	Species Value %	SV
0.7854	16	68	0.68
Condition Value (CV)	Location Value (LV)	dbh (cm) Largest Transplantable Tree (LTT)*	Cost of LTT ($)
0.6	0.75	7	379
Basic Method			
Cross-sectional Area of actual tree:			
(Tree area constant) X $(dbh)^2$ =		201.06	cm^2
Cross-sectional area of LTT:			
(Tree area constant) X $(dbh)^2$ =		38.48	cm^2
$Cost/cm^2$:			
(Cost of LTT)/(CrossXArea of LTT) =		9.85	$\$/cm^2$
Value of tree:			
(CrossXArea of actual ree) X (Cost) =		1980.08	$
Species Value:			
(Value of tree) X (SV) =		1346.46	$
Condition Value :			
(Value of tree) X (CV) =		807.87	$
Location Value:			
(Value of tree) X (LV)=		605.90	$
Final Appraised Value of Green Ash (rounded to the nearest hundred) (CAN)		600	$

APPENDIX VI. Tree value for diameter class 20.1 - 30cm

Green Ash: *Fraxinus pennsylvanica*			
Tree Area Constant	dbh (cm)	Species Value %	SV
0.7854	24.3	68	0.68
Condition Value (CV)	Location Value (LV)	dbh (cm) Largest Transplantable Tree (LTT)*	Cost of LTT ($)
0.7	0.75	7	379
Basic Method			
Cross-sectional Area of actual tree:			
(Tree area constant) X (dbh)^2 =		463.77	cm^2
Cross-sectional area of LTT:			
(Tree area constant) X (dbh)^2 =		38.48	cm^2
Cost/cm^2 :			
(Cost of LTT)/(CrossXArea of LTT) =		9.85	\$/cm^2
Value of tree:			
(CrossXArea of actual ree) X (Cost) =		4567.26	$
Species Value:			
(Value of tree) X (SV) =		3105.74	$
Condition Value :			
(Value of tree) X (CV) =		2174.02	$
Location Value:			
(Value of tree) X (LV)=		1630.51	$
Final Appraised Value of Green Ash (rounded to the nearest hundred) (CAN)		1600	$

APPENDIX VII. Tree value for diameter class 30.1 – 40cm

Green Ash: *Fraxinus pennsylvanica*			
Tree Area Constant	dbh (cm)	Species Value %	SV
0.7854	32	68	0.68
Condition Value (CV)	Location Value (LV)	dbh (cm) Largest Transplantable Tree (LTT)*	Cost of LTT ($)
0.6	0.75	7	379
Basic Method			
Cross-sectional Area of actual tree:			
(Tree area constant) X $(dbh)^2$ =		804.25	cm^2
Cross-sectional area of LTT:			
(Tree area constant) X $(dbh)^2$ =		38.48	cm^2
Cost/cm^2 :			
(Cost of LTT)/(CrossXArea of LTT) =		9.85	\$/cm^2
Value of tree:			
(CrossXArea of actual ree) X (Cost) =		7920.33	$
Species Value:			
(Value of tree) X (SV) =		5385.82	$
Condition Value :			
(Value of tree) X (CV) =		3231.49	$
Location Value:			
(Value of tree) X (LV)=		2423.62	$
Final Appraised Value of Green Ash (rounded to the nearest hundred) (CAN)		2400	$

APPENDIX VIII. Tree value for 44cm tree

Green Ash: *Fraxinus pennsylvanica*			
Tree Area Constant	dbh (cm)	Species Value %	SV
0.7854	44	68	0.68
Condition Value (CV)	Location Value (LV)	dbh (cm) Largest Transplantable Tree (LTT)*	Cost of LTT ($)
0.7	0.75	7	379
Basic Method			
Cross-sectional Area of actual tree:			
(Tree area constant) X (dbh)^2 =		1520.53	cm^2
Cross-sectional area of LTT:			
(Tree area constant) X (dbh)^2 =		38.48	cm^2
Cost/cm^2 :			
(Cost of LTT)/(CrossXArea of LTT) =		9.85	\$/cm^2
Value of tree:			
(CrossXArea of actual ree) X (Cost) =		14974.37	$
Species Value:			
(Value of tree) X (SV) =		10182.57	$
Condition Value :			
(Value of tree) X (CV) =		7127.80	$
Location Value:			
(Value of tree) X (LV)=		5345.85	$
Final Appraised Value of Green Ash (rounded to the nearest hundred) (CAN)		5300	$

APPENDIX IX. Tree value for diameter class 20 - 25cm

Green Ash: *Fraxinus pennsylvanica*			
Tree Area Constant	dbh (cm)	Species Value %	SV
0.7854	22.4	68	0.68
Condition Value (CV)	Location Value (LV)	dbh (cm) Largest Transplantable Tree (LTT)*	Cost of LTT ($)
0.72	0.75	7	379
Basic Method			
Cross-sectional Area of actual tree:			
(Tree area constant) X $(dbh)^2$ =		394.08	cm^2
Cross-sectional area of LTT:			
(Tree area constant) X $(dbh)^2$ =		38.48	cm^2
Cost/cm^2 :			
(Cost of LTT)/(CrossXArea of LTT) =		9.85	$/$cm^2$
Value of tree:			
(CrossXArea of actual ree) X (Cost) =		3880.96	$
Species Value:			
(Value of tree) X (SV) =		2639.05	$
Condition Value :			
(Value of tree) X (CV) =		1900.12	$
Location Value:			
(Value of tree) X (LV)=		1425.09	$
Final Appraised Value of Green Ash (rounded to the nearest hundred) (CAN)		1400	$

APPENDIX X. Tree value for diameter class 25.1 - 30 cm

Green Ash: *Fraxinus pennsylvanica*			
Tree Area Constant	dbh (cm)	Species Value %	SV
0.7854	28.2	68	0.68
Condition Value (CV)	Location Value (LV)	dbh (cm) Largest Transplantable Tree (LTT)*	Cost of LTT ($)
0.72	0.75	7	379
Basic Method			
Cross-sectional Area of actual tree:			
(Tree area constant) X $(dbh)^2$ =		624.58	cm^2
Cross-sectional area of LTT:			
(Tree area constant) X $(dbh)^2$ =		38.48	cm^2
Cost/cm^2 :			
(Cost of LTT)/(CrossXArea of LTT) =		9.85	$/$cm^2$
Value of tree:			
(CrossXArea of actual ree) X (Cost) =		6150.94	$
Species Value:			
(Value of tree) X (SV) =		4182.64	$
Condition Value :			
(Value of tree) X (CV) =		3011.50	$
Location Value:			
(Value of tree) X (LV)=		2258.62	$
Final Appraised Value of Green Ash (rounded to the nearest hundred) (CAN)		2300	$

APPENDIX XI. Tree value for Diameter class 30.1 – 35cm

Green Ash: *Fraxinus pennsylvanica*			
Tree Area Constant	dbh (cm)	Species Value %	SV
0.7854	32.1	68	0.68
Condition Value (CV)	Location Value (LV)	dbh (cm) Largest Transplantable Tree (LTT)*	Cost of LTT ($)
0.72	0.75	7	379
Basic Method			
Cross-sectional Area of actual tree:			
(Tree area constant) X $(dbh)^2$ =			
		809.28	cm^2
Cross-sectional area of LTT:			
(Tree area constant) X $(dbh)^2$ =			
		38.48	cm^2
Cost/cm^2 :			
(Cost of LTT)/(CrossXArea of LTT) =			
		9.85	$/$cm^2$
Value of tree:			
(CrossXArea of actual ree) X (Cost) =			
		7969.91	$
Species Value:			
(Value of tree) X (SV) =			
		5419.54	$
Condition Value :			
(Value of tree) X (CV) =			
		3902.07	$
Location Value:			
(Value of tree) X (LV)=			
		2926.55	$
Final Appraised Value of Green Ash (rounded to the nearest hundred) (CAN)		2900	$