Exploring the Costs of Tree Removal on Studley Campus as a Result of Surface Renovation Policies

Sustainability 3502 Final Project

SUST 3502 The Campus as a Living Labratory

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Executive Summary

This project calculated the costs of a university campus tree removal policy at Dalhousie University, in Halifax, Nova Scotia. The policy, stipulates that trees within six feet of a building be removed as needed for renovations. The project initially identified trees that could potentially be removed using GIS data. With tree inventory data, the project completed a cost analysis of tree removal and biomass replacement, which is required under another campus policy. An online tree benefit calculator was used to calculate the potential lost benefits if these trees were to be removed.

The results of the cost analysis were affected by significant limitations, at the identification stage, influencing the validity of the results. Despite this, the project represents a framework for which similar studies could be undertaken in the future. The results revealed that the greatest cost to the university from the removal policy was incurred by the subsequent replacement policy. The project also compared the benefits derived at present from a tree with the benefits derived from the saplings that would be planted under the biomass replacement policy. This comparison showed that, there was a significant difference in wastewater retention capability. The project reflects on the findings of the cost analysis and the implications it has to the university and campus sustainability.

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1.0 Introduction

This project will investigate the possible impacts of Dalhousie's *Natural Environment and Landscape Policy and Guidelines*. This policy requires the removal of vegetation within six feet of a building when renovating exterior surfaces to facilitate construction activities such as setting up scaffolding. Dalhousie's *Natural Environment and Landscape Policy and Guidelines* outlines campus design standards to enhance and protect the natural environment during the planning and construction of future developments and maintenance on all University campuses (Department of Facilities Management, 2013). The intentions of plans often make claims such as these but are focused long-term, so that the associated short-term costs have either not been considered or provided. Our project seeks to quantify the short-term potential costs, using both financial and environmental indicators of the tree removal policy through a cost analysis.

Prior to the *Natural Environment and Landscape Policy and Guidelines*, Dalhousie did not have any policies on the placement of trees and vegetation. Planting and removal were administered by the Grounds Manager, and therefore did not follow any procedure (S. Cushing, personal communication, February 26, 2014). The lack of policy in the past has lead to the current situation where trees and other vegetation need to be removed in order for renovation projects to occur on buildings. The creation of the *Natural Environment and Landscape Policy and Guidelines* sets out the framework, so that in future the issue of tree removal due to adjacency to buildings will not occur.

In our initial literature review for this project we found a significant amount of research that explored the benefits of urban trees. Dwyer, McPherson, Schroeder, & Rowntree (1992) provide a summary of benefits, which include energy and carbon dioxide conservation, air quality, urban hydrology, noise reduction, and ecological benefits. In addition to these, there are social benefits of trees, which include desirable environments, medical and psychological services, real estate values, and community and economic development (Dwyer et al., 1992; Roy, Byrne & Pickering, 2012; Millward & Sabir, 2010; Ysunetsugu et al., 2013). It can be understood, that trees provide a variety of important services that are quantified using a range of measures and methods. Trees can also hold qualitative value, while important when understanding the benefits of trees, is beyond the scope of this project.

Our assessment of the policy's impacts will be carried out on Dalhousie's Studley Campus, located on the urban Halifax peninsula. It has been selected due to a limitation with the available building polygon datasets available at the Dalhousie GIS Centre. As the main campus, new buildings and renewal projects are frequently occurring on this campus. The project intends to determine the number of trees that could be affected by the six-foot buffer when construction occurs. The project then plans to identify the financial costs of replanting each affected tree, and the cost of losing the ecological and social services that these trees provide to their environment. Exploring the costs can help to gain awareness and emphasize the importance of trees. The project also will explore the costs associated with policies, specifically in the context of Dalhousie, but also act as an investigation to reflect on policy development in general.

2.0 Methods

2.1. Site Area

Dalhousie's Studley Campus (appendix 1) was chosen as a specific case study site for the project. This location was mainly selected because of the available GIS building polygon datasets for this particular region. Studley campus is also the main campus for Dalhousie University, containing a large concentration of faculties, administrations, services, and pedestrian traffic. As a result, the impacts of losing these trees would be prominent here and a significant concern for the University. The impacts of the proposed policy will be analyzed on the assumption that every building on this campus would eventually have to undergo at least surface renovations, thus, calculating the benefits of each tree within the 6 foot buffer.

2.2. Creating an Inventory

To begin our analysis, an inventory was created of all the trees affected by the 6ft buffer on Studley Campus. This was compiled using Esri's ArcMap GIS software. Dalhousie's Office of Sustainability carried out a tree inventory of the three Halifax campuses starting in 2009. The inventory produced two documents; a shapefile spatial dataset, which displays the location of each tree as a point on the landscape and a spreadsheet document, which thoroughly identifies their species type, diameters at breast height (DBH), as well as other observations. Each tree was given an ID, which corresponds to an ID included in the shapefile dataset. For the spatial analysis, a building polygon shapefile dataset was provided by the Dalhousie GIS Centre. This shapefile includes the recently constructed Oceanography building and the LeMarchant Mixed Use Building.

For this analysis, a six-foot buffer was created around the building polygon layer using the Buffer geoprocessing tool. Following this, a select by location query was conducted which selected tree points which intersected with this six foot buffer (Figure 3). These trees were exported to their own shapefile layer, called 'bufftree' and their ID numbers were copied into an excel spreadsheet. The VLOOKUP function was used to cross reference these values with the inventory spreadsheet and extract values for the tree width and species type for each tree within the six-foot buffer (Figure 3).

2.3. Calculating Costs

Following the inventory analysis, the various costs associated to the removal of trees were researched to calculate a tangible value for the costs accrued when following through with the policy.

2.3.1 Removal Costs

The costs of tree removal vary somewhat depending on several factors including the width of the tree, the species type, and the location. We contacted Dahousie's Facilities Management department for estimates on carrying through with this policy, but yielded no definite cost, due to a variety of factors including, but not limited to species, height, diameter and amount of trees to be removed. In order to determine an average cost for tree removal we researched online and found information saying that tree removal companies were charging between nine and ten dollars per foot, in regards to total height (Urman, 2009; Tree Removal, 2012; Home Advisor, 2014). In order to keep the calculations for removal cost relatively simple we decided to use the ten dollars per foot as our base cost.

2.3.2. Replacement Costs

In addition to this, Dalhousie's *Natural Environment and Landscape Policy and Guidelines* contains a biomass replacement policy. This policy requires that for each tree removed on campus, new trees whose collective diameter equal the diameter of the removed tree need to be planted (Department of Facilities Management, 2013). Replacement trees are typically five cm (1.8 inches) in diameter and cost 500$ per sapling to purchase and plant (S. Cushing, personal communication, February 26, 2014). To calculate this biomass replacement cost, the diameters of each tree affected by the policy were summed up and divided by the diameter of the saplings (1.8 inches) to calculate how many saplings would be needed if this policy were followed. This number was then multiplied by the purchase and planting cost of 500$ to produce a final cost for biomass replacement.

2.3.3. Tree Benefit Calculator

The monetary cost of removing and disposing of a tree is a small part of the larger value of services and benefits provided by the existence of the trees that are lost during its removal. Following the inventory analysis, the characteristics from were inputted into a tree benefit calculator at http://www.davey.com/arborist-advice/education/national-tree-benefit-calculator.aspx The diameter at breast height (DBH) and the species type of each tree were inputted into the website. Since the website only covered the United States, Northeastern Maine was used as the geographic location for the calculations. The following inputs were then recorded on the excel sheet: stormwater retention (gallons/year), property value increase (dollars/year), energy saved through cooling (kwh/year), CO2 reduction in pounds/year.

3.0 Results

Total Combined Stormwater collected per year (Gallons) - 150,475
Total Combined Annual Property Value Increase ($) - $4605
Total Combined Energy Saved (kW/h) - 8104
Total Combined Reduction of CO2 (lbs per year) - 36845
Total Combined Tree Removal Cost - $41846.24 (10% of costs)
Total combined cost to replace all trees in buffer area - $377,000.00 (90% of costs)
Total combined cost of tree removal and replacement - $418,846.24

3.1. Inventory Observations

While examining the results of the inventory, many observations were made on the information gathered. Our project found that a total of 211 trees would be impacted by the current policy in place. After totaling and performing a weighted average within the excel spreadsheet, we established that the average diameter of the trees was 7 inches.

There were not many spatial trends and observations found within the data that were collected aside from the relevance of tree size in grouped locations. A correlation between location and tree size suggests that certain sections were planted on the same occasion; this is an assumption as the actual data of dates planted was unavailable. After pulling data from the inventory and GIS map, it was apparent that tree location had no specific patterns and trees were randomly dispersed throughout Studley campus.

3.2. Cost observations

Through the observations of our results, our project calculated that the tree replacement cost was the most expensive task and accounts for about 90% of all costs involved. We also calculated that stormwater retention is significantly lower in replacement trees, making the removal of larger trees, much more detrimental to the environment. This also speaks to the fact that larger trees are much more beneficial and more environmental factors will be sacrificed and lost after its removal. We also came to the conclusion that because of Halifax's climate, energy saved is considered to be not as important as the weather and temperature of the area do not reach extremely higher temperatures. Energy saved would be considered much more important in places with high temperatures in the summer, as trees provide an oasis of shade for the building creating less of a demand for air conditioning, which uses substantial amounts of electricity.

4.0 Case Study: Replacement Benefit Comparison

We wanted to compare the benefits derived from an existing tree, with the benefits of the saplings that would replace the tree if it were to be cut down. This study aimed to examine how effective the replacement policy was at actually replacing the benefits as calculated by the Davey tree benefit calculator. For this study, we used a red oak with a diameter at breast height of 16.93 inches, using the same parameters in the calculator used throughout our study. We compared the benefits this tree provided with the nine, 1.97-inch saplings that would replace the oak if it were to be removed. The results of the comparison below (Figure 1) show that the replacement saplings at present would provide under half the stormwater retention capability and CO2 reduction capability. This shows that at present the replacement policy does not adequately replace the benefits of this study tree. In the future, as these trees grow, they would eventually provide a greater amount of benefits.

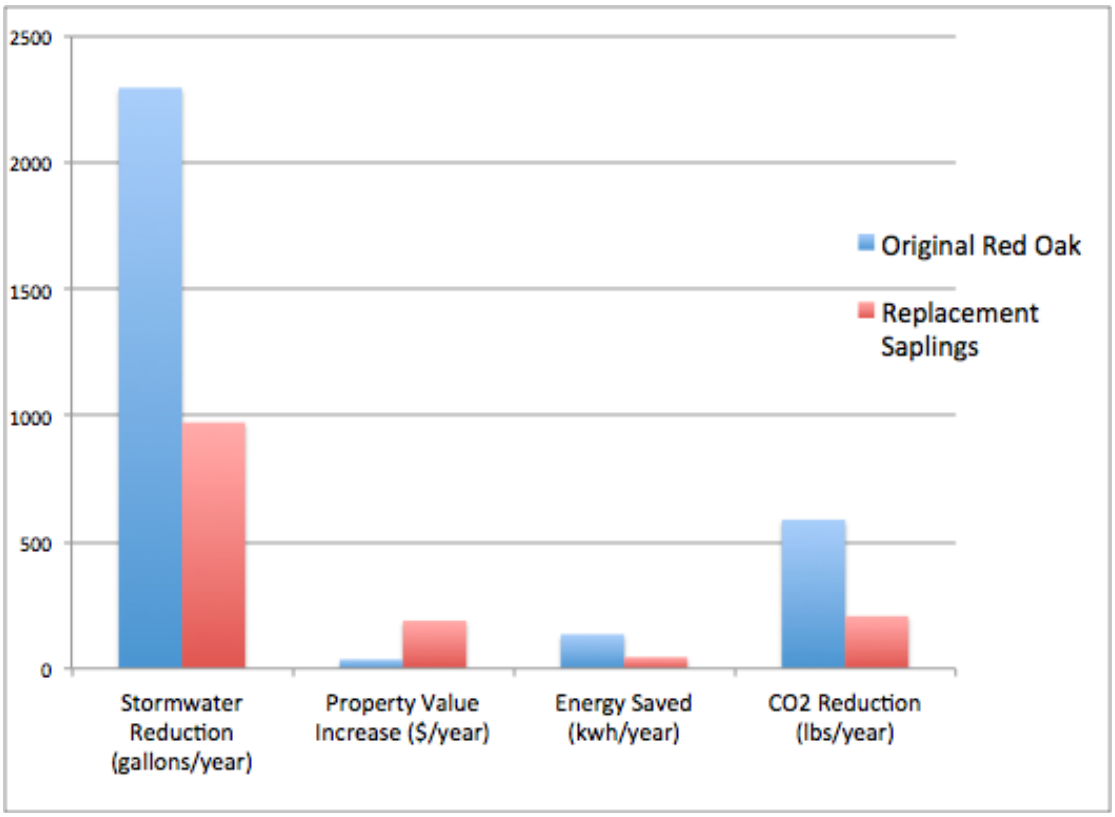

Figure 1. Case Study: Replacement Benefits. This graph depicts a comparison between the benefits of an existing Red Oak and the benefits of the saplings that would replace it.

5.0. Discussion

5.1. Limitations

Our project experienced some significant limitations, which would have affected the results of the cost analysis. The data provided by the GIS Centre with the campus buildings was current, including the recently completed Oceanography building and the almost completed LeMarchant Mixed Use building. The tree data used for the spatial analysis was from the Office of Sustainability's campus tree inventory, which began in 2009. The result of using these datasets was that many trees were included into the cost analysis that would have already been removed, increasing the cost and amount of benefits provided by total trees. Despite this limitation, we would emphasize that our project does offer a useful framework for why and how a cost analysis process should occur.

We would also like to acknowledge the limitation of the tree benefit calculator tool. The tool only allows regions in the USA to be selected as a factor in the calculator. We selected the closest geographical region to Nova Scotia, the Northeast, which included Maine and the Atlantic coast. This could have impacted the accuracy of the calculator somewhat. We would also like to acknowledge the limitation of the calculator itself, which is a generalized tool that operates on a model, and therefore cannot accurately account for the actual benefits of trees on campus. The calculator does offer an estimated amount, and was useful when considering the scope of this project.

5.2 Results

The results of our cost analysis show that the initial policy of tree removal only constitutes 9%, between the cost of removal and replacement. This means that the initial policy of removal is not nearly as financially significant as the subsequent policy of replacement. The high cost could be a deterrent to tree removal, or be an impetus to investigating alternatives to conventional scaffolding as both a cost and other benefit saving measure. These alternatives would require their own research and cost analysis. A Genie hydraulic mechanical lift could be used potentially, but this recommendation would again, require its own research and analysis against the cost of removal and the benefits the tree provide.

Through the potential removal of the trees, the tree calculator allowed us to calculate and define the indirect benefits that would eventually be lost upon every trees removal, including stormwater runoff, increased property value, energy saved in kWh, and CO2 reduction. Although the guidelines do not directly state the reason for replacement, the policy allows these indirect costs to be considered as being important and valued in the trees replacement, reinforcing the qualitative values of the trees.

6.0. Discussion and Recommendations

6.1. Application: Expanding this policy possibly to local government

In considering our results, which showed that tree biomass replacement cost made up the majority of monetary costs incurred from tree removal. This led to a discussion on whether such policies could work as effective incentives for environmental protection at the municipal level. This policy would do two things. Firstly, it would deter developers from removing trees unless it was absolutely necessary. This places a market incentive signal on the value of current trees. Secondly, it would promote the future expansion of the municipality's urban forest when trees were cut down, developing the benefits the urban forest provides.

6.2. Recommendations for future study

We would recommend that this research project be conducted again in the future with an updated tree inventory, and corresponding spatial data. A more accurate cost could be realized from this. Likewise, knowing more information about the exact removal costs per tree would generate more precise costs, as our removal costs were an estimate based on the information we received from Dalhousie's Facilities Management.

6.3. Implications of Policies

A key characteristic of the tree removal policy is that it places emphasis on the future. Eventually, no trees will be left within 6 feet of a building.

However, mandatory costs arise from the implementation of the tree removal policy through the biomass replacement policy. Here, we observe here the consequences of having policies interact with each other. As individual policies, the tree removal and biomass replacement policy pose few financial implications. However, the combination of these two policies creates significant mandatory expenses for the university. Though not all trees within the 6ft buffer will be removed at one single time it is important to know the eventual cost that will occur over time if the policy is kept in place. There is also an increase in cost over time that is based on the fact that as the trees grow in both diameter and height the cost of removal and biomass replacement will also increase.

7.0. Conclusion

In summary, after conducting the research we have come to the conclusion that there are many costs that occur through the campus tree removal policy at Dalhousie University. This conclusion has been made after conducting a cost analysis on both tree removal and biomass replacement following Dalhousies current policy, *Natural Environment and Landscape Policy and Guidelines*. After discussing the significant limitations into our cost analysis above we have concluded that the cost of tree removal and biomass replacement combined would total to an amount of $418,846.24. Our project also defined many other social benefits that are lost in the removal of the 210 trees within the 6-foot buffer. However, on top of the costing results and the social benefits lots, this project reveals a multitude of topics for discussion around the policies implemented by the university. The interaction between the tree removal policy and the biomass replacement policy results in significant required costs to the university. The replacement policy creates sustainable action towards the campuses unavoidable and foreseeable construction, and generates a demand of conservation, as costs can be immense both in monetary values and social costs. Although there are many costs associated with the removal of the trees there is also some aspect of benefits that the replacement of the new trees will have in the future after their growth. These benefits come from the understanding that with the removal of one tree there will be a replacement yield of several small saplings, which will grow into greater benefits in the future.

8.0. References

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9.0. Acknowledgements

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Appendix A

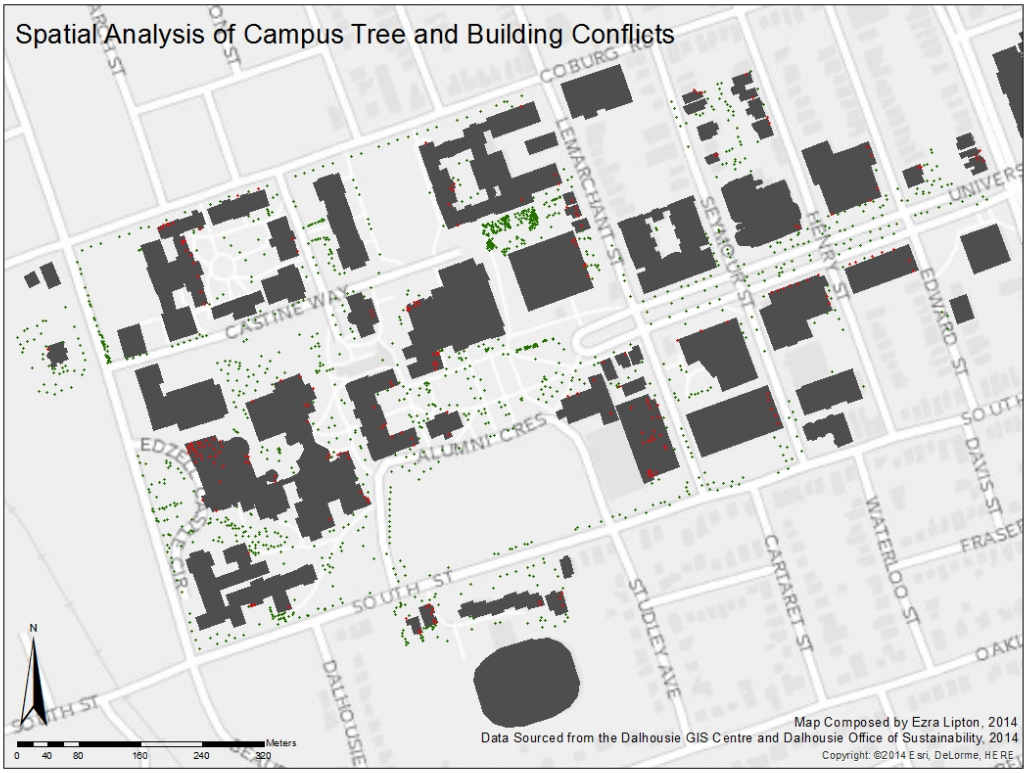

Figure 2. GIS map showing the location of trees throughout Studley campus with the affected trees shown in red

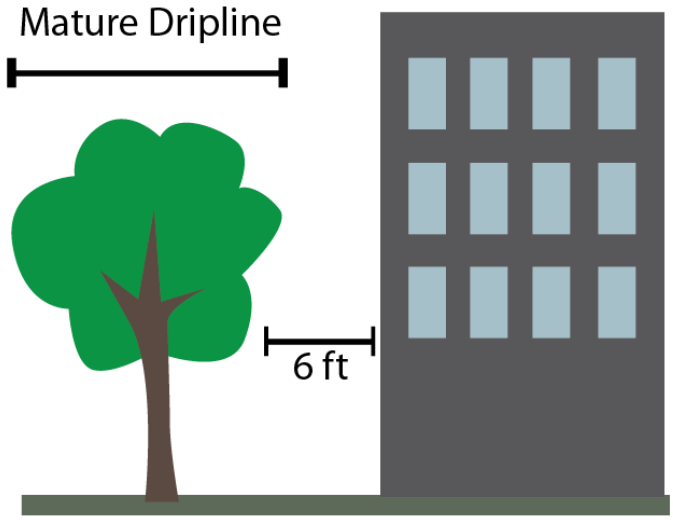

Figure 3. Illustration showing the buffer distance that trees must be outside of to avoid removal in situations that require building restoration (Illustration by Uytae Lee).

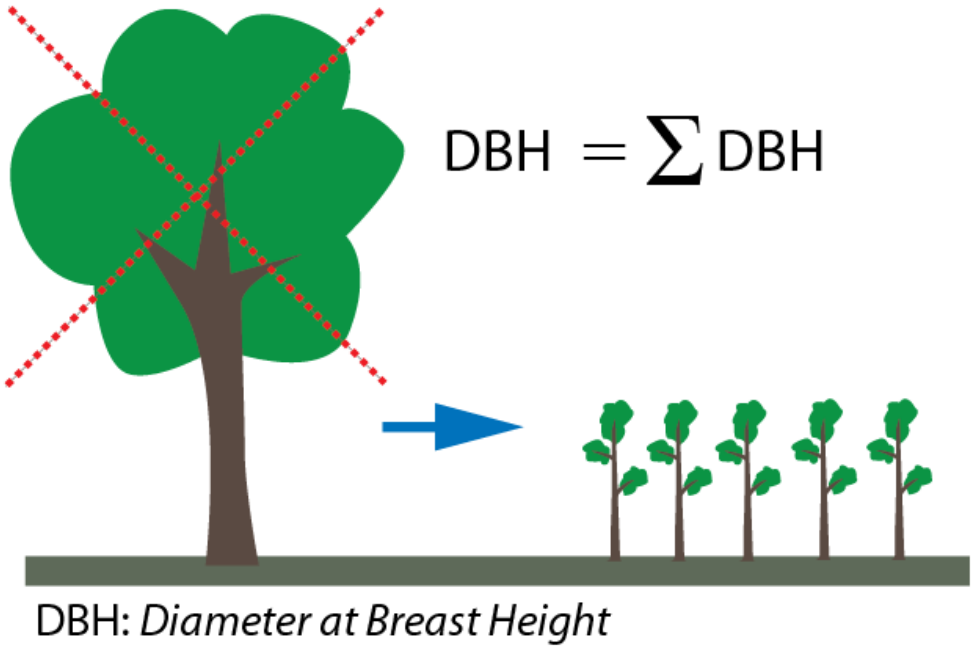

Figure 4. An illustration depicting an example of Dalhousie's biomass replacement policy

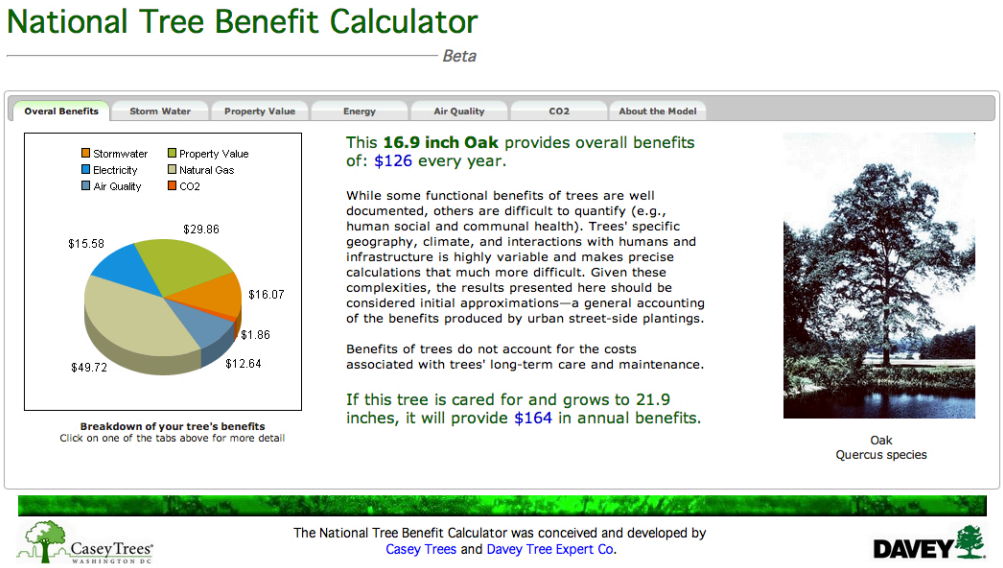

Figure 5. Screen shot of the National Tree Benefit Calculator we used to determine additional benefits that trees provide.

Appendix B

PDF copies of Excel spreadsheets showing tree and sapling data (Shown Below)

Tree spreadsheet

Common Name	Width in Inches	Stormwater Gallons per Year	Total Combined Stormwater collected per year (Gallons)	Property Value $/Year	Total Combined Annual Property Value Increase ($)	Energy Saved Kilowatt / hours	Total Combined Energy Saved (kW/h)
x	x	x		x		x	
x	x	x	**150,475**	x	**$4,605.00**	x	**8,104**
Red Oak	16.93	2,295		$36.00		135	
Red Oak	11.81	1,450		$31.00		90	
Red Maple	18.90	2,309		$31.00		114	
Mountain Ash	12.20	590		$10.00		44	
Scotch Pine	11.81	1,231		$18.00		58	
Sugar Maple	11.42	1,102		$30.00		64	
Sugar Maple	11.02	1,047		$29.00		60	
Sugar Maple	16.14	1,779		$38.00		98	
Austrian Pine	14.96	1,657		$17.00		86	
Austrian Pine	17.72	2,093		$16.00		96	
Red Maple	7.48	757		$34.00		34	
Red Maple	11.42	1,272		$33.00		66	
Red Maple	7.09	709		$34.00		31	
Red Oak	18.11	2,507		$38.00		141	
Red Maple	9.06	961		$34.00		44	
Red Oak	20.47	2,933		$40.00		152	
Service Berry	0.00						
Red Oak	13.78	1,768		$33.00		113	
Norway Maple	12.60	1,028		$30.00		74	
Red Maple	7.87	810		$34.00		36	
Red Maple	9.06	961		$34.00		44	
Red Maple	7.48	757		$34.00		34	
Red Maple	7.48	757		$34.00		34	
Red Maple	6.69	658		$34.00		29	
Red Maple	3.94	317		$34.00		12	
Red Maple	10.63	1,164		$33.00		59	
Red Maple	7.87	806		$34.00		36	
Red Maple	9.06	961		$34.00		44	
White Birch	2.36	130		$34.00		5	
Red Oak	11.02	1,323		$30.00		82	
Red Oak	13.78	1,768		$33.00		113	
Red Oak	18.90	2,649		$39.00		145	
Mountain Ash	14.17	695		$11.00		52	
Crab Apple	9.06	504		$13.00		32	

Tree spreadsheet

CO2 Reduction (lbs per year)	Total Combined Reduction of CO2 (lbs per year)	Total Height (m)	Total Height (Feet)	Approximate Cost for Tree Removal ($10/foot)	Total Combined Tree Removal Cost	Total width/inches of sapling	Total number of saplings needed to replace tree (Rounded up to nearest tree)
x							
x	**36,485**				**$41,846.24**	1.97 (5 cm)	
588		11	36.08	$360.80			9
369		9	29.52	$295.20			6
411		8	26.24	$262.40			10
243		9.5	31.16	$311.60			7
204		6.5	21.32	$213.20			6
270		12	39.36	$393.60			6
257		13	42.64	$426.40			6
420		13	42.64	$426.40			9
291		8	26.24	$262.40			8
333		13	42.64	$426.40			9
152		8	26.24	$262.40			4
265		10.5	34.44	$344.40			6
142		8	26.24	$262.40			4
641		11	36.08	$360.80			10
193		5.4	17.712	$177.12			5
746		11	36.08	$360.80			11
		3	9.84	$98.40			0
454		11	36.08	$360.80			7
367		10.5	34.44	$344.40			7
162		8.5	27.88	$278.80			4
193		8.5	27.88	$278.80			5
152		8	26.24	$262.40			4
152		8.5	27.88	$278.80			4
132		9	29.52	$295.20			4
65		9	29.52	$295.20			2
240		9	29.52	$295.20			6
162		9	29.52	$295.20			4
193		6	19.68	$196.80			5
31		5	16.4	$164.00			2
335		10	32.8	$328.00			6
454		10	32.8	$328.00			7
676		8.5	27.88	$278.80			10
290		13	42.64	$426.40			8
137		6.5	21.32	$213.20			5

Total Cost to replace tree with saplings per Dalhousie Standards ($500 per Sapling)	Total combined cost to replace all trees in buffer area	Total combined cost of tree removal and replacement
	$377,000.00	**$418,846.24**
$4,500.00		
$3,000.00		
$5,000.00		
$3,500.00		
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$2,500.00		
$1,000.00		
$3,000.00		
$3,500.00		
$5,000.00		
$4,000.00		
$2,500.00		

White Birch	5.91	560		$34.00		24	
Norway Maple	3.94	171		$9.00		12	
Mountain Ash	0.00						
Forsythia	0.00						
Mountain Ash	11.02	527		$10.00		39	
Mountain Ash	10.24	485		$10.00		35	
Honey Suckle	0.00						
Yew	0.00						
Red Twig Dogwood	0.00						
Yew	0.00						
Red Twig Dogwood	0.00						
Wintercreeper Euonymus	0.00						
Sandcherry	0.00						
Scotch Pine	9.84	961		$18.00		40	
Norway Maple	9.06	611		$20.00		42	
Norway Maple	6.30	363		$14.00		25	
Flowering Quince	0.00						
Spirea	0.00						
Spirea	0.00						
Golden Ninebark	0.00						
Weigelia	0.00						
Spirea	0.00						
Lilac	0.00						
Lilac	0.00						
English Rose	0.00						
Norway Maple	25.59	2,948		$73.00		143	
Norway Maple	23.62	2,612		$66.00		132	
Yew	0.00						
Yew	0.00						
Wintercreeper Euonymus	0.00						
Wintercreeper Euonymus	0.00						
Yew	0.00						
Yew	0.00						
Yew	0.00						
Yew	0.00						
Norway Maple	8.27	539		$18.00		37	
Norway Maple	9.84	703		$22.00		49	
Norway Maple	6.69	398		$15.00		27	

Tree spreadsheet

113		9.5	31.16	$311.60			3
60		4	13.12	$131.20			2
		2	6.56	$65.60			0
		2.5	8.2	$82.00			0
214		9.5	31.16	$311.60			6
195		9.5	31.16	$311.60			6
		2	6.56	$65.60			0
		2.5	8.2	$82.00			0
		1.5	4.92	$49.20			0
		0	0	$0.00			0
		1.5	4.92	$49.20			0
		0	0	$0.00			0
		1.5	4.92	$49.20			0
149		12	39.36	$393.60			5
211		6.2	20.336	$203.36			5
127		6.5	21.32	$213.20			4
		2	6.56	$65.60			0
		2	6.56	$65.60			0
		2.5	8.2	$82.00			0
		2.5	8.2	$82.00			0
		2	6.56	$65.60			0
		2.5	8.2	$82.00			0
		2.5	8.2	$82.00			0
		2	6.56	$65.60			0
		1	3.28	$32.80			0
1059		13	42.64	$426.40			13
944		13.5	44.28	$442.80			12
		1	3.28	$32.80			0
		1	3.28	$32.80			0
		0.5	1.64	$16.40			0
		0.5	1.64	$16.40			0
		1	3.28	$32.80			0
		1	3.28	$32.80			0
		2.5	8.2	$82.00			0
		2.5	8.2	$82.00			0
187		10	32.8	$328.00			5
246		10	32.8	$328.00			5
139		10	32.8	$328.00			4

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Tree spreadsheet

Norway Maple	9.84	703		$22.00		49	
Red Maple	8.27	856		$34.00		39	
Red Maple	8.27	856		$34.00		39	
Red Maple	3.14	222		$34.00		9	
Forsythia	0						
Forsythia	0						
Yew	5.9	348		$30.00		11	
Rhododendron	0						
Common Juniper	0						
Yew	0						
Yew	0						
Lilac	5.9	266		$8.00		20	
Weigelia	0						
Tree Lilac	14.17	689		$11.00		51	
Lilac	0						
Japanese Maple	1.18	26		$4.00		1	
Boston Ivy	0						
Weigelia	0						
European Hawthorn	3.9	166		$7.00		13	
Norway Maple	19.68	1,974		$51.00		113	
Norway Maple	8.26	533		$18.00		36	
Norway Maple	14.96	1,300		$36.00		96	
Pieris	0						
Yew	0						
Norway Maple	16.92	1,585		$43.00		103	
White Elm	12.59	1,438		$58.00		90	
Norway Maple	9.05	604		$20.00		41	
Boulevard Cypress	16.92	1,968		$16.00		93	
Yew	0						
Boulevard Cypress	10.62	1,066		$18.00		47	
Silver Linden	24.4	3,165		$58.00		135	
Red Oak	23.62	3,128		$60.00		145	
Lilac	0						
Red Oak	22.83	3,128		$60.00		145	
Honey Suckle	0						
Scotch Elm	2.7	197		$38.00		9	
Scotch Elm	3.93	297		$41.00		14	
Honey Suckle	0						
Flowering Quince	0						
Green Ash	11.81	1,343		$33.00		84	
Norway Maple	1.96	55		$5.00		3	

Tree spreadsheet

246		10	32.8	$328.00			5
172		11	36.08	$360.80			5
172		11	36.08	$360.80			5
48		5	16.4	$164.00			2
		1.5	4.92	$49.20			0
		2.5	8.2	$82.00			0
56		4	13.12	$131.20			3
		3	9.84	$98.40			0
		3	9.84	$98.40			0
		2	6.56	$65.60			0
		1.5	4.92	$49.20			0
103		4.5	14.76	$147.60			3
		1.5	4.92	$49.20			0
288		5.8	19.024	$190.24			8
		0	0	$0.00			0
7		2	6.56	$65.60			1
		11	36.08	$360.80			0
		3.5	11.48	$114.80			0
62		3	9.84	$98.40			2
719		9	29.52	$295.20			10
184		10.5	34.44	$344.40			5
468		14	45.92	$459.20			8
		1	3.28	$32.80			0
		2	6.56	$65.60			0
574		13	42.64	$426.40			9
414		12	39.36	$393.60			7
209		10	32.8	$328.00			5
321		9	29.52	$295.20			9
		3	9.84	$98.40			0
170		7.5	24.6	$246.00			6
621		9	29.52	$295.20			13
819		13	42.64	$426.40			12
		1.5	4.92	$49.20			0
819		12.5	41	$410.00			12
		3.5	11.48	$114.80			0
47		5	16.4	$164.00			2
75		5	16.4	$164.00			2
		2.5	8.2	$82.00			0
		2.5	8.2	$82.00			0
312		10.5	34.44	$344.40			6
18		3	9.84	$98.40			1

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Tree spreadsheet

Berberis	0						
Dwarf Alberta Spruce	1.18	19		$12.00		1	
Mountain Ash	5.9	547		$27.00		30	
Mountain Ash	3.14	213		$25.00		11	
Sycamore Maple	2.75	100		$7.00		6	
White Birch	5.51	508		$34.00		21	
Choke Cherry	4.33	185		$7.00		14	
White Willow	3.93	312		$34.00		12	
Silver Linden	26.77	3,627		$56.00		148	
Red Oak	27.16	4,197		$47.00		197	
Red Oak	32.67	5,328		$53.00		231	
Scotch Elm	31.49	5,193		$93.00		238	
Scotch Elm	0						
Flowering Quince	5.51	363		$39.00		19	
Sycamore Maple	7.87	497		$17.00		34	
Sycamore Maple	6.29	354		$14.00		24	
White Ash	0						
Flowering Quince	9.055	807		$61.00		42	
European Hawthorn	5.9	266		$8.00		20	
Norway Maple	0						
Forsythia	0						
Yew	3.14	114		$18.00		4	
Hemlock	4.72	131		$9.00		9	
White Cedar	0						
Rhododendron	9.84	464		$9.00		34	
Red Maple	10.23	1,110		$34.00		55	
Austrian Pine	7.87	707		$18.00		27	
Austrian Pine	0						
Austrian Pine	0						
Lilac	0						
Wintercreeper Euonymus	0						
Potentilla	0						
Potentilla	0						
False Cypress	0						
Flowering Quince	0						
Spirea	0						
Grey Birch	2.755907	n/a					
Grey Birch	4.724412	n/a					
Sugar Maple	2.362206	149		$38.00		11	

Tree spreadsheet

		1	3.28	$32.80			0
3		0.75	2.46	$24.60			1
112		5.2	17.056	$170.56			3
43		5	16.4	$164.00			2
34		5	16.4	$164.00			2
103		5.5	18.04	$180.40			3
70		5	16.4	$164.00			3
64		2	6.56	$65.60			2
696		20	65.6	$656.00			14
1019		15	49.2	$492.00			14
1238		15	49.2	$492.00			17
1260		15	49.2	$492.00			16
		16	52.48	$524.80			0
136		2	6.56	$65.60			3
172		12	39.36	$393.60			4
124		13	42.64	$426.40			4
		11	36.08	$360.80			0
277		1.5	4.92	$49.20			5
103		9	29.52	$295.20			3
		8.5	27.88	$278.80			0
		1.5	4.92	$49.20			0
22		2	6.56	$65.60			2
51		3	9.84	$98.40			3
		2.5	8.2	$82.00			0
186		0	0	$0.00			5
227		8	26.24	$262.40			6
102		10	32.8	$328.00			4
		10	32.8	$328.00			0
		6	19.68	$196.80			0
		3	9.84	$98.40			0
		0.25	0.82	$8.20			0
		0.5	1.64	$16.40			0
		0.5	1.64	$16.40			0
		0.5	1.64	$16.40			0
		2	6.56	$65.60			0
		1	3.28	$32.80			0
		5	16.4	$164.00			2
		10	32.8	$328.00			3
38		4	13.12	$131.20			2

Tree spreadsheet

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Red Oak	3.93701	n/a					
Sugar Maple	1.7716545	79		$37.00		5	
European Beech	4.1338605	257		$52.00		18	
Sugar Maple	3.3464585	266		$39.00		21	
Sycamore Maple	20.472452	n/a					
Red Oak	1.968505	n/a					
Yew	0	n/a					
Yew	0	n/a					
European Hawthorn	2.362206	36		$19.00		7	
Eastern Red Cedar	1.968505	56		$13.00		3	
American Chestnut	3.93701	n/a					
Pin Oak	6.299216	529		$73.00		36	
Pin Oak	5.118113	370		$62.00		25	
Dwarf White Pine	0	n/a					
Red Elm	25.590565	3,327		$103.00		249	
Silver Maple	2.755907	175		$111.00		19	
Silver Maple	2.755907	175		$111.00		19	
Red Elm	1.968505	n/a					
Lilac	0	n/a					
Norway Maple	14.960638	1,675		$62.00		112	
Forsythia	0	n/a					
Forsythia	0	n/a					
Red Maple	2.362206	108		$31.00		11	
Zelkova	2.362206	n/a					
Red Maple	3.149608	173		$40.00		14	
Red Maple	3.149608	173		$40.00		14	
Red Maple	3.149608	173		$40.00		14	
Red Maple	3.149608	173		$40.00		14	
Red Maple	3.149608	173		$40.00		14	
Silver Linden	2.362206	n/a					
Wintercreeper Euonymus	0	n/a					
Red Elm	25.590565	3,327		$103.00		249	
Norway Maple	24.803163	3,042		$68.00		185	
Red Elm	31.49608	4,150		$71.00		294	
Lilac	0	n/a					
Red Oak	2.755907	n/a					
Norway Maple	17.716545	2,062		$65.00		130	
Box Elder	14.173236	1,658		$118.00		134	
Green Ash	16.535442	2,013		$121.00		162	

Tree spreadsheet

		6.2	20.336	$203.36			2
21		4.5	14.76	$147.60			1
80		6	19.68	$196.80			3
68		6	19.68	$196.80			2
		12	39.36	$393.60			11
		5	16.4	$164.00			1
		3	9.84	$98.40			0
		1	3.28	$32.80			0
32		4.5	14.76	$147.60			2
9		4	13.12	$131.20			1
		5.5	18.04	$180.40			2
156		6	19.68	$196.80			4
111		4	13.12	$131.20			3
		0.5	1.64	$16.40			0
959		12	39.36	$393.60			13
74		5	16.4	$164.00			2
74		5	16.4	$164.00			2
		0.5	1.64	$16.40			1
		0	0	$0.00			0
441		13	42.64	$426.40			8
		0	0	$0.00			0
		0	0	$0.00			0
48		3.5	11.48	$114.80			2
		4	13.12	$131.20			2
62		4	13.12	$131.20			2
62		4	13.12	$131.20			2
62		4	13.12	$131.20			2
62		4	13.12	$131.20			2
62		4	13.12	$131.20			2
		4.5	14.76	$147.60			2
		0.5	1.64	$16.40			0
959		17.5	57.4	$574.00			13
643		15	49.2	$492.00			13
1073		12	39.36	$393.60			16
		1.5	4.92	$49.20			0
		5.5	18.04	$180.40			2
504		11	36.08	$360.80			9
531		7.5	24.6	$246.00			8
638		14.5	47.56	$475.60			9

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Red Maple	16.535442	2,013		$121.00		162	
Siberian Elm	43.30711	11,713		$85.00		342	
Siberian Elm	19.291349	5,745		$85.00		227	
#N/A	0	n/a					
Red Osier Dogwood	0	n/a					
Yew	0	n/a					
White Cedar	7.87402	n/a					
Yew	0	n/a					
Rhododendron	0	n/a					
Hemlock	11.81103	n/a					
Hemlock	7.086618	n/a					
Norway Maple	0	n/a					
Shrub Bed	0	n/a					
Shrub Bed	0	n/a					
Norway Maple	7.87402	721		$56.00		55	
Norway Maple	15.74804	1,785		$63.00		117	
Austrian Pine	5.905515	598		$31.00		16	
#N/A	#N/A						
#N/A	#N/A						
#N/A	#N/A						
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Tree spreadsheet

638		13	42.64	$426.40			9
1175		15	49.2	$492.00			22
839		12	39.36	$393.60			10
		6	19.68	$196.80			0
		3	9.84	$98.40			0
		2	6.56	$65.60			0
		8	26.24	$262.40			4
		2	6.56	$65.60			0
		1	3.28	$32.80			0
		10	32.8	$328.00			6
		9	29.52	$295.20			4
		4	13.12	$131.20			0
		1	3.28	$32.80			0
		1	3.28	$32.80			0
223		8	26.24	$262.40			4
460		8	26.24	$262.40			8
51		4	13.12	$131.20			3
		#N/A					
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Tree spreadsheet

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Sapling Spreadsheet

xce	Width in Inches	Total width/inches of sapling	Total number of saplings needed to replace tree (Rounded up to nearest tree)	Stormwater Gallons per Year	Sapling Stormwater Gallons per Year (# of saplings multiplied by base amount)	Property Value $/Year	Sapling Property Value $/Year ((# of saplings multiplied by base amount)
x	x	1.97 (5 cm)		x	108	x	$21
x	x			x		x	
Red Oak	16.93		9	2295	972	$36	$189
Red Oak	11.81		6	1450	648	$31	$126
Red Maple	18.9		10	2309	1080	$31	$210
Mountain Ash	12.2		7	590	756	$10	$147
Scotch Pine	11.81		6	1231	648	$18	$126
Sugar Maple	11.42		6	1102	648	$30	$126
Sugar Maple	11.02		6	1047	648	$29	$126
Sugar Maple	16.14		9	1779	972	$38	$189
Austrian Pine	14.96		8	1657	864	$17	$168
Austrian Pine	17.72		9	2093	972	$16	$189
Red Maple	7.48		4	757	432	$34	$84
Red Maple	11.42		6	1272	648	$33	$126
Red Maple	7.09		4	709	432	$34	$84
Red Oak	18.11		10	2507	1080	$38	$210
Red Maple	9.06		5	961	540	$34	$105
Red Oak	20.47		11	2933	1188	$40	$231
Service Berry							
Red Oak	13.78		7	1768	756	$33	$147
Norway Maple	12.6		7	1028	756	$30	$147
Red Maple	7.87		4	810	432	$34	$84
Red Maple	9.06		5	961	540	$34	$105
Red Maple	7.48		4	757	432	$34	$84
Red Maple	7.48		4	757	432	$34	$84
Red Maple	6.69		4	658	432	$34	$84
Red Maple	3.94		2	317	216	$34	$42
Red Maple	10.63		6	1164	648	$33	$126
Red Maple	7.87		4	806	432	$34	$84
Red Maple	9.06		5	961	540	$34	$105
White Birch	2.36		2	130	216	$34	$42
Red Oak	11.02		6	1323	648	$30	$126
Red Oak	13.78		7	1768	756	$33	$147
Red Oak	18.9		10	2649	1080	$39	$210
Mountain Ash	14.17		8	695	864	$11	$168
Crab Apple	9.06		5	504	540	$13	$105

Sapling Spreadsheet

Energy Saved Kilowatt / hours	Sapling Energy Saved Kilowatt / hours (# of saplings multiplied by base amount)	CO2 Reduction (lbs per year)	Sapling CO2 Reduction lbs/year (# of saplings multiplied by base amount)
x	5	x	23
x		x	
135	45	588	207
90	30	369	138
114	50	411	230
44	35	243	161
58	30	204	138
64	30	270	138
60	30	257	138
98	45	420	207
86	40	291	184
96	45	333	207
34	20	152	92
66	30	265	138
31	20	142	92
141	50	641	230
44	25	193	115
152	55	746	253
113	35	454	161
74	35	367	161
36	20	162	92
44	25	193	115
34	20	152	92
34	20	152	92
29	20	132	92
12	10	65	46
59	30	240	138
36	20	162	92
44	25	193	115
5	10	31	46
82	30	335	138
113	35	454	161
145	50	676	230
52	40	290	184
32	25	137	115

Sapling Spreadsheet

White Birch	5.91		3	560	324	$34	$63
Norway Maple	3.94		2	171	216	$9	$42
Mountain Ash							
Forsythia							
Mountain Ash	11.02		6	527	648	$10	$126
Mountain Ash	10.24		6	485	648	$10	$126
Honey Suckle							
Yew							
Red Twig Dogwood							
Yew							
Red Twig Dogwood							
Wintercreeper Euonymus							
Sandcherry							
Scotch Pine	9.84		5	961	540	$18	$105
Norway Maple	9.06		5	611	540	$20	$105
Norway Maple	6.3		4	363	432	$14	$84
Flowering Quince							
Spirea							
Spirea							
Golden Ninebark							
Weigelia							
Spirea							
Lilac							
Lilac							
English Rose							
Norway Maple	25.59		13	2948	1404	$73	$273
Norway Maple	23.62		12	2612	1296	$66	$252
Yew							
Yew							
Wintercreeper Euonymus							
Wintercreeper Euonymus							
Yew							
Yew							
Yew							
Yew							
Norway Maple	8.27		5	539	540	$18	$105
Norway Maple	9.84		5	703	540	$22	$105
Norway Maple	6.69		4	398	432	$15	$84

Sapling Spreadsheet

24	15	113	69
12	10	60	46
39	30	214	138
35	30	195	138
40	25	149	115
42	25	211	115
25	20	127	92
143	65	1059	299
132	60	944	276
37	25	187	115
49	25	246	115
27	20	139	92

Sapling Spreadsheet

Norway Maple	9.84		5	703	540	$22	$105
Red Maple	8.27		5	856	540	$34	$105
Red Maple	8.27		5	856	540	$34	$105
Red Maple	3.14		2	222	216	$34	$42
Forsythia							
Forsythia							
Yew	5.9		3	348	324	$30	$63
Rhododendron							
Common Juniper							
Yew							
Yew							
Lilac	5.9		3	266	324	$8	$63
Weigelia							
Tree Lilac	14.17		8	689	864	$11	$168
Lilac							
Japanese Maple	1.18		1	26	108	$4	$21
Boston Ivy							
Weigelia							
European Hawthorn	3.9		2	166	216	$7	$42
Norway Maple	19.68		10	1974	1080	$51	$210
Norway Maple	8.26		5	533	540	$18	$105
Norway Maple	14.96		8	1300	864	$36	$168
Pieris							
Yew							
Norway Maple	16.92		9	1585	972	$43	$189
White Elm	12.59		7	1438	756	$58	$147
Norway Maple	9.05		5	604	540	$20	$105
Boulevard Cypress	16.92		9	1968	972	$16	$189
Yew							
Boulevard Cypress	10.62		6	1066	648	$18	$126
Silver Linden	24.4		13	3165	1404	$58	$273
Red Oak	23.62		12	3128	1296	$60	$252
Lilac							
Red Oak	22.83		12	3128	1296	$60	$252
Honey Suckle							
Scotch Elm	2.7		2	197	216	$38	$42
Scotch Elm	3.93		2	297	216	$41	$42
Honey Suckle							
Flowering Quince							
Green Ash	11.81		6	1343	648	$33	$126
Norway Maple	1.96		1	55	108	$5	$21

Sapling Spreadsheet

49	25	246	115
39	25	172	115
39	25	172	115
9	10	48	46
11	15	56	69
20	15	103	69
51	40	288	184
1	5	7	23
13	10	62	46
113	50	719	230
36	25	184	115
96	40	468	184
103	45	574	207
90	35	414	161
41	25	209	115
93	45	321	207
47	30	170	138
135	65	621	299
145	60	819	276
145	60	819	276
9	10	47	46
14	10	75	46
84	30	312	138
3	5	18	23

Sapling Spreadsheet

Berberis							
Dwarf Alberta Spruce	1.18		1	19	108	$12	$21
Mountain Ash	5.9		3	547	324	$27	$63
Mountain Ash	3.14		2	213	216	$25	$42
Sycamore Maple	2.75		2	100	216	$7	$42
White Birch	5.51		3	508	324	$34	$63
Choke Cherry	4.33		3	185	324	$7	$63
White Willow	3.93		2	312	216	$34	$42
Silver Linden	26.77		14	3627	1512	$56	$294
Red Oak	27.16		14	4197	1512	$47	$294
Red Oak	32.67		17	5328	1836	$53	$357
Scotch Elm	31.49		16	5193	1728	$93	$336
Scotch Elm							
Flowering Quince	5.51		3	363	324	$39	$63
Sycamore Maple	7.87		4	497	432	$17	$84
Sycamore Maple	6.29		4	354	432	$14	$84
White Ash							
Flowering Quince	9.055		5	807	540	$61	$105
European Hawthorn	5.9		3	266	324	$8	$63
Norway Maple							
Forsythia							
Yew	3.14		2	114	216	$18	$42
Hemlock	4.72		3	131	324	$9	$63
White Cedar							
Rhododendron	9.84		5	464	540	$9	$105
Red Maple	10.23		6	1110	648	$34	$126
Austrian Pine	7.87		4	707	432	$18	$84
Austrian Pine							
Austrian Pine							
Lilac							
Wintercreeper Euonymus							
Potentilla							
Potentilla							
False Cypress							
Flowering Quince							
Spirea							
Grey Birch	2.755907		2		216		$42
Grey Birch	4.724412		3		324		$63
Sugar Maple	2.362206		2	149	216	$38	$42

Sapling Spreadsheet

1	5	3	23
30	15	112	69
11	10	43	46
6	10	34	46
21	15	103	69
14	15	70	69
12	10	64	46
148	70	696	322
197	70	1019	322
231	85	1238	391
238	80	1260	368
19	15	136	69
34	20	172	92
24	20	124	92
42	25	277	115
20	15	103	69
4	10	22	46
9	15	51	69
34	25	186	115
55	30	227	138
27	20	102	92
	10		46
	15		69
11	10	38	46

Sapling Spreadsheet

Red Oak	3.93701		2		216		$42
Sugar Maple	1.7716545		1	79	108	$37	$21
European Beech	4.1338605		3	257	324	$52	$63
Sugar Maple	3.3464585		2	266	216	$39	$42
Sycamore Maple	20.472452		11		1188		$231
Red Oak	1.968505		1		108		$21
Yew							
Yew							
European Hawthorn	2.362206		2	36	216	$19	$42
Eastern Red Cedar	1.968505		1	56	108	$13	$21
American Chestnut	3.93701		2		216		$42
Pin Oak	6.299216		4	529	432	$73	$84
Pin Oak	5.118113		3	370	324	$62	$63
Dwarf White Pine							
Red Elm	25.590565		13	3327	1404	$103	$273
Silver Maple	2.755907		2	175	216	$111	$42
Silver Maple	2.755907		2	175	216	$111	$42
Red Elm	1.968505		1		108		$21
Lilac							
Norway Maple	14.960638		8	1675	864	$62	$168
Forsythia							
Forsythia							
Red Maple	2.362206		2	108	216	$31	$42
Zelkova	2.362206		2		216		$42
Red Maple	3.149608		2	173	216	$40	$42
Red Maple	3.149608		2	173	216	$40	$42
Red Maple	3.149608		2	173	216	$40	$42
Red Maple	3.149608		2	173	216	$40	$42
Red Maple	3.149608		2	173	216	$40	$42
Silver Linden	2.362206		2		216		$42
Wintercreeper Euonymus							
Red Elm	25.590565		13	3327	1404	$103	$273
Norway Maple	24.803163		13	3042	1404	$68	$273
Red Elm	31.49608		16	4150	1728	$71	$336
Lilac							
Red Oak	2.755907				0		$0
Norway Maple	17.716545		9	2062	972	$65	$189
Box Elder	14.173236		8	1658	864	$118	$168
Green Ash	16.535442		9	2013	972	$121	$189

Sapling Spreadsheet

	10		46
5	5	21	23
18	15	80	69
21	10	68	46
	55		253
	5		23
7	10	32	46
3	5	9	23
	10		46
36	20	156	92
25	15	111	69
249	65	959	299
19	10	74	46
19	10	74	46
	5		23
112	40	441	184
11	10	48	46
	10		46
14	10	62	46
14	10	62	46
14	10	62	46
14	10	62	46
14	10	62	46
	10		46
249	65	959	299
185	65	643	299
294	80	1073	368
	0		0
130	45	504	207
134	40	531	184
162	45	638	207

Sapling Spreadsheet

Red Maple	16.535442		9	2013	972	$121	$189
Siberian Elm	43.30711		22	11713	2376	$85	$462
Siberian Elm	19.291349		10	5745	1080	$85	$210
#N/A							
Red Osier Dogwood							
Yew							
White Cedar	7.87402		4		432		$84
Yew							
Rhododendron							
Hemlock	11.81103		6		648		$126
Hemlock	7.086618		4		432		$84
Norway Maple							
Shrub Bed							
Shrub Bed							
Norway Maple	7.87402		4	721	432	$56	$84
Norway Maple	15.74804		8	1785	864	$63	$168
Austrian Pine	5.905515		3	598	324	$31	$63
#N/A	#N/A						
#N/A	#N/A						
#N/A	#N/A						
#N/A	#N/A						
#N/A	#N/A						
#N/A	#N/A						
#N/A	#N/A						
#N/A	#N/A						
#N/A	#N/A						
#N/A	#N/A						
#N/A	#N/A						
#N/A	#N/A						

Sapling Spreadsheet

162	45	638	207
342	110	1175	506
227	50	839	230
	20	432	92
	30	648	138
	20	432	92
223	20	432	92
460	40	864	184
51	15	324	69